almanach 12

TECHNISCHE FAKULTÄT DER
CHRISTIAN-ALBRECHTS-UNIVERSITÄT
ZU KIEL

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Christian-Albrechts-Universität zu Kiel

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Herausgeber:
Dekanat Technische Fakultät
Christian-Albrechts-Universität zu Kiel
Kaiserstraße 2, 24143 Kiel
Tel.: 0431/880-6001, -6068
Fax: -6003
dekanat@tf.uni-kiel.de
http://www.tf.uni-kiel.de

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Table of contents

Foreword 5

Computer Science

Department of Computer Science 7
Algorithmic Optimal Control - CO2 Uptake of the Ocean 11
Business Information Technology 17
Communication Systems 21
Computer-Aided Program Development 23
Computer Media 27
Computer Science Education 29
Dependable Systems 31
Discrete Optimization 39
Information Systems Engineering 45
Multimedia Information Processing 59
Programming Languages and Compiler Construction 67
Real Time Systems / Embedded Systems 75
Scientific Computing 83
Software Engineering 87
Technical Computer Science 99
Theoretical Computer Science 105
Theory of Parallelism 109

Electrical Engineering and Information Technology

Institute of Electrical and Information Engineering 113
Automatic Control 115
Communications 123
Computational Electromagnetics 131
Digital Signal Processing and System Theory 137
Information and Coding Theory 147
Integrated Systems and Photonics 153
Microwave Laboratory 159
Nanoelectronics 169
Power Electronics and Electrical Drives 177
Technology of Silicon-Based Micro- and Nano-Systems 191
Wireless Communications 193

Materials Science

Institute for Materials Science 199
Biocompatible Nanomaterials 201
Functional Nanomaterials 207
General Materials Science 217

Inorganic Functional Materials 229
Materials and Processes for Nanosystem Technologies 239
Microanalysis of Materials 241
Multicomponent Materials 251
Nanochemistry and Nanoengineering 265
Nanoscale Magnetic Materials - Magnetic Domains 273
Synthesis and Real Structures 281
CMA Centre for Materialanalytics 291
Functional Morphology and Biomechanics At Zoological Institute 295

Organization
Deanship 297
Friends of the Faculty of Engineering 301
Service Centre 303

Preface

Dear Reader,

In 2012, one of the events with high impact on our university were the decisions on the Excellence Initiative in June. The renewal proposal of the cluster of excellence **The Future Ocean**, with Prof's Hasselbring and Srivastav as PIs (among others), has been approved for 2012 - 2017 with a funding of approx. 29 Million Euros. Several additional members of the Faculty of Engineering are involved in the research activities of this cluster, in the second CAU cluster of excellence **Inflamation at Interfaces**, and the graduate school **Human Development in Landscapes**. The cluster of excellence proposal **Materials for Life** reached the final round in the application procedure, but unfortunately was not selected for funding in this final round.

Prof. Dr. Martina Gerken was awarded an ERC Starting Grant of 1.5 Mio. EUR for five years to evaluate photo-switching of smart surfaces for integrated biosensors. Dr.-Ing. Jost Adam has joined the Institute for Electrical and Information Engineering in October 2012. He is heading the group of Integrated Systems and Photonics during the parental leave of absence of Prof. Dr. Martina Gerken. Thomas Meurer joint the faculty as professor for **Automatic Control**. He received the Kardinal-Innitzer-Förderpreis for his habiliation thesis entitled **Contributions to Motion Planning and Tracking Control for Distributed-Parameter Systems in Single- and Higher-Dimensional Spatial Domains**, completed at the Technical University Vienna.

Several scientific achievements could be mentioned. As an example, the HZG/CAU research group **Nanochemistry and Nanoengineering**, headed by Prof. Elbahri, has been recognized from editorial boards as outstanding results and featured as cover stories in journals such as Advanced Materials, Advanced Functional Materials and Materials Today. Prof. Adelung was involved in inventing the new material **aerographite**, the lightest material in the world.

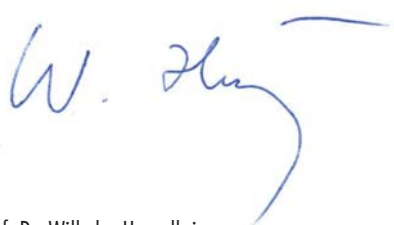
As in the previous years, the faculty was involved in various form of technology transfer: Professors Adelung, Fuchs, Hasselbring and Koch received the **ISH-Transferpreis 2012**. In addition, Prof. Elbahri received a special award **Nanotechnology** within a competition for ideas of the state of Schleswig-Holstein. Prof. Rosenkranz received the Celtic-Award 2012 in Gold for the joint project **100 Gigabit Ethernet Transport Technologies**. Rodrigo Lima de Miranda, from Prof. Quandt's group, funded the spin-off company **Acquandas GmbH**.

In June 2012, the third **KoSSE-Tag** took place at the Wissenschaftszentrum Kiel. At this event, the competence cluster Software System Engineering KoSSE presents its technology transfer activities to the public. With, again, one hundred participants, this event has been established as a community meeting of the regional software industry.

Prof. Quandt became member of the board of DGM (Deutsche Gesellschaft für Materialkunde) and member of Acatech (Deutsche Akademie der Technikwissenschaften). Prof. Faupel became member of the Minerva-Weizmann committee.

As a final note, it deserves mention that -- after serious financial problems in 2010/2011 -- the faculty managed to get its financial situation under control, despite continuous structural underfunding.

Plans for measures for energetic restoration of the buildings at the east campus have been made, now we need to find ways to realize these measures together with the university board and the government.



Prof. Dr. Wilhelm Hasselbring
Dean of the Faculty of Engineering

almanach 12

Department of Computer Science

For the Department of Computer Science 2012 was a busy and successful year, despite the drastic budget cuts and savings in the faculty that had taken effect in 2011: the department had lost a full professorship in business information technology.

In 2012 the department gained recognition for its research both through individual research results and results of joint efforts. One of the two best paper awards that members of the department received was for a paper, co-authored by Professor Schimmler and two of his PhD students, on a statistical model for DNA sequencing, emphasizing the interdisciplinary nature of some of the research in the department. Of the papers published by members of the department in the most highly ranked journals in computer science , one is on multi-threaded reactive programming, co-authored by Professor von Hanxleden, another on bipartite matching, co-authored by Dr. Lasse Kliemann, Professor Anand Srivastav, and two of their students, and two more concern combinatorics on words in a broader sense, both co-authored by members of the group of Professor Nowotka.

2012 was an exciting year for the department as it shaped the department's profile more than previous years. There is a larger research initiative emerging which takes an integrated approach to how research data and knowledge is created, shared, and processed and how research takes place in a digital communication and information environment. One of the activities in this respect is the involvement with a large-scale research initiative ''science 2.0'', started by the Leibniz-Gemeinschaft in 2012. Professor Tochtermann, who heads the research group for new media technology of the department, is now at the heart of ''science 2.0'', a research network dealing „with the investigation of new fields for research and development, originating from the application of new participative and collaborative internet technologies in all phases of research''. Two other groups of the department, the computer networks group and the software engineering group, also engage in the project.

For the software and systems engineering initiative of the department, it was an especially good year. The annual *KoSSE-Tag* , with more than one hundred participants, was once again a great success. By now, this event has established itself as *the* community meeting of the regional software industry. On the research side of computer and systems engineering, the department became involved in the priority programme ''Design For Future Managed Software Evolution'' (SPP 1593) of the DFG: Professor Hasselbring, heading the research group for software engineering, is one of its coordinators.

In 2012 Professors Thalheim and Slawig gathered a large, interdisciplinary group of researchers from almost all faculties of the university, making modelling in science the topic of their joint research effort. On a smaller scale, but equally promising, is a new initiative by Professors Börm, Nowotka, Schimmler, and Slawig. Their goal is to make high-performance computing a stronger topic within the department, with regard to research, teaching, and also infrastructure: funding for a high performance computer is being raised.

2012 once more showed that the computer science department is well-connected internationally. An outstanding example is the cooperation with the Universiti Technologi MARA in Malaysia (the largest Malaysian university: 170.000 students and a yearly budget of approx. one billion USD). In 2012, the department signed a cooperation treaty with that university and later in the year Professor Tochtermann was named ''Visiting Professor''. Another outstanding example is an initiative by Professor Srivastav that established a research network between German and Indian universities in the field of algorithm engineering and is funded jointly by the DFG and the Indian Ministry of Science and Technology. As a result four Indo-German projects emerged, two of them with involvement from the department of computer science.

Within the university, the department of computer science is equally well-connected. An excellent example for this is the renewal proposal of the cluster of excellence ''The Future Ocean'', which was approved for the period from 2012 to 2017 with a funding of approx. 29 Million Euros. Several research groups of the department take part in the research activities of the cluster: the groups headed by Professors Börm, Koch, Luttenberger, and Slawig, and Professors Hasselbring and Srivastav are principal investigators of it.

With the number of graduates as high as 89, 2012 was the most successful year since the beginning of the millennium. This is due, on the one hand, to the continuous efforts of the quality management in the teaching group headed by Professor Börm, and on the other, the efforts of Professors Speck and Thalheim in trying to compensate for the lost professorship in business information technology. As in the previous years, the department held a strong position as a centre of technology transfer: Professors Hasselbring and Koch received the *ISH-Transferpreis*.

Fig. 1: Graduates in Computer Science and Business Information Technology at the Winterfest 2012 (Photo: Axel Schön, Copyright: CAU)

Personnel

Head of the group: Prof. Dr. W. Hasselbring (July/August), Prof. Dr. R. von Hanxleden(Jan.-June), Prof. Dr. T. Wilke (Sept.-Dec.);

Staff:

A. Bock	01.01.-31.12.2012	CAU, 50 percent
Computer Science and Business Information Technology Examination Office		
W. Burmeister	01.01.-31.12.2012	CAU
Computer and IT support team		
C. Dort	01.01.-31.12.2012	CAU
Computer and IT support team		
J.-M. Eitzen	01.08.-31.12.2012	CAU, 25 percent
Computer Science Department's Office		

PD Dr. F. Huch	01.01.-31.12.2012	CAU, 65 percent
Computer Science and Business Information Technology Examination Office		
F. Lorenz	01.01.-31.03.2012	CAU, 50 percent
Computer Science and Business Information Technology Examination Office		
Dr. I. Pfannschmidt	01.01.-31.12.2012	CAU
Computer Science Department's Office		
P. Pichol	01.01.-31.12.2012	CAU
Computer and IT support team		
B. Scheidemann	01.01.-31.12.2012 (50%)	CAU
Computer Science and Business Information Technology Examination Office		
M. Sotiriadis-Gräßler	15.05.-31.12.2012 (50%)	CAU
Computer Science and Business Information Technology Examination Office		
R. Staecker	01.08.-31.12.2012	CAU, 25 percent
Computer Science Department's Office		
Ä. Straßner	01.01.-31.07.2012	CAU
Computer Science Department's Office		

Scientific Staff:

H. Krasemann	01.04.-30.09.2012	Lecturer
Privacy Protection		
Dr. H. Lindhorst	01.04.-30.09.2012	Lecturer
IT Law		
Dr. M. Margraf	01.01.-31.03.2012	Lecturer
IT Security		
Dr. A. Salski	01.01.-31.12.2012	Lecturer
KI		

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

Inf-ITSec4: IT-Sicherheit (4), 2 (+ 1) hrs Lecture (+ Exercises)/Week,
M. Margraf (+ M. Margraf)

Inf-Fuzzy: Fuzzy, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
A. Salski (+ A. Salski)

Summer 2012

Inf-InfRecht: Informatikrecht, 2 hrs Lecture/Week,
H. Lindhorst

Inf-DatSchutz: Datenschutz, 2 hrs Lecture/Week,
H. Krasemann

Inf-KI: Künstliche Intelligenz, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
A. Salski (+ A. Salski)

Winter 2012/2013

Inf-Fuzzy: Fuzzy, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
A. Salski (+ A. Salski)

Algorithmic Optimal Control - CO_2 Uptake of the Ocean

What is Algorithmic Optimal Control?

In many scientific and technological applications, optimization problems for differential equations occur. Such tasks are called problems of optimal control. These problems are very complex in the field of mathematical analysis, numerical transformation, and algorithmic realization. They are a main topic of our research group. Important research areas are:

1. mathematical analysis and development of algorithms for optimal control problems,
2. nonlinear optimization methods,
3. analysis and numerical mathematics of nonlinear partial differential equations (transport equations, equations of fluid mechanics),
4. algorithmic sensitivity and gradient calculations (automatic differentiation).

What is oceanic CO_2 uptake?

Oceans are able store large amounts of carbon dioxide (CO_2)by its fixation from the atmosphere. The oceans act as an enormous carbon sink, and have taken up about a third of the CO_2 emitted by human activity. This fact is quite important for climate discussion where the central topic concerns CO_2 as a greenhouse gas and its effects on global climate changes. The change of oceanic uptake of CO_2 caused by climate changes (e. g. increasing temperatures) is able to generate feedback effects. As the uptake of CO_2 is mainly driven by geobiochemical mechanisms, the aims of the project A3 are sensitivity analysis and data assimilation (i. e. adaptation of model parameters to measured results) in geobiochemical models coupled with ocean circulation models. These aims are implemented by using applied mathematics and computer science.

Results

3-D Parameter Identification in Marine Ecosystems with Surrogate-based Optimization

We have applied the Surrogate-based Optimization (SBO) method on a parameter identification problem for a 3-D biogeochemical model. SBO is a method for acceleration of optimization processes when the underlying model itself is of very high computational complexity. In these cases, pure simulation runs already require huge amount of computer time, whereas optimization runs may become unfeasible even with high-performance hardware. As a consequence, the key idea of SBO is to replace the original, and computationally expensive, (high-fidelity) model by a so-called surrogate, which is created from a less accurate but computationally cheaper (low-fidelity) model with a suitable correction approach to increase its accuracy. To date, the SBO approach has been widely and successfully used in engineering applications and also for parameter identification in a 1-D marine ecosystem model of NPZD type. In this paper, we apply the approach to a two-component biogeochemical model. The model is spun-up into a steady seasonal cycle via the Transport Matrix Approach. The low-fidelity model we use consists of a reduced number of spin-up iterations (several decades instead of the millennia used for the original model). A multiplicative correction operator is further exploited to extrapolate the rather inaccurate low-fidelity model onto the original one. This corrected model builds our surrogate. We validate this SBO method by twin-experiments that use synthetic observations generated by the original model. The proposed SBO technique is shown to yield a solution close to the target with a significant gain of computational efficiency. Without further regularization techniques, the method is able to identify most model parameters. The method is simple to implement and presents a promising and pragmatic tool to calibrate biogeochemical models in a global three-dimensional setting.

GPU hardware accelerates Ecosystem Simulations

We have ported an implementation of the spin-up for marine ecosystem models based on transport matrices to graphics processing units (GPUs). The original implementation was designed for distributed-memory architectures and uses the

Portable, Extensible Toolkit for Scientific Computation (PETSc) library that is based on the Message Passing Interface (MPI) standard. The spin-up computes a steady seasonal cycle of ecosystem tracers with climatological ocean circulation data as forcing. Since the transport is linear with respect to the tracers, the resulting operator is represented by matrices. Each iteration of the spin-up involves two matrix- vector multiplications and the evaluation of the biogeochemical model used. The original code was written in C and Fortran. On the GPU, we use the Compute Unified Device Architecture (CUDA) standard, a customized version of PETSc, and a commercial CUDA Fortran compiler. We describe the extensions to PETSc and the modifications of the original C and Fortran codes that had to be done. Here we make use of freely available libraries for the GPU. We analyze the computational effort of the main parts of the spin-up for two exemplar ecosystem models and compare the overall computational time to those necessary on different CPUs. The results show that a consumer GPU can compete with a significant number of cluster CPUs without further code optimization.

Linear Quadratic Optimal Control leads to an improved Ecosystem Model

We use an optimization method for enhancement of a climate model, namely a one dimensional non-linear marine ecosystem model of NPZD type. The original model contains temporally constant parameters that are subject to optimization in order to improve the fit of the model output to observational data. In several publications, this fit turned out to be rather poor. In this work, the method of Linear Quadratic Optimal Control (LQOC) is used to allow for temporally variant, but annually periodic parameters, in a linearized version of the original model. The periodicity of the parameters is assured by a special choice of the reference trajectory needed in the linearization process. The optimal periodic parameters obtained are used in the original non-linear model. In both validation and prediction experiments, they lead to a significant reduction of the model-data misfit, compared to results obtained with optimized constant parameters.

Personnel

Head of the group: Prof. Dr. T. Slawig;

Scientific Staff:

Dipl.-Math. M. El Jarbi	15.03.-14.07.2012		CAU
Dipl.-Math. A. Heinle Cluster Future Ocean A3	01.01.-31.10.2012	(50%)	DFG
Dipl.-Math. A. Heinle	01.11.-31.12.2012	(50%)	CAU
Dipl.-Math. C. Kratzenstein SPP 1253	01.01.-31.12.2012	(50%)	DFG
Dr. H. Mütze Cluster Future Ocean A3	01.01.-31.10.2012	(50%)	DFG
Dr. H. Mütze E-Learning	01.-31.12.2012	(50%)	CAU
Dr. H. Mütze	01.-30.11.2012	(50%)	DFG
Dipl.-Math. J. Piwonski Cluster Future Ocean A3	01.01.-31.10.2012	(50%)	DFG
Dipl.-Math. J. Piwonski	01.11.-31.12.2012	(50%)	CAU
J. Reimer Cluster Future Ocean	01.01.-31.12.2012	(50%)	DFG

Winter 2011/2012

Klimamodelle und Klimasimulationen, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
T. Slawig (+ C. Kratzenstein)

Algorithmische Aspekte numerischer Verfahren, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
T. Slawig (+ J. Burmeister)

Masterseminar - Numerische Mathematik, 2 hrs Seminar/Week,
S. Börm (+ T. Slawig, M. Braack)

Oberseminar Algorithmische Optimale Steuerung - Informatik in der Meeresforschung, 2 hrs Seminar/Week,
T. Slawig

Summer 2012

Inf-MeerKli: Informatik in Meeres- und Klimaforschung, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
T. Slawig (+ A. Heinle)

Inf-PP: Programmierpraktikum, 1 (+ 2) hrs Lecture (+ Exercises)/Week,
T. Slawig (+ M. El Jarbi)

Inf-PPM: Programmierpraktikum Mathematik, 1 (+ 2) hrs Lecture (+ Exercises)/Week,
T. Slawig (+ M. El Jarbi)

Inf.-Sem-MathKlima: Mathematik und Informatik in Klimamodellen, 2 hrs Seminar/Week,
T. Slawig

Nichtlineare Optimierung, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
T. Slawig (+ J. Piwonski)

Masterprojekt - Algorithmische Optimales Steuerung / Klimasimulation, 2 hrs Exercise/Week,
T. Slawig

Oberseminar Algorithmische Optimale Steuerung - Informatik in der Meeresforschung, 2 hrs Seminar/Week,
T. Slawig

Winter 2012/2013

Inf-AlgDiff: Algorithmisches Differenzieren, 2 (+ 4) hrs Lecture (+ Exercises)/Week,
T. Slawig (+ J. Piwonski)

Inf-AlgNum: Algorithmische Aspekte numerischer Verfahren, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
T. Slawig (+ J. Burmeister)

Inf-InfNat: Informatik für Naturwissenschaftler, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
T. Slawig (+ S. Esquivel)

Introduction to Matlab, 1 hrs Workshop/Week,
T. Slawig

Matlab Advanced, 1 hrs Workshop/Week,
T. Slawig

Masterprojekt - Algorithmische Optimale Steuerung / Klimasimulation, 4 hrs Exercise/Week,
T. Slawig

NF-Inf-1: Informatik für Nebenfächler, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
T. Slawig (+ S. Esquivel)

NF-Inf-1v: Informatik für Nebenfächler (vertiefend), 4 (+ 2) hrs Lecture (+ Exercises)/Week,
T. Slawig (+ S. Esquivel)

Oberseminar Algorithmische Optimale Steuerung - Informatik in der Meeresforschung, 2 hrs Seminar/Week,
T. Slawig

Third-Party Funds

DFG Cluster Future Ocean, *Personal,* 01.01.2012-31.12.2014 (132300,00 EUR)
DFG SPP 1253, *Personal/Sachmittel,* 01.01.-31.12.2012 (141500,00 EUR)

Further Cooperation, Consulting, and Technology Transfer

Prof. Dr. Andreas Oschlies **GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel**, Kiel
Dr. Iris Kiest, **GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel**, Kiel
Prof. Dr. Andreas Griewank, **MATHEON** and **Humboldt-Universität zu Berlin**, Berlin
Prof. Dr. Nicolas Gauger, **RWTH Aachen** Aachen
Dr, Uwe Prüfert, **TU Bergakademie Freiberg**, Freiberg
Prof. Dr. Slawomir Koziel, **Reykjavik University** Reykjavik (Iceland)
Prof. Dr. Kai Graf, **FH Kiel**, Kiel

Diploma, Bachelor's and Master's Theses

E. Siewertsen, *Simulation von biogeochemischen Prozessen in 3-D auf GPUs,* 31.03.2012
J.-H. Wohlers, *Nichtnegative Lösungen gewöhnlicher Differentialgleichungen,* 04.03.2012

Dissertations / Postdoctoral Lecture Qualifications

Malte Prieß, *Surrogate-based Optimization for Marine Ecosystem Models,* 27.01.2012

Publications

Published in 2012

M. Schuerch, S. Temmerman, A. Vafeidis, T. Slawig, *Modelling the influence of changing storm patterns on the ability of a salt marsh to keep pace with sea level rise.,* Journal of Geophysical Research - Earth Surface, (2012)

N. Gauger, A. Griewank, A. Hamdi, C. Kratzenstein, E. Özkaya, T. Slawig, *Automated Extension of Fixed point PDE Solvers for Optimal Design with Bounded Retardation,* Leugering G., Engell S., Griewank A., Hinze M., Rannacher R., Schulz V., Ulbrich M., Ulbrich S. (eds): Constrained Optimization and Optimal Control for Partial Differential Equations. Birkhäuser International Series of Numerical Mathematics, **160**, 99 - 122 (2012)

M. Prieß, T. Slawig, *Aggressive Space Mapping for the Optimization of a Marine Ecosystem Model.,* International Journal of Mathematical Modeling and Numerical Optimization, **3**, 98 - 116 (2012)

T. Slawig, U. Prüfert, *Mathematics-based Optimization in the COMSOL Multiphyscis Framework,* Proceeding of the COMSOL Conference Stuttgart 2011, (2012)

T. Slawig, *Mathematik, Informatik und Klimaforschung*, Schleswig-Holsteinische Universitätsgesellschaft, Itzehoe, 02.02.2012

M. El Jarbi, *Reducing the Model-Data Misfit in a Marine Ecosystem Model Using Periodic Parameter and Linear Quadratic Optimal Control,* 83rd Annual Meeting of the International Association of Applied Mathematics and Mechanics, Darmstadt, 26.-30.03.2012

C. Kratzenstein, *Parameter Identification in Ocean Modelling via Oneshot Optimization*, EGU General Assembly 2012, Wien, Österreich, 07.-12.04.2012

T. Slawig, *Algorithmic Differentiation and Parameter Optimization in Climate Models*, Seminar des Instituts für angewandte Mathematik der Universität Dortmund, Dortmund, 15.-16.05.2012

J. Reimer, *Optimizing Measurements for Parameter Estimation,* Tagung des Clusters 'Ozean der Zukunft', Schleswig, 20.-21.08.2012

C. Kratzenstein, *The one-shot optimization strategy for parameter identification in marine ecosystem models,* 3rd International Conference on Earth System Modelling, Hamburg, 17.-21.09.2012

almanach 12

Business Information Technology

The working group is focused on the support of systems development and integration by improved validation (and generation) concepts. One major research challenge is the quality of the models used to describe commercial systems. Furthermore, the usability of systems is an issue of the working group.

The working group provides courses for the various computer science courses (bachelor´s, master´s, and diploma). Moreover, the group supports the establishment of the new courses in business information systems. The interdisciplinary cooperation is strengthened by joint seminars with the Faculty of Business, Economics and Social Sciences, and Education Science.

Results

Business process models in different notations have been enhanced in order to improve the checkability of these models. These new model languages are used to express both the model to be validated as well as the specification of the basis of the validation.

This enables non-checking experts (e.g. business domain experts) to use the checking concept in order to validate their processes and to understand the checking results.

To increase the usability of systems a questionnaire system has been tested which allows better understanding of the users´ wishes.

Personnel

Head of the group: Prof. Andreas Speck; Secretary: Sylvia Lassen (50%)
Technical Staff: B.Sc. Timo Hebebrand

Scientific Staff:

Dipl.-Inf. Harm Brandt User Driven Innovation	01.01.-31.12.2012	(50%)	Drittmittel
Dipl.-Inf. Harm Brandt	01.10.2012-31.03.2013	(50%)	HSP
Dipl.-Wirt.-Inf. Sven Feja	01.01.-31.12.2012		Land
Dipl.Ing. Aneta Lotycz	01.01.-30.09.2012		Land
Dipl.Ing. Aneta Lotycz	01.10.-31.12.2012		Land ZBW
Dipl.-Ing. Sören Witt DSM	01.01.-30.09.2012	(50%)	Drittmittel
Dipl.Ing. Sören Witt	01.01.-31.12.2012	(50%)	HSP

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

WInf-WInf1:-Grundlagen Wirtschaftsinformatik I, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
A. Speck (+ S. Feja)

WInf-WInf1-WW: Wirtschaftsinformatik I für Wirtschaftswissenschaftler, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
A. Speck (+ B. Thalheim, S. Feja)

WInf-WInf3: Wirtschaftsinformatik III, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
A. Speck (+ S. Witt)

WInf-Proj:Projektgruppe, 4 hrs Exercise/Week,
A. Speck (+ S. Witt)

WInf-MSc-Sem2: Interdisziplinäres Seminar (Betriebliche Anwendungssysteme), 2 hrs Seminar/Week,
A. Speck (+ S. Feja, O. Sörensen)

Interdisziplinäres Forschungsseminar, 2 hrs Seminar/Week,
A. Speck (+ O. Sörensen)

WInf-BetrStan:Betreibliche Standardsoftware, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
A. Speck (+ S. Feja, A. Lotycz)

WInf-eC:E-Commerce, 3 (+ 1) hrs Lecture (+ Exercises)/Week,
A. Speck (+ S Witt)

WInfMSc-Pro2:Projekt Wirtschaftsinformatik (Betriebliche Anwendungssysteme, 3 hrs Practical/Week,
A. Speck (+ S. Feja, S. Witt)

Winter 2012/2013

WInf-WInf1:-Grundlagen Wirtschaftsinformatik I, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
A. Speck (+ S. Feja)

WInf-WInf1-WW:-Grundlagen Wirtschaftsinformatik I für Wirtschaftswissenschaftler, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
A. Speck (+ S. Feja, S. Witt)

WInf-BetrStan: Bertriebliche Standardsoftware, 4 (+ 3) hrs Lecture (+ Exercises)/Week,
A. Speck (+ S. Feja, A. Lotycz)

WInf-GenProg: Generative Programmierung, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
A. Speck (+ S. Feja, S. Witt)

WInf-Pro: Projektgruppe, 4 hrs Practical/Week,
A. Speck (+ S. Witt, S. Feja)

WInf-MSc-Sem2: Interdisziplinäres Seminar, 2 hrs Seminar/Week,
A. Speck (+ S. Witt, S. Feja)

Third-Party Funds

EU Interreg 4A –User driven Innovation–, *Personal,* 01.01.-31.12.2012 (222460 EUR)
BMWi EXIT-Programm Projekt runpat, *Personal,* 01.11.-31.12.2013 (91600 EUR)

Diploma, Bachelor's and Master's Theses

M. Dölcker, *Realisierung des Sichtenkonzepts MMultiViewffür Geschäftsprozessmodelle im Business Application Modeler,* 12.09.2012
T. Ercan, *Theoretische Verifizierung und praktische Validierung der Business Modeling Notation,* 28.09.2012
M. Jöhnke, *Entwicklung und Evaluation eines Continuos Integration Konzeptes für die SharePiont Softwareentwicklung,* 28.09.2012
M.E. Classe, *Integration und Evaluation verschiedener Model-Checker im Business Application Modeller,* 28.03.2012
B. Lebrecht, *Konzept und Umsetzung eines Eclips-Plugins zur Manipulation von XML-Daten in einer grafischen Oberfläche in BAM,* 30.03.2012

J. Bombien, *Anbahnungsunterstützung für Transferprojekte*, 29.03.2012
J. Schmidt, *Konzeption und prototypische Umsetzung eines Prozessstrassenkonzepts in Activiti Framework mit BPMN2.0*, 29.09.2012

Dissertations / Postdoctoral Lecture Qualifications

S. Feja, *Validierung von MultiView-basierten Prozessmodellen mit grafischen Validierungsregeln am Beispiel von Sicherheits- und Datenschutzmodellierung*, 30.04.2012

Publications

Published in 2012

A. Speck, S. Feja, S. Witt, T. Stuht, E. Pulvermüller, *Rule Determination and Process Verification using Business Capabilities*, 5th IFIP WG8.1 Working Conference on the Practice of Enterprise Modelling (PoEM 2012), (2012)
A. Speck, S. Witt, S. Feja, C. Prietz, *Integrated Privacy Modelling and Validation for Business Process Models*, Proceedings of the 2012 Joint EDBT/ICDT, 196 - 205 (2012)

Presentations

A. Speck, *Qualitätssicherung in Geschäftsprozessmodellen*, 7. Norddeutsche Fachtagung für Qualitätssicherung, Lübeck, Germany, 26.09.2012

almanach 12

Communication Systems

The Research Group for Communication Systems (AG ComSys) has been established in the Dept. of Computer Science of the CAU Kiel since Oct. 2000, and is directed by Prof. Dr.-Ing. Norbert Luttenberger.

Results

1. XML language technology for marine and biological research

In the context of the Future Ocean Cluster of Excellence, AG ComSys closely cooperated with oceanographers and biologists from CAU and IfM Geomar. The project goal is to combine formal descriptions of scientific workflows with GML/XML schemas that describe the format of measurement data and related meta-data. A graphical workflow editor was designed and implemented that lets researchers describe their scientific workflow in great detail. Each workstep in a workflow is attributed with grammar elements that are used to validate obtained measurement data and meta-data.

2. Verification of Railway Infrastructures

In close co-operation with Funkwerk IT GmbH, an ontology-based verifier for railway infrastructures was designed and partly implemented. In 2009, the focus was on establishing a railML-based ontology for railway infrastructures and the formalization of railway infrastructure design rules in SWRL language (Semantic Web Rule Language).

3. UML-to-OWL transformation

In close cooperation with ZBW (Leibniz Information Centre for Economics) work was started to transform UML-based conceptual models into OWL-based conceptual models and vice-versa.

Personnel

Head of the group: Prof. Dr.-Ing. N. Luttenberger; Secretary: K. Flöth, M. Sotiriadis-Gräßler (50%)
Technical Staff: M. Westphal (50%)

Scientific Staff:

MSc. M. Lodemann	01.08.-31.12.2012	Land SH
MSc. M. Lodemann Railway infrastructure verification	01.01.-31.07.2012	ISH-HWT
Dipl.-Inf. J. Zedlitz MaWiFo	01.01.-31.12.2012	ZBW

Lectures, Seminars, and Laboratory Course Offers

Summer 2012

Projektmodul - Communication Systems, 6 hrs Exercise/Week,
N. Luttenberger

Kommunikationssysteme, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
N. Luttenberger (+ N. Luttenberger)

Academic Writing, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
N. Luttenberger (+ N. Luttenberger)

Winter 2012/2013

Betriebssysteme, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
N. Luttenberger (+ N. Luttenberger, C. Motika, C. D. Schulze)

XML in Communication Systems, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
N. Luttenberger (+ N. Luttenberger, M. Lodemann)

Masterprojekt - Communication Systems, 4 hrs Exercise/Week,
N. Luttenberger

Third-Party Funds

ISH, *ITIS*, 01.01.-31.07.2012 (51.458,89 EUR)

Publications

Published in 2012

C. Gerke, J. Bleidiesel, M. Lodemann, N. Luttenberger, *XML-Schemata zum Datenaustausch im Planungsprozess von elektrischen Stellwerken*, Eisenbahntechnische Rundschau, **3**, 48 - 51 (2012)

H. Peters, O. Schulz-Hildebrandt, N. Luttenberger, *A novel sorting algorithm for many-core architectures based on adaptive bitonic sort*, IPDPS 2012, Shanghai, China, (2012)

J. Zedlitz, J. Jörke, N. Luttenberger, *From UML to OWL 2*, D. Lukose, A.R. Ahmad and A. Suliman (Eds.): KTW 2011, CCIS 295, 154 - 163 (2012)

J. Zedlitz, N. Luttenberger, *Transforming Between UML Conceptual Models And OWL2 Ontologies*, 5th International Terra Cognita Workshop 2012, in conjunction with the 11th International Semantic Web Conference, November 12, 2012, Boston, USA, (2012)

J. Zedlitz, H. Peters, N. Luttenberger, *A Pattern For Interrelated Numerical Properties*, 3rd Workshop on Ontology Patterns, in conjunction with the 11th International Semantic Web Conference, November 12, 2012, Boston, USA, (2012)

Computer-Aided Program Development

In the last year the research group investigated the fundamentals of programming languages in combination with formal methods for problem specification and development, the use of relation-algebraic and relation-like methods in mathematics and computer science, the application of graphs as a modelling tool and as objects for formal development of declarative and relational algorithms, and computational problems from Social Choice Theory and the theory of cooperative games. Again this has been done with specific regard to tool support and led to the further development of the ROBDD-based relation-algebraic system RELVIEW as well as the QOBDD-based simple games laboratory. Both tools are available free of charge via the research group's Web sites.

Results

With regard to relation algebra and the RELVIEW system, we have continued our work on computational problems from Social Choice Theory and cooperative Game Theory. In Social Choice Theory we have investigated the computation of certain choice sets defined on tournaments and on general dominance relations. We also have studied the modelling of voting systems and the aggregation of the individual preferences to a collective dominance relation. This opens new research directions in view of the manipulation and control of elections. In Simple Games Theory we have continued the study of their modelling and the translation of one model into another. Based on this, we investigated the solution of important computational problems in simple games and the visualization of the results. Besides Social Choice Theory and cooperative Game Theory, we have combined relation algebra and the RELVIEW system also for the solution of other computational problems, mostly hard combinatorial ones. For instance, we considered problems on chessboards. The computing technique we have developed to solve such problems is very flexible, and as such, is especially appropriate for experimentation and teaching. We have applied it to solve independence and domination problems on rectangular chessboards and also have investigated how it can be generalized to other chessboard problems and topologies.

Motivated by the good results we obtained via RELVIEW when solving computational problems from cooperative Game Theory, we continued our studies in the application of binary decision diagrams to solve problems on simple games, weighted voting games, and related fields. Among other things, this led to new and very general ROBDD-based algorithms that for a set of sets efficiently compute the subset of its maximal (resp. minimal) subsets. Under certain preconditions, namely that the input is both an upset and a downset, their efficiency increases considerably. In the meantime both algorithms are part of RELVIEW and available via pre-defined operations. Applications of the algorithms include, for example, the computation of the Banks set in Social Choice Theory, the computation of the set of minimal winning coalitions and the Holler-Packel power index in cooperative Game Theory, the computation of the set of maximal losing coalitions in cooperative Game Theory, and the computation of the set of bases in independence systems.

One of most interesting choice sets on tournaments is the Banks set. However, its computation is known to be NP-complete. We have thus developed a randomized algorithm for approximating the Banks set. Experimentally we were able to show that our algorithm performs well on tournaments of size up to $n = 70$. To this end, we have implemented our method within the RELVIEW system. Furthermore, we have investigated the approximation ratio from a theoretical perspective.

Concerning our work in the field of functional graph algorithms, we have continued to employ algebraic means to develop functional versions of graph algorithms. We have successfully developed a function that computes the Kleene closure of a given graph, which is a generalisation of a result from 2011. Experiments have shown that this function yields better running times in applications than a naive implementation of the well-known Kleene algorithm in Haskell. Furthermore we have successfully combined algebraic means with the generate-prune-technique to develop functional equivalents of the Dinic algorithm and the Hopcroft-Karp-algorithm, thereby improving the results we have obtained last year.

Personnel

Head of the group: Prof. Dr. Rudolf Berghammer; Secretary: Jane-Maria Eitzen (50%)

Scientific Staff:

Dipl.-Inf. Stefan Bolus 01.01.2011-31.07.2012 DFG
SOCIAL SOFTWARE for elections, the allocation of tenders and coalition/alliance formation (SSEAC)

Dipl.-Math. Nikita Danilenko 01.01.-31.12.2012
Functional algorithms for discrete problems

Dipl.-Math. Insa Stucke 01.03.-31.12.2012
Approximation algorithms for Social Choice problems

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

Arbeitsgemeinschaft Informatik, Logik und Mathematik, 2 hrs Seminar/Week,
R. Berghammer (+ M. Hanus)

Oberseminar für Diplomanden und wiss. Mitarbeiter, 2 hrs Seminar/Week,
R. Berghammer

Inf-Math-A: Mathematik für Informatiker A - Grundlagen und Diskrete Strukturen, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
R. Berghammer (+ N. Danilenko, B. Langfeld)

Inf-Sem-MathMed: Mathematische Methoden in der Informatik (Proofs from THE BOOK), 2 hrs Seminar/Week,
R. Berghammer

Summer 2012

Arbeitsgemeinschaft Informatik, Logik und Mathematik, 2 hrs Seminar/Week,
R. Berghammer (+ M. Hanus)

Oberseminar für Diplomanden und wiss. Mitarbeiter, 2 hrs Seminar/Week,
R. Berghammer

Inf-BDD: Binäre Entscheidungsdiagramme, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
R. Berghammer (+ N. Danilenko)

Inf-Sem-MathMed: Mathematische Methoden in der Informatik, 2 hrs Seminar/Week,
R. Berghammer (+ N. Danilenko)

MS1101: Modellierung nebenläufiger Systeme, 4 hrs Lecture/Week,
R. Berghammer (+ R. von Hanxleden, M. Spönemann)

Winter 2012/2013

Arbeitsgemeinschft Informatik, Logik und Mathematik, 2 hrs Seminar/Week,
R. Berghammer (+ M. Hanus)

Oberseminar für Diplomanden und wiss. Mitarbeiter, 2 hrs Seminar/Week,
R. Berghammer

Inf-Sem-MathMed: Mathematische Methoden in der Informatik (Relationale Methoden), 2 hrs Seminar/Week,
R. Berghammer (+ N. Danilenko, I. Stucke)

MS0402: Ordnungen und Verbände, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
R. Berghammer (+ I. Stucke)

Inf-SemPS: Semantik von Programmiersprachen, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
R. Berghammer (+ N. Danilenko)

Third-Party Funds

DFG, *LogiCCC: SOCIAL SOFTWARE for elections, the allocation of tenders and coalition/alliance formation (SSEAC)*, 01.01.-31.12.2011 (41.424,07)
DFG, *Workshop in Kiel: Social Choice & Social Software*, 02.-05.05.2013 (9.355,81)

Further Cooperation, Consulting, and Technology Transfer

Applications of relational methods in computer Science: with B. Möller (Augsburg), G. Schmidt (München), R.A. Schmidt (Manchester, UK), G. Struth (Sheffield, UK) and M. Winter (St. Catheriens, Canada).

Social software for elections, aggregation of tenders and coalition formation: with J.L. Garcia-Lapresta (Valladolid, Spain), H. Nurmi (Turku, Finland), A. Rusinowska and M. Grabisch (Paris, France) and H. de Swart (Tilburg, The Netherlands).

Evolutionary and approximation algorithms, binary decision diagrams: with F. Neumann (Adelaide, Australia) and T. Friedrich (Saarbrücken).

Finance mathematics and system development: Ariva.de Kiel.

Dissertations / Postdoctoral Lecture Qualifications

J. Christiansen, *Investigating minimally strict functions in functional programming*, 12.01.2012
S. Bolus, *A QOBDD-based approach to simple games*, 28.06.2012

Publications

Published in 2012

R. Berghammer, *Ordnungen, Verbände und Relationen mit Anwendungen*, Springer Vieweg Verlag Wiesbaden, **2**, (2012)
R. Berghammer, *Relation-algebraic modelling and solution of chessboard independence and domination problems.*, Journal on Logic and Algebraic Programming, **81**, 625 - 642 (2012)
R. Berghammer, S. Bolus, *On the use of binary decision diagrams for solving problems on simple games.*, European Journal of Operational Reseach, **222**, 529 - 541 (2012)
R. Berghammer, F. Neumann, T. Friedrich, *Convergence of set-based multi-objective optimization, indicators and deteriorative cycles.*, Theoretical Computer Science, **456**, 2 - 17 (2012)
R. Berghammer, S. Fischer, *Simple rectangle-based functional programs for computing reflexive-transitive closures.*, Kahl W., Griffin T.G. (eds.): Relational and Algebraic Methods in Computer Science, **7560**, 114 - 129 (2012)
N. Danilenko, *Using Relations to Develop a Haskell Program for Computing Maximum Bipartite Matchings*, Kahl, W., Griffin, T.G. (eds.): Relational and Algebraic Methods in Computer Science, **7560**, 130 - 145 (2012)

Presentations

N. Danilenko, *A Graph-Theoretic View on Vector-Matrix Multiplication*, Workshop der GI-Fachgruppe, Bad Honnef, Germany, 01.-04.05.2012

R. Berghammer, *Computing tournament solutions using relation algebra and* RelView, SSEAC Workshop on Social Choice and Social Software, Kiel, Germany, 03.-05.05.2012

S. Bolus, *A QOBDD-based approach to simple games*, SSEAC Workshop on Social Choice and Social Software, Kiel, Germany, 03.-05.05.2012

R. Berghammer, *Simple rectangle-based functional programs for computing reflexive-transitive closures*, 13th International Conference on Relational and Algebraic Methods in Computer Science, Cambridge, UK, 17.-20.09.2012

N. Danilenko, *Using Relations to Develop a Haskell Program for Computing Maximum Bipartite Matchings*, 13th International Conference on Relational and Algebraic Methods in Computer Science, Cambridge, UK, 17.-20.09.2012

Further Activities and Events

In 2012 the group organized the SSEAC Workshop on Social Choice and Social Software. It took place in Kiel from May 3-5, 2012, with guests from France, Germany, The Netherlands, and the UK.

R. Berghammer, S. Bolus, and N. Danilenko worked as reviewers for various scientific publications.

R. Berghammer is a member of the international working group ''Relational Methods in Computer Science. He is the chair of the Steering Committee of the conference series ''Relational and Algebraic Methods in Computer Science'' (RAMiCS) and one of the editors of the electronic journal ''Journal on Relational Methods in Computer Science''. In 2012 he was a member of the programme committee of RAMiCS 13 that took place in September 2012 in Cambridge (UK), and of the programme committee of the 10th Workshop on Boolean Problems, that took place in September 2012 in Freiberg. R. Berghammer is also a member of the German initiative ''Softwarevisualisierung''. For details, see URL http://www.softwarevisualisierung.de.

Guests in 2012: P. Höfner (Sydney, Australia), B. Möller (Augsburg), F. Neumann (Adelaide, Australia). and G. Schmidt (München).

Computer Media

Since June 2010 Prof. Dr. Klaus Tochtermann has been Managing Director of the Leibniz Centre for Economics (ZBW - Deutsche Zentralbibliothek für Wirtschaftswissenschaften Leibniz-Informationszentrum Wirtschaft).

Further information about the Leibniz Centre for Economics is available on the web: http://www.zbw.eu/

Leibniz Centre for Economics
Managing Director Prof. Dr. Klaus Tochtermann
Düsternbrooker Weg 120
D-24105 Kiel
Tel. + 49(0)431/8814-333
Fax + 49(0)431/8814-530
Email director@zbw.eu
Internet http://www.zbw.eu

almanach 12

Computer Science Education

This is the first time that a separate section on computer science education (also known as computing education) has been part of the Almanac of the technical faculty. The reason is that computer science education has now established itself as a major area of activity of the computer science department of the faculty.

Computer science education has played a role in the CS department since the mid-nineties when the department became involved in a state-wide programme for educating teachers in computer science. This programme still exists, and the department is still involved. Early in the millennium, the department installed a curriculum for computer science as a third subject in teacher education, and soon thereafter the first CS teachers graduated.

When, in 2007, CAU switched to bachelor´s and master´s programmes in teacher education, it also established computer science as a major subject. There is a general interest for this subject, and this year (2013) we should see the first graduate. The coursework for the bachelor´s programme consists of basic courses in computer science providing future teachers with fundamental skills, while the master´s programme consists of advanced electives in computer science. Overall, the students take part in four specific courses on computer science education, which at present, are taught by experienced secondary school teachers.

Even though the foci of computer science education at CAU are the study programmes for teachers, research in computer science education is growing continuously. A first study was carried out at Gesamtschule Friedrichsort where a new curriculum for a beginners´ course in computer science was evaluated; the results were submitted for publication in 2012. A large-scale study on an initiative combining elements of computer science and arts into one school subject was carried out during the last two years; the results were submitted for publication only recently. A third study is evaluating the merits of the ''software challenge'', a programming competition carried out by the department for a number of years and aimed at attracting school children to computer science.

Personnel

Head of the group: Prof. Dr. Thomas Wilke—in charge on behalf of the department;

Scientific Staff:

Dr. Detlef Kähler	01.01.-31.12.2012	CAU, 12.5 %
StR Sönke Schulmeister	01.01.-31.12.2012	CAU, 50.0 %
Prof. Dr. Thomas Wilke	01.01.-31.12.2012	CAU
Dr. Lars Willert	01.01.-31.12.2012	CAU, 25.0 %

almanach 12

Dependable Systems

The Dependable Systems group investigates mathematical methods for the discovery and prevention of errors in computer systems. Modern computer systems are too complex to guarantee a high level of safety (that is, correct functionality) by mere testing or code inspection. Our research helps to find rigorous proofs, or at least strong indications, that a system possesses a certain safety feature or, in the case where it does not, to deliver a counter example. In particular, we work in the field of formal specification and verification, model-checking, and the satisfiability problem of certain logics.

Another field of research of our group is the investigation of algorithmic and combinatorial problems of sequential structures. Sequences are the most basic, non-trivial structures. Research on finding ways to efficiently transform, search, compress, generate, and analyze sequences is fundamental with an extremely wide application area.

Results

Verification of Concurrent Systems

We consider the problem of software safety in the context of embedded multicore systems. Embedded systems are often used in safety critical applications such as airbag systems in cars or aircraft controllers. There exists a variety of methods for preventing and detecting errors in embedded code. For singlecore systems such methods have worked reasonably well in practice, however, the introduction of multicore embedded systems changes the situation drastically since programs are executed in parallel on the same system now. The most prominent error class introduced with such parallelism is called race condition. Race conditions occur when two or more processes compete for a resource in an unregulated and hence unpredictable fashion. Such errors are extremely hard to detect by testing or code inspection alone. Therefore we investigate formal methods to analyze concurrent systems so that race conditions are reliably detected. These analysis methods are aimed and tailored for real-world industrial applications. The goal is to construct a method (and the appropriate tool support) that finds race conditions reliably and fully automatically. These two requirements are very strong and not met by any approach known to us.

Our first approach is the employment of interval constraint solving algorithms for code analysis. These algorithms have a very high (exponential) worst case complexity. Our goal is to push the borders of using such formal methods to such a degree that real-world industrial code can be verified with reasonable efforts. There are several strategies that we employ and implement in our verification tool MEMICS. Firstly, we use preprocessing steps of low computational complexity in

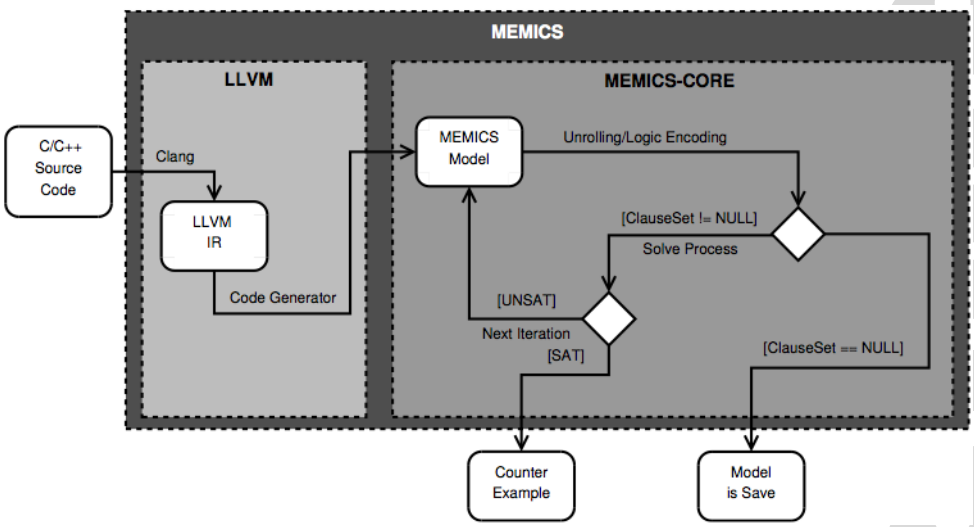


Fig. 2: An overview of the structure of MEMICS.

order to limit the problem size as much as possible to its core. Secondly, we optimize our solver to work best on constraints that are generated from actual software and are not random. Constraints that model actual programs have a certain implicit structure that distinguishes them from other possible inputs. Our tool should work well on such special inputs instead of all possible inputs. Last but not least, we embedded the theory of memory arithmetics and access into the core of our solver in order to limit the size of the input model. Traditionally, the entire computational environment of a program is modelled in the logic of a constraint solver, which increases the model considerably. We try to circumvent that problem with our approach. The approach described is implemented in a tool called MEMICS, which is developed together with the Daimler AG within a larger BMBF research project called ARAMiS.

High Performance Software Verification

The formal verification of software is a method for gaining more trust in safety critical systems that is rapidly growing in importance, as outlined in the previous paragraph. A precise analysis is only possible by applying formal methods. A core technique in that approach involves constraint solving procedures. These (decision) procedures for certain suitable logics are powerful but also of high algorithmic complexity. In fact, their asymptotic worst case complexity is exponential in most cases. Therefore, there is no hope in applying this approach to all possible input instances. Yet, the advantages of the approach in terms of the precision of the analysis make it indispensable. On the positive side, not just the complexity of the analysed systems grows but also the performance of computers.

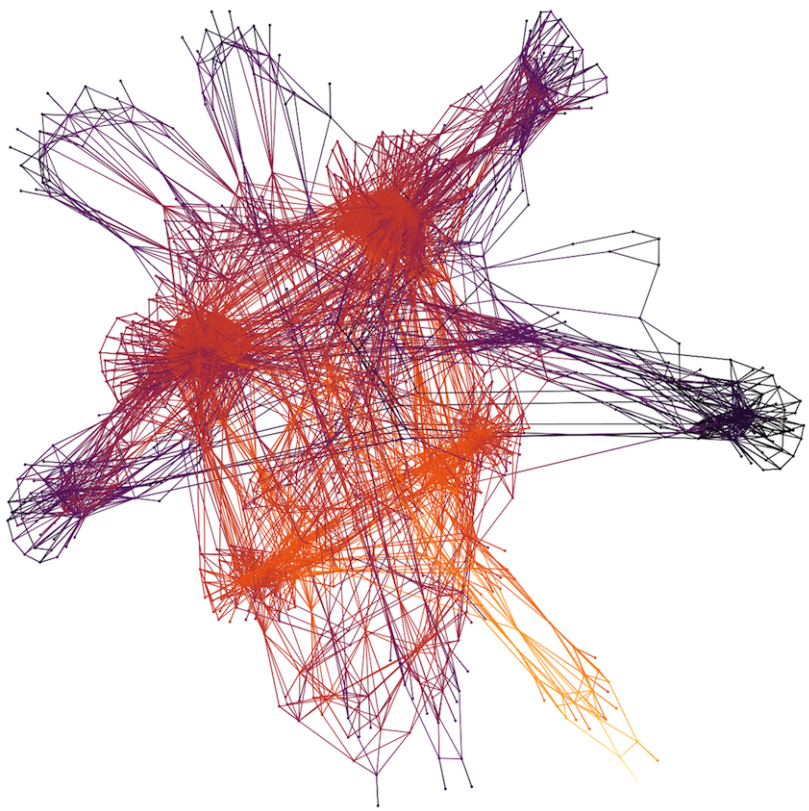


Fig. 1: The dependency graph of a verification problem.

In recent decades that speedup was mainly due to faster processing units and expanded memory; new hardware increased the speed of solvers, basically without any modification of the implementation. However, that situation has changed drastically. Currently, a computational speedup is achieved by parallel hardware only. Parallel processing units have wide application, ranging from desktop computers to simple smart phones. The number of cores of a processor has replaced

the clock speed as a measurement of performance. That means that tools that are to take advantage of faster computers need to employ algorithms that work in parallel. In the field of constraint solving, parallel approaches can be found only in a very mild form so far, for example, solvers working on quad-core PCs. Scaling up such programs is a nontrivial task. In fact, new algorithms and approaches are needed. We investigate approaches for constraint solvers especially designed for massively parallel hardware. First investigations focus on large shared-memory computers (such as a CRAY XMT) for two reasons. Firstly, the low data locality of constraint satisfaction problems indicates a shared memory for a first approach. Secondly, current developments suggest that future PCs will employ architectures using a shared memory, as seen in modern CPUs and coprocessors such as the recent Intel Xeon Phi. Developing efficient verification tools on a CRAY supercomputer may therefore lead the way to efficient verification tools on future consumer hardware.

Algorithms on Sequences

Sequences of symbols of a finite alphabet are the most fundamental nontrivial data structure. The examples range from bit streams in data communication, text, and speech processing, to RNA sequences in molecular biology and number theoretical questions in mathematics. Algorithmic questions on sequences arise therefore in many areas. Search, pattern matching, encodings, and sequence alignments are tasks that frequently occur and need to be computed efficiently. Naturally, algorithms on sequences have been investigated for a long time. However, many new questions emerge with new applications of data processing: for example the handling of large genomic data bases in microbiology, or fast online pattern matching for monitoring data streams.

One particular area of interest for us is the detection of repetitions in sequences i.e. modulo morphic or antimorphic permutations. A morphic permutation is the extension of a permutation on the alphabet to sequences over that alphabet. In other words, a morphic permutation is a function that takes a sequence and gives a sequence of the same length generated by permuting the letters (not the positions of letters!) of the input. In the antimorphic case, the same happens as in the morphic case and additionally the order of letters is reversed, like reading a word from right to left instead of the conventional left to right direction. A well-known instance of an antimorphic permutation (involution in fact) is the Watson-Crick complement of the DNA polymerase.

Matching patterns in a way parameterized by permutations, or more general morphisms and antimorphisms, is a largely unexplored field which we investigate. Repetitious modulo permutations occur in many facets ranging from genomic data to musical forms. In particular, the newly developing field of digital sciences promises a wide area of application of these new and more general matching algorithms; it is a fact that more and more scientific progress is made by the computational analysis of huge amounts of experimental data. In 2012, considerable progress was made by our group in the investigation of algorithms on sequences, as is documented by a number of publications.

Combinatorics on Words

Combinatorics on words is the field of investigation of properties of sequences. The motivation for dealing with sequential structures has been indicated in the paragraph above by pointing out their ubiquity and the need to understand and process them. In fact, combinatorics on words provides the theoretical foundation for algorithms on sequences. Consequently, much of our work in 2012 has been focused on questions involving morphic and antimorphic permutations. In particular, avoidance questions were discussed, i.e. questions on whether certain repetitions under permutations can be avoided in a sequence at all. Moreover, the inferences of different pseudo-periods (period modulo morphisms and antimorphisms) were investigated and so called Fine and Wilf like theorems were established.

When the application of processing of real world data from application areas like microbiology is considered, one often has to deal with imperfect data, i.e. sequences that contain false or incomplete information due to sensoric or experimental conditions. The investigation of partial words, being words that contain undefined positions, addresses this fact. Results on connecting the combinatorics on partial words with regular languages, i.e. sets of words that are recognised by finite automata, were published in 2012.

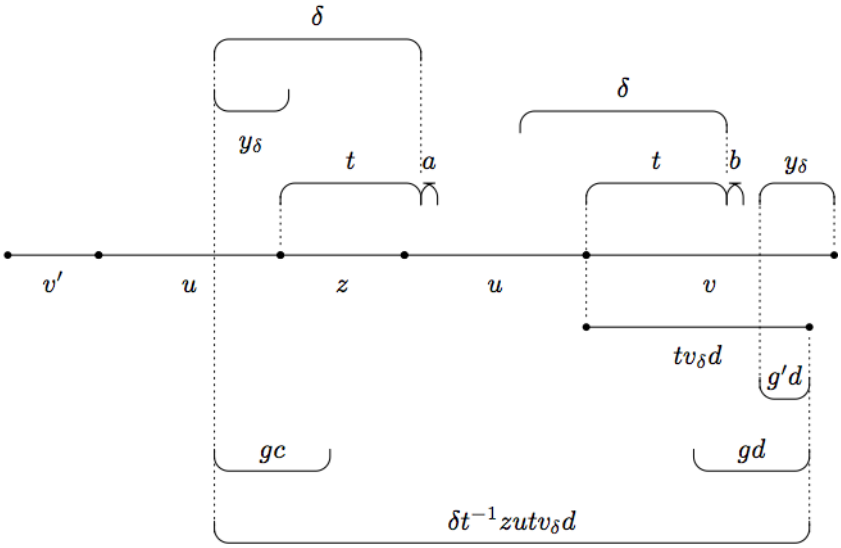


Fig. 3: Some word factorization.

Another result published in 2012 deals with a subtle interaction of the period of a word and the length of its longest unbordered factors. A factor (a subsequence of a word) is called unbordered if there is no proper prefix that also occurs as a suffix of the same word. This result solves the Ehrenfeucht-Silberger problem which was open for more than 30 years and sheds a new light on words with a weak global structure which are usually harder to handle than those with a short period.

Personnel

Head of the group: Prof. Dr. D. Nowotka; Secretary: G. Walsdorf

Scientific Staff:

Dr. F. Manea	01.01.-31.12.2012	DFG
Dipl.-Inf. M. Müller	01.01.-31.12.2012	DFG
Dipl.-Inf. P. Sieweck	02.04.-31.12.2012	BMBF
MSc J. Traub	01.01.-31.12.2012	Daimler

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

Inf-GSoZu: Grundlagen der Softwarezuverlässigkeit, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Dirk Nowotka

Summer 2012

Inf-EntVer: Entscheidungsverfahren, 3 (+ 1) hrs Lecture (+ Exercises)/Week,
Dirk Nowotka

NF-Inf-2: Systematisches Programmieren, 2 hrs Lecture/Week,
Dirk Nowotka

Winter 2012/2013

Inf-SWT: Softwaretechnik, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Dirk Nowotka (+ S. Frey, J. Waller)

Übung zu: Hochleistungsrechnen, 2 hrs Exercise/Week,
Dirk Nowotka

Third-Party Funds

DFG, *Heisenbergprofessur,* 15.11.2011-14.11.2014 (324.800 EUR)
DFG, *Kombinatorische Aspekte von Wörtern und deren Anwendungen,* 01.05.2011-31.10.2014 (365.000 EUR)
BMBF, *ARAMiS - Automotive, Railway and Avionics Multicore Systems,* 01.04.2012-30.11.2014 (327.030 EUR)

Further Cooperation, Consulting, and Technology Transfer

Academic cooperation:

- University of Stuttgart (Prof. Dr. Erhard Plödereder),
- Max Planck Institut Informatik, Saarbrücken (Dr. Pawel Gawrychowski),
- Charles University of Prague, Czech Republic (Prof. Dr. Dr. Stepan Holub),
- Turku University, Finland (Prof. Dr. Tero Harju, Prof. Dr. Juhani Karhumäki),
- University of Winnipeg, Canada (Prof. Dr. James Currie),
- University of Waterloo, Canada (Prof. Dr. Jeffrey Shallit).

Industrial cooperation and technology transfer:

- Daimler AG (R&D) and 20 more companies within the BMBF ARAMiS project,
- Kompetenzverbund in Software Systems Engineering (KoSSE).

Publications

Published in 2012

D. Nowotka, J. Traub, *MEMICS - Memory Interval Constraint Solving of (concurrent) Machine Code,* Proc. of Automotive - Safety & Security 2012, GI-Edition LNI, **210**, 69 - 83 (2012)

F. Manea, M. Müller, D. Nowotka, *The Avoidability of Cubes under Permutations,* Proc. of Developments in Language Theory (DLT) 2012, LNCS, **7410**, 416 - 427 (2012)

F. Manea, R. Mercas, D. Nowotka, *Fine and Wilf's Theorem and Pseudo-repetitions,* Proc. of Mathematical Foundations of Computer Science (MFCS) 2012, LNCS, **7464**, 668 - 680 (2012)

S. Holub, D. Nowotka, *The Ehrenfeucht-Silberger problem,* Journal of Combinatorial Theory, Series A, **119**, 668 - 682 (2012)

V. Halava, J. Karhumäki, D. Nowotka, G. Rozenberg, *Words, Graphs, Automata, and Languages; Special Issue Honoring the 60th Birthday of Professor Tero Harju,* Fundamenta Informaticae, **116**, (2012)

C. Grozea, F. Manea, M. Müller, D. Nowotka, *String Matching with Involutions,* Proc. of Unconventional Computation and Natural Computation (UCNC) 2012, LNCS, **7445**, 106 - 117 (2012)

F. Manea, B. Truthe, *On Internal Contextual Grammars with Subregular Selection Languages*, Proc. of Descriptional Complexity of Formal Systems (DCFS) 2012, LNCS, **7386**, 222 - 235 (2012)
J. Dassow, F. Manea, R. Mercas, *Connecting Partial Words and Regular Languages*, Proc. of Computability in Europe (CiE) 2012, LNCS, **7318**, 151 - 161 (2012)
F. Manea, R. Mercas, V. Mitrana, *Hairpin Lengthening and Shortening of Regular Languages*, Festschrift J. Dassow, LNCS, **7300**, 145 - 159 (2012)
J. Dassow, F. Manea, B. Truthe, *Networks of Evolutionary Processors: Computationally Complete Normal Forms*, Natural Computing, **11**, 595 - 607 (2012)
J. Dassow, F. Manea, B. Truthe, *Generating Networks of Splicing Processors*, RAIRO - Theoretical Informatics and Applications, **46**, 547 - 572 (2012)
F. Manea, *Complexity Results for Deciding Networks of Evolutionary Processors*, Theoretical Computer Science, **456**, 65 - 79 (2012)
J. Dassow, F. Manea, B. Truthe, *On Contextual Grammars with Subregular Selection Languages*, Theoretical Computer Science, **449**, 64 - 73 (2012)
J. Dassow, F. Manea, M. Selamat, S. Turaev, *Language Classes Generated by Tree Controlled Grammars with Bounded Nonterminal Complexity*, Theoretical Computer Science, **449**, 134 - 144 (2012)

Presentations

D. Nowotka, J. Traub, *MEMICS - Memory Interval Constraint Solving of (concurrent) Machine Code*, Automotive - Safety & Security 2012, Karlsruhe, Germany, 14.-15.11.2012
T. Harju, M. Müller, *Square-Free Words generated by Applying Permutations to a Prefix*, Russian-Finnish Symposium on Discrete Mathematics (RuFiDiM) 2012, Turku, Finland, 25.-28.09.2012
C. Grozea, F. Manea, M. Müller, D. Nowotka, *String Matching with Involutions*, Unconventional Computation and Natural Computation (UCNC) 2012, Orléans, France, 03.-07.09.2012
F. Manea, R. Mercas, D. Nowotka, *Fine and Wilf's Theorem and Pseudo-repetitions*, Mathematical Foundations of Computer Science (MFCS) 2012, Bratislava, Slovakia, 27.-31.08.2012
F. Manea, M. Müller, D. Nowotka, *The Avoidability of Cubes under Permutations*, Developments in Language Theory (DLT) 2012, Taipei, Taiwan, 14.-17.08.2012
F. Manea, B. Truthe, *On Internal Contextual Grammars with Subregular Selection Languages*, Descriptional Complexity of Formal Systems (DCFS) 2012, Braga, Portugal, 23.-25.07.2012
J. Dassow, F. Manea, R. Mercas, *Connecting Partial Words and Regular Languages*, Computability in Europe (CiE) 2012, Cambridge, UK, 18.-23.06.2012
D. Nowotka, *Avoidability under Permutations*, BIRS Workshop Outstanding Challenges in Combinatorics on Words, Banff, Canada, 20.-24.02.2012

Further Activities and Events

F. Manea, M. Müller, and D. Nowotka served as reviewers for the following conferences: Developments in Language Theory (DLT), Russian-Finnish conference on Discrete Mathematics (RuFiDiM), Symposium on Theoretical Aspects of Computer Science (STACS), Current Trends in Theory and Practice of Computer Science (SOFSEM), Computability in Europe (CiE), Descriptional Complexity of Formal Systems (DCFS), and the following journals: International Journal on Foundations of Computer Science (IJFCS), Information Processing Letters (IPL), Journal of Integer Sequences, Theoretical Computer Science (TCS)

F. Manea served as a reviewer for the US National Security Agency's Mathematical Sciences Programme.

F. Manea served as a member of the programme committees of the Workshop on Developments in Computational Models (DCM), the Workshop on Non-Classical Models of Automata and Applications (NCMA), and the Advances in the Theory of

Computing track of the Symposium on Symbolic and Numeric Algorithms for Scientific Computing (SYNASC) in 2012.

D. Nowotka served as a reviewer for the AMS MathSciNet.

D. Nowotka co-edited the special issue of Fundamenta Informaticae on the occasion of the 60th birthday of Tero Harju, Turku, (Festschrift).

almanach 12

Discrete Optimization

Discrete or combinatorial optimization is a branch of mathematical optimization. It is concerned with solving discrete, finite optimization problems efficiently. 'Algorithm Engineering' in discrete optimization is a key area of the discrete optimization group in Kiel.

Among international cooperations a special focus is on Indo-German projects in Algorithm Engineering (DFG priority program 1307).

The methods and results of modern discrete optimization touch many different areas of mathematics and computer science, as for example, combinatorics, graph theory, stochastics, or the theory of complexity.

A central topic in discrete optimization is the design of efficient algorithms for NP-hard discrete optimization problems using sub-optimal paradigms such as randomization or approximation. Specific topics are: approximation algorithms, randomized and de-randomized algorithms, algorithms for multicast-networks, combinatorial and geometric discrepancy theory, combinatorial game theory, and discrete geometry.

A major focus of the group is on interdisciplinary research projects within the cluster of excellence ''The Future Ocean'' and further with economics, medicine, life sciences and industrial partners.

Results

The group is part of several highly competitive research clusters. Among them are the DFG priority programme 1307 ''Algorithm Engineering'', the cluster of excellence ''The Future Ocean'' and the DFG-DST Indo-German network on ''Algorithm Engineering''.

Personnel

Head of the group: Prof. Dr. A. Srivastav; Secretary: A. Lochte-Holtgreven (50%)

Scientific Staff:

MA A. Afanasiewa	01.01.-31.12.2012		DFG (25%)
Cluster of Excellence 'The Future Ocean'			
Dipl. Inf. D. Ehlers	01.01.-31.12.2012	(50%)	DFG / CAU
Engineering randomisierter Algorithmen für Optimierungsprobleme in Hypergraphen			
Dipl. Math. M. El Ouali	01.01.-31.12.2012	(50%)	DFG / CAU
Engineering randomisierter Algorithmen für Optimierungsprobleme in Hypergraphen			
Priv.-Doz. Dr. M. Gnewuch	01.01.-31.03.2012		DFG
Hochdimensionale numerische Integration			
Priv.-Doz. Dr. G. Jäger	01.01.-31.12.2012		Guest professor
(Umea University, Sweden)			
Dr. L. Kliemann	01.01.-31.12.2012		CAU
Algorithm Engineering in discrete optimization, Algorithmic Game Theory			
M.A. O. Kliemann	01.01.-31.12.2012		DFG (25%)
Engineering randomisierter Algorithmen für Optimierungsprobleme in Hypergraphen			

Dipl. Math. P. Munstermann	01.01.-31.12.2012	(50%)	DFG / CAU
Engineering randomisierter Algorithmen für Optimierungsprobleme in Hypergraphen			
Dr. V. Sauerland	01.-31.10.2012	(50%)	DFG
Cluster of Excellence 'The Future Ocean'			
MSc Mayank Singhal	01.09.-31.12.2012	(50%)	DFG
Algorithm Engineering, Discrepancy Theory			
G. Wittig-Srivastav	01.06.-31.12.2012		CAU
Projektkoordination			

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

Graphentheorie, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
A. Srivastav (+ L. Kliemann)

Masterabschlussseminar, 2 hrs Seminar/Week,
A. Srivastav (+ L. Kliemann)

Graphenalgorithmen, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
G. Jäger

Die probalistische Methode und ihre Anwendung, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
M. Gnewuch

Summer 2012

Mathematik für Informatiker A, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
A. Srivastav (+ L. Kliemann)

Oberseminar Algorithmen, Kombinatorik und Komplexität, 2 hrs Seminar/Week,
A. Srivastav (+ K. Jansen)

Seminar - Diskrete Mathematik, 2 hrs Seminar/Week,
A. Srivastav (+ L. Kliemann)

Proseminar Kombinatorik, 2 hrs Seminar/Week,
A. Srivastav

Parallele Algorithmen, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
A. Srivastav (+ L. Kliemann)

Winter 2012/2013

Graphentheorie, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
A. Srivastav (+ L. Kliemann)

Mathematik für Informatiker A, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
A. Srivastav (+ L. Kliemann, M. El Ouali, C. Gießen)

Seminar Kombinatorik, 2 hrs Seminar/Week,
A. Srivastav

Oberseminar Algorithmen, Kombinatorik und Komlpexität, 2 hrs Seminar/Week,
A. Srivastav

Seminar Diskrete Mathematik, 2 hrs Seminar/Week,
A. Srivastav

Third-Party Funds

DFG SPP 1307 Phase 1, *Engineering randomisierter Algorithmen für Optimierungsprobleme in Hypergraphen,* 01.10.2007-31.10.2012 (134600 Euro)
DFG SPP 1307 Phase 2, *Engineering randomisierter Algorithmen für Optimierungsprobleme in Hypergraphen,* 01.10.2009-30.06.2013 (136000 Euro)
DFG, *Exzellenzcluster The Future Ocean - Numerische Simulation,* 01.01.-31.12.2012 (61.600 Euro)
DFG, *Hochdimensionale numerische Integration,* 01.04.2009-31.03.2012 (117000 Euro)
DFG SPP 1307 Phase 3, *Engineering von Matching- und Überdeckungsalgorithmen in großen Graphen und Hypergraphen,* 25.08.2011-24.08.2013 (177650 Euro)
DFG SPP 1401, *Indo-German Workshop on Engineering and Analysis of Evolutionary Algorithms (Indo-German Project),* 01.01.2012-30.04.2013 (19916 Euro)
DFG SPP Phase 3 Teil 2, *Algorithm Engineering for Evolutionary Algorithms (Indo-German Project),* 23.01.2012-23.01.2013 (19900 Euro)
DFG SPP KL2078/1, *Algorithm for Data Streaming Processing (Indo-German Project),* 23.01.2012-23.01.2013 (12700 Euro)

Further Cooperation, Consulting, and Technology Transfer

Cooperations with:

S. Ganguly (IIT Kanpur, India), Algorithms for Data Stream Processing,

C. Patvardhan (DEI Agra, India), Engineering of Evolutionary Algorithms,

J. Baldeaux (University of Technology, Sydney, Australia) Project: Infinite-dimensional integration in the randomized setting,

J. Dick (University of New South Wales, Sydney, Australia) Projects: Fractional discrepancy, multivariate and infinite-dimensional integration,

B.Doerr, C. Doerr (formerly Winzen), M.Wahlstroem (Max-Planck-Institut für Informatik, Saarbrücken) Project: Algorithms to calculate discrepancies and to construct small discrepancy samples.

S. Mayer (Haussdorff Centre for Mathematics, Bonn) K. Ritter (Technische Universität Kaiserslautern) Project: Infinite-dimensional integration on Hilbert spaces

Diploma, Bachelor's and Master's Theses

I. Stucke, *Approximationsalgorithmen f. ganzzahlige Packungsprobleme durch positive Korrelation, Dipl. Thesis,* 21.02.2012
C. Gießen, *Vergleich von SLS und VDS zur Hybridisierung evolutionärer Algorithmen, Dipl. Thesis,* 25.02.2012
I. Kusemeier, *Netzwerkerzeugungsspiele mit Transfers, Dipl. Thesis,* 27.06.2012
I. Uhortsyn, *Balancierte Biclique in balancierten, bipartiten Graphen, Dipl. Thesis,* 26.10.2012
H. Kirchhoff, *Network Congestion Games, Dipl. Thesis,* 26.11.2012
O. Schink, *Price of Anarchy in 'Sum Network Creation Games' in der unilateralen und bilateralen Variante, Bachelor Thesis,* 26.11.2012
J. Schiemann, *Bäume und Chordale Graphen bei Nash-Gleichgewichten in 'Network Creation Games', Bachelor Thesis,* 26.11.2012

Dissertations / Postdoctoral Lecture Qualifications

V. Sauerland, *Algorithm Engineering for some Complex Practise Problems, Dissertation,* 23.05.2012

Publications

Published in 2012

Sebastinan Eggert, Lasse Kliemann, Peter Munstermann, Anand Srivastav, *Bipartite Matching in the Semi-Streaming Model,* Algorithmica, **63**, 490 - 508 (2012)

Michael Gnewuch, *Infinite-Dimensional Integration on Weighted Hilbert Spaces,* Mathematics of Computation, **81**, 2175 - 2205 (2012)

Michael Gnewuch, M. Wahlström, C. Winzen, *A new randomized algorithm to approximate the star discrepancy based on threshold accepting,* SIAM Journal on Numerical Analysis 50, **50**, 781 - 807 (2012)

Michael Gnewuch, *Weighted Geometric Discrepancies and Numerical Integration on Reproducing Kernel Hilbert Spaces,* Journal of Complexity, **28**, 2 - 17 (2012)

Michael Gnewuch, *Entropy, Randomization, Derandomization, and Discrepancy,* L. Plaskota, H. Wozniakowski (Eds.),Monte Carlo and Quasi-Monte Carlo Methods 2010, 43 - 78 (2012)

Michael Gnewuch, *Infinite-dimensional integration: Optimal randomized multilevel algorithms in the ANOVA setting and related new results,* Dagstuhl Reports Vol.2, **9**, 208 - 209 (2012)

A. Srivastav, C. Patvardhan, V. Prem Prakash, *Novel quantum-inspired evolutionary algorithms for the quadratic knapsack problem,* International Journal of Mathematics in Operational Research (Vol. 4), **2**, 114 - 127 (2012)

Mourad El Ouali, Gerold Jäger, *The b-Matching Problem in Hypergraphs: Hardness and Approximation,* Proceedings of COCOA 2012, **LNCS 7402**, 200 - 211 (2012)

Mourad El Ouali, Helena Fohlin, Anand Srivastav, *A Randomized Approximation Algorithm for the Partial Vertex Cover Problems in Hypergraphs,* MedAlg 2012, **LNCS 7659**, 174 - 187 (2012)

Presentations

Anand Srivastav, *Low Discrepancy Computations,* Dayalbagh Educatinal Institute, Deemed University, Agra, India, 08.-08.07.2013

Anand Srivastav, *Parallel Quantum Evolutionary Algorithms,* Dayalbagh Educational Institute, Deemed University, Agra, India, 07.-07.02.2013

Lasse Kliemann, *Engineering of a Population-Based Quantum-Inspired Evolutionary Algorithm for Massive Data,* DFG Priority Program 1307 Colloquium, Frankfurt/Main, 02.-04.07.2012

Lasse Kliemann, *Matching in Bipartite Graph Streams,* Streaming Workshop at TU Dortmund, Dortmund, 23.-26.07.2012

Anand Srivastav, Lasse Kliemann, *(1+1/k)-Approximate Maximum Matching in Bipartite Graph Streams in O(k$\hat{5}$) Passes and Improvements,* ISMP 2012, Berlin, 21.-24.08.2012

Michael Gnewuch, *Convergence of Net Quadratures in Fractional Haar Wavelet Spaces and Spaces of Fractional Smoothness,* Oberseminar Theoretische Numerik, Friedrich-Schiller-Universität, Jena, 04.-04.10.2012

Michael Gnewuch, *Infinite-Dimensional Integration: Optimal Randomized Multilevel Algorithms in the ANOVA,* Dagstuhl Seminar 12391, Algorithms and Complexity for Continuous Problems, Dagstuhl, 24.-24.09.2012

Michael Gnewuch, *Randomized Algorithms to Approximate Discrepancies an Applications,* 3. Intl. Conference on Uniform Distribution Theory 2012, Smolenice, Slovakia, 28.-28.06.2012

Michael Gnewuch, *New Multilevel Algorithms Based on Quasi-Monte-Carlo Point Sets,* 10th Intl. Conference on Monte-Carlo and Quasi-Monte-Carlo Methods, Sydney, Australia, 13.-13.02.2012

Further Activities and Events

-Further Activities and Events:

A. Srivastav: Organisation of the session 'Graph Optimization Problems in the Semi-Streaming Model', International Symposium on Mathematical Programming, Berlin 21.-24.8.2013.

M. Gnewuch won the 2012 Information-Based Complexity Price. The prize consists of $3000 and a plaque, presented at the Seminar on Algorithms and Complexity for Continuous Problems at Schloss Dagstuhl, Germany, in September 2012. This annual prize is given for outstanding contributions to information-based complexity.

M. Gnewuch joined the editorial board of ''Journal of Complexity'' (published by Elsevier).

M. Gnewuch was invited by Frances Y. Kuo and Ian H. Sloan (University of New South Wales, Sydney), to a research stay in Sydney from Feb. 13 to March 31, 2012.

M. Gnewuch: Research Fellow at the University of New South Wales, Sydney, Australia, from April 1, 2012 to March 31, 2013.

M. Gnewuch: Member of the programme committee of the 10th International Conference on Monte Carlo and Quasi-Monte Carlo Methods in Scientific Computing (MCQMC 2012) in Sydney, Australia.

M. Gnewuch: Organization of the mini-symposium ''Theoretical and Computational Aspects of Discrepancy'' at the 10th International Conference on Monte Carlo and Quasi-Monte Carlo Methods in Scientific Computing (MCQMC 2012) in Sydney, Australia. (Joint with Peter Kritzer, JKU Linz)

M. Gnewuch: Reviewer for ''Discrete and Computational Geometry'', ''Journal of Complexity'', ''Journal of Computational and Applied Mathematics'', ''Mathematics of Computation'', ''Mathematische Nachrichten'', the proceedings of ''Monte Carlo and Quasi-Monte Carlo Methods 2012'' and ''AMS Reviews''

almanach 12

Information Systems Engineering

Research and teaching in the department of Information Systems Engineering concentrate on the following topics:

- integrated development of information systems based on co-design of structuring, functionality, distribution and interaction,

- theory of models, modelling and conceptual modelling,

- intelligent information systems and intelligent data exploration,

- theory of database systems, semantics of databases,

- analysis and prediction of crystal structures,

- theory and technology of content management systems,

- development, languages, methodologies, and programming of web information systems and the knowledge web,

- migration, evolution, performance assessment, forecasting, and tuning for large database applications.

Results

BPMN (Business process modelling and notation)

An abstract model for the dynamic semantics of the core process modelling concepts in the OMG standard for BPMN 2.0 has been created based on the development of a complete formalization of BPMN 1.0 and 1.1 that is the result of an international collaboration over the last few years. The UML class diagrams associated therein with each flow element are extended with a rigorous behaviour definition, which reflects the inheritance hierarchy structure by refinement steps. The correctness of the resulting precise algorithmic model for an execution semantics for BPMN can be checked by comparing the model directly with the verbal explanations in the BPMN standard. Thus, the model can be used to test reference implementations and to verify properties of interest for (classes of) BPMN diagrams. Based on the model a native BPMN 2.0 Process Engine and a BPMN debugger have been implemented.

Co-design of structuring, functionality, interaction and distribution of information systems

Traditional software engineering and information systems engineering are structured, comprising requirements analysis and definition, systems design, systems implementation and testing, and systems operation and maintenance. For web information systems the traditional approach suffers from three obstacles: late integration of architectural decisions, neglect of user expectations, and late implementations.

The co-design approach integrates application domain description with development of presentation and information systems. At the same time the specification is executable due to our simulation system. The co-design methodology has been assessed by the SPICE committee and has been evaluated to be one of the first methodologies at maturity level 3. The methodology has been extended to web information systems. Coherence and co-existence of UML diagrams can be based on a global ASM-backed systems model. This model supports co-evolution and co-development of sets of UML diagrams.

Component systems are becoming the main approach for efficient and effective development of large systems. Based on the approaches to application modelling that have been developed in the department in the past, an approach to component-based information systems has been developed and tested in application projects. The theory of component systems has been extended by facilities for view exchange among components.

Data mining design

Data mining algorithms aim to provide some means to expose the hidden information behind data. However, considering a particular problem statement raises the question as to which algorithm should be employed, and moreover, how and which processing steps should be nested to convey a target-aimed knowledge discovery process. Present approaches, such as the CRISP-DM, are mainly focused on the management or description of such processes but they do not really describe how such a discovery process should be designed. A novel framework has been developed that aims at the design of knowledge discovery processes where the prior knowledge of a user and his goals are central to the process design.

Moving object databases and analysis

Current research in moving object databases focuses on data structures allowing the efficient storage and analysis of fine-grained data, i.e. trajectories are mostly indexed and analyzed by their spatial and/or temporal attributes, e.g. position and time. Analysis itself, however, often requires the association of such fine-grained data to more coarse-grained queries such as "return all trajectories where a turn has occurred and it is followed by a speed up" . To cover the resulting gap, the fundamentals of a framework for classification of moving objects based on their "behaviour" was developed. In this case, classification is defined as the assignment of trajectory streams to predefined scenarios that represent interactions between arbitrary moving objects. To allow efficient association of trajectory data with coarse-grained scenario descriptions as above, a novel index structure for trajectories of moving objects was developed using techniques from the area of computational movement analysis. The proposed index has the advantage that it uses not only the spatiotemporal domain of trajectories but also their topologies. In that context, the notion of topology is provided as the relation between characteristic events during the life span of a moving object. Providing and using that kind of meta-information allows for the efficient computation of similarities between trajectories at a high level of abstraction.

Database technology

Many modern applications are becoming performance critical. At the same time, the size of some databases has been increasing to levels that cannot be well supported by current technology. Performance engineering has been ruled in the past mainly by reactive techniques such as performance monitoring. A new active method for performance improvement has been developed. One of the potential methods for active performance improvement is performance forecasting based on assumptions of future operations and on extrapolations from the current situation.

Exceptions are considered to be unusual states that could be, but must not be, taken primarily into account. They form exclusions, represent cases to which a rule does not apply, and form specific states that are not going to be handled (at least by the current system) or might represent legal objections against the typical state. Information systems architectures can be made more flexible to cope with exceptions in a way that these systems are exception-aware, exception-reactive, and provide a management of exceptions in a coherent form.

Modernization of information systems is a fundamental but sometimes neglected aspect of conceptual modelling. The management of evolution, migration, and refinement and the ability for information systems to deal with modernization is an essential component in developing and maintaining truly useful systems that minimize service disruption and down-time, and maximize availability of data and applications. Migration and evolution are interwoven aspects. Migration strategies such as 'big bang', 'chicken little', and 'butterfly' can be based on systematic evolution steps. Evolution steps use the theory of model suites.

Classical software development methodologies take architectural issues as granted or pre-determined. Web information systems pay far more attention to user support and thus require sophisticated layout and playout systems. These systems go beyond what has been known for presentation systems. A framework has been developed that is based either on early architectural decisions, or on integration of new solutions into existing architectures. It allows co-evolution of architectures and software systems.

Database theory

The theory of integrity constraints has led to a large body of knowledge and to many applications. Integrity constraints

are however often misunderstood, are given in the wrong database context or within the wrong database models, often combine a number of very different facets of semantics in databases, and are difficult to specify. A unifying approach to specification and treatment of integrity constraints has been developed.

NULL is a special marker used in SQL to indicate that a value for an attribute of an object does not exist in the database. The three-valued and many-valued logics developed in the past do not properly reflect the nature of this special marker. To support this we introduce a non-standard generalization of para-consistent logics. These logics reflect the nature of these markers. The solutions developed can be used without changing database technology.

Modelling with multi-level abstraction refers to representing objects at multiple levels of one or more abstraction hierarchies, mainly classification, aggregation, and generalization. Multiple representation, however, leads to accidental complexity, complicating modelling and extension. A theory of m-objects has been developed that offers powerful techniques for modular and redundancy-free models, for query flexibility, for heterogeneous level-hierarchies, and for multiple relationship-abstraction.

Local database normalization aims at the derivation of database structures that can easily be supported by the DBMS. Global normalization has not received appropriate attention in research despite the interest in its implementations. Our research on systematic treatment of this normalization resulted in new ER-based normalization techniques.

A general theory of database transformations defines the background for queries and updates, which are two fundamental types of computation in any database: the first provides the capability to retrieve data, and the second is used to maintain databases in the light of ever-changing application domains. In theoretical studies of database transformations, considerable effort has been directed towards exploiting the close ties between database queries and mathematical logics. It is widely acknowledged that a logic-based perspective for database queries can provide a yardstick for measuring the expressiveness and complexity of query languages.

Practical experience shows that the maintenance of very large database schemata causes severe problems and no systematic support is provided. Based on the analysis of a recent study, larger schemata may be built by composing smaller ones and frequently recurring meta-structures. Our approach leads to a category of schemata that is finitely complete and co-complete. We show that all constructors of the recently introduced schema algebra are well-defined in the sense that they give rise to schema morphism. The algebra is also complete in the sense that it captures all universal constructions in the category of schemata.

Graph-based analysis of inorganic crystal structures

A crystal-chemical approach to high-temperature superconductivity based upon the notion of structural valency has been extended by an analysis of bond paths. Combinations of these paths represent infinite units of strongly overlapping orbitals (IUSOOs). These units are assumed to be the conducting units in unconventional superconductors.

A database is under construction providing information on IUSOOs for all inorganic crystal structures with data available in sufficient quality. Solutions have been developed and implemented for the computation and characterization of IUSOOs and for the problem of assigning stoichiometric valences to atoms in the case of non-integer values being given as oxidation numbers in crystal structure data.

Information privacy

Privacy is becoming a major issue of social, ethical and legal concern on the Internet. The development of information technology and the Internet have major implications for the privacy of individuals. A new conceptual model for databases that contain exclusively private information has been developed. The model utilizes the theory of infons to define "private infons", and develops taxonomy of these private infons based on the notions of proprietary and possession. The proposed model also specifies different privacy rules and principles, derives their enforcement, and develops and tests architecture for this type of database. The model allows several variants for privacy supporting systems. The concept of privacy wallets

has been implemented.

Knowledge bases and knowledge web

The internet and web applications have changed business and human life. Nowadays almost everybody is used to obtaining data through the internet. Most applications are still Web 1.0 applications. Web 2.0 community collaboration and annotated data on the basis of Web 3.0 technologies support new businesses and applications. The quality dimension of the web is however one of the main challenges. Knowledge web information systems target high-quality data on safe grounds, with a good reference to established science and technology and with data adaptation to the user's needs and demands. They can be built based on existing and novel technologies.

The knowledge web approach has been applied to management of processes that allow flexible handling of catastrophes. Another application targets delivery of actionable information on demand in a way that users in juristical environments can easily assimilate them to perform their tasks.

Our knowledge web approach is based on advanced content management and on the theory of media types. Content management is the process of handling information within an organization or community. We developed, applied, and implemented a novel data model for content, which treats semantic information not only as describing metadata but also incorporates on the same level the data itself, the intention behind it, its usage, and its origin.

Random databases

We consider stochastic modelling for databases with uncertain data and for some basic database operations (for example, join, selection) with exact and approximate matching. Approximate join is used for merging data or removing duplication in large databases. Distribution and mean of the join sizes are studied for random databases. A random database is treated as a table with independent random records with a common distribution (or a set of random tables). Our results can be used for integration of information from different databases, multiple join optimization, and various probabilistic algorithms for structured random data.

Quality management and assessment for information and software systems

Software and information systems design and development coexist and co-evolve with quality provision, assessment and enforcement. However, most (including current) research provides only bread-and-butter lists of useful properties without giving a systematic structure for evaluating them. Software engineers have been putting forward numerous quantities of metrics for software products, processes and resources but a theoretical foundation is still missing. We developed and applied a framework for quality property specification, quality control, quality utilization, and quality establishment. Our framework has a theoretical basis that is adaptable to all stages of software development.

Theory of models and modelling

Conceptual modelling is one of the central activities in Computer Science. A theory of conceptual models and a theory of modelling acts have been developed in our group. They are based on a general theory of modelling as an art, an apprenticeship, and a technology. Modelling is based on an explicit choice of languages, on application of restrictions, on negotiation, and on methodologies. Languages are defined through their syntactics, their semantics, and their pragmatics. Modelling is a process and is based on modelling acts. These modelling acts are governed by the purpose of modelling itself and of the model or models.

Conceptual modelling has changed over the years. Nowadays small scale conceptual modelling has become state-of-the-art for specialists and educated application engineers. Large scale conceptual modelling has been mainly developed within companies that handle large and complex applications. It covers a large variety of aspects such as models of structures, of business processes, of interaction among applications and with users, of components of systems and abstractions, or of derived models such as data warehouses and OLAP applications. We developed new architectural techniques for large scale conceptual modelling.

In software and information systems development different aspects and facets of the system being developed are usually analyzed and modelled independently from each other. A recurring challenge is the integration of the different partial models of the software system into one single consistent model. With the notion of model suites we introduce an approach which can be used to integrate heterogeneous models, to check consistency between those models, and to facilitate a consistent evolution of them. Model suites are based on explicit controllers for maintenance of coherence. They apply application schemata for their explicit maintenance and evolution, use tracers for establishment of their coherence, and thus support co-evolution of information system models. The use of model suites helps to minimize or completely avoid the risks, ambiguities, and contradictions, which normally result from the parallel use of different modelling languages and modelling tools.

Web information systems

We developed a general specification method for clouds. Technically, we understand a cloud as a federation of software services that are made available via the web and can be used by any application. A common understanding in the web services community is that a service is defined as a function or operation with the appropriate input/output specification. We take a general view regarding a service as a piece of software that not only provides functionality but also data. Services thus combine a hidden database layer with an operation-equipped view layer, and can be anything from a simple function to a fully-fledged web information system or a data warehouse.

Web information systems should also support speech dialogues. Their workflow and supporting infrastructure can be specified by storyboards. The integration of speech dialogues is however an unsolved issue due to the required flexibility, the wide variety of responses, and the expected nativeness. Speech dialogues must be very flexible in both recognition of questions and in generation of appropriate answers. We thus introduce a pattern-based approach to specification and utilization of speech dialogues. These patterns reflect the dialogue speech since answers and responses with a speech dialogue are instantiations or refinements of these patterns. It is possible to create patterns for common dialogue-forms. The results of this work show that only small adaptations regarding the storyboard concept are necessary and the extension of the presentation layer with a channel-dependent renderer is sufficient to be able to model natural language dialogues.

The design and reification of web information systems is a complex task, for which many integrated development methods have been proposed. While all these methods ultimately lead to the construction of web pages, very little attention is paid to the layout of these pages. Screenography developed in our group provides principles and rules for page layout that originate from knowledge of visual perception and communication and then investigates how layout can support the intentions associated with the WIS. This amounts to guidelines for partitioning pages and using layout objects, colour, light, and texture to obtain rhythm, contrast, and perspective as the carriers for web page comprehension. We use a pattern approach to systematic development of laying and playouting. These patterns can be combined to larger complex patterns. Therefore, an algebra for pattern construction will be developed.

On a high level of abstraction the storyboard of a web information system specifies who will be using the system, in what way, and for which goals. Storyboard pragmatics deals with the question as to what the storyboard means for its users. One part of pragmatics is concerned with usage analysis by means of life cases, user models, and contexts. We also addressed another part of pragmatics that complements usage analysis by WIS portfolios. These comprise two parts: the information portfolio, and the utilization portfolio. The former is concerned with information consumed and produced by the WIS users, which leads to content chunks. The latter captures functionality requirements, which depend on the specific category to which the WIS belongs.

Personnel

Head of the group: Prof. Dr. B. Thalheim; Secretary: S. Jureit (50%)
Technical Staff: Steffen Gaede

Scientific Staff:

Dipl.-Inf. K. Jannaschk	01.01.-31.12.2012	CAU
apl.-Prof. Dr. H.-J. Klein,	01.01.-31.12.2012	CAU
M. Sc. R. Noack	01.01.-30.09.2012	HSP
Dipl.-Inf. T. Polomski	01.01.-31.12.2012	BMWI
Projekt: Verbundprojekt: PITAS - Piraterie- und Terrorabwehr auf Seeschiffen		
Dipl.-Inf. O. Sörensen	01.01.-31.12.2012	CAU

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

MSS0503 - Seminar Datenbanksysteme, 2 hrs Seminar/Week,
H.-J. Klein

MSS0504: Oberseminar, 2 hrs Seminar/Week,
H.-J. Klein

MS0506: Verteilte Informationssysteme, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
H.-J. Klein (+ O. Sörensen)

WInf-Proj: Business Information Systems Project, 4 hrs Exercise/Week,
K. Jannaschk (+ R. Noack)

Summer 2012

Inf-IS: Informationssysteme (DB), 4 (+ 2) hrs Lecture (+ Exercises)/Week,
H.-J. Klein (+ C. Robenek, H. Schnoor, S. Preugschat)

WInf-BAppE: Selected Topics in Business Application Engineering, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
B. Thalheim (+ S. Feja)

MSS0504: Oberseminar - Technologie der Informationssysteme, 2 hrs Seminar/Week,
H.-J. Klein, B. Thalheim

WInf-ISADD: IS Analysis, Design and Development, 3 (+ 2) hrs Seminar (+ Exercises)/Week,
B. Thalheim (+ O. Sörensen)

WInf-ModIS: Modellierung von Informationssystemen (WInf-ModIS), 2 (+ 1) hrs Lecture (+ Exercises)/Week,
B. Thalheim (+ O. Sörensen)

WInf-MSc-Pro1: Projekt - Wirtschaftsinformatik (Informationssysteme), 4 hrs Exercise/Week,
B. Thalheim (+ R. Noack)

WInf-Proj-BA2: Abschlussprojekt - Wirtschaftsinformatik (Informationssysteme), 4 hrs Exercise/Week,
B. Thalheim (+ K. Jannaschk, R. Noack)

WInf-Sem2: Seminar - Wirtschaftsinformatik (Modelle betrieblicher Informationssysteme), 2 hrs Seminar/Week,
B. Thalheim (+ K. Jannaschk, S. Witt)

WInf-WInf2: Wirtschaftsinformatik II, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
B. Thalheim (+ S. Feja)

WInf-WInf2-WW: Wirtschaftsinformatik II für Wirtschaftswissenschaftler, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
B. Thalheim (+ S. Feja)

Winter 2012/2013

Data Mining, Data Application and Statistics (ISOS), 3 hrs Lecture/Week,
B. Thalheim (+ K. Jannaschk)

MS0505: Datenbanktheorie, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
H.-J. Klein, (+ H.-J. Klein,)

MSP0501: Masterprojekt - Datenbankprogrammierung (Masterpraktikum DB), 4 hrs Exercise/Week,
H.-J. Klein, (+ T. Polomski)

MSS0504: Oberseminar - Technologie der Informationssysteme, 2 hrs Seminar/Week,
H.-J. Klein, B. Thalheim

WInf-InfMinKD: Information Mining and Knowledge Discovery, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
B. Thalheim (+ K. Jannaschk)

WInf-MSc-Pro1: Projekt - Wirtschaftsinformatik (Informationssysteme), 5 hrs Exercise/Week,
H.-J. Klein, B. Thalheim

WInf-WebInfSys: Web Information Systems (WInf-WebInfSys), 2 (+ 1) hrs Lecture (+ Exercises)/Week,
B. Thalheim (+ K. Jannaschk, O. Sörensen)

WInf-WInf3: Wirtschaftsinformatik 3, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
B. Thalheim (+ O. Sörensen)

Third-Party Funds

AIF, *ZIM - Zentrales Innovationsprogramm Mittelstand,* 01.10.-31.12.2012 (171.184,00 EUR)
BMWI, *A knowledge based system for detecting and classifying piracy attacks using scenario descriptions and sensor data (within project PITAS),* 01.01.-31.12.2012 (160.740,00 EUR)
DAAD, *Projektbezogener Personenaustausch mit Finnland - PPP Finnland,* 01.01.-30.06.2012 (12.697,00 EUR)

Further Cooperation, Consulting, and Technology Transfer

University of Antwerp (Jan Paredaens),

Humboldt University Berlin (Johann Christoph Freytag, Oliver Günther),

Alfred Renyi Institute Budapest (Gyula Katona, Dezšö Miklós),

KIng Saud University Riyadh (Ajantha Dahanayake),

Keio University, Fujisawa, Japan (Yasushi Kiyoki),

MTA SZTAKI Budapest (Janos Demetrovics),

Cottbus University of Technology (Heinrich-Theodor Vierhaus),

University of Dortmund (Gabriele Kern-Isberner, Joachim Biskup),

Technical University Hamburg-Harburg (Joachim W. Schmidt),

Klagenfurt University (Heinrich Mayr),

Louisiana State University (Peter P. Chen),

Software Competence Centre Hagenberg (Klaus-Dieter Schewe, Bernhard Freudenthaler, Felix Kossak),

Lomonossov University Moscow (Elyar Gasonov, Valerij B. Kudrjavcev),

Charles University Prague (Jaroslav Pokorny),

Microsoft Research Redmond (Yuri Gurevich),

Frauenhofer-Institut IDMT Erfurt (Klaus-Peter Jantke),

Brigham Young University, Salt Lake City (David Embley),

Silicon Valley Lab IBM (Laura Haas, Holger Kache),

Tampere University of Technology (Hannu Jaakkola),

Tampere University (Hannu Kangassalo),

Umea University (Stephen Hegner, Oleg Seleznev),

Versailles University (Elisabeth Metais),

Portland State University (Lois Delcambre, David Maier),

Australian National University Qing Wang),

University of Vermont (X. Sean Wang),

Universita di Pisa (Egon Börger),

Auckland University, Australia (Hui Ma, Sebastian Link),

KEIO University Tokyo (Yasushi Kiyoki),

NICT Institut Kyoto (Koji Zettsu).

Diploma, Bachelor's and Master's Theses

U. Bakhtina, *Application of classification algorithms for prediction of biological quality indices*, 30.09.2012
M. Bick, *Suche in externen Wissensdatenbanken mittels einer dienstorientierten Softwarearchitektur*, 30.09.2012
D. Degraf, *Die Realisierung des Schutzes personenbezogener Daten in einer Database as a Service-Architektur mittels Unverkettbarkeit*, 15.12.2012
H. Dubaschny, *Erstellung von Referenz-Datenbankschemata am Beispiel einer Finanzinstitutsanwendung*, 30.09.2012
F. Göttsch, *Identifikationsverfahren für die Produktionslogistik*, 30.09.2012
M. Grebasch, *Literaturaufbereitung zum Storyboarding und zu theoretischen Grundlagen von Web-Informationssystemen*, 30.09.2012
R. Grießbach, *Integration einer graphenorientierten Datenbank zur Datenanalyse*, 30.09.2012
J. Hoffmann, *Realisierung eines Ansatzes zur Privacy-Unterstützung - Protokollentwicklung und Dokumentenverwaltung*, 30.09.2012
F. Holst, *Konzeptionierung und prototypische Umsetzung eines Frameworks zur Codegenerierung*, 30.09.2012
S. Kausch, *Metadatenverwaltung für das Produktionscontrolling*, 30.09.2012
T. Müller, *Gefahrenanalyse anhand unvollständiger Daten*, 31.03.2012
S. Pörksen, *Eine interaktive Schnittstelle zur Kontrolle und Aufbereitung von Kristallstrukturdaten für graphbasierte Analyseprogramme*, 31.03.2012

O. Preikszas, *Entwicklung und Realisierung von Techniken des webbasierten interaktiven Lernens in Webinarform,* 30.09.2012
F. Ralfs, *Entwurf und Realisierung einer graphischen Schnittstelle für anorganische Datenbanken,* 31.03.2012
N. Sasse, *Analyse und Anwendung von Methoden der Assoziationsanalyse am Beispiel des Benthon im Kieler Ostseeraum,* 30.09.2012
C. Schielke, *Realisierung eines Ansatzes zur Privacy-Unterstützung - Kryptographie,* 30.09.2012
S. Schmidt, *Steuerungsparameter in Workflow-Mustern bei der Erfassung wissenschaftlicher Experimentaldaten,* 30.09.2012
J. Starke, *Methoden der univariaten Zeitreihenanalyse,* 30.09.2012
K. Steffensen, *Datengestützte Auslieferung von Werbeobjekten im Performance Marketing,* 30.09.2012
L. Stehnken, *Topologiebasierte Indizierung von Trajektorien bewegter Objekte,* 31.03.2012
B. Ulrich, *Entwicklung eines Analyse- und Bewertungswerkzeugs für Express-Zertifikate,* 30.09.2012

Publications

Published in 2012

S. Amarakoon, A. Dahanayake, B. Thalheim, *A framework for modelling medical diagnosis and decision support services,* International Journal of Digital Information and Wireless Communications (IJDIWC), **4**, 7 - 26 (2012)
S. Amarakoon, A. Dahanayake, B. Thalheim, *Domain requirements modelling framework for cross-disciplinary service systems development,* ICCNDT, Gulf University, Bahrain, 189 - 203 (2012)
M. Berg, A. Düsterhöft, B. Thalheim, *Adaptation in speech dialogues: Poissibilities to make human-computer interaction more natural,* Baltic Conference: Human-Computer Interaction BaSoTI 7, Rostock, 7 - 16 (2012)
M. Berg, *Natürlichsprachlichkeit in Dialogsystemen,* Informatik-Spektrum Journal, Springer Verlag, 1 - 11 (2012)
M. Berg, A. Düsterhöft, B. Thalheim, *Query and answer forms for sophisticated database interfaces,* Proceedings European Japanese Conference 2012, 179 - 198 (2012)
M. Berg, *Survey on Spoken Dialogue Systems: User Expectations regarding Style and Usability,* XIV International PhD Workshop, OWD 2012, Conference Archives PTETiS, 256 - 261 (2012)
M. Berg, A. Düsterhöft, B. Thalheim, *Towards interrogative types in task-oriented dialogue systems,* NLDB, Lecture Notes in Computer Science, Springer, **7337**, 302 - 307 (2012)
P. Broman, B. Thalheim, *Interactive data extraction from semi-structured text,* Information Modelling and Knowledge Bases XXII, Frontiers in Artificial Intelligence and Applications, IOS Press, **237**, 1 - 19 (2012)
A. Dahanayake, B. Thalheim, *A conceptual model for IT service systems,* Journal of Universal Computer Science, 18(17), 2452 - 2473 (2012)
A. Dahanayake, B. Thalheim, *Continuous database engineering,* Int. Journal Business Inf. Syst., 11(4), 26 - 58 (2012)
A. Düsterhöft, M. Klettke, K.-D. Schewe, *Conceptual Modelling and Its Theoretical Foundations - Essays Dedicated to Bernhard Thalheim on the Occasion of His 60th Birthday,* Lecture Notes in Computer Science, Springer Verlag, **7260**, (2012)
F. Förster, B. Thalheim, *An effectual approach for a data and information management for humanists,* Qualitative and Quantitative Methods in Libraries (QQML), **2**, 121 - 128 (2012)
F. Förster, B. Thalheim, *Vernetzung von Datenbanken geisteswissenschaftlicher Forschungsprojekte,* Wisskom2012, Karlsruhe, (2012)
S. Hartmann, H. Köhler, S. Link, B. Thalheim, *Armstrong databases and reasoning for functional dependencies and cardinality constraints over partial bags,* FoIKS, Lecture Notes in Computer Science, Springer, **7253**, 164 - 183 (2012)
T. Hashimoto, J. Henno, H. Jaakkola, A. Sasa, B. Thalheim, *Infrastructures for knowledge systems environments,* Information Modelling and Knowledge Bases XXII, Frontiers in Artificial Intelligence and Applications, IOS Press, **237**, 369 - 398 (2012)

H. Jaakkola, B. Thalheim, *Exception-aware (information) systems,* Proceedings European Japanese Conference 2012, 333 - 346 (2012)

Y. Kiyoki, B. Thalheim, *Analysis-driven data collection, Integration and Preparation for Visualisation,* Proceedings European Japanese Conference 2012, 161 - 178 (2012)

H.-J Klein, F. Liebau, *A crystal chemical approach to superconductivity. II. An analysis of local bond-valence distribution in inorganic compounds.,* Zeitschrift für Kristallographie, **227**, 179 - 189 (2012)

H.-J Klein, *The use of periodic graphs for representing and analysing crystal structures,* Zeitschrift für Kristallographie, **227**, 612 - 618 (2012)

H. Ma, K.-D. Schewe, B. Thalheim, Q. Wang, *A formal model for the interoperability of service clouds,* Service Oriented Computing and Applications, **6**, 189 - 205 (2012)

H. Ma, K.-D. Schewe, B. Thalheim, Q. Wang, *Conceptual modelling of services,* Journal of Universal Computer Science, 18(17), 2361 - 2363 (2012)

E. Sivogolovko, B. Thalheim, *Semantic approach to cluster validity notion,* ADBIS, Advances in Intelligent Systems and Computing, Springer, **186**, 229 - 239 (2012)

O. Sörensen, B. Thalheim, Q. Wang, *A Conceptual Justification for Model Transformations,* A Ghose and F Ferrarotti, editors, Asia-Pacifc Conference on Conceptual Modelling (APCCM 2012), ACS, Australia, **130**, 43 - 50 (2012)

B. Thalheim, Q. Wang, *Data migration: A theoretical perspective,* DKE, 14(4), (2012)

B. Thalheim, *Privacy-enhanced information systems,* Grundlagen von Datenbanken, CEUR Workshop Proceedings,, **850**, 3 (2012)

B. Thalheim, *Syntax, semantics and pragmatics of conceptual modelling,* NLDB, Lecture Notes in Computer Science, Springer, **7337**, 1 - 9 (2012)

B. Thalheim, *The art of conceptual modelling,* Information Modelling and Knowledge Bases XXII, Frontiers in Artificial Intelligence and Applications, IOS Press, **237**, 149 - 168 (2012)

B. Thalheim, *The notion of a conceptual model,* N. Seyff and A. Koziolek, editors, Modelling and Quality in Requirements Engineering, Verlagshaus Monsenstein und Vannerdat, ISBN 978-3-86991-740-5, 11 - 20 (2012)

B. Thalheim, *The science and art of conceptual modelling,* A. Hameurlain et al., editor, TLDKS VI, Lecture Notes in Computer Science, Springer, **7600**, 76 - 105 (2012)

Presentations

B. Thalheim, *Pattern-Based Construction of Large Information Systems Schemata,* Technical University Tampere, Kolloqium, Pori, Finland, 08.02.2012

S. Hartmann, H. Koehler, S Link, B. Thalheim, *Armstrong databases and reasoning for functional dependencies and cardinality constraints over partial bags,* Seventh International Symposium on Foundations of Information and Knowledge Systems (FoIKS), Kiel, Germany, 09.03.2012

B. Thalheim, *Codesign + Pattern + Storyboarding, Open Models as a Foundation of future Enterprise Systems,* Seminar Open Models, Dagstuhl, Germany, 25.03.2012

b Thalheim, *The Science and Art of Conceptual Modelling, Open Models as a Foundation of future Enterprise Systems,* Seminar Open Models, Dagstuhl, Germany, 27.03.2012

B. Thalheim, *Privacy-Enhanced Information Systems,* 24. Workshop Grundlagen von Datenbanken (GvD) 2012, Lübbenau, Germany, 31.05.2012

B. Thalheim, *Query and Answer Forms for Sophisticated Database Interfaces,* European Janpanese Conference 2012 (EJC 2012, Prague, Czech Republic, 05.06.2012

B. Thalheim, *Analysis-Driven Data Collection, Integration and Preparation for Visualisation,* European Janpanese Conference 2012 (EJC 2012), Prague, Czech Republic, 06.06.2012

B. Thalheim, *Exception-Aware (Information) Systems,* European Janpanese Conference 2012 (EJC 2012), Prague, Czech Republic, 07.06.2012

B. Thalheim, *Information Modelling and Data Mining,* European Janpanese Conference 2012 (EJC 2012), Prague, Czech Republic, 07.06.2012
B. Thalheim, *Theoria Cum Praxi: Informatik als Handwerkskunde oder als Kulturgut?,* Kolloquium, BTU Cottbus, Cottbus, Germany, 08.06.2012
B. Thalheim, *Syntax, Semantics and Pragmatics of Conceptual Modelling,* NLDB 2012, Groningen, Netherlands, 27.06.2012
B. Thalheim, *Das Modell des Modelles,* Workshop Science and Art of Modelling, Kiel, Germany, 29.06.2012
B. Thalheim, *Der Modellkatalog,* Workshop Science and Art of Modelling, Kiel, Germany, 29.06.2012
B. Thalheim, *The Extended Entity-Relationship Modelling Language HERM,* Eötvös Loránd University of Sciences, Kolloquium, Budapest, Hungary, 03.07.2012
B. Thalheim, *Co-Design of Structure, Functionality, Distribution, and Interaction,* Eötvös Loránd University of Sciences, Kolloquium, Budapest, Hungary, 04.07.2012
B. Thalheim, *Database and Information Systems Theory,* Eötvös Loránd University of Sciences, Kolloquium, Budapest, Hungary, 05.07.2012
B. Thalheim, *Dynamic and Generic Workflows,* Software Competence Center Hagenberg, Linz, Austria, 11.10.2012
B. Thalheim, *Co-Design of Structuring, Functionality, Interactivity and Distribution,* ER 2012 (International Conference on Conceptual Modelling), Florence, Italy, 16.10.2012
B. Thalheim, *Science and Art of Modelling,* DFG, Bonn, Germany, 05.11.2012
B. Thalheim, *Domain Requirements Modelling Framework for Cross-Disciplinary Service System Develop- ment,* ICCNDT'12, Sanad, Bahrain, 11.11.2012
B. Thalheim, *Wann Webdaten zu Informationen und Wissen werden,* Night of the Profs, Chistian-Albrechts-University, Kiel, Germany, 19.11.2012
B. Thalheim, *Grounding and Basis of Models - Beyond T. Kuhn (in Russian),* Kolmogorow-Lecture, Lomonossow-University, Moscow, Russia, 25.12.2012
B. Thalheim, *Culture, Science and Art of Modelling (in Russian),* Kolmogorow-Lecture, Lomonossow-University, Moscow, Russia, 27.12.2012
B. Thalheim, *Models of models (in Russian),* Kolmogorow-Lecture, Lomonossow-University, Moscow, Russia, 28.12.2012

Further Activities and Events

FoIKS - Seventh International Symposium on Foundations of Information and Knowledge Systems, Kiel, Germany, March 5-9, 2012

Local organisation chair

S. Gaede, K. Jannaschk, S. Jureit, H.-J. Klein, R. Noack, O. Sörensen, B. Thalheim.

B. Thalheim

Kolmogorow-Professor, Lomonossow-University, Moscow, since 2005.

Member of programme committee:

ABZ 2012, June 2012,
ADBIS 2012, September 2012,
APCCM 2012, January, February 2012,
BIS 2012, May 2012,
CroWE 2012, July 2012,
CTS 2012, May 2012,
CAiSE 2012, June 2012,

CMS 2012, May 2012,
DEXA 2012, September 2012,
EJC 2012, June 2012,
ER 2012, October 2012,
IS 2012, September 2012,
NLDB 2012, June 2012,
UNISCON 2012, June 2012,
WEBIST 2012, April 2012,
WISM 2012, October 2012.

Member of steering committees of international conferences:

ABZ, ADBIS, Baltic DB, EJC, ER, ISTA , NLDB, SDKB.

Editorial board membership:

Data and Knowledge Engineering (DKE),
Journal of Intelligent Information Technologies,
Journal of Web Engineering,
Enterprise Modelling and Information Systems Architectures,
Serdica Journal of Computing.

Editor and Co-Chair of the Conference Proceedings:

Semantics in Data and Knowledge Bases, 5th International Workshop, SDKB 2011, LNCS 7693, Springer 2012.

Co-Chair:

- of the German group of DAMA International,
- of the Schleswig-Holstein Regional Group of the German Computer Science Society,
- of Graduate School Human Development in Landscape,
- of the Rotary-Club, Kiel-Düsternbrook,
- ombudsman of German Computer Science Society, Schleswig-Holstein.

Co-Chairman of workshops:

CMS 2011, Milan.

Member of the Scientific Advisory Board: with Dataport.

Member of board:

Graduate School Human Development in Landscapes.

Member of:

-Cluster of Excellence Inflammation at Interfaces,
-Cluster of Excellence Future Ocean,
-Graduate School Human Development in Landscapes,
-Foundation Board and Advisor of DAMA International.

Reviewer of doctoral theses:

ETH Zurich, Switzerland,
Lomonossow- University Moscow, Russia,
Christian-Albrechts-University Kiel, Germany,

University Delft, Netherlands,
University of Technology, Melbourne, Australia,
Technion, Haifa, Israel.

Deputy:

for German Computer Science Society at Max-Planck Society.

Reviewer:

-for the German Research Foundation, DAAD, Australian Science Foundation, National Science Foundation (USA),
-AQAS (accreditation agency),
and a series of conferences and journals in Mathematics, Computer Science and Engineering.

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Multimedia Information Processing

The Multimedia Information Processing group (MIP) is active in research and applications of 3D technology, computer vision, and computer graphics. The main focus of the group is on various aspects of 3D data processing from image and video data, and on sensor fusion with range and navigation data. In 2012, 12 researchers were involved in 11 research projects. Project funding was supplied by DFG, EU, Chinese Research Council, BMWi, Land Schleswig-Holstein, Innovationsstiftung S-H, Fraunhofer (ISIT, IPM), Professor Petersen Stiftung, and Industry (Volkswagen, WISKA, IBAK).

Results

The MIP group continued its active research in 3D technology and computer vision in 2012. Not all activities of MIP in 2012 can be discussed here, so we highlight some of the important research achievements, as well as efforts for converting research into products.

- KoSSE: As part of the competence centre Software Systems Engineering KoSSE, MIP worked on developing modular computer vision systems, together with IBAK. A key issue of the subproject MoSeS is the development of modular, reusable computer vision components for fast prototyping. Application areas are autonomous navigation, and sewer pipe inspection systems. Two researchers were employed here with additional support of staff from MIP. In addition, two PhD students from China with CRC stipends add expertise in robotic navigation and self-localisation tasks.

- InterReg IRFO: The bi-national consortium IRFO (Intelligent Robotics for Flexible Object handling) between Denmark (SDU Odense/Sonderborg, DTI Odense) and CAU-MIP is supported by the EU InterReg programme and is successfully developing new approaches to handle dynamic and flexible objects using 3D robot vision and robot handling. MIP´s part involves 3D-Data capture and modelling of deformable objects in realtime. Two researchers have been investigating novel sensors and data fusion modalities.

- Underwater imaging: The close collaboration in the Excellence Cluster *Future Ocean* between GEOMAR and CAU on underwater imaging is actively pursued by MIP researchers. Supported by DFG, novel image processing approaches for underwater 3D reconstruction currently are being investigated by one researcher. In addition, there is a close collaboration on underwater archaeology between the archaeology diving team of the CAU and MIP.

- 3D documentation for archaeological findings: Funded by the DFG in the Graduate School *Human development in landscapes*, one MIP researcher investigates the use of 3D for documenting archaeological findings during excavations. This allows one to conserve all information, combine shape and position of finds with semantic meanings, and will help the archaeologist to reconstruct the site in 3D for later reuse.

- Holographic Imaging: Novel multi-camera systems and multiview display technology will allow the reconstruction of a virtual 3D environment to enable fully immersive 3D viewing in the future. MIP is actively developing technologies for such holographic systems and Augmented Reality devices together with Fraunhofer ISIT and IPM amongst others. Efficient depth-compensated rendering, as being developed by MIP, allows huge compression rates and the necessary computation speedup to handle the huge amount of data. A holographic light-field camera is currently being built; the necessary funding has been supplied by the Professor Petersen Foundation.

DeCSMedia: successful technology transfer from research towards product in 3D-TV

In 2011, the successful work on 3D-TV systems (supported by EU project 3D4YOU 2007-2011) led MIP researchers to create within MIP the subgroup DeCSMedia (supported by the BMWi EXIST technology transfer programme). In 2012, all research goals were reached and DeCSMedia, now a Spin-off company, received further funds in the second stage of the BMWi and ESF EXIST programme. This will lead to the development of a new generation of 3D-TV capture systems for autostereoscopic 3D-Television (3D-TV without glasses).

DeCSMedia GmbH is currently developing an innovative depth-capture system for 3D-Television that is based on depth-measuring cameras. This depth-sensing device is then hooked onto traditional broadcast cameras, enabling them to convert the standard 2D Video into a 3D-TV stream, even for multiple viewpoints as needed for autostereoscopic glasses-less displays. Prototypes of the system have already been produced and allow 3D-production. Given the broad interest in 3D-production and the high cost of current 3D-productions, this device might well revolutionize the 3D capture market.

Fig. 1: The founders of DeCSMedia GmbH with their 3D capture device. From left to right: Anatol Frick, Falko Kellner, and Dr. Ingo Schiller.

Personnel

Head of the group: Prof. Dr.-Ing. R. Koch; Secretary: R. Staecker (50%)
Technical Staff: T. Storm

Staff:

M. Kolasinki DeCSMedia	01.05.-31.12.2012	EXIST

Scientific Staff:

D. Chen	01.01.-31.07.2012	Chinese Research Council
S. Esquivel Land	01.01.-31.12.2012	CAU
Dr.-Ing. O. Fleischmann ISIT	01.11.-31.12.2012	Fraunhofer

M. Franke	01.01.-31.12.2012	ISH
Modulare Dezentrale Schiffsüberwachungstechnik		
A. Frick	01.01.-31.12.2012	EXIST
DeCSMedia		
A. Jordt	01.01.-31.12.2012	EU
Interreg		
A. Jordt (Sedlazeck)	01.01.-31.12.2012	DFG/EU
Modelling of Seafloor Structures, InterReg		
D. Jung	01.01.-31.12.2012	CAU
Land		
F. Kellner	01.01.-31.12.2012	EXIST
DeCSMedia		
A. Petersen	01.01.-30.11.2012	EU
KoSSE		
Dr.-Ing. I. Schiller	01.01.-31.12.2012	EXIST
DeCSMedia		
R. Wulff	01.01.-30.09.2012	DFG
Graduiertenkolleg Human Landscapes		
L. Zhang	01.01.-31.12.2012	Chinese Research Council

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

MSP0601 Vertiefende Übung Visuelle Modellierung, 4 hrs Masterprojekt/Week,
R. Koch (+ D. Jung)

Inf-MultInf Einführung in die Bildverarbeitung, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
R. Koch (+ D. Jung)

Seminar - Visuelle Modellierung, 2 hrs Seminar/Week,
R. Koch (+ S. Esquivel)

Informatik für Nebenfächler (vertiefend), 2 (+ 2) hrs Exercise (+ Exercises)/Week,
S. Esquivel (+ S. Esquivel, D. Jung)

MS0603 3D-Rekonstruktion aus Bildfolgen, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
R. Koch (+ S. Esquivel)

Summer 2012

Seminar Visuelle Modellierung, 2 hrs Seminar/Week,
R. Koch (+ S. Esquivel)

MS0602 Multimediale Signal- und Bildverarbeitung, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
R. Koch (+ S. Esquivel)

BA6.7 Projektmodul, Bachelorarbeiten, 2 hrs Thesis seminar/Week,
R. Koch (+ S. Esquivel)

Informatik II für Ingenieurwissenschaften, 3 (+ 3) hrs Lecture (+ Exercises)/Week,
R. Koch (+ D. Jung, O. Fleischmann)

MS0601 Computer Graphik, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
R. Koch (+ D. Jung)

Winter 2012/2013

MSP0601 Vertiefende Übung Visuelle Modellierung, 4 hrs Masterprojekt/Week,
R. Koch (+ D. Jung)

Informatik für Nebenfächler (vertiefend), 2 (+ 2) hrs Exercise (+ Exercises)/Week,
S. Esquivel (+ S. Esquivel)

080092 Inf-EinfBV: Einführung in die Bildverarbeitung, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
R. Koch (+ D. Jung, O. Fleischmann)

MSP0601: Masterprojekt - Vertiefende Übung Visuelle Modellierung, 2 hrs Seminar/Week,
R. Koch (+ M. Franke, S. Esquivel)

MSS0601: Seminar - Visuelle Modellierung, 2 hrs Seminar/Week,
R. Koch (+ S. Esquivel, D. Jung)

Third-Party Funds

ISH, *Transferprämie,* 01.04.2011-31.12.2013 (20.000,00 EUR)
WISKA/Verbundprojekt PITAS, *Software für visuelles Detektions- und Reaktionssystem, Bildanalyse und Kamerasteuerung,* 28.09.2010-30.06.2013 (41.000,00 EUR)
ISH, *MoDEST,* 01.05.2011-30.04.2013 (120.000,00)
FHG-ISIT, *Konzeptstudie für portables Spatial Augmented Reality System,* 01.10.2011-31.03.2014 (205.000,00)
FHG-IPM, *3D-Signage,* 01.10.2011-30.09.2013 (25.000,00)
DFG Graduate School, *1 Stipend,* 01.01.2010-31.12.2012 (42.800,00)
Chinese Research Council, *1 Stipend,* 01.09.2009-31.08.2013 (62.000,00)
VW, *Optical See-Through,* 11.04.-30.06.2012 (6.000,00)
BMWi, *EXIST,* 01.09.2011-28.02.2013 (466.532,00)
DFG, *Seafloor Modelling Folgeprojekt,* 01.09.2012-31.08.2014 (156.500,00)
EKSH/ISH, *Transferprämie,* 01.12.2012 (5.000,00)
EU, *InterReg,* 01.09.2009-30.09.2012 (273.000,00)
EU, *KoSSE,* 01.08.2009-31.08.2012 (3330.000,00)
Chinese Research Council, *1 Stipend,* 01.04.2010-31.07.2012 (31.000,00)

Further Cooperation, Consulting, and Technology Transfer

Dr. Hunger, **Fa. IBAK**, Kiel

Prof. Dr.-Ing. Michael Felsberg, **Linköping University**, Linköping, Sweden

Fabian Doil, **VW**, Wolfsburg

Prof. Joachim Weickert, **Uni Saarland**, Saarbrücken

Yoav Schechner, **Israel Institute of Technology** Haifa, Israel

Soenke Ehlers, **Fa. WISKA** Kaltenkirchen

Prof. Bernhard Wagner, **Fraunhofer Institut, ISIT**, Itzehoe

Dr. Uwe Franke, **Daimler AG**, Sindelfingen

Dr Jürgen Steimle, **MIT**, Cambridge Boston, USA

Prof. Dr. Reinhard Klette **CITR - The University of Auckland**, Auckland, New Zealand

Diploma, Bachelor's and Master's Theses

M. Lichtner, *Kamera zu Inertialsensorik Kalibrierung durch nicht lineare Ausgleichsrechnung,* 17.09.2012
J. Retzlaff, *Bewegungskompensation in Tiefenbildern durch Odometriedaten,* 21.09.2012
M. Rau, *Segmentierung bewegter Objekte in Tiefendaten,* 21.09.2012
T. Steinigeweg, *Automatische Objektmodellierung aus Tiefendaten mit impliziten Oberflaechenfunktionen,* 21.09.2012
M. Nannt, *Objekterkennung und Poseschätzung in Tiefenbildern,* 21.09.2012
K. Rathlev, *Entwicklung einer inversiven Kinematik für die PowerCube Plattform,* 21.09.2012
C. Butschek, *Pfadplanung für einen Greifarm auf einer mobilen Roboterplattform,* 21.09.2012
W. Pappa, *Waldgeschichtsarchive in der Landschaft: computergestützte Mustererkennung von Kohlemeilerstellen in Reliefdaten (supervised by Dr. Nelle),* 22.03.2012
R. Weiss, *Farb- und Kontrastverbesserung in Unterwasserbildern,* 22.03.2012
F. Dubrownik, *Effizientes bildbasiertes Erzeugen neuer Ansichten auf einen FPGA,* 22.03.2012
H. Grow, *Bildregistirierung zur Texturierung zylinderförmiger Szenen mit einer Fisheye-Kamera,* 22.03.2012
A. Kalali, *Image Blending und Helligkeitsausgleich für Texturen von Kanalrohren,* 22.03.2012
T. Börding, *Bildbasiertes Erzeugen neuer Ansichten einer Szene auf der Grafikkarte,* 22.12.2012
J. Hoffmann, *Fusion von 3D-Punktdaten mit lokaler Oberflächenschätzung,* 22.12.2012
J. Bork, *Rekonstruktion einer zum Teil unter Wasser liegenden Szene (Studienarbeit),* 09.03.2012

Dissertations / Postdoctoral Lecture Qualifications

O. Fleischmann, *On The Analysis and Decomposition of Intrinsically One-Dimensional Signals and their Superpositions (Supervised by Prof. Dr. G. Sommer),* 23.11.2012
K. Haase, *Maritime Augmented reality mit a priori Wissen aus Seekarten,* 13.09.2012
C. Menk, *Photorealistic Visualization Techniques for Using Spatial Augmented Reality in the Design Process,* 10.02.2012

Publications

Published in 2012

R. Koch, N. Pears, Y. Liu, *3D Imaging, Analysis and Applications - Introduction,* 3D Imaging, Analysis and Applications Pears et al. (Eds.), Springer London, 1 - 31 (2012)
A. Petersen, R. Koch, *Video-based realtime IMU-camera Calibration for Robot Navigation,* Proceedings of SPIE, Real-time Image and Video Processing 2012 843706, (2012)
A. Petersen, R. Koch, *A Novel State Parametrization for Stereo Slam,* Proceeding of VisApp 2012, (2012)
L. Zhang, R. Koch, *Line Matching Using Appearance Similarities and Geometric Constraints,* Pattern Recognition: Proceedings of DAGM/OAGM, 236 - 245 (2012)
A. Sedlazeck-Jordt, R. Koch, *Refractive Calibration of Underwater Cameras,* Computer Vision ECCV, Lecture Notes in Computer Science, **7576**, 846 - 859 (2012)
A. Sedlazeck, R. Koch, *Perspective and Non-perspective Camera Models in Underwater Imaging - Overview and Error Analysis Outdoor and Large-Scale Real-World Scene Analysis,* Lecture Notes in Computer Science, **7474**, 212 - 242

(2012)
A. Jordt, R. Koch, *Direct Model-based Tracking of 3D Object Deformations in Depth and Colour Video*, International Journal of Computer Vision IJCV, (2012)
A. Fugl, A. Jordt, H. Petersen, M. Willatzen, R. Koch, *Estimation of Material Properties and Pose for Deformable Objects from Depth and Colour Images*, Pattern Recognition, Proceedings of DAGM/OAGM, **7476**, 165 - 174 (2012)
L. Zhang, R. Koch, *LBD: A fast and robust line descriptor based on line band representation*, Technical Report, (2012)
O. Fleischmann, G. Sommer, *Automatic Scale Selection of Superimposed Signals.*, A. Pinz, T. Pock, H. Bischof, and F. Leberl (Eds.), Pattern Recognition, **7476**, 297 - 306 (2012)
F. Kellner, B. Bolte, G. Bruder, U. Rautenberg, F. Steinicke, M. Lappe, R. Koch, *Geometric Calibration of Head-Mounted Displays and its Effects on Distance Estimation*, IEEE Transactions on Visualization and Computer Graphics 2012, 589 - 596 (2012)
R. Wulff, R. Koch, *Image-Based 3D Documentation of Archaeological Trenches Considering Spatial, Temporal and Semantic Aspects.*, Computer Applications and Quantitative Methods in Archaeology CAA 2012, (2012)
L. Zhang, R. Koch, *Vanishing Points Estimation and Line Classification in a Manhattan World*, Proceedings of the ACCV 2012, November 2012, Daejeon, Korea, (2012)
L. Zhang, C. Xu, K.-M. Lee, R. Koch, *Robust and Efficient Pose Estimation from Line Correspondences*, Proceedings of the ACCV 2012, November 2012, Daejeon, Korea, (2012)

Presentations

A. Petersen, *Video-based realtime IMU-camera Calibration for Robot Navigation*, SPIE Photonics Europe, Brussells, Belgium, 16.-19.04.2012
A. Petersen, *A Novel State Parametrization for Stereo Slam*, VisApp, Rome, Italy, 24.-26.02.2012
L. Zhang, *Line Matching Using Appearance Similarities and Geometric Constraints*, DAGM 2012, Graz, Austria, 28.-31.08.2012
A. Sedlazeck-Jordt, *Refractive Calibration of Underwater Cameras*, ECCV 2012, Florence, Italy, 07.-13.10.2012
A. Jordt, *Direct Model-based Tracking of 3D Object Deformations in Depth and Colour Video*, DAGM 2012, Graz, Austria, 28.-31.08.2012
F. Kellner, *Geometric Calibration of Head-Mounted Displays and its Effects on Distance Estimation*, IEEE VR 2012, Costa Mesa, USA, 04.-08.03.2012
R. Wulff, *Image-Based 3D Documentation of Archaeological Trenches Considering Spatial, Temporal and Semantic Aspects.*, Computer Application and Quantitative Methods in Archaeology CAA 2012, Southampton, UK, 26.-29.03.2012
L. Zhang, *Vanishing Points Estimation and Line Classification in a Manhattan World*, Proceedings of the ACCV 2012, November 2012, Daejeon, Korea, 06.-09.11.2012
L. Zhang, *Robust and Efficient Pose Estimation from Line Correspondences*, Proceedings of the ACCV 2012, November 2012, Daejeon, Korea, 06.-09.11.2012

Further Activities and Events

On November 26th for the third time running, **Prof. Dr.-Ing Reinhard Koch** was awarded the **Technologietransferprämie**, a prize for intensive transfer of knowledge and cooperation with industry. The prize, endowed with 5000 Euro, was donated by the **Innovationsstiftung Schleswig-Holstein und der Gesellschaft für Energie und Klimaschutz Schleswig-Holstein**

Anne Jordt presented a poster at the **Oceanology** conference in London March 12th to March 16th. The title was *Underwater Computer Vision*. **Anne Jordt** was financed by the **Excellence Cluster Future Ocean**

Former Student **Dr. Clemens Rabe** has won the **Karl-Heinz-Beckurts Award 2012**. Together with his colleagues from

Daimler Benz Research he developed *6D-Vision: Spatio-Temporal Machine Vision*. The award recognizes research which finds its way to industry.

Prof. Dr.-Ing Reinhard Koch was invited to speak on **Digital Ship 2012** in Hamburg, His talk was on *Augmented Reality: Intuitive User Interfaces in Marine Navigation Systems*

Prof. Dr.-Ing Reinhard Koch gave a series of seminar talks at the Department of Computer Science, University of Auckland, New Zealand.

At the annual Symposium of the DAGM in Graz, Austria, the **German Association on Pattern Recognition, DAGM** elected **Prof. Dr.-Ing Reinhard Koch** as vice-president for a 3 year period.

The **Kiel Week 2012** saw and heard **Prof. Dr.-Ing Reinhard Koch** and **Anne Sedlazeck-Jordt** with *Dem Ozean auf den Grund gegangen* give a talk and demonstration about chances and limitations of underwater image processing.

Prof. Dr.-Ing Reinhard Koch was invited as Keynote Speaker to **27th Image and Vision Computing** in Dunedin Zealand 26th-28th November 2012, his subject *Depth Cameras*.

Andreas R. Fugl from the **Mærsk McKinney Møller Instituttet, Syddansk Universitet Odense, Denmark** visited our group from March 3rd to March 25th and worked with **Andreas Jordt** on: *Estimation of Material Properties*. The cooperation resulted from the **INTERREG-Project**.

Reviews

Member of the programme committee of the following international conferences and workshops:

- 3DimPVT 2012,
- CVMP 2012,
- DAGM 2012,
- EG 2012,
- ECCV 2012,
- ICPR 2012,
- SSIAI 2012,
- WDIA 2012,
- VMV 2012.
- Member of the Technical Committee of the DAGM, and spokesman of the TK since 2009.
- German Representative of the International Association on Pattern Recognition, IAPR since 2009.

Member of the editorial board for the following journals:

- Journal of Realtime Image Processing (JRTIP), Springer, since 2007,
- Journal of Visual Communications and Image Representation (JVCI) Elsevier, since 2008.

Reviewer for the following journals:

- IEEE-IE Transactions IE, Special Issue on Optomechatronics,
- International Journal of Image and Graphics,

- IEEE - BTS Broadcast Systems,
- IEEE T-PAMI Transactions of Pattern Analysis and Machine Intelligence,
- Journal on CVIU Computer Vision and Image Understanding,
- International Journal on Computer Vision

Programming Languages and Compiler Construction

The research group ''Programming Languages and Compiler Construction'' is interested in the design, implementation, and application of programming languages intended to support the reliable implementation of complex systems. The research ranges from object-oriented design methods and the analysis of concurrent and distributed systems, to the implementation and application of declarative programming languages, in particular, in the area of web-based systems.

During the period reported below, the research group worked on a new advanced implementation of the multi-paradigm language Curry and achieved new research results related to the design, implementation, analysis, and application of declarative programming methods.

Results

The scientific work of the research group involved all areas related to declarative programming languages, e.g. design, semantics, implementation, development tools, and the application of such languages. Declarative programming languages are based on clear mathematical foundations. They abstract from the underlying computer architecture and thus provide a higher programming level leading to more reliable systems. In particular, much of the research is focused on the integration of the most important declarative programming paradigms: functional and logic programming.

Fig. 1: The programming language and program development groups on a climbing trip

In relation to the *application* of declarative languages, we continued our work on the design and implementation of the web framework Spicey. Spicey enables the generation in a few minutes of complete web applications from a specification of the underlying complex data model. Since the generated implementation is a high-level declarative program, it is easy to adapt this program to various customer requirements. In contrast to other web frameworks, our framework exploits high-level declarative programming techniques so that it yields reliable implementations that avoid data inconsistencies at various levels. We applied this system to implement a web-based interface to access the module database of the Institute of Computer Science, which is used to plan the curriculum; it was quite positively evaluated by an accreditation committee.

To explore the integration of declarative and object-oriented programming techniques, we developed a new web-based survey system that combines surveys, quizzes, and self-tests. The flexible creation of such applications is enabled by a domain-specific language to describe surveys and tests. The complete system is implemented in the programming language Scala, which combines functional and object-oriented features and exploits the web framework Play. The developed survey

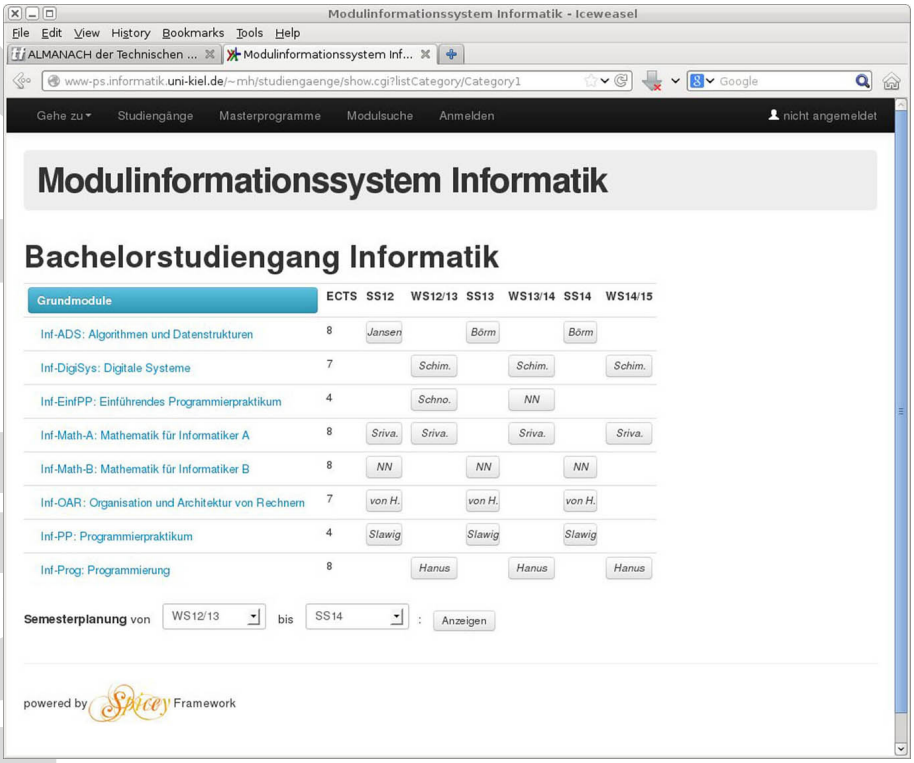


Fig. 2: The interface to the module database of the Institute of Computer Science

system, called SuSy, is freely available.

In the area of *software technique* related to declarative languages, we collaborated with the Portland State University (Oregon, USA) and developed a transformation tool to support the development of reliable declarative programs written in the multi-paradigm programming language Curry. First, we set up a framework with precise notions of specifications, contracts, and assertions for declarative programs. Since specifications, contracts, assertions, and programs are written in the same language (Curry), it is used as a wide-spectrum language for software development. For instance, specifications are written in Curry and are thus executable. Hence, they can be used as an initial implementation. If this implementation is not efficient enough, one can develop a more efficient one, e.g. by using specific data structures and algorithms for the given problem domain. In this case one can use the initial specification as a contract or assertion to check the validity of the new implementation. This general idea is supported by a new tool (DSDCurry), which transforms, if necessary, specifications into implementations or assertions. Based on other work of our group on different methods for assertion checking, DSDCurry also supports various kinds of assertion checks, like strict, lazy, or faithful assertions.

We also investigated several issues related to the *implementation* of functional logic programming languages. In particular, we continued our development of a new implementation of Curry, called KiCS2, that is based on compiling Curry programs into purely functional Haskell programs. The advantage of this implementation is the explicit representation of non-deterministic computed results in a single data structure. This provides for the application of various search strategies (depth-first, breadth-first, iterative deepening, parallel) to explore the search space. Since these opportunities are unique to KiCS2, we investigated the comparison of different search strategies in a single system. In most other systems, an incomplete depth-first search strategy is used for efficiency reasons. We showed that the preference of an incomplete strategy is not really necessary, since complete search strategies like breadth-first or iterative deepening are applicable in practice with a small overhead only. Based on the positive results, we started the distribution of our new implementation, which is available as open-source software.

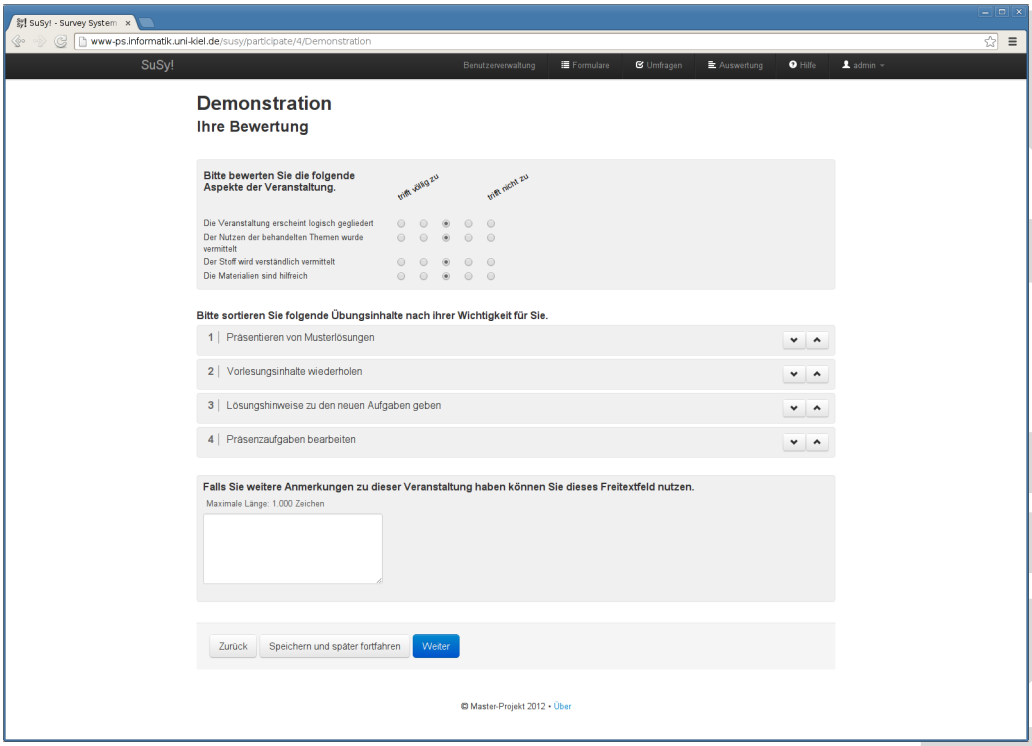


Fig. 3: A screenshot of the survey system SuSy

The practical use of our new implementation in various implementation projects (e.g. in the module database discussed above) also showed some performance problems in specific situations. In particular, the combination of non-deterministic evaluations that are lazily passed to other operations could cause a duplication of the work to traverse the underlying data structures. In order to avoid such problems, we developed a new program analysis to identify such points in a program together with a program transformation to optimize it.

In the area of the *design and semantics* of declarative languages, we had developed, in a previous collaboration with the Portland State University (Oregon, USA), a new technique to encapsulate non-deterministic computations in functional logic programs. It is based on associating to each function a set-valued function encapsulating the non-determinism caused by the function's execution. It is the first referentially transparent approach to encapsulate non-deterministic computations and thus solves a long-standing problem in this area. Due to the advanced implementation techniques used in KiCS2, we were also able to implement set functions in this system. Thus, KiCS2 is the first implementation with a full support for set functions. During these implementation efforts, it turned out that the original proposal for set functions is underspecified so that various semantic options (empty result sets, nested set functions) are unclear. Therefore, we developed a new abstract description of all these details and obtained the first denotational description of set functions. This description is not only of theoretical interest, but is also the basis of our new implementation of set functions.

Finally, we finished a comprehensive survey on functional logic programming that might be used as a standard reference in this area in future research and teaching activities.

Personnel

Head of the group: Prof. Dr. Michael Hanus; Secretary: Jane-Maria Eitzen (50%)
Technical Staff: Dipl.-Ing. (FH) Thomas Heß (50%)

Scientific Staff:

Dr. Sebastian Fischer	01.01.-31.12.2012	Guest
PD. Dr. Frank Huch	01.01.-31.12.2012	CAU (35%)
M. SC. Björn Peemöller	01.01.-31.12.2012	CAU
Dipl.-Inf. Lars Prädel	01.10.-31.12.2012	CAU
Dipl.-Inf. Fabian Reck	01.01.-31.12.2012	CAU
Dr. Friedemann Simon	01.01.-31.12.2012	CAU

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

Arbeitsgemeinschaft Informatik, Logik und Mathematik, 2 hrs Seminar/Week,
M. Hanus (+ R. Berghammer)

MSS0303: Masterabschlussseminar - Programmiersprachen, 2 hrs Seminar/Week,
M. Hanus

Inf-Prog: Programmierung, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
M. Hanus (+ F. Reck, L. Prädel)

MS0302: Übersetzerbau, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
M. Hanus (+ F. Reck)

MS0304: Funktionale Programmierung, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
F. Huch (+ B. Peemöller)

Inf-PtKI: Programmiertechniken für die Künstliche Intelligenz, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
F. Simon

NF-Inf-3: Programmiertechniken für die Künstliche Intelligenz für Nebenfächler, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
F. Simon

Summer 2012

Arbeitsgemeinschaft Informatik, Logik und Mathematik, 2 hrs Seminar/Week,
M. Hanus (+ R. Berghammer)

MSS0303: Masterabschlussseminar - Programmiersprachen, 2 hrs Seminar/Week,
M. Hanus

Inf-FortProg: Fortgeschrittene Programmierung, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
M. Hanus (+ B. Peemöller)

MS0301: Prinzipien von Programmiersprachen, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
M. Hanus (+ F. Reck)

Inf-MP-PS: Mastermodul - Programmiersprachen und Programmiersysteme, 6 hrs Practical/Week,
M. Hanus (+ B. Peemöller)

Inf-PM-PS: Projektmodul - Programmiersprachen und Programmiersysteme, 6 hrs Practical/Week,
M. Hanus (+ B. Peemöller)

Winter 2012/2013

Arbeitsgemeinschaft Informatik, Logik und Mathematik, 2 hrs Seminar/Week,
M. Hanus (+ R. Berghammer)

MSS0303: Masterabschlusseminar - Programmiersprachen, 2 hrs Seminar/Week,
M. Hanus

Inf-MS-Sem-PS: Programmiersprachen und Programmiersysteme, 2 hrs Seminar/Week,
M. Hanus (+ F. Huch)

Inf-Prog: Programmierung, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
M. Hanus (+ F. Reck, B. Peemöller, L. Prädel, N. Danilenko, D. Ehlers, P. Munstermann)

MS0303: Deklarative Programmiersprachen, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
M. Hanus (+ B. Peemöller)

MS0306: Nebenläufige und verteilte Programmierung, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
F. Huch (+ F. Reck)

Inf-Sem-PS: Programmierung und Programmiersprachen, 2 hrs Seminar/Week,
M. Hanus

Further Cooperation, Consulting, and Technology Transfer

During the reported period, the research group collaborated with:

Sergio Antoy (Portland State University, Oregon, USA)

Jan Christiansen (Kiel)

Sebastian Fischer (Kiel)

Daniel Seidel (Universität Bonn)

Diploma, Bachelor's and Master's Theses

Ercan Kücükkaraca, *Requirements Traceability in Model Based Systems Engineering*, 07.03.2012
Lutz Seemann, *Entwicklung einer formalen Beschreibungssprache für Algorithmen im medizinischen Kontext*, 22.03.2012
Lutz Häußler, *Melodiesuche in digitaler Notenschrift - Entwicklung einer in Haskell eingebetteten Sprache zur musterbasierten Suche in Musik als temporales Medium*, 30.03.2012
Christoph Wulf, *Typsichere Einbettung von Datenbankanfragen in Scala*, 30.03.2012
Jan Rasmus Tikovsky, *Integration eines Finite-Domain-Constraint-Solvers in KiCS2*, 02.08.2012
Sandra Dylus, *An API Search Engine for Curry*, 13.09.2012
Stefan Exner, *Ein universeller Anfrageeditor für Ruby on Rails Datenmodelle*, 24.09.2012
Jonas Oberschweiber, *Type Inference for a Declarative Intermediate Language*, 25.09.2012
Arne Kowalewski, *Entwicklung und Vergleich von maschinellen Spielern für Gomoku, Gobang und Pente*, 27.09.2012
Christian Wischmann, *Erweiterung eines Web-basierten Umfragesystems um eine XML-Schnittstelle und um XSL-Transformationen*, 27.09.2012
Jens-Uwe Bahr, *A computer player for billiards based on artificial intelligence techniques*, 28.09.2012
Timo von Holtz, *Integration of HaskellDB in Hascat*, 28.09.2012
Sebastian Schäfer, *A Compiler for Functional Languages on GPUs*, 07.11.2012
Marian Palkus, *An Eclipse-Based Integrated Development Environment for Curry*, 04.12.2012

Heiko Hoffmann, *Eine verteilte generische Analyseumgebung für deklarative Programme,* 04.12.2012
Maike K. Hargens, *Erweiterung des Ruby-on-Rails Testframeworks um randomisierte Ausführungen,* 04.12.2012
Christian Kitzlinger, *Entwicklung einer Layoutbeschreibungssprache für Smartphone Anwendungen,* 15.12.2012

Publications

Published in 2012

Sergio Antoy, Michael Hanus, *Contracts and Specifications for Functional Logic Programming,* Proc. of the 14th International Symposium on Practical Aspects of Declarative Languages, PADL 2012, **Springer LNCS 7149**, 33 - 47 (2012)

Sven Efftinge, Moritz Eysholdt, Jan Köhnlein, Sebastian Zarnekow, Robert von Massow, Wilhelm Hasselbring, Michael Hanus, *Xbase: Implementing Domain-Specific Languages for Java,* Proc. of the 11th International Conference on Generative Programming and Component Engineering, GPCE'12, 112 - 121 (2012)

Sebastian Fischer, Michael Hanus, Yukiyoshi Kameyama, Chung-chie Shan, Naoki Takashima, *Lazy Delimited Nondeterminism,* Proceedings of the 21st International Workshop on Functional and (Constraint) Logic Programming, WFLP 2012, (2012)

Michael Hanus, *Improving Lazy Non-Deterministic Computations by Demand Analysis,* IfI, CAU Kiel, **Research Report 1209**, (2012)

Michael Hanus, *Improving Lazy Non-Deterministic Computations by Demand Analysis,* Technical Communications of the 28th International Conference on Logic Programming (ICLP 2012), **LIPIcs Vol. 17**, 130 - 143 (2012)

Michael Hanus, *Functional Logic Programming: From Theory to Curry,* Ganzinger Festschrift, **Springer LNCS 7797**, 123 - 168 (2012)

Michael Hanus, Sven Koschnicke, *An ER-based Framework for Declarative Web Programming,* Theory and Practice of Logic Programming, (2012)

Michael Hanus, Björn Peemöller, Fabian Reck, *Search Strategies for Functional Logic Programming,* Proceedings of the 5th Working Conference on Programming Languages (ATPS 2012), **Springer LNI 199**, 61 - 74 (2012)

Jan Christiansen, Michael Hanus, Fabian Reck, Daniel Seidel, *A Denotational Semantics for Weak Encapsulation in Curry,* Proceedings of the 26th Workshop on Logic Programming, WLP 2012, 139 - 153 (2012)

Presentations

Michael Hanus, *Contracts and Specifications for Functional Logic Programming,* 14th International Symposium on Practical Aspects of Declarative Languages, Philadelphia, USA, 23.01.2012

Fabian Reck, *Search Strategies for Functional Logic Programming,* 5. Arbeitstagung Programmiersprachen (ATPS 2012), Berlin, 27.02.2013

Björn Peemöller, *Specialising Functional Patterns,* 29. Workshop GI-FG Programmiersprachen und Rechenkonzepte, 02.05.2012

Michael Hanus, *Improving Lazy Non-Deterministic Computations by Demand Analysis,* 29. Workshop GI-FG Programmiersprachen und Rechenkonzepte, 04.05.2012

Fabian Reck, *Negation as failure with Set Functions,* 29. Workshop GI-FG Programmiersprachen und Rechenkonzepte, Bad Honnef, 04.05.2012

Michael Hanus, *Improving Lazy Non-Deterministic Computations by Demand Analysis,* 28th International Conference on Logic Programming, Budapest, Ungarn, 06.09.2012

Fabian Reck, *A Denotational Semantics for Weak Encapsulation in Curry,* 26th Workshop on Logic Programming, Bonn, 25.09.2012

M. Hanus: Programme committee member of the Fifth Working Conference on Programming Languages (ATPS 2012), Berlin, February 2012 (part of the conference Software Engineering 2012)

M. Hanus: Programme committee member of WFLP 2012 (21st International Workshop on Functional and (Constraint) Logic Programming), Nagoya (Japan), May 2012

M. Hanus: Programme committee member of WLP 2012 (26th Workshop on (Constraint) Logic Programming), Bonn, September 2012

M. Hanus: Member of the Editorial Board of the Journal of Functional and Logic Programming

M. Hanus: Member of the steering committee of the Symposia on Logic-based Program Synthesis and Transformation

M. Hanus: Chair of the steering committee of the ACM SIGPLAN Symposia on Principles and Practice of Declarative Programming

M. Hanus: Member of the executive committee and vice-chair of the GLP (Gesellschaft für Logische Programmierung), German-speaking branch of the Association for Logic Programming (ALP)

M. Hanus: Member of the advisory board of the GLP (Gesellschaft für Logische Programmierung), German-speaking branch of the Association for Logic Programming (ALP)

M. Hanus: Member of the selection committee of the DAAD (German Academic Exchange Service) for the project-related support to scientific cooperation with Spain and Portugal

M. Hanus: Member of the advisory board of the ''Berufsakademie an der Wirtschaftsakademie Schleswig-Holstein''

M. Hanus: Member of the executive board of the ''Fakultätentag Informatik der Bundesrepublik Deutschland''

M. Hanus: Chair of the selection committee of the award for the best diploma or master thesis in computer science in Germany 2012

M. Hanus: Member of the selection committee of the b + m-Preis Software- und Systems-Engineering 2012

M. Hanus: Chair of the examinations board of computer science studies, University of Kiel

M. Hanus: Member of the Senate Curriculum Committee, University of Kiel

M. Hanus: Vice-member of the Senate Equal Opportunities Committee, University of Kiel

F. Huch: Organization of the 29th Workshop of the GI-Fachgruppe Programmiersprachen und Rechenkonzepte, Bad Honnef (Germany), May 2012

F. Huch: Member of the Steering CommiteeCommittee of Symposia on Implementation and Application of Functional Languages (IFL)

F. Huch: Chair of the executive committee of the Fachgruppe ''Programmiersprachen und Rechenkonzepte'' of the Gesellschaft für Informatik e.V.

F. Simon: Participation in seminars for students planning professional careers

F. Simon: ''Computer Museum'', representative of the Faculty of Engineering in the board of control

Real Time Systems / Embedded Systems

The research interest of the RTSYS group is the systematic design and analysis of ''computers that are not perceived as such'', which is one definition of *embedded systems*. These systems appear in all contexts of daily life: miniaturized hearing aids, x-ray scanners, cell phones, airbag controllers, anti-lock brakes, and fly-by-wire aircraft. Such systems not only have to provide the correct outputs to the environment, they also have to provide these in time. In other words, these are *real-time systems.* Of particular interest for us are *reactive systems*, which continuously react to (mainly discrete) input events of the environment with corresponding output events.

Results

Current research activities concentrate on the development of reactive embedded real-time systems. Key areas are:

- Pragmatics-aware model-based design of complex reactive systems,
- Automatic layout of graphical models,
- Deterministic concurrency and synchronous languages.

The **pragmatics-aware model-based design** concentrates on the practical aspects of creating, maintaining, and visualizing graphical system models, with the goal of enhanced designer effectiveness and productivity. The Kiel Integrated Environment for Layout Eclipse Rich Client (KIELER) is a prototypical modelling environment that serves as a test bed to explore and validate novel modelling approaches. A key enabler is the ability to automatically compute the layout of graphical models. This frees the user from the tedious task of manually drawing diagrams and allows novel techniques such as customized views during simulation. Novel developments in 2012 include developments in the automatic generation of light-weight transient views of model components developed in the KIELER Light-weight Diagrams project (KLighD), and extended simulation capabilities for SyncCharts. Since 2010 KIELER's layout capabilities are also part of UC Berkeley's Ptolemy system, in 2012 they were further improved.

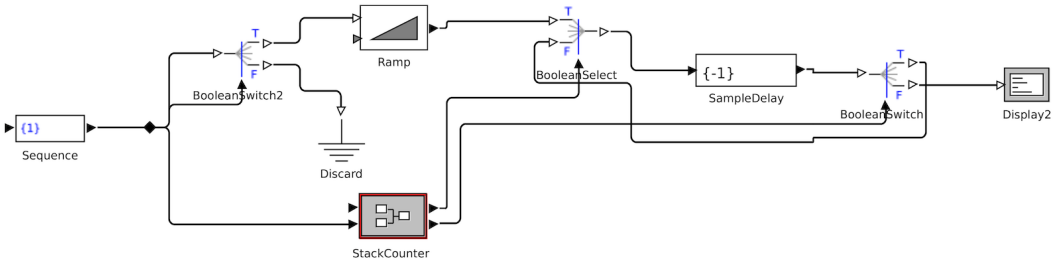
The major result in the area **deterministic concurrency and synchronous languages** is the development of a novel model of computation, termed *Sequential Constructiveness*, which combines deterministic, synchronous concurrency with sequential scheduling information inherent in traditional programming languages such as C or Java. This builds on a large body of theoretical work that has emerged from the synchronous programming community since the 1980s but is also of practical interest for designing safety-critical systems. Sequential Constructiveness has emerged from collaboration with colleagues working in theoretical computer science, notably Prof. Michael Mendler (U Bamberg), and with industrial users, notably National Instruments.

Personnel

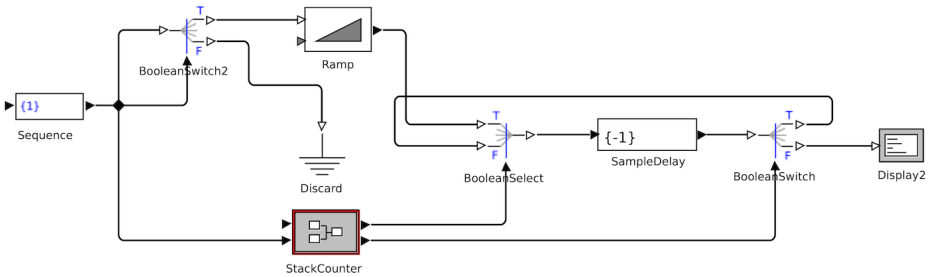
Head of the group: Prof. Dr. R. von Hanxleden; Secretary: G. Walsdorf (50%)
Technical Staff: T. Grebien (50%)

Scientific Staff:

Dipl.-Inf. Ass. iur. I. Fuhrmann PRETSY	15.03.-31.12.2012	DFG
Dipl.-Inf. C. Motika	01.01.-31.12.2012	CAU
Dipl.-Inf. C. Schneider MENGES	01.01.-31.12.2012	EU



(a) Layout using [Spönemann et al. 2009] (3 edge crossings, 30 edge bends)



(b) Layout using improved algorithm (1 edge crossing, 14 edge bends)

Fig. 1: A Ptolemy model representing a stack, illustrating recent improvements in the automatic layout of dataflow diagrams (example by Edward A. Lee, UC Berkeley, adapted from [Klauske et al. 2012]).

Dipl.-Inf. C. D. Schulze	01.01.-31.12.2012	CAU
Dipl.-Inf. M. Spönemann	01.01.-31.12.2012	CAU

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

MS1102: Synchrone Sprachen, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
R. von Hanxleden

Übung zu: Synchrone Sprachen, 2 hrs Exercise/Week,
R. von Hanxleden (+ C. Motika)

MSP1101: Praktikum Echtzeitsysteme/Eingebettete Systeme, 4 hrs Practical/Week,
R. von Hanxleden (+ C. Motika)

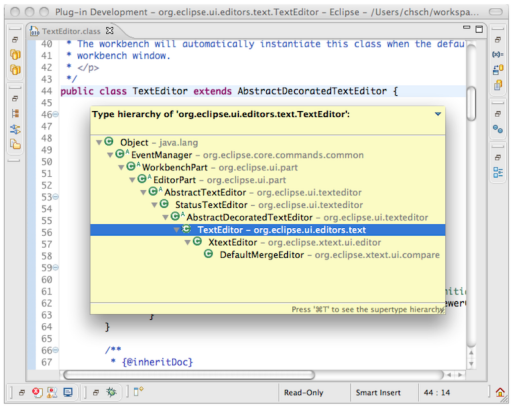
BA6.1: Projektmodul - Echtzeitsysteme/Eingebettete Systeme, 6 hrs Practical/Week,
R. von Hanxleden

Inf-Sem-Echtz: Bachelorseminar Echtzeitsysteme / Eingebettete Systeme (Layoutalgorithmen für Graphen), 2 hrs Seminar/Week,
R. von Hanxleden (+ M. Spönemann)

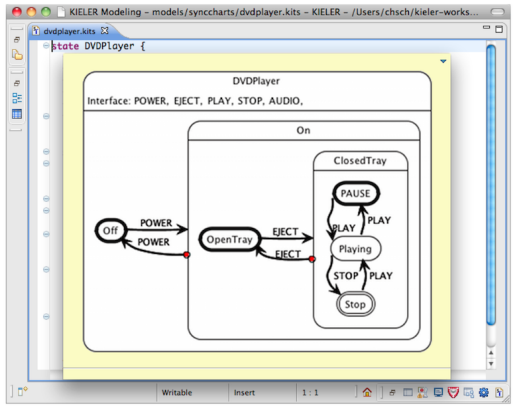
MSS1101: Masterseminar Echtzeitsysteme / Eingebettete Systeme (Layoutalgorithmen für Graphen), 2 hrs Seminar/Week,
R. von Hanxleden (+ M. Spönemann)

MSS1102: Masterabschlussseminar - Echtzeitsysteme / Eingebettete Systeme, 2 hrs Seminar/Week,
R. von Hanxleden

Summer 2012



(a) Inheritance hierarchy of a class.



(b) Proposal: transient Statechart diagram.

Fig. 2: Illustration of transient views. Given some textual model, one can automatically generate abstract, graphical views that highlight certain aspects (adapted from [Schneider et al. 2012]).

Inf-OAR (G2.2): Systemorientierte Informatik II - Organisation und Architektur von Rechnern, 3 (+2) hrs Lecture (+ Exercises)/Week,
R. von Hanxleden

Übung zu: Systemorientierte Informatik II - Organisation und Architekturen von Rechnern, 2 hrs Exercise/Week,
R. von Hanxleden (+ C. D. Schulze, M. Spönemann)

MS1101: Modellierung nebenläufiger Systeme, 4 (+2) hrs Lecture (+ Exercises)/Week,
R. von Hanxleden

Übung zu: MS1101: Modellierung nebenläufiger Systeme, 2 hrs Exercise/Week,
R. von Hanxleden (+ M. Spönemann)

MSP1101: Praktikum Echtzeitsysteme/Eingebettete Systeme (Modellbahn), 4 hrs Practical/Week,
R. von Hanxleden (+ C. Motika)

BA6.1: Projektmodul - Echtzeitsysteme/Eingebettete Systeme (Modellbahn), 6 hrs Practical/Week,
R. von Hanxleden (+ C. Motika)

Inf-Sem-Echtz: Bachelorseminar Echtzeitsysteme / Eingebettete Systeme (Synchrone Sprachen), 2 hrs Seminar/Week,
R. von Hanxleden

MSS1101: Seminar - Echtzeitsysteme / Eingebettete Systeme (Synchrone Sprachen), 2 hrs Seminar/Week,
R. von Hanxleden (+ C. Motika)

MSS1102: Masterabschlussseminar - Echtzeitsysteme / Eingebettete Systeme, 2 hrs Seminar/Week,
R. von Hanxleden

Winter 2012/2013

Inf-AP-ES: Abschlussprojekt - Echtzeitsysteme/Eingebettete Systeme (Eclipse Modeling), 6 hrs Practical/Week,
W. Hasselbring (+ C. D. Schulze, M. Spönemann)

MSP1101: Masterprojekt - Echtzeitsysteme/Eingebettete Systeme (Eclipse Modeling), 4 hrs Practical/Week,
W. Hasselbring (+ C. D. Schulze, M. Spönemann)

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Fig. 3: Participants of the seminar ''Layoutalgorithmen für Graphen'', WS 2011/12 (06.02.)

Third-Party Funds

Zukunftsprogramm Wirtschaft (ZPW), *Modellbasierte Entwurfsmethoden für eine neue Generation elektronischer Stellwerke (MENGES)*, 01.08.2009-31.07.2012 (217.560 EUR)

DAAD Programm des Projektbezogenen Personenaustauschs (PPP) USA, *Multi-View Modeling and Pragmatics*, 01.01.-31.12.2012 (9.634 EUR)

DFG Sachbeihilfe, *Precision-Timed Synchronous Reactive Processing (PRETSY)*, 01.11.2011-30.10.2014 (251.925 EUR)

Further Cooperation, Consulting, and Technology Transfer

Cooperation with Edward A. Lee, University of California, Berkeley, on the automatic layout of Ptolemy II diagrams and simulation of SyncCharts (funded by DAAD PPP).

Cooperation with the Software Engineering group (Prof. Hasselbring), b+m Informatik AG and Funkwerk Information Technologies GmbH on the model-based design of railway signalling applications (project MENGES).

Cooperation with ETAS/Bosch, on visual model exploration.

Cooperation with Michael Mendler, Bamberg University, on worst case reaction time analysis.

Cooperation with Petra Mutzel, University of Dortmund, on layout algorithms with port constraints.

Cooperation with Partha Roop and Zoran Salcic, University of Auckland, New Zealand, on reactive processors and timing analysis.

Cooperation with the Daimler Center for Automotive IT Innovations (Berlin), on the automatic layout of Simulink diagrams.

Cooperation with Irkutsk State University, on model-based design and reactive processors (funded by DAAD,

Ostpartnerschaften-Programm)

Diploma, Bachelor's and Master's Theses

T. Mahnke-Nissen, *(Diploma Thesis) souq - Eine verteilte Anwendung zur einfachen Erfassung und Propagation von Forschungsdaten,* 30.01.2012

I. Fuhrmann, *(Diploma Thesis) Layout of Compound Graphs,* 15.02.2012

A. Bosy, *(Bachelor Thesis) Synthese von graphischen Darstellungen aus einer textuellen Verhaltensbeschreibung,* 31.03.2012

S. Gundlach, *(Bachelor Thesis) Synthese von Datenflussdiagrammen aus annotierten C-Programmen,* 31.03.2012

T. Grebien, *(Diploma Thesis) Managing Academic Eclipse-Based Projects,* 17.08.2012

J. Carstens, *(Master Thesis) Node and Label Placement in a Layered Layout Algorithm,* 27.09.2012

P. Klose, *(Master Thesis) A Generic Framework for Topology-Shape-Metrics-Based Layout,* 12.10.2012

B. Duderstadt, *(Diploma Thesis) SCCharts: A Sequentially Constructive Statecharts Dialect,* 26.11.2012

Publications

Published in 2012

X. Li, R. von Hanxleden, *Multi-Threaded Reactive Programming - The Kiel Esterel Processor,* IEEE Transactions on Computers, **61(3)**, 337 - 349 (2012)

R. von Hanxleden, E. A. Lee, C. Motika, H. Fuhrmann, *Multi-View Modelling and Pragmatics in 2020 - Position Paper on Designing Complex Cyber-Physical Systems,* In Pre-Proceedings of the 17th International Monterey Workshop on Development, Operation and Management of Large-Scale Complex IT Systems, Oxford, UK, (2012)

C. Schneider, M. Spönemann, R. von Hanxleden, *Transient View Generation in Eclipse,* Technical Report, Christian-Albrechts-Universität zu Kiel, Department of Computer Science, **1206**, (2012)

S. Banerjee, *Timing Analysis for the Precision Timed ARM Processor,* Technical Report, Christian-Albrechts-Universität zu Kiel, Department of Computer Science, **1212**, (2012)

C. Schneider, M. Spönemann, R. von Hanxleden, *Transient View Generation in Eclipse,* Proceedings of the First Workshop on Academics Modeling with Eclipse, Kgs. Lyngby, Denmark, (2012)

L. K. Klauske, C. D. Schulze, M. Spönemann, R. von Hanxleden, *Improved Layout for Data Flow Diagrams with Port Constraints,* Proceedings of the 7th International Conference on Diagrammatic Representation and Inference (DIAGRAMS'12), Cambridge, UK, **volume 7352 of LNAI, Springer**, 65 - 79 (2012)

C. Motika, R. von Hanxleden, M. Heinold, *Synchronous Java: Light-Weight, Deterministic Concurrency and Preemption in Java,* Technical Report, Christian-Albrechts-Universität zu Kiel, Department of Computer Science, **1213**, (2012)

C. Motika, H. Fuhrmann, R. von Hanxleden, E. A. Lee, *Executing Domain-Specific Models in Eclipse,* Technical Report, Christian-Albrechts-Universität zu Kiel, Department of Computer Science, **1214**, (2012)

R. von Hanxleden, N. Holsti, B. Lisper, J. Gustafsson, N. M. Islam, E. Ploedereder, W. Fellger, S. Gepperth, F. Krause, R. Wilhelm, A. Bonenfant, H. Casse, M. de Michiel, C. Rochange, S. Bünte, L. Kovacs, W. Puffitsch, M. Zolda, J. Zwirchmayr, D. Kästner, S. Wegener, R. Kirner, M. C. Olesen, A. Prantl, M. Schoeberl, *The WCET Tool Challenge 2011,* Technical Report, Christian-Albrechts-Universität zu Kiel, Department of Computer Science, **1215**, (2012)

R. von Hanxleden, E. A. Lee, C. Motika, H. Fuhrmann, *Multi-View Modelling and Pragmatics in 2020 - Position Paper on Designing Complex Cyber-Physical Systems,* Proceedings of the 17th International Monterey Workshop on Development, Operation and Management of Large-Scale Complex IT Systems, Oxford, UK, **volume 7539 of LNCS**, (2012)

W. Goerigk, R. von Hanxleden, G. Hasselbring, G. Hennings, R. Jung, H. Neustock, H. Schaefer, C. Schneider, E. Schultz, T. Stahl, S. Weik, S. Zeug, *Entwurf einer domänenspezifischen Sprache für elektronische Stellwerke,* Software Engineering 2012: Fachtagung des GI-Fachbereichs Softwaretechnik, Berlin, Lecture Notes in Informatics,

Gesellschaft für Informatik, (2012)

Presentations

R. von Hanxleden, E. A. Lee, C. Motika, H. Fuhrmann, *Multi-View Modelling and Pragmatics in 2020 - Position Paper on Designing Complex Cyber-Physical Systems*, 17th International Monterey Workshop on Development, Operation and Management of Large-Scale Complex IT Systems, Oxford, UK, 19.-21.03.2012

C. Schneider, *Modellieren statt Malen - Ein pragmatischer Ansatz*, LACTOSE-Workshop Fraunhofer FIRST, Berlin, Germany, 19.04.2012

R. von Hanxleden, *Tipps zur Antragstellung aus der Sicht eines Antragsgutachters*, Informationsveranstaltung EU-Forschungsrahmenprogramm im Bereich Informations- und Kommunikationstechnologien - IKT, Kiel, Germany, 31.05.2012

R. von Hanxleden, *The Sequentially Constructive Model of Computation*, Presentation at Laboratoire d'Informatique de l'École normale supérieure (ENS), Paris, France, 13.06.2012

R. von Hanxleden, M. Spönemann, C. D. Schulze, *Pragmatics-Aware Modelling with the Kiel Integrated Environment for Layout Eclipse Rich Client (KIELER)*, ETAS Group Presentation, Stuttgart, Germany, 22.06.2012

C. Schneider, M. Spönemann, R. von Hanxleden, *Transient View Generation in Eclipse*, First Workshop on Academics Modeling with Eclipse, Kgs. Lyngby, Denmark, 02.07.2012

L. K. Klauske, C. D. Schulze, M. Spönemann, R. von Hanxleden, *Improved Layout for Data Flow Diagrams with Port Constraints*, 7th International Conference on Diagrammatic Representation and Inference (DIAGRAMS'12), Cambridge, UK, 02.-06.07.2012

C. Motika, C. D. Schulze, *Plans for Improving Automatic Layout in Ptolemy*, Ptolemy Lunch, EECS Department, UC Berkeley, Berkeley, CA, USA, 05.09.2012

I. Fuhrmann, C. Motika, C. D. Schulze, *A Short Introduction to New Layout Features*, Ptolemy Lunch, EECS Department, UC Berkeley, Berkeley, CA, USA, 12.09.2012

I. Fuhrmann, C. Motika, C. D. Schulze, *Ptolemy Modal Models enhanced by SyncCharts Immediate Transitions*, Ptolemy Lunch, EECS Department, UC Berkeley, Berkeley, CA, USA, 19.09.2012

R. von Hanxleden, *Pragmatics-Aware Modelling*, Seminar at National ICT Australia (NICTA), Sydney, Australia, 10.10.2012

R. von Hanxleden, *Synchronous C: A Proposal for Light-Weight, Deterministic Concurrency*, Pretzel Weekly Forum at the Department of Electrical and Computer Engineering, University of Auckland, Auckland, New Zealand, 08.11.2012

R. von Hanxleden, *Pragmatics-Aware Modelling*, Seminar at the Department of Computer Science, University of Auckland, Auckland, New Zealand, 28.11.2012

Further Activities and Events

R. von Hanxleden:

Chair of the Department of Computer Science (until 30.06.2012).

Member of the *ArtistDesign European Network of Excellence on Embedded System Design*.

Programme Committee member for the *International Conference on Embedded Software (EMSOFT'12)*, the *Embedded System Design (ESD) Track at the International Symposium on Electronic System Design (ISED) 2012*, the *17th International Monterey Workshop on Development, Operation and Management of Large-Scale Complex IT Systems* and the *Methodische Entwicklung von Modellierungswerkzeugen (MEMWe2011) Workshop* at the *GI-Jahrestagung INFORMATIK 2012*.

Reviewer for the *ACM Transactions on Embedded Computing Systems (ACM TECS)* and the *IEEE Transactions on Software Engineering (IEEE TSE)*.

Reviewer of the EU-FP7 Project DESTECS (*Design Support and Tooling for Embedded Control Software*).

Research visit to the University of Auckland, to NICTA, Sydney, and to Swinburne and Monash Universities, Melbourne (10.2012-03.2013).

I. Fuhrmann, C. Motika, C. D. Schulze:

Research stay at UC Berkeley, visiting Prof. E. Lee and his group (03.-22.09.2012).

C. Motika, C. Schneider:

Demonstration of the Model-Railway, Girls' Day 2012 (26.04.2012) and the *Schnupperstudium* (16./17.10.2012)

C. Motika, R. von Hanxleden:

Reviewers for *" Enterprise Modelling and Information Systems Architectures (EMISA)"* (Journal).

J. Carstens, I. Fuhrmann, T. Grebien, , R. von Hanxleden, P. Klose, C. Motika, C. Schneider, C. D. Schulze, M. Spönemann:

Reviewers for the *International Conference on Embedded Software* (EMSOFT'12).

T. Grebien, R. von Hanxleden, C. Krüger, C. Motika, C. Schneider, C. D. Schulze, M. Spönemann:

Reviewers for *GI SICHERHEIT 2012 Sicherheit - Schutz und Zuverlässigkeit*.

I. Fuhrmann, R. von Hanxleden, C. Motika, C. Schneider, C. D. Schulze, M. Spönemann:

Reviewers for *International Symposium on Electronic System Design (ISED) 2012*.

B. Duderstadt, T. Grebien, R. von Hanxleden, C. Motika, C. Schneider, C. D. Schulze, M. Spönemann:

Reviewers for *ACM SIGPLAN/SIGBED Conference on Languages, Compilers, Tools and Theory for Embedded Systems (LCTES) 2012*.

R. von Hanxleden, C. Motika, C. D. Schulze, M. Spönemann:

Reviewers for *Proceedings of the 17th International Monterey Workshop on Development, Operation and Management of Large-Scale Complex IT Systems* (LNCS volume 7539).

Further Activities

PRETSY-Workshop (23.-25.05.2012)

Visit from Alexei Zhukov, Irkutsk State University (02.-28.04.2012)

Visit from Subarno Banerjee, IAESTE Internship from National Institute of Technology, Durgapur, India (19.05.-21.09.2012)

Visit from Indrajit Malatesh Nadgir, ETAS India (23.04.-04.05.2012)

Visit from Matthew Viele, National Instruments (14.05.2012)

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Scientific Computing

The Scientific Computing group develops fast solvers for mathematical problems arising, for example, in physics and engineering. The currently most important applications are numerical simulations of natural phenomena. The laws underlying these phenomena are typically described by differential or integral equations that frequently cannot be solved analytically and therefore have to be handled by numerical methods. This task includes several aspects:

1. The mathematical problem has to be translated into a form that can be handled by a computer, e.g. by using a *discretization technique* to replace infinitesimal quantities by finite ones.

2. If the problem involves large amounts of data, e.g. measurements resulting from experiments, *compression methods* have to be employed to reduce the storage requirements and allow computers to process the data more efficiently. Currently the research group focuses on $\mathcal{H}^2$-matrix algorithms that can save more than 98% of storage in some applications.

3. An efficient *solution algorithm* has to be developed in order to keep the computing time as low as possible. Of particular interest are algorithms of optimal order, i.e. algorithms that can handle n elements of data in n units of time. Both multigrid methods and $\mathcal{H}^2$-matrix preconditioners are currently being investigated by the research group.

4. In order to keep computing times as low as possible, the algorithms have to be implemented in a way that takes advantage of the properties of the underlying hardware, e.g. by using *parallel algorithms* or *vectorization*.

Results

In 2012, a new book on ''Numerical methods for Eigenvalue Problems'' by Steffen Börm and Christian Mehl (TU Berlin) was published. It is based in large parts on lectures given at the CAU Kiel and will be used in future lectures on the topic of eigenvalue methods.

In the Winter semester, the new lecture series „Einführung in das Hochleistungsrechnen" (introduction to high-performance computing) by Steffen Börm, Dirk Nowotka and Philipp Sieweck attracted a large number of students. Of particular interest are the programming exercises that gave students the chance to experience the advantages (and sometimes also the disadvantages) of techniques like vectorization, parallelization and heterogeneous computing (e.g. with GPGPUs) on their own computers.

The research activities of the Scientific Computing group currently focus on three research projects:

Efficient approximation of integral operators. Funded by the DFG grant BO 3289/2-1, we investigate a new method for treating integral equations resulting from d-dimensional elliptic partial differential equations. Discretizing these equations leads to matrices that are too large to be stored directly in a computer, therefore we have to use compression methods in order to reduce the storage requirements. In this project, we have developed a compression scheme that comes close to the efficiency of multipole and cross approximation methods. Compared to multipole methods, it offers the advantage of being a ''grey box'' algorithm that can be directly applied to a range of problems without having to be adapted by hand for each of them. Compared to standard cross approximation schemes, the new method offers the advantage of being provably reliable and robust.

The underlying idea is to use Green's formula: the fundamental solution of an elliptic partial differential operator in d-dimensional space can be expressed by an integral on a $(d-1)$-dimensional manifold, therefore we can use $(d-1)$-dimensional quadrature to construct an approximation. The first phase of the project demonstrated that the new method converges exponentially. In the second phase, we combined the approach with a robust variant of the cross approximation technique and were able to reduce both the storage requirements and the runtime significantly. A first paper has been accepted for publication and several more are in preparation.

Preconditioners for integral and elliptic partial differential equations. The solution operators of elliptic partial differential equations share many important properties with integral operators, therefore it should be possible to treat them by similar compression techniques. Unlike integral operators, the solution operators are not given explicitly, therefore we cannot apply our compression techniques directly. In this project, we construct approximations of the solution operators by combining on-the-fly compression with standard factorization methods in order to reduce the complexity from $\sim n^3$ operations to only $\sim n \log n$, thus allowing us to handle very large matrices efficiently. The entire procedure relies on an efficient algorithm that can approximate the product of two $n \times n$ matrices in only $\sim n \log n$ operations.

Previous multiplication algorithms were not suited for recursive operation and therefore could not preserve the high efficiency for the entire computation of the solution. We have developed a new approach that is based on local low-rank updates to submatrices and is ideally suited for recursive algorithms. Experiments indicate that the new method can indeed approximate the entire solution operator using only $\sim n \log n$ operations and even only $\sim n$ units of storage. Using the DFG grant BO 3289-4/1, we will continue this research and hope to both improve the efficiency even further and apply the new algorithms to real-world applications.

New approach to matrix equations. Matrix equations appear in many fields of applied mathematics, e.g. Sylvester's equation $AX + XB = C$ plays an important role in control theory, while computing the correlations of solutions of stochastic partial differential equations leads to equations of the form $AXA = B$. If the unknown matrix X if of size $n \times n$, even just setting all of its entries to given values would require $\sim n^2$ operations and take far too long for large values of n.

We are developing a new approach to solve matrix equations more efficiently: the matrix equation is translated into a variational formulation that can then be approximated by Galerkin's method. By using suitable trial and test spaces inspired by $\mathcal{H}^2$-matrices, we can approximate the original equation by an equation involving only $\sim n$ unknown variables. We have developed an efficient algorithm for constructing the reduced system of equations and are currently investigating several solution strategies, e.g. Krylov methods or multigrid iterations. In order to facilitate the multigrid approach, we are considering more general trial and test spaces that would result in slightly more complex algorithms but could lead to significantly reduced computing times.

Personnel

Head of the group: Prof. Dr. S. Börm; Secretary: D. Scheel (50%)

Scientific Staff:

Dipl.-Math. N. Albrecht	01.01.-31.12.2012	(50%)	CAU
Dipl.-Math. D. Boysen	01.01.-31.12.2012	(50%)	CAU
Dipl.-Math. J. Burmeister	01.01.-31.12.2012		CAU
Dipl.-Math. J. Gördes	01.01.-31.12.2012		DFG
Separation der Fundamentallösungen elliptischer Differentialgleichungen mit Hilfe von Quadraturverfahren			
Dipl.-Math. K. Reimer	01.01.-31.12.2012		CAU

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

Einführung in die numerische Mathematik, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
S. Börm (+ J. Burmeister, N. Albrecht, K. Reimer)

Wissenschaftliches Rechnen, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
S. Börm (+ D. Boysen)

Elementare numerische Methoden und ihre Implementierung 1, 1 (+ 1) hrs Practical (+ Exercises)/Week,
S. Börm (+ J. Burmeister)

Summer 2012

Numerische Verfahren für Differentialgleichungen, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
S. Börm (+ J. Burmeister, N. Albrecht)

Numerik nicht-lokaler Operatoren, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
S. Börm (+ K. Reimer)

Numerische Mathematik für Ingenieure, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
S. Börm (+ D. Boysen)

Elementare numerische Methoden und ihre Implementierung 2, 1 (+ 1) hrs Practical (+ Exercises)/Week,
S. Börm (+ J. Burmeister)

Winter 2012/2013

Einführung in die numerische Mathematik, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
S. Börm (+ J. Burmeister, N. Albrecht, D. Boysen)

Iterative Verfahren für große Gleichungssysteme, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
S. Börm (+ K. Reimer)

Hochleistungsrechnen, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
S. Börm (+ D. Nowotka)

Elementare numerische Methoden und ihre Implementierung 1, 1 (+ 1) hrs Practical (+ Exercises)/Week,
S. Börm (+ J. Burmeister)

Third-Party Funds

Deutsche Forschungsgesellschaft, *Separation der Fundamentallösungen elliptischer Differentialgleichungen mit Hilfe von Quadraturverfahren,* 01.02.2010-31.03.2013 (170.500 EUR)

Diploma, Bachelor's and Master's Theses

J. Gnutzmann, *Das QZ-Verfahren,* 10.01.2012
I. Eichstädt, *Krylov-Unterraum-Verfahren für nicht-symmetrische Matrizen,* 23.02.2012
H. F. Pohl, *Schnelle Multipol-Verfahren zur Simulation von Mehrkörpersystemen,* 08.03.2012
L. Schramm, *Eine Mehrgitter-Methode für die Maxwell-Gleichungen,* 04.04.2012
A. Johanson, *Approximation von Integraloperatoren durch überlappende Paneel-Clusterung,* 25.06.2012
E. Frick, *Schwarz-Verfahren,* 16.10.2012

Publications

Published in 2012

S. Börm, C. Mehl, *Numerical Methods for Eigenvalue Problems,* De Gruyter Textbook, (2012)
S. Börm, S. LeBorne, *$\mathcal{H}$-LU factorization in preconditioners for augmented Lagrangian and grad-div stabilized saddle point problems,* Int. J. Numer. Methods Fluids, **68**, 83 - 98 (2012)

S. Börm, *$\mathcal{H}^2$-Matrix Compression*, New Developments in the Visualization and Processing of Tensor Fields, 339 - 362 (2012)

Further Activities and Events

Prof. Dr. Steffen Börm continues to serve as Associate Editor of the SIAM Journal on Scientific Computing (SISC).

The DFG granted funding (''Sachbeihilfe'') for project BO 3289/4-1 on the subject ''$\mathcal{H}^2$-Matrix-Vorkonditionierer für Integral- und elliptische partielle Differentialgleichungen''.

A winter school on hierarchical matrix techniques was organized by Steffen Börm, Lars Grasedyck (RWTH Aachen) and Wolfgang Hackbusch (MPI MIS Leipzig) at the Max-Planck-Institute for Mathematics in the Sciences, Leipzig.

Software Engineering

Research of the Software Engineering Group focuses on Software Engineering for parallel and distributed systems. Traditionally, software engineering addresses the process of constructing and evolving software systems. The operation of systems that are expected continuously to provide services with required quality properties is another great challenge. One goal of the Software Engineering Group is to investigate innovative techniques and methods for engineering, evolving and operating continuously running software systems.

Of particular interest are our **KoSSE** network with colleagues of the Computer Science Institutes in Kiel and Lübeck (https://www.kosse-sh.de), and the KoSSE office that we are establishing together with the Cluster Management DiWiSH (http://www.diwish.de/). In 2012, the KoSSE projects DynaMod, MENGES and Xbase were completed and the new projects iObserve and ESN Software Lab started. Prof. Hasselbring received the **ISH -Transferprämie 2012**, for the second time.

We contribute to several **research data management** activities, for instance in the Excellence Cluster Future Ocean, in the project MaWiFo on research data management in economics (with the ZBW, Leibniz-Informationszentrum Wirtschaft), and the project PubFlow on publication workflows for research data.

Passing the review process of the **SPEC Research Group**'s repository of tools for quantitative system evaluation and analysis, was a great success for our monitoring framework **Kieker**, for which we designed a new website at http://www.kieker-monitoring.net/.

Results

Kieker

In addition to studying the construction and evolution of software services, the software engineering discipline needs to address the operation of continuously running software services. Needed for robust operation are means for effective monitoring of software runtime behaviour. In contrast to profiling for development activities, monitoring of operational services should only impose a small performance overhead. Furthermore, instrumentation should be non-intrusive to the business logic, as far as possible.

The Kieker framework supports monitoring of software runtime behaviour, e.g. performance or (distributed) trace data. The flexible architecture allows the replacement or addition of framework components, including monitoring probes, analysis components, and record types shared by logging and analysis. Kieker creates Sequence Diagrams, Dynamic Call Trees, Markov chains, and Component Dependency Graphs from monitoring data. As a non-intrusive instrumentation technique, Kieker currently employs, but is not restricted to, aspect-oriented programming.

Extensive lab studies quantified the low overhead caused by the framework components. Qualitative evaluations provided by industrial case studies demonstrate the practicality of the approach.

The KoSSE-Symposium ''Application Performance Management'' (Kieker Days 2012), which took place on November 29/30, 2012 in Kiel, was a great success. 50 participants from academia and industry listened to 16 talks presented by researchers and practitioners.

Kieker is available as open-source software. For more information on Kieker, refer to http://www.kieker-monitoring.net

Kieker is a recommended tool of the SPEC Research Group: http://research.spec.org/projects/tools.html

DynaMod

In the DynaMod project, we are investigating techniques for model-driven modernization of software systems. Innovative aspects are the combination of static and dynamic analysis, i.e. hybrid analysis, for reverse engineering architectural and usage models, as well as its semantic augmentation by information supporting subsequent generative forward engineering

steps, including tests. The conceptual modernization is performed on the architectural level by defining transformations among the extracted models of the outdated system and of the target architecture.

DynaMod was completed in 2012 with a two-year funding from the German Federal Ministry of Education and Research (BMBF), and is associated with KoSSE. The project consortium consists of the b+m Informatik AG (development partner and consortium leader), the University of Kiel (scientific partner), as well as two associated companies, Dataport and HSH Nordbank AG. One focus of the Software Engineering Group is to employ and extend Kieker for the dynamic analysis of legacy systems, e.g. based on Visual Basic 6, COBOL, and .NET platforms.

For more information on DynaMod, refer to http://kosse-sh.de/dynamod/

MENGES

The objective of the project MENGES is the development of a model-driven software tool chain for a new type of electronic railway control centre. The project started in January 2010 and ended in December 2012.

The research focused on engineering the application domain of electronic railway control centres, the technical domain of programmable logic controllers and the development of domain specific languages (DSL) for describing topological and behavioural structures of this application domain. The application domain has, especially in the topological aspect, a wide range of variations due to topographical and technical specifics, as well as existing components. Therefore, the design of the DSLs and its meta-model includes variation points for future extensions. The tool chain is based on Eclipse EMF for meta-modelling, Xtext for implementing textual DSLs, Kieler for layout of graphical DSLs, and Kieker for Profiling and Monitoring.

For more information on MENGES, refer to http://menges.informatik.uni-kiel.de/

Xbase

In the project Xbase a new base language for the language development framework Xtext is being developed. The project started in May 2010 and was completed in April 2012. The project is funded by the BMBF KMU innovative initiative and is associated with KoSSE. This project is realized in cooperation with itemis AG. Xbase, is an open source project, and is released with Xtext. In the first eight months of the project, we focused on the Xbase language syntax and its type system. These specifications are essential for the development of a runtime environment, i.e. an interpreter. For proper documentation, the language Xdoc was developed. Featuring concepts that are recurring in many documentation tasks, such as embedding code blocks in various languages or linking to Java classes, Xdoc is able to generate Eclipse help plugins as well as PDF files. The Xbase language specification is written in Xdoc and the previous Xtext documentation has been migrated to Xdoc.

For more information on Xbase, refer to http://kosse-sh.de/projekte/xbase/

MaWiFo

The project MaWiFo (Management wirtschaftswissenschaftlicher Forschungsdaten - Management of economic research data) is a research cooperation between the ZBW (Leibniz Information Centre for Economics) and the Department of Computer Science at the University of Kiel. The objective is to examine the requirements of suitable information infrastructures for the management of economic research data, with focus on economics research groups in Kiel. Due to the special nature of economics research data and of economists' needs, an active exchange between economists, computer scientists, and librarians is essential.

MaWifo itself is realized by three computer scientists of the ZBW; one researcher is based at the software engineering group. To gain a deeper insight into the daily work of economists with research data, semi-structured interviews are currently conducted. The researcher affiliated to the software engineering group additionally investigates the application of workflow technologies in order to automate parts of the computational processing life cycle of research data in the

domain of fisheries by so-called scientific workflows. Therefore, standard business workflow technologies and model-driven software development technologies are employed.

For more information on MaWiFo, please refer to http://mawifo.zbw.eu/.

PubFlow

The goal of PubFlow is to investigate workflow support for research data publication and build a software prototype to assist researchers in their daily work with research data. PubFlow is not about long-term preservation but is about the workflows from institutional archives towards publication of research and archival data in world data centres. The goal of the project is to create a workflow environment for the work with research data, based on established business workflow systems, to increase the degree of automation in the publication process. The assumption is that the quality of the published data will increase if the data is enriched with automatically collected provenance data.

To meet the requirements that scientific workflows pose on the business workflow systems that are employed in PubFlow, a software environment will be developed in which the business workflow engine is embedded. This software environment provides tools for the automatic collection of provenance information as well as enhanced business workflow monitoring features and interfaces for the interaction with the users and the data archives. The software architecture is a service-oriented architecture, such that individual software components can be exchanged independently. In PubFlow, Kieker is extended for workflow monitoring.

To facilitate the work with scientific workflows, the PubFlow system will provide various abstraction mechanisms. Scientists and data managers will be able to define their workflows in a BPMN 2.0 compliant, customized, domain-specific workflow language, which then will be translated to BPEL for execution. During their daily work, scientists interact through a simple, easy to use task-management interface with the PubFlow system. There should be no need for them to deal with complex workflows.

In the first phase of the project the ideas and tools created will be tested in the field of Marine Sciences. The PubFlow project started in August 2011 and will last until July 2014.

For more information on PubFlow, refer to http://www.pubflow.uni-kiel.de/

iObserve

The increased adoption of service-oriented technologies and cloud computing creates new challenges for the adaptation and evolution of long-living software systems. Software services and cloud platforms are owned and maintained by independent parties. Software engineers and system operators of long-living software systems only have limited visibility and control over those third-party elements. Traditional monitoring provides software engineers and system operators with execution observation data which are used as a basis to detect anomalies. If the services and the cloud platform are not owned and controlled by the engineers of the software systems, monitoring the execution of the software system is not straightforward.

The aim of the iObserve project is to develop and validate advanced techniques which empower the system engineers to observe and detect anomalies of the execution of software systems they do not fully own and control. It will extend and integrate previous work on adaptive monitoring, online testing, and benchmarking and will use models@runtime as a means to adjust the observation and anomaly detection techniques during system operation. To demonstrate the feasibility and potential benefits gained, and for providing feedback to guide the research, the results will be continuously evaluated using an established research benchmark (CoCoME) as well as an industry-driven open-source application (Eclipse Skalli) that runs on a cloud platform.

The iObserve project started in November 2012 and will last until October 2015.

For more information on iObserve, refer to http://www.dfg-spp1593.de/index.php?id=44

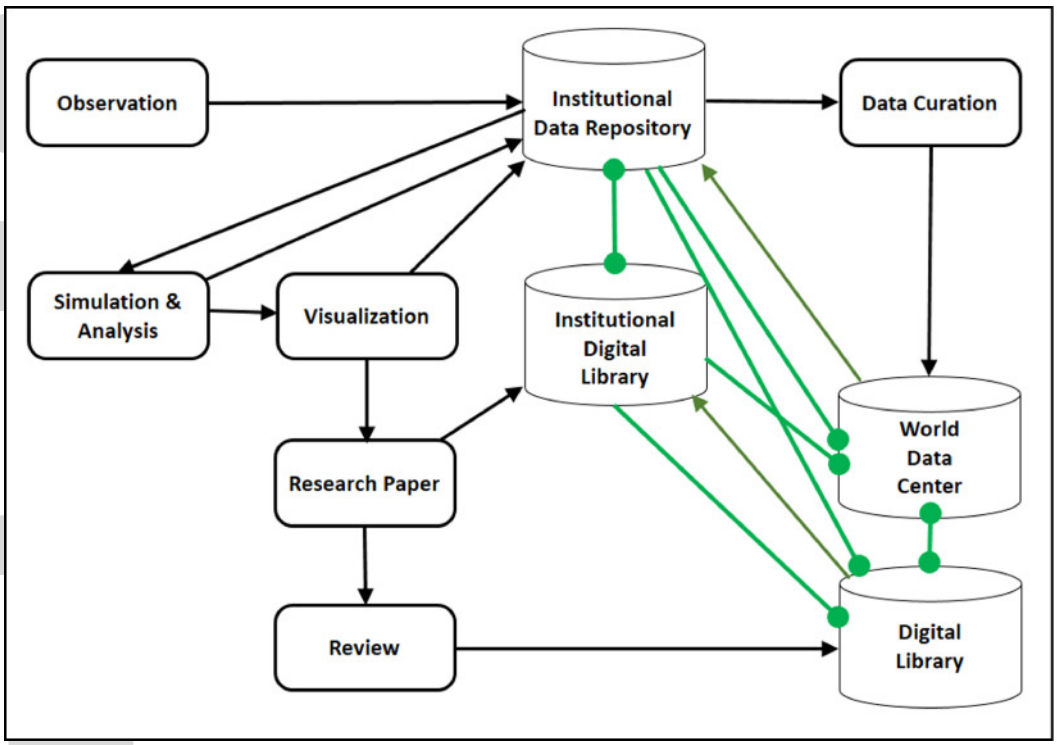

Fig. 2: Data and paper flows in PubFlow

ESN Software Lab

ESN Software Lab is a collaborative project between ESN EnergieSystemeNord GmbH and the software engineering group to advance technology transfer in software engineering. In the first phase, we are inventing a new product line architecture for web-based software cockpits. The ESN Software Lab started in November 2012.

Personnel

Head of the group: Prof. Dr. W. Hasselbring; Secretary: H. Capell (50%), C. Krüger (50%)
Technical Staff: B.Sc. A. Lange, B.Sc. M. Westphal (50%)

Staff:

Prof. Dr. W.-P. de Roever	01.01.-31.12.2012	retired

Scientific Staff:

Dipl.-Inf. P. Brauer PubFlow	01.01.-31.12.2012	DFG
Dipl.-Wirt.-Inf. J. Ehlers Kieker	01.01.-31.03.2012	CAU
M.Sc. F. Fittkau ESN Software Lab	01.04.-31.12.2012	CAU, ESN
M.Sc. S. Frey CloudMIG, Kieker	01.01.-31.12.2012	CAU

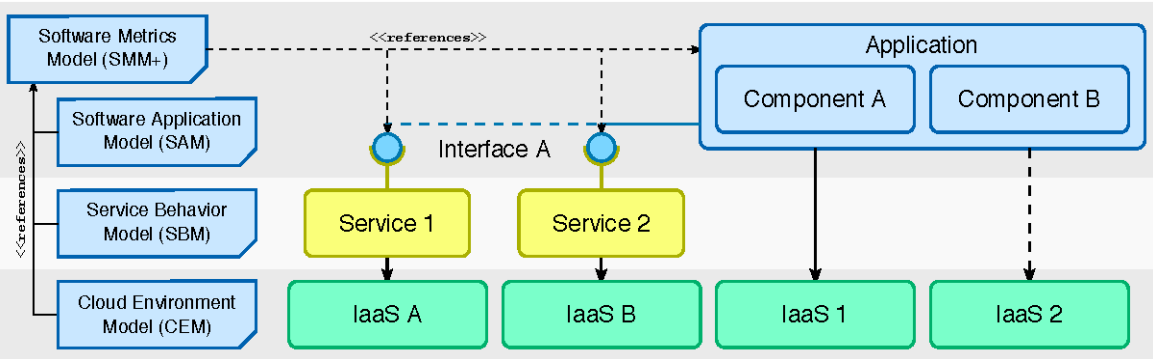

Fig. 3: Integrated Observation and Modelling Techniques to Support Adaptation and Evolution of Software Systems in iObserve

Dipl.-Inform. S. Gudenkauf ProCol, SCOPE	01.01.-30.04.2012	OFFIS
Arne Johanson HOSST	01.11.-31.12.2012	GEOMAR
Dipl.-Inform. R. Jung MENGES, Kieker, iObserve	01.01.-31.12.2012	ZPW / EFRE, DFG
Dipl.-Inform. G. Scherp MaWiFo	01.01.-31.12.2012	ZBW
Dipl.-Inform. A. van Hoorn DynaMod, Kieker	01.01.-31.12.2012	BMBF
Dipl.-Inform. R. von Massow Xbase	01.01.-30.04.2012	BMBF
Dipl.-Inf. J. Waller Kieker	01.01.-31.12.2012	CAU
M.Sc. C. Wulf ESN Software Lab	01.04.-31.12.2012	CAU, ESN

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

Softwarearchitektur, 2 (+ 1) hrs Seminar (+ Exercises)/Week,
W. Hasselbring (+ S. Frey)

Softwareprojekt, 3 hrs Exercise/Week,
W. Hasselbring (+ J. Ehlers)

Softwaretechnik, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
W. Hasselbring (+ S. Frey, J. Waller)

Masterseminar - Software Performance Engineering, 2 hrs Seminar/Week,
W. Hasselbring (+ J. Ehlers, J. Waller, S. Frey)

Projektmodul - Software Engineering, 6 hrs Exercise/Week,
W. Hasselbring (+ S. Frey, J. Waller)

Summer 2012

Softwareprojekt, 3 hrs Exercise/Week,
W. Hasselbring (+ F. Fittkau, C. Wulf)

Masterprojekt - Software Engineering für parallele und verteilte Systeme, 4 hrs Exercise/Week,
W. Hasselbring (+ J. Waller, S. Frey)

Masterseminar - Empirical Methods in Software Engineering Research, 2 hrs Seminar/Week,
W. Hasselbring (+ F. Fittkau)

Software Engineering für parallele und verteilte Systeme, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
W. Hasselbring (+ S. Frey, J. Waller)

Projektmodul - Software Engineering, 6 hrs Exercise/Week,
W. Hasselbring (+ S. Frey, J. Waller)

Winter 2012/2013

Softwarearchitektur, 2 (+ 1) hrs Exercise (+ Exercises)/Week,
W. Hasselbring (+ W. Hasselbring)

Softwareprojekt, 3 hrs Exercise/Week,
W. Hasselbring (+ F. Fittkau, C. Wulf)

Softwaretechnik, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
D. Nowotka (+ S. Frey, J. Waller)

Masterseminar - Software Performance Engineering, 2 hrs Seminar/Week,
W. Hasselbring (+ J. Waller, S. Frey, C. Wulf, F. Fittkau)

Projektmodul - Software Engineering, 6 hrs Exercise/Week,
W. Hasselbring (+ S. Frey, J. Waller)

Third-Party Funds

DFG, *iObserve: Integrated Observation and Modelling Techniques to Support Adaptation an Evolution of Software Systems*, 01.11.2012-31.10.2015 (247.683 EUR)

DFG, *PubFlow: Publikationsprozesse für Forschungsdaten: Von der Erhebung und Verarbeitung zur Archivierung und Publikation*, 01.08.2011-31.07.2014 (218.500 EUR)

BMBF, *Verbundprojekt DynaMod - Dynamische Analyse für modellgetriebene Software-Modernisierung*, 01.01.2011-31.12.2012 (131.350 EUR)

BMBF, *Verbundprojekt Xbase: Produktivitätssteigerung bei der Implementierung domänspezifischer Sprachen durch effektive Wiederverwendung*, 01.05.2010-30.04.2012 (133.205 EUR)

ISH, *Transferprämie 2011*, 01.06.2011-31.05.2013 (10.000 EUR)

ISH, *Transferprämie 2012*, 01.11.2012-31.12.2013 (10.000 EUR)

ZBW (Leibniz-Informationszentrum Wirtschaft, *MaWiFo: Management wirtschaftswissenschaftlicher Forschungsdaten*, 01.01.2011-31.12.2012 (TV L-E13)

ZPW/EFRE (Zukunftsprogramm Wirtschaft), *Menges: Modellbasierte Entwurfmethoden für eine neue Generation elektronischer Stellwerke*, 01.08.2009-31.12.2012 (217.560 EUR)

ESN Energie Systeme Nord GmbH, *ESN Software Lab*, 16.11.2012-15.11.2013 (85.650 EUR)

Helmholtz Association, *Helmholtz Research School Ocean System Science and Technology (HOSST)*, 01.11.2012-31.10.2015 (Ph.D. Scholarship)

Further Cooperation, Consulting, and Technology Transfer

In DynaMod, we cooperate with b+m Informatik AG, HSH Nordbank AG, and Dataport.

In the excellence cluster Future Ocean, we cooperate with the Kiel Data Management Team at GEOMAR.

In Kieker, we cooperate with several industrial partners such as b+m Informatik AG and XING AG as well as with researchers from other universities, such as Karlsruhe Institute of Technology (KIT), RWTH Aachen, and the University of Novi Sad, Serbia.

In KoSSE (Kompetenzverbund in Software Systems Engineering, http://www.kosse-sh.de/), we cooperate with several groups of the computer science departments of Kiel and Lübeck, with the Cluster Management DiWiSH, and with several regional companies.

In MaNIDA, the Helmholtz Initiative and Networking Fund Project for a Marine Network for Integrated Data Access, we cooperate with AWI (Alfred Wegener Institute for Polar and Marine Sciences), MARUM (Centre for Marine Environmental Sciences), HZG (Institute of Coastal Research of Helmholtz-Zentrum Geesthacht), BSH (Federal Maritime and Hydrographical Agency), and GEOMAR (Helmholtz Centre for Ocean Research Kiel).

In MaWiFo, we cooperate with ZBW (Leibniz-Informationszentrum Wirtschaft), the group on Computer Media (Prof. Dr. Klaus Tochtermann), and with the group for Communication Systems (Prof. Dr. Norbert Luttenberger).

In MENGES, we cooperate with b+m Informatik AG and Funkwerk Information Technologies GmbH as well as with the group for Realtime Systems and Embedded Systems (Prof. Dr. Reinhard von Hanxleden).

In PubFlow, we cooperate with GEOMAR (their Library and Data and Computing Centre), ZBW (Leibniz-Informationszentrum Wirtschaft), as well as the Library and Computing Centre of the CAU, and the excellence cluster Future Ocean.

In Xbase, we cooperate with itemis AG.

In iObserve, we cooperate with the Karlsruhe Institute of Technology (KIT), the University of Duisburg-Essen and SAP AG.

In ESN Software Lab, we cooperate with ESN EnergieSystemeNord GmbH.

Diploma, Bachelor's and Master's Theses

T. C. Bielefeld, *Online performance anomaly detection for large-scale software systems (Received b+m Software and Systems Engineering Award 2012)*, 31.03.2012
A. Clausen, *Transforming Python into KDM to Support Cloud Conformance Checking*, 30.09.2012
P. Döhring, *Visualisierung von Synchronisationspunkten in Kombination mit der Statik und Dynamik eines Softwaresystems*, 07.10.2012
F. Fittkau, *Simulating Cloud Deployment Options for Software Migration Support*, 31.03.2012
P Johannsen, *Single Sign-On Authentifizierung von webbasierten Anwendungen am Beispiel von sozialen Netzwerken*, 31.03.2012
B. Konarski, *Ein 3D-Ansatz zur Visualisierung der Kernauslastung in Mulitprozessorsystemen*, 15.07.2012
K. Y. Lübbe, *Improving a Transformation of Java Models to KDM*, 30.09.2012
O. Prinz, *Transformation of Java Bytecode to KDM Models as a Foundation for Dependency Analysis*, 31.07.2012
B. Richter, *Dynamische Analyse von COBOL-Systemarchitekturen zum modellbasierten Testen*, 31.08.2012
C. Wulf, *Automatic Conformance Checking of C#-based Software Systems for Cloud Migration*, 31.03.2012

Dissertations / Postdoctoral Lecture Qualifications

J. Ehlers, *Self-Adaptive Performance Monitoring for Component-Based Software-Systems*, 20.04.2012
S. Gudenkauf, *Domain-Specific Modelling for Coordination Engineering*, 06.02.2012

Publications

Published in 2012

D. Bahls, G. Scherp, K. Tochtermann, W. Hasselbring, *Towards a Recommender System for Statistical Research Data*, Proceedings of the 2nd International Workshop on Semantic Digital Archives (SDA 2012), 61 - 72 (2012)

P. C. Brauer, W. Hasselbring, *Capturing provenance information with a workflow monitoring extension for the Kieker framework*, The Third International Workshop on the role of Semantic Web in Provenance Management, (2012)

S. Efftinge, M. Eysholdt, J. Köhnlein, S. Zarnekow, R. von Massow, W. Hasselbring, M. Hanus, *Xbase: implementing domain-specific languages for Java*, Proceedings of the 11th International Conference on Generative Programming and Component Engineering (GPCE 2012), 112 - 121 (2012)

F. Fittkau, S. Frey, W. Hasselbring, *CDOSim: Simulating Cloud Deployment Options for Software Migration Support*, Proceedings of the 6th IEEE International Workshop on the Maintenance and Evolution of Service-Oriented and Cloud-Based Systems, 37 - 46 (2012)

F. Fittkau, S. Frey, W. Hasselbring, *Cloud User-Centric Enhancements of the Simulator CloudSim to Improve Cloud Deployment Option Analysis*, Proceedings of the European Conference on Service-Oriented and Cloud Computing (ESOCC), 200 - 207 (2012)

S. Frey, W. Hasselbring, B. Schnoor, *Automatic Conformance Checking for Migrating Software Systems to Cloud Infrastructures and Platforms*, Journal of Software: Evolution and Process, (2012)

S. Frey, A. van Hoorn, R. Jung, B. Kiel, W. Hasselbring, *MAMBA: Model-Based Analysis Utilizing OMG's SMM*, Proceedings of the 14. Workshop Software-Reengineering (WSR '12), 37 - 38 (2012)

W. Goerigk, R. von Hanxleden, W. Hasselbring, G. Hennings, R. Jung, H. Neustock, H. Schaefer, C. Schneider, C. Schultz, T. Stahl, S. Weik, S. Zeug, *Entwurf einer domänspezifischen Sprache für elektronische Stellwerke*, Software Engineering 2012; Fachtagung des GI-Fachbereichs, (2012)

S. Gudenkauf, S. Kruse, W. Hasselbring, *Domain-Specific Modelling for Coordination Engineering with SCOPE*, Proceedings of Modellierung 2012, 203 - 218 (2012)

N. Huber, A. van Hoorn, A. Koziolek, F. Brosig, S. Kounev, *S/T/A: Meta-modelling Run-time Adaptation in Component-Based System Architectures*, 9th IEEE International Conference on e-Business Engineering (ICEBE 2012), (2012)

H. Knoche, A. van Hoorn, W. Goerigk, W. Hasselbring, *Automated Source-Level Instrumentation for Dynamic Dependency Analysis of COBOL Systems*, 14. Workshop Software-Reengineering (WSR '12), (2012)

A. van Hoorn, A. Waller, W. Hasselbring, *Kieker: A Framework for Application Performance Monitoring and Dynamic Software Analysis*, 3rd joint ACM/SPEC International Conference on Performance Engineering (ICPE 2012), (2012)

J. Waller, W. Hasselbring, *A Comparison of the Influence of Different Multi-Core Processors on the Runtime Overhead for Application-Level Monitoring*, International Conference on Multicore Software Engineering, Performance and Tools (MSEPT), 42 - 53 (2012)

C. Wulf, S. Frey, W. Hasselbring, *A Three-Phase Approach to Efficiently Transform C# into KDM*, Department of Computer Science, Kiel University, **TR-1211**, (2012)

Presentations

T. C. Bielefeld, A. van Hoorn, *OPAD: Online Performance Anomaly Detection with Kieker*, 7th Hamburg Web Performance Meetup, Microsoft Deutschland GmbH, Hamburg, Germany, 24.10.2012

P. C. Brauer, *Kieker.Workflow - Workflow Monitoring mit Kieker,* KoSSE-Symposium Application Performance Management (Kieker Days 2012), Kiel, Germany, 29.11.2012

P. C. Brauer, *Provenance data archival in PubFlow,* SWIB12, Köln, Germany, 26.11.2012

P. C. Brauer, *Publikationsprozesse für Forschungsdaten,* Science 2.0, Berlin, Germany, 30.03.2012

P. C. Brauer, *Workflow generierte Provenienz Metadaten in PubFlow,* PubFlow Workshop 2012, Kiel, Germany, 23.03.2012

N. Ehmke, *Assembling and Executing Kieker Analysis Configurations via Java API and Web UI,* KoSSE-Symposium Application Performance Management (Kieker Days 2012), Kiel, Germany, 29.-30.11.2012

F. Fittkau, *Online Trace Visualization for System and Program Comprehension in Large Software Landscape,* KoSSE-Symposium Application Performance Management (Kieker Days 2012), Kiel, Germany, 30.11.2012

S. Gudenkauf, *Entwurf nebenläufiger Softwarearchitekturen mit SCOPE,* parallel 2012, Karlsruhe, Germany, 23.05.2012

W. Hasselbring, *iObserve: Integrated Observation and Modelling Techniques to Support Adaptation and Evolution of Software Systems,* KoSSE-Symposium Application Performance Management (Kieker Days 2012), Kiel, Germany, 29.-30.11.2012

W. Hasselbring, *Reverse Engineering von Softwarearchitekturen durch dynamische Analyse,* Websphere Business User Group, Kiel, Germany, 11.05.2012

W. Hasselbring, *Perspektiven für KoSSE,* KoSSE-Tag, Kiel, Germany, 13.06.2012

W. Hasselbring, *Forschungsdatenmanagement am Standort Kiel,* PubFlow Workshop, Kiel, Germany, 23.03.2012

W. Hasselbring, *Application Performance Monitoring: Fehlerdiagnose, Kapazitätsmanagement, Reverse Engineering und mehr,* Schwäbisch Hall Kreditservice AG, Schwäbisch Hall, Germany, 02.10.2012

W. Hasselbring, *Rekonstruktion von Softwarearchitekturen durch dynamische Analyse,* GI-Fachtagung Architekturen, Paderborn, Germany, 02.07.2012

A. van Hoorn, *Kieker: Overview, Review, and Outlook,* KoSSE-Symposium Application Performance Management (Kieker Days 2012), Kiel, Germany, 29.11.-30.12.2012

A. van Hoorn, *Kieker: A Framework for Application Performance Monitoring and Dynamic Software Analysis,* 3rd ACM/SPEC International Conference on Performance Engineering (ICPE 2012), Boston, MA, USA, 25.05.2012

A. van Hoorn, *Model-Driven Online Capacity Management for Resource Efficienct Component-Based Software Systems,* GI-Dagstuhl seminar on Quality-of-Service Attributes in Service-and Cloud-based Systems: Specification, Modelling, Monitoring, Prediction, and Optimisation, Schloss Dagstuhl, Wadern, Germany, 22.05.2012

A. van Hoorn, *Wir nehmen Ihre Software auf den Kieker,* Winterfest der Technischen Fakultät / Tag der Informatik, Kiel, Germany, 06.12.2012

A. van Hoorn, *Architecture-based Online Capacity Management: Modelling, Monitoring and Adaptation,* Seminar of the Department of Distributed and Dependable Systems (D3S), Charles University, Prague, Czech Republic, 20.06.2012

J. Waller, *Analysis and Visualization of Monitoring Data in 3D,* KoSSE-Symposium Application Performance Management (Kieker Days 2012), Kiel, Germany, 29.-30.11.2012

J. Waller, *A Comparison of the Influence of Different Multi-Core Processors on the Runtime Overhead for Application-Level Monitoring,* International Conference on Multicore Software Engineering, Performance and Tools (MSEPT), Prague, Czech Republic, 31.05.2012

J. Waller, *Wie funktioniert Facebook,* Girls' Day, Kiel, Germany, 26.04.2012

C. Wulf, *Detection and Utilization of Potential Parallelism in Software Systems,* KoSSE-Symposium Application Performance Management (Kieker Days 2012), Kiel, Germany, 29.-30.11.2012

Further Activities and Events

S. Frey:

- Reviewer for the following journals and publishers:

Jahresbericht 2012

  - IEEE Internet Computing,
  - International Journal On Advances in Intelligent Systems,
- Member of the programme committee of the following conferences:

  CLOUD COMPUTING 2012: The Third International Conference on Cloud Computing, GRIDs, and Virtualization,
  CGC 2012: Second International Conference on Cloud and Green Computing.

W. Hasselbring:

- Member of the SPEC Research Group Steering Committee,
- Member of the Excellence Cluster Future Ocean (Principal Investigator for the second Phase),
- Member of the Excellence Cluster Inflammation at Interfaces,
- Member of the Computational Sciences Centre at CAU,
- Chairman of the Kiel KoSSE Projects,
- Chairman of the Board of GI-Fachgruppe Softwaretechnik,
- Board of GI-Fachgruppe Software-Architektur,
- Dean, Faculty of Engineering.
- Reviewer for the following funding agencies:
  - DFG: Deutsche Forschungsgemeinschaft,
  - FWF: Fonds zur Förderung der wissenschaftlichen Forschung, Österreich.
- Editorial Board of the following journals:
  - Advances in Software Engineering,
  - Enterprise Modelling and Information Systems Architectures - An International Journal,
  - International Journal of Software Architecture,
  - International Review on Modelling and Simulations,
  - Softwaretechnik-Trends.
- Reviewer for the following journals and publishers:
  - Computer Standards & Interfaces.
- Member of the programme committee for various conferences and workshops:

  CSMR 2012: 16th European Conference on Software Maintenance and Re-engineering,
  SE 2012: GI-Fachtagung Software Engineering,
  MAT 2012: GI-Workshop Modellierung in der Automatisierungstechnik,
  PESOS 2012: 4th International Workshop on Principles of Engineering Service-Oriented Systems,
  MMSM 2012: GI-Workshop Model-based and model-driven software modernization,

WICSA/ECSA 2012: 10th Working IEEE/IFIP Conference on Software Architecture (WICSA) and the 6th European Conference on Software Architecture (ECSA),

EMISA 2012: Fachtagung – Der Mensch im Zentrum der Modellierung (International Workshop on Enterprise Modelling and Information Systems Architecture),

SAWOSA 2012: South African Workshop on Software Architecture,

Informatik 2012: GI/GMDS-Workshop Datenmanagement und Interoperabilität im Gesundheitswesen,,

TEAR 2012: 7th Workshop on Trends in Enterprise Architecture Research

SE 2013: GI-Fachtagung Software Engineering,

NFPinDSML 2012 Fourth International Workshop on Non-functional System Properties in Domain Specific Modeling Languages,

ICPE 2013: International Conference on Performance Engineering,

ICSE 2013: International Conference on Software Engineering,

CSMR 2013: 17th European Conference on Software Maintenance and Re-engineering,

BCSE 2013: Workshop Business Clouds Software Engineering,

SESoS 2013: International Workshop on Software Engineering for Systems-of-Systems,

DFF 2013: 5. Workshop Design for Future,

PESOS 2013: 5th International Workshop on Principles of Engineering Service-Oriented Systems,

SERENE 2013: 5th International Workshop on Software Engineering for Resilient Systems,

ECSA 2013: 7th European Conference on Software Architecture,

CBI 2013: 15th IEEE Conference on Business Informatics.

- Organization of
  - KoSSE-Tag 2012.

A. van Hoorn:

- Organization of
  - KoSSE-Symposium: Application Performance Management (Kieker Days 2012).

Technical Computer Science

The research group ''Technical Computer Science'' works in the area of the physical design of computer systems and their applications in different fields. The main focus is on massively parallel systems, particularly systems that can speed up computer intensive operations by the use of special purpose hardware architectures. The activities during 2012 can be subsumed under three headings: first, the on-going development of the massively parallel architecture RIVYERA, second, the development and implementation of new parallel algorithms for specific computationally demanding problems in bioinformatics, and third, the deployment of massively parallel algorithms for economic optimisation problems.

Results

RIVYERA

Many problems in scientific computing and cryptanalysis are currently intractable due to the limitations of standard PC architectures or clusters of them. Solutions for that lack of performance are problem specific architectures such as supercomputers, grid computing, or even application specific circuits (ASICs). Lately, a new architectural approach has proven its benefits: the field programmable gate arrays. These reconfigurable silicon devices combine the flexibility of general-purpose circuits, like CPUs in computers, with the speed-up of ASICs.

The Technical Computer Science research group utilizes these reconfigurable devices in a massively parallel architecture called RIVYERA. The RIVYERA architecture has been designed and developed in a HWT2-project funded by the ISH (Innovation Society Schleswig-Holstein). During 2009 to 2012 this design was implemented in several stages. It uses new versions of the XilinX-Spartan series: the Spartan3-5000. In 2011 we designed a prototype of the new machine with Spartan6 chips, which has been in operation since July 2012.

Massively Parallel Implementation of Algorithms in Bioinformatics

Projects in the area of bioinformatics focus on the modification and massively parallel implementation of existing algorithms on the FPGA-based hardware architecture RIVYERA. The goal is to speed up application runtimes by orders of magnitude, and thus solve problems in sizes that are unfeasible for standard PCs or even GPU-based systems and small computer clusters. Major topics include biological sequence alignment and de-novo assembly of genome sequences including read error correction as well as problems considering SNPs, such as SNP imputation.

Biological sequence alignment is commonly used in variable specifications for different kinds of problems, e.g. heuristic or optimal alignments of short reads against a reference genome, or inexact searches in genomic or protein databases. These state subproblems for more complex applications with a biological or medical background, e.g. SNP detection for discovering genetic diseases.

One milestone already reached was the implementation in 2011 of the NCBI BLASTp algorithm for the RIVYERA architecture [ICCS2011]. BLASTp processes inexact searches for protein database queries, i.e. identifying similar sequences in a protein sequence database corresponding to the query. Now in 2012, we have successfully improved our previous application by a factor of two, leading to about a 400-fold increase in speed compared to a standard PC [ISBRA2012].

Besides database searches, biological sequence alignment may be used to compare genomic sequences of an individual according to a reference sequence, e.g. to detect genomic variations (SNPs). Raw sequence data is currently provided in short nucleotide sequences ($\sim$100 base pairs), so-called ''reads'', while a reference sequence may have a size of about 3.3 billion base pairs in the case of the human genome. Furthermore, read data may be erroneous with about 1%-2% error rate. For the alignment of these short reads against the reference a variety of short read alignment algorithms is available. Most of them are heuristics providing different trade-offs in alignment quality and speed.

Currently, the best trade-offs with alignment quality and speed are provided by short read alignment algorithms based

on the Burrows-Wheeler transformation. However, for a typical complete read set which has to be aligned against the human genome, the expected runtime on standard PCs will exceed several days, if not weeks. The running project on implementation of the Burrows-Wheeler based aligner ''BWA'' on the RIVYERA architecture is currently in its completion phase. The accomplished speedup depends on the read set and settles at about 100-fold compared to standard PC architectures.

Another challenging problem in bioinformatics concerns the generation of complete genome sequences from reads: the so called ''de-novo assembly''. This may be described in brief as a huge jig-saw puzzle with millions of pieces containing errors. De-novo assembly is divided into several parts. Those algorithms providing the best quality are based on the creation and modification of de-Bruijn graphs, e.g. SOAPdenovo. The first two steps of this algorithm consist of the error correction of reads and the de-Bruijn graph creation. Since these are the most time-consuming steps (more than 80 per cent of the total runtime, which may again be days in the case of the human genome on a standard PC), two further projects have been started to create an error correction algorithm and de-Bruijn graph creation algorithm for the RIVYERA architecture and are now in their completion phase as well.

Regarding the quality of de-novo assemblies, we have analysed read sets used as input data in terms of coverage, i.e. how often a base has been read by the process of read generation. Our findings show that even with a high average coverage a significant number of areas still remain uncovered [ICACC2012]. This leads to disconnected de-Bruijn graphs and thus, too many parts of an assembled genome instead of one sequence (per chromosome).

All projects considering bioinformatics algorithms are done in close collaboration with the Institute of Clinical Molecular Biology (ICMB) at the UKSH and the SciEngines GmbH (manufacturer of the RIVYERA). In this collaboration, a new project has been started considering the acceleration of the SNP imputation algorithm MaCH on the RIVYERA system.

Massively Parallel Portfolio Optimization

RIVYERA has turned out to be very suitable for optimization problems in the area of financial mathematics (portfolio optimization, strategy analysis). In 2012 we developed a number of parallel financial mathematics algorithms for the architecture. These algorithms have been implemented in VHDL. The results achieved are impressive in terms of runtime and energy efficiency.

Mobile Client for Workflow Management Systems

The department of Computer Science of the CAU has concentrated on ''Software and Systems Engineering'' during the last year. Together with the University of Lübeck, seven projects have been funded in this context. One of these projects is managed by the Technical Computer Science research group. The goal is the development of a mobile client for workflow management systems. The maintenance of infrastructure and industrial plants requires a high degree of coordination. The software environment is typically heterogeneous. Therefore,a universal client must integrate different task models and provide a unified interface to the user. The client is mainly developed for the application field of energy suppliers. Here, a large variety of end devices are currently used. The client must, therefore, be adaptable to all these end devices. The project started in October 2009 and was funded until September 2012. The project has been successfully completed.

Personnel

Head of the group: Prof. Dr. M. Schimmler; Secretary: B. Scheidemann (50%)
Technical Staff: Dipl.-Ing. G. Diesner

Staff:

I. Pohlmann	01.01.-31.12.2012	(50%)	CAU

Scientific Staff:

M. Sc. M. Abbas	01.01.-31.12.2012	
M. Sc. S. Koschnicke	01.01.-31.12.2012	CAU
M. Sc. F. Schatz	01.01.-31.12.2012	Getdigital
Dr.-Ing. Ch. Starke	01.01.-31.12.2012	KoSSE
Dipl.-Inf. L. Wienbrandt	01.01.-31.12.2012	CAU/BLK
M. Sc. C. M. Y. Yeo	01.01.-31.12.2012	CAU

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

Digitale Systeme, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
M. Schimmler (+ S. Koschnicke, M. Schimmler, L. Wienbrandt, C. M. Y. Yeo)

Algorithmenentwurf für massiv parallele Hardware, 4 hrs Practical/Week,
M. Schimmler (+ S. Koschnicke, L. Wienbrandt)

Algorithmen der Bioinformatik, 2 hrs Seminar/Week,
M. Schimmler (+ L. Wienbrandt, C. M. Y. Yeo)

Hardwarepraktikum, 4 hrs Practical/Week,
M. Schimmler (+ S. Koschnicke, L. Wienbrandt, C. M. Y. Yeo)

Digital Systems, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
M. Schimmler

Summer 2012

Hardwarepraktikum, 4 hrs Practical/Week,
M. Schimmler (+ S. Koschnicke, L. Wienbrandt, C.M.Y. Yeo)

Rechnergestützter Entwurf digitaler Systeme, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
M. Schimmler (+ M. Schimmler, C.M.Y. Yeo)

Implementierung massiv paralleler Systeme, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
M. Schimmler (+ S. Koschnicke, M. Schimmler, L. Wienbrandt)

Masterprojekt - Algorithmenentwurf für massiv parallele Hardware, 4 hrs Practical/Week,
M. Schimmler (+ S. Koschnicke, L. Wienbrandt)

Algorithmen der Bioinformatik, 2 hrs Seminar/Week,
M. Schimmler (+ L. Wienbrandt, C.M.Y. Yeo)

Winter 2012/2013

Digitale Systeme, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
M. Schimmler (+ S. Koschnicke, M. Schimmler, C.M.Y. Yeo)

Digital Systems, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
M. Schimmler (+ M. Schimmler, C.M.Y. Yeo)

Hardwarepraktikum, 4 hrs Practical/Week,
M. Schimmler (+ S. Koschnicke)

Algorithmenentwurf für massiv parallele Hardware, 4 hrs Practical/Week,
M. Schimmler (+ S. Koschnicke)

Algorithmen der Bioinformatik, 2 hrs Seminar/Week,
M. Schimmler (+ L. Wienbrandt, C.M.Y. Yeo)

Third-Party Funds

Ministerium für Wissenschaft, Wirtschaft und Verkehr, *BLK-Modellversuch*, 01.01.2011-31.12.2012 (50.000,00)
Ministerium für Wissenschaft, Wirtschaft und Verkehr, *BLK-Modellversuch*, 01.08.2012-31.07.2013 (60.000,00)
Ministerium für Wissenschaft, Wirtschaft und Verkehr, *Universeller Aufgabenclient zur Unterstützung des technischen Betriebsmanagements bei verteilter Datenhaltung*, 01.10.2009-30.09.2012 (176.233,00)
ESN, *Universeller Aufgabenclient zur Unterstützung des technischen Betriebsmanagements bei verteilter Datenhaltung*, 01.10.2009-30.09.2012 (20.234,36)
GISWORK, *Universeller Aufgabenclient zur Unterstützung des technischen Betriebsmanagements bei verteilter Datenhaltung*, 01.10.2009-30.09.2012 (2.251,60)
Dr. Werner Petersen-Stiftung, *Software-Challenge*, 06.06.2012 (30.000,00)
SciEngines GmbH, *scholarship Software-Challenge*, 19.06.2012 (3.600,00)
Innovationsstiftung Schleswig-Holstein, *scholarship Software-Challenge*, 01.10.2011-30.09.2012 (14.400,00)
WTSH GmbH, *Software-Challenge*, 27.03.2012 (3.545,89)
Coronic GmbH, *scholarship Software-Challenge*, 04.09.2012 (3.600,00)
Frauenbeauftragte CAU, *Software-Challenge*, 04.05.2012 (3.600,00)

Diploma, Bachelor's and Master's Theses

C. A. Rathje, *Massively Parallel Attack on WP A2-A Dictionary Attack Using the Reconfigurable Hardware Platform RIVYERA*, 21.12.2012
J. Kässens, *A Distributed Shared Memory Core for FPGA Clusters*, 14.12.2012
N. Paulsen, *Hoch performantes Short-Read Alignment durch Weiterentwicklung des SMARTI-Algorithmus*, 28.09.2012
J. Bissel, *Entwicklung einer generischen Alignment-Anwendung auf einer massiv-parallelen Hardwareplattform RIVYERA*, 20.06.2012
B. Stade, *Implementierung eines effizienten Verfahrens zur Identifizierung gekoppelter Nukleotid-Polymorhismen aus Exom-Sequenzierungen in das Programmpaket 'snpActs'*, 29.03.2012

Dissertations / Postdoctoral Lecture Qualifications

Ch. Starke, *High Performance Computing zur technischen Finanzmarktanalyse*, 30.06.2012

Publications

Published in 2012

F. Schatz, L. Wienbrandt, S. Schimmler, *Probability Model for Boundaries of Short-Read Sequencing (Best Paper Award)*, Advances in Computing and Communications (ICACC), ISBN: 978-1-4673-1911-9, IEEE Xplore, 223 - 228 (2012)
F. Schatz, S. Koschnicke, N. Paulsen, M. Schimmler, *Master/Slave Assignment Optimization for High Performance Computing in an EC2 Cloud Using MPI*, Network Protocols and Algorithms, ISSN 1943-3581 Volume 4, Macrothink Institute, **1**, 22 - 33 (2012)

Ch. Starke, V. Grossmann, L. Wienbrandt, S. Koschnicke, J. Carstens, M. Schimmler, *Optimizing Investment Strategies with the Reconfigurable Hardware Platform RIVYERA,* International Journal of Reconfigurable Computing, (2012)

A. Abbas, C. A. Rathje, L. Wienbrandt, M. Schimmler, *Dictionary Attack on TrueCrypt with RIVYERA S3-5000,* 2012 IEEE 18th International Conference on Parallel and Distributed Systems (ICPADS), 93 - 100 (2012)

Ch. Starke, V. Grossmann, L. Wienbrandt, M. Schimmler, *An FPGA-Implementation of an Investment Strategy Processor,* Procedia Computer Science, **9**, 1880 - 1889 (2012)

L. Wienbrandt, D. Siebert, M. Schimmler, *Improvement of BLASTp on the FPGA-Based High-Performance Computer RIVYERA,* Lecture Notes in Computer Science, **7292**, 275 - 286 (2012)

Presentations

L. Wienbrandt, D. Siebert, M. Schimmler, *Improvement of BLASTp on the FPGA-Based High-Performance Computer RIVYERA,* ISBRA 2012, Dallas, USA, 21.-23.05.2012

A. Abbas, C. A. Rathje, L. Wienbrandt, M. Schimmler, *Dictionary Attack on TrueCrypt with RIVYERA S3-5000,* ICPADS2012, Singapore, Singapore, 17.-19.12.2012

F. Schatz, L. Wienbrandt, M. Schimmler, *Probability Model for Boundaries of Short-Read Sequencing (Best Paper Award),* ACC2012, Koch, India, 08.-11.08.2012

Ch. Starke, V. Grossmann, L. Wienbrandt, M. Schimmler, *An FPGA-Implementation of an Investment Strategy Processor,* ICCS2012, Omaha, USA, 04.-06.06.2012

Theoretical Computer Science

The group studies topics in cryptography, complexity theory, logic in computer science, automata theory, and computer science education.

Results

Security Analysis for Cryptographic Protocols

Many cryptographic protocols achieve (or aim to) complex security goals that have both strategic and epistemic (knowledge-related) components. For such properties, a violation of the security property cannot be defined as a property of a single run of the protocol but one has to consider dependencies and relations between different runs to decide whether a protocol is secure.

In the working group, a suitable ATL-based logic (QAPI) was developed that allows the formal specification of such security goals and a decidability result was proven: it is decidable whether a given a protocol satisfies a given security property specified in QAPI.

Computational Social Choice

An problem often studied in the context of (electronic) elections is that of *manipulation*: the question is how a group of voters, who have complete knowledge about the votes of all other voters, have to cast their votes in an election to achieve a desired result. Classical results show that every non-trivial voting system yields situations in which it is "better" for a voter not to vote honestly, but "strategically"; in the literature on computational social choice, this is known as manipulation.

In joint work with co-authors in Kraków and Rochester, the group achieved a complexity result for the manipulation problem concerning the case of 4 candidates: the *Llull* voting system can be efficiently manipulated. (Note that in this context, this is a negative result, as one hopes the manipulation problem to be computationally hard, meaning that voters cannot solve it in practice.) The result also applies to the "weighted" case in which different voters have varying degrees of influence over the election outcome.

The reason why this result is interesting is that it is one of the very few cases in which a non-trivial algorithm is exhibited for the manipulation problem: most efficient manipulation algorithms simply let all "manipulating" voters vote identically, which in the case of a fixed number of candidates leads to a trivial algorithm (with usually a non-trivial correctness proof). Our algorithm is significantly more complex and uses techniques from approximation algorithms to obtain an exact solution of the manipulation problem.

Automata on Infinite Words and Temporal Logic

The model of a Büchi automaton is widely considered *the* model of an automaton on infinite words. In 2012, two fundamental results on this automaton model were obtained and published by the theory group. First, it was shown that different complementation procedures known from earlier work can be unified elegantly. Second, a new framework for classifying discrete temporal properties over the natural numbers was developed: the use of so-called prophetic automata, special reverse deterministic Büchi automata, turned out to be especially suited for classification purposes.

Dynamic Information Flow Security

Information-flow security is a well-established technique to model security issues arising in MILS-based architectures (Multiple Independent Levels of Security). The main idea is that data that should only be visible to agents with a high security clearance should never change the view for agents that have a lower security clearance. In the working group, this notion was studied in a dynamic setting. In addition to creating precise security definitions (correcting mistakes made by earlier definitions in the literature), unwinding relations, notions of uniform and consistent policies, and complexity results were established.

Computing Education

See separate section on *computer science education*.

Personnel

Head of the group: Prof. Dr. Th. Wilke; Secretary: K. Flöth (halbe Stelle, 19.05.-31.12.), F. Lorenz (halbe Stelle, 01.01.-31.03.), D. Patz
Technical Staff: H. Schmidt (halbe Stelle, Krankheitsvertretung)

Scientific Staff:

Dipl.-Math. S. Eggert	01.01.-31.12.2012	CAU
Dipl.-Päd. J. Lembke	01.02.-31.08.2012	ISH, 25 %
Dipl.-Math. S. Preugschat	01.04.-30.09.2012	CAU, 50 %
Dipl.-Math. S. Preugschat	01.01.-31.12.2012	CAU, 50 %
Dipl.-Math. T. Radtke	01.02.-31.07.2012	ISH, 50 %
Dipl.-Math. T. Radtke	01.-31.01.2012	ISH, 75 %
Dr. H. Schnoor	01.01.-31.12.2012	CAU
StR S. Schulmeister	01.01.-31.12.2012	CAU, 50 %

Lectures, Seminars, and Laboratory Course Offers

Summer 2012

Inf-LogInf: Logik in der Informatik, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Th. Wilke (+ S. Preugschat)

Inf-MS-Sem-Theorie: Masterseminar Theoretische Informatik, 2 hrs Lecture/Week,
Th. Wilke

Inf-Sem-Theorie: Bahnbrechende Beiträge zur Informatik, 2 hrs Lecture/Week,
S. Eggert (+ Th. Wilke)

MS0105: Angewandte Logik, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Th. Wilke (+ H. Schnoor)

Wie wird im Internet sicher kommuniziert?, 1 hrs Lecture/Week,
Th. Wilke

Winter 2012/2013

Abschlussarbeiten AG Wilke, 2 hrs Lecture/Week,
Th. Wilke (+ S. Eggert, H. Schnoor)

Inf-AP-EdSoft: Bildungssoftware, 6 hrs Lecture/Week,
Th. Wilke

Inf-EinfPP: Einführendes Programmierpraktikum, 3 hrs Exercise/Week,
H. Schnoor (+ S. Preugschat, S. Schulmeister, S. Eggert)

Inf-MP-ITSec: Masterprojekt Kryptographie und IT-Sicherheit, 4 hrs Exercise/Week, Th. Wilke

MS0101: Kryptographie, 4 (+ 2) hrs Lecture (+ Exercises)/Week, Th. Wilke (+ H. Schnoor)

Third-Party Funds

Innovationsstiftung Schleswig-Holstein, *Wenn Bilder laufen lernen, ist Informatik nicht weit!*, 16.06.2010-31.10.2012 (133.080 EUR)
DiWiSH, *Schnupperstudium Informatik*, 15.-19.10.2012 (1.500,00 EUR)

Further Cooperation, Consulting, and Technology Transfer

The group works with groups in Trier (Prof. Dr. Ralf Küsters), Hannover (Prof. Dr. Heribert Vollmer), Rochester (Prof. Dr. Edith Hemaspaandra), Marseille (Prof. Dr. Nadia Creignou), Paris (Prof. Dr. Arnaud Durand), Krakow (Prof. Dr. Piotr Faliszewski), Jerusalem (Prof. Orna Kupferman), Houston (Prof. Moshe Y. Vardi), and Sydney (Prof. Dr. Ron van der Meyden).

Diploma, Bachelor's and Master's Theses

Arnd Gongoll, *Implementierung eines eID-Servers (Bachelorarbeit)*, 19.02.2012
Hauke Reklies, *Der OpenPGP-Standard (Bachelorarbeit)*, 30.09.2012
Oliver Woizekowski, *Informationsflusssicherheit bei alternativen Systemmodellen (Diplomarbeit)*, 20.11.2012

Publications

Published in 2012

Piotr Faliszewski, Edith Hemaspaandra, H. Schnoor, *Weighted Manipulation for Four-Candidate Llull Is Easy*, Proceedings of ECAI, 318 - 323 (2012)
H. Schnoor, *Deciding Epistemic and Strategic Properties of Cryptographic Protocols*, Proceedings of ESORICS, 91 - 108 (2012)
S. Preugschat, T. Wilke, *Effective Characterizations of Simple Fragments of Temporal Logic Using Prophetic Automata*, FoSSaCS, 135 - 149 (2012)
Christoph Dürr, Thomas Wilke, *29th International Symposium on Theoretical Aspects of Computer Science, STACS 2012*, LIPIcs, **14**, (2012)
S. Eggert, H. Schnoor, Th. Wilke, *Dynamic Noninterference: Consistent Policies, Characterizations and Verification*, CoRR, **1208.5580**, 1 - 37 (2012)

Presentations

H. Schnoor, *Deciding Epistemic and Strategic Properties of Cryptographic Protocols*, ESORICS 2012, Pisa, Italien, 10.-14.09.2012
Piotr Faliszewski, Edith Hemaspaandra, H. Schnoor, *Weighted Manipulation for Four-Candidate Llull Is Easy*, ECAI 2012, Montpellier, Frankreich, 27.-31.08.2012
S. Preugschat, T. Wilke, *Effective Characterizations of Simple Fragments of Temporal Logic Using Prophetic Automata*, FOSSACS 2012, 24.01.-01.04.2012

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Further Activities and Events

» Th. Wilke has been a member of the Council of the European Association for Theoretical Computer Science (EATCS).

» Th. Wilke has been vice speaker of the division Grundlagen of the Gesellschaft für Informatik (GI GB GInf).

» Th. Wilke has been a member of the editorial boards of the following journals and series: Fundamenta Informaticae, Formal Methods in System Design, and Lecture Notes in Logic.

» Th. Wilke was co-chair of the programme committee of STACS 2012 and STACS 2013.

» The group organized a workshop for computer science and art teachers.

» The group organized one week of Schnupperstudium Informatik, jointly with the business office of the department and Priv.-Doz. Dr. Frank Huch.

» The group organized a computer animation contest for schools in Schleswig-Holstein.

Theory of Parallelism

Our group performs research in the field of optimization problems. On the one hand, we are interested in efficient approximation algorithms, and on the other, in algorithm engineering in order to use these algorithms for practical applications. The group's main areas of interest include: approximate solvers for linear programs (which generate provably good solutions quickly as opposed to solving instances to optimality in excessive time), approximation schemes (which permit a controllable trade-off between efficiency and accuracy), parameterized complexity (where the aim is to obtain better running times for instances with a special structure), scheduling problems (which include problems in industrial production planning), geometrically constrained packing problems (which feature several optimization aspects and model, for instance, the packaging of goods in containers or the loading of trucks with resources), network flow problems (which model the transportation of physical commodities as well as data), and finally, timetabling problems (which are fundamental in staff scheduling in administrative systems, educational systems and medical care).

Personnel

Head of the group: Prof. Dr. K. Jansen; Secretary: U. Iaquinto (50%)
Technical Staff: P. Karimi Massouleh (50%)

Scientific Staff:

L. Chen Guest researcher	01.01.-30.09.2012		Chinese Academy of Science
K.-M. Klein	01.01.-31.12.2012		CAU
S. Kraft	01.01.-31.12.2012		DFG
Felix Land	01.02.-31.12.2012		DFG
Kati Land	01.02.-31.12.2012		DFG
L. Prädel	01.01.-30.09.2012	(50%)	DFG
L. Prädel Hochschulpakt 20/20	01.01.-30.09.2012	(50%)	CAU
C. Robenek Hochschulpakt 20/20	01.01.-30.09.2012	(50%)	CAU
C. Robenek	01.01.-30.09.2012	(50%)	DFG

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

Vorlesung - Effiziente Algorithmen, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
K. Jansen (+ K.-M. Klein)

Seminar - Approximative Algorithmen, 2 hrs Seminar/Week,
K. Jansen

Seminar - Algorithmen und Komplexität, 2 hrs Seminar/Week,
K. Jansen

Fortgeschrittenenseminar - Algorithmen, Kombinatorik und Komplexität, 2 hrs Seminar/Week,
K. Jansen (+ A. Srivastav)

Summer 2012

Vorlesung - Algorithmen und Datenstrukturen, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
K. Jansen (+ K.-M. Klein, L. Prädel)

Vorlesung - Approximative Algorithmen, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
K. Jansen

Seminar - Algorithmen und Komplexität, 2 hrs Seminar/Week,
K. Jansen (+ F. Kumm, K. Land)

Seminar - Theoretische Informatik, 2 hrs Seminar/Week,
K. Jansen (+ F. Kumm, K. Land)

Fortgeschrittenenseminar - Algorithmen, Kombinatorik und Komplexität, 2 hrs Seminar/Week,
K. Jansen (+ A. Srivastav)

Winter 2012/2013

Vorlesung - Theoretische Grundlagen der Informatik, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
K. Jansen (+ K.-M. Klein)

Seminar - Algorithmen und Komplexität, 2 hrs Seminar/Week,
K. Jansen (+ F. Land, K. Land)

Seminar - Theoretische Informatik, 2 hrs Seminar/Week,
K. Jansen (+ F. Land, K. Land)

Fortgeschrittenenseminar - Algorithmen, Kombinatorik und Komplexität, 2 hrs Seminar/Week,
K. Jansen (+ A. Srivastav)

Third-Party Funds

DFG-Projekt, Entwicklung und Analyse von approximativen Algorithmen für zwei- und dreidimensionale Packungsprobleme, *Personal, travel, and aquisition,* 01.10.2011-31.01.2014 (211.700 EUR)
DFG-Projekt, Entwicklung von effizienten polynominellen approximationsschemata für Scheduling- und verwandte Optimierungsprobleme, *Personal, travel, and aquisition,* 01.10.2010-30.09.2013 (205.200 EUR)
DFG-Projekt, Entwicklung von Approximationsalgorithmen für Scheduling auf heterogenen Maschinen, *Personal, travel, and aquisition,* 01.02.2012-31.01.2015 (228.100 EUR)

Further Cooperation, Consulting, and Technology Transfer

Our group cooperates closely with the workgroup of Prof. Guochuan Zhang from the College of Computer Science of Zhejiang University, China, with Roberto Solis-Oba from the University of Western Ontario, Canada, as well as with Denis Trystram who is working at the LIG - Laboratoire d'Informatique de Grenoble, France with whom we are establishing an ERASMUS partnership programme.

Diploma, Bachelor's and Master's Theses

S. Finke, *Optimierung des Transportproblems basierend auf Simulated Annealing, Bachelor Theses,* 28.09.2012
S. Berndt, *Robuste Online-Verfahren für Bin Packing, Master Theses,* 17.08.2012

Dissertations / Postdoctoral Lecture Qualifications

C. Robenek, *Approximation Algorithms for 2-Dimensional Packing and Related Scheduling Problems, Dr. Ing.*, 21.09.2012

L. Prädel, *Approximation Algorithms for Geometric Packing Problems, Dr. Ing.*, 21.12.2012

Publications

Published in 2012

F. Diedrich, K. Jansen, L. Prädel, U. Schwarz, O. Svensson, *Tight approximation algorithms for scheduling with fixed jobs and non-availability*, ACM Transactions on Algorithms, **8 (3)**, (2012)

K. Jansen, R. Solis-Oba, *Packing squares with profits*, SIAM Journal on Discrete Mathematics, **26(1)**, 263 - 279 (2012)

K. Jansen, H. Zhang, *Scheduling malleable tasks with precedence constraints*, Journal of Computer and System Sciences, **78(1)**, 245 - 259 (2012)

K. Jansen, *A fast approximation algorithm for the multiple knapsack problem*, 38th International Conference on Current Trends in Theory and Practice of Computer Science (SOFSEM 2012), (2012)

M. Bougeret, P.-F. Dutot, K. Jansen, C. Robenek, D. Trystram, *Tight approximation for scheduling parallel jobs on identical clusters*, 14th Workshop on Advances in Parallel and Distributed Processing Symposium (APDCM 2012), (2012)

K. Jansen, *A (3/2+ϵ) approximation algorithm for scheduling malleable and non-malleable parallel tasks*, 24th Annual ACM Symposium on Parallelism in Algorithms and Architectures (SPAA 2012), (2012)

K. Jansen, S. Kraft, *An Improved Approximation Scheme for Variable-Sized Bin Packing*, 37th International Symposium on Mathematical Foundations of Computer Science (MFCS 2012), Springer LNCS, **7464**, 529 - 541 (2012)

A. Gupta, K. Jansen, J.D.P. Rolim, R.A. Servedio, *Approximation, Randomization, and Combinatorial Optimization. Algorithms and Techniques*, APPROX 2012 and RANDOM 2012, Springer LNCS, **7408**, (2012)

Presentations

L. Chen, *An EPTAS for scheduling machines with capacity constraints*, 21st International Symposium on Mathematical Programming (ISMP 2012), Berlin, Germany, 19.-24.08.2012

K. Jansen, *A fast approximation algorithm for the multiple knapsack problem*, 38th International Conference on Current Trends in Theory and Practice of Computer Science (SOFSEM 2012), Spindleruv Mlyn, Tschechien, 21.-27.01.2012

K. Jansen, *A (3/2+ϵ) approximation algorithm for scheduling malleable and non-malleable parallel tasks*, International Workshop on Approximation, Parameterized and EXact algorithms (APEX 2012), Paris, France, 28.-29.02.2012

K. Jansen, *A (3/2+ϵ) approximation algorithm for scheduling malleable and non-malleable parallel tasks*, 24th Annual ACM Symposium on Parallelism in Algorithms and Architectures (SPAA 2012), Pittsburgh, USA, 25.-27.06.2012

K.-M. Klein, K. Jansen, *A Robust AFPTAS for Bin Packing with Polynomial Migration*, 7th Scheduling for Large Scale Systems Workshop, Pittsburgh, USA, 28.-30.06.2012

K. Jansen, S. Kraft, *An Improved Approximation Scheme for Variable-Sized Bin Packing*, 37th International Symposium on Mathematical Foundations of Computer Science (MFCS 2012), Bratislava, Slovakia, 27.-31.08.2012

R. Harren, K. Jansen, L. Prädel, R. van Stee, *A 5/3+ϵ Approximation Algorithm for 2D Strip Packing*, 11th Cologne-Twente Workshop on Graphs and Combinatorial Optimization (CTW 2012), Munich, Germany, 29.-31.05.2012

R. Harren, K. Jansen, L. Prädel, R. van Stee, *A 5/3+ϵ Approximation Algorithm for 2D Strip Packing*, 9th EURO Special Interest Group on Cutting and Packing Meeting (ESICUP), La Laguna, Spain, 21.-23.03.2012

Further Activities and Events

Prof. Jansen has been a member of the Steering Committee of the Special Interest Group on Algorithms of the Gesellschaft für Informatik (GI) since 2010.

Prof. Jansen was involved in the organization of the following conferences:

he was a workshop Co-Chair of the *Workshop on Approximation Algorithms for Combinatorial Optimization Problems (APPROX 2012)* and the *Workshop on Randomization and Approximation Techniques in Computer Science (RANDOM 2012)* taking place at the MIT in Cambridge, USA.

Prof. Jansen was a programme committee member of the following:

10th Workshop on Parallel Systems and Algorithms (PASA 2012) in Munich,

the *International Workshop on Approximation, Parameterized and EXact algorithms(APEX 2012)* in Paris, France,

the *Workshop on Approximation and Online Algorithms (WAOA 2012)* in Ljubljana, Slovenia,

and the *2nd International Symposium on Combinatorial Optimization (ISCO 2012)* in Athens, Greece.

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Institute of Electrical and Information Engineering

The Institute of Electrical and Information Engineering (ET&IT) of the Christian-Albrechts-Universität zu Kiel (CAU) is extensively integrated into cooperative and interdisciplinary research projects. Within the topic *Information Engineering* members of ET&IT closely cooperate with the Department of Computer Science. ET&IT also maintains a close research partnership with the Institute for Materials Science mainly in the research area ''Nanosystems Engineering''. In particular, several members of ET&IT are principal investigators in the Collaborative Research Centre SFB 855 *Magneto-Electric Composites - Future Biomagnetic Interfaces*, working together with materials scientists, physicists, and physicians. In addition, the Institute has been engaged in the *Computational Sciences Centre* of the CAU and in the regional research network *CEwind - Centre of Competence in Wind Energy*.

The Institute of ET&IT consists of 11 professorships including the external professorship held by Prof. Dr.-Ing. Wolfgang Benecke, who is also the Managing Director of the Institut für Siliziumtechnologie (ISIT) in Itzehoe. One of these professorships was reassigned in 2012: in November 2012, Prof. Dr.-Ing. Thomas Meurer took over the professorship ''Automatic Control'' as the successor of Prof. Dr.-Ing. Helmut Röck. Two of the Institute's professors will retire in 2013: Prof. Dr.-Ing. Friedrich W. Fuchs (*Power Electronics and Electrical Drives*) at the end of March 2013, and Prof. Dr.-Ing. Reinhard Knöchel at the end of September 2013. Thus, in 2012, two commissions have been working to fill these two upcoming vacancies with results still pending.

In October 2012, Prof. Dr.-Ing. Gerhard Schmidt was elected as a new executive member of the board and thereby relieved Prof. Dr.-Ing. Ludger Klinkenbusch of this office.

In November 2012, Prof. Dr. Martina Gerken received an outstanding award for her pioneer research in the field of nanotechnology: she was awarded a European Research Councils (ERC) Starting Grant. From mid 2013, her project PhotoSmart will be funded for five years with a total of 1.5 million EUR. Also in November 2012, Prof. Dr.-Ing. Friedrich W. Fuchs was awarded the Technologietransferprämie of the Innovationsstiftung Schleswig-Holstein and the Gesellschaft für Energie und Klimaschutz Schleswig-Holstein for building up a professional network for power electronics with partners from industry and universities in northern Germany. In December 2012, Prof. Thomas Meurer received the Kardinal-Innitzer-Förderungspreis for his habilitation thesis entitled ''Contributions to Motion Planning and Tracking Control for Distributed-Parameter Systems in Single- and Higher-Dimensional Spatial Domains" , completed at the Technical University Vienna.

The number of new students, who enrolled in the five academic courses offered by the Institute of ET&IT in 2012, stayed nearly the same as in the previous year. In the summer semester 2012, 12 freshmen enrolled in the master's programmes *Electrical and Information Engineering* and *Electrical and Information Engineering and Business Management*. For the winter semester 2012/2013 a total of 230 new students enrolled in the Institute's academic courses. In detail, 75 students started the bachelor's programme *Electrical and Information Engineering* and 109 enrolled in the bachelor's programme *Electrical and Information Engineering and Business Management*. In the corresponding master's programmes 22 students took up their studies, and 24 new students enrolled in the international 4-semester master's programme *Digital Communications* where all courses are offered in English.

In 2012, the Institute of ET&IT again was very active in the promotion of young talent. In particular, the Institute successfully participated in the events *Girls´ Day* and *Power Girls & Boys*.

Automatic Control

The research activities of the Chair of Automatic Control (Chair of Automation and Control Engineering until November 2012) comprise mathematical modelling of dynamic systems, model-based control and observer design for nonlinear and distributed-parameter systems with applications in smart adaptive structures, cooperative multi-agent systems, chemical, biochemical and thermal processes, as well as computational methods for control. Herein, research has a strong focus on the development of analytical and semi-analytical methods and their numerical and experimental evaluation.

The teaching by the chair addresses control design for linear systems using frequency and state space techniques, nonlinear control systems taking into account differential geometric and Lyapunov-based approaches, optimization and optimal control, control of distributed-parameter systems, as well as model-based estimator and observer design. Basic and advanced student lab hours complete the curriculum.

Since November 2012 Prof. Dr.-Ing. habil. Thomas Meurer, formerly Associate Professor at Vienna University of Technology, has been head of the chair.

Results

Distributed-Parameter Systems and Control Theory (Thomas Meurer)

Distributed-parameter systems are characterized by state variables depending on both time and space. Hence, mathematical modelling yields a system description in terms of partial differential equations (PDEs). Well known examples include, elastomechanic or thermomechanic structures in mechatronics or aeronautics, fixed-bed and tubular reactors in chemical and process engineering, reheating and cooling processes in the steel industry as well as forming, heat exchangers, fluid flow and fluid-structure interactions, and collective dynamics of robots, crowds, and flocks.

The research activities in particular address the development of systematic model-based analysis and design techniques for motion planning, feedback stabilization, and observer design. In this, so-called late lumping approaches are considered that directly exploit the underlying mathematical PDE structure. For this, novel flatness-, backstepping- and passivity-based techniques are developed for linear and nonlinear distributed parameter systems with single, and in particular, higher-dimensional spatial domains. In addition, it is shown that the combination of the approaches studied yields sophisticated tracking control concepts able to realize prescribed spatio-temporal paths. Stability (exponential or asymptotic) of the feedback and tracking control schemes is analyzed using operator and semigroup theory.

In order to address the complexity arising in many applications, e.g. due to complex shaped geometries or the number of dependent state variables, semi-analytical design techniques are deduced by combining the developed analytical approaches with numerical discretization and approximation schemes such as finite difference, finite volume, or finite element methods.

Smart Material Structures (Thomas Meurer)

Smart material structures with distributed actuators and sensors being embedded in an elastic carrier occur in a large variety of applications, with the purpose of, for example, vibration suppression, static or dynamic shape control, or also fault detection. However, the rapid progress in actuator development supports the evolution of new application areas such as adaptive optics in telescopes, adaptive wings, or so-called smart skins. Here it is desired to realize a transiently varying shape to achieve for example, the modulation of optical wave fronts, the reduction of drag, or the improvement of aeroelastic characteristics. For this, piezoelectric elements typically serve as actuators by exploiting the indirect piezoelectric effect to convert electrical voltage into mechanical strain.

Taking into account the spatial extension as well as the actuator and sensor distribution, modelling of smart material structures leads to a mathematical description in terms of partial differential equations. This PDE formulation is exploited

for motion planning, stabilization, and observer design. Results in particular deal with systematic approaches for flatness-based motion planning of piezoactuated beam and plate structures, and their combination in terms of the so-called two-degree-of-freedom (2DOF) control concept with passivity-based feedback control to stabilize the distributed-parameter tracking error dynamics. Herein, a novel non-collocated feedback control design has been developed which yields a dynamic output feedback involving a distributed-parameter state observer whose output corrections are similarly determined by utilizing the passivity concept. The asymptotic stability of the closed-loop control is verified in a rather general setting by making use of operator and semigroup theory. In order to tackle complex structural geometries or local variations of the material properties, finite element techniques are included into the design systematics to realize powerful semi-analytical approaches.

As a complement to simulation studies, state-of-the-art experimental facilities are created to evaluate the approaches developed for lightweight flexible beam and plate structures with piezoelectric actuation, as are depicted in Fig. 1 (left). Measurement results for rest-to-rest bending motion of the plate structure with transition times close to the first structural eigenfrequency are also shown in Fig. 1 (right). These results nicely confirm the high tracking accuracy achieved by the application of the proposed 2DOF control concept. Similar results are obtained for torsional and combined bending-torsional motion trajectories.

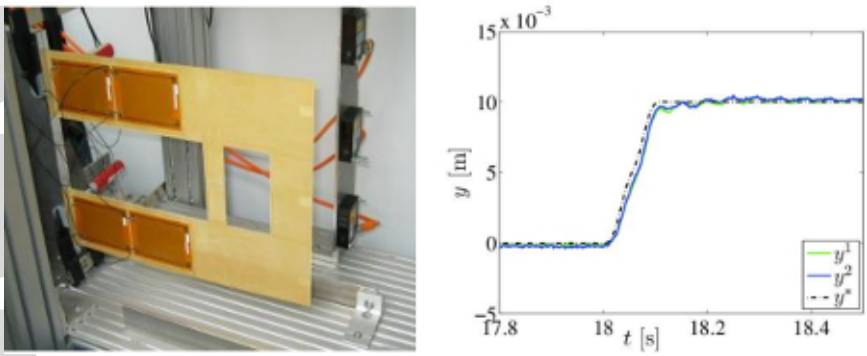

Fig. 1: Flexible plate structures with embedded piezoelectric macro-fibre composite (MFC) actuators: Experimental set-up (left) and measurement results for rest-to-rest bending motion comparing output and desired trajectory (right).

Multi-Agent Systems (Thomas Meurer)

In the past decades, extensive research has been conducted on the cooperative formation control of multi-agent systems with possible applications ranging from UAVs through transportation systems to micro-satellite clusters. Thus, different analysis and design approaches have emerged depending on the available communication topology and the multi-agent formation control task considered. Besides the discrete analysis of the interconnected individual agents, continuous models based on PDEs have been used to model, analyse, and control many particle systems, traffic flow, or large vehicular platoons.

The research activities at the Chair of Automatic Control focus on the application of PDE-based motion planning and feedback control strategies, e.g. to achieve the finite-time deployment of mobile agents into desired formation profiles. Formations are thereby governed by the steady state solutions of the PDEs. Here, both nonlinear and time-varying PDEs with single and higher dimensional domain are considered to enlarge the class of deployment shapes. Flatness-based techniques are considered for this and combined for example, with backstepping-based state feedback control and observer design for the tracking error dynamics. With this, a rather generic analysis and design tool is developed which, in particular, is independent of the actual communication topology. The latter is imposed by the transfer from the agent continuum to the discrete formulation by means of suitable discretization techniques for PDE systems.

Simulation results for multi-agent formation control are shown in Fig. 2 assuming a leader-follower configuration. Here, linear diffusion-convection-reaction equations and the semilinear viscous Burger's equation are used to represent the agent

continuum, and hence serve as a basis for control design. The task considered addresses the transfer from an initial spatial agent formation to a desired final spatial formation within a prescribed transition interval. Due to nonlinear characteristics of the Burger's model evolving shock-like behaviour a rather rich class of steady state solutions, and hence formation profiles, is available and is exploited in the solution of the control problem.

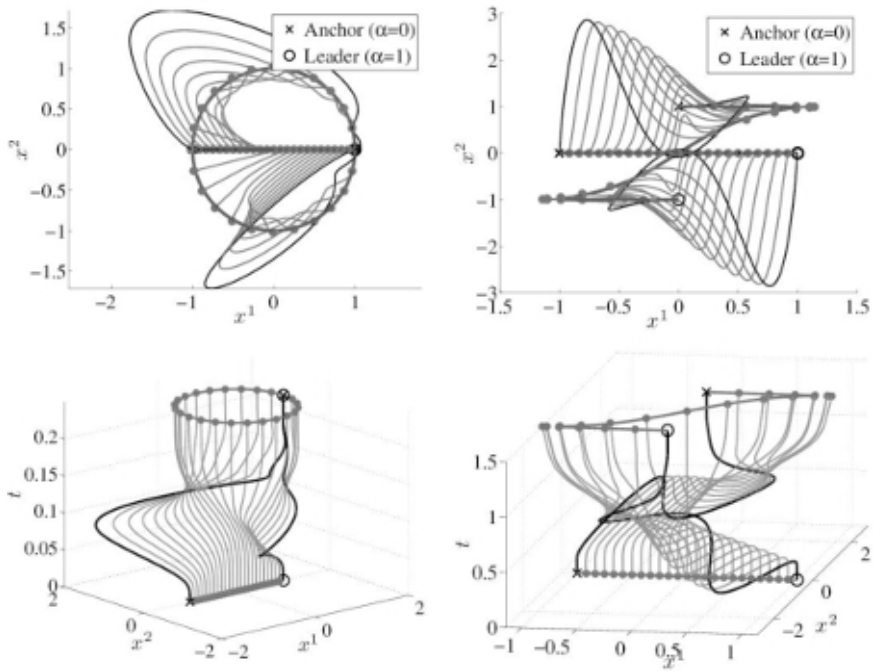

Fig. 2: Agent trajectories in the (x^1,x^2)-plane (top) and the (x^1,x^2,t)-domain (bottom) for 2 different desired final formations. Black lines correspond to the anchor ($\times$) and leader ($\circ$) paths, grey lines represent the follower's motion ($\bullet$).

Coriolis Mass Flow Meter (Felix Koschmieder)

A coriolis mass flow meter (CMFM) measures the mass flow density of a fluid simultaneously. Hence, CMFMs are used in nearly all branches of industry from food, via the chemical industry, to oil and gas. To reduce measurement uncertainties in CMFMs adaptive model based correction schemes for self-calibration have to be implemented in the measurement device.

The mechanical lumped parameter model of the CMFM describes the oscillation of the measuring pipe in the first and second eigenmode. The Euler-Lagrange-Formalism gives the appropriate pair of coupled second order differential equations. The basis for the density measurement is the relation between the oscillating mass and the eigenfrequency of the first eigenmode. The eigenfrequency can be calculated as $\omega_{01} = \sqrt{c_1/m_1}$, where c_1 is the effective spring constant and m_1 is the effective mass, which is proportional to the density of the measured medium. The stiffness of the pipe c_1 is a function of many different parameters such as temperature, temperature gradients, stress, stress gradients, process pressure, flow rate, etc. For a high precision density measurement the stiffness c_1 has to be estimated online. In order to gather additional information about the internal parameters of the CMFM, the measuring pipe is not only stimulated at its fundamental eigenfrequency ω_{01} but also at two additional frequencies $\omega_{b1} = \omega_{01} + \Delta\omega$ and $\omega_{b2} = \omega_{01} - \Delta\omega$.

In the established design the difference in frequency $\Delta\omega$ is chosen to be sufficiently large to enable measurement separation by filters. Due to the high quality factor of the first eigenmode (about 5000) any additional stimulation results in a poor signal to noise ratio (SNR) of the sensor signals. To enhance the SNR, the difference of the excitation frequency $\Delta\omega$ has to be chosen small. Therefore, conventional filters are replaced by an extended Kalman-filter, which estimates the three phasors of the three excitation frequencies ω_{01}, ω_{b1} and ω_{b2}. This set-up was already used successfully in

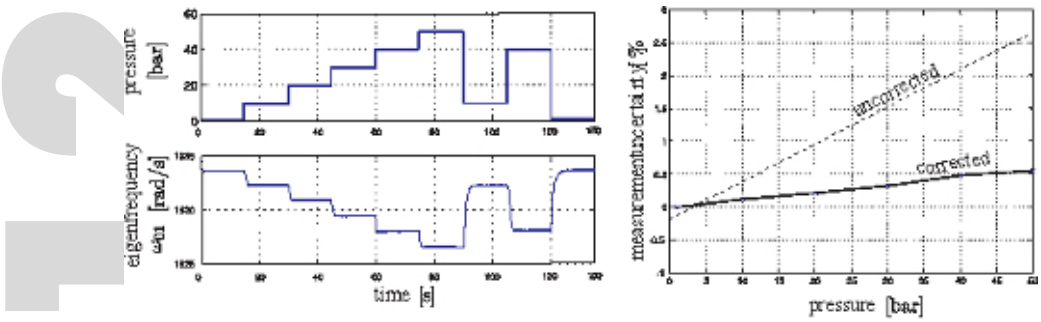

Fig. 3: Influence of the process pressure on the coriolis mass flow meter.

the nonlinear MIMO phasor control of the CMFM for estimation of the phasor of the sinusoidal oscillation. If the density measurement in Fig. 3 is not corrected, the measurement uncertainty increases up to 2.8 % at a system pressure of 50 bar, but with correction the measurement uncertainties are smaller than 0.6 %. Due to the improvement in SNR the estimation of the stiffness is now 60 times faster than before at equivalent measurement uncertainties.

Control in Biotechnology (Eduard Peter)

Streptococcus thermophilus is one of the most important bacteria in the dairy industry, producing lactic acid. For this reason it is extensively used as a starter culture for the manufacture of several dairy products such as yoghurt or cheese. The main roles of Streptococcus thermophilus in milk fermentation are to acidify the milk by metabolizing the substrate lactose into lactate, to preserve the product, and to add aroma compounds.

In the industrial production of Streptococcus thermophilus it is of major importance to determine exactly the time when the bacteria reach maximal activity. This time indicates the end of the fermentation process and initiates the downstream processing of the bacterial culture. As a result, the harvesting time is a very important factor determining the quality of the starter culture and hence has to be predicted at a very early stage of the fermentation process to prepare the downstream process in time.

To predict the optimal harvesting time an adaptive model-based approach has been developed using a dynamic model of the batch fermentation process. The mathematical model consists of a set of coupled ordinary differential equations, where the biomass, the concentration of the substrate lactose, and the concentration of the product lactate serve as state variables. Due to the sensitivity of the biotechnological process, the model parameters have to be adapted exploiting on-line measurements. Using the appropriate model parameters, the bacterial activity and thus the harvesting time for the starter culture can be predicted by simulating the dynamic process model. Adjustment of the model parameters to the real process is done by linking the dynamic process model to a newly developed static pH model serving as the measurement model. This static model, which is specific for each fermentation process, is derived from first principles; it uses material balances, together with an electroneutrality condition, to mathematically model the impact of added base, lactate, and other chemicals on the equilibrium pH value in the actual fermentation process. The lactate concentration serves as the linking information between both of the models.

At the first stage of fermentation, on-line measurements of the pH value are used to synchronize the dynamic process model and the fermentation process. The calculated lactate concentration resulting from the dynamic process model with uncertain starting conditions is fed back into the pH model and is used for a model-based calculation of the pH value. By minimizing the difference between measured and calculated pH value the appropriate starting conditions of the fermentation process, i.e. the initial concentration of the bacteria, can be determined. At the second stage of the fermentation process, i.e. when the pH value has fallen below a predefined set point and the pH controller is adding base to the medium to ensure a constant pH value, the amount of added base is used to calculate the lactate concentration via the pH model. Comparing the lactate concentrations resulting from the dynamic process and the static pH model enables

the continuous adaption of the parameters of the dynamic model. The predicted harvesting time for the starter culture finally results from dynamic simulation of the continuously adapted process model.

Control of a Micro Mechanical Mirror (Thomas von Wantoch)

In cooperation with the Fraunhofer ISIT a laboratory set-up to demonstrate a laser scanning projection display has been developed and successfully implemented. It consists of a RGB-laser source, MEMS 2D-Scanner and analog/digital system electronics. Scanning the collimated laser beam by a resonantly driven biaxial micro mirror produces a continuously moving Lissajous trajectory on the projection area. In order to display video data the laser intensity is synchronized with the mirror angular deflection as well as the RBG pixel data in the image memory. The control and image processing algorithms are realized as digital logic circuits using a FPGA-based DSP-System.

Personnel

Head of the group: Prof. Dr.-Ing. T. Meurer, Prof. Dr.-Ing. H. Röck; Secretary: S. Marquardt-Hansen (50%)
Technical Staff: Dipl.-Ing (FH) M. Lieb

Scientific Staff:

Dipl.-Ing. F. Koschmieder Coriolis Mass Flow Measurement	01.01.-31.12.2012	CAU
Prof. Dr. E. Pawluk Nonlinear Control	01.01.-31.03.2012	Guest
Dipl.-Wirtsch.-Ing. E. Peter Process Control in the Dairy Industry	01.01.-31.12.2012	CAU
Dipl.-Ing. Thomas von Wantoch Control of a Micro Mechanical Mirror	01.01.-31.03.2012	CAU

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

Einführung in die robuste Regelung, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
H. Röck (+ E. Peter)

Regelungstechnik I, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
K. Lebert (+ T. von Wantoch)

Masterpraktikum Regelungstechnik, 4 hrs Lab/Week,
H. Röck (+ E. Peter, F. Koschmieder, T. von Wantoch)

Ausgewählte Kapitel der Regelungstechnik, 2 hrs Seminar/Week,
H. Röck (+ E. Peter, F. Koschmieder, T. von Wantoch)

Anleitung zum wissenschaftlichen Arbeiten, 1 hrs Lecture/Week,
H. Röck (+ E. Peter, F. Koschmieder, T. von Wantoch)

Summer 2012

Digitale Regelung, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
H. Röck (+ F. Koschmieder)

Winter 2012/2013

Regelungstechnik I, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
T. Meurer (+ F. Koschmieder, E. Peter)

Third-Party Funds

Industrie, *Regelung und Zustandsschätzung thermischer Produktionsprozesse*, 01.06.-31.12.2012 (15.000 EUR)

Diploma, Bachelor's and Master's Theses

A. Reinhardt, *Untersuchung eines Konzeptes zur Parameterschätzung und linearisierenden Regelung eines mikromechanischen Spiegels (MEMS)*, 18.02.2012

P. Romanowski, *Parameteridentifikation und Linearisierung eines Duffing-Oszillators mit Hilfe eines FPGA-basierten DSP-Systems*, 09.05.2012

K. von Fleischbein, *Vorsteuerungsentwurf und Modellierung durch künstliche neuronale Netze am doppelt invertierten Pendel*, 30.07.2012

C. Mallas, *Realisierung einer adaptiven Regelung eines mikromechanischen Spiegels mit Hilfe eines FPGA-basierten DPS-Systems*, 20.08.2012

S. Vollstedt, *Untersuchung verschiedener Regelungskonzepte zur Linearisierung und Regelung eines Duffing-Oszillators*, 21.08.2012

F. Rützel, *Reibwertschätzer zur Fahrdynamikregelung im querdynamischen Grenzbereich*, 30.09.2012

C. Erlhofer, *Modellbasierte nichtlineare Flugregelung eines Quadrokopters*, 23.10.2012

Publications

Published in 2012

T. Meurer, *Control of Higher-Dimensional PDEs: Flatness and Backstepping Designs*, Series: Communications and Control Engineering, Springer-Verlag, (2012)

T. Meurer, J Schröck, A. Kugi, *Trajektorienplanung für eine piezo-aktuierte elastische Kirchhoff Platte.*, e&i elektrotechnik und informationstechnik, **129**, 11 - 17 (2012)

J. Henikl, J. Schröck, T. Meurer, A. Kugi, *Infinit-dimensionaler Reglerentwurf für Euler-Bernoulli Balken mit Macro-Fibre Composite Aktoren*, at-Automatisierungstechnik, **60**, 10 - 19 (2012)

B. Schörkhuber, T. Meurer, A. Jüngel, *Flatness-based trajectory planning for semilinear parabolic PDEs*, Proc. IEEE 51st Annual Conference on Decision and Control (CDC), 3538 - 3543 (2012)

T. Meurer, M. Saidani, *Motion planning for the 2D Stokes equations*, Proc. IEEE 51st Annual Conference on Decision and Control (CDC), 1572 - 1577 (2012)

E. Peter, H. Röck, *On-line estimation of lactic acid concentration during batch fermentations of Streptococcus thermophilus based on pH measurement*, Proc. IEEE 12th Int. Conference on Control, Automation and Systems (ICCAS), 851 - 855 (2012)

J. Schröck, T. Meurer, A. Kugi, *Motion planning for an elastic Kirchhoff plate*, Proc. American Control Conference (ACC), 652 - 657 (2012)

Presentations

T. Meurer, M. Saidani, *Motion planning for the 2D Stokes equations*, 51st IEEE Conference on Decision and Control (CDC), Maui, USA, 10.-13.12.2012

B. Schörkhuber, T. Meurer, A. Jüngel, *Flatness-based trajectory planning for semilinear parabolic PDEs*, 51st IEEE Conference on Decision and Control (CDC), Maui, USA, 10.-13.12.2012

T. Meurer, *Trajektorienplanung und Folgeregelung für verteilt-parametrische Systeme: Von der Methodenentwicklung*

zur Anwendung, Seminar Chair of Automatic Control and Systems Theory, Ruhr-Universität, Bochum, Deutschland, 15.-15.11.2012

E. Peter, H. Röck, *On-line estimation of lactic acid concentration during batch fermentations of Streptococcus thermophilus based on pH measurement*, 12th International Conference on Control, Automation and Systems (ICCAS 2012), Jeju Island, Korea, 17.-21.10.2012

T. Meurer, *Finite Element Based Trajectory Planning for Distributed-Parameter Thermal Systems*, 6th European Congress on Computational Methods in Applied Sciences and Engineering, Wien, Österreich, 10.-14.09.2012

T. Meurer, J. Schöck, A. Kugi, *Motion planning for an elastic Kirchhoff plate*, American Control Conference, Montreal, Canada, 27.-29.06.2012

T. Meurer, *Model-based control of piezoactuated flexible structures: motion planning, stabilization and tracking*, New Trends and Challenges in Modeling and Control of Microsystems, Besancon, France, 31.05.-01.06.2012

T. Meurer, *Nicht-kollokierte Stabilisierung eines Euler-Bernoulli-Balkens mit verteilten Aktoren*, Theory and Application of Distributed Parameter Systems, Saarbrücken, Deutschland, 17.-17.01.2012

Further Activities and Events

Prof. Meurer serves as Chair of the IFAC Technical Committee 2.6 Distributed Parameter Systems.

Prof. Meurer serves as Associate Editor for Conference Editorial Board of the IEEE Control Systems Society.

Prof. Meurer serves as Associate Editor for the IFAC Journal Control Engineering Practice.

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Communications

The research activities of this group are as follows: optical communications (measurement, prototyping, and simulation of high speed data communication systems, optical amplifiers for WDM, equalization of optical transmission channels, optical modulation formats, optical line coding, WDM networks), simulation and modelling of communication systems (development and application of modular simulation tool on system level), and synchronization in communication systems (clock and carrier synchronization, PLL-applications).

Results

Optical Wireless Communication

At the end of 2012 the chair for Communication started to build up a new research field: optical wireless communication (OWC). Instead of using the well-known optical fibre, free space transmission is used. This technique has been used in terrestrial short distance applications for several years already, but there is an increasing interest in long haul transmissions such as inter-satellite or earth-to-satellite links. The main advantage, in addition to higher bitrates, is the reduced power consumption compared to RF set-ups. However, OWC requires a direct line of sight (LOS) between transmitter and receiver, which impairs the system flexibility. Other possible applications are underwater as well as indoor OWC. The latter, also known as visible light communication (VLC), uses LEDs for both illumination and data transmission in rooms.

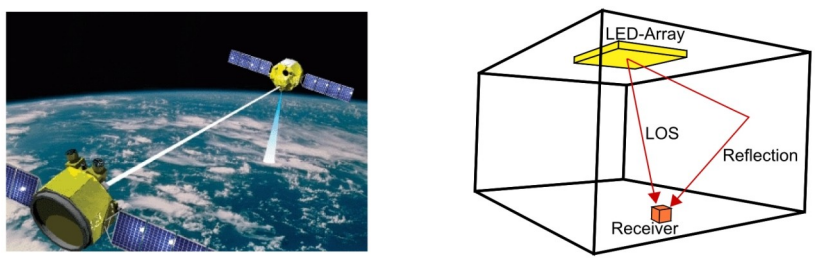

Fig. 1: Applications for optical wireless communication: inter-satellite (a) and indoor (b)

Tomlinson-Harashima Precoding

Invented independently and almost simultaneously by M. Tomlinson in 1971 and H. Harashima and H. Miyakawa in 1972, *Tomlinson-Harashima precoding* (THP) is a pre-compensation method that is exactly fitted to the channel impulse response in order to completely compensate for its linear impairments, and is in fact a generalization of partial response precoding. THP is very popular in the field of wireless communications, namely in multiple-input multiple-output (MIMO) scenarios. It offers an alternative to the decision-feedback equalizer (DFE) with the possibility to apply channel coding conjunctively.

THP uses the same structure as a decision-feedback equalizer (DFE), i.e. a feedback loop. In the case of DFE, a nonlinear device, namely a decision device, is inserted in the upper arm of the feedback loop in order to avoid instability and/or noise power enhancement problems. In order to allow for stability for the precoder, THP uses a nonlinear device as well, namely a shifted modulo 2M device, where M is even and stands for the number of constellation points in a bipolar M-ASK modulation. The compatibility of THP with linear fibre-optic communication systems has been investigated within a bachelor´s thesis.

No Guard Interval Coherent OFDM (NGI-CO-OFDM)

Due to the rapid increase in IP data traffic, large-capacity and cost-effective optical fibre transmission is required for realizing future optical transport networks (OTN). So far, 100 Gb/s/ch wavelength-division multiplex transmission has been extensively investigated for long-haul transport of 100G Ethernet channels over OTNs. Polmux NGI-CO-OFDM emerged as a promising candidate for future transmission systems because it matches the advantages of single-carrier coherent reception with regards to chromatic dispersion (CD) and polarization mode dispersion (PMD); it also has the capability of using higher-order digital modulation formats (e.g. QPSK, 16-QAM) together with the well-shaped compact OFDM signal spectrum in order to reach high spectral efficiency.

In conventional IFFT-based OFDM CD and PMD tolerance is improved by use of a guard interval (GI) and training symbols for channel estimation. In NGI-OFDM all subcarriers used are equalized in parallel after separation and coherent reception in the digital domain as for single-carrier transmission. The linear distortion caused by CD and PMD is equalized by fixed-tap linear equalizers and adaptive finite impulse response (FIR) filters with blind channel estimation by a modified constant modulus based algorithm (MCMA). Besides the forward error correction and Ethernet overhead of 11% there is no additional overhead. NGI-CO-OFDM is investigated by numerical simulations and experiments. To investigate such NGI-based DWDM systems more easily in the lab a programmable optical WaveShaper was purchased, thereby complementing our already well-equipped laboratory for optical communications. A WaveShaper provides a wide range of programmable optical filtering and switching solutions for optical test applications and delivers extremely fine control of filter characteristics, including centre wavelength, bandwidth, shape, dispersion, and attenuation.

Fig. 2: New equipment in LNT-lab: Optical WaveShaper

Fig. 3: LNT staff in 2012

Head of the group: Prof. Dr. Werner Rosenkranz; Secretary: Petra Usinger
Technical Staff: Dipl.-Ing. (FH) Sandra Robien

Scientific Staff:

M.Sc. Susmita Adhikari Optical Communication	01.01.-31.12.2012	Industry
Dr.-Ing. Abdulamir Ali Orthogonale Frequenzmultiplextechnik (OFDM)	01.01.-31.12.2012	Land
Dipl-Wirth.-Ing. Dennis Clausen OFDM-Konzepte für das optische Zugangsnetz	01.07.-31.12.2012	BMBF
Dipl.-Ing. Annika Dochhan Modulationsverfahren	01.01.-31.10.2012	Industry
Dr.-Ing. Jochen Leibrich Modulationsformate und Simulationswerkzeuge	01.01.-31.12.2012	CAU
M.Sc. Roi Rath Kanalentzerrung	01.01.-31.12.2012	Industry/Land
Dipl.-Ing. Christian Ruprecht OFDM-Konzepte für das optische Zugangsnetz	01.01.-31.12.2012	BMBF
M.Sc. Semjon Schaefer SASER - Signalverarbeitung für sichere Übertragung	01.11.-31.12.2012	BMBF
Dipl.-Ing. Johannes von Hoyningen-Huene Optical Communication	01.01.-31.12.2012	Industry
Dr. Jing Xu OFDM-Konzepte für das optische Zugangsnetz	01.01.-31.10.2012	BMBF
Dipl.-Ing. Jiani Zhao Optical Communication	01.02.-04.06.2012	Land

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

Nachrichtenübertragung II, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
W. Rosenkranz (+ J. von Hoyningen-Huene)

High-Speed Systems and Networks, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
W. Rosenkranz (+ J. Leibrich, J. Xu, C. Ruprecht)

Numerische Simulation analoger und digitaler Nachrichtensysteme, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
J. Leibrich (+ J. Zhao)

Projekt, 3 hrs Projekt/Week,
W. Rosenkranz und Mitarbeiter

Communications Lab, 4 hrs Lab/Week,
W. Rosenkranz und Mitarbeiter

Seminar Nachrichtentechnik, 3 hrs Seminar/Week,
W. Rosenkranz und Mitarbeiter

Seminar über Bachelor- und Masterarbeiten der Nachrichtentechnik, 2 hrs Seminar/Week,
W. Rosenkranz und Mitarbeiter

Anleitung zum wissenschaftlichen Arbeiten für Studierende der Elektrotechnik und Informationstechnik, 2 hrs Seminar/Week,
W. Rosenkranz und Mitarbeiter

Digital Communications, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
W. Rosenkranz (+ A. Ali)

Advanced Topics Lab, 6 hrs Lab/Week,
W. Rosenkranz und Mitarbeiter

Summer 2012

Nachrichtenübertragung, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
W. Rosenkranz (+ J. von Hoyningen-Huene)

Optical Communicatons, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
W. Rosenkranz (+ J. Leibrich)

Projekt, 3 hrs Projekt/Week,
W. Rosenkranz und Mitarbeiter

Bachelorpraktikum Nachrichten- und Informationstechnik, 4 hrs Lab/Week,
W. Rosenkranz und Mitarbeiter

Seminar Nachrichtentechnik, 2 hrs Seminar/Week,
W. Rosenkranz und Mitarbeiter

Seminar über ausgewählte Kapitel der Nachrichtentechnik, 3 hrs Seminar/Week,
W. Rosenkranz und Mitarbeiter

Seminar über Studien- und Diplomarbeiten der Nachrichtentechnik, 2 hrs Seminar/Week,
W. Rosenkranz und Mitarbeiter

Anleitung zum wissenschaftlichen Arbeiten für Studierende der Elektrotechnik und Informatonstechnik, 2 hrs Seminar/Week,
W. Rosenkranz und Mitarbeiter

Winter 2012/2013

Nachrichtenübertragung II, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
W. Rosenkranz (+ J. von Hoyningen-Huene)

High-Speed Systems and Networks, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
W. Rosenkranz (+ C. Ruprecht)

Numerische Simulation analoger und digitaler Nachrichtensysteme, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
J. Leibrich (+ S. Schaefer)

Projekt, 3 hrs Projekt/Week,
W. Rosenkranz und Mitarbeiter

Communications Lab, 4 hrs Lab/Week,
W. Rosenkranz und Mitarbeiter

Seminar Nachrichtentechnik, 3 hrs Seminar/Week,
W. Rosenkranz und Mitarbeiter

Seminar über Bachelor- und Masterarbeiten der Nachrichtentechnik, 2 hrs Seminar/Week,
W. Rosenkranz und Mitarbeiter

Anleitung zum wissenschaftlichen Arbeiten für Studierende der Elektrotechnik und Informationstechnik, 2 hrs Seminar/Week,
W. Rosenkranz und Mitarbeiter

Digital Communications, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
W. Rosenkranz (+ A. Ali)

Advanced Topics Lab, 6 hrs Lab/Week,
W. Rosenkranz und Mitarbeiter

Third-Party Funds

BMBF, *OFDM-Konzepte für das optische Zugangsnetz*, 01.01.-31.12.2012 (165.700)
BMBF, *Signalverarbeitung für sichere Übertragung*, 01.01.-31.12.2012 (84.000)
Industry, -, 01.01.-31.12.2012 (92.200)
Industry, -, 01.05.-31.10.2012 (47.600,00)

Further Cooperation, Consulting, and Technology Transfer

The chair is member of the contact group which annually arranges the Workshop **Optical Communications**:

- TU Munich(Prof. N. Hanik),

- ''Research Centre COM'' , TU Kopenhagen (Prof. P. Jeppesen),

- FhG Heinrich Hertz Institut, Berlin,

- Deutsche Telekom T-Systems, Berlin, Darmstadt.

Diploma, Bachelor's and Master's Theses

Jan Törber, *Untersuchung von Konzepten zur Spitzenwert-Reduktion in der optischen OFDM-Übertragung*, 16.02.2012
Srihari Yenugula, *PMD Compensator in Polmux-DQPSK 112Gbit/s Transmission Systems*, 02.05.2012
Christian Schmidt, *Tomlinson-Harashima Precoding for Fiber-Optic Transmission Links*, 24.08.2012
Semjon Schaefer, *Untersuchungen zur optischen OFDM-Übertragung mit direkt moduliertem Laser*, 28.09.2012
Sebastian Kleis, *Elektronische Signalverarbeitung in der kohärenten optischen Datenübertragung im Grenzbereich der Taktfrequenz verfügbarer A/D-Wandler*, 30.11.2012

Dissertations / Postdoctoral Lecture Qualifications

Christina Hebebrand, *Digitale Signalverarbeitung in kohärenten optischen Kommunikationssystemen mit mehrstufigen Modulationsformaten*, 01.06.2012
Abdulamir Ali, *Investigations of OFDM-Transmission for Direct Detection Optical Systems*, 24.10.2012

Publications

Published in 2012

J. von Hoyningen-Huene, C. Ruprecht, A. Ali, W. Rosenkranz, *Experimental IM/DD OFDMA Transmission with Scalable Receiver Frontend for PON Scenarios*, OFC, **OW4B.6**, (2012)

R. Ryf, R. Essiambre, J. von Hoyningen-Huene, P. Winzer, *Analysis of Mode-Dependent Gain in Raman Amplified Few-Mode Fibre,* OFC, **OW1D.2**, (2012)

J. Xu, A. Ali, C. Ruprecht, J. von Hoyningen-Huene, J. Zhao, J. Leibrich, W. Rosenkranz, *OFDM Remodulation for 10-Gb/s/channel WDM-PON with Simple Carrier Extraction and Enhanced Tolerance to Rayleigh Noise,* OFC, **OW4B.7**, (2012)

S. Adhikari, S. Sygletos, A.D. Ellis, B. Inan, S.L. Jansen, W. Rosenkranz, *Enhanced Self-Coherent OFDM by the Use of Injection Locked Laser,* OFC, **JW2A.64**, (2012)

X. Liu, J. Xu, Q. Wang, C.C.K. Chan, *Rayleigh Noise Mitigated 70-km-Reach Bi-directional WDM-PON with 10-Gb/s Directly Modulated Manchesterduobinary as Downstream Signal,* OFC, **OW1B.2**, (2012)

Y. Chen, S. Adhikari, N. Hanik, S.L. Jansen, *Pilot-aided Sampling Frequency Offset Compensation for Coherent Optical OFDM,* OFC, **OTh4C.2**, (2012)

A. Diaz, A. Napoli, S. Adhikari, Z. Maalej, A. Lobato, M. Kuschnerov, J. Prat, *Analysis of back-propagation and RF pilot-tone based nonlinearity compensation for a 9x224Gb/s POLMUX- 16QAM system,* OFC, **OTh3C.5**, (2012)

B. Inan, B. Spinnler, F. Ferreira, A. Lobato, S. Adhikari, V.A.J.M. Sleiffer, D. van den Borne, N. Hanik, S.L. Jansen, *Equalizer Complexity of Mode Division Multiplexed Coherent Receivers,* OFC, **OW3D.4**, (2012)

A. Ali, J. Leibrich, W. Rosenkranz, *Design Considerations and Performance Comparison of High-Order Modulation Formats using OFDM,* Journal of Networks, IEEE, **5, Vol. 7**, 757 - 763 (2012)

W. Rosenkranz, J. von Hoyningen-Huene, *Equalization Equalization Technologies for NGA,* OECC, (2012)

C. Ruprecht, W. Rosenkranz, *OFDMA Based PONs with Reduced Hardware Requirements through Advanced Signal Processing,* ICTON, **Tu.B3.2**, (2012)

W. Rosenkranz, J. von Hoyningen-Huene, *Nonlinearity Compensation and Equalization in Access Networks,* OECC, **5B3-2**, (2012)

D. Clausen, C. Ruprecht, W. Rosenkranz, *Experimental Investigation of Bit and Power Loading in 10 Gbit/s Next Generation Optical OFDM Access Networks,* InOwO, (2012)

W. Rosenkranz, J. von Hoyningen-Huene, C. Ruprecht, J. Xu, *Electronics and Signal Processing for Next Generation Optical Access and Metro Networks,* SODC, (2012)

R. Rath, J. Leibrich, W. Rosenkranz, *On the Optimization of Link Design Using Nonlinear Equalization for 100Gb/s 16QAM Transmission,* ECOC, **P3.10**, (2012)

S. Adhikari, A.D. Ellis, B. Inan, S.L. Jansen, W. Rosenkranz, *Stabilization of self-coherent OFDM with injection locked laser,* ICTON, **We.A1.2**, (2012)

B. Inan, S.L. Jansen, B. Spinnler, F. Ferreira, D. van den Borne, M. Kuschnerov, A. Lobato, S. Adhikari, V.A.J.M. Sleiffer, N. Hanik, *DSP requirements for MIMO spatial multiplexed receivers,* IEEE Photonics Society's Summer Topicals, (2012)

S. Adhikari, S.L. Jansen, M. Kuschnerov, B. Inan, M. Bohn, W. Rosenkranz, *Investigation of spectrally shaped DFTS-OFDM for long haul transmission,* The International Online Journal of Optics, **Issue26, Vol. 20**, 608 - 614 (2012)

Presentations

J. von Hoyningen-Huene, C. Ruprecht, A. Ali, W. Rosenkranz, *Experimental IM/DD OFDMA Transmission with Scalable Receiver Frontend for PON Scenarios,* OFC 2012, paper OW4B.6, Los Angeles, CA, USA, 06.-08.03.2012

R. Ryf, R. Essiambre, J. von Hoyningen-Huene, P. Winzer, *Analysis of Mode-Dependent Gain in Raman Amplified Few-Mode Fibre,* OFC 2012, paper OW1D.2, Los Angeles, CA, USA, 06.-08.03.2012

J. Xu, A. Ali, C. Ruprecht, J. von Hoyningen-Huene, J. Zhao, J. Leibrich, W. Rosenkranz, *OFDM Remodulation for 10-Gb/s/channel WDM-PON with Simple Carrier Extraction and Enhanced Tolerance to Rayleigh Noise,* OFC 2012, paper OW4B.7, Los Angeles, CA, USA, 06.-08.03.2012

X. Liu, J. Xu, Q. Wang, C.C.K. Chan, *Rayleigh Noise Mitigated 70-km-Reach Bi-directional WDM-PON with 10-Gb/s Directly Modulated Manchesterduobinary as Downstream Signal,* OFC 2012, paper OW1B.2, Los Angeles, CA, USA, 06.-08.03.2012

S. Adhikari, S. Sygletos, A.D. Ellis, B. Inan, S.L. Jansen, W. Rosenkranz, *Enhanced Self-Coherent OFDM by the Use of Injection Locked Laser,* OFC 2012, paper JW2A.64, Los Angeles, CA, USA, 06.-08.03.2012

Y. Chen, S. Adhikari, N. Hanik, S.L. Jansen, *Pilot-aided Sampling Frequency Offset Compensation for Coherent Optical OFDM,* OFC 2012, paper OTh4C.2, Los Angeles, CA, USA, 06.-08.03.2012

A. Diaz, A. Napoli, S. Adhikari, Z. Maalej, A. Lobato, M. Kuschnerov, J. Prat, *Analysis of back-propagation and RF pilot-tone based nonlinearity compensation for a 9x224Gb/s POLMUX- 16QAM system,* OFC 2012, paper OTh3C.5, Los Angeles, CA, USA, 06.-08.03.2012

B. Inan, B. Spinnler, F. Ferreira, A. Lobato, S. Adhikari, V.A.J.M. Sleiffer, D. van den Borne, N. Hanik, S.L. Jansen, *Equalizer Complexity of Mode Division Multiplexed Coherent Receivers,* OFC 2012, paper OW3D.4, Los Angeles, CA, USA, 06.-08.03.2012

W. Rosenkranz, J. von Hoyningen-Huene, *Equalization Equalization Technologies for NGA,* OECC 2012, Busan, South Korea, 02.-06.07.2012

C. Ruprecht, W. Rosenkranz, *OFDMA Based PONs with Reduced Hardware Requirements through Advanced Signal Processing,* ICTON 2012, Tu.B3.2, Warwick, Coventry, UK, 02.-05.07.2012

W. Rosenkranz, J. von Hoyningen-Huene, *Nonlinearity Compensation and Equalization in Access Networks,* OECC 2012, Busan, South Korea, 02.-06.07.2012

J. Leibrich, *Quasi-kontinuierliche Auswahl der spektralen Effizienz durch mehrdimensionale Codierung,* Workshop der ITG Fachgruppe 5.3.1, Nürnberg, Germany, 05.-06.07.2012

D. Clausen, C. Ruprecht, W. Rosenkranz, *Experimental Investigation of Bit and Power Loading in 10 Gbit/s Next Generation Optical OFDM Access Networks,* 17th International OFDM Workshop 2012 (InOwO 2012), Essen, Germany, 29.-30.08.2012

B. Inan, S. Jansen, B. Spinnler, F. Ferreira, D. van den Borne, M. Kuschnerov, A. Lobato, S. Adhikari, V.A.J.M. Sleiffer, N. Hanik, *DSP requirements for MIMO spatial multiplexed receivers,* The IEEE Photonics Society's Summer Topicals 2012, Seattle, Washington, USA, 09.-11.07.2012

W. Rosenkranz, J. von Hoyningen-Huene, C. Ruprecht, J. Xu, *Electronics and Signal Processing for Next Generation Optical Access and Metro Networks,* SODC 2012, Hangzhou, China, 16.-20.09.2012

R. Rath, J. Leibrich, W. Rosenkranz, *On the Optimization of Link Design Using Nonlinear Equalization for 100Gb/s 16QAM Transmission,* ECOC 2012, P3.10, Amsterdam, Nederlands, 16.-20.09.2012

R. Rath, J. Leibrich, W. Rosenkranz, *Digital Back-Propagation for the Improvement of Link Design,* Workshop on Optical Communication Systems, Berlin, Germany, 02.-02.10.2012

J. Leibrich, *Introducing Flexibility into the Network Using Multidimensional Constellations,* Workshop on Optical Communication Systems, Berlin, Germany, 02.-02.10.2012

J. von Hoyningen-Huene, *Nonlinearity Equalization Techniques for DMLTransmission Impairments,* Workshop on Optical Communication Systems, Berlin, Germany, 02.-02.10.2012

Y. Chen, C. Ruprecht, N. Hanik, *System Impairments Mitigation for NGPON2 via OFDM,* Workshop on DSP in Optical Systems, Göteborg, Sweden, 04.-04.10.2012

S. Adhikari, A.D. Ellis, B. Inan, S.L. Jansen, W. Rosenkranz, *Stabilization of self-coherent OFDM with injection locked laser,* ICTON 2012, We.A1.2, Warwick, Coventry, UK, 02.-05.07.2012

Further Activities and Events

Mitgliedschaft von Prof. Rosenkranz in folgenden Gremien:

* Fachausschuss 5.1 der ITG im VDE: *" Signal- und Systemtheorie"*

* Fachausschuss 5.3 der ITG im VDE: *" Optische Nachrichtentechnik"*

* Fachgruppe 5.3.1 der ITG im VDE: *" Simulation und Modellierung in der optischen Nachrichtentechnik"*

* Normungsausschuss 412.2 *" Komponenten für Kommunikationskabelanlagen"* der DKE

Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE

Prof. Rosenkranz ist Mitglied im Programmkomitee folgender internationaler Konferenzen:

* *" IEEE/OSA Optical Fibre Communication (OFC)"*
* *" European Conference on Optical Communications (ECOC)"*
* *" IEEE International Conference on Transparent Optical Networks (ICTON)"*
* *" Asia Communications and Photonics Conference and Exhibition (ACP)"*
* *" International Conference on Computers, Communications and Power (ICCCP)"*
* Chair of the Photonic Detection Technical Group of OSA (Optical Society of America)

Awards

Das Drittmittelprojekt 100GET wurde von Eureka Celtic-Plus als „Candidate for the Innovation Award 2012" nominiert.

Herr Semjon Schaefer wurde vom Förderverein der TF als bester Master-Abschluss im Studiengang Wirtschaftsingenieurwesen Elektrotechnik und Informationstechnik des Studienanfängerjahrgangs 2011 ausgezeichnet.

Computational Electromagnetics

The activities in the Computational Electromagnetics group include the analytical and numerical treatment of electromagnetic fields and corresponding applications towards the solution of relevant technical problems. Research in these areas focuses on the development of methods to analytically and numerically calculate electromagnetic fields (e.g. multipole analysis, finite-difference methods, finite-element methods, integral-equation methods). These methods are then applied to improve existing codes (such as Finite-Difference Time-Domain (FDTD) algorithms) and to investigate and solve problems in the area of Electromagnetic Compatibility (EMC), among others. Furthermore, the research comprises fundamental investigations regarding electromagnetic fields (e.g. uniqueness theory and its application to inverse problems, scattering by canonical objects). Finally, new multipole-based approaches are being investigated to solve biomagnetic problems with the aim to improve corresponding medical applications like magnetoencephalography (MEG) and magnetocardiography (MCG). On the educational side the group offers courses in electromagnetic theory, computational electromagnetics, mathematical methods in field theory, electromagnetic compatibility, fields and waves in biological systems, and tomographic methods in medicine.

Results

a) Time-domain near-field to near-field transformation

Multipole analysis is a classical technique to analytically describe electromagnetic, acoustic, and elastic fields and waves using series expansions. It is an orthogonal decomposition of the field into the dipole, quadrupole, octopole, etc. fields with respect to a chosen origin. Historically, such methods have been successfully employed to solve several classical boundary value problems in the frequency domain. Applications of spherical-multipole analysis include the diffraction by a perfectly conducting or dielectric sphere (Mie solution) and the diffraction by a perfectly conducting cone. The current project uses the extraordinary features of multipole analysis to evaluate and post-process near-fields obtained by numerical schemes. Within the FDTD-method, a near-field to near-field or a near-field to far-field transformation utilizes an equivalence principle: the sources of the field are replaced by electric and magnetic dipoles suitably distributed on a surface completely enclosing all radiating sources. Conventionally, for each far-field point of interest a numerical integration over this whole surface used to be required. As has been shown for the frequency-domain, and later for the time-domain, the new approach avoids that problem. In addition, the analytical multipole expansions of the near- and far-fields allow for a systematic post-processing as well as an enhancement of the numerically obtained results using the spatial frequency filter provided by this technique.

b) Numerical and analytical examination of shielding and shielding effectiveness

Shielding is one of the most important steps to ensure the electromagnetic compatibility of devices and systems. Shape and position of the shielding structures depend on the desired mechanical features and the frequency range of the anticipated disturbances. Quantitative measures of a shield's capability to reduce the influence of electrical and magnetic disturbances at low frequencies are the electric shielding effectiveness and the magnetic shielding effectiveness. However, these measures are not applicable for high frequency disturbances or pulsed (transient) disturbances. Consequently, this research project concentrates on the evaluation of definitions of the shielding effectiveness for these cases. We are particularly interested in the case where the source of interference is located in the near-field as compared to that where it is located in the far-field.

c) Statistical EMC

Statistical EMC is an important part of statistical electromagnetics, as many parameters in EMC (frequencies, amplitudes, waveforms, geometry) are known only by means of their statistical parameters. Such statistically varying parameters might be given in terms of the first few moments of their statistical distributions. The special direction of this research is the combination with a spherical-multipole expansion of the electromagnetic field where the spherical-multipole amplitudes

are described through their statistical moments. This leads to a very compact and non-redundant description of the field statistics applicable, for instance, to the investigation of the statistical moments of the shielding effectiveness as a function of those of the geometrical parameters of the shielding structure. The method is particularly useful in the case of small variations of these parameters.

d) Complex rays and multipole analysis

Geometric optics is used to handle scattering of fields by electrically large objects, i.e. structures of dimensions much larger than the wavelength. At geometric singularities like edges or tips, geometric optics fails and diffraction must be taken into account. This leads to diffraction coefficients which can be shown to dominate the field outside the directions of reflection. Usually, these diffraction coefficients are calculated from solutions for canonical structures. As an example the edge diffraction coefficient has been derived from the series expansion of the field diffracted by a wedge. The associated special case of a half-plane has been solved by Sommerfeld.

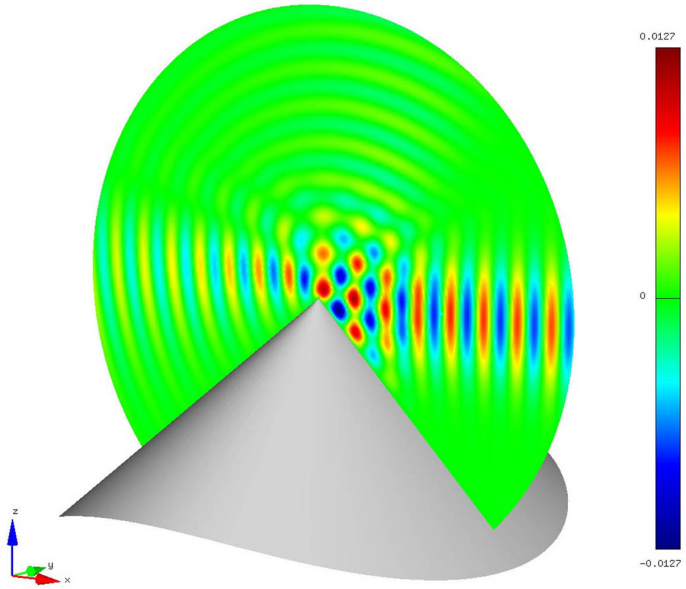

Fig. 1: Snapshot of the acoustic field for a complex-source beam impinging on an acoustically soft semi-infinite circular cone.

In this DFG-sponsored research project we have determined diffraction coefficients for the elliptic cone. This structure is most interesting particularly because it includes a very general tip. Moreover, by appropriately choosing the ellipticity parameters the elliptic cone includes as special cases the circular cone as well as the plane angular sector and the corresponding tip geometries. The associated diffraction coefficients are obtained by a numerical evaluation of the corresponding spherical-multipole expansion in sphero- conal coordinates. The commonly observed convergence problems in the case of plane-wave incidence are avoided by choosing a complex-source beam as the incident field. Possible applications include a more precise consideration of the fields scattered by aircraft and airport constructions to improve instrument landing systems.

e) Multipole-based reconstruction methods for the biomagnetic problem

The project is part of the Collaborative Research Centre (SFB) 855 on "Magnetoelectric Composites - Future Biomagnetic Interfaces" founded by the Deutsche Forschungsgemeinschaft (DFG). It focuses on new strategies for the measurement

of biomagnetic fields (from the brain and heart) on optimized surfaces and new algorithms for the solution of the corresponding inverse problem.

f) Modelling and localization of cardiomagnetic sources

The project is part of the Collaborative Research Centre (SFB) 855 on „Magnetoelectric Composites - Future Biomagnetic Interfaces" founded by the Deutsche Forschungsgemeinschaft (DFG). The goal of this project is to model physiological and pathological currents in the heart by means of a minimal number of unknowns.

Personnel

Head of the group: Prof. Dr.-Ing. L. Klinkenbusch; Secretary: S. Thielbörger (50%)
Technical Staff: Dipl.-Ing. J. Buschmann (50%)

Scientific Staff:

Dipl.-Phys. H. Ahrens	01.01.-31.12.2012		DFG
SFB855 - D1: Multipole-based reconstruction schemes			
Dipl.-Phys. F. Argin	01.01.-31.12.2012		DFG
SFB855 - D1: Multipole-based reconstruction schemes			
M.Sc. H. Brüns	01.11.-31.12.2012		DFG
Scattering by semi-infinite structures			
Dipl.-Phys. K. Körber	01.01.-31.12.2012		CAU
Statistical EMC			
Dr.-Ing. V. Motrescu	01.01.-31.03.2012	(50%)	DFG
SFB 855 - D4: Modelling and reconstruction of magnetocardiographic sources			

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

Elektromagnetische Felder 2, 3 (+ 1) hrs Lecture (+ Exercises)/Week,
L. Klinkenbusch (+ K. Körber)

Numerische Feldberechnung, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
L. Klinkenbusch (+ K. Körber)

Intensivübung Elektromagnetische Felder, 1 hrs Exercise/Week,
L. Klinkenbusch (+ F. Argin, K. Körber, H. Ahrens)

Projekt, 3 hrs Lecture/Week,
L. Klinkenbusch (+ K. Körber)

Tomgraphische Verfahren in der Medizin, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
L. Klinkenbusch (+ H. Ahrens)

Seminar Medizintechnik, 2 hrs Seminar/Week,
L. Klinkenbusch

Summer 2012

Elektromagnetische Verträglichkeit, 2 (+ 1) hrs Lecture (+ Exercises)/Week,

L. Klinkenbusch (+ K. Körber)

Seminar Feldtheorie, 1 hrs Seminar/Week,
L. Klinkenbusch

Elektromagnetische Felder 1, 3 (+ 1) hrs Lecture (+ Exercises)/Week,
L. Klinkenbusch (+ K. Körber)

Mathematische Methoden in der Feldtheorie, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
L. Klinkenbusch (+ K. Körber)

Projekt, 3 hrs Exercise/Week,
L. Klinkenbusch (+ K. Körber)

Felder und Wellen in biologischen Systemen, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
L. Klinkenbusch (+ F. Argin)

Winter 2012/2013

Elektromagnetische Felder 2, 3 (+ 1) hrs Lecture (+ Exercises)/Week,
L. Klinkenbusch (+ K. Körber)

Numerische Feldberechnung, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
L. Klinkenbusch (+ K. Körber)

Intensivübung Elektromagnetische Felder, 1 hrs Exercise/Week,
L. Klinkenbusch (+ F. Argin, K. Körber, H. Ahrens)

Projekt, 3 hrs Lecture/Week,
L. Klinkenbusch (+ K. Körber)

Tomgraphische Verfahren in der Medizin, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
L. Klinkenbusch (+ F. Argin)

Seminar Medizintechnik, 2 hrs Seminar/Week,
L. Klinkenbusch

Third-Party Funds

DFG, *Semi-infinite Strukturen*, 01.01.-31.12.2012 (1/1 E13 + 1 WiMi + Sachmittel)
DFG, *SFB 855 TP D1*, 01.01.-31.12.2012 (2 E13 + Sachmittel)
DFG, *SFB 855 TP D4*, 01.01.-31.03.2013 (0.5 E13)

Further Cooperation, Consulting, and Technology Transfer

1. Prof. Dr. H. Chaloupka, Bergische Universität Wuppertal, Subject: Multimode Antennas

2. Prof. Dr. R. Sikora, Westpommeranian University Szczecin (Poland), Subject: Non-destruction evaluation & ERASMUS partnership

3. Prof. Dr. E. Cardelli, University Perugia (Italy), Subject: ERASMUS partnership

4. Prof. Dr. E. Heyman, Tel-Aviv University (Israel), Subject: Complex-Source Beams and Multipole Expansions

5. Prof. L. Pichon, University Paris-Sud (XV), Paris (France) Subject: EMC of complex systems & ERASMUS partnership

6. Prof. G. Manara, University of Pisa (Italy), Subject: Ray methods & ERASMUS partnership

7. Prof. Dr. K.-J. Langenberg, Kassel University, Subject: Multipole Expansions of Elastic Waves

Diploma, Bachelor's and Master's Theses

Philipp Scheider, *Theoretische Untersuchung einer Multipolantenne zur Messung elektromagnetischer Felder*, 26.04.2012

Hendrik Brüns, *Elektromagnetische Streuung eines Complex-Source Beams (CSB) am Kreiskegel*, 23.10.2012

Christoph Wellert, *Entwicklung und Test einer kugelförmigen Multipolschnittstelle für FDTD*, 14.06.2012

Sebastian Salzer, *Numerische Simulation eines breitbandigen Nahfeldkopplers für die Suszeptibilitätsprüfung von Medizingeräten*, 04.04.2012

Publications

Published in 2012

V. Motrescu, L. Klinkenbusch, *Simulations of magnetocardiographic signals using realistic geometry models of the heart and torso*, Adv. Rad. Sci., **10**, 85 - 91 (2012)

K. Körber, L. Klinkenbusch, *Statistical Multipole Formulations for Shielding Problems*, Adv. Rad. Sci., **10**, 233 - 238 (2012)

F. Argin, H. Ahrens, L. Klinkenbusch, *Improved measurement surface for MEG using magnetic-dipole sources and a spherical-multipole expansion*, Adv. Rad. Sci., **10**, 93 - 97 (2012)

H. Ahrens, F. Argin, L. Klinkenbusch, *A Comparison of minimum norm and MUSIC for a combined MEG/EEG sensor array*, Adv. Rad. Sci., **10**, 99 - 104 (2012)

M. Katsav, E. Heyman, L. Klinkenbusch, *Scattering and Diffraction of a Complex-Source Beam by a Wedge*, Proc. of the 2012 IEEE International Symposium on Antennas and Propagation and USNC/URSI National Radio Science Meeting, Chicago, IL (USA), (2012)

M. Katsav, E. Heyman, L. Klinkenbusch, *Complex-Source Beam Diffraction by an Acoustically Soft or Hard Circular Come (invited)*, Proc. 2012 International Conference on Electromagnetics in Advanced Applications (ICEAA 2012), Cape Town (South Africa), (2012)

Presentations

L. Klinkenbusch, *Sphärische Multipolanalyse des elektromagnetischen Feldes: Harmonie von Theorie und Realität (Invited)*, Festveranstaltung: 50 Jahre Theoretische Elektrotechnik an der Universität Hannover, Hannover, Deutschland, 18.05.2012

M. Katsav, E. Heyman, L. Klinkenbusch, *Scattering and Diffraction of a Complex-Source Beam by a Wedge*, IEEE APS/URSI Symposium 2012, Chicago, USA, 10.07.2012

M. Katsav, E. Heyman, L. Klinkenbusch, *Complex-Source Beam Diffraction by an Acoustically Soft or Hard Circular Cone (invited)*, International Conference on Electromagnetics in Advanced Applications (ICEAA'12), Cape Town, South Africa, 06.09.2012

H. Brüns, L. Klinkenbusch, *Electromagnetic Diffraction and Scattering of a Complex - Source Beam by a Semi - Infinite Circular Cone*, Kleinheubacher Tagung, Miltenberg, Deutschland, 25.09.2012

K. Körber, L. Klinkenbusch, *Statistical Multipole Expansions for Arbitrary Shielding Geometries*, Kleinheubacher Tagung 2012, Miltenberg, Deutschland, 25.09.2012

H. Ahrens, F. Argin, L. Klinkenbusch, *Comparison of the Extended Kalman Filter and the Unscented Kalman Filter for Magnetocardiography Activation Time Imaging*, Kleinheubacher Tagung 2012, Miltenberg, Deutschland, 26.09.2012

F. Argin, H. Ahrens, L. Klinkenbusch, *Optimization of the sensor array for biomagnetic measurements using multipole expansions*, Kleinheubacher Tagung 2012, Miltenberg, Deutschland, 26.09.2012

L. Klinkenbusch, *Sphärische Multipolanalyse des elektromagnetischen Feldes: Geschichtliche Entwicklung und aktuelle Anwendungen (Invited)*, Kolloquium der Technischen Fakultät der Friedrich-Alexander-Universität Erlangen,

Erlangen, Deutschland, 29.11.2012

L. Klinkenbusch, *Spherical-Multipole Expansion of Electromagnetic Fields,* Internal Seminar BMW Forschung und Technik, München, Deutschland, 30.11.2012

Further Activities and Events

Since 2009, Prof. Klinkenbusch has been a Committee member of the German Academic Exchange Service (Deutscher Akademischer Austauschdient - DAAD) for the region Near-East/ North Africa. Until September 2012, Prof. Klinkenbusch served as the Managing Director of the Institute of Electrical and Information Engineering. Since July 2012, he has been acting as Vice Dean of the Faculty of Engineering. He also has been the representative of the Faculty of Engineering in the Schleswig-Holsteinische Universitätsgesellschaft.

Prof. Klinkenbusch is member of VDE, elected member of URSI Commission B, and a Fellow of IEEE. He serves in the IEEE Antennas and Propagation Education Committee. In 2012 he was elected member of the URSI Commission B Technical Advisory Board (B-TAB). In 2012, he has been serving as Technical Reviewer, Chairman, and Organizer of Special Sessions for several international scientific journals and conferences.

Digital Signal Processing and System Theory

At the end of 2012, The group ''Digital Signal Processing and System Theory'' (abbreviated in the following as DSS), comprised two professors, Prof. Dr. Ing. Gerhard Schmidt (head) and Prof. Dr.-Ing. Ulrich Heute, a secretary, and a technician (both also working for the Information & Coding Theory group), two external lecturers, 19 PhD students (internal and external), as well as several co-workers on a short-term job basis. Furthermore, we had several guests during 2012, e.g. Prof. Dr.-Ing. A. N. Hossen from SQU Oman, and Prof. Dr.-Ing. Jürgen Freudenberger from the University of Konstanz.

We focus on two major research topics: **speech and audio processing**, and **medical signal processing**:

- The investigation of speech communication in automotive environments (e.g. hands-free or in-car communication systems) was continued in 2012 and a second car was equipped with various real-time signal processing capabilities in order to verify our theoretical approaches in real automotive environments. Also the investigation of automatic evaluation schemes for in-car communication and for text-to-speech (TTS) systems was continued successfully. While our research in the automotive environment is based on university and industry funding, the research on the evaluation of TTS systems is a cooperative work with the Telecom laboratories at TU Berlin, based on DFG funding. In addition, research on the (real-time) simulation of acoustic environments continued and led to good results, not only in our semi-anechoic chamber but also in smaller environments (such as cars).

- Our cooperation with the Neurology and the Neuropediatrics Department of the University Clinics Kiel continued with great success. The core of this cooperation is based on a huge DFG-funded bundle of 17 scientific projects (''Sonder-Forschungsbereich'', ''SFB-855'') with groups from materials science, physics, electrical and information engineering, and medicine. The DSS part concerns the digital processing of encephalographic signals gained from newly developed magneto-electric sensors. In particular, the cooperation with Prof. Hossen concerns syndrome-classification problems based on such signals. Furthermore, research was started on brain-computer interfaces, which turned out to be a very interesting research branch.

Besides our work in the two main focus areas we continued our cooperation with the Federal-Navy Research Institute for Under-Water Acoustics and Geophysics (FWG) with two interesting research projects: marine mammal detection, and tracking of underwater objects. The large BMWi-funded project ''PITAS'' continued in 2012. The project concerns detection and classification of pirate or terrorist attacks against ships; apart from DSS and three other groups of TF, it involves also teams from four industrial companies in Schleswig-Holstein. This project was prolonged until the end of 2013.

Also in 2012, we were very happy to gain as lecturers in this group, Dr.-Ing. M. Krini (from Nuance in Ulm) and Dr.-Ing. M. Muthuraman (from the Neurology department of our own university). Dr.-Ing. M. Krini and Dr.-Ing. M. Muthuraman teach neural networks, and medical signal processing with special emphasis on frequency domain approaches.

Results

On-going work led to numerous publications and presentations.

Prof. Heute and Prof. Schmidt co-chaired special sessions at the ITG Conference on Speech Communication in Braunschweig, Germany, in September 2012. Prof. Heute's session concerned speech-signal quality: he chaired the session together with Prof. S. Möller, TU Berlin, and Dr. H.W. Gierlich, HeadAcoustics, Herzogenrath, and he presented an overview of current activities on instrumental speech-quality estimation. Prof. Schmidt's session was on automotive signal processing, which he co-chaired with Prof. Fingscheidt from the University of Braunschweig.

In the various fields of DSS, of course, the co-workers presented their results also:

- **Speech quality**: As mentioned, this is still a central item of DSS research within a continuous and extremely fruitful cooperation with "T-Labs" at TU Berlin, especially the group of Prof. Dr.-Ing. Sebastian Möller. The joint DFG project was prolonged until autumn 2013. Christoph Norrenbrock presented results at four conferences in Darmstadt, Germany, Portland, USA ("Interspeech" and "Blizzard Workshop"), and Braunschweig, Germany. An IEEE journal contribution submitted in 2011 appeared in 2012. Furthermore, he was a co-author of various papers with our partners in Berlin.

- **Real-time audio processing**: Meanwhile seven PhD students are using our real-time framework called "KiRAT" in their research projects. This tool is a soft- and hardware combination and the abbreviation "KiRAT" stands for Kiel Real-Time Audio Toolkit. It is used now for speech and audio research in some of our SONAR projects, and for medical research.

  In summer 2012 the DSS audio lab reached its first (of three) expansion stage. It is now possible to work on two cars in parallel, create real-time ambiances with up to 64 input and outputs in parallel, and do signal enhancement, ambiance simulation, and system evaluation at the same time. Fig. 1 shows as an example, the use of the low reverb part of the lab during a recording session for generating a so-called Lombard data base (speech signals that are recorded in very noisy environments with adaptive noise cancellation afterwards).

Fig. 1: Recording session in the low reverb part of the audio lab.

- **Medical signal processing**: Noise and artefact reduction in EEGs and, in the future, MEGs are the central topic of the DSS part of the above mentioned SFB-855, to be carried out by Alina Santillán Guzmán. She presented the state of her work at two SFB seminars in Sankelmark and Leck, in March and September 2012, as well as at an international conference in San Diego, USA.

  The same kinds of signals are also analyzed by Abdul Rauf Anwar, M.Sc., cooperating closely with our lecturer Dr.-Ing. M. Muthuraman who has been a member of the Neurology group of Kiel's University Clinics since 2010. The aim is to find a deeper understanding of tremor diseases and, especially, the mis-led information flow in the brain. Kidist Gebremariam Mideksa, M.Sc., also works with these signals, aiming for a comparison, and possibly, combination of EEG and MEG information. The results of both scientists led to various publications, both in journals and at conferences, notably the IEEE meeting at San Diego, USA.

  Research on brain computer interfaces started in 2012. The DSS team will try to help patients in the "REHA Haus Buchholz" (a nursing home specializing in patients with brain lesions) in simplifying their everyday life. In

order to reach this goal we focus our research now also on robust pattern recognition of commands using low-cost wireless EEG interfaces (see Fig. 2).

Fig. 2: Wireless EEG headset for research on brain-computer interfaces.

- **SONAR signal processing**: Kathrin Wilkens finished her work for an FWG-BMV funded project on active-sonar DSP. The outcome of her work was documented in her dissertation, which was successfully defended in 2012.

  Before he left DSS, Dennis Küter worked on the PITAS system, and especially on novel concepts of sonar sensors. A patent proposal was the outcome of his efforts. His successor was Tim Claussen who is now developing hardware and software components for a complete sonar system, the basic transmitter and receiver of which were constructed by an industrial partner within PITAS. Tim Claussen has made great process with this development and it is now possible to process 46 inputs and 32 output channels at 192 kHz using the KiRAT framework.

- **SONAR and RADAR signal processing**: Viet Duc Nguyen also works with PITAS, and his part concerns object tracking and sensor fusion. He also acts as the project coordinator as far as the TF parts of PITAS are concerned. The state of his and Tim Claussen´s work are documented in two project reports; Viet Duc Nguyen also had a contribution to the international conference on ''Future Security'' in Bonn.

- **Marine-mammal detection and classification**: In close cooperation with FWG and, especially, with Drs. Ludwig, Knoll, and Nissen, a huge database was created and sorted by Roman Kreimeyer. The results of his classification approaches were published at various workshops and conferences.

- **Real-time speech and audio processing**: This topic is the largest one in the DSS team. Currently five internal and four external PhD students are focusing on this topic. Jochen Withopf and also Sebastian Rohde (since summer) are investigating so-called in-car communication systems that improve the communication between the passengers of a vehicle. Anne Theiß continued to investigate automatic evaluation procedures for in-car communication systems. Christian Lüke does research on acoustic environment simulation, allowing for reliable and reproducible testing of speech and audio equipment in virtual environments that are very close to reality. Vasudev Kandade Rajan investigates multi-channel speech enhancement systems for automotive applications and teleconference systems. For the latter type of systems we have now equipped some of our rooms with a multitude of compact microphone arrays, loudspeakers, cameras, and screens (see Fig. 3). The focus here is on the complexity optimized processing (and transmission) of multi-channel HD audio streams.

Fig. 3: Test system for multi-channel HD audio conference systems (here we use 4 compact arrays with 14 microphones in total).

Personnel

Head of the group: Prof. Dr.-Ing G. Schmidt; Secretary: S. Schuchardt (50%)
Technical Staff: Dipl.-Ing. T. Rabsch (50%)

Staff:

Prof. Dr.-Ing. U. Heute	01.01.-31.12.2012	Lecturer and PhD supervisor
Dr.-Ing. M. Krini	01.01.-31.12.2012	Lecturer
Dr.-Ing. M. Muthuraman	01.09.-31.12.2012	Lecturer

Scientific Staff:

M. Sc. A. R. Anwar Brain Information Flow	01.01.-31.12.2012	DAAD / PhD student
M. Sc. H. Bakkari Automotive Signal Processing	01.10.-31.12.2012	External PhD student
Dipl.-Ing. M. Christoph Audio Signal Processing	01.01.-31.12.2012	External PhD student
Dipl.-Ing. Tim Claussen Sonar-System Realization	01.04.-31.12.2012	PITAS / PhD student
M.Sc. M. Haide Environmental Signal Processing	01.01.-31.12.2012	External PhD student
M.Sc. P. Hannon Model-Based Speech Enhancement	01.01.-31.12.2012	External PhD student

M.Sc. V. Kandade Rajan Automotive Speech Enhancement	15.11.-31.12.2012	Industry / PhD student
Dipl.-Ing. R. Kreimeyer Marine-Mammal Protection	01.01.-31.12.2012	FWG / PhD student
Dipl.-Phys. Dennis Küter Sonar-System Concept	01.01.-31.03.2012	PITAS / Co-worker
Dipl.-Phys. C. Lüke Adaptive Ambiance Simulation	01.01.-31.12.2012	CAU / PhD student
M.Sc. Kidist G. Mideksa EEG and MEG Combination	01.01.-31.12.2012	SFB and SH Fell. / PhD st.
Dipl.-Wirtsch.-Ing. D. Nguyen Sensor Fusion and Tracking	01.01.-31.12.2012	PITAS / PhD student
Dipl.-Ing. C. Norrenbrock TTS Speech Quality	01.01.-31.12.2012	DFG / PhD student
M.Eng. K. Pikora Tracking of Underwater Objects	01.01.-31.12.2012	FWG / PhD student
Dipl.-Wirtsch.-Ing. S. Rohde Automotive Signal Enhancement	01.06.-31.12.2012	Industry / PhD student
M.Sc. A. Santillán Guzmán EEG and MEG Signal Enhancement	01.01.-31.12.2012	DFG SFB / PhD student
M.Sc. Sebastian Stenzel Multi-Channel Speech Enhancement	01.01.-31.12.2012	External PhD student
M.Sc. A. Theiß Automatic Evaluation of Automotive Speech Enhancement Systems	01.02.-31.12.2012	CAU / PhD student
Dipl.-Ing. J. Withopf In-Car Communication	01.01.-31.12.2012	CAU / PhD student
M.Sc. A. Wolf In-Car Communication	01.01.-31.12.2012	External PhD student

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

Advanced Digital Signal Processing, 2 (+1) hrs Lecture (+ Exercises)/Week,
G. Schmidt (+ V. Kandade Rajan)

Advanced Signals and Systems, 3 (+2) hrs Lecture (+ Exercises)/Week,
G. Schmidt (+ A. Theiß)

Speech and Audio Processing - Recognition and Audio Effects, 2 (+1) hrs Lecture (+ Exercises)/Week,
G. Schmidt (+ C. Lüke)

Signals and Systems II, 2 (+1) hrs Lecture (+ Exercises)/Week,

G. Schmidt (+ J. Withopf)

Communications Lab, 3 hrs Lab/Week,
G. Schmidt (+ together with several members of the faculty)

Summer 2012

Speech and Audio Processing - Adaptive Filters, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
G. Schmidt (+ C. Lüke)

Digital Signal Processing, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
G. Schmidt (+ A. Theiß)

Signals and Systems I, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
G. Schmidt (+ J. Withopf)

Neural Networks, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
M. Krini

System Theory Lab, 3 hrs Lab/Week,
G. Schmidt (+ A. Theiß)

Seminar on Topics in Digital and Optical Communications, 3 hrs Seminar/Week,
G. Schmidt (+ together with several members of the faculty)

Real-Time Processing Lab, 3 hrs Lab/Week,
G. Schmidt (+ C. Lüke)

Winter 2012/2013

Advanced Digital Signal Processing, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
G. Schmidt (+ V. Kandade-Rajan)

Advanced Signals and Systems, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
G. Schmidt (+ A. Theiß)

Speech and Audio Processing - Recognition and Audio Effects, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
G. Schmidt (+ C. Lüke)

Signals and Systems II, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
G. Schmidt (+ J. Withopf)

Communications Lab, 3 hrs Lab/Week,
G. Schmidt (+ together with several members of the faculty)

Real-Time Processing Lab, 3 hrs Lab/Week,
G. Schmidt (+ C. Lüke)

Medical Signal Processing, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
M. Muthuraman

Third-Party Funds

Industry, *Research on the topics described before*, 01.01.-31.12.2011 (Adequate payment)
Bundesamt für Wehrtechnik und Beschaffung (BMV), *New Concepts for Sonar Detection, Classification, and Tracking*, 01.01.-31.12.2011 (Adequate payment)
Bundesamt für Wehrtechnik und Beschaffung (BMV), *Detection and Classification of Marine Mammals by means of Speaker-Recognition Methods*, 01.01.-31.12.2012 (50 000 EUR)

DFG, *Synthetic Speech-Signal Quality Measurement,* 01.01.-31.12.2011 (60 000 EUR)
DFG / SFB-855, *Digital Signal Processing for New MEG Sensors,* 01.01.-31.12.2012 (68 000 EUR)
BMWi, *PITAS,* 01.01.-31.12.2012 (120 000 EUR)
DAAD, *Brain Source Analysis,* 01.01.-31.12.2011 (18 000 EUR)
Grad. Fellowship SH, *EEG and MEG Combination,* 01.01.-31.12.2012 (15 000 EUR)

Diploma, Bachelor's and Master's Theses

M. Fischer, *Empirical Mode Decomposition Applied on EEG Signals in Real Time,* 01.11.2012
L. Joldrichsen, *Echtzeitimplementierung eines frequenzselektiven Verfahrens zur Wiedergabe bewegter virtueller Quellen,* 01.09.2012
C. Manß, *Analyse des Partikel-Filters unter Berücksichtigung neuester Rechnertechnologie,* 01.08.2012
S. Jaschke, *Establishment and Analysis of a Speech Database in Consideration of the Lombard Effect,* 01.08.2012
D. Jesch, *Pitch Estimation of Marine Mammal Vocalizations,* 01.07.2012
S. Rohde, *Untersuchung von Methoden zur Unterdrückung akustischer Rückkopplungen,* 01.06.2012
J. Harmstorf, *Aufzeichnung und Echtzeit-Verarbeitung räumlicher Audiosignale zur Reproduktion akustischer Umgebungen,* 01.06.2012
M. Brodersen, *Analyse von Mikrofonsignalen und automatische Mikrofonkalibrierung,* 01.05.2012
M. Glukhova, *Automated Evaluation of In-Car Communication Systems within a Real-Time Framework,* 01.05.2012
B. Temesgen Gebru, *Automated Quality Assessment of Text-to-Speech Signals Using Acoustic Markers,* 01.05.2012
S. Heidkamp, *Implementierung eines Echtzeitsystems zur Bandbreitenerweiterung von schmalbandigen Sprachsignalen,* 01.04.2012
F. Köster, *Instrumentelle Schätzung prosodischer Qualiät für synthetisierte Sprachsignale,* 01.04.2012
M. Dechert, *Optimierung der Signalwiedergabe von kommunikationsunter-stützenden Systemen in Fahrzeugen,* 01.02.2012
N. Eiselt, *Entwicklung und Aufbau mehrdimensionaler Mikrofon-Arrays zur Echtzeit-Sprachverbesserung mittels Beamforming,* 01.01.2012

Dissertations / Postdoctoral Lecture Qualifications

Kathrin Wilkens, *Multi-Hypothesentracking-Verfahren mit datenfusionierenden Algorithmen,* 30.03.2012

Publications

Published in 2012

G. Schmidt, A. Theiß, J. Withopf, A. Wolf, *Evaluation of In-Car Communication Systems,* J. Hansen, P. Boyraz, K. Takeda, H. Abut (eds.), Digital Signal Processin for In-Vehicle Systems and Safety, Springer, 73 - 107 (2012)
F. Hinterleitner, C. Norrenbrock, S. Möller, U. Heute, *What Makes this Voice Sound so Bad? A Multidimensional Analysis of state-of-the-art Text-to-Speech Systems,* Proc. IEEE SLT Workshop, Miami, Florida, USA, (2012)
V. D. Nguyen, *Small-Target Radar Detection and Tracking within the PITAS Hard- and Software Environment,* Future Security Conference, Bonn, Germany, (2012)
A. Santillán Guzmán, U. Heute, U. Stephani, A. Galka, *Muscle Artifact Suppression Using Independent-Component Analysis and State-Space Modelling,* IEEE-EMBS, San Diego, USA, (2012)
C. Norrenbrock,, F. Hinterleitner, U. Heute, S. Möller, *Towards Perceptual Quality Modeling of Synthesized Audiobooks-Blizzard Challenge 2012,* Blizzard Challenge Workshop, Portland, OR, USA, (2012)
C. Norrenbrock, F. Hinterleitner, U. Heute, S. Möller, *On the Use of Vocal-Tract Approximations for Instrumental Quality Assessment,* ITG Fachtagung Sprachkommunikation, Braunschweig, Germany, (2012)
C. Norrenbrock, F. Hinterleitner, U. Heute, *Dimension-based Diagnostic Prediction of Speech Quality,* ITG Fachtagung

Sprachkommunikation, Braunschweig, Germany, (2012)
J. Withopf, G. Schmidt, *Suppression of Instationary Distortions in Automotive Environments*, ITG Fachtagung Sprachkommunikation, Braunschweig, Germany, (2012)
M. Krini, G. Schmidt, *Method for Temporal Interpolation of Short-term Spectra and its Appliction to Adaptive System Identification*, Proc. ICASSP, Kyoto, Japan, (2012)
J. Withopf, L. Jassoume, G. Schmidt, A. Theiß, *A Modified Overlap-Add Filter Bank With Reduced Delay*, Proc. DAGA, Darmstadt, Germany, (2012)
C. Lüke, J. Bajorat, G. Schmidt, *Real-Time Implementation of an Adaptive Beamformer-Postfilter System*, Proc. DAGA, Darmstadt, Germany, (2012)
S. Ludwig, V. Peschko, D. Lorenzen, R. Kreimeyer, M. Knoll, *Acoustic and Visual Survey of Cetaceans in the Azores Front Area*, 26th Annual Conference of the ECS, Gallway, Ireland, (2012)
R. Kreimeyer, *Merkmalsextraktion von Klicklauten zur Erkennung von Meeressäugern*, Proc. DAGA, Darmstadt, Germany, (2012)
C. Norrenbrock, F. Hinterleitner, U. Heute, *On Prosodic Quality of Text-to-Speech Signals*, Proc. DAGA, Darmstadt, Germany, (2012)
R. Kreimeyer, *Feature Extraction of Modulated Marine-mammal Sounds for Species Classification*, Proc. ECUA 2012, Edinburgh, Scotland, (2012)
C. Norrenbrock, F. Hinterleitner, U. Heute, S. Möller, *Instrumental Assessment of Prosodic Quality for Text-to-Speech Signals*, IEEE Signal Processing Letters, **19(5)**, (2012)
F. Hinterleitner, C. Norrenbrock, S. Möller, *On the Use of Fujisaki Parameters for the Quality Prediction of Synthetic Speech*, Proc. ESSV, Cottbus, Germany, (2012)

Patent Applications

Dennis Küter, U. Heute, *Detektion und Ortung unter Wasser mit einem quasi-kontinuierlichen Signal*, DPMA, 12.08.2012, 102012017131.5

Further Activities and Events

Membership and activities of U. Heute:

- Advisory Committee, European Association for Signal, Speech, and Image Processing (EURASIP),
- Scientific Committee, ISCA International Conference on Speech Processing (''Interspeech 2012''), Portland, USA,
- Scientific Committee and Session Co-Chair, ITG Conference on Speech Communication, Braunschweig, Germany,
- Reviewer for various international journals (IEEE, EURASIP / Elsevier, Springer, etc.)
- Editorial Board of the CAU University Journal ''Christiana Albertina'',
- Section Head, SH University Association, Kiel Section

Membership and activities of G. Schmidt:

- Member of the ITU focus group ''CarCom'' (standardization in telecommunication),
- Scientific Committee and Session Co-Chair, ITG Conference on Speech Communication, Braunschweig, Germany,
- Reviewer for various international journals (IEEE, EURASIP / Elsevier, Springer, etc.)

The paper ''*What makes this Voice Sound so Bad? A Multi-Dimensional Analysis of State-of-the-Art Text-to-Speech Systems*'' by F. Hinterleitner, C. Norrenbrock, S. Möller, and U. Heute achieved a ''Best-Paper Award'' at the ''Spoken-Language Technology Workshop'' (SLT'12) at Miami Beach, USA, Dec. 2012.

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Information and Coding Theory

The **research activities** of the Information and Coding Theory group (ICT) of the University of Kiel are in the general area of baseband signal processing for wireless digital communications. Emphasis is on the design and evaluation of new digital transmission techniques and systems, the evolution of existing wireless standards, and the development of corresponding software algorithms. The proposed transmission techniques are motivated by insights from applied information theory. Among our goals is to serve more users in future cellular radio systems, to increase data rates, and to reduce transmission power and signal bandwidth per data bit.

The main expertise is in the area of channel coding (turbo codes, low-density parity check codes, decoding with reliability information, space-time codes), applied information theory (particularly multi-user information theory), digital modulation schemes (adaptive modulation and channel coding, superposition modulation, orthogonal frequency-division multiplexing), joint communication and navigation, and development of modern receiver algorithms (equalization, channel estimation, synchronization, interference rejection). Among the applications are cellular radio systems (GSM and UMTS enhancements, WLAN, LTE, LTE-Advanced), EM underwater communications, in-body communications, satellite radio, and terrestrial broadcasting systems.

Concerning **teaching**, we offer lectures and exercises, partly in English, on channel coding, information theory, wireless communications and advanced wireless communications with the emphasis on digital signal processing, within the international master's course on "Digital Communications". A lecture on time series analysis (with a focus on medical applications) is offered in the form of a teaching assignment. Furthermore, several seminars and labs are provided for our bachelor's and master's students.

Results

Superposition Modulation (Dapeng Hao, Meelis Noemm, Tianbin Wo). Superposition modulation (SM) is a novel digital modulation scheme that can be used in high-rate mobile communications. The signal points of SM are derived by linearly superimposing binary antipodal symbols with proper power and phase allocation. Unlike conventional PSK/QAM modulation, the signal points of SM are quasi-Gaussian distributed instead of being designed. A special case of SM is interleave-division multiplexing (IDM). IDM can be used as a coded modulation scheme or as a multiplexing scheme. It is particularly suitable for hierarchical signalling.

Power and phase allocation is an important issue for superposition modulation. The constellation diagram and the maximum achievable mutual information are highly influenced by the applied power and phase allocation. Different power and phase allocation schemes were investigated and compared; we observed that conventional rectangular QAM modulation could be derived by SM with unequal power and orthogonal phase allocation. In the low-to-moderate signal-to-noise region, SM with equal power and uniform phase allocation shows higher potential to achieve the Shannon capacity than other power and phase allocation schemes.

Besides extensive investigations on power and phase allocation of SM, the information theoretical properties of SM were investigated. By means of an extensive analysis, the pros and cons of SM have been clarified, and also its potential, in the sense of approaching the capacity of the Gaussian channel, and is now well understood. Theoretical limits for coded as well as uncoded SM systems were derived, which serve as guidelines for practical system design.

The most important result is in finding reasons for the previously known limit on the bandwidth efficiency of coded SM systems. Based on this finding, novel coding schemes have been investigated to further improve the system performance. With sophisticated channel coding employing long codewords, our results are less than 1 dB away from channel capacity even for large bandwidth efficiencies, which currently marks the world record.

Joint Communication and Navigation (Rebecca Adam, Kathrin Schmeink). Joint communication and navigation is gaining more and more interest in research. The advantages and applications cover a wide range. In particular, there are many synergy effects that can be exploited. However, it is a challenging task to combine communication and navigation because the requirements of both techniques are quite different. ICT tries to face this problem with a generic system concept based on different multiple access schemes. The core part of the concept is joint channel and parameter estimation. A maximum-likelihood approach has been investigated, which leads to a nonlinear optimization problem. Different optimization algorithms have been applied, such as the Levenberg-Marquardt method, particle swarm optimization, and simulated annealing. Performance limits like the Cramer-Rao Lower Bound (CRLB) have been derived, and the influence of oversampling has been investigated and shown to be beneficial. Furthermore, the overall system performance has been investigated for different realistic channel scenarios.

Channel Estimation and Interference Cancellation for MIMO-OFDM (Dapeng Hao, Christopher Knievel, Zhenyu Shi). Multi-user multiple-input multiple-output (MIMO) transmission techniques in combination with orthogonal frequency-division multiplexing (OFDM) promise to provide the desired performance of next-generation cellular radio systems. MIMO-OFDM has been selected as a key technology for the IEEE 802.11n wireless local area network (WLAN) standard and for 3GPP Long Term Evolution (LTE), which is the successor of third generation cellular radio systems (such as UMTS). The successor of LTE, called LTE-Advanced (LTE-A), is expected to close the gap between stationary and mobile communications by supporting high data rates.

Channel estimation, data detection, and interference cancellation are challenging tasks in multi-antenna scenarios. ICT developed a graph-based iterative receiver employing joint data detection and channel estimation, which utilizes correlation in time, frequency, and space in order to improve channel estimation and data detection quality. This graph-based receiver has lower computational complexity, expands the restriction of training symbols, and shows very good performance when compared to iterative as well as non-iterative state-of-the-art algorithms.

Recently, additional effort has been spent on graph-based soft channel estimation and data detection. By means of improving the initialization and by taking into account inherent correlation caused by the message exchange, the algorithm could be significantly improved to support higher-order modulation formats. The improved receiver supports a larger variety of channel codes and even copes with a very small number of training symbols. It has been tested for cellular environments taking co-channel interference into account. Emphasis has been on 3GPP LTE-A as a special application.

Diver Detection (Meelis Noemm). Within the BMWi project PITAS, a piracy and terrorism defence system for ships is being developed. In this framework, ICT proposed an advanced signal design for diver detection that is capable of discriminating between moving objects (like divers) and stationary objects (like the sea bed), while providing an improved range resolution compared to alternatives. A patent application is pending.

Time Series Analysis (Andreas Galka). The work of A.Galka deals with the development and application of new tools for the analysis of time series from neuroscience, such as electroencephalograms (EEG) and functional magnetic resonance imaging (FMRI) data sets. In most cases the analysis is based on state-space modelling within a Kalman filtering and maximum-likelihood framework. Tasks such as artefact removal, noise reduction, decomposition into physiological components, source analysis, and estimation of task or stimulus related activations can be approached by this analysis.

Hybrid RF/FSO MIMO Transmission (Mark Gregory). Driven by the demand for extremely high data rates but also secure data transmission and license-free operation, free-space optical communication has been studied increasingly over the last few years. Broadband sensor performance needs high-speed interfaces for the data; sensitive data needs secure data transmission and a high availability.

To satisfy these demands, a hybrid transmission system has been studied, combining the advantages of radio frequency (RF) and free-space optical (FSO) systems. It has been shown and proven by field measurements that the complementary behaviour of both systems to channel impacts can highly increase the availability, particularly in a maritime environment.

A promising technique that increases the performance of both FSO links and RF links is the multiple-input multiple-output (MIMO) approach. It has been shown that this well-known technique to mitigate fading effects can be applied to the optical domain to decrease the impact of light wave distortion due to propagation in a turbulent medium.

In 2012, the receiver side of an FSO MIMO system was investigated further. Linear as well as nonlinear detectors in combination with different coding/decoding schemes have been applied to measured channel data.

Personnel

Head of the group: Prof. Dr.-Ing. P. A. Hoeher; Secretary: S. Schuchardt (50%)
Technical Staff: Dipl.-Ing. T. Rabsch (50%)

Scientific Staff:

Dipl.-Ing. R. Adam Joint Navigation and Communication	01.04.2009-31.12.2012	DFG
Dipl.-Ing. G. Forkel Network Coding	01.10.-31.12.2012	CAU
Dr. rer. nat. A. Galka Time Series Analysis	01.06.2009-31.12.2012	Lecturer
Dipl.-Ing. M. Gregory Free-space Optical MIMO Communications	01.01.2010-31.12.2012	External PhD Student
M.Sc. Dapeng Hao 3GPP LTE-A	01.01.2007-30.09.2012	Industry
Dipl.-Ing. Ch. Knievel 3GPP LTE-A	15.03.2009-31.12.2012	CAU
M.Sc. M. Noemm Sonar Signal Design	01.06.2009-31.12.2012	BMWi
Dipl.-Ing. K. Schmeink Joint Navigation and Communication	01.04.2007-30.06.2012	CAU
M.Sc. Z. Shi Superposition Modulation	01.01.2009-31.12.2012	DFG
M.Sc. A. Yaqot Convex Optimization for Cognitive Radio	01.10.-31.12.2012	DAAD
Dipl.-Ing. V. Zeiger Underwater Navigation	01.01.2010-31.12.2012	External PhD Student

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

Grundlagen der Kanalcodierung, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
P.A. Hoeher (+ and Research Assistants)

Information Theory and Coding I, 2 (+ 1) hrs Lecture (+ Exercises)/Week,

P.A. Hoeher (+ and Research Assistants)

Advanced Wireless Communications (DSP), 2 (+1) hrs Lecture (+ Exercises)/Week,
P.A. Hoeher (+ and Research Assistants)

Communications Lab, 4 hrs Practical/Week,
P.A. Hoeher (+ W. Rosenkranz, G. Schmidt, and Research Assistants)

Advanced Topics Lab, 4 hrs Practical/Week,
P.A. Hoeher (+ W. Rosenkranz, G. Schmidt, and Research Assistants)

Informationstechnik und Codierung, 1 hrs Seminar/Week,
P.A. Hoeher

Summer 2012

Theoretische Grundlagen der Informationstechnik, 2 (+1) hrs Lecture (+ Exercises)/Week,
P.A. Hoeher (+ and Research Assistants)

Information Theory and Coding II, 2 (+1) hrs Lecture (+ Exercises)/Week,
P.A. Hoeher (+ and Research Assistants)

Wireless Communications (DSP), 2 (+1) hrs Lecture (+ Exercises)/Week,
P.A. Hoeher (+ and Research Assistants)

Real-time Signal Processing Lab, 4 hrs Practical/Week,
P.A. Hoeher (+ W. Rosenkranz, G. Schmidt, and Research Assistants)

Informationstechnik und Codierung, 1 hrs Seminar/Week,
P.A. Hoeher

Time Series Analysis, 2 (+1) hrs Lecture (+ Exercises)/Week,
A. Galka

Projekt, 3 hrs Seminar/Week,
P.A. Hoeher (+ and Research Assistants)

Winter 2012/2013

Grundlagen der Kanalcodierung, 2 (+1) hrs Lecture (+ Exercises)/Week,
P.A. Hoeher (+ and Research Assistants)

Information Theory and Coding I, 2 (+1) hrs Lecture (+ Exercises)/Week,
P.A. Hoeher (+ and Research Assistants)

Advanced Wireless Communications (DSP), 2 (+1) hrs Lecture (+ Exercises)/Week,
P.A. Hoeher (+ and Research Assistants)

Communications Lab, 4 hrs Practical/Week,
P.A. Hoeher (+ W. Rosenkranz, G. Schmidt, and Research Assistants)

Advanced Topics Lab, 4 hrs Practical/Week,
P.A. Hoeher (+ W. Rosenkranz, G. Schmidt, and Research Assistants)

Informationstechnik und Codierung, 1 hrs Seminar/Week,
P.A. Hoeher

Third-Party Funds

DFG, *Joint Navigation and Communication based on Interleave-Division Multiple Access (HO 2226/11-1)*, 15.03.2009-30.11.2013 (1xE13 + Working and Travelling Expenses)
DFG, *Superposition Mapping: Theory and Applications (HO 2226/12-1)*, 01.10.2010-30.09.2012 (1xE13 + Working and Travelling Expenses)
DFG, *Superposition Mapping: Theory and Applications (HO 2226/12-2)*, 01.10.2012-30.09.2013 (1x13 + Working and Travelling Expenses)
Industry, *3GPP LTE-A Interference Cancellation*, 01.10.2010-30.09.2012 (NDA)
BMWi, *PITAS (Pirate Defense)*, 01.09.2010-31.08.2013 (ca. 200000 EUR/group)

Further Cooperation, Consulting, and Technology Transfer

Besides cooperation with other universities, the Information and Coding Theory Lab has collaborations with numerous companies and research institutes, including:

- DoCoMo Euro Labs, Munich,
- GEOMAR Helmholtz Centre for Ocean Research, Kiel,
- L-3 Communications ELAC Nautik GmbH, Kiel,
- Raytheon Anschütz, Kiel,
- Tesat Spacecom, Backnang.

Diploma, Bachelor's and Master's Theses

A. Mourad, *Low-Complexity Channel Coding for Superposition Modulation*, 22.02.2012
A. Joecks, *Mehrkanalkombination zur Nutzung von Diversität in inkohärenten Empfängern für Mehrträgersysteme in der akustischen Unterwasserkommunikation*, 10.04.2012
B. Khan, *Irregular Convolutional Coding for Superposition Modulation*, 30.11.2012
J.P. Neira Vesga, *Beamforming for Multi-Dimensional Graph-Based Channel Estimation in LTE-A*, 07.12.2012
R. Chepyha, *Impact of Morphology and Topology on LTE Coverage*, 11.12.2012
K. Khadka, *Detection Algorithms for Superposition Modulation*, 27.12.2012

Dissertations / Postdoctoral Lecture Qualifications

K. Schmeink, *Joint Communication and Positioning based on Interleave-Division Multiplexing*, 09.11.2012

Publications

Published in 2012

C. Knievel, P.A. Hoeher, A. Tyrell, G. Auer, *Multi-dimensional graph-based soft iterative receiver for MIMO-OFDM*, IEEE Transaction on Communications, **60**, 1599 - 1606 (2012)
T. Wo, P.A. Hoeher, Z. Shi, *Graph-based soft channel estimation for fast fading channels*, IEEE Transactions on Wireless Communications, **11**, 4243 - 4251 (2012)
C. Knievel, P.A. Hoeher, G. Auer, *On the combining of correlated random measures with application to graph-based receivers*, IEEE Communications Letters, **16**, 1996 - 1999 (2012)

C. Knievel, P.A. Hoeher, *On particle swarm optimization for MIMO channel estimation,* Journal of Electrical and Computer Engineering, **2012**, (2012)

K. Schmeink, R. Adam, P.A. Hoeher, *Performance limits of channel parameter estimation for joint communications and positioning,* EURASIP Journal on Advances in Signal Processing, **2012:178**, (2012)

M. Noemm, A. Mourad, P.A. Hoeher, *Superposition modulation with irregular convolutional coding,* in Proc. IEEE GLOECOM, Anaheim, USA, (2012)

C. Knievel, P.A. Hoeher, A. Tyrell, G. Auer, *Improving multi-dimensional graph-based soft channel estimation,* in Proc. IEEE Vehicular Technology Conference, Yokohama, Japan, (2012)

M. Gregory, P.A. Hoeher, *Log-APP detection for FSO repetition MIMO links,* in Proc. IEEE Int. Conference on Space Optical Systems and Applications (ICSOS '12), Ajaccio, France, (2012)

V. Zeiger, S. Badri-Hoeher, P.A. Hoeher, *Impact of speed of sound uncertainties on model-based positioning,* in Proc. of MTS/IEEE OCEANS '12, Hampton Roads, VA, USA, (2012)

Z. Shi, P.A. Hoeher, *Low-density hybrid check coded superposition mapping in BICM-OFDM,* in Proc. 7th International Symposium on Turbo Codes & Iterative Information Processing, Gothenburg, Sweden, (2012)

D. Hao, P.A. Hoeher, *A low-complexity tree search detection algorithm for superposition modulation,* in Proc. 7th International Symposium on Turbo Codes & Iterative Information Processing, Gothenburg, Sweden, (2012)

V. Zeiger, S. Badri-Hoeher, P.A. Hoeher, *Model-based positioning,* in Proc. Oceanology International, London, UK, (2012)

Patent Applications

M. Noemm, P.A. Hoeher, *Signal Design for Diver Detection,* Deutsches Patent- und Markenamt, 22.07.2012, DPMA-Az. 10 2012 105 460.6

Further Activities and Events

Prof. Dr. Peter Adam Hoeher is a director of the Institute of Electrical and Information Engineering, member of the Convention of the Faculty of Engineering, head of the examination board on Digital Communications, member of the examination board on Electrical Engineering, head of the advisory board of the Institute of Electrical and Information Engineering, and the Bafög representative of the Institute. He is a member of the Excellence Cluster "The Future Ocean". He is an IEEE Senior Member, vice-chair of the German chapter of the IEEE Communications Society, member of the VDE/ITG Fachausschuss 5.1, and co-founder and managing director of a start-up in telecommunications. In 2012, he has been heading an appointments committee on Control Theory.

Dipl.-Ing. Rebecca Adam has been on sabbatical at UCLA, Los Angeles.

Dipl.-Ing. Christopher Knievel is a member of the examination board on Electrical & Information Engineering and on Industrial Engineering.

M.Sc. Meelis Noemm is a member of the examination board on Digital Communications.

Dr.-Ing. Tianbin Wo has received the CAU Faculty Award for his outstanding PhD thesis.

M.Sc. Alaa Mourad has received the Werner Petersen Award for his outstanding master's thesis.

M.Sc. Najeeb ul Hassan has received the DAAD award for his outstanding master's thesis.

Integrated Systems and Photonics

The research activities of the group for Integrated Systems and Photonics (ISP) focus on projects in the areas of nanotechnology, optical technologies, and integrated systems. The research covers the entire spectrum of modelling, design, fabrication, and experimental characterization. As Prof. Dr. Martina Gerken is taking a parental leave of absence, Dr.-Ing. Jost Adam has been heading the group since October 2012. Dr. Adam is a postdoctoral fellow with the Photonics Laboratory, University of California, Los Angeles, and an expert in numerical modelling, waveguide theory and high-throughput optical microscopy.

In 2012 we successfully acquired two new research projects: Prof. Dr. Martina Gerken was awarded an ERC Starting Grant of 1.5 M EUR for five years to evaluate photo-switching of smart surfaces for integrated biosensors; funding of a joint project with the university hospital of the LMU in Munich was granted by the BMBF for demonstration of multiparameter, label-free, optical biosensors. Furthermore, we started a joint DFG project with the Fraunhofer Institute for Silicon Technology in Itzehoe to investigate wafer-level microoptical systems.

2012 was a successful research year with many results that are detailed below as well as in our publications. Three particular highlights were: 1. The successful bio-functionalized of photonic crystal surfaces with aptamers for the label-free optical detection of thrombin, 2. the demonstration of a compact passive, pressure sensing device that may be read remotely with an optical beam, and 3. the demonstration of a tuneable virtually imaged phased array (VIPA).

Results

Nanostructured organic light emitting diodes (OLEDs)

Organic light emitting diodes (OLEDs) show great potential for general lighting applications. At present, in conventional OLEDs, only 20% of the generated light is emitted to free space, while about 80% is trapped as waveguide modes or surface plasmon polaritons in the OLED layer stack, or by total internal reflection in the substrate. We investigate nanostructuring of the emitter layer as a technique to increase the light outcoupling from OLEDs. Many parameters of the geometry are to be considered together with the OLED's broad wavelength range when optimizing the light outcoupling. In order to sweep this large parameter space, in 2012 we implemented the fast, matrix algebra-based, rigorous-coupled-wave analysis (RCWA) that calculates radiation coupling of the leaky modes. We found that the organic stack thickness plays an important role in the radiation coupling and that the choice of thickness can significantly increase the light outcoupling.

Experimentally, we focused on nanostructured layers close to the emission layer fabricated by nanoimprint lithography. Conventional imprint resist layers exhibit a refractive index close to that of the organic emission layers. In order to increase the outcoupling efficiency of the imprinted grating structure, a high refractive index contrast is desired. We experimented with different grating layers obtained by introducing nanoparticles into polymer grating layers to increase their refractive index.

Biosensors employing photonic crystal slabs

The detection of biological materials, e.g. biomarkers or microbial pathogens, is of high importance for human health. We investigate label-free biosensors employing a periodically nanostructured sensor surface (photonic crystal slab). In 2012 we worked on optimizing the sensitivity of the photonic crystal slab that is used as the transducer. Finite-difference time-domain simulations and experimental measurements were performed to maximize the response of the signal to mass changes on the surface of the PCS. We found that modifying the geometry of the PCS, such as its slab thickness, changes the sensitivity by a factor of 14.5, thus demonstrating the requirement of optimized photonic crystal slabs. In collaboration with the group of Dr. Buhmann at the university hospital of the LMU in Munich we demonstrated experimentally label-free detection of the protein thrombin. We immobilized the anti-thrombin aptamers on the surface of a photonic crystal slab using a self-developed local bio-functionalization procedure containing silanization of the surface. In a further step, which

was the actual bio-detection, we brought a buffer solution spiked with thrombin onto the surface of the bio-functionalized photonic crystal slab. The response triggered by the binding process between the aptamers and the thrombin proteins was detected optically as shown in Fig. 1.

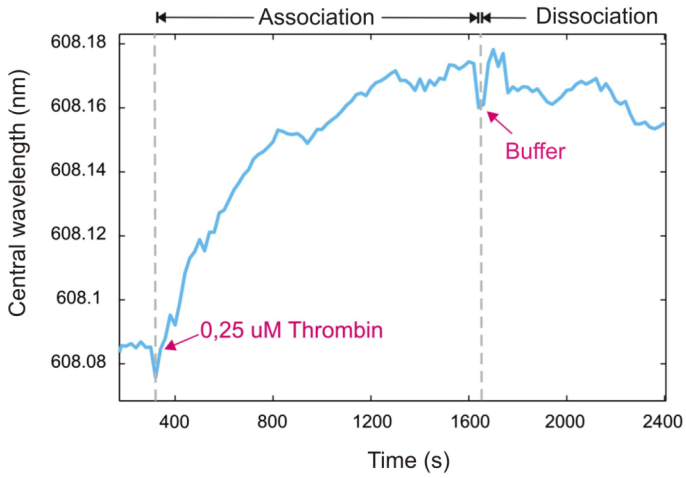

Fig. 1: Binding kinetics of thrombin to a bio-functionalized photonic crystal surface measured by evaluation of the central wavelength of an optical resonance.

Using a photonic crystal slab as a transducer, we developed a compact biosensor with an OLED as the light source and an organic photodiode (OPD) as the detector. Crossed polarization filters are used to suppress excitation light. Hence, only the resonances provided by the photonic crystal slab are observed at the OPD. To demonstrate the refractive index dependency of the signal, we used two different refractive indices: pure water (n = 1.33), and a blend of water and glycerol (n = 1.43). As expected, an increase of the refractive index leads to an intensity decrease in the OPD current. This new system is promising for mobile applications.

Integrated optics

Integrated optical systems are interesting for many applications. In 2012 we investigated two types of integrated optical systems: a pressure measurement system, and a tuneable virtually imaged phased array.

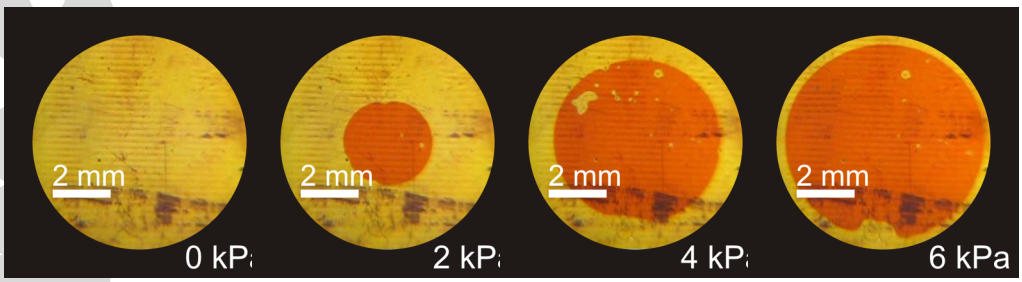

Fig. 2: Photographs of the visual pressure sensor image for four different pressure values.

We experimentally demonstrated a pressure sensor consisting of a small chamber sealed by a polydimethylsiloxan-membrane. Near this membrane a photonic crystal slab is placed on the inside of the chamber. By raising the pressure outside the chamber the membrane is deformed towards the inside and contacts the photonic crystal slab. The evaluation is performed by taking optical transmission images through the slab. In areas where the membrane touches the photonic crystal surface, the effective refractive index of the mode changes due to the higher refractive index of the membrane compared to air. This higher refractive index leads to a shift of the mode's central wavelength. By filtering the transmission

spectrum through the PCS with a certain configuration of crossed polarization filters the resulting resonance shift is visible as a colour change. Hence, the contact area can now be seen as a coloured dot with a high contrast to the surrounding non-contact area (Fig. 2). The size of this dot is indicative of the pressure outside the chamber. The pressure sensor is completely passive and may be evaluated remotely using an optical beam.

A virtually imaged phased array (VIPA) is based on a modified Fabry-Perot resonator and acts as a spectral disperser. Focussed light entering the entrance window results in multiple reflected beams, which interfere with each other and form a periodic angular dispersion pattern (Fig. 3(a)). The resonator consists of a PDMS-layer (170 um) sandwiched between a highly-reflective and a semi-transparent silver layer. Tuning is achieved by Joule heating of the semi-transparent silver layer, which changes the resonator properties and enables adjustment of the output angles corresponding to a single wavelength. In a wavelength-division multiplexing (WDM) setup this allows for switching of input-to-output channel mapping (Fig. 3(a)). In a laser measurement setup the resonance orders show a distinct motion upon tuning (Fig. 3(b)). Tuning through one free angular range (one resonance order to the next) is achieved by a temperature increase of 7.2 K, which is produced by a Joule heating power density of 2.4 mW/mm ^ 2.

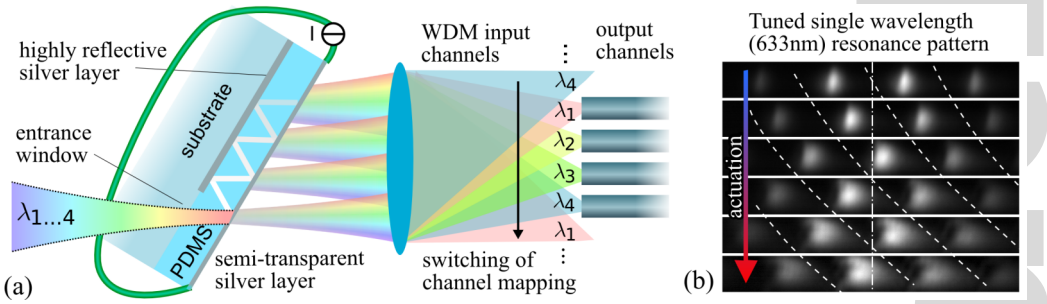

Fig. 3: (a) A tuneable, elastomer-based VIPA in a WDM setup allows for switching of input-to-output channel mapping. (b) Resonance pattern of the VIPA at a single wavelength (633 nm) shows a distinct motion of diffraction orders (separated by dashed lines) upon tuning.

Modelling of magnetoelectric sensors

Within the framework of the SFB 855 we are designing magnetoelectric (ME) sensor structures. In 2012 we extended our analytic models to calculate the bending oscillation and resulting voltage signals of cantilevers with magnetostrictive and piezoelectric layers on a substrate excited by oscillating magnetic fields at resonance. Besides optimizing cantilever sizes and layer thicknesses of the functional materials and substrate with respect to signals and resonance frequencies, e.g. for brain pacemaker signals, we investigated multilayers and magnetoelectric nanocomposites of different layer sequence. Resonant magnetoelectric cantilever oscillation is known to enhance the sensitivity by the quality factor of the device due to build-up of vibrational energy from the exciting oscillatory magnetic fields. Systematic investigation of different thickness ratios of the piezoelectric (PE) and magnetostrictive (MS) layers for Si substrates (Sub) (between zero and four times the active stack thickness) yields similar narrow and broad maxima separated by a minimum response region for both layer sequences. However, the behaviour with PE fraction and the origin of the minima is greatly different in both cases. In the MS-PE-Sub sequence the minimum is attributed to voltage cancellation in the PE layer associated with strain reversal above and below the zero-strain plane of the bending mode. In the PE-MS-Sub sequence the minimum originates from absence of bending mode excitation. As a result, we find that both mechanisms, i.e. bending mode excitation and charge polarization in the piezoelectric layer, are important for high resonant magnetoelectric response and must be optimized for highly sensitive cantilever designs.

Using finite element method (FEM) simulations we modelled different kinds of structured ME-Sensors. Trenches in the substrate or weights at the dip were investigated to decrease the mechanical resonance frequency of the cantilevers. Due to the high electric potential in thinned regions the possibility of using a pickup region was suggested to further increase the ME coefficient. Many established sensor geometries are very long compared to their active layer thickness and are thus

not computable in a 3D FEM formulation due to the high number of mesh elements. Therefore, a 2D-FEM approach was developed and validated.

Personnel

Head of the group: Dr.-Ing. J. Adam, Prof. Dr. M. Gerken; Secretary: S. Thielbörger (50%)
Technical Staff: Dipl.-Ing. J. Buschmann (50%), J. Greve

Scientific Staff:

Dipl.-Wi.-Ing. H. Block Microoptical systems	04.05.-31.12.2012	CAU/DFG
Dipl.-Ing. J. L. Gugat Magneto-electric sensors	01.06.-31.12.2012	DFG
Dipl.-Wi.-Ing. T. Karrock Microoptical systems	01.08.-31.12.2012	CAU/DFG
Dipl.-Ing. C. Kluge Nanostructured organic optoelectronics	01.01.-31.12.2012	CAU
Dr. M.C. Krantz Magneto-electric sensors	01.01.-31.12.2012	DFG
Dipl.-Ing. P. Metz Microoptical systems	01.01.-31.12.2012	CAU/DFG
Dr.-Ing. Y. Nazirizadeh Nanostructures for analysis and imaging	01.01.-31.12.2012	BMBF
M.Sc. A. Pradana Nanostructured organic optoelectronics	01.01.-31.12.2012	CAU
Dr. M. Rädler Lab-on-a-chip	01.01.-30.04.2012	BMBF
Dipl.-Wi.-Ing. D. Threm Lab-on-a-chip	01.01.-31.12.2012	BMBF/CAU

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

Grundgebiete der Elektrotechnik I, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
M. Gerken (+ staff and student tutors)

Photonic Components, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
M. Gerken (+ Arfat Pradana)

Seminar Integrierte Systeme und Photonik, 2 hrs Seminar/Week,
M. Gerken

Praktikum Optoelektronik, 4 hrs Exercise/Week,
Scientific staff

Summer 2012

Grundgebiete der Elektrotechnik II, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
M. Gerken (+ staff and student tutors)

Optische Systeme, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
M. Gerken (+ P. Metz)

Seminar Integrierte Systeme und Photonik, 2 hrs Seminar/Week,
M. Gerken

Praktikum Optoelektronik, 4 hrs Exercise/Week,
Scientific staff

Bachelorpraktikum Mikro-Nano-Optosystemtechnik, 4 hrs Practical/Week,
M. Gerken (+ H. Kohlstedt, W. Benecke, scientific staff)

Winter 2012/2013

Grundgebiete der Elektrotechnik I, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
J. Adam (+ staff and student tutors)

Micro- and Nano-Optics, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
J. Adam

Seminar Integrierte Systeme und Photonik, 2 hrs Seminar/Week,
J. Adam

Praktikum Optoelektronik, 4 hrs Exercise/Week,
Scientific staff

Third-Party Funds

BMBF, *Nanostrukturierte optoelektronische Bauelemente*, 01.03.2007-28.02.2012 (1.600.000 EUR)
DFG, *Entwurf, Herstellung und experimentelle Charakterisierung von aktiven hochdispersiven Dünnschichtfiltern für die Brennweitendurchstimmung*, 01.10.2008-31.03.2012 (213.000 EUR)
COST, *Towards Functional Sub-Wavelength Photonic Structures*, 17.12.2007-20.01.2012 (Reisekosten)
DFG/SFB 855, *Magnetoelektrische Verbundstoffe - biomagnetische Schnittstellen d. Zukunft, Teilprojekt C1*, 01.01.2010-31.12.2013 (477.000 EUR)
DFG, *Mikro-Auge basierend auf Glasoptiken und durchstimmbaren Dünnschichtfiltern herstellbar in waferbasierter Fertigung*, 30.09.2011-28.02.2015 (250.650 EUR)
BMBF, *Multiparametrische Biomarker-Bestimmung auf Wegwerfchips*, 01.04.2012-31.03.2014 (235.539 EUR)
ERC, *Photo-switching of smart surfaces for integrated biosensors*, 01.07.2013-30.06.2018 (1.499.878 EUR)

Diploma, Bachelor's and Master's Theses

H. Block, *Durchstimmbare optische Blenden auf Basis thermisch aktuierter Dünnschichtfilter*, 17.04.2012
J. L. Gugat, *Erhöhung der Empfindlichkeit von Chiplaboren für optische Messungen*, 08.05.2012
S. Schob, *Optimal design of silicon-based 2D non-periodic nanophotonic structures*, 15.05.2012
B.-O. Meyer, *Portables optisches Messsystem für einen Photonischen-Kristall-Biosensor*, 07.08.2012
S. Wigger, *Entwicklung eines Messsystems für die Effizienz von organischen Leuchtdioden mit multiperiodischen Gittern*, 07.08.2012
C. Behnke, *Elastomer basierter thermisch durchstimmbarer Resonator für die Spektroskopie*, 21.08.2012
F. v. Oertzen, *Optimierung von photonischen Kristallen für die Biosensorik*, 04.09.2012

M. Bremer, *Nanostructured integrated optical devices in LiNbO3,* 13.12.2012

Publications

Published in 2012

D. Threm, J. L. Gugat, A. Pradana, M. Rädler, J. Mikat, M. Gerken, *Self-aligned Integration of Spin-coated Organic Light-Emitting Diodes and Photodetectors on a Single Substrate,* IEEE Photonics Technology Letters, Vol. 24, **11**, 912 - 914 (2012)

M. Hansen, M. Ziegler, H. Kohlstedt, A. Pradana, M. Rädler, M. Gerken, *UV capillary force lithography for multiscale structures,* J. Vac. Sci. Technol. B 30(3), **031601**, (2012)

D. Threm, Y. Nazirizadeh, M. Gerken, *Photonic Crystal Biosensors towards On-Chip Integration,* Journal of Biophotonics, Vol. 5, Issue 8 - 9, 601 - 616 (2012)

Y. Nazirizadeh, T. Karrock, M. Gerken, *Photonic crystal slabs for surface contrast enhancement in microscopy of transparent objects,* Opt. Express, **20**, 14451 - 14459 (2012)

C. Kluge, M. Rädler, A. Pradana, M. Bremer, P. Jakobs, N. Barié, M. Guttmann, M. Gerken, *Extraction of guided modes from organic emission layers by compound binary gratings,* Optics Letters Vol. 37, Iss. 13, 2646 - 2648 (2012)

Y. Nazirizadeh, T. Karrock, M. Gerken, *Visual device for pressure measurement using photonic crystal slabs,* Opt. Lett., **37**, 3081 - 3083 (2012)

B. Gojdka, V. Hrkac, J. Xiong, M. Gerken, L. Kienle, T. Strunskus, V. Zaporojtchenko, F. Faupel, *A critical evaluation of the 0-3 approach for magnetoelectric nanocomposites with metallic nanoparticles,* J. Appl. Phys., **112**, (2012)

Patent Applications

Y. Nazirizadeh, T. Karrock, M. Gerken, J. Roider, *Vorrichtung zur optischen Darstellung des Augeninnendrucks sowie Verfahren dazu,* Deutsche Patentanmeldung, 13.06.2012, keine

Presentations

C. Kluge, P. Metz, A. Pradana, Y. Nazirizadeh, M. Rädler, M. Gerken, *Influence of waveguide thickness on the angular colour impression of nanostructured organic emission layers,* Proc. 16th European Conference on Integrated Optics, Sitges, Spain, 18.-20.04.2012

D. Threm, Y. Nazirizadeh, M. Gerken, *Compact Biosensor with Organic Optoelectronic Devices,* Gordon Research Seminar on Bioanalytical Sensors, Newport, RI, USA, 16.-17.06.2012

D. Threm, Y. Nazirizadeh, M. Gerken, *Compact Biosensor with Organic Optoelectronic Devices,* Gordon Research Conference on Bioanalytical Sensors, Newport, RI, USA, 17.-22.06.2012

P. Metz, M. Krantz, S. Suhr, M. Gerken, *Wavefront and polarization effects in actively tunable thin-film resonators for beam alignment in optical interconnects,* Proc. IEEE ICTON, Warwick, England, 02.-05.07.2012

Microwave Laboratory

The **Microwave Laboratory** of the Christian Albrechts University of Kiel (CAU) has continued research in the areas of **ultra-wideband technology (UWB)**, and **high frequency materials and components**. The working area of **microwave sensors**, where highly recognized research has been carried out during the last few decades, has been further extended to field based sensors, which include for example eddy current sensors, low frequency capacitive sensors, and magnetoelectric sensors. Another working area is **molecular spectroscopy**, where work on spectrometer construction continues.

UWB-technology concentrates on sensors for the characterization of condition, composition, and history of natural materials. At present the research is focused on non-contacting determination of the properties of dielectric objects that may be much smaller than the footprint of the interrogating antenna. Over the years the laboratory has acquired considerable expertise in the application of dielectric spectroscopy and in the use of multivariate statistics to analyse the response of UWB signals.

Industrial and medical microwave sensors are areas where the microwave laboratory has a long established experience. A wide range of sensors has been created in the past. Present work concentrates on millimetre wave Doppler radar sensors for the characterization of aerosols for example, on other radar sensors, and on sensors for medical applications. In addition, a novel density independent measurement method was enhanced; it is suited for moisture measurements up to very high moisture levels. Significant effort has been devoted to investigations concerning the characterisation of thin film magnetoelectric sensors in collaboration with others working in materials research at Kiel, and to low noise electronic circuits for interrogating such devices.

Molecular spectroscopy is focused not only on spectroscopy itself, but also on the development of new spectrometers in the millimetre and sub-millimetre wave region.

Results

The near range radar has been designed within the framework of a subproject ''Radar and Tracking'' that itself is part of the PITAS-project. This work is devoted to the detection of small targets, like rubber or plastic boats, within one mile around a cargo ship and identification of possible threats such as pirates.

The radar designed is a complex system consisting of a transceiver module, an antenna, an antenna drive, and a signal processing module. The transceiver generates pulses with 50 ns width and pulse repetition frequency of 40 kHz. The radiation pulse power is about 70 W, which provides a range resolution size of 7.5 m and a maximum unambiguous theoretical range of the radar of about 3.7 km. The antenna, with a fan-shaped directional pattern, has half-power beamwidths of about 1 degree in the horizontal plane and about 15 degrees in the vertical plane. This provides a high angular resolution in the azimuthal plane and target detection at the sea surface, even with ship motion in rough sea conditions. The antenna gain is more than 30 dB and the side-lobe level is less than -24 dB. A specially designed antenna feeder provides a very good matching of the input port of the antenna (S11 $<$ -30 dB). The antenna drive module permits the control of the antenna rotation speed. The angle sensor of the module detects the accurate position of the antenna for the further data processing. The signal processing module consists of a FPGA board and two-channel A/D converter with a sampling rate of 500 MSPS per channel. The algorithm programmed in the FPGA performs a pulse coherent signal processing which allows the detection of position and speed of a target with RCS (radar cross-section) down to 1 sq m. Moreover, the algorithm includes a so called directional detector to estimate whether the target moves towards or away from the ship. Coherent data processing, in combination with a directional detector, significantly increases the probability of target detection and decreases the rate of false alarm. All parts of the radar are enclosed in a splash-water-protected housing (Fig. 1) which permits the radar to be field tested on board ship under actual sea-going conditions.

Collaborative Research Centre SFB 855 ''Magnetoelectric Composite Materials - Biomagnetic Interfaces of the Future''
Subproject C3: Sensor Modelling and Electronic Signal Processing

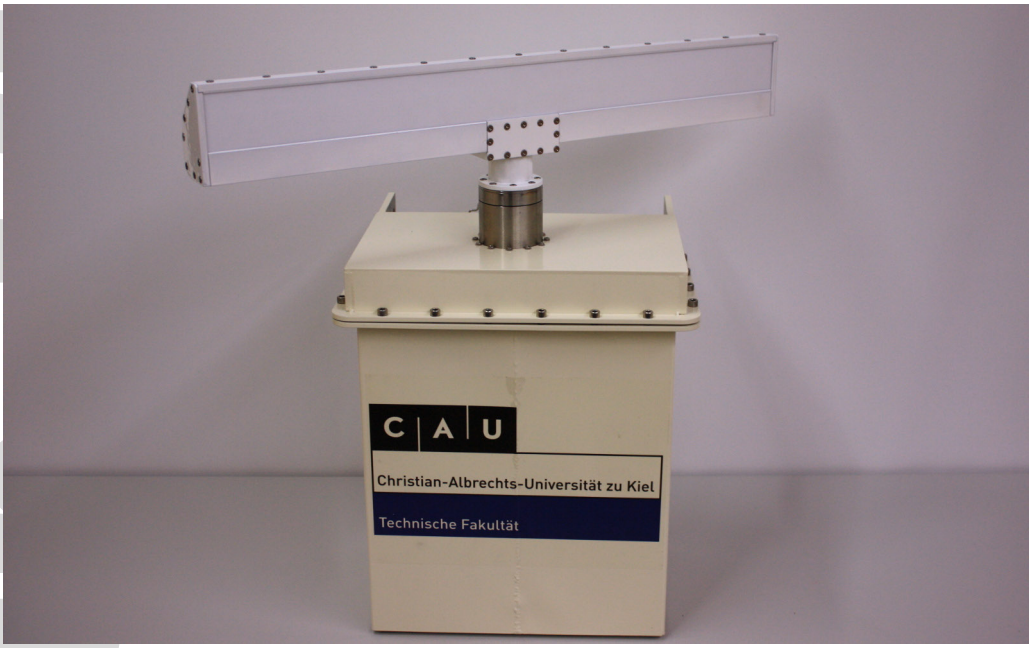

Fig. 1: Near range radar prototype.

The aim of the collaborative research centre SFB 855 is the development of a high sensitivity magnetoelectric (ME) detection unit that is able to measure biomagnetic signals in the picotesla range. In 2012 a second ME measurement setup was installed to have a higher throughput in sensor characterization. The noise characterization of ME sensors with interdigital structures using lead zirconate titanate (PZT) as the ferroelectric phase, led to a signal to noise ratio comparison between aluminum nitride and PZT based ME sensors. Furthermore a new technique for the reduction of external vibration noise allows the measurement of brain pacemaker signals with ME sensors for the first time. For this reason head phantoms with varying conductive areas have been developed.

Non-contacting characterization of the dielectric properties of objects of irregular shape

The aim of the DFG-project ISOPerm (irregular shaped objects permittivity) is to develop an UWB method for the measurement of the dielectric properties of irregularly shaped bodies by using a non-contacting approach. Industrial processes often require the determination of the process parameters, e.g. water content of bulk materials. Unlike existing methods, and as a novel approach, an attempt was made using multivariate analysis to separate those effects due to the geometry of the object from those due to its dielectric properties. It was successfully proven that the determination of the dielectric properties is possible, regardless of shape, size and orientation of the objects under test. It was also shown that related properties such as for example, the water content of water-ethanol mixtures, the carbon content of carbon loaded silicones, or the moisture content of moist clay granules, can be determined directly from the time domain data. A main focus in 2012 was the hardware development and the improvement of system performance (see Fig. 2). An FPGA based system was brought into operation which offers superior performance regarding speed and accuracy. Novel components like an eight-fold UWB signal combiner were designed and installed. Besides the impulse technique a system using maximum-length-sequences as stimuli was developed. A novel approach using orthogonal codes for measurement purposes is under investigation.

Early Detection of Dental Pulp Inflammations

Dental pulp inflammations lead to a degradation of the jaw bone because the human body wants to reject the affected tooth. Often the tooth can be preserved by a root canal therapy. The problem is that an unequivocal diagnosis is difficult to provide; with X-rays the bone degeneration is only detectable in a relatively advanced state. Furthermore the patients

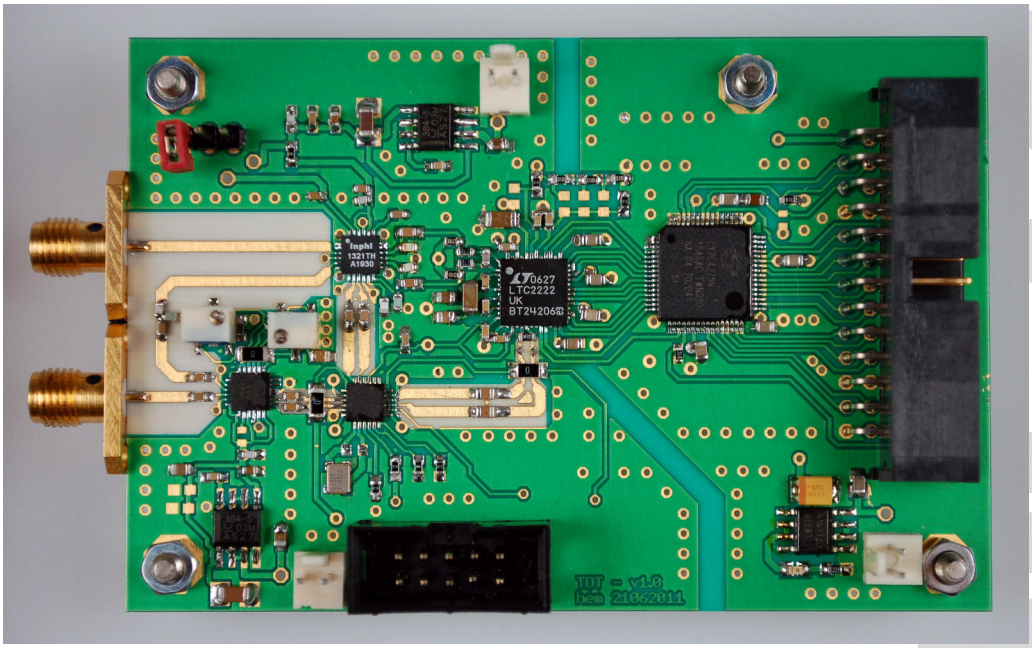

Fig. 2: Miniaturized ultra-wideband sampling oscilloscope.

are often not able to locate the source of the pain precisely.

However, it can be expected that inflammation changes the material properties of the tissue involved. Firstly it can be observed that the ph-value becomes lower: hence there are more free charge carriers and the electric conductivity will increase. Secondly the tissue swells because locally the amount of body fluid increases: this effect and the degeneration and replacement of the jaw bone, cause changes of the permittivity.

The idea of this project is the detection of the material properties by microwave sensors. In principle microwave sensors are able to penetrate the gingiva and see the tissues around the tooth root. The results of the measurements are immediately available without ionizing radiation. A possible suitable structure is a ring resonator with a gap. Like pincers the ring resonator can be opened at the gap and filled with the possibly inflamed area. Changes of the permittivity can easily be detected by the ring resonator. Additionally an eddy current sensor could detect changes of the conductivity of the tissue. However due to the wide distribution of several parameters (thickness and density of the jaw bone, parameter difference of healthy and inflamed tissue) and distortions caused by metals in the oral cavity (dental fillings, tongue piercings) the signal processing of this application is somewhat ambitious. The project started In 2012 with computer simulations and measurement of the dielectric properties of pig jaws. In the future a prototype will be developed and tested on human patients.

This project is carried out together with the Klinik für Paradontologie und Zahnerhaltungskunde of the Universitäts Klinikum Schleswig-Holstein (Prof. Dörfer).

Microstrip Filter Design with Fuzzy Logic

The main goal of this research is to develop an accurate, fast, and general modelling tool based on Fuzzy systems in the area of microwave circuit design. In this regard, three different categories were considered: bandpass filters, bandstop filters, and couplers. In the area of bandpass filter design, different resonant structures were subjected to modelling: square open loop, split ring, spiral, and triangular resonators. Based on the modelling results, a number of filters were designed and fabricated. A good agreement between the simulated and the measured results shows the accuracy of the modelling technique. The accuracy was also proved by a fullwave- based simulator. In the next step, a novel slow-wave

open loop resonator was proposed in order to realize spurious-free responses. The results were reported and compared with conventional open loop resonators. The miniaturization level of the proposed resonator was also compared with these. Based on the proposed resonator, two different filters were designed, one of which was fabricated. A novel metamaterial-based resonator was also proposed, designed, and constructed, based on our Fuzzy-based modelling technique. Bandstop filters are the second area in which the modelling procedure was implemented and the results utilized for filter design. Couplers are other passive structures which have been investigated with the modelling technique developed here. Finally it can be concluded that the success of all these different modelling problems has proved the generality, speed, and accuracy of the procedure.

THz Spatial Harmonic Magnetrons (SHMs)

The aim of the project is the consideration of employing SHMs in THz frequency range sources. Considering the peculiar conditions governing SHMs and simplifying the equations of motions of electrons in the presence of DC and RF electric and magnetic fields, we have developed an approximate theory for optimizing the geometrical parameters of the anode structure of these devices in order to provide a maximum efficiency for a specific frequency. Based on this theory, and using an accurate simulation model developed in the CST-Particle studio, we have designed and simulated several millimetre-wave and THz frequency SHMs. The maximum efficiency and pulsed-output power of these oscillators at 140 GHz and 220 GHz are 7% and 11kW, and 3% and 1.6 kW, respectively.

Cocoon-PUFs

A new Physical Unclonable Function (PUF) technology is proposed. This technology targets the implementation of a highly secure unclonable electromechanical device. The resulting system includes a physical unit providing identification properties that are mutually-dependent on both microelectronic and mechanical components (see Fig. 3). The technology is based on combining very high frequency wave propagation, scattering, and reflection, based on dielectric and/or magnetic particles or composites (potted) in matrices of a closed medium with mechanical spatial factors related to the encapsulation material. It is assigned the name Cocoon-based Physical Unclonable Function (Cocoon-PUF). The resulting fingerprint properties are related to the transmitters and sensors integrated on the chip die, and the spatially randomized distribution in the encapsulation matrix (potting material), offering unpredictable (hence practically impossible to clone or duplicate) mechatronic units. The targeted Cocoon-PUF is to build rigging-resistant non-silicon based mechanical footprints in tamper resistant packaging. Additionally, the proposed technology fits the tendency and requirement of protection against Electro-Magnetic-Pulse (EMP) surges (as TEMPEST design), which can be seen as an additional satisfactory side effect of the Electro-Magnetic-Compatibility (EMC) of the Cocoon protection principle.

Molecular Spectroscopy

Molecular spectroscopy in the range of millimetre- and sub-millimetre wavelengths (carried out by Prof. Guarnieri) allows the investigation of free molecules in the gas phase. In this state the molecules are in continuous motion proportional to their thermal energy. A part of this energy is stored as rotational energy. The activity of the lab was concentrated on the improvement of the resolution of the millimetre- and sub-millimetre wave spectrometer to allow very precise measurements of transition frequencies between rotational energy states. Astronomical observations in millimetre- and sub-millimetre wavelengths have led to the discovery of many different molecules in the interstellar clouds. Laboratory spectra of such molecules in the millimetre- and sub-millimetre range measured with a precision $\leq$ 1 kHz are therefore needed for modern astrophysical investigations. To this purpose this laboratory's spectrometer has been supplemented with devices that have allowed the observation of absorption lines with lamb-dip (a result of a saturated absorption process) accuracy. This method allows the measurement of the absorption lines with a precision $\leq$ 1 kHz. A corresponding paper was published in 2007 in Astrophysics Letters. Further to increase the sensitivity of the InSb-Detector-chip in the frequency range near 1 THz (0.3 mm wavelength) a suitable cryostat provided with a neodymium permanent magnet delivering a magnetic field of 1,4 Tesla around the InSb-chip, is under construction in the local workshop of the faculty. Within the scope of the DFG-cooperation project with the Institute of Applied Physics of the Russian Academy of Science

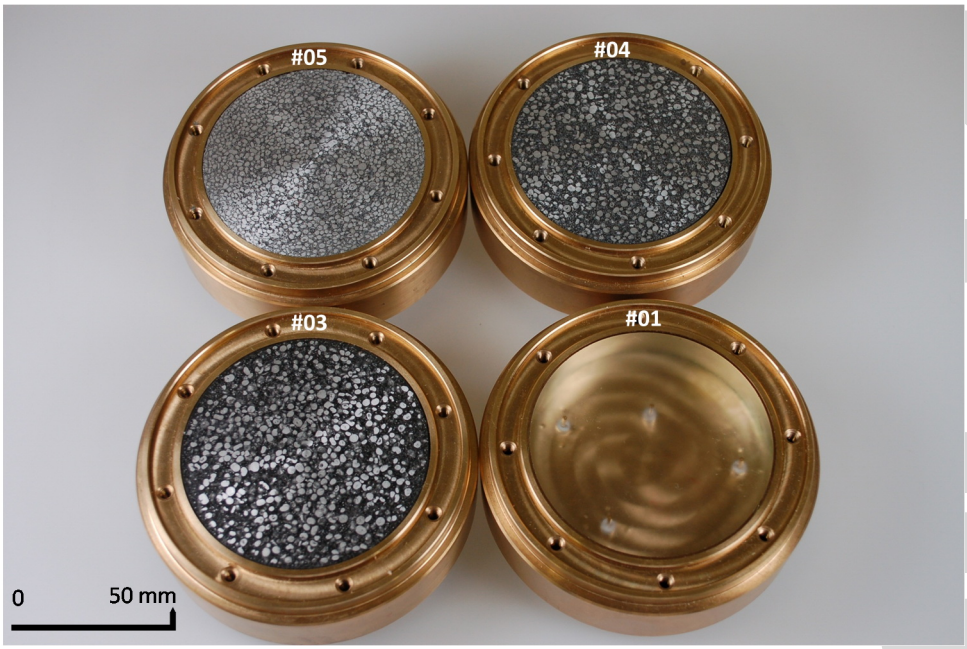

Fig. 3: Four different Cocoon-PUF prototypes fabricated with different granules/particle mass and size. Sample #01 is an ungranulated sample used for reference measurements. Samples #03, #04 and #05 are granulated samples having the same particle mass but with different randomized distribution techniques, which have been proven to have uncorrelated RF fingerprints.

(Nizhnii Novgorod) spectra of the HCCCN (propyne nitrile), NH3 (ammonia), and various isotopologues of water have been investigated with the goal of obtaining precise transition frequencies in the millimetre- and sub-millimetre range (accuracy ≤ 1 kHz) for investigation of the dynamics of interstellar clouds.

Personnel

Head of the group: Prof. Dr.-Ing. R. Knöchel; Secretary: M. Bork
Technical Staff: H. Runkowske, Dipl.-Ing. (FH) W. Taute

Scientific Staff:

M.Sc. C.-C. Chao	01.01.-31.12.2012		externally funded
Through wall radar			
Dr.-Ing. F. Daschner	01.01.-31.12.2012		CAU
Resonant stents / Microwave sensors / Early detection of dental pulp in inflammations			
Dipl.-Ing. R. El Korch	01.01.-31.08.2012		BMWi / CAU
High level moisture measurement with microwave resonators			
Dipl.-Ing. R. Jahns	01.01.-31.12.2012		DFG
Magnetoelectric sensors			
Dr.-Ing. M. Kheir	01.02.-31.12.2012		CAU
Cocoon-PUF			
Dipl-Ing. S. Klein	01.04.-30.06.2012	(50%)	CAU
Near range radars			

Dr.-Ing. H. Kreft Cocoon-PUF	15.01.-31.12.2012		CAU
Dipl.-Ing. H. Mextorf Non-contacting characterisation of irregular shaped objects	01.01.-31.12.2012		DFG
M.Sc. N. Nasresfahani Metamaterials in microwave structures	01.01.-31.12.2012		DAAD
M.Sc. P. Rezaee Microwave filter design with fuzzy logic	01.01.-31.12.2012		DAAD
Dipl.-Ing. W. Stellmach Near range radars	01.01.-31.12.2012	(50%)	BMWi
I. Teliban Magnetoelectric sensors	01.10.-31.12.2012		DFG
M.Sc. O. Teplyuk Near range radars	01.01.-31.12.2012		CAU
Dipl.-Ing. J. Wolff	15.-31.12.2012	(50%)	BMWi

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

Nichtlineare Schaltungen, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ R. Jahns)

Leitungstheorie, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
F. Daschner (+ R. El Korch)

Hochfrequenzschaltungen und -systeme: Aktive Schaltungen, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ H. Mextorf)

Rauschen in Kommunikations- und Messsystemen, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ W. Stellmach)

Hochfrequenz-Messtechnik, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
F. Daschner (+ F. Daschner)

Radar, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ H. Mextorf)

Projekt, 3 hrs Practical/Week,
R. Knöchel

Masterpraktikum Mikrowellen und EMV, 4 hrs Practical/Week,
F. Daschner (+ R. Jahns, A. Teplyuk, H. Mextorf, R. El Korch)

Seminar Hochfrequenztechnik, 2 hrs Seminar/Week,
R. Knöchel

Summer 2012

Radar, 2 (+ 1) hrs Lecture (+ Exercises)/Week,

R. Knöchel (+ O. Teplyuk)

Hochfrequenz-Messtechnik, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
F. Daschner (+ F. Daschner)

Hochfrequenzschaltungen und -systeme: Passive Systeme, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ H. Mextorf)

Bachelorpraktikum Hochfrequenztechnik, 4 hrs Practical/Week,
F. Daschner (+ R. Jahns, O. Teplyuk, H. Mextorf, R. El Korch)

Projekt, 3 hrs Practical/Week,
R. Knöchel

Seminar Hochfrequenztechnik, 1 hrs Seminar/Week,
R. Knöchel

Winter 2012/2013

Leitungstheorie, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ F. Daschner)

Nichtlineare Schaltungen, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ R. Jahns)

Hochfrequenzschaltungen und -systeme: Aktive Schaltungen, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ H. Mextorf)

Rauschen in Kommunikations- und Messsystemen, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ R. Jahns)

Projekt, 3 hrs Practical/Week,
R. Knöchel

Masterpraktikum Mikrowellen und EMV, 4 hrs Practical/Week,
F. Daschner (+ R. Jahns, A. Teplyuk, H. Mextorf)

Seminar Hochfrequenztechnik, 2 hrs Seminar/Week,
R. Knöchel

Hochfrequenz-Messtechnik, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
F. Daschner (+ F. Daschner)

Third-Party Funds

Deutsche Forschungsgemeinschaft, *Kontaktlose Bestimmung der dielektrischen Eigenschaften unregelmäßig geformter Objekte (ISOPerm) - Folgeprojekt,* 01.02.2011-31.01.2013 (126300)

Deutsche Forschungsgemeinschaft, *Aufbau und Optimierung von Spektrometern für den Submillimeterwellen-Bereich sowie Fortsetzung der rotationsspektroskopischen Messungen an interstellaren Spezies,* 01.10.2008-31.03.2013 (53995 EUR)

Deutsche Forschungsgemeinschaft, *Sonderforschungsbereich 855, Subproject C3: Sensor Modelling and Electronic Signal Processing,* 01.01.2010-31.12.2013 (579100 EUR)

Bundesministerium für Wirtschaft und Technologie, *Verbundprojekt: PITAS - Piraterie und Terrorabwehr auf Seeschiffen; Sensorik und Tracking,* 01.07.2010-31.12.2013 (1029711 EUR)

Innovationsstiftung Schleswig-Holstein, *''lütttng.'' - Schüler-Technik- Akademie,* 25.05.2010-22.08.2012 (26140 EUR)

Deutscher Akademischer Austauschdienst, *Leonhard-Euler-Projekt, Zielland: Ukraine,* 01.09.2011-31.08.2012 (7380)

Deutscher Akademischer Austauschdienst, *Leonhard-Euler-Projekt, Zielland: Ukraine,* 01.09.2012-31.08.2013 (8175)

Further Cooperation, Consulting, and Technology Transfer

There is close cooperation concerning ''magnetic nano composites'' for rf applications with the departments of ''Multicomponent materials'' (Prof. Faupel) and ''Inorganic functional materials'' (Prof. Quandt) in the **Faculty of Engineering of CAU**.

With the latter department (Prof. Quandt) there is also cooperation with regard to ''magnetoelectric sensors''.

There exists a cooperation concerning radiophysics and radioelectronics, radar technology, and biological effects of electromagnetic waves and fields, with the **Kharkov National University (KNU)**, Kharkov, Ukraine, in association with research institutes of the Ukrainian academy of science, the ''Institute of Radiophysics (IRE)'', (Prof. Khlopov) and the ''Institute of Radioastronomy (IRA)'', (Prof. Vavriv). There is also some cooperation within the framework of the Leonard Euler Program of the German Academic Exchange Service (DAAD).

With the **Technische Universität Hamburg Harburg**, (Prof. Dr. A. Jacob), we cooperate in the areas of ''microwave components'', ''microwave measurements'', and ''radar technology''.

With Prof. Dr. K. Schünemann, **Technische Universität Hamburg Harburg** and Prof. G. Khlopov, **Institute of Radiophysics**, Kharkov, Ukraine we cooperate in the area of industrial radar sensors.

Concerning sub-millimetre spectrometers and molecular spectroscopy we work in cooperation with the **Applied Physics Institute** of the **Russian Academy of Science** (Dr. Gera Golubjatnikov and Dr. Vladimir Markov) .

Cooperations with industry include: **AMS - Advanced Microwave Systems**, Hamburg, in the area of microwave sensors for density and moisture determination of materials,

Thales, Kiel, in the area of antennas,

and Bikotronic Industrie-Elektronik GmbH, Deidesheim.

A cooperation concerning resonant stents and other stent solutions is carried out together with the **Paediatric Cardiology Clinical Centre of the Christian-Albrechts-University (PD Dr. Rickers)**. The measurements regarding heterotopic bone inductions are carried out together with the **Department of Oral and Maxillofacial Surgery of the Clinical Centre of the Christian-Albrechts-University (PD Dr. Dr. Becker)**. The project on early detection of dental pulp inflammation is a cooperation with the **Department of Conservative Dentistry of the Christian-Albrechts-University (Prof. C. Dörfer)**.

As in previous years there is cooperation with **Dr M Kent**, a UK consultant, in the application of dielectric measurements and multivariate analysis.

Diploma, Bachelor's and Master's Theses

L.-P. Röstel, *Entwicklung eines optischen Verfah-rens zur Charakterisierung von magnetoelektrischen Sensoren,* 11.01.2012
C. Plueschke, *Verbessertes Abtastoszilloskop mit FPGA,* 13.04.2012
B. Weiß, *Multisensorsystem zur Detektion von Piratenangriffen auf Handelsschiffe,* 02.07.2012
J.-P. Kroll, *Entwicklung eines Kopfphantoms für biomagnetische Messungen,* 12.10.2012
T. Chorrosch, *Aufbau eines schnellen M-Sequenz-Generators,* 23.10.2012
J. Wolff, *Entwicklung und Implementierung einer Radarsignalverarbeitung mit FPGA,* 08.11.2012
T. Conradt, *Auswertung breitbandiger dielektrischer Spektren mit der Unabhängigkeitsanalyse,* 26.11.2012

Dissertations / Postdoctoral Lecture Qualifications

O. Teplyuk, *Radar Sounding of Disperse Streams,* 17.02.2012
C.-C. Chao, *Automatic Ultra Wideband Radar System for Life Detection of Hidden Humans,* 15.05.2012

Publications

Published in 2012

F. Daschner, M. Kent, R. Knöchel, *Dielectric UWB Microwave Spectroscopy,* Handbook of Ultra-Wideband Short-Range Sensing, Wiley-VCH, Weinheim, 688 - 698 (2012)

R. Jahns, H. Greve, E. Woltermann, E. Quandt, R. Knöchel, *Sensitivity enhancement of magnetoelectric sensors through frequency-conversion,* Sensors and Actuators A, **183**, 16 - 21 (2012)

S. Marauska, V. Hrkac, T. Dankwort, R. Jahns, H.J. Quenzer, R. Knöchel, L. Kienle, B. Wagner, *Sputtered thin film piezoelectric aluminium nitride as a functional MEMS material,* Microsystems Technologies, **18**, 787 - 795 (2012)

S. Marauska, R. Jahns, C. Kirchhof, M. Claus, E. Quandt, R. Knöchel, B. Wagner, *Packaged MEMS Magnetic Field Sensor Based on Magnetoelectric Composites,* Proceedings of the 23rd Micromechanics and Microsystems Europe Workshop, (2012)

S. Marauska, R. Jahns, H. Greve, E. Quandt, R. Knöchel, B. Wagner, *MEMS magnetic field sensor based on magnetoelectric composites,* Journal of Micromechanics and Microengineering, **22**, 065024 (2012)

E. Lage, C. Kirchhof, V. Hrkac, L. Kienle, R. Jahns, R. Knöchel, E. Quandt, D. Meyners, *Exchange biasing of magnetoelectric composites,* Nature Materials, (2012)

E. Laurandakis, R. Weigel, H. Mextorf, R. Knöchel, *Circuit Agility,* IEEE Microwave Magazine, **3**, 111 - 121 (2012)

H. Mextorf, F. Daschner, M. Kent, R. Knöchel, *Non-Contacting Moisture Sensing using a Dedicated UWB Time Domain Instrument,* Frequenz, Journal of RF-Engineering and Telecommunications, **66**, 11 - 12 (2012)

H. Mextorf, F. Daschner, M. Kent, R. Knöchel, *Non-Contacting Moisture Sensing using a Dedicated UWB Time Domain Instrument,* Proceedings German Microwave Conference, 1 - 4 (2012)

H. Mextorf, F. Daschner, M. Kent, R. Knöchel, *Signal Quality Considerations for Free-Space UWB Moisture Measurements,* Proceedings MIKON 2012, 627 - 630 (2012)

H. Mextorf, F. Daschner, M. Kent, R. Knöchel, *UWB Time Domain Transmission Sensor for Free-Space Moisture Measurements,* IEEE MTT-S International Microwave Symposium Digest, 1 - 3 (2012)

H. Mextorf, J. Sachs, F. Daschner, M. Kent, R. Knöchel, *Free-Space Moisture Prediction of Small Objects using M-Sequences,* Proceedings ICUWB 2012, 260 - 264 (2012)

P. Rezaee, R. Knöchel, M. Tayarani, *Simple, fast, and accurate parametric modeling of the coupling and external quality factor for microstrip filter design using active learning method,* AEÜ-International Journal of Electronics and Communications, **66**, **8**, 668 - 676 (2012)

N. Nasresfahani, K. Schünemann, *Particle-in-cell simulations of a spatial-harmonic magnetron with a cold secondary emission cathode,* IEEE Transactions on Plasma Science, **40**, 3512 - 3519 (2012)

N. Nasresfahani, K. Schünemann, *Towards in the application of MNG-loaded slow wave structures in spatial harmonic magnetrons,* Proceedings of the 6th International Congress on Advanced Electromagnetic Materials in Microwaves and Optics, 487 - 489 (2012)

N. Nasresfahani, K. Schünemann, *Surface Wave Cylindrical Metamaterial Loaded Resonator,* Proceedings of 7th German Microwave Conference, 1 - 4 (2012)

N. Nasresfahani, P. Rezaee, K. Schünemann, R. Knöchel, *Miniaturized Coaxial Cavity Resonator Based on Anisitropic Negative Permeability Metamaterial Loading,* Microwave and Optical Technology Letters, **54**, **3**, 595 - 599 (2012)

H. Kreft, *Cocoon-PUF, a Novel Mechatronic Secure Element Technology,* Adaptive Hardware and Systems (AHS), 227 - 232 (2012)

G. Khlopov, R. Knöchel, W. Stellmach, A. Teplyuk, *Efficiency of Pulse and FMCW Radar under Condition of the Sea*

Clutter Impact, Proceedings of the German Microwave Conference, (2012)
B. E. Beck-Broichsitter, D. W. Christofzik, F. Daschner, R. Knöchel, R. Smeets, P. Warnke, J. Wiltfang, S. T. Becker, *Endocultivation: Metabolism During Heterotopic Osteoinduction In Vivo - Monitoring with Fiber Optic Detection Devices*, Tissue Engineering Part C: Methods, **18(10)**, 740 - 746 (2012)

Presentations

N. Wagner, F. Daschner, A. Scheuermann, M. Schwing, *Analysis of coupled hydraulic and dielectric material properties of soils: a multivariate approach*, International Workshop on Impedance Spectroscopy, Chemnitz, Germany, 26.-28.09.2012

Further Activities and Events

Prof. Knöchel served until July 2012 as the Dean of the Faculty of Engineering (Technische Fakultät).

Prof. Knöchel is active in the IEEE-MTT (Microwave Theory and Techniques) Society. He was chairman of subcommittee-29 ''Broadband Microwave Systems'' within the programme committee of the ''International Microwave Symposium'', IMS, which is the biggest conference worldwide in that area. He is also Chairman of the technical committee MTT-16, ''Microwave Systems'', and since 2007, a member of the selection committee for the ''IEEE MTT Distinguished Microwave Lecturers''. He also represents the MTT on the executive committee of the ''International Conference on Ultra-Wideband, ICUWB''. He is a member of the editorial board of ''Frequenz'' and a reviewer for the journals ''IEEE Transactions on Microwave Theory and Techniques'', ''IEEE Microwave and Wireless Components Letters'', as well as journals of the UK ''Institute of Physics'' (IOP) among others. He is also a member of VDE Expert Group 7.3, ''Mikrowellentechnik''. Apart from his membership of the IEEE he is also a member of the ''European Microwave Association, EuMA'' and of URSI, commission A.

Prof. A. Guarnieri, is working in the microwave laboratory and leads the ''molecular spectroscopy'' work.

Nanoelectronics

Exciting new opportunities for future information technology arise from unconventional and novel electronic materials, nanoscale phenomena, and advanced processing technologies that start at the atomistic level. It is expected that with the trend of aggressive downscaling of commercial electronic devices into the nanoscale regime, quantum mechanical effects will become steadily more important. This trend will lead to a change of paradigm, i.e. future nanoelectronic devices exploiting electron tunnelling and/or spin transport will rely on the fundamental laws of quantum mechanics rather than on classical electrodynamics. In this context, new materials and material combinations are urgently required in order to develop tunnel junctions with enhanced functionalities. The chair of Nanoelectronics is focusing on medium and long-term tasks, on emerging far-reaching concepts, and on issues of physics and technology well ahead of the mainstream development of the nanoelectronics industry. The research platform of the AG Nanoelectronic is defined by three main pillars: new device concepts based on quantum phenomena, interfacial studies, and novel fabrication routes. For example, we will explore multiferroic tunnel junctions based on complex oxide materials, superconducting junctions for quantum bits, and lateral tunnel junctions (nanogaps). Therefore, a considerable technological and metrological infrastructure is needed. Part of the equipment, such as an electron-beam-writer, a focused ion beam system, as well as a Pulsed Laser Deposition system, is available via the recently installed *Kieler Nanolabor*. Various current-voltage acquisition systems, magneto- resistance set-ups, and ferroelectric thin films analyzers for a temperature range between 4.2 K and 300 K are part of our lab. On the system level, neuromorphic circuits will lead in the future to parallel computing and low power dissipation. Recently our group became active in the development of neuromorphic circuits comprising memristive devices to mimic synaptic activities. Our activities are embedded in the recently founded Collaborative Research Centre SFB 855 on magneto-electric composites and heterostructures for medical sensor applications, as well as in the Focal Point of Support on *Nano and Surface Science* within the CAU Kiel.

Results

Combinatorial Sputtering of FeSi thin Films

Nico Ruppelt and Ondrej Vavra

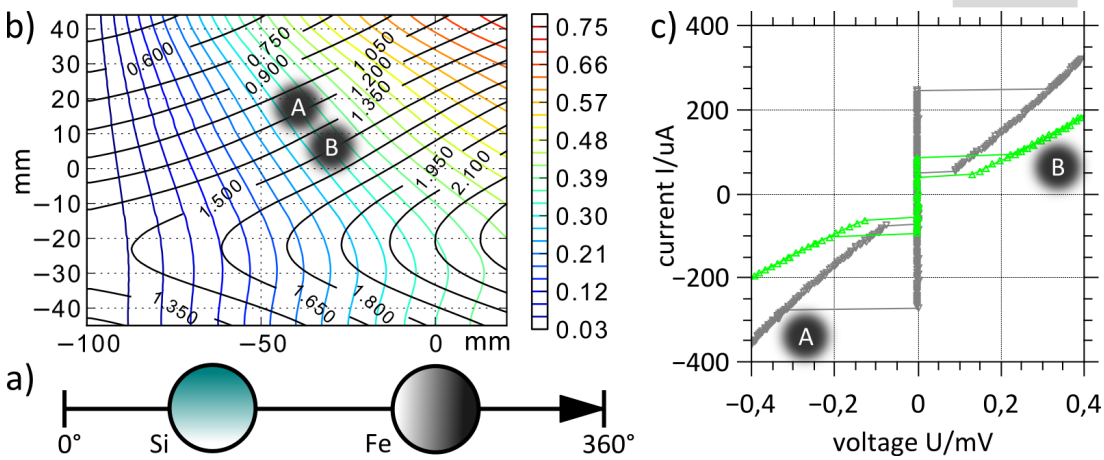

Fig. 1: a) Inhomogeneous material layers, collected during one rotation cycle in the sputtering system: Si gradient perpendicular to the direction of movement, Fe with gradient parallel to movement. b) Simulation for resulting thickness and composition of the FeSi alloy on the wafer after one cycle: thickness (black lines, A), Fe concentration (coloured lines/colour bar, 0: pure silicon, 1: pure iron). c) IV characteristics for junctions with Fe_xSi_{1-x} interlayer thickness 4.8 nm and 5.7 nm for junction A and B, respectively, and an iron content $x = 0.4$. The position of the devices in the FeSi landscape are marked in b).

Regions, where the quantum states of two superconductors couple in a non-trivial way, are called Josephson Junctions (JJ). If the coupling region contains magnetic atoms the junction can be in the π-state. This type of coupling is desired for simpler designs of flux qubits in quantum computing and superconducting logic circuits. In combination with conventional 0-state junctions flux vortices with half of the flux quantum, called semifluxons, can arise in the barrier of the junction. Their dynamics are interesting for physical research.

Up to the critical current density Josephson Junctions exhibit a zero voltage drop. We are investigating different barrier structures and materials between superconducting electrodes in order to achieve high critical current densities in the π-state for technologically feasible devices. One of our approaches is the use of ferromagnetic insulators as a barrier between two superconducting electrodes that combines the magnetic properties of iron with the insulating character of silicon at low temperatures. The current transport through the junction depends on the composition and thickness of the FeSi layer.

A systematic study is facilitated by a combinatorial sputtering approach for the fabrication of such junctions. Instead of using an alloy target with a fixed composition we employ two elemental targets, Fe and Si. They are alternatingly used to deposit submonolayers. By using shutters and a timing logic we could achieve a thickness gradient along one axis of the wafer for Si layers, and a thickness gradient along the perpendicular direction for Fe (Fig. 1a)). The calculated superposition of both layers is shown in Figure 1b). Several cycles are necessary to obtain a film thickness in the nanometre range. With measurements of several junctions along lines of constant stoichiometry or constant thickness the influence of the other parameter on the junction properties can be studied readily. In Fig. 1c) the current voltage curves for two junctions (A and B) are shown, which differ only in the thickness t of the FeSi interlayer. While the critical current in junction A (4.8 nm) is above 250 uA, it is suppressed down to 90 uA in junction B (5.7 nm). In addition, the latter exhibits a higher normal resistance, which can intuitively be linked to the increased thickness.

In conclusion, the update of our sputtering system as presented helps to avoid run-to-run variations in the sputter rates as well as the fabrication process, and allows the creation of material libraries for the rapid screening of device characteristics.

An Electronic Version of Pavlov´s Dog

Martin Ziegler and Mirko Hansen

A dog hears a bell ringing and starts drooling. Such a reaction is named classical conditioning and was investigated experimentally first by the Russian scientist Ivan Pavlov, winner of the Nobel Prize for Physiology and Medicine in 1904. In his milestone experiment a dog was presented with food (the unconditional stimulus) causing it to automatically salivate (the unconditioned response). If a bell (neutral stimulus) was rung several times in addition, the dog learned to associate the neutral stimulus with the unconditioned stimulus and began to salivate even if only the bell rang (conditioned response). Ever since, Pavlov´s experiment has been considered a milestone for implicit learning processes.

Neuromorphic engineering tries to emulate neural pathways underlying memory and learning. When it comes to cognitive and recognition tasks, the brains of vertebrates can outperform the world´s most powerful digital computers. In a human brain data processing and storage are inseparably linked in complex neuronal networks of synapses with up to 10^{14} flexible connections. Learning and memory belong to the fact that new connections between neurons are created, or existing connections are reinforced or weakened. Hence, synapses are plastic. Memresistive devices may be able to emulate this plasticity: such devices exhibit a memory characteristic in the form of hysteretic current-voltage curves consisting of high and low resistance branches. Depending on the prior charge flow through the device these resistances can vary. This memory effect allows the synaptic plasticity to be copied onto electronic circuits, which might even be able to recreate cognitive skills electronically in the future. The aim of our project is to design neural circuits with electronic devices at the crossroads between neurobiology, material science, and nanoelectronics to mimic biological learning. Initially we have succeeded in electronically recreating the classical *Pavlov´s Dog* experiment using memristive devices. In order to mimic the associative behaviour of Pavlov´s dog in the form of an electronic circuit two electrical impulses were linked via a memristive device to a comparator (see Fig. 2). The two pulses represent the food and the bell in Pavlov´s experiment. The comparator produces the output signal (representing saliva) when a threshold value (learning) is reached. To behave

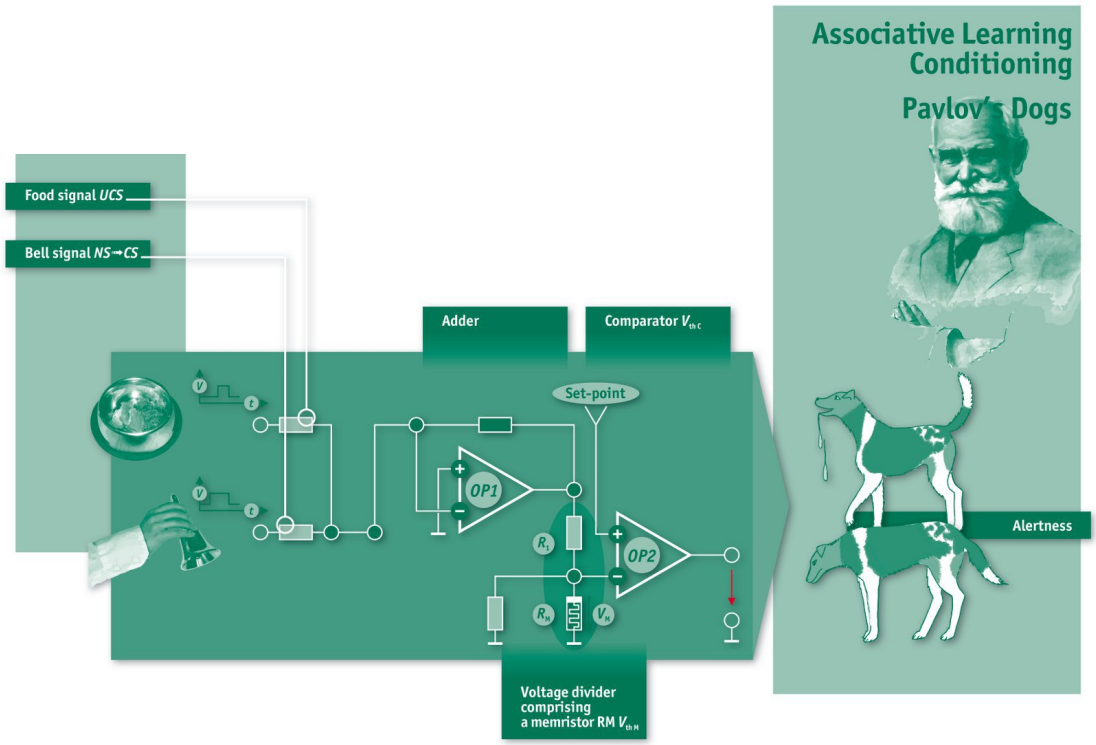

Fig. 2: Electronic circuit layout to mimic associative learning

as a realistic substitute for the basic building blocks in nerve cells an important characteristic of the memresistive device is that it must exhibit a threshold voltage. Below this threshold value the memristive device behaves like any ordinary linear resistor. However, when the threshold value is exceeded, a hysteretic (changed) current-voltage characteristic will appear.

By applying appropriate and timed stimuli the threshold value of the memristive device was exceeded and a change in the device resistance was reached after multiple repetitions. After this learning phase a bell pulse alone was sufficient to trigger the comparator, equivalent to salivation in Pavlov´s experiment (see Fig. 3). Beyond that, we were able to prove that the electrical circuit is able to unlearn a particular behaviour if both impulses are no longer applied simultaneously (see Fig. 3). This investigation shows that memristive devices enable us to mimic neurobiological learning phenomena. Hence, the electronic version of Pavlov´s dog can learn new tricks.

Personnel

Head of the group: Prof. Dr. H. Kohlstedt; Secretary: T. Bittner (50%)
Technical Staff: Dipl.Ing.(FH) N. Röschmann

Scientific Staff:

M. Hansen	01.07.-31.12.2012	Stipendium
Dr. A. Petraru	01.01.-31.12.2012	CAU
N. Ruppelt KO 1953/11-1, BA 521	01.01.-31.12.2012	DFG
Dr. R. Soni SFB 855	01.01.-31.12.2012	DFG

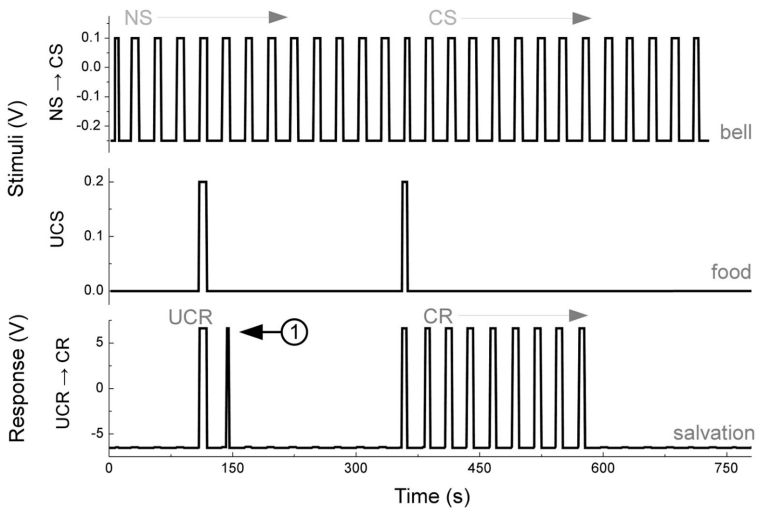

Fig. 3: Experimental demonstration of associative memory within the memristive circuitry of Figure 2. If the neutral stimulus NS (upper curve) merges the unconditional stimulus UCS (lower curve) the resistance of the system is enhanced. After two sequences the circuitry learned to associate the neutral stimuli with that of the unconditioned stimulus.

Dr. O. Vavra	01.01.-31.12.2012	CAU
Dr. M. Ziegler	01.01.-31.12.2012	CAU

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

Nanoelectronics, 3 hrs Seminar/Week,
H. Kohlstedt (+ A. Petraru, O. Vavra, M. Ziegler)

Fabrication of Electronic Devices, 2 (+1) hrs Lecture (+ Exercises)/Week,
H. Kohlstedt (+ A. Petraru)

Interface and Surface Physics, 2 (+1) hrs Lecture (+ Exercises)/Week,
M. Ziegler (+ A. Petraru)

Analysis of Scientific Papers, 2 hrs Seminar/Week,
H. Kohlstedt (+ M. Ziegler, A. Petraru, O. Vavra)

X-ray Diffraction, 2 hrs Practical/Week,
A. Petraru

Summer 2012

Electronics, 3 (+2) hrs Lecture (+ Exercises)/Week,
H. Kohlstedt (+ M. Ziegler, A. Petraru, O. Vavra, H. Kohlstedt)

Sensors, 2 (+1) hrs Lecture (+ Exercises)/Week,
Hermann Kohlstedt (+ Adrian Petraru)

Bachelor´s Practice Micro Nano Opto, 3 hrs Practical/Week,
H. Kohlstedt (+ O. Vavra, A. Petraru, M. Ziegler)

Nanoelectronic Devices, 3 (+ 2) hrs Seminar (+ Exercises)/Week,
H. Kohlstedt (+ M. Ziegler)

Winter 2012/2013

Nanoelectronics, 3 hrs Seminar/Week,
H. Kohlstedt (+ A. Petraru, O. Vavra, M. Ziegler)

Fabrication of Electronic Devices, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
H. Kohlstedt (+ A. Petraru)

Interface and Surface Physics, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
M. Ziegler (+ A. Petraru)

Analysis of Scientific Papers, 2 hrs Seminar/Week,
H. Kohlstedt (+ M. Ziegler, A. Petraru, O. Vavra)

X-ray Diffraction, 2 hrs Practical/Week,
A. Petraru

Third-Party Funds

DFG, SFB 855, Teilprojekt A4, *Magnetoelektrische Verbundwerkstoffe - biomagnetische Schnittstellen der Zukunft*, 01.01.2009-31.12.2013 (268300 EUR)
DFG, *Semifluxons in ferromagnetic Josephson junctions*, 01.12.2010-30.11.2013 (211450)
BMBF era-nat, *Oxide Heterostructures*, 01.04.2013-31.03.2015 (24000)

Further Cooperation, Consulting, and Technology Transfer

Prof. R. Kleiner, Prof. D. Koelle, University of Tuebingen, Germany, Experimentalphysik II and Centre for Collective Quantum Phenomena: Josephson junctions for quantum bits.

Priv. Doz. Dr. N. A. Pertsev, F. Ioffe Physico-Technical Institute, St. Petersburg, Russia: Landau-theory on strain effects in magnetoelectric heterostructures.

Fa. Oerlikon, Leybold, Cologne, Germany: development of thin film processes.

Dr. R. Droopad, Texas State University, USA, Department of Physics: Development of epitaxial Si-SrTiO3 wafers for magnetoelectric sensors.

Dr. J. Schubert, Research Centre Juelich, Institute for Bio-and Nanotechnology, Germany: Rutherford backscattering spectrometry for complex oxides.

Prof. Krautschneider, Priv. Doz. Dr. D. Schroeder, Technical University Hamburg-Harburg, Germany: Memresistive Devices for neuromorphic circuiits

Priv. Doz. Dr. K. Ochs, Priv. Doz. Dr. T. Mussenbrock, Ruhr-University Bochum, Germany: Circuits Simulations

Priv. Doz. Dr. T. Bartsch, Medical Faculty, Clinical Centre, Schlesweig-Holstein: Brain Circuits

Dr. Doo Seok Jeong, Korea Institute of Science and Technology (KIST), South Korea.

Diploma, Bachelor's and Master's Theses

F. Thams, *Erstellung einer Sitzkomfortsteuerung auf Basis eines neu entwickelten Leiterplattendrucksensors in Verbindung mit Ventilen, Luftkissen und einer Mikrocontrollersteuerung*, 27.04.2012

M. Hansen, *Ionische Festkörperleiter in metallischen Tunnelkontakten für Memristoren,* 15.05.2012
O. Schirmer, *Kontrollierbare Veränderung der Dehnungszustände von magnetoelktrischen Sensoren durch feldgesteuerte PMN-PT (100) Substrate,* 24.07.2012
H. Winterfeld, *Oxidsche Heterostrukturen für magnetoelektrische Sensoren,* 23.11.2012
C. Riggert, *Einsatz von Memristoren in lernfähigen Schaltungen,* 16.07.2012
P. Sahin, *Integration of self-organized Nanowires into microchips,* 07.06.2012

Publications

Published in 2012

H. Sickinger, A. Lipmann, M. Weides, R. G. Mints, H. Kohlstedt, D. Koelle, R. Kleiner, E. Goldobin, *Experimental evidence of a phi Josephson junction,* Phys. Rev. Lett., **109**, (2012)
M. Ziegler, R. Soni, T. Patelczyk, M. Ignatov, T. Bartsch, P. Meuffels, H. Kohlstedt, *An Electronic Version of Pavlov´s Dog,* Adv. Func. Mat., **22**, 2744 - 2749 (2012)
D.S. Jeong, R. Thomas, R.S. Katiyar, J.F. Scott, H. Kohlstedt, A. Petraru, C.S. Hwang, *Emerging memories: resistive switching mechanisms and current status,* Rep. on Prog. in Phys., **75**, (2012)
M. Hansen, M. Ziegler, H. Kohlstedt, A. Pradana, M. Raedler, M. Gerken, *UV capillary force lithography for multiscale structures,* Journal of Vacuum Science and Technology B, **30**, (2012)
A. Petraru, R. Soni, H. Kohlstedt, *Tunneling magnetoresistance and electroresistance properties of composite-barrier ferroelectric tunnel junctions,* Physica Status Soldi-Rapid Research Letters, **6**, 138 - 140 (2012)
D.B. Strukov, H. Kohlstedt, *Resistive switching phenomena in thin films: Materials, devices, and applications,* MRS Bulletin, **37**, 108 - 117 (2012)
M. Ziegler, M. Oberlaender, D. Schroeder, W. H. Krautschneider, H. Kohlstedt, *Memresistive operation mode of floating gate transistors: A two-terminal MeMFlash-cell,* Appl. Phys. Lett., **101**, 263504 (2012)
N. A. Pertsev, H. Kohlstedt, *Magnetoresistive Memory with Ultralow Critical Current for Magnetization Switching,* Adv. Func. Mat., **22**, 4696 - 4703 (2012)

Presentations

A. Petraru, *Strain-dependent magnetoelectric properties of epitaxial CoFe2O4/Pb(Zr1-xTix)O3/SrRuO3 heterostructures on PMN-PT substrates,* CIMTEC: International Conferences on Modern Materials and Technologies, Montecatini, Italy, 10.-14.06.2012
H. Kohlstedt, *Strain dependent magnetoelectric properties of heteroepitaxial CFO/PZT/SRO composite on PMN-PT substrates.,* MFM 7:Multifunctional Materials (invited), Gamboa, Panama, 05.-09.08.2012
Martin Ziegler, *An Electronic Version of Pavlov´s Dog,* European Materials Research Scociety meeting, Strasbourg, France, 13.-17.05.2012
H. Kohlstedt, *Tunnel Junctions for Non-Volatile Memories,* Workshop Materials for Non-Volatile Memories, Muenchen, Germany, 24.-24.04.2012
H. Kohlstedt, *An Electronic Version of Pavlov´s Dog,* Nature Conference: Frontiers in Electronic Materials (invited), Aachen, Germany, 17.-20.06.2012
Martin Ziegler, *Demonstration of implicate memory in electronic circuits by using memresistive devices,* Nature Conference: Frontiers in Electronic Materials, Aachen, Germany, 17.-20.06.2012
H. Kohlstedt, *Strain dependent magnetoelectric properties of heteroepitaxial CFO/PZT/SRO composite on PMN-PT substrates.,* MSE Darmstadt, Darmstadt, Germany, 25.-27.07.2012
N. Ruppelt, *Combinatorial Sputtering for low Tc Josephson Junctions,* Kryoelektronische Bauelemente, Freundenstadt, Germany, 30.09.-02.10.2012
O. Vavra, *Thickness and concentration map of Nb-FexSi1-x-AlOx-Nb Josephson junction,* Kryoelektronische Bauelemente,

Freundenstadt, Germany, 30.09.-02.10.2012

Mirko Hansen, *Memristive devices for neuromorphic systems,* 12th Dresden Microelectronics Academy, Dresden, Germany, 03.-08.09.2012

Further Activities and Events

Head of Exmaniation Committee and Students Contact Person (W. Ing.)

Head of Engineering Branch Library (Technical Faculty, East Coast)

Representative of the ETIT (CAU Kiel) of the *Fakultaetentag der Elektrotechnik und Informationstechnik* (FTEI)

Organization and host of the 56. plenary assembly (2012) of the FTEI at the CAU Kiel May 9th and 10th 2012, (Thora Bittner, Hermann Kohlstedt)

Member of the Examination Committee: Material Science

Member of the Examination Committee: Digital Communication

Editorial board CIMTEC: International Conferences on Modern Materials and Technologies, Montecatini, Italy

Guest Scientist: Priv. Doz. Dr. Nikolay A. Pertsev, A. F. Ioffe Inst. of 07.01.2012 to 28.02.2012

Guest Scientist: Dr. Doo Seok Jeong, KAIST 01.09.2012 to 30.11.2012

Examination Board Member: PhD Thesis, Mr. Daniel Pantl, (11.04.2012) Martin-Luther-Universitaet-Wittenberg

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Power Electronics and Electrical Drives

As in the previous year, in 2012 the institute was able to work under quite positive circumstances. The research activities were again focused on power electronic applications, power electronic circuits, and electrical drives and their control. The application areas of our research activities are mainly focused on renewable energy conversion, including grid integration and electrical drives for vehicles. The research results are documented in 17 publications and 3 doctoral theses. The research cooperation with industrial companies has been enhanced. As in the past few years an industry seminar was held. Technology transfer is still an important aspect in this matter, which was honoured this year by the Institute receiving the technology promotion award of Schleswig-Holstein. The institute is still highly active in the competence centres of CEwind e.G. and KLSH (power electronics). In 2012 we organized in Kiel the meeting of LE Nord (network of power electronic university chairs in northern Germany). With respect to our infrastructure we have developed a power semiconductor test device in our laboratory to characterize power switches, and gate drive units. Furthermore we have developed an IGBT gate drive unit, and an electrical load emulator. We are working on the implementation of a microgrid for the analysis of grid integration. Our teaching activities were continued as planned. The courses ''Renewable Energy Systems I and II'' (wind energy and photovoltaic), given for the second time, have proved their value and the master´s laboratory course has been enhanced and optimized. The interest of the students in the master´s programmes ''Renewable Energy Systems'' and ''Drive and Control Technology'' is again high. Additionally, we gave a master´s course in the CEwind's ''Master of Wind Engineering''. The number of first-year students (Bachelor) in electrical and information engineering remained at a constant satisfactory value with more than 200 students. In 2012 we were again active in the supervision of first-year students. Again a high number of very good (and in some cases excellent) student bachelor´s and master´s theses have been finished in the group. In 2012 many awards were given for good work: Mr Brüske received the faculty award for the best diploma certificate, Mr Panten was received the faculty award for the best bachelor´s certificate, and the award for the best PhD thesis was given to Mr Rothenhagen who worked at our institute. In addition the Petersen Award for the best technical bachelor´s thesis in Northern Germany was given to Mr Panten. On the 31th march 2013 Prof. Fuchs will retire officially. In the following three years he will continue his research activities as the supervisor of the current research projects and will give lectures until the new head of the institute has started. It is to be hoped that his successor as head of the chair will take office in 2013. One team member, Mr. Thomsen, left the institute after successful work. In the first part of 2012 the following new team members started their work at the institute: Ms Buchert, Mr Benkendorff, Mr Brüske, Mr Günter, Mr Jessen, and Mr Petersen. We wish them all the best for the new job.

Results

Optimization of a Power Stack for Wind Turbines (Benkendorff)

The development of the energy market has initiated a broad discussion on the future use and production of wind energy. This research project is the optimization of an inverter for a wind turbine generator. In addition to space savings in the wind turbine generator, the increase of reliability by simplification of maintenance effort has to be addressed. The Power Stack (PS) with 1000A / 1000VAC consists of three main units. The control unit includes an optional stack microcontroller and a power supply for the gate drivers. The additional safety appliance monitors voltage, current, and temperature to ensure a safe and low-maintenance operation. The power unit of the PS consists of a low-inductive bus bar, a dc-link, and power semiconductors. A low inductive inverter layout is one of the basic elements for operating power modules with short switching times and achieving a high efficiency of the system. With a cooling unit (a liquid-cooled heat sink) the heat can be dissipated. The work package started in 2012 and included simulations and comparison of adequate inverter topologies for the PS. In early 2013 the focus of research is the low-inductive inverter design, the study of the switching behaviour of the semiconductors, and possible implementation of active gate control in the gate driver to increase the energy density and achieve a high efficiency.

Analysis of Multilevel Inverters and New Power Semiconductors for Solar Applications (Gebhardt)

A highly efficient inverter is necessary for feeding the grid with photovoltaic energy. Limitations of classical two level inverters regarding power quality and efficiency can be eliminated with multilevel topologies. These topologies reduce the filter effort and so the total inverter costs, weight, and volume can be lowered in spite of the higher complexity. In this research project different multilevel topologies for photovoltaic applications are investigated concerning efficiency, filter design, PWM techniques, leakage currents, and driver circuits. In 2012 the comparison and analysis of different five level topologies was finished and experimental investigations on these systems, which will be deepened in 2013, have started. Another research field is the analysis and application of modern power semiconductors. These new technologies can further increase the efficiency of power electronic systems. Besides power semiconductors based on silicon carbide (SiC), which are now used in commercial products, new power semiconductors based on gallium nitride (GaN) are in an early development phase. These devices with blocking voltages of a few hundred volts could be a key technology in the coming years, for photovoltaic applications for example. A power semiconductor test bench was built in the laboratory and the switching behaviour of three SiC devices was investigated in 2012.

Fig. 1: New power semiconductor test bench for measurements on the switching behaviour of power semiconductors and their driver circuits up to 1200 V at different temperatures

In 2012 a new IGBT gate drive unit was developed. The driver circuit is designed for switching IGBTs up to 1700 V blocking voltage and can directly replace commercial driver circuits that were formerly used at the institute. The driver was successfully tested in the power semiconductor test bench and in a 30 kVA drive setup. The new driver allows optimization of the switching behaviour in the different applications and leads to a strong cost reduction.

Investigation on autonomous controlled inverters in microgrids to improve control behaviour in case of grid voltage disturbances (Reese)

Due to the constant change towards decentralized power production the density of inverters in the distribution grid is constantly increasing, and therefore, the influence of each inverter on other active loads increases as well. As the voltage quality and stable operation have to be ensured under these circumstances, new approaches for the control of each autonomous inverter are required. The aim of this research work is the improvement of the control behaviour of parallel acting, autonomous controlled inverters in microgrids. Therefore positive and negative interactions between parallel acting inverters will be identified and used to enhance the voltage quality and stability of microgrids under stationary and

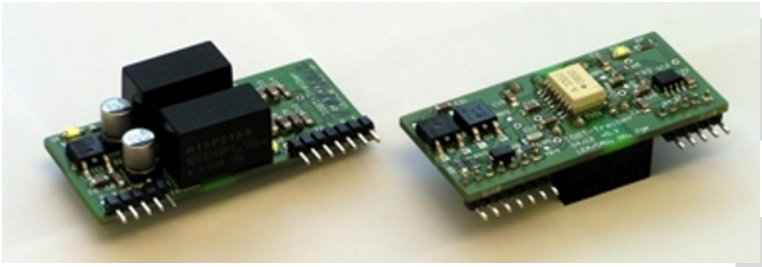

Fig. 2: IGBT gate drive unit for IGBTs up to 1700 V, developed at LEA

transient grid faults. Conventional and modern control methods for voltage source inverters will be compared. In 2012 the laboratory test bench was built. Control strategies for load balancing with parallel distributed power generation systems were developed and implemented. Furthermore, investigations were carried out to consider the influence of phase locked loop techniques in the case of parallel acting inverters. In 2013 control methods for riding through Grid Faults and enhancing the grid voltage quality by parallel acting inverters will be investigated in the laboratory and the project will be documented.

Battery Buffer and Power management for Electric Vehicles (5 kW, 24V) (Schröder)

During strong acceleration of electric vehicles, the battery has to deliver high peak currents. Thus, due to the internal serial resistance, the battery voltage drops under high load condition. During regenerative braking, the battery is charged by a high current and the battery voltage increases significantly. These circumstances cause a strictly load dependent battery voltage and the lifetime of the battery decreases. These drawbacks can be bypassed by a battery buffer system, which consists of a dc-dc-converter and electric double layer capacitors. During the electrochemical energy transfer this system is able to save the regenerative braking energy with higher efficiency than the battery . The energy is transferred back to the system during high load conditions. Thus, the maximum battery power is reduced; battery downsizing or increase in lifetime is possible. In this project, the hardware design and the control of such a battery buffer system for an electric lift truck propulsion system have been designed, built, and tested. Further, the vehicle operation, with respect to efficiency and battery stress, has been compared with and without an applied buffer system . The system efficiency could be increased by about 5 % with this additional system. Additionally, the rise in the battery temperature during operation could be reduced severely. The project has been concluded.

Analysis and optimization of power electronic converter systems for small wind turbines (Buchert)

Small wind turbines are characterized by their power (below 70 kW), their swept area (less than 200 sq m) and their height (under 20 m). Up till now, although the construction of the system is simple it rarely has good power efficiency. It is essential to optimize such turbines. Therefore, a converter system needs investigation in this direction. Such a system should provide low costs, and be efficient over a wide wind speed range. The grid codes for a low voltage grid, which are becoming increasingly strict, have to be taken into account. So far, some literature research has been carried out concerning machine and converter topologies. Simulations of small wind turbines with a permanent magnet synchronous generator were made. In the near future a first prototype of a small wind turbine converter should be developed and tested in the laboratory.

Inductive Power Transfer Systems for Electric Vehicles (Petersen)

The power supply of Electric Vehicles (EVs) is a key issue that has to be addressed in order to improve the customer's acceptance of EVs. Inductive Power Transfer (IPT) systems are a promising solution for safe and comfortable battery recharging. To maximize the IPT system efficiency it is essential to achieve high coupling between the primary and secondary sides. 3D-FEM simulations are performed to determine the coupling coefficient for different kinds of core designs in normal position and for different displacement scenarios. It has been shown that for normal position circular single-sided

cores have the highest coupling, while rectangular double-sided cores are more tolerant against misalignment. Another research field is the analysis of different resonant compensation topologies (serial-serial, serial-parallel, parallel-serial, parallel-parallel) used to compensate for the large leakage inductances in IPT systems. The different topologies have been investigated and the advantages and merits regarding efficiency, transferable power, and load dependency have been evaluated. The third research field is the application of modern power semiconductors to improve the efficiency and compactness of IPT systems, which are key points for electric vehicles.

Grid-adaptive Control and Active-Filter Functionality of grid-connected PWM-inverters in Wind Energy Applications (Hoffmann)

Power electronic generator systems in distributed regenerative power generation applications are used to generate and feed electrical power to the mains. The capacity of the mains is dependent on the line-impedance. The mains line-impedance is usually not constant and is time and frequency dependent, especially in distributed regenerative power generation applications with weak grid conditions. Moreover, the mains line-impedance affects the harmonic content as well as the reactive power present in the network. The standard grid connected PWM converter for regenerative power applications is initially provided for only feeding fundamental power into the grid. Equipped with a properly designed current and voltage control it is also possible to affect the mains power quality with respect to low-frequency current harmonics, fundamental three-phase voltage and current unbalances, and reactive power components. The aim of this research and development project is to investigate different grid-adaptive control strategies for grid-connected PWM converters in distributed regenerative power generation applications, by using conventional and modern control methods. The grid-adaptive converter control should be able to estimate the line-impedance and lead to a reduction, or elimination, of voltage harmonics in the lower-frequency range (Active-Filter functionality), a compensation of reactive power components, as well as grid-voltage unbalances, all in addition to the fundamental power feed-in. The research project was successfully continued in 2012. Key research results, (e.g. a finite control set model-based predictive current control scheme or an extended Kalman-Filter for grid-impedance estimation), have been published at international conferences and the work was honoured with an IEEE ECCE 2012 student presentation award. The project will be concluded in 2013.

Electric Propulsion Drive Trains for Working Vehicles and Cars (40kW, 400V) (Brüske)

The market for electrically powered vehicles and cars will grow rapidly in the future, mainly due to energy and environmental problems. Besides robustness, high efficiency is a key criterion for competitiveness of these vehicles. An optimization of the electric propulsion drive train as the main energy consuming unit is especially necessary. The main parts of the electrical drive train are the battery, the motor, and the voltage source inverter (VSI) that is the connecting interface between the battery and the motor. An optional DC/DC converter between the battery and the VSI can decouple the system voltage level from the battery voltage. The design of the VSI is dependent on the design of the whole electrical propulsion drive train. Therefore detailed analyses of the machine and the possible use of an additional DC/DC converter are necessary and have been conducted. One of the main targets of this work package is the optimization of the VSI. In 2012, different topologies for the VSI were analyzed and compared. Another aspect was the comparison of different power switches for application in the VSI, e.g. IGBT and Superjunction MOSFET. To optimize the switching performance, active gate control methods will be used. For high voltage MOSFETs investigations were conducted in theory and simulation. More precisely a two-voltage step approach for the turn-on process of the SJ MOSFET has been analyzed.

Grid Integration of Wind Turbines with Energy Storage System (Grunau)

The amount of injected power from regenerative energy sources like wind turbines (WTs) to the mains is increasing steadily. With an annual growth of approximately 30% of decentralized feeders it can be foreseen that the main part of energy injection into the grid will be dominated by WTs and other regenerative energy sources in the future. Because a WT's power flow fluctuates due to wind conditions, the grid is exposed to negative effects concerning stability and quality of power systems. This research project aims to investigate and describe such effects, develop solutions, and see how a power system's stability and quality can be strengthened and enhanced by means of the combinations of WT and energy storage

systems (ESS). Also strategies are under investigation to dimension the storage, construct the ESS, and connect it to the WT or wind farm. Long term and short term ESS can be distinguished for balancing power demands and realizing power system support respectively. Even though the prices for batteries are very high, investigations show that the utilization of ESS can lead to future financial benefits for WT operators. Assuming that the market penetration of wind power will increase in the future, it could be shown that ESS can improve significantly the quality and stability of power systems. The effect of fluctuating power injection could be shown to result in system frequency deviations. Also an inverter was built to emulate different storage technologies with flexible dimensioning.

Modern Control of Induction Machines with Torsional Load and Gearbox (Thomsen)

Conventional electrical drive systems consist of an inverter fed ac motor and a load. The load is connected to the motor via transmission elements which have a non-ideal transmission behaviour such as a finite torsional stiffness. This finite stiffness can lead to unwanted torsional oscillations. Backlash effects can occur if gearboxes or clutches are located in the drive system and yield to high torque impulses. Torsional oscillations and torque impulses can stress both the mechanical and electrical components and thus can reduce the lifetime of the system significantly. The aim of this research work is a highly dynamic speed control with active damping of torsional vibrations, limiting the influence of backlash and the adaptation of unknown parameters. In 2012 the project was concluded and documented.

Power Girls & Power Boys Event

All results obtained have been achieved by current and former LEA employers. To maintain a steady and continuous flow of new engineers, our chair organizes the annual Power Boys and Power Girls event. Pupils from 10 -11 years old deal with the subject of new energies practically, e.g. with wind and solar power.

Fig. 3: Powergirls and -boys

Personnel

Head of the group: Prof. Dr.-Ing. F.W. Fuchs; Secretary: P. Bekendorf, M. Marter
Technical Staff: B. Doneit

Scientific Staff:

Dipl. - Wirtsch.-Ing. B. Benkendorff	01.07.-31.12.2012	Zukunftsprogramm SH/Industrie

Optimization of a Power Stack for Wind Turbines

Dipl. - Wirtsch.-Ing. St. Brüske	16.01.-31.12.2012	Interreg

Electric propulsion drive trains - high efficient and robust electric propulsion drives including battery buffering system for working vehicles and cars

Dipl. - Wirtsch.-Ing. K. Buchert	01.02.-31.12.2012	Zukunftsprogramm SH/ Industrie

Analysis and optimization of a small wind turbine system

Dipl.- Ing. M. Böttcher	01.01.-31.12.2012	Zukunftsprogramm SH/ Industrie

CEwind - Kompetenzzentrum Windenergie S-H Phase II: Condition Monitoring für frequency inverters and control of generators in wind power stations

Dipl.- Ing. F. Gebhardt	01.01.-31.12.2012	CAU

Analysis of Multilevel Inverters and New Power Semiconductors for Solar Applications

Dipl. - Wirtsch.-Ing. S. Grunau	01.01.-31.12.2012	CAU

Wind Turbines and Energy Storage Systems

M.Sc. S Günter	01.02.-31.12.2012	BMU

Development of a current generator to measure the frequency dependent low voltage grid impedance

Dipl.- Ing. N. Hoffmann	01.01.-31.12.2012	Zukunftsprogramm SH/Industrie

CEwind - Kompetenzzentrum Windenergie S-H Phase II: Grid-adaptive control and active-filter functionality of grid-connected converters in wind turbine applications

M. Eng. L. Jessen	01.05.-31.12.2012	Stipendiat

Investigation of interactions between distributed generation in electrical power systems with a high penetration of converters

Dipl. - Wirtsch.-Ing. M. Petersen	01.03.-31.12.2012	Zukunftsprogramm SH/ Industrie

Inductive Charging for Electric Vehicles

Dipl. - Wirtsch.-Ing. J. Reese	01.01.-31.12.2012	CAU

Investigation on autonomous controlled inverters in microgrids

Dipl.-Ing. J. Schröder	01.01.-31.12.2012	Frauenhofer ISIT/Land SH

Battery Buffer System and Power Management

Dipl.-Ing. S. Thomsen	01.01.-31.03.2012	DFG

Modern control of electrical drives with oscillatory mechanical loads

Winter 2011/2012

Power Electronics I- Basics, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
F.W. Fuchs (+ S. Grunau)

Power Electronics III- Electrical drives, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
F.W. Fuchs (+ J. Schröder)

Control of Electrical Drives, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
F.W. Fuchs (+ M. Böttcher)

Power Electronics - laboratory course, Master´s, 4 hrs Lab/Week,
F. W. Fuchs (+ F. Gebhardt, J. Schröder, N. Hoffmann, J. Reese, S. Grunau, M. Böttcher)

Seminar on Power Electronics, 2 hrs Seminar/Week,
F.W. Fuchs (+ J. Reese, N. Hoffmann, J. Schröder, S. Thomsen)

Power Electronics - excursion, 1 hrs excursion/Week,
F.W. Fuchs (+ J. Reese, F. Gebhardt, S. Grunau)

Power Electronic Generator Systems for Wind Turbines, 3 (+ 1) hrs Masters Study course Wind Enegineering in CEwind (+ Exercises)/Week,
F.W. Fuchs (+ S. Grunau, J. Schröder, F. Gebhardt, J. Reese)

Renewable Energy Systems II, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
F.W. Fuchs (+ J. Reese, F. Gebhardt)

Summer 2012

Basics of electrical energy systems and power engineering, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
F.W. Fuchs (+ S. Grunau, S. Günter, M. Petersen)

Power Electronics II - Advanced, 3 (+ 1) hrs Lecture (+ Exercises)/Week,
F.W. Fuchs (+ S. Brüske)

Renewable Energy Systems I, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
F.W. Fuchs (+ S. Grunau)

Power Electronics - laboratory course, Bachelor´s, 4 hrs Lab/Week,
F.W. Fuchs (+ F. Gebhardt, J. Reese, K. Buchert, S. Brüske, S. Günter, M. Petersen)

Seminar on Power Electronics, 2 hrs Seminar/Week,
F.W. Fuchs (+ J. Reese, K. Buchert, S. Brüske)

Power Electronics - excursion, 1 hrs excursion/Week,
F. W. Fuchs (+ J. Reese)

Winter 2012/2013

Power Electronics I- Basics, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
F.W. Fuchs (+ M. Petersen)

Power Electronics III- Electrical drives, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
F.W. Fuchs (+ B. Benkendorff)

Control of Electrical Drives, 2 (+1) hrs Lecture (+ Exercises)/Week,
F.W. Fuchs (+ K. Buchert)

Power Electronics - laboratory course, Master´s, 4 hrs Lab/Week,
F. W. Fuchs (+ F. Gebhardt, J. Reese, S. Grunau, B. Benkendorff, K. Buchert, S. Günter, L. Jessen)

Seminar on Power Electronics, 2 hrs Seminar/Week,
F.W. Fuchs (+ J. Reese, K. Buchert, M. Petersen, S. Brüske, S. Grunau, B. Benkendorff)

Power Electronics - excursion, 1 hrs excursion/Week,
F.W. Fuchs (+ K. Buchert, B. Benkendorff)

Power Electronic Generator Systems for Wind Turbines, 3 (+1) hrs Masters Study course Wind Enegineering in CEwind (+ Exercises)/Week,
F.W. Fuchs (+ S. Grunau, F. Gebhardt, S. Brüske, B. Benkendorff, K. Buchert)

Renewable Energy Systems II, 2 (+1) hrs Lecture (+ Exercises)/Week,
F.W. Fuchs (+ J. Reese, F. Gebhardt)

Third-Party Funds

EU / State SH (CE wind), *Grid-adaptive control and active-filter functionality of grid-connected converters for wind-turbine applications*, 01.10.2008-31.12.2012 (361.978 EUR)
BMU, *Power current generator for feed in of high frequency measuring current into electrical grids*, 01.02.2012-31.01.2015 (328.265 EUR)
Interreg (EU), *Optimization of the drive for electric cars*, 01.02.2012-31.01.2015 (258.192 EUR)
DFG, *Control of Electrical Drives with Active Damping of Mechanical Oscillations and Adaption of Unknow Parameters*, 01.02.2009-31.01.2012 (219.715 EUR)
EK SH, *Optimization of the Drive Train of Small Windturbines*, 01.04.2013-31.03.2015 (146.300 EUR)
EK SH, *Inductive Charging*, 01.04.2013-31.03.2015 (112.840 EUR)
EU / State SH (CE Wind), *Condition Monitoring for frequency converters at wind turbine generators*, 01.09.2009-31.08.2012 (100.000 EUR)
Industry, *Control of a brake*, 01.11.2012-31.03.2013 (40.000 EUR + MWSt)
Industry, *Control Systems for High Power Converters*, 01.07.2011-29.02.2012 (30.135 EUR)
Industry, *Sensorless control of a permanent magnet synchronous machine*, 01.05.-30.08.2012 (24.375 EUR + MWSt)
Industry, *Inductive Charging SiC Power Semiconductors*, 01.05.-30.06.2012 (17.377 EUR + MWSt)
Industry, *Preparation of a battery backup system for application in an electric car*, 01.01.-31.03.2012 (15.900 EUR + MWSt)
Industry, *Grid Adaptive Control of Active Rectifiers I*, 01.04.2011-31.03.2013 (13.500 EUR + MWSt)
Industry, *Grid Adaptive Control of Active Rectifiers II*, 01.06.2010-31.03.2013 (13.500 EUR + MWSt)
Industry, *Netzadaptive Regelung des Netzpulsstromrichters für Windenergieanlagen*, 15.09.2011-31.12.2012 (5.000 EUR + MWSt)
Industry, *Training course on power electronics, electrical machines and electrical drives and their control*, 01.03.2012 (4.800 EUR + MWSt)
Industry, *Support for elaboration and presention of an offer for converter development*, 01.11.2011-31.01.2012 (3.100 EUR + MWSt)

Diploma, Bachelor's and Master's Theses

M. Andresen, *PI-basierte Zustandsraumregelung eines Netzpulsstromrichters mit netzseitigem LCL-Filter bei reduzierter Anzahl an Messsensoren und variierenden Netzimpedanzen*, 11.12.2012

S. Baresel, *Vergleich konventioneller PFC-Schaltungen mit Interleaved PFC-Schaltungen zur Effizienzsteigerung von Traktionsbatterieladegeräten*, 27.09.2012

T. Behling, *Untersuchung resonanter Topologien von induktiven Ladesystemen für Elektrofahrzeuge*, 13.11.2012

B. Benkendorff, *Entwurf, Aufbau und Inbetriebnahme von IGBT Treiberschaltungen*, 02.05.2012

S. Claes, *Modellierung und Sensitivitätsanalyse von parallel arbeitenden Energieerzeugern hinsichtlich der Stabilität*, 07.03.2012

S. Dippner, *Spannungsstabilität beim Anschluss von Windenergieanlagen an schwachen Netzen*, 12.09.2012

M. Fox, *Untersuchungen der Netzfrequenzregelung nach Netzanschlussregeln durch eine um ein Energiespeichersystem erweiterte Windenergieanlage mit Doppeltgespeister Asynchronmaschine*, 26.09.2012

J. Götter, *Analyse der Wechselwirkung parallelgeschalteter regenerativer Energieerzeuger unter verschiedenen Netzbedingungen*, 23.08.2012

A. Güttler, *Untersuchung von Modulationsverfahren für einen fehlertoleranten dreistufigen NPC-basierten Umrichter für den Einsatz in Windenergieanlagen*, 02.05.2012

H.-K. Helbig, *Vergleich, Analyse und Bewertung von Topologien zur Realisierung eines bidirektionalen Ladegeräts für Elektrofahrzeuge sowie Aufbau und Inbetriebnahme*, 18.05.2012

F. Hinkelmann, *Untersuchung von aktiven Verfahren zur Inselnetzerkennung bei parallelen Umrichtern sowie Reduktion der dadurch bedingten Netzrückwirkungen*, 11.12.2012

F. Huth, *Entwurf, Implementierung und Untersuchung einer optimierten Regelung für Wechselrichter in Photovoltaik-Anwendungen*, 30.04.2012

A. Jakovenko, *Untersuchung eines Fuzzy-basierten Power Management Systems zur Anbindung eines kurzzeitigen Energiespeichersystems an Windenergieanlagen*, 21.10.2012

F. Kahl, *Vergleich von Primär- und Sekundärregelungsverfahren in isolierten Niederspannungsnetzen hinsichtlich der Stabilität und Netzspannungsgüte*, 12.11.2012

J. Krüger, *Untersuchung von Ansteuerungsverfahren für einen fünfstufigen M2C für den Einsatz in der Photovoltaik*, 30.10.2012

F. Lukoschus, *Netzimpedanz-adaptive Aktive Dämpfungsverfahren für die Regelung eines Netzpulsstromrichters mit LCL-Filter unter Verwendung eines Erweiterten Kalman-Filter-Ansatzes*, 27.09.2012

M. Mehnert, *Identifikation der äquivalenten Netzimpedanz durch selektive Einspeisung von inter-harmonischen Stromoberschwingungen*, 31.08.2012

N. Meyer, *Untersuchung der Auswirkung der Phasenzahl auf das Verhalten von mehrphasigen Gleichstromstellern mit gekoppelten Induktivitäten.*, 11.08.2012

T. Möller, *Untersuchung und Bewertung des Modular High Frequency Umrichter für den Einsatz in Elektrofahrzeugen*, 03.09.2012

J. Most, *Modellierung, Messung und Bewertung leitungsgebundener EMV von dreiphasigen Wechselrichtertopologien*, 18.01.2012

A. Osmanbasic, *Online-Identifikation der äquivalenten Netzimpedanz mit Verwendung eines Kalman-Filters für Windenergieanwendungen*, 18.01.2012

C. Ould-Mohamed, *Auslegung, Aufbau, Inbetriebnahme und Untersuchung eines Energiespeichersystem - Prototyps zum Einsatz in Windenergieanlagen*, 04.05.2012

N. Panten, *Regelung eines Netzpulsstromrichters mit Aktiv-Filter Funktionalität durch überlagerte Spannungsregelung von Oberschwingungen und Unsymmetrien der Netzspannung*, 20.04.2012

M. Päsler, *Optimierung, Erweiterung und Inbetriebnahme eines Emulators für Solarmodule*, 27.07.2012

M. Petersen, *Vergleich, Bewertung und Realisierung von Verfahren zur sensorreduzierten Stromregelung in mehrphasigen Gleichstromstellern (Current-Sharing) in einem System zur Stützung der Batteriespannung bei drehstrombetriebenen Fahrzeugen*, 20.01.2012

B. Rumpf, *Diskontinuierliche PWM zur Reduzierung von Schaltverlusten von zweistufigen Netzpulsstromrichtern mit Aktiv-Filter-Funktionalität*, 14.08.2012

S. Schmidt, *Identifikation der äquivalenten Netzimpedanz unter Verwendung eines durch einen Parameterschätzer erweiterten Luenberger-Beobachters,* 29.07.2012

N. Steffen, *Wechselwirkungen von Methoden zur Bestimmung der Netzqualität bei parallelen Umrichtern in isolierten Netzstrukturen,* 17.09.2012

J. Storm-Ohm, *Entwicklung eines Powermanagements für ein Batteriestützungssystem mit Hilfe von Neuronalen Netzen,* 14.12.2012

H. Vach, *Vergleich von Multilevel-Topologien und Entwurf, Aufbau und Inbetriebnahme eines 5-Level Wechselrichters für Photovoltaik,* 04.05.2012

S. Walz, *Regelung eines permanenterregten Synchrongenerators unter Berücksichtigung von Reluktanzeinflüssen bei variierenden Lastbedingungen,* 21.08.2012

M. Wegner, *Vergleich und Bewertung von DCM und CCM in mehrphasigen Gleichstromstellern,* 09.02.2012

Dissertations / Postdoctoral Lecture Qualifications

Jörg Dannehl, *Regelung von Netzpulsstromrichtern mit LCL-Filter für Antriebe mit kleiner Kapazität im Zwischenkreis,* 03.07.2012

Björn Wittig, *Verbesserung des Schalt- und Betriebsverhaltens von Leistungs-MOSFETs mit niedriger Spannungsfestigkeit und hoher Stromtragfähigkeit durch Optimierung der Treiberschaltung,* 13.07.2012

Christian Wessels, *Durchfahren von Netzwerkfehlern bei Windenergieanlagen mit FACTS,* 09.11.2012

Publications

Published in 2012

M. Böttcher, M. Paulsen, F. W. Fuchs, *Laboratory Setup for Power Cycling of IGBT Modules with Monitoring of ON-State Voltage and Thermal Resistance for State of Ageing Detection,* PCIM Europe 2012, Nürnberg, (2012)

R. Dudde, D. Friedrich, K. von Platen, S. Taube, N. Eggert, H. Solmecke, J. Zitzelsberger, F. Osterwald, R. Isernhagen, F.W. Fuchs, R. Eisele, C. Weber, M. Berger, *Competence Centre for Power Electronics, Development of an advanced, modular frequency converter for traction control,* 6. Smart Systems Integration Conference and Exhibition, Zürich, (2012)

F.W. Fuchs, *Buchkapitel Leistungselektronik-Generator-Systeme in Windenergieanlagen,* CEwind e.G., Schaffarczyk, Alois (Hrsg.): Einführung in die Windenergietechnik, Carl-Hanser-Verlag, München, (2012)

F.W. Fuchs, F. Gebhardt, N. Hoffmann, A. Knop, R. Lohde, J. Reese, C. Wessels, *Research Laboratory for Grid Integration of Distributed Renewable Energy Resources - Design and Realization -,* Energy Conversion Congress and Exposition (ECCE), 2012 IEEE vol., no., pp.1974-1981, (2012)

F.W. Fuchs, N. Hoffmann, J. Reese, C. Wessels, R. Lohde, S. Grunau, F. Gebhardt, *Research Laboratory for Grid-integration of Distributed Renewable Energy Resources - Integration Analysis of DERs -,* EPE-PEMC 2012 ECCE Europe, Novi Sad, Serbia, (2012)

F. Gebhardt, H. Vach, F.W. Fuchs, *Comparison of Transformerless Multilevel Topologies for Photovoltaic Application Concerning Efficiency, Leakage current and Mechanical Volume,* PCIM 2012, Nürnberg, (2012)

F. Gebhardt, H. Vach, F.W. Fuchs, *Analytical Derivation of Power Semiconductor Losses in MOSFET Multilevel Inverters,* EPE-PEMC 2012 ECCE Europe, Novi Sad, Serbia, (2012)

S. Grunau, F.W. Fuchs, *Effect of Wind-Energy Power Injection into Weak Grids,* EWEA - European Wind Energy Association Conference, 2012, (2012)

S. Grunau, M. Fox, F.W. Fuchs, *Comparison of a Three and Four Phase Interleaved Bidirectional DC/DC-Converter for the Operation in an Energy Storage System in Wind Turbines,* EPE-PEMC 2012 ECCE Europe, Novi Sad, Serbia, (2012)

N. Hoffmann, M. Hempel, M.C. Harke, F.W. Fuchs, *Observer-based grid voltage disturbance rejection for grid connected voltage source PWM converters with line side LCL filters,* Energy Conversion Congress and Exposition (ECCE), 2012

IEEE , vol., no., pp.69-76, 15-20 Sept. 2012, (2012)
N. Hoffmann, M. Andresen, F.W. Fuchs, F.W.;, L. Asiminoaei, P.B. Thogersen, *Variable sampling time finite control-set model predictive current control for voltage source inverters,* Energy Conversion Congress and Exposition (ECCE), 2012 IEEE , vol., no., pp.2215-2222, 15-20 Sept. 2012, (2012)
N. Hoffmann, F.W. Fuchs, *Online Grid Impedance Estimation for the Control of Grid Connected Converters in Inductive-Resistive Distributed Power-Networks Using Extended Kalman-Filter,* ECCE 2012, Raleigh, USA, (2012)
J. Reese, F.W. Fuchs, *Influence of the Grid Impedance on the Operating Range of n Parallel Connected Inverters,* PCIM, 2012, Nürnberg, (2012)
J.C. Schroeder, M. Petersen, F.W. Fuchs, *Current Sharing in Multiphase Interleaved Converters by Means of One Current Sensor,* PCIM, 2012, Nürnberg, (2012)
J.C. Schroeder, M. Petersen, F.W. Fuchs, *One-Sensor Current Sharing in Multiphase Interleaved DC/DC Converters with Coupled Inductors,* EPE-PEMC 2012 ECCE Europe, Novi Sad, Serbia, (2012)
J.C. Schroeder, F.W. Fuchs, *Detailed characterization of coupled inductors in interleaved converters regarding the demand for additional filtering,* Energy Conversion Congress and Exposition (ECCE), 2012 IEEE , vol., no., pp.759-766, 15-20 Sept. 2012, (2012)
C. Wessels, N. Hoffmann, M. Molinas, F. Fuchs, *StatCom Control at Wind Farms with Fixed Speed Induction Generators under Asymmetrical Grid Faults,* Industrial Electronics, IEEE Transactions on , accepted for publication in special section on grid-integration of wind-energy, (2012)
B. Wittig, F.W. Fuchs, *Analysis and Comparison of Turn-Off Active Gate Control Methods for Low Voltage Power MOSFETs with High Current Ratings,* Power Electronics, IEEE Transactions on, 2012, vol.27, no.3, pp.1632 - 1640, (2012)

Presentations

B. Benkendorff, *Stand der Technik von Power-Stacks,* Mitarbeiterseminar, 12.11.2012
M. Böttcher, *Ergebnisse der Lastwechseltests von IGBT-Modulen mit Analyse hinsichtlich Lebensdauervorhersage und Fehlerfrüherkennung,* Mitarbeiterseminar, 24.01.2012
M. Böttcher, *Fortschritte in der Leistungselektronik - Themenbereich Schaltungstechnik,* Industrieseminar, 19.04.2012
M. Böttcher, *Condition Monitoring and Fault Tolerance for Power Electronic Converters in Wind Turbines,* Industrie, 05.07.2012
M. Böttcher, *Vergleich fehlertoleranter 3L-NPC-basierter Umrichtertopologien für den Einsatz in Windenergieanlagen,* Mitarbeiterseminar, 12.11.2012
St. Brüske, *Stand der Technik - Elektromobilität, insbesondere Fahrumrichter,* Mitarbeiterseminar, 04.06.2012
St. Brüske, *Fehlertolerante, NPC-basierte Multilevel-Topologie - Funktionsweise, Ansteuerung und Fehlerdiagnose,* LE-Nord, 22.06.2012
St. Brüske, *Aktueller Projektstand,* Mitarbeitervortrag, 12.11.2012
K. Buchert, *Vorstellung praktisches Arbeitsthema - Elektrische Last,* Mitarbeitervortrag, 30.05.2012
K. Buchert, *Stand der Technik von Kleinwindanlagen,* Mitarbeitervortrag, 05.06.2012
K. Buchert, *Vertiefung der Stand der Technik von Kleinwindanlagen,* Mitarbeitervortrag, 12.11.2012
F. Gebhardt, *Fortschritte und aktuelle Trends im Bereich der Leistungshalbleiter,* Industrieseminar, 16.02.2012
F. Gebhardt, *Analysis of Multilevel Inverters and New Power Semiconductors for Solar Applications - Comparison of Topologies Concerning Efficiency, Leakage current and Mechanical Volume,* Industrieseminar, 05.07.2012
F. Gebhardt, *Leistungshalbleiter-Vermessung mit dem neuen Leistungshalbleiter - Teststand,* Mitarbeitervortrag, 04.07.2012
F. Gebhardt, *Analysis of Multilevel Inverters and New Power Semiconductors for Solar Applications - Analytical Derivation of Power Semiconductor Losses in MOSFET Multilevel Inverters,* Industrie, 16.10.2012
F. Gebhardt, *Erfassung von Drehzahl und Rotorlage mit dem Infineon Tricore TC1796,* Mitarbeitervortrag, 12.11.2012
S. Grunau, *Wind Turbines with Energy Storage System,* Industrie, 19.04.2012

S. Grunau, *Fortschritte in der Leistungselektronik - Themenbereich: Erneuerbare Energien,* Mitarbeitervortrag, 12.04.2012

S. Grunau, *Wind Turbines with Energy Storage System,* Industrie, 22.06.2012

S. Grunau, *Netzintegration von Windenergieanlagen mit Energiespeichersystem,* Mitarbeitervortrag, 08.06.2012

S. Grunau, *Research Laboratory for Grid-integration of Distributed Renewable Energy Resources - Integration Analysis of DERs -,* EPE-PEMC 2012 ECCE Europe, Novi Sad, Serbia, 04.09.2012

S. Grunau, *Fortschritte in der Leistungselektronik - Themenbereich: Erneuerbare Energien,* Industrieseminar, 16.10.2012

S. Grunau, *Netzintegration von Windenergieanlagen mit Energiespeichersystem,* Mitarbeitervortrag, 12.11.2012

S. Günter, *Stand der Technik - Methoden der Messstromeinspeisung,* Mitarbeitervortrag, 04.06.2012

S. Günter, *Vergleich der Verlustleistungen verschiedener schnellschaltender Leistungshalbleister,* Mitarbeitervortrag, 12.11.2012

N. Hoffmann, *Fortschritte und aktuelle Trends in der Regelung von leistungselektronischen Anwendungen,,* Industrieseminar, 16.02.2012

N. Hoffmann, *PWM methods for the control of a 1.2 MW grid-connected converter including the pulse dropping region,* Industrie, 21.03.2012

N. Hoffmann, *Erweiterter Kalman-Filter zu Identifikation der äquivalenten Netzimpedanz für die netzadaptive Regelung von Netzpulsstromrichtern,* Industrie, 10.05.2012

N. Hoffmann, *Offshore Windenergieanlagen,* Schleswig-Holsteiner Universitätsgesellschaft, 04.06.2012

N. Hoffmann, *Erweiterter Kalman-Filter zur Schätzung der äquivalenten Netzimpedanz für die netzadaptive Regelung von Netzpulsstromrichtern,* Mitarbeitervortrag, 04.07.2012

N. Hoffmann, *Closed-loop Upcc-control for grid-connected voltage-source converters with LCL filter to provide an active filter functionality,* Industrie, 05.07.2012

N. Hoffmann, *Observer-based Grid Voltage Disturbance Rejection for Grid Connected Voltage Source PWM Converters with Line Side LCL Filters,* ECCE, 17.09.2012

N. Hoffmann, *Variable Sampling-Time Finite Control-Set Model-Based Predictive Current Control for Voltage Source Inverters,* ECCE, 18.09.2012

N. Hoffmann, *Online Grid Impedance Estimation for the Control of Grid Connected Converters in Inductive-Resistive Distributed Power-Networks using Extended Kalman-Filter,* ECCE, 19.09.2012

N. Hoffmann, *PWM methods for the control of a 1.2 MW grid-connected converter including the pulse dropping region,* Industrie, 16.10.2012

N. Hoffmann, *Fortschritte und aktuelle Trends in der Regelung von elektrischen Antrieben und Netzpulsstromnrichtern,* Mitarbeitervortrag, 12.11.2012

N. Hoffmann, *PWM methods for the control of a 1.2 MW grid-connected converter including the pulse dropping region,* Industrie, 22.11.2012

N. Hoffmann, *Luenberger-Beobachter zur Verbesserung des Störgrößenverhaltens von Netzpulsstromrichtern mit netzseitigem LCL-Filter,* Mitarbeitervortrag, 12.11.2012

N. Hoffmann, *Modelling and effects of cross-coupling dynamics for the indirect current control of voltage-source converters operating at high fundamental to sampling frequency ratios,* Industries, 11.12.2012

L. Jessen, *Netzimpedanzmessungen in öffentlichen Niederspannungsnetzen durch Strominjektion,* Mitarbeitervortrag, 08.06.2012

L. Jessen, *Anforderungen an Einspeiser in Niederspannungsnetzen nach VDE-Anwendungsregel - VDE-AR-N 4105:2011-08 -,* Mitarbeitervortrag, 12.11.2012

M. Petersen, *Stand der Technik zu induktiven Ladeverfahren,* Mitarbeitervortrag, 06.06.2012

M. Petersen, *Entwicklung einer Current-Sharing-Methode für dreiphasige DC/DC-Wandler,* LE Nord, 22.06.2012

M. Petersen, *Untersuchung der Kerngeometrie zur Maximierung der Kopplung zwischen stationärer und mobiler Systemspule bei induktiven Ladesystemen,* Mitarbeitervortrag, 12.11.2012

J. Reese, *Synchronisierung und geberlose Drehzahlerfassung eines dieselelektrischen Antriebsstrangs mit permanenterregter Synchronmaschine,* Industrie, 16.02.2012
J. Reese, *Synchronisierung und geberlose Drehzahlerfassung eines dieselelektrischen Antriebsstrangs mit permanenterregter Synchronmaschine,* Industrie, 19.04.2012
J. Reese, *Investigation on autonomous controlled Inverters to improve control mode of microgrids - Sensitivity Analysis and effects of parallel Inverters,* Industrie, 22.06.2012
J. Reese, *Sensorlose Regelung einer Synchronmaschine mit oberflächenmontierten Permanentmagneten,* Mitarbeitervortrag, 03.07.2012
J. Reese, *Synchronisierung und geberlose Drehzahlerfassung eines dieselelektrischen Antriebsstrangs mit permanenterregter Synchronmaschine,* Industrie, 22.08.2012
J. Reese, *Analysis, Synthesis and Measurement Verification of the Equivalent Output Impedance of AC Voltage Controlled Inverters in Microgrids,* Industrie, 16.10.2012
J. Reese, *Analysis, Synthesis and Measurement Verification of the Equivalent Output Impedance of AC Voltage Controlled Inverters in Microgrids and Laboratory Test Bench for Investigations on Microgrids,* Mitarbeitervortrag, 18.10.2012
J. Reese, *Fortschritte und aktuelle Trends in der Regelung von elektrischen Antrieben und Netzpulsstromnrichtern,* Mitarbeitervortrag, 12.11.2012
J. Schröder, *Fortschritte und aktuelle Trends im Bereich Emobilität,* Industrieseminar, 16.02.2012
J. Schröder, *Entwicklung eines optimierten Batteriestützungssystems mit Powermanagement zur Entlastung der Batterie und zur Effizienzsteigerung in Flurförderfahrzeugen,* Industrie, 22.06.2012
J. Schröder, *Realisierung eines Batteriestützungssystems als Kompaktversion zum Einsatz im Prototypenfahrzeug,* Mitarbeitervortrag, 05.07.2012
J. Schröder, *Detailed Characterization of Coupled Inductors in Interleaved Converters Regarding the Demand for Additional Filtering,* ECCE, 20.09.2012
J. Schröder, *Allgemeiner Vergleich zwischen gekoppelten und diskreten Induktivitäten in mehrphasigen Gleichstromstellern,* Mitarbeitervortrag, 12.11.2012

Further Activities and Events

Committee Work (Prof. Fuchs):

Chairman of the Advisory Board of CE wind e.G. Competence Centre for Research in Wind Energy of Universities in Schleswig-Holstein,

Convenor of the German standardization committee for power electronics (DKE-K331) and spokesperson for Germany on the international committee (IEC-TC22),

Head of examination committee and students contact person for the study course ''Electrical and Information Engineering and Business Information'',

Associate Editor IEEE Transactions on Power Electronics,

Reviewer, Session Chair, Topic Chair (EPE-, ECCE-, IECON-conferences respectively).

Infrastructure

- New test setup for characterization of the dynamic performance of power transistors up to 1700 V

- Development of an IGBT gate drive unit for IGBTs up to 1700 V

- Development of an electrical load

- Prototype of an inductive energy transfer system (500 W)

Contribution to external representation of the Faculty of Engineering

Tech to you (industry fair Hannover, tour for pupils, guided by research assistants, April 2012)

Information course for the *Kiel University Information Days* (March 2012)

Power Girls and Boys (Three-day event for 10-11 year old pupils, introduction to technical experiments in renewable energy)

Presentation on ''Offshore Wind Energy'' for the Schleswig-Holstein University association (4 times)

Evaluation of pupils projects on energy in the frame of the pupils competition of the journal „Focus"

Technology of Silicon-Based Micro- and Nano-Systems

Since October 2008 Prof. Dr.-Ing. Wolfgang Benecke has been Managing Director of the Fraunhofer-Institut für Siliziumtechnologie (ISIT) in Itzehoe.

Fraunhofer ISIT develops and manufactures components in microelectronics and microsystems technology, from the design phase, including system simulation, through prototyping and fabrication of samples, up to series production. Even though components manufactured at Fraunhofer ISIT, such as acceleration sensors, valves, and deflection mirrors are often just a fraction of a millimetre in size, there is a wide range of applications: the devices are implemented in areas like medical care, environmental and traffic engineering, communication systems, automotive industry, and mechanical engineering. Working under contract, ISIT develops these types of components in accordance with customer requirements, also creating the application specific integrated circuits (ASICs) needed for the operation of sensors and actuators. Included in this service is the system integration using miniaturized assembly and interconnection technology.

Together with Vishay Siliconix Itzehoe GmbH, the institute operates a professional semiconductor production line which is up-to-date in all required quality certifications (e. g. ISO 9001, TS 16949). This line is used in parallel for PowerMOS and microsystem production, and for R&D projects developing new devices and technological processes.

Other fields of activity at ISIT focus on assembly and packaging techniques for microsystems, analysis of the quality and reliability of electronic components, and development of advanced power-supply components for electronic systems.

The institute employs a staff of around 150 people.

Further information about Fraunhofer ISIT is available on the web: www.isit.fraunhofer.de.

In addition the Institute publishes an Annual Report which can be ordered at ISIT.

Fraunhofer-Institut für Siliziumtechnologie,
Managing Director: Professor Dr. Wolfgang Benecke
Fraunhoferstr. 1
D-25524 Itzehoe
Tel. + 49(0)4821/17-4211 (Secretary)
Fax + 49(0)4821/17-4250
Email info@isit.fraunhofer.de
Internet www.isit.fraunhofer.de

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Wireless Communications

The research of the Wireless Communications group (CWC) focuses on the physical aspects of wireless communications, i.e. antennas and channel modelling.

Antennas are key components of many rf systems for wireless communications and sensing, as they perform the transition from guided waves to free space propagating waves. Antenna design is often seen as an art in applying basic electromagnetic principles to create real structures with the required properties. Nowadays, applications offer limited space for the integration of the wireless modules and therefore, the antenna performance especially is dominated by obstacles to integration. The group's research activities particularly aim to master this integration challenge. Applications range from reconfigurable multiband antennas for SDR (software defined radio), multiple antenna systems for small MIMO (multiple input multiple output) terminals, UWB (ultra wideband) antennas for combined communication and localization, and antenna implantation into the human body for medical implants and BAN (body area networks).

Detailed knowledge of the electromagnetic propagation channel is essential to gain optimum performance in all wireless communication, sensing, and locating applications. In terms of wireless communications the channel properties set the upper bound of the capacity for a given SNR (signal to noise ratio). While channel models of typical urban or indoor environments are already standardized for common mobile communication systems, such as GSM, UMTS, and IEEE 802.11, more specific environments such as aircraft cabins, or in and on the body wireless channels, become an interesting research topic.

Results

UWB Communication and Localization

The Wireless Communications group works on design and integration of UWB antennas for a combined communication and localization system. The system is intended for integration into an aircraft cabin. The antennas designed cover the frequency range from 3.1 GHz to 10.6 GHz. In the framework of a BMWi project grant and in cooperation with Airbus, multiple two antenna systems are integrated into the cabin's ceiling while a miniature mobile device contains a single antenna which is specifically designed to work in close proximity to the human body.

Currently, the CWC evaluates the RF localization of medical implants and surgical instrumentation in cooperation with the Department of Neurosurgery of the Kiel University hospital.

Reconfigurable MIMO Antenna Integration into Small Terminals

MIMO (Multiple Input Multiple Output) is a technique to utilize multiple antenna systems to increase the capacity of modern communication systems. The integration of multiple low correlated antennas is especially challenging if we look at small terminals such as mobile phones. As part of his PhD thesis, Robert Martens investigates the coupling between multiple antenna elements on small terminal platforms and its influence on the element correlation. First results indicate a relation between the element correlation and the characteristic modes established on the common finite ground plate. It can already be foreseen that these promising findings will have the potential to derive design rules for the integration of multiple antennas into small terminals. As a short term prospect such rules are valuable, for example, for the design of LTE (Long Term Evolution) mobile terminals and WLAN IEEE802.11.n devices.

Recently the CWC won research grants from the DAAD, DFG, the BMBF and the ENIAC European framework. Furthermore, cooperation with the Fraunhofer ISIT in Izehoe in the area of piezoelectric MEMS for reconfigurable antennas has been established.

Implanted Antennas and RF propagation within the human body

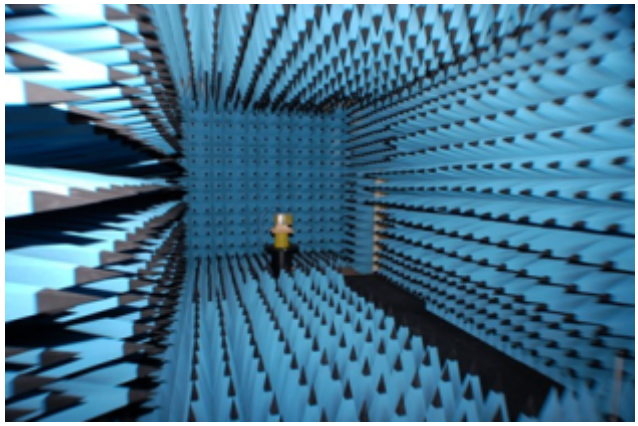


Fig. 1: Shielded absorber room for antenna measurements.

A Body Area Network (BAN) is a combination of several electronic applications that are worn on or in the body, preferably having a wireless interconnection with each other, or with external peripheral devices. The applications can range over consumer electronic devices, security equipment, medical devices for telemedicine, and electronic implants. In order to allow for high data rates, reliable links, and low power consumption, UWB (Ultra WideBand) technology has been considered recently for future BANs. The CWC aims at developing and integrating new miniaturized antennas and channel models for BANs of different applications. The antennas are developed and optimized taking into account realistic integration in the chassis of the application and realistic implantation into the body.

Recently the CWC won a project grant within a targeted focus area of the DFG and started collaboration with the Department of Neurosurgery of the Kiel University hospital.

In addition, project proposals of the CWC are included in the cluster proposal M4L.

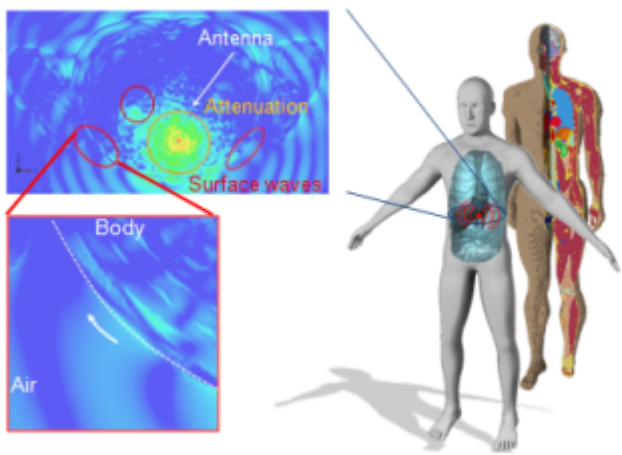


Fig. 2: In and on body radio propagation of wireless medical implants.

Personnel

Head of the group: Prof. Dr.-Ing. D. Manteuffel; Secretary: M. Bork
Technical Staff: Dipl.-Ing. W. Taute

Scientific Staff:

Dipl.-Ing. Y. Chen EPAMO	01.01.-31.12.2012	BMBF / EU
Dipl.-Ing. M. Grimm UWB BAN	01.01.-31.12.2012	DFG
Dipl.-Wirtsch.-Ing. R. Martens MIMO	01.01.-31.12.2012	DFG
Dipl.-Wirtsch.-Ing. F. Marx EPAMO	01.01.-25.03.2012	BMBF / EU
Dipl.-Ing. E. Safin	01.01.-31.12.2012	CAU
M.Sc. Sana Salama Reconfiguable Antennas	01.01.-31.03.2012	DAAD

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

Grundgebiete der Elektrotechnik III, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
D. Manteuffel (+ E. Safin)

Antennas, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
D. Manteuffel (+ Y. Chen)

Funkbasierte Kommunikation und Sensorik in der Medizintechnik, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
D. Manteuffel (+ M. Grimm)

Projekt, 3 hrs Practical/Week,
D. Manteuffel (+ R. Martens)

Masterpraktikum Mikrowellen und EMV, 4 hrs Practical/Week,
D. Manteuffel (+ R. Martens)

Advanced Topics Lab, 6 hrs Practical/Week,
D. Manteuffel

Summer 2012

Wireless Communication (RF), 2 (+ 1) hrs Lecture (+ Exercises)/Week,
D. Manteuffel (+ Y. Chen)

Hochfrequenztechnik, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
D. Manteuffel (+ R. Martens)

Seminar EM Modelling, 3 hrs Seminar/Week,
E. Safin

Projekt, 3 hrs Practical/Week,
R. Martens

Winter 2012/2013

Grundgebiete der Elektrotechnik III, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
D. Manteuffel (+ E. Safin)

Antennas, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
D. Manteuffel (+ Y. Chen)

Funkbasierte Kommunikation und Sensorik in der Medizintechnik, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
D. Manteuffel (+ M. Grimm)

Projekt, 3 hrs Practical/Week,
D. Manteuffel (+ R. Martens)

Masterpraktikum Mikrowellen und EMV, 4 hrs Practical/Week,
D. Manteuffel (+ R. Martens)

Advanced Topics Lab, 6 hrs Practical/Week,
D. Manteuffel

Third-Party Funds

Deutsche Forschungsgemeinschaft, *Antennen und Wellenausbreitung für am und im Körper betriebene Funkanwendungen basierend auf ultra breitbandiger Technologie (Schwerpunktprogramm UKoLoS)*, 01.10.2010-31.01.2013 (124960 EUR)

Deutsche Forschungsgemeinschaft, *Integration von Mehrantennensystemen in kleinen mobilen Endgeräten auf Basis der Theorie der Charakteristischen Moden*, 01.12.2010-30.11.2013 (187440 EUR)

Bundesministerium für Bildung und Forschung / Projektträger im DLR, *ENIAC-Verbundprojekt EPAMO - Teilvorhaben: MEMS basierte rekonfigurierbare Antennen für mobile Terminals*, 01.04.2011-31.03.2014 (353713 EUR)

Bundesministerium für Bildung und Forschung, *Numerische 3D-Feldsimulationen für Konzeptentwicklung und Integration der Antennen für Aufbau mobiler Demonstratorplattformen (Verbundprojekt KoAMo)*, 01.03.2012-28.02.2015 (213948 EUR)

DAAD, *Reconfiguable Antennas*, 01.10.2011-30.09.2012 (12000 EUR)

Further Cooperation, Consulting, and Technology Transfer

The Wireless Communications group (CWC) cooperates with several international universities, such as the University of Nice, Helsinki University of Technology, and Loughborough University. Industrial cooperation has been conducted with I2R Singapore, IMST GmbH, Airbus and Draeger.

Diploma, Bachelor's and Master's Theses

L. Tremp, *Entwicklung eines Messsystems zur drei-dimensionalen Messung der Abstrahlcharakteristik von Antennen*, 10.02.2012

R. Börck, *Entwicklung eines Wheeler-Cap zur Messung des Wirkungsgrads kleiner Antennen*, 23.05.2012

T. Hadamik, *Entwicklung eines Speisenetzwerkes für ein planares Mehrantennensystem für mobile 4G-LTE Endgeräte*, 30.08.2012

A. Iwers, *HF Materialparameter-Charakterisierung von Kunststoffen für explosionsgeschützte Geräte*, 11.09.2012

J. Schmalz, *Einfluss unterschiedlicher Positionen von körpernahmen Funkapplikationen auf die omnidirektionale Abstrahlung*, 11.09.2012

R. Andersen, *Berechnung der charakteristischen Moden auf der Oberfläche verlustbehafteter Körper für die Entwicklung von multimodalen Systemen*, 12.11.2012

Publications

Published in 2012

D. Manteuffel, M. Grimm, *Localization of a functional capsule for wireless neuro-endoscopy*, Biomedical Wireless Technologies, Networks, and Sensing Systems (BioWireleSS), 61 - 64 (2012)

R. Martens, D. Manteuffel, *A feed network for the selective excitation of specific characteristic modes on small terminals*, Antennas and Propagation (EUCAP), 1842 - 1846 (2012)

E. Safin, R. Martens, D. Manteuffel, *Modal source reconstruction based on radiated far-field for antenna design*, Antennas and Propagation (EUCAP), 1645 - 1649 (2012)

M. Grimm, D. Manteuffel, *Evaluation of the Norton equations for the development of body-centric propagation models*, Antennas and Propagation (EUCAP), 311 - 315 (2012)

D. Manteuffel, M. Grimm, *On- and in-body path loss models based on antenna de-embedding*, International Conference on Electromagnetics in Advanced Applications - Antennas and Propagation in Wireless Communications 2012 (ICEAA-IEEE APWC 2012), (2012)

D. Manteuffel, R. Martens, *Multiple Antenna Integration in Small Terminals*, ISAP 2012 - International Symposium on Antennas and Propagation, 211 - 224 (2012)

D. Manteuffel, *Small Terminal Antenna Concepts for Reconfigurable MIMO Handsets*, APCAP 2012 - Asia Pacific Conference on Antennas and Propagation, (2012)

R. Martens, D. Manteuffel, *2-Port Antenna Based on the Selective Excitation of Characteristic Modes*, APS 2012 - IEEE International Symposium on Antennas and Propagation, (2012)

Y. Chen, D. Manteuffel, *Distributed MEMS Impedance Matching Network Using a SW-DGS Technique*, Antennas and Propagation Conference (LAPC), 1 - 4 (2012)

Further Activities and Events

VDE ITG Fachauschschuss 7.1 ''Antennen'': Appointed national committee member.

EurAAP (European Association on Antennas and Propagation): WG Delegate to the delegate assembly.

EurAAP WG on Small Antennas: Chairman of the working group.

ESoA - European School of Antennas: Member of the board of directors.

Standardization: ICES working group TC34 member.

Editor of the IET Proceedings on Microwave, Antennas and Propagation.

Steering Committees and Technical Program Committees. In 2012 Prof. Manteuffel served on the TPC of the following international conferences: EuCAP 2012 - European Antennas and Propagation Conference, LAPC 2012 - Loughborough Antennas and Propagation Conference, iWAT 2012 - International Workshop on Antenna Technology.

Institute for Materials Science

The Institute for Materials Science continued its story of success in the fields of research, teaching, and technology transfer during 2012. Here are some of the highlights.

The institute gained visibility by a number of high-ranking scientific publications. Within the framework of the collaborative research centre SFB 855, a team centred around the group ''Inorganic Functional Materials'' (Prof. Quandt) published results concerning a highly sensitive composite material for biomagnetic sensing. The approach presented in Nature Materials will be of key importance for the second funding period of the SFB, which will be starting in 2014, depending on the positive outcome of the SFB's evaluation in September 2013.

The group of Prof. Adelung (Functional Nanomaterials), in collaboration with researchers from TU Hamburg-Harburg (Prof. Schulte), published results on the creation of so-called Aerographite, which now holds the world record for the solid material with the lowest density. The corresponding paper was published as a cover story in Advanced Materials and made a splash not just within the scientific community. As another highlight, the same group developed a method for ''joining the un-joinable'', promoting the adhesion between low surface energy polymers via ZnO tetrapods as linkers (published in Advanced Materials and highlighted in Nature).

The recent papers of the HZG/CAU research group ''Nanochemistry and Nanoengineering'' (headed by Prof. Elbahri) should also be mentioned, particularly the design of a perfect black absorber utilizing plasmonic metamaterials presented as a frontispiece in Advanced Materials. As a feature trial for energy saving membranes, Elbahri's research group has developed a novel efficient water filtration membrane, which was selected and appeared as a cover story in Materials Today. In addition the group has bridged the gap between Filtration, Bioscience, and Plasmonics by developing a novel concept of smart materials based on ''Plasmonic Bionanocomposites''; this has been published as an inside front cover story in Advanced Functional Materials.

The applied character of most research projects is also emphasized by the establishment of the first spin-off from the department of Prof. Quandt; the company Acquandas GmbH is headed by Dr. Lima de Miranda and is working on smart material based devices.

The third-party funding activities (which were already at a high level before) rose again, as indicated by the large number of positively evaluated research applications. Members of the institute created several noteworthy joint research projects with colleagues from abroad, e.g. the Mercator Professorship of Prof. D.C. Johnson within the framework of SPP1386 (''Nanothermoelectrics'').

In experimental sciences much of the quality of scientific work depends on the availability of a suitable infrastructure like the clean room facilities at the Nanolab and the TEM centre. The latter, headed by Prof. Kienle, is being upgraded at the moment by the installation of a new transmission electron microscope, procured on the basis of a proposal approved by the DFG and with funding from the state of Schleswig-Holstein. Moreover, the DFG supported the application of Prof. Selhuber-Unkel (Biocompatible Nanomaterials) for a new atomic force microscope, enabling her group to investigate biological structures on the nanoscale.

Furthermore, several members of the institute were honoured by scientific prizes and appointed to scientific boards. Prof. Adelung received the ISH-Transferpreis, an award for transferring knowledge and concepts to industry, and was also awarded ''Prof of the Night'' at the Night of the Profs at the CAU.

In addition, Prof. Elbahri obtained a special award ''Nanotechnology'' within a competition for ideas run by the state of Schleswig-Holstein. Since 2012 Prof. Quandt is an elected board member of the ''Deutsche Gesellschaft für

Materialkunde" and Acatech (Deutsche Akademie der Technikwissenschaften). Prof. Faupel was appointed as member of the Minerva-Weizmann committee.

Last but not least, the institute is increasingly attractive to students as proved by the still increasing large number of first-year students in the bachelor´s and master´s study courses. We are especially proud of the high percentage of female students. With 40 % female students this is a German record with respect to engineering study courses.

Biocompatible Nanomaterials

The "Biocompatible nanomaterials" department focuses on investigating cell-material interactions with an interdisciplinary approach, by combining methods from materials science, physics, chemistry, and biology. The long-term goal is to control living cells with nano- and microstructures from the level of single molecules to many cells and to understand quantitatively cell adhesion mechanobiology. This particularly includes experiments with force microscopy techniques and optical microscopy. In 2012, the group relocated to building A where our labs and offices are located on the 1st floor.

Results

Intracellular motion in *Acanthamoeba castellanii* and carbohydrate dependent adhesion studies

Acanthamoeba castellanii are free living amoebae that can destroy target cells by an extracellular killing mechanism that is induced by the formation of a close contact between the amoeba and the target cell. This process is mediated by carbohydrates. Subsequently, granules that contain pore-forming proteins are transported to the contact site between amoeba and target cell. For a deeper understanding of the intracellular processes that cause the extracellular killing mechanism, the movement of small lipid granules, as well as of vacuoles, was observed with a high-speed camera. It was found that in amoebae, particles are mostly actively transported either by molecular motors or intracellular convection. The influence of molecular motors, walking on microtubuli or actin filaments, was investigated by inhibiting either the molecular motor directly or the polymerization of the filaments. We found that the diffusion and active motion of intracellular compartments is significantly controlled by molecular motors and cytoskeletal filaments.

To mimic the adhesion of Acanthamoeba to target cells, gold nanostructured surfaces were produced and functionalized with mannose. It was found that there is an influence of the density of the carbohydrate molecules on the spreading area of the amoebae and on the number of adhering Acanthamoeba. Furthermore, the influence of matrigel, mainly composed of collagen IV and laminin-1, and of the protein fibronectin on amoebic adhesion and spreading was investigated. Also here, an increase in the spreading area and cell number in comparison to non-functionalized glass surfaces was found.

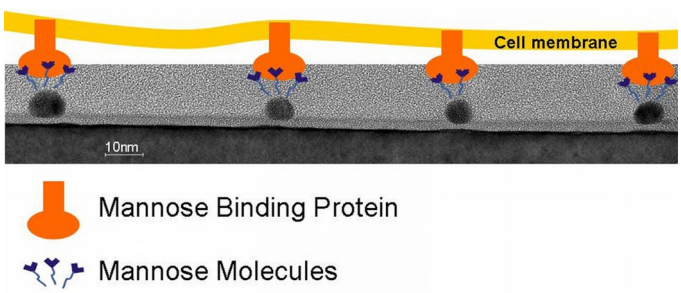
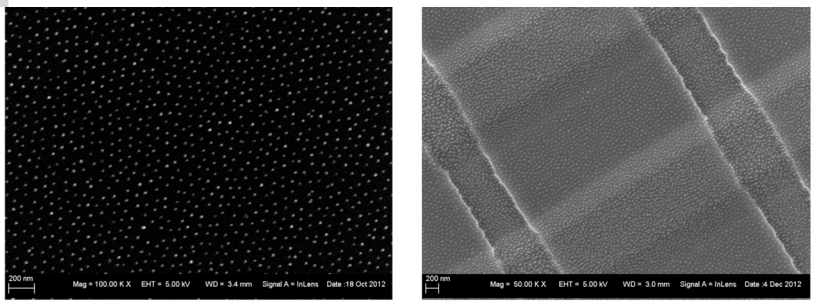


Fig. 1: Transmission electron microscopy image of gold nanodots on a Silicon wafer. The nanodots are biofunctionalized with mannose disulphide. Mannose mediates the adhesion of *Acanthamoeba castellanii* via their mannose binding proteins, which serve as adhesion receptors. By varying the nanodot density on a surface, the influence of the concentration of mannose is investigated.

Gold nanostructures for controlling cell adhesion on surfaces

Detaching cells from a surface (cell harvesting) is a challenge considering that it is commonly done using an enzymatic approach, which is harmful for the cells. We aim for a more gentle approach, i.e. to detach eukaryotic and prokaryotic cells by developing nanostructured surfaces where light-driven switchable cell adhesion is feasible. Using Diblock Copolymer Micelle Nanolithography, these nanostructures are introduced onto the surface as nanometre-sized monodispersed gold particles ordered in a quasi-hexagonal pattern. The spacing between the gold dots (5-8 nm in size) can be varied from 20 to 200 nm with nanometre precision (Figure 2a). Moreover, we can apply this technique to surfaces with a structured

microtopography (Figure 2b). Regular microtopographies on surfaces can be obtained with photolithography followed by an etching step. Subsequently, we create patterns of the gold nanodots within the microdomains. With this protocol, we are able to generate different spacings of gold dots on one single substrate in a single step. The gold dots are functionalized with photoswitchable azobenzene molecules incorporated with RGD peptides in order to mediate specific cell adhesion to surfaces through integrins. Using the photoswitching properties of azobenzenes, we aim to switch cell adhesion in a spatially and temporally defined fashion.



a b

Fig. 2: a: Hexagonal pattern of gold nanodots. b: Gold nanodots on a surface with structured microtopography.

Microencapsulation of lipophilic ingredients by spray drying

The food industry uses spray-drying of emulsions to increase the shelf life of functional foods and protect different components, such as volatile flavours or valuable nutrients like vitamins, probiotics, and enzymes. After spray-drying, the bioactive components are enclosed in microcapsules that delay their degradation (Figure 3a). We are collaborating with the group of Prof. Schwarz at the Department of Food Technology of the Institute of Human Nutrition and Food Science at CAU, and Prof. Drusch at the Institute of Food Technology and Food Chemistry (Technische Universität Berlin), who are investigating a method to reinforce these microcapsules. They use electrostatic layer-by-layer adsorption of charged proteins and polysaccharides on the emulsion droplets prior to spray-drying. In particular, β-lactoglobulin, the major whey protein in cow's milk, is used. It forms fibrillar aggregates upon prolonged heating at low pH. We use different atomic force microscopy techniques, such as topographical imaging, quantitative imaging, and force spectroscopy, to study β-lactoglobulin fibril formation (Figure 3b) as well as microcapsule surface morphology and mechanical stability (Figure 3c).

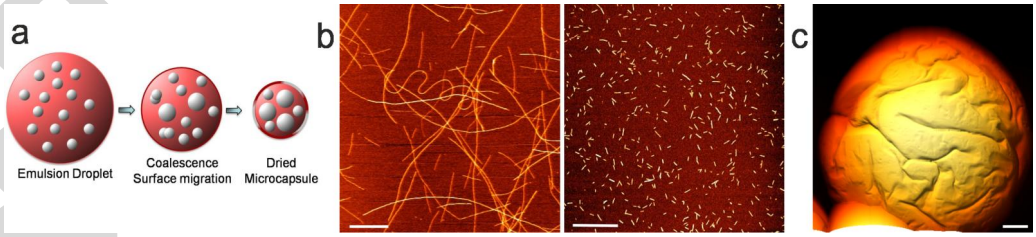


Fig. 3: a: Oil droplets in aqueous matrix (emulsion droplet) shrink during spray drying and form a solid microparticle (dried microcapsule). b: β-lactoglobulin fibrils to act as interfacial agents at the oil-water interface: The initially several micrometres long fibres (left) are shortened by application of high pressure and/or shear force (right). Scale bars in the AFM topography images are 1 μm. c: Microcapsule from spray-dried emulsion droplet. The scale bar in this AFM topography image is 5 μm.

Elastic polyacrylamide beads (EPABs) as novel force sensors

Phagocytosis is an essential mechanism found in many cell types. It is of key importance for the functioning of biological systems and tissues and plays a significant role for the immune system. So far, the forces acting during the uptake of

target cells and artificial particles are still not known. In order to elucidate the complexity of such force generation events during phagocytosis in different cellular systems and to gain further insight into the underlying processes, we fabricate elastic polyacrylamide beads (EPABs). These beads can be manufactured with a large variety of Young's moduli, and can be equipped with many types of biofunctionalizations. To this end, we transfer the concept of traction force microscopy into the third dimension and synthesize fluorescent EPABs with incorporated fluorescent nanoparticles by means of inversed emulsion polymerization. The elasticity of these particles can be changed by varying the amounts of crosslinker and is characterized with AFM.

Personnel

Head of the group: Prof. Dr. C. Selhuber-Unkel; Secretary: E. Riemer (50%)
Technical Staff: Manuela Lieb (50%)

Scientific Staff:

S. Gutekunst	01.05.-31.12.2012	CAU
Elastic polymer particles as force sensors		
M.Sc. L. Kadem	01.01.-31.12.2012	DFG
SFB 677, Teilprojekt B11		
Dr. C. Lamprecht	01.01.-31.12.2012	Materials for Life Award
Atomic force microscopy on single molecules and live cells		
Qian Li	31.03.-31.12.2012	DFG
Cell adhesion and magnetic particle detection with ME sensors		
M.Sc. J. Reverey	01.01.-31.12.2012	DFG
A nanobiophysical approach to elucidate target-cell killing by amoebic parasites		
Dr. S. Viebig	01.01.-31.07.2012	CAU
Biocompatibility studies		

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

Advanced Materials A - Polymers, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
C. Selhuber-Unkel

Cell Mechanics, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
C. Selhuber-Unkel

Biokompatible Nanomaterialien, 2 hrs Seminar/Week,
C. Selhuber-Unkel

Summer 2012

Grundlagen der Optik und Lichtmikroskopie, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
C. Selhuber-Unkel

Bioinspired Materials, 2 hrs Lecture/Week,
C. Selhuber-Unkel

Biokompatible Nanomaterialien, 2 hrs Seminar/Week,

C. Selhuber-Unkel

Chemie für Materialwissenschaftler 2, 3 hrs Exercise/Week,
S. Gutekunst

Winter 2012/2013

Cell Mechanics, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
C. Selhuber-Unkel

Chemistry and Physics of Biomaterials, 3 (+ 1) hrs Lecture (+ Exercises)/Week,
C. Selhuber-Unkel (+ R. Adelung, L. Kienle)

Chemistry and Physics of Biomaterials, 1 hrs Seminar/Week,
C. Selhuber-Unkel

Biokompatible Nanomaterialien, 2 hrs Seminar/Week,
C. Selhuber-Unkel

Third-Party Funds

DFG, *Sachbeihilfe zur Einrichtung einer Nachwuchsgruppe im Emmy Noether-Programm zum Thema: A nanobiophysical approach to elucidate target-cell killing by amoebic parasites,* 01.06.2010-30.05.2015 (1.244.542 Euro)
DFG, *Schaltbare Zelladhäsion: SFB 677/B11,* 01.07.2011-30.06.2015 (237.600 Euro)
DFG, *Magnetoelektrische Verbundwerkstoffe: SFB 855, Pauschale Mittel,* 01.10.-31.12.2012 (11.000 Euro)
DFG, Major Instrumentation Program, *Atomic Force Microscope,* 29.03.2012 (125.072 Euro)

Further Cooperation, Consulting, and Technology Transfer

Prof. D. Adam, UKSH: adhesion forces of Jurkat cells on biopolymer surfaces.
Prof. M. Gerken, Universität Kiel, Lehrstuhl für Integrierte Systeme und Photonik: cell adhesion on photonic crystals.
Prof. S. Gorb, Universität Kiel, Zoologisches Institut: common projects on investigating adhesion with AFM.
Prof. R. Herges, Prof. T. K. Lindhorst, Universität Kiel, Otto-Diels-Institut: switchable cell adhesion (SFB „Function by switching").
Prof. M. Leippe, Universität Kiel, Zoologisches Institut: characterizing biophysical properties of amoebae.
Prof. R. Mentlein, Dr. K. Hattermann, UKSH: chemokines in adhesion.
Prof. R. Metzler, TU München: diffusion and ageing in cells.
Assoc. Prof. L. Oddershede, Niels Bohr Institute, University of Copenhagen: optical tweezers.
Prof. E. Quandt, Universität Kiel, Lehrstuhl für Anorganische Funktionsmaterialien: NiTi and magnesium thin films.
Dr. C. Röhl, UKSH, Toxikologie, and Prof. J. Spatz, MPI for Metal Research, Stuttgart: toxicity of silver nanoparticles.
Prof. K. Schwarz, Dr. Y. Seifert, Universität Kiel, Institut für Humanernährung und Lebensmittelkunde: nanotopography and nanostructure of biopolymer fibrils.

Diploma, Bachelor's and Master's Theses

A. Moehring, *Cell adhesion to magnesium under dynamic conditions,* 07.09.2012

Publications

Published in 2012

Y. Nazirizadeh, T. Becker, J. Reverey, C. Selhuber-Unkel, D. H. Rapoport, U. Lemmer, M. Gerken, *Photonic crystal slabs for surface contrast enhancement in microscopy of transparent objects.*, Optics Express, **20**, 14451 - 14459 (2012)

Presentations

C. Lamprecht, V. Ruprecht, S. Wieser, M. Brameshuber, E. Heister, N. Gierlinger, P. Hinterdorfer, A. Ebner, *Single-particle studies of selective carbon nanotube binding and transport in human carcinoma cells using folic acid as targeting ligand (poster)*, Treffen der Norddeutschen Biophysiker, Borstel, Germany, 13.01.2012

L. Kadem, M. Holz, S. Viebig, R. Herges, C. Selhuber-Unkel, *Photo-switchable Cell Adhesion on Functionalized Nanostructures (poster)*, Treffen der Norddeutschen Biophysiker, Borstel, Germany, 13.01.2012

C. Lamprecht, B. Plochberger, B. Unterauer, V. Ruprecht, S. Wieser, M. Brameshuber, E. Notburga Gierlinger, P. Heister, P. Hinterdorfer, A. Ebner, *Targeted drug delivery with carbon nanotubes (poster)*, XIV Linz Winterworkshop, Linz, Austria, 03.-06.02.2012

J. Reverey, J.-H. Jeon, V. Tejedor, R. Metzler, L. Oddershede, C. Selhuber-Unkel, *Diffusion of micro- and nanoparticles in living cells (poster)*, Edgar Lüscher Seminar, Klosters, Switzerland, 04.-11.02.2012

J. Reverey, L. Kadem, C. Selhuber-Unkel, *Bio-inspired Nanomaterials for Controlling Cell Functions (talk)*, DGM conference on Bio-inspired materials, Potsdam, Germany, 20.-23.03.2012

L. Kadem, M. Holz, S. Viebig, R. Herges, C. Selhuber-Unkel, *Photo-switchable Cell Adhesion on Functionalized Nanostructures (poster)*, Spring Meeting of the DPG, Berlin, Germany, 25.-30.03.2012

J. Reverey, S. Viebig, M. Leippe, C. Selhuber-Unkel, *Contact Formation between pathogenic Amoebae and Target Cells (poster)*, Spring Meeting of the DPG, Berlin, Germany, 25.-30.03.2012

J. Reverey, C. Selhuber-Unkel, *Contact-dependent processes in parasitic amoebae (talk)*, Seminar New Materials and Biosystems, Antholz, Italy, 25.-31.03.2012

L. Kadem, *Photo-switchable Cell Adhesion on Biocompatible Nano-structured Surfaces (talk)*, Seminar New Materials and Biosystems, Antholz, Italy, 25.-31.03.2012

C. Lamprecht, *AFM for in vivo protein-protein interaction detection (talk)*, Seminar New Materials and Biosystems, Antholz, Italy, 25.-31.03.2012

C. Selhuber-Unkel, *Characterizing Cell-Surface Interactions with Atomic Force Microscopy (invited talk)*, Interface Biology of Implants, Rostock, Germany, 09.-12.05.2012

C. Selhuber-Unkel, *Förderprogramme für Nachwuchswissenschaftler - ein Erfahrungsbericht (invited talk)*, DGM Impulsvortrag, Nachwuchsforum at the innomateria, Cologne, Germany, 21.05.2012

C. Selhuber-Unkel, *Investigating dynamic processes in Acanthamoebae (invited talk)*, Colloquium of the SFB 863, TU Munich, Munich, Germany, 01.06.2012

L. Kadem, M. López-García, H. Kessler, J. P. Spatz, C. Selhuber-Unkel, *Investigation of cell-nanostructure interactions with force microscopy*, Cimtech, Montecantini Terme, Italy, 10.-14.06.2012

C. Lamprecht, *Atomic force microscopy as nanoscopic method in life sciences (invited talk)*, Department of Food Technology, Christian-Albrechts-University of Kiel, Kiel, Germany, 25.06.2012

S. Gutekunst, C. Selhuber-Unkel, *Mechanoelastic Force-Measurements with living cells (talk)*, Cooperation-Meeting, Sonderborg, Denmark, 08.08.2012

L. Kadem, M. Holz, *Photoswitchable surfaces: A dynamic control over cell adhesion (talk)*, SFB 677 Summer School, Ratzeburg, Germany, 09.-10.08.2012

C. Lamprecht, L. Kadem, J. Reverey, R. Metzler, C. Selhuber-Unkel, *Advanced force microscopy techniques for investigating cellular interactions*, International Materials Research Congress, Cancun, Mexico, 12.-18.08.2012

Qian Li, M. Holz, R. Herges, C. Selhuber-Unkel, *Cell Adhesion on Nanostructured photoswitchable surfaces (poster)*, Molecular Switches: Elementary Processes and Applications, Plön, Germany, 20.-22.08.2012

L. Kadem, M. Holz, Qian Li, C. Lamprecht, V. Chandrasekaran, T. K. Lindhorst, R. Herges, C. Selhuber-Unkel, *Nanostructured Surfaces as Platforms for Photoswitchable Cell Adhesion (poster)*, Molecular Switches: Elementary Processes and Applications, Plön, Germany, 20.-22.08.2012

J. Reverey, V. Chandrasekaran, M. Leippe, T. K. Lindhorst, C. Selhuber-Unkel, *Investigation and biomimicry of target cell killing by Acanthamoeba (poster)*, Molecular Switches: Elementary Processes and Applications, Plön, Germany,

20.-22.08.2012

S. Gutekunst, C. Selhuber-Unkel, *Three-dimensional elastic force sensors for live cell investigations (poster)*, Forces and Flow in Biological Systems, DPG Physics School, Physikzentrum, Bad Honnef, Germany, 23.-28.09.2012

L. Kadem, M. Holz, S. Viebig, R. Herges, C. Selhuber-Unkel, *Switching Cell Adhesion on Nanostructured Surfaces (poster)*, Materials Science and Engineering Conference, Darmstadt, Germany, 24.-27.09.2012

J. Reverey, S. Viebig, M. Leippe, C. Selhuber-Unkel, *Contact Formation between pathogenic Amoebae and Functionalized Surfaces (talk)*, Materials Science and Engineering Conference, Darmstadt, Germany, 25.-27.09.2012

C. Lamprecht, B. Plochberger, B. Unterauer, V. Ruprecht, S. Wieser, M. Brameshuber, N. Gierlinger, E. Heister, P. Hinterdorfer, A. Ebner, *Targeted drug delivery with CNTs: selective CNT binding and uptake by human carcinoma cells (talk)*, Materials Science and Engineering Conference, Darmstadt, Germany, 25.-27.09.2012

C. Lamprecht, L. Kadem, J. Reverey, M. Holz, R. Herges, T. K. Lindhorst, C. Selhuber-Unkel, *Single-cell adhesion force spectroscopy on photo-switchable nano-surfaces (poster)*, Materials Science and Enineering Conference, Darmstadt, Germany, 25.-27.09.2012

C. Selhuber-Unkel, *Investigating target-cell killing in amoebae (invited talk)*, Centre for Nanoscience (CeNS), LMU Munich, Munich, Germany, 09.10.2012

L. Kadem, J. Reverey, C. Selhuber-Unkel, *Biocompatible nanostructures for controlling cell adhesion (poster)*, Japanese-German Frontiers of Science meeting (JAGFOS) of the Alexander von Humboldt Foundation, Potsdam, Germany, 25.-28.10.2012

J. Reverey, L. Kadem, V. Chandrasekaran, M. Leippe, T. K. Lindhorst, C. Selhuber-Unkel, *Carbohydrate dependent adhesion of pathogenic Acanthamoebae to structured Surfaces (poster)*, Annual Meeting Deutsche Gesellschaft für Biomaterialien (DGBM), Hamburg, Germany, 01.-03.11.2012

Further Activities and Events

C. Selhuber-Unkel: member of the planning group for the Japanese-German Frontiers of Science Meeting 2013 (Alexander von Humboldt foundation)

Functional Nanomaterials

The group ''Functional Nanomaterials'' deals with the development of new materials on the basis of their nanostructures. They can be functional elements as well as completely new materials. The research projects cover the complete range from basic research all the way to applications. After finishing the enlargement of the group in 2010/11 and equipping the laboratory with basic experimental installations, 2012 was an extremely successful year for the group.

Two research articles especially generated extremely high interest. One concerned the new ultralightweight material Aerographite, which was developed in collaboration with the TUHH and found an outstanding international interest. After the publication as a cover story in the high ranking journal ''Advanced Materials'', not only many scientific news pages and magazines reported the finding but also several public television channels, countless print media, and radio channels explained the new carbon material. At the maximum, more than half a million webpages in many countries reported about aerographite. Currently (January and February 2013), the article is the most accessed on average over the last year in the journal ''Advanced Materials''. The part of the development of the aerographite synthesis that was done in Kiel was a by-product of the collaborative research initiative SFB855 ''Magnetoelectric Composites - Future Biomagnetic Interfaces'', funded by the ''Deutsche Forschungsgemeinschaft''(DFG). The other article was about work performed in the framework of the SFB 677, ''Function by switching'', which received similar great attention; it is a joint work with Prof. Staubitz from Chemistry and Prof. Gorb from Biology. The publication published in Advanced Materials describes how to ''Join the unjoinables'': how to stick two low energy polymers, Teflon (PTFE) and Silicone (PDMS), together. The article describes a new method to adhere chemically incompatible materials. It was selected as a research highlight by the journal ''Nature'', one of the most important journals in science. Furthermore, many magazines focusing on chemistry, materials science, and adhesion reported it in several languages, for example French and Italian. Due to its useful outcome, several companies requested sample material, making it an ideal project for technology transfer.

After 2011, the group was again honoured by the ISH technology foundation with a so- called ''Transferprämie'', which is an award of 5000 Euro third party funds given in cooperation with ''The Ministry of Science, Economic Affairs and Transport'' for technology transfer with companies in Schleswig-Holstein. A further visible technology transfer activity was the founding of the ''Nanoproofed research and development GmbH'' with some members of the Functional Nanomaterials group, making it partially a spin-off company.

Teaching does not only comprise lectures, it also includes research in the group within the framework of bachelor´s and master´s theses. Interdisciplinary seminars continued also in 2012 together with Prof. Theobald, the managing director of the Centre for Ethics in Life Sciences. This seminar will now be integrated in the ''Gustav Radbruch network''. In the framework of public relations, public lectures were given in ''Saturday morning physics'', the ''Universitätsgesellschaft Schleswig-Holstein'' and the ''Night of the Profs'' where the lecture was voted as the best of the evening by the participants.

An additional third party project dealing with the top coating of wind turbine blades received funding within the nanomarin network project, bringing the group to a size of 10 researchers in December (2 Postdoctoral researchers, 8 PhD students). One PhD student is shared with the chair for general materials science in the group of Prof. Föll, in preparation for the fusion of both groups in 2014.

Results

In 2012 especially, more results were found and published by the group than ever before. Therefore, only a small selection of the current results can be presented. In addition to the selection made below, it is worth mentioning that in the SFB 855 project the first magneto-electric sensors were produced on the basis of the new flame transport synthesis. The c-axis oriented crystals have lengths up to the centimetre scale.

Aerographite:

The synthesis recipe for Aerographite (Fig. 1) was described nicely by other groups in a generally understandable manner in the free encyclopaedia Wikipedia on the basis of the joint publication with the TUHH group. This is reproduced here as a suitable introduction to the subject: ''Aerographite is produced by chemical vapour deposition using a ZnO template. The template consists of micron-thick rods, often in the shape of multipods that can be synthesized by mixing comparable amounts of Zn and polyvinyl butyral powders and heating the mixture at 900°C. The aerographite synthesis is carried out at about 760°C under an argon gas flow, to which toluene vapours are injected as a carbon source. A thin (15 nm), discontinuous layer of carbon is deposited on ZnO which is then etched away by adding hydrogen gas to the reaction chamber. Thus the remaining carbon network closely follows the morphology of the original ZnO template. In particular, the nodes of the aerographite network originate from the joints of the ZnO multipods''. From our point of view there are two points that have to be emphasized that make the synthesis special. Firstly, the ZnO tetrapod network, which was created in Kiel, consists of interpenetrating tetrapods (see Fig. 1a). This gives the network an extremely high porosity, more than 98 %, which is much higher than other porous ZnO materials based on particles. Secondly, the special synthesis was done at the TUHH in Hamburg by the collaboration partners Mathias Mecklenburg and Prof. Karl Schulte, where carbon is deposited on the ZnO network and at the same time removed by hydrogen etching (Fig. 1b). The material obtained can be seen as an increased diameter version of carbon nanotubes, which allows them to form junctions. Thus aerographite consists of a tube network with closed outer shells (Fig. 1c) or open ribbon network like shells (Fig. 1d). The Wikipedia article describes the structure as well: ''Aerographite is a black freestanding material that can be produced in various shapes occupying a volume of up to several cubic centimetres. It consists of a seamless interconnected network of carbon tubes that have micron-scale diameters and a wall thickness of about 15 nm. Because of the relatively lower curvature and larger wall thickness, these walls differ from the graphene-like shells of carbon nanotubes and resemble vitreous carbon in their properties. These walls are often discontinuous and contain wrinkled areas that improve the elastic properties of aerographite. The carbon bonding in aerographite has an sp^2 character, as confirmed by electron energy loss spectroscopy and electrical conductivity measurements. ''

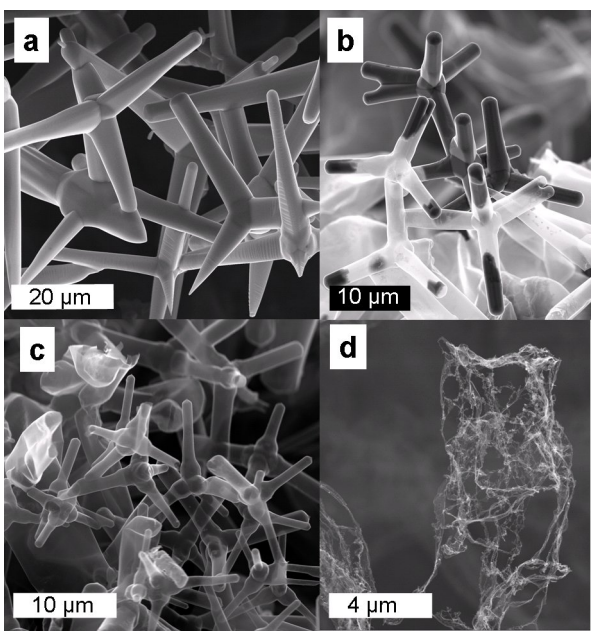


Fig. 1: Electron microscopy of the Aerographite synthesis steps. a) A highly porous interconnected ZnO network formed by the flame transport synthesis approach in Kiel is the basis template for Aerographite. b) During the Synthesis at the TUHH, carbon gets deposited on the outside of the ZnO crystal network, while at the same time the network decomposes. The micrograph shows a partial decomposition state c) Aerographite after synthesis. The electron transparent carbon tubes resemble the structure of the ZnO network d) an even more lightweight variant consists of a hollow framework instead of closed tubes and having densities below 200 microgram per cubic centimetre

This special internal structure leads to interesting properties, which are described in Wikipedia as well: ''Upon external compression, the conductivity increases, along with material density, from 0.2 S/m at 0.18 mg/cm^3 to 0.8 S/m at 0.2 mg/ cm^3. The conductivity is higher for a denser material, 37 S/m at 50 mg/ cm^3''. Application wise, many promising experiments are on the way, including a hybrid material we call Aeromagnet with large magnetostrictive coefficient. For lithium ion batteries, high performance cathodes are built on the basis of Aerographite. This is a further joint project with the general material science group of Helmut Föll.

Nanostructure assisted composite materials

Another main motivation for the further exploration of ZnO nano- and microstructured crystals is the ability to form new composite materials. Work was done on a novel concept for self-reporting materials: stress sensitive photoluminescence in ZnO tetrapod filled elastomers could be utilized as a failure indicator for composites. Detection of material failure in general is a difficult task, because the crack length of micro cracks inside the material has to be inspected on a regular base. It is even more difficult to detect material failure in composite materials; up to now there is no criterion like a maximal crack length to identify the status of a composite. The new concept to design so-called self-reporting composite materials was realized with the group of Cord Zollfrank at the TU-Munich. The concept utilizes zinc oxide tetrapod crystals (Fig. 2a) as a filler material for composites which at the same time reveals material failure by a visual signal under UV light. ZnO fillers are able to significantly strengthen polymers, much more than equal fractions of roundish fillers. The luminescent features in the green and UV region of zinc oxide tetrapodal crystals are well established; these characteristics were now detected under mechanical load (see Fig. 2b) and showed pronounced variations (see Fig. 2c), which can help to detect internal damage of composite materials. The micro/nano sized crystals give a visual warning when the composite material is about to fail under stress. An electron microscopy image of the failure surface is shown in Fig. 2d.

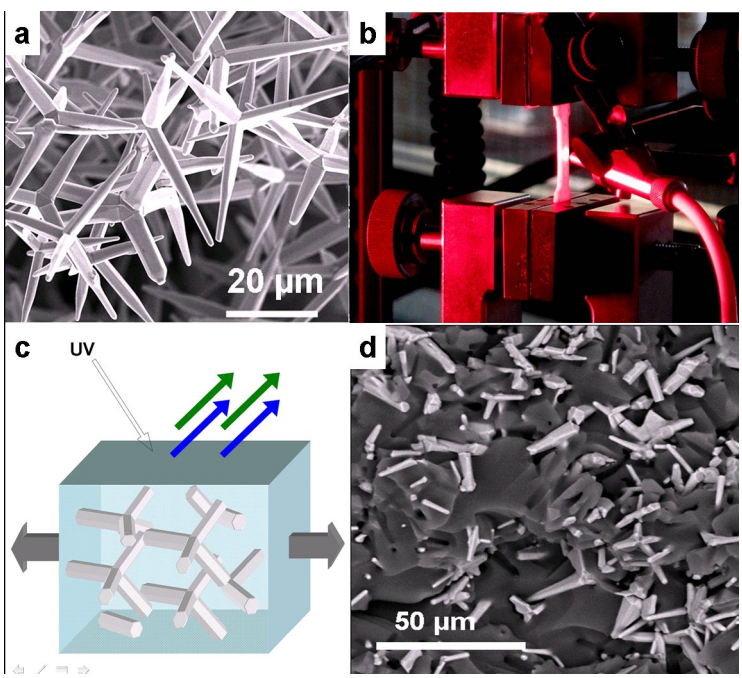


Fig. 2: Self reporting composites reveal their mechanical status in the fluorescence signal. a) filler material used for the polymer: tetrapodal ZnO b) A filled composite is tested in the Instron tensile test machine under illumination in the group of Cord Zollfrank c) Principle of detection: the polymer composite material emits different colours of fluorescent light, depending on its mechanical status. d) Composite surface after failure: the broken tetrapods show high energy dissipation

The alteration of the luminescent characteristics of defined semiconductor microstructures under load, (as show for zinc oxide tetrapods), might also be interesting for many other fluorescent material systems to apply them as ´self-reporting

materials´. The findings are published in another Advanced Materials article.

Composite polymer materials are used in diverse fields from dental implants to airplane turbines. A particular interesting application is that in rotor blades of wind turbines. In a group with three companies, a project financed by the federal ministry of economics, seeks to strengthen the polymer coating and integrates a resistive heating directly into the polymer. Resistive heaters are regularly used to de-ice rotor blades but usually they are inside the blades.

Biomedical projects

With the concentration on biomedical research within the surface and nano-science focus of the university, more activities in the Functional Nanomaterials group are shifting towards this issue.

Further progress especially is being made in the antiviral project of metal oxide nanoparticles, in collaboration with Deepack Shukla from the University of Chicago, USA. Two further publications, one in antiviral research and the other in Plos One, describe how metal oxides immobilize viral particles. Besides ZnO, the application of tin oxide (SnO_2) nanowires seems an effective treatment against HSV-1 infection. The SnO_2 nanowire network serves as a carrier of negatively charged structures that compete with HSV-1 attachment to cell-bound heparan sulphate (HS). This mechanism therefore inhibits entry into the cell and subsequently the cell-to-cell spread of the virus that is based on reproduction of viruses inside the cells. In the Plos One article we report that "this promising new approach can be developed into a novel form of broad-spectrum antiviral therapy especially since HS has been shown to serve as a cellular co-receptor for a number of other viruses as well, including the respiratory syncytial virus, adeno-associated virus type 2, and human papilloma virus". Fig. 3 shows the tin dioxide wool-like flexible ceramic base material as it was produced by flame transport synthesis (viewgraph from the publication). Although the antiviral mechanism is not unique to SnO_2 nanowires (as shown in the 2011 Almanac with ZnO), it might be more cost effective and tolerable as compared to other nanoparticles previously mentioned. Experiments for in-vivo studies are now started; they will reveal the healing potential of these therapies.

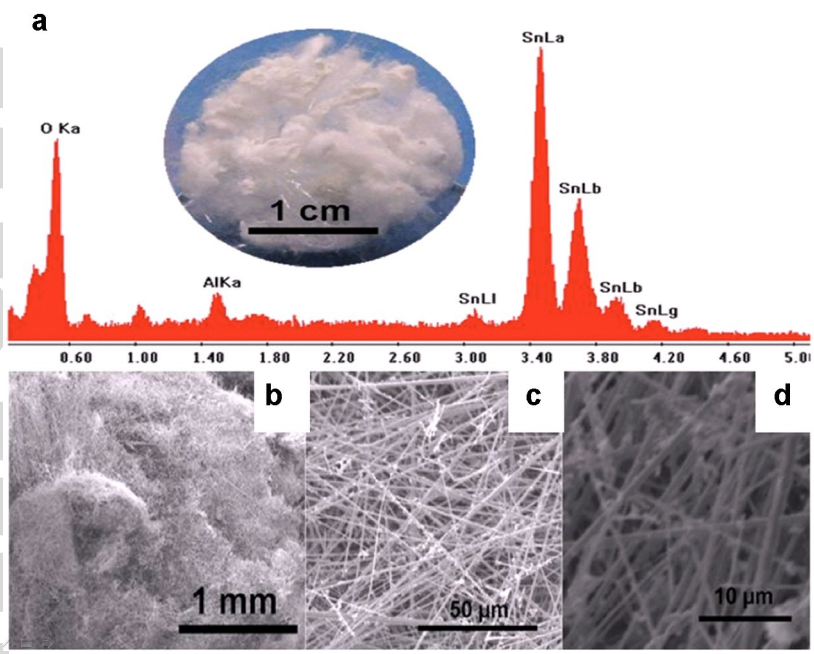


Fig. 3: Scanning electron microscopy results of SnO_2 nanowires synthesized by flame transport approach. (From Plos One article). a) Energy dispersive X-ray absorption (EDX) spectrum showing the purity of SnO_2 nanowires. The inset is the digital camera image demonstrating the wire, fluffy wool type of structures of tin oxide. b)-d): SEM images of SnO_2 nanowires in increasing order of magnifications

Further details about the cytotoxicity of tetrapodal ZnO have been revealed in collaboration with Dr. Claudia Röhl from the

toxicology department. In contrast to Zinc chloride or Zinc nanoparticles, tetrapodal ZnO has a critical dose of about two orders of magnitude more, which is a negligible cytotoxicity. First hints show that the special shape of the tetrapods might be the reason for the good cell compatibility.

Personnel

Head of the group: Prof. Dr. R. Adelung; Secretary: Dipl.-Geol. B. Minten
Technical Staff: Dipl.-Ing. R. Kloth (50%), Technician C. Ochmann (50%), Dipl.-Ing. S. Rehders (50%)

Scientific Staff:

M.Sc. D.M. Gedamu Nanowire electronics	01.01.-31.12.2012	DFG, CAU
M.Sc. I. Hölken Anwendung und Eigenschaften oxidischer Nanomaterialien	01.-31.12.2012	CAU
M.Sc. X. Jin Piezo composites	01.01.-31.12.2012	SFB 855, SFB 677, CAU
Dipl.-Ing. S. Kaps Piezomaterials	01.01.-31.12.2012	SFB 855, CAU
Dr. Y.K. Mishra Nanowires and nanostructures	01.01.-31.12.2012	CAU, AvH Grand
M.Sc. S. Nöhren Herstellung und Theorie poröser Nanomaterialien	01.-31.12.2012	CAU
M.Sc. I. Paulowicz Synthesis and characterization of nanostructures	01.01.-31.12.2012	CAU
M.Sc. A. Schuchardt Aeromaterials and electrical properties	01.01.-31.12.2012	CAU
Dr. S. Wille Anti-fouling	01.01.-31.12.2012	BMBF
M.Sc. E.S.E.S.A. Zarie Drug evaporation	01.01.-31.12.2012	Grant Government Egypt, CAU

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

Biomaterials, 2 hrs Lecture/Week,
R. Adelung

mawi-102: Mathematik für Materialwissenschaftler I, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
R. Adelung (+ B. Gojdka)

mawi-503: Halbleitertechnik und Nanoelektronik, 4 hrs Lecture/Week,
R. Adelung

mawi-503: Halbleitertechnik und Nanoelektronik, 1 hrs Seminar/Week,

R. Adelung

Nano Ethik Technologie, 2 hrs Seminar/Week,
R. Adelung (+ W. Theobald)

mawi-907: Semiconductor, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Y.K. Mishra

Seminar Funktionale Nanomaterialilen, 2 hrs Seminar/Week,
Y.K. Mishra

Summer 2012

Mathematik für Materialwissenschaftler II, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
R. Adelung (+ S. Harms, T. Strunskus)

mawi-414: Voraussetzungen und Auswirkungen Nanotechnologie, 2 hrs Lecture/Week,
R. Adelung

mawi-414: Voraussetzungen und Auswirkungen Nanotechnologie, 1 hrs Seminar/Week,
R. Adelung

Seminar Funktionale Nanomaterialilen, 2 hrs Seminar/Week,
Y.K. Mishra

mawi-e008: Neue Medien - Neue Moral?, 2 hrs Seminar/Week,
R. Adelung (+ W. Theobald)

Winter 2012/2013

mawi-929: Chemistry and Physics of Biomaterials, 2 hrs Lecture/Week,
R. Adelung (+ C. Selhuber-Unkel, L. Kienle)

mawi-102: Mathematik für Materialwissenschaftler I, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
R. Adelung

mawi-503: Halbleitertechnik und Nanoelektronik, 4 hrs Lecture/Week,
R. Adelung (+ H. Föll)

mawi-503: Halbleitertechnik und Nanoelektronik, 1 hrs Seminar/Week,
R. Adelung (+ H. Föll)

mawi-E010: Technologie und Gesellschaft 2, 2 hrs Seminar/Week,
R. Adelung (+ W. Theobald)

mawi-907: Semiconductor, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Y.K. Mishra

Seminar Funktionale Nanomaterialilen, 2 hrs Seminar/Week,
Y.K. Mishra

Solid State Physics I, 2 (+ 1) hrs Exercise (+ Exercises)/Week,
F. Faupel (+ A. Schuchardt)

Third-Party Funds

Botschaft der Arabischen Republik Ägypten, *Ägyptisches Regierungsstipendiat in Long Term Mission System für Zarie für 4 Jahre,* 07.03.2009-06.03.2013 (66000 EUR)

DFG (SFB 855/1-2010 Teilprojekt IGK), *Magnetoelektrische Verbundwerkstoffe - biomagnetische Schnittstellen der Zukunft: Integriertes Graduiertenkolleg,* 01.01.2010-31.12.2013 (378272 Euro)

DFG (SFB 855/1-2010 Teilprojekt A5), *Magnetoelektrische Verbundwerkstoffe - biomagnetische Schnittstellen der Zukunft: Herstellung von vertikal freistehenden magnetoelktrischen Kompositen,* 01.01.2010-31.12.2013 (339840 Euro)

DFG (SFB 855/1-2010 Teilprojekt Z), *Magnetoelektrische Verbundwerkstoffe - biomagnetische Schnittstellen der Zukunft: wiss. Hilfskräfte,* 01.01.2010-31.12.2013 (29600 EURO)

BMBF, *Anti-fouling - Entwicklung, Analyse und Wirksamkeitstests neuartiger Beschichtungen auf ZnO Nanostrukturbasis,* 01.03.2010-29.02.2012 (140784 Euro)

University Kiel, *Beihilfe Exzellenzcluster: Unterstützung Fortbildung von Clusterdokteranden,* 01.03.2010-31.10.2012 (5000 EURO)

DFG (Ad 183/5-2), *Heisenberg-Professur: Interdisziplinäre anwendungsnahe Forschung mit nanostrukturierten Materialien,* 01.07.2010-30.06.2012 (227400 Euro)

DFG (SFB 677/2 2011 C10), *Funktion durch Schalten: Photoaschaltbare Adhäsive,* 01.07.2012-30.06.2015 (474240 EURO)

EU (Interreg-Projekt), *Technet Nano (074),* 29.12.2011-28.03.2014 (112925 EURO)

ETSH, *Transferprämie 2012,* 26.11.2012-31.12.2013 (5000 EURO)

BMWi, *Nanobasierte Beschichtungstechnologie für den Erosions- und Vereisungsschutz von Offshore-Windenergieanlagen (DKL:WEA),* 01.11.2012-31.10.2014 (160810 EURO)

Further Cooperation, Consulting, and Technology Transfer

University:

Dr. D. K. Avasthi, Materials Science Group, Inter University Accelerator Centre New Delhi, India, Experiments with composite materials

Prof. Dr. T. Bosch, Zoologisches Institut und Museum (Sektion Biologie), Allgemeine Zoologie, CAU Kiel, Viral experiments with nanostructures

Prof. Dr. F. Faupel, Institut für Materialwissenschaft - Materialverbunde, CAU Kiel, Various projects ranging from nanostructures to superhydrophobicity

Prof. Dr. S. Gorb, Institut für Zoologie, CAU Kiel, Switchable adhesion

Prof. Dr. B. Größner-Schreiber, Universitätsklinikum Schleswig-Holstein, Zahnerhaltungskunde und Paradontologie, CAU Kiel, Titanium and ceramic dental materials

Prof. Dr. M. Kern, Universitätsklinikum Schleswig-Holstein, Klinik für Zahnärztliche Prothetik, Propädeutik und Werkstoffkunde, CAU Kiel, Chemical and microscopy on dental materials

Prof. Dr. L. Kienle, Institut für Materialwissenschaft - Sythesis and Real Structure, CAU Kiel, Transmission electron microscopy

Prof. Dr. L. Kipp, Experimentelle und Angewandte Physik, CAU Kiel, Diffractive optics for contact lenses

Prof. Dr. H. Kohlstedt, Institut für Elektrotechnik und Informationstechnik - Nanoelektonik, CAU Kiel, Nanowires field effect transistors

Prof. Dr. E. Quandt, Institut für Materialwissenschaft - Anorganische Funktionsmaterialien, CAU Kiel, Magnetoelectric materials

PD Dr. C. Röhl, Institut für Toxikologie, CAU Kiel, Toxicity of nanostructures of ZnO

Prof. Dr. C. Ronning, Universität Jena, Photoluminescence ZnO Nanobridges

Prof. Dr. D. Shukla, University of Illinois, Chicago, USA, Antiviral properties of ZnO nanostructures

Dr. F. Spors, Western University of Health Sciences, Pomona CA, USA, Antiviral studies of nanostructures

Prof. Dr. Anne Staubitz, Institut für Organische Chemie, CAU Kiel, Switchable polymers

Prof. Dr. H. Steckel, Pharmazeutisches Institut, CAU Kiel, Nanostructured Pharmaceuticals

Prof. Dr. K. Schulte, TU Hamburg, Aerographite

Prof. Dr. I. Tiginyanu, TU of Moldova, Galiumnitrite Dr. V. Tiwari, Midwestern University, Illinois, USA, Antiviral properties of ZnO nanostructures

Prof. Dr. C. Zollfrank, TU München, Self-reporting materials

Research Institutes:

Prof. Dr. H.-G. Rubahn, Mads Clausen Institute, University of Southern Denmark, EU Interreg project: Technet Nano

Industry:

nanoproofed r&d GmbH, Scharbeutz (Gleschendorf), BMBF-Projekt Anti-fouling, Photocatalytic substances, Forschung und Entwicklung zu Materialsynthese und -analytik

IRATEC, Institut für Rohrleitungs- und Apparatetechnik GmbH, Magdeburg, Forschung und Entwicklung zu Materialsynthese und -analytik

OIS, Offshore Industrie Service GmbH, Rostock, Forschung und Entwicklung zu Materialsynthese und -analytik

Wöhlk, Schönkirchen, Examination of contact lenses

Diploma, Bachelor's and Master's Theses

M. Deng, *Tailoring the wettability of tetrapod ZnO-Polymer composites,* 17.02.2012
O. Dudko, *Untersuchung des Einflusses der n-Dotierung mit Aluminium und der Glühtemperatur auf elektrische Eigenschaften des durch die Batch-Methode hergestellten Zinkoxids,* 26.04.2012
M. Baytekin, *Surface modification of Ti by chemical etching and subsequent hydroxyapatite sputtering for biomedical applications,* 08.05.2012
G. Haidarschin, *Anwendungspotential amorpher Kohlenstoffschichten auf tribologisch beanspruchte Bauteile von Axialkolbenmaschinen,* 02.07.2012
C. Skawianczyk, *Characterization of mechanical properties of aerographite,* 13.08.2012
A. Vahl, *Optimierung der Synthese- und Calcinierungsbedingungen zur Herstellung von reinphasigem, kubischem* $Li_7La_3Zr_2O_{12}$, 02.08.2012
K. Meß, *Experiments for the artificial replica of the gecko´s foot structure with the polymer PDMS,* 22.08.2012
S. Schröder, *Studies on electrical and electrochemical properties of Aerographite with regard to a potential application as an electode in a Lithium ion accumulator,* 29.08.2012
N. Wohner, *Cap network structures for 19° Carbon nanocones,* 29.08.2012
M. Schultes, *Untersuchung der Festigkeitsunterschiede bei nahtlos gewalzten Stahlrohren,* 14.09.2012
J. Jacobsen, *Synthese von Metalloxid-Nanostrukturen mittels Flammspritzverfahren,* 05.12.2012

Publications

Published in 2012

D. Gedamu, I. Paulowicz, S. Jebril, Y.K. Mishra, R. Adelung, *Procedures and properties for a direct nano-micro integration of metal and semiconductor nanowires on Si chips,* Journal of Nanotechnology, **2012**, 325732 (2012)

R. Adelung, W. Theobald, G. Grosse-Bölting, A. Olbricht, T. Reibisch, F. Wulff, *Vom technisch Kleinsten zum denkbar Größten,* Menschenbilder (Eds. W. Theobald, and H. Rosenau), **19**, 129 - 138 (2012)

S. Kaps, Y.K. Mishra, V. Hrkac, H. Greve, L. Kienle, E. Quandt, R. Adelung, *High aspect ratio free standing ZnO-magnetostrictive mesoscale cylindrical magnetoelectric core shell composite,* MRS Online Proceedings Library, **1398**, (2012)

F.N. Sayed, O.D. Jayakumar, R. Sasikala, R.M. Kadam, S.R. Bharadwaj, L. Kienle, U. Schürmann, S. Kaps, R. Adelung, J.P. Mittal, A.K. Tyagi, *Photochemical hydrogen generation using nitrogen-doped TiO_2-Pd nanoparticles: Facile synthesis and effect of Ti^{3+} incorporation,* J. Phys. Chem. C, **116**, 12462 - 12467 (2012)

Y.K. Mishra, V.S.K. Chakravadhanula, V. Hrkac, S. Jebril, D.C. Agarwal, S. Mohapatra, D.K: Avasthi, L. Kienle, R. Adelung, *Crystal growth behaviour in Au-ZnO nanocomposite under different annealing environments and photoswitchability,* J. Appl. Phys., **112**, 64308 (2012)

E.S. Zarie, V. Kaidas, D. Gedamu, Y.K. Mishra, R. Adelung, F.H. Furkert, R. Scherließ, H. Steckel, B.G. Schreiber, *Solvent free fabrication of micro and nanostructured drug coatings by thermal evaporation for controlled release and increased effects,* PLoS ONE, **7**, 40746 (2012)

M. Mecklenburg, A. Schuchardt, Y.K. Mishra, S. Kaps, R. Adelung, A. Lotnyk, L. Kienle, K. Schulte, *Aerographite: Ultra lightweight flexible nanowall carbon microtube-material with outstanding mechanical performance,* Advanced Materials, **24**, 3486 - 3490 (2012)

X. Jin, J. Stueben, L. Heepe, A. Kovalev, Y.K. Mishra, R. Adelung, S.N. Gorb, A. Staubitz, *Joining the un-joinable: Adhesion between low surface energy polymers using tetrapodal ZnO linkers,* Advanced Materials, **24**, 5676 - 5680 (2012)

J. Trigillo, T.E. Antoine, I. Paulowicz, Y.K. Mishra, R. Adelung, D. Shukla, *Tin oxide nanowires suppress herpes simplex virus-1 entry and cell-to-cell membrane fusion,* PLoS ONE, **7**, 48147 (2012)

T.E. Antoine, Y.K. Mishra, J. Trigillo, R. Adelung, D. Shukla, *Prophylactic, therapeutic and neutralizing effects of zinc oxide tetrapod structures against herpes simplex virus type-2 infection,* Antiviral Research, **96**, 363 - 375 (2012)

Patent Applications

R. Adelung, *Method for Generating Oxidic Nanoparticles from a Material Forming Oxide Particles,* International Patent Office, 06.03.2012, US 8,129,000 B2

R. Adelung, *Verfahren zur Nanostrukturerzeugung mittels spinodaler Entnetzung,* European Patent Office, 04.04.2012, EP 2 206 153 B1

R. Adelung, *Elast. Material mit einem auf Partikelebene durch Nanobrücken zw. Partikeln überbrückten Porenraum,* Deutsches Patentamt, 06.12.2012, DE 10 2010 012 385 B4

Presentations

R. Adelung, *Flammen Transport Synthese: Beschichtung und Herstellung von Metalloxid Nanostrukturen in Kg pro Minute Maßstab (talk)*, 17. Schwerpunkttreffen: Chemische Nanofunktionsschichten und Nanotechnologie bei Fa. Nanoproofed, Gleschendorf, 20.03.2012

X. Jin, S. Wille, D. Gedamu, R. Adelung, J. Strüben, A. Staubitz, L. Heepe, A. Kovalev, S. Gorb, *Concave micro/nanoparticles as powerful facilitators for bonding of non-adhesive polymers (poster)*, DPG-Frühjahrstagung 2012, Berlin, 25.-30.03.2012

I. Paulowicz, Y.K. Mishra, S. Wille, R. Adelung, *ZnO micro- and nanostructures for photocatalytic applications (talk)*, DPG-Frühjahrstagung 2012, Berlin, 25.-30.03.2012

A. Schuchardt, M. Mecklenburg, Y.K. Mishra, S. Kaps, R. Adelung, A. Lotnyk, L. Kienle, K. Schulte, *Aerographite: A new carbon nanomaterial with densities below 0.2 mg/cm3 and outstanding mechanical properties (talk)*, DPG-Frühjahrstagung 2012, Berlin, 25.-30.03.2012

P. Sahin, N.O. Urs, D. Gedamu, T. Behrendt, R. Adelung, *Simple synthesis of metal and metal oxide nanowires for device application (poster)*, DPG-Frühjahrstagung 2012, Berlin, 25.-30.03.2012

R. Adelung, *Functional nanomaterials for electronics and life science (invited talk)*, 14. German-American Frontiers of Engineering Symposium, Potsdam, 28.-31.03.2012

R. Adelung, *Nanotechnologie: Beispiele für Chancen und Risiken (talk)*, TF Sicherheitsingenieure, Kiel, 06.06.2012

R. Adelung, *Anti-viral properties of ZnO (talk)*, German-Moldova Workshop on Electrochemical Nano-Structuring of Materials, Kiel, 23.07.2012

Y.K. Mishra, *Aerographite: Properties of an extremely lightweight material (talk)*, German-Moldova Workshop on Electrochemical Nano-Structuring of Materials, Kiel, 23.07.2012

X. Jin, *Progress report in project SFB 677 TP C10 (talk)*, Summer School 2012, Ratzeburg, 08.-09.08.2012

R. Adelung, *Hierarchical materials for photoswitchable adhesives (talk)*, 2. SFB 677-Tagung: Molecular Switches: Elementary Processes and Applications, Plön, 20.-22.08.2012

X. Jin, J. Strüben, *Tetrapodal ZnO microparticles as powerful linkers between low surface energy polymers (poster)*, 2. SFB 677-Tagung: Molecular Switches: Elementary Processes and Applications, Plön, 20.-22.08.2012

R. Adelung, *Functional Nanomaterials: From electronic to biomedical application (invited talk)*, 14th International Conference School, Palanga, Lithuania, 28.-31.08.2012

R. Adelung, Y.K. Mishra, C. Röhl, D. Shukla, F. Spors, V. Tiwari, *Increased virostatic potential and cell viability with ZnO micro-nanoparticles after UV-treatment (talk)*, Materials Science Engineering (MSE) 2012, Darmstadt, 25.-27.09.2012

R. Adelung, S. Kaps, V. Hrkac, L. Kienle, *Unconventional fabrication schemes for magnetoelectric sensors based on piezoelectric and magnetostictive materials (poster)*, Materials Science Engineering (MSE) 2012, Darmstadt, 25.-27.09.2012

Y.K. Mishra, S. Kaps, A. Schuchardt, I. Paulowicz, X. Jin, M. Deng, D. Gedamu, S. Wille, R. Adelung, *Simple and large scale fabrication of ZnO nano-micro structures for multifunctional applications (talk)*, Materials Science Engineering (MSE) 2012, Darmstadt, 25.-27.09.2012

Y.K. Mishra, *Aerographite, the lightest material in the world,* Humboldt Evening, Kiel, 01.11.2012

R. Adelung, *Flame transport synthesis for the fabrication of nanostructured based materials systems (invited talk)*, KIT Symposium: Nano-structure in dispese systems: production, characterization and functionality, Karlsruhe, 11.-13.11.2012

R. Adelung, *Knappe Güter (invited talk)*, Night of the Profs 2012, Kiel, 16.11.2012

General Materials Science

A BMU proposal concerning novel ways of processing solar cells (with ISFH GmbH Hameln) has been approved. AMAT will obtain about € 180.000 for the investigation of the galvanic deposition techniques for Cu on thin film Si solar cells.

The DFG CELLOplus project is running well; it is in its last year of funding and will end in May 2013. In future solar cell research, SHALUM (''SHAded LUMinescence'') activities will be emphasized; a proposal is in the making.

The BMBF project ''AlkaSuSi'' (Alkalimetall, Schwefel und Silizium) is running well (together with Fraunhofer ICT and IWS and also Bayer); a critical ''stop project'' criterion was met. AMAT produced superior Si nanowire anodes for the intended high capacity Li ion battery.

The BMU project ''SolarWinS'' (Solarforschungscluster zur Ermittlung des maximalen Wirkungsgradniveaus von multikristallinem Silicium), while progressing nicely on the research part, suffers from the crisis in the German photovoltaic industry and the closure of several companies. Nevertheless it was continued.

The work for the SFB 855 (magneto-electric composite materials) has produced some remarkable results but not yet a functioning sensor. The ''Mold Nanonet'' project, an EU-funded partnership with the Technical University of Moldova, has started.

New cooperations with Prof Adelung's group (Functional Nanomaterials) and Prof. Selhuber-Unkel's group (Biocompatible Nanomaterials) have been started.

Otherwise, activities are cut back as planned in view of Prof. Föll's retirement in early 2014.

Results

New projects started in 2012:

Only a few small new projects were started in 2012, always in cooperation with partners. For details see ''**Cooperations**''.

Cooperation projects running in 2012:

Our work for the BMU project ''SolarWinS'' (successor of the ''SolarFocus'' project) continued smoothly and will carry on into 2013. A follow-up project is envisioned but the on-going disappearance of the German solar industry will endanger a continuation.

Work on the Si nanowire anode for Li ion batteries carried out with the Fraunhofer Institutes for Chemical Technology (ICT) and Material and Beam Technology (IWS) as part of the Alka-SuSi project (BMBF), has met the ''stop project'' criterion of 250 Wh/kg which is already a benchmark in Li ion batteries. The final goal of the project is to accomplish 400 Wh/kg. Our Si microwire array anodes demonstrated a superior performance with fading close to zero over 100 charging/discharging cycles.

Regarding the CELLO technique, the research focus of the last year was on the evaluation of the use of the blue laser and of higher harmonics in the photo-impedance signals (within a DFG project). The latter proved to be a valuable tool for the study of current matching for so-called a-Si/c-Si tandem solar cells (collaboration with Bosch, Stuttgart). Most importantly, it became clear that for the fitting of short-circuit current data, the *RC* time constant of the majority carriers has to be taken into account separately for each laser.

The cooperation with Bosch is running well. Besides the PhD work done in Stuttgart with a CELLO unit in-situ, several students guided by AMAT perform thesis work at Bosch on a regular base.

The experimental work concerning the SFB 855 (magneto-electric composite materials) has focused on the electrochemical deposition of Ni nanowires inside macroporous InP membranes. It transpired that the deposition of a dielectric interlayer

by ALD was the decisive step to produce ultra-high aspect ratio ($>$1000:1) Ni nanowires. This technique can now be applied for growing all kinds of metal nanowires inside porous InP membranes. Fig. 1 gives an example.

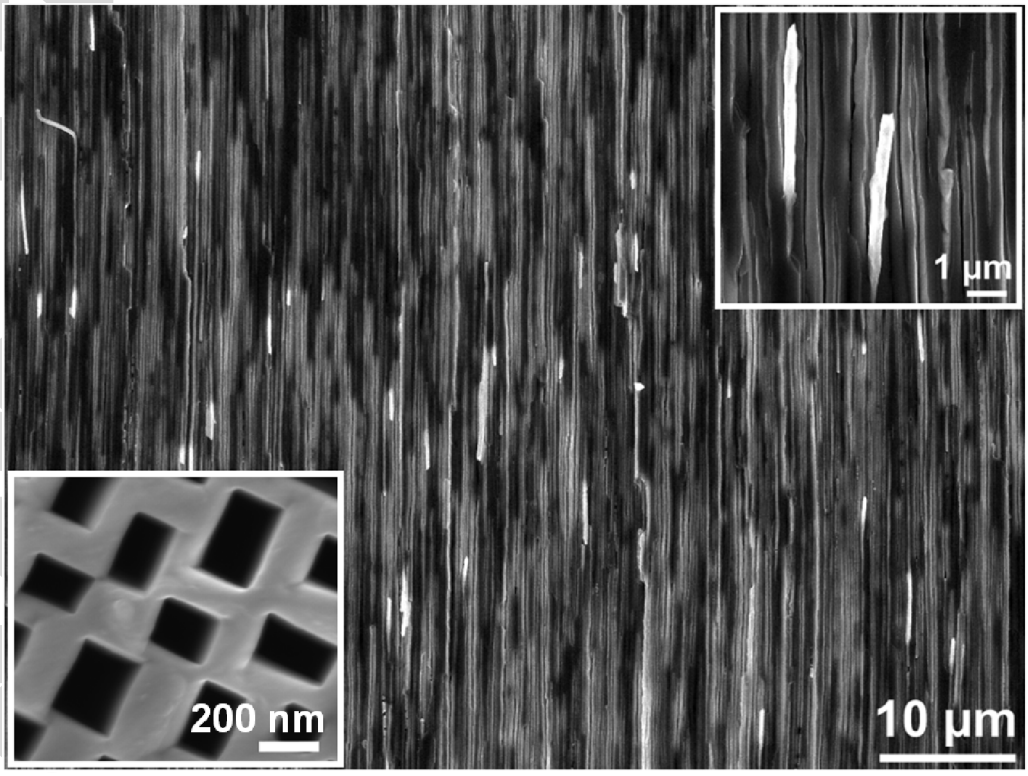


Fig. 1: Cross-sectional SEM image of the Ni NWs embedded in the porous InP membrane (inset right: high magnification of single Ni wires, inset left: top view on filled membrane).

Single-crystalline InP membranes were also investigated as anode material for new generation Li-ion batteries. This anode exhibits a high capacity per area of $\sim$63 mAh/cm^2 and a maximum possible capacity of $\sim$800 mAh/g is achieved which is much higher than that of commercial graphite anodes ($\sim$350 mAh/g). The total anode capacity is freely scalable by adjusting the InP membrane thickness.

The production of Si nano-needles (actually rather ''silicon micro-needles''), i.e. Si rods with diameters in the sub-μm range and defined length from a few to several μm, has been further explored. Samples are tested by the group of Prof. Selhuber-Unkel for various biological applications.

Internal projects:

Advancing the unique CELLO measurement technique is an on-going internal project, on top of the CELLO based cooperation projects. The focus in 2012 was on:

(i) improving the fit model including majority carriers,

(ii) adding an additional constant illumination for injection-level variation even under short-circuit conditions,

(iii) comparison of detailed data with thermography and luminescence measurements.

Substantial improvements were reached with the SHALUM (''SHAded LUMinescence'') technique. New hardware was constructed by a diploma student enabling fully PC-controlled serial measurements. A systematic study of the injection level dependence of the series resistance showed a significant change in the qualitative behaviour (for details, see Fig. 3 below).

The detailed mechanisms behind macropore formation in p-type silicon were investigated. The focus was on modulating the pore diameter, a pre-requisite for various applications discussed elsewhere. In-situ FFT impedance measurements were the key to the understanding of this (very complex) process. This tool has also been used to explain the importance of water in the (typically organic) electrolytes during the etching of p-Si macropores.

Research Details

Si micro-/nanoparticles attract increasing interest with regard to possible biological and medical applications such as drug delivery. Si is an abundant biocompatible material and at the centre of highly developed micro-processing techniques. Low-dimensional Si particles have been fabricated by different methods, including electrochemical means. All prior methods, however, suffered from high costs and low yields. Moreover, many methods only produce particles embedded in a certain matrix, e.g. SiO_2.

In contrast, the SiPaKi (Silicon Particles Kiel) method, developed in the AMAT group, yields large numbers of mono-disperse single-crystalline Si micro-/nanorods with tuneable sizes and shapes. The comparatively simple process consists of two main steps: (1) electrochemical etching of macropores in Si; pores with periodical diameter bulges are produced; the distance between bulges corresponds to the length of the final particles, (2) chemical etching of the macroporous Si; pore diameters increase until the pore walls collapse at the bulges, leaving the desired micro- or nanorods behind (see Fig. 2).

After their production, the rods can be made nano-porous or functionalized depending on the application.

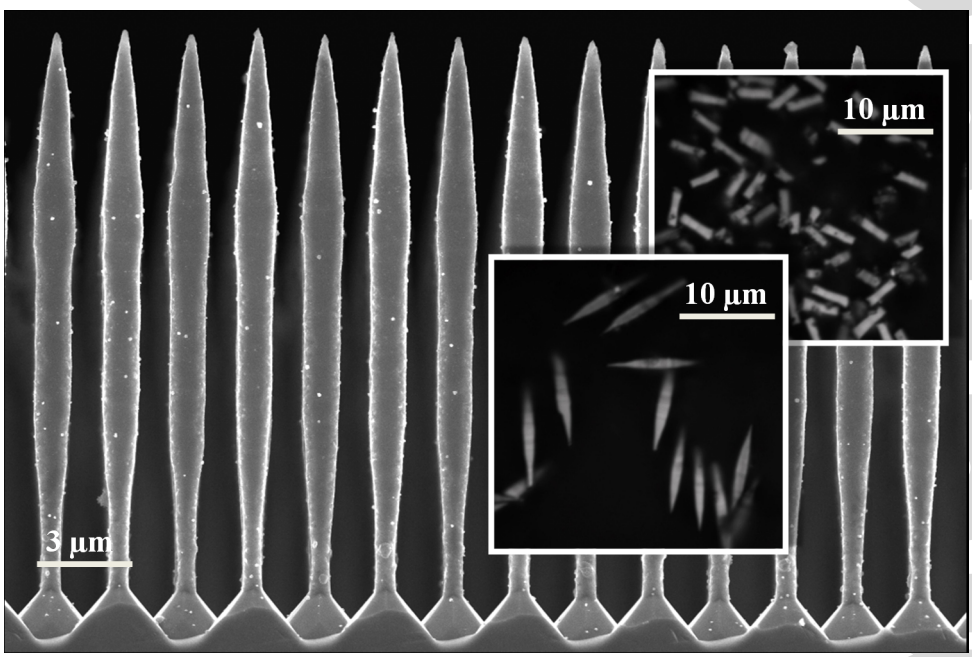


Fig. 2: Si microrods of different sizes and shapes produced in the AMAT group.

SHALUM is getting close to becoming a major characterization method for solar cells. Since the model-based data extraction from luminescence pictures is rather involved, research focused on quantitative comparisons of CELLO and SHALUM data. Fig. 3 gives an example.

Figure 3 shows a CELLO photocurrent map (a) and a series resistance map (b) of a multicrystalline Si solar cell. The upper edge of this cell, as well as a few places in the cell area, show markedly increased recombination activity, leading to lower photocurrent and photovoltage generation. As a consequence, under open circuit or MPP conditions compensating lateral currents into these regions occur (indicated by white arrows), which lead to ohmic losses by building up lateral voltage differences due to the series resistance of grid plus emitter.

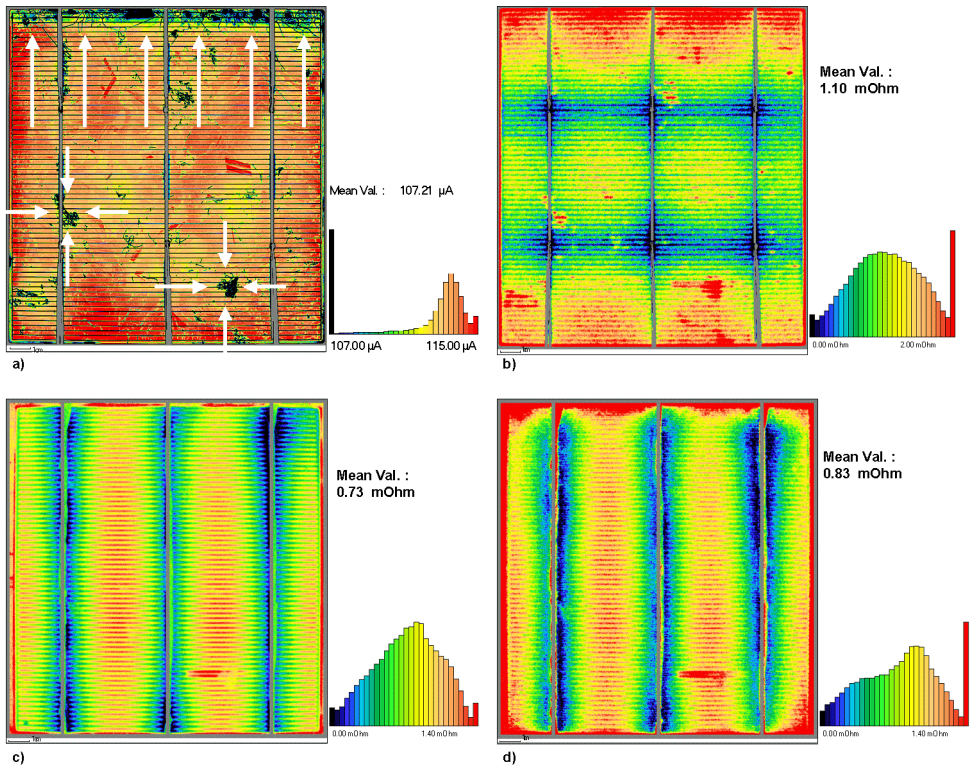


Fig. 3: Data maps of the same solar cell obtained by CELLO and SHALUM. See text for details.

The lower row of Fig. 3 shows two series resistance images obtained from luminescence measurements: one taken at high injection level (c), the other at low injection level (d). At high injection, the series resistance image shows a technologically regular series resistance distribution, apart from a broken grid finger (lower centre). Compared to this, for low injection the series resistance has increased in those areas showing increased series resistance in the CELLO series resistance map. Note also that the absolute values follow the trend that with increasing injection level (lowest for the CELLO map) the mean series resistance value decreases.

Teaching

The AMAT Hyperscripts are still used extensively around the globe as evidenced in the following statistics:

2007: 20.3 million hits, 1,510 GByte downloads; 2008: 19 million hits, 1,692 GByte downloads; 2009: 18.5 million hits, 2,240 GByte downloads; 2010: 20.6 million hits, 2,341 GByte downloads; 2011: 20.6 million hits, 1,452 GByte downloads; 2012: 19.7 million hits, 940 GByte downloads.

Equally gratifying is the Google ranking of all relevant search strings (e.g. chapter and subchapter headings) where the AMAT Hyperscripts usually are found in first or second place (then after Wikipedia).

Personnel

Head of the group: Prof. Dr. Helmut Föll; Secretary: Katrin Brandenburg (50%)
Technical Staff: Dipl.-Ing. (FH) Jörg Bahr

Scientific Staff:

Dr. Jürgen Carstensen 01.01.-31.12.2012 CAU
Theory, software development, supervision of teaching

Dr. Ala Cojocaru	01.04.-31.05.2012		EU
and 16.07.2012 - 15.08.2012 MOLD-NANONET			
M.Sc. Mark-D. Gerngroß	01.01.-31.12.2012		DFG
SFB 855 Magnetoelectric Composites - Future Biomagnetic Interfaces			
M.Sc. Iris Hölken	01.-31.12.2012	(50%)	CAU
Dr. Yogendra Mishra	01.07.-31.12.2012		CAU
M.Sc. Sandra Nöhren	01.-31.12.2012	(50%)	CAU
M.Sc. Emmanuel Ossei-Wusu	01.01.-31.12.2012		BMBF
Macroporous Si for solar cell uses; optimization of pore etching			
Dr. habil. George Popkirov	15.06.-30.11.2012		Drittmittel
Dr. Enrique Quiroga-González	01.01.-31.12.2012		BMBF
Si nanowire anode for Li ion battery			
Dr. Jan-Martin Wagner	01.01.-31.12.2012		DFG
Theory and development for multi-colour CELLO (incl. impedance and non-linear behaviour) and for shaded luminescence techniques			

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

Quantenmechanische Aspekte in der Materialwissenschaft, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Jürgen Carstensen

Aktuelle Fragen der Forschung, 2 hrs Seminar/Week,
Helmut Föll (+ Jürgen Carstensen)

Materialwissenschaft I, 3 (+ 1) hrs Lecture (+ Exercises)/Week,
Helmut Föll (+ Mark-D. Gerngroß)

Advanced Mathematics - Computational Mathematics (2 groups), 2 (+ 2) hrs Lecture (+ Exercises)/Week,
Jürgen Carstensen (+ Jan-Martin Wagner)

Basic Laboratory Course for Master´s Students, 4 hrs Practical/Week,
Emmanuel Ossei-Wusu (+ et al.)

Halbleitertechnik und Nanoelektronik, 4 (+ 1) hrs Lecture (+ Exercises)/Week,
Helmut Föll (+ Rainer Adelung)

Materialanalytik 2, 4 hrs Practical/Week,
Enrique Quiroga-González (+ et al.)

Grundlagen der Materialwissenschaft, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
Helmut Föll (+ Jan-Martin Wagner, Mark-D. Gerngroß)

Advanced Mathematics - Mathematics for Material Science, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Jürgen Carstensen

Defects, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Helmut Föll (+ Stephan Warnat)

Semiconductors, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Yogendra Mishra (+ Helmut Föll)

Summer 2012

Materialwissenschaft II, 3 (+ 1) hrs Lecture (+ Exercises)/Week,
Helmut Föll (+ Jan-Martin Wagner)

Aktuelle Fragen der Forschung, 2 hrs Seminar/Week,
Helmut Föll

Computergestützte Mathematik, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Jürgen Carstensen

Advanced Materials B, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Helmut Föll (+ Eckhard Quandt, Enrique Quiroga-González)

Scientific Methods, 4 hrs Practical/Week,
Enrique Quiroga-González (+ et al.)

Winter 2012/2013

Quantenmechanische Aspekte in der Materialwissenschaft, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Jürgen Carstensen

Aktuelle Fragen der Forschung, 2 hrs Seminar/Week,
Helmut Föll (+ Jürgen Carstensen)

Materialwissenschaft I, 3 (+ 1) hrs Lecture (+ Exercises)/Week,
Helmut Föll (+ Mark-D. Gerngroß)

Advanced Mathematics - Computational Mathematics (2 groups), 2 (+ 2) hrs Lecture (+ Exercises)/Week,
Jürgen Carstensen (+ Jan-Martin Wagner)

Basic Laboratory Course for Master´s Students, 4 hrs Practical/Week,
Emmanuel Ossei-Wusu (+ et al.)

Halbleitertechnik und Nanoelektronik, 4 (+ 1) hrs Lecture (+ Exercises)/Week,
Helmut Föll (+ Rainer Adelung)

Grundlagen der Materialwissenschaft, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
Helmut Föll (+ Jan-Martin Wagner, Mark-D. Gerngroß)

Advanced Mathematics - Mathematics for Material Science, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Jürgen Carstensen

Defects, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Helmut Föll

Semiconductors, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Yogendra Mishra (+ Helmut Föll)

Materialanalytik 2, 4 hrs Practical/Week,
Enrique Quiroga-González (+ et al.)

Third-Party Funds

Alexander von Humboldt-Stiftung, *Institutspartnerschaft mit der TU Moldova,* 01.07.2010-30.04.2013 (55.000 EUR)

DFG, *SFB 855, TP A3 Magnetoelektrische 1-3-Komposite,* 01.01.2010-31.12.2013 (350.700 EUR)
BMBF, *AlkaSuSi Neue Materialkonzepte für Alkalimetall-Schwefel-Batterien bzw. Alkalimetall-Silizium-Batterien,* 01.05.2011-30.04.2014 (259.769 EUR)
BMBF, *Projektpauschale zu: AlkaSuSi Neue Materialkonzepte für Alkalimetall-Schwefel-Batterien bzw. Alkalimetall-Silizium-Batterien,* 01.05.2011-30.04.2014 (25.976,90)
Unterauftrag BMU-Projekt Universität Konstanz, *SolarWinS, TP 6: Herstellung und Analyse von Solarzellen aus hochreinem kristallinem Silizium,* 01.02.2011-31.01.2014 (87.000 EUR)
EU 7th Framework Programme, *MOLD-NANONET,* 01.12.2011-31.05.2014 (47.658 EUR)
DFG, *Schnelle quantitative und ortsaufgelöste Komplettcharakterisierung von Solarzellen durch Kombination von ''CELLO'' und FFT-Impedanzspektroskopie,* 12.12.2011-11.12.2012 (71.180 EUR)
DFG, *Programmpauschale zu Schnelle quantitative und ortsaufgelöste Komplettcharakterisierung von Solarzellen durch Kombination von ''CELLO'' und FFT-Impedanzspektroskopie,* 12.12.2011-11.12.2012 (14.200 EUR)
DAAD, *Zuschuss zu einer Kongressreise für Herrn Dr. E. Quiroga-González, Perth, Australien,* 15.-18.04.2012 (2.229 EUR)
DAAD, *Zuschuss zu einer Kongressreise für Herrn M.Sc. Mark-Daniel Gerngroß, Honolulu, Hawaii, U. S. A.,* 07.-12.10.2012 (1.477 EUR)
DAAD, *Zuschuss zu einer Kongressreise für Herrn M.Sc. Emmanuel Ossei-Wusu, Honolulu, Hawaii, U. S. A.,* 07.-12.10.2012 (1.477 EUR)

Further Cooperation, Consulting, and Technology Transfer

Bosch AG, Stuttgart, Germany

Ongoing shared supervision of bachelor's and master's theses. Continuous cooperation based on the CELLO technique (measurements on various Bosch specimens); external PhD student (see above).

Centrosolar, Hamburg, Germany

CELLO investigations of cells and modules (i) regarding the influence of module-making with respect to potential-induced degradation and (ii) for yield engineering issues.

Condias, Itzehoe, Germany

Explorative experiments (based on an AMAT patent) concerning electrochemical processing of large Si wafers.

Contros GmbH, Kiel, Germany

Better sensors for deep ocean applications based on porous Si membranes. First results are promising.

Dispatch Energy Innovations GmbH, Itzehoe, Germany

Loose scientific cooperation with respect to Li-Ion Batteries.

FH Kiel and o.m.t. GmbH, Lübeck, Germany

FFT impedance measurements for the characterization of Li ion batteries as input for a battery control system.

Fraunhofer-Institut ICT, Pfinztal, Germany / **IWS**, Dresden, Germany

Cooperation within the ''AlKaSuSi'' project (see above).

Fraunhofer-Institut ISE (Solare Energiesysteme), Freiburg / Gelsenkirchen, Germany

Scientific cooperation with Dr. Warta and Prof. Dr. Schindler within the framework of the SolarFocus / SolarWinS project.

INFICON GmbH, Köln, Germany (world market leader for vacuum leak detection)

AMAT produces prototype of novel sensors based on porous Si. Results are encouraging; a major project might result in 2013.

Hanwha Q Cells (formerly Q-Cells), Bitterfeld-Wolfen, Germany

Based on previous CELLO measurements on cells made from different feedstock material and contact via SolarWinS project: evaluation of further collaboration.

ISFH GmbH, Hameln/Emmerthal, Germany

Cooperation within the framework of the SolarFocus / SolarWinS project, and a new common BMU project (start in 2013: see above). Informal cooperations with respect to Si nanowire formation and application of porous Si membranes in Li ion batteries.

Lund University, Sweden

Scientific cooperation with Prof. Christelle Prinz. Samples with different microwire array structures are provided to make biological tests. Especially, growth of optical cells is planned.

Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany

Scientific cooperation with Dr. Breitenstein within the framework of the SolarFocus / SolarWinS projects. CELLO and SHALUM measurements in comparison to thermography measurements.

Nanoproofed GmbH, Scharbeutz (S.-H. Start-up), Germany

CELLO measurements for the characterization of novel AR coatings on modules. General cooperations on other topics via Prof. Adelung's group.

Nanotechnology Research Centre, Cairo, Egypt

Proposal to A. v. Humboldt foundation concerning 2-year stay of senior researcher Dr. Osama Tobail at AMAT. Mr. Tobail was a guest in 2012 and will join the group again in 2013. The common research topic is nanostructuring of materials by electrochemical means for Li ion battery electrodes.

NEXT eV (Land Niedersachsen), Germany

TripSi project (+ 2 FhG Inst.) proposal (AMAT € 190,000.–)

Roth & Rau (OTB), Eindhoven, Netherlands

CELLO measurements concerning rear side passivation issues of high-efficiency solar cells.

SolarWorld, Freiberg, Germany

CELLO measurements to some special questions concerning high-efficiency solar cells.

Technical University of Moldova, Chisinau, Moldova

Scientific cooperation with Prof. Dr. I.M. Tiginyanu for more than 10 years. In 2012 a joint A. v. Humboldt project (€ 55,000.–) and a joint EU project (€ 48,000.–).

University College Cork, Ireland

Scientific cooperation with Dr. Colm O'Dwyer. Different kinds of Si porous membranes and porous pieces with different structures have been supplied to Cork with the aim to test their application in thermoelectrics and antireflection coatings, and to make some Raman microscopy studies.

University Konstanz, Germany

Partner within the ''SolarWinS'' project; possible new direct cooperation concerning large-area pore etching.

University New South Wales, Australia (Prof. Green)

Participation in ''round robin'' concerning quantitative solar cell characterization.

In most cases, the cooperation is motivated because there is either some interesting research or because the partially unique methods and processes of AMAT could be beneficial to a partner. In many first encounters with companies, ''proof of principle'' is the first goal, typically without direct remuneration. Instead, partners might supply specimens and technologies that are not available elsewhere. In this context it is necessary to point out that no university or research organization (short of large ''national centres'') is capable of producing solar cells that could rival the ones mass-produced by industry. State-of-the-art research with solar cells thus is only possible by cooperation with industry.

First cooperations with companies concerning possible novel products are always hoped to blossom eventually into full-fledged funded projects. That happens, but not all too often. Instead, the rewards are scientific insights and publications. Projects concerning prototypes invariably rely on the possibility of some technology transfer, and that needs ''interface'' companies like ET&TE. Since the CAU administration is opposed to this concept, many of the projects above are doomed to fail.

Diploma, Bachelor's and Master's Theses

Moges Gebeyehu Tessema, *Study on Electrochemical Cu Deposition on Si Microwire Arrays*, 15.02.2012
Mostafa Jamel, *Characterization of Metallization Processes on Industrial Si Solar Cells Using the CELLO Technique*, 16.04.2012
Hauke Hartz, *Untersuchung des Einsatzes wässriger Bindersysteme für Lithium-Ionen-Batterien*, 16.05.2012
Umut Tunca Sanli, *Development and Characterization of Front Side Metallization for Crystalline Silicon Solar Cells*, 11.07.2012
Mathias Hoppe, *Aufbau, Programmierung und Test eines PC-gesteuerten Messplatzes für Lumineszenz-Messungen an Solarzellen*, 17.09.2012
Maira Indrikova, *Preparation and characterisation of high-energy nickel cobalt manganese oxide (HE-NCM) pouch cells for lithium ion batteries*, 15.10.2012
Sandra Nöhren, *Study of Si Microwire Slurry - Anodes by Cyclovoltammetry Methods*, 07.11.2012
Iris Hölken, *Si-rich oxide by plasma enhanced chemical vapour deposition*, 14.11.2012

Publications

Published in 2012

M. Kasemann, L. Reindl, B. Michl, W. Warta, A. Schütt, J. Carstensen, *Contactless qualitative series resistance imaging on solar cells*, IEEE Journal Photovoltaics, **2**, 181 (2012)
E. Ossei-Wusu, J. Carstensen, H. Föll, *Analysis of p-Si macropore etching using FFT- impedance spectroscopy*, Nanoscale Res. Lett., **7**, 320 (2012)
M.-D. Gerngross, J. Carstensen, H. Föll, *Electrochemical and Galvanic Fabrication of a Magnetoelectric Composite Sensor Based on InP*, Nanoscale Res. Lett., **7**, 379 (2012)
M.-D. Gerngross, J. Carstensen, H. Föll, *Single-Crystalline Membranes in Indium Phosphide: Fabrication Process and Characterization Using FFT Impedance Analysis*, J. Electrochem. Soc., **159(11)H**, 857 (2012)
M.-D. Gerngross, E. Quiroga-González, J. Carstensen, H. Föll, *Single-crystalline porous indium phosphide as novel anode material for Li-ion batteries*, J. Electrochem. Soc., **159(12)A**, 1941 (2012)
A. Schütt, J. Carstensen, H. Föll, S. Keipert-Colberg, D. Borchert, *CELLO analysis of solar cells with silicon oxide/silicon*

nitride rear side passivation: parasitic shunting, surface recombination, and series resistance as rear side influences, Proc. 27th European Photovoltaic Solar Energy Conference, 2BV.5.14, Frankfurt, (2012)

A. Schütt, J. Carstensen, J.-M. Wagner, H. Föll, M. Nguyen, S. Klein, *Spectrally resolved local CELLO characterization of tandem solar cells using linear and 2nd harmonic response analysis,* Proc. 27th European Photovoltaic Solar Energy Conference, 3DV.1.61, Frankfurt, (2012)

C. Shen, H. Kampwerth, M. Green, T. Trupke, J. Carstensen, A. Schütt, *Luminescence based efficiency and other important parameters imaging of silicon solar cells,* Proc. 27th European Photovoltaic Solar Energy Conference, 2DO.3.2, Frankfurt, (2012)

M. Nguyen, M. Stegmaier, A. Schütt, J. Carstensen, H. Föll, *The influence of the electrode sheet resistance on local photocurrent excitations in microcrystalline Silicon thin film solar cells,* Proc. 27th European Photovoltaic Solar Energy Conference, 3DV.1.59, Frankfurt, (2012)

E. Quiroga-González, J. Carstensen, H. Föll, *Good cycling performance of high-density arrays of Si microwires as anodes for Li ion batteries,* Electrochim. Acta , DOI: 10.1016/j.electacta.2012.10.154, (2012)

Presentations

E. Quiroga-González, J. Carstensen, H. Föll, *Advances in the fabrication of anodes based on Si wire arrays for Li-ion batteries,* Kraftwerk Battery, Münster, Germany, 06.-07.03.2012

M.-D. Gerngroß, J. Carstensen, H. Föll, *ME 1-3 Composites,* Spring Meeting SFB 855, Akademie Sankelmark, Oeversee, Germany, 07.-09.03.2012

J. Carstensen, *Von Nanoporenätzung über Batterieelektroden zur Solarzellencharakterisierung für Gigawattleistungen,* NINA-Workshop, Scharbeuz, Germany, 20.03.2012

M.-D. Gerngroß, J. Carstensen, H. Föll, *Electrochemical and galvanic fabrication of a magnetoelectric composite sensor based on InP (Invited),* 8th International Conference on Porous Silicon - Science and Technology - 2012 (PSST), Malaga, Spain, 25.-30.03.2012

E. Ossei-Wusu, J. Carstensen, H. Föll, *Analysis of p-Si Macropore etching using FFT-Impedance Spectroscopy (poster),* 8th International Conference on Porous Silicon - Science and Technology - 2012 (PSST), Malaga, Spain, 25.-30.03.2012

E. Quiroga-González, J. Carstensen, H. Föll, *Good Cycling Performance of high Density Arrays of Si Wires of 1 mm in Diameter as Anodes for Li ion Batteries,* 10^{th} spring meeting of the International Society of Electrochemistry, Perth, Australia, 15.-18.04.2012

J.-M. Wagner, J. Carstensen, *CELLO - ''solar cell local characterization'',* Vorlesungsreihe ''Moderne Methoden der Charakterisierung von Solarzellen und Halbleitermaterial'' am MPI für Mikrostrukturphysik, Halle, Germany, 31.05.2012

E. Quiroga-González, *Good cycling performance of high density arrays of Si wires of 1 μm in diameter as anodes for Li ion batteries (Invited),* Public presentation at University of Kiel, Kiel, Germany, 21.06.2012

E. Quiroga-González, *Advances in the fabrication of anodes based on Si wire arrays for Li-ion batteries,* Third meeting, AlkaSuSi project (Alkalimetall, Schwefel und Silizium), Kiel, Germany, 21.06.2012

J. Carstensen, *Dielektrische Rückseitenpassivierung: Unterschiedliche Passivierbarkeit von Körnern, Korngrenzen und Versetzungen,* SolarWinS-Projekttreffen, Apolda, Germany, 10.07.2012

E. Quiroga-González, *Si microwire arrays as anode material of next-generation Li-ion batteries with the highest possible capacity (Invited),* German-Moldova Workshop on Electrochemical Nano-Structuring of Materials, Kiel, Germany, 23.07.2013

E. Quiroga-González, *Research experiences in Germany and silicon micro-machining (Invited),* Seminar at University of Sonora, Hermosillo, Mexico, 03.-05.09.2012

E. Quiroga-González, *La Universidad de Kiel y el estudio de baterías de Litio con la máxima capacidad posible (Invited),* Talk at Technological Institute of Hermosillo, Hermosillo, Mexico, 06.09.2012

H. Föll, *Herstellung und Erprobung von optimierten Silizium-Anoden für bessere Li-Ionen-Batterien (Invited)*, Colloquium at Institut für Solarenergieforschung Hameln (ISFH), Hameln, Germany, 18.09.2012

A. Schütt, J. Carstensen, H. Föll, S. Keipert-Colberg, D. Borchert, *CELLO analysis of solar cells with silicon oxide/silicon nitride rear side passivation: parasitic shunting, surface recombination, and series resistance as rear side influences (poster)*, 27th European Photovoltaic Solar Energy Conference and Exhibition, Session Reference: 2BV.5.14, Frankfurt, Germany, 24.-28.09.2012

A. Schütt, J. Carstensen, J.-M. Wagner, H. Föll, M. Nguyen, S. Klein, *Spectrally resolved local CELLO characterization of tandem solar cells using linear and 2nd harmonic response analysis (poster)*, 27th European Photovoltaic Solar Energy Conference and Exhibition, Session Reference: 3DV.1.61, Frankfurt, Germany, 24.-28.09.2012

E. Quiroga-González, J. Carstensen, H. Föll, *Si microwire arrays as anode materials of next-generation Li-ion batteries with the highest possible capacity*, MSE congress, Darmstadt, Germany, 25.-27.09.2012

E. Ossei-Wusu, J. Carstensen, E. Quiroga-González, M. Amirmaleki, H. Föll, *Investigation of pore diameter modulation in different depths in p-type silicon*, 222nd Electrochemical Society (ECS) Conference, Honolulu, Hawaii, U. S. A., 07.-12.10.2012

M.-D. Gergroß, J. Carstensen, H. Föll, *Fabrication of a single-crystalline porous InP membrane by electrochemical and photoelectrochemical etching*, 222nd Electrochemical Society (ECS) Conference, Honolulu, Hawaii, U. S. A., 07.-12.10.2012

M.-D. Gerngroß, E. Quiroga-González, J. Carstensen, H. Föll, *Single-Crystalline Porous Indium Phosphide as Novel Anode Material for Li-Ion Batteries*, 222nd Electrochemical Society (ECS) Conference, Honolulu, Hawaii, U. S. A., 07.-12.10.2012

E. Quiroga-González, *Advances in the fabrication and characterization of anodes based on Si wire arrays for Li-ion batteries*, Fourth meeting, AlkaSuSi project (Alkalimetall, Schwefel und Silizium), Dresden, Germany, 16.11.2012

Further Activities and Events

Prof. Dr. H. Föll is the co-executive director of the Institute for Materials Science, Faculty of Engineering, Christian-Albrechts-University Kiel.

Prof. Dr. H. Föll is a member of the executive board of the ''Förderverein der Technischen Fakultät'' at Christian-Albrechts-University Kiel.

Prof. Dr. H. Föll is the ''Vertrauensdozent für Angelegenheiten der Deutschen Forschungsgemeinschaft'' at Christian-Albrechts-University Kiel.

Guests in 2012:

01.02.2012 - 30.04.2012

Vaidas Antanavicius, Vilnius University, Lithuania, Erasmus Programme

01.07.2012 - 31.07.2012

Dr. Osama Tobail, Egypt Nanotechnology Centre (EGNC), Giza, Egypt

Inorganic Functional Materials

The chair of ''Inorganic Functional Materials'' concentrates on the research and development of smart materials in thin film form and their applications, mainly in the area of micro- and nanotechnology, using cost-effective processes that are capable of mass-production. Smart materials directly transduce electrical, magnetic, or thermal energy into mechanical energy or vice versa and are therefore very attractive for the realization of miniaturized actuators or sensors.

The related physical effects are magnetostriction, the piezo electric effect, and the shape memory effect. Thin film fabrication processes are an attractive approach to fabricate smart materials as this technology offers easy downscaling into the μm- or nm-range by a cost-effective manufacturing technology, is compatible to microelectronics fabrication, and allows the realization of novel materials, such as for example, multilayers that show superior behaviour compared to their traditional bulk counterparts. Furthermore, the combination of different smart materials allows the realization of multiferroic composites. An example is the class of magnetoelectric composites that consist of piezoelectric and magnetostrictive constituents. These materials are the basis for highly sensitive magnetic field sensors, which are a major part of the research within the SFB 855 ''Magnetoelectric composites - future biomagnetic interfaces''.

The Kieler Nanolabor provides thin film technology, especially magnetron sputtering, as well as lithography and etching processes, for the fabrication of materials and devices. Special equipment has been set-up for the characterization of the physical effects and functional properties of these ''intelligent'' micro-actuators and sensors

Results

In recent years, minimal invasive transaortic valve replacement has become an important branch in surgical heart valve replacement. The aim of this DFG funded project, collaborating with the group of experimental cardio surgery and valve replacement of Prof. Lutter at the UKSH (Universitätsklinikum Schleswig-Holstein) in Kiel, is to engineer and characterize a thin film heart valve stent, completely fabricated from TiNi shape memory alloy. Due to superelasticity, shape memory, and the excellent biocompability properties of the material, a TiNi heart valve holds advantages in crimpability, long durability, and low risk for thromboembolism.

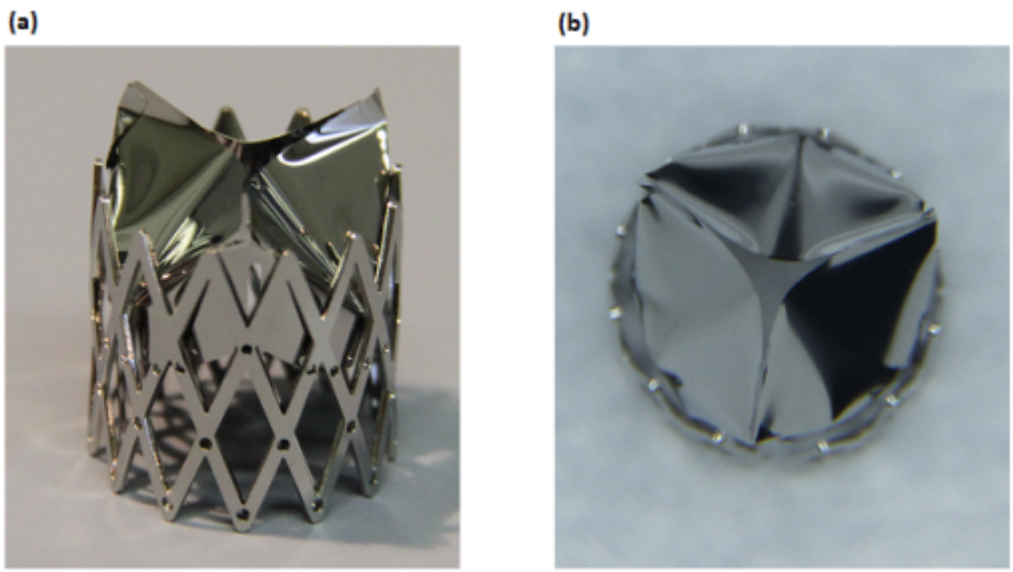


Fig. 1: First three leaflet TiNi heart valve model with 14 μm film thickness: a) side view, b) top view.

The main aspect of this project is to develop a manufacturing process to fabricate a hybrid heart valve stent, consisting of

a laser cut TiNi stent and a TiNi thin film leaflet. Important steps are: 1) the computer aided engineering and design, 2) development of a process to produce a TiNi thin film leaflet and subsequently integrate this in a stent. Additionally, the system should be characterized including mechanical and fatigue testing as well as medical characterization of the heart valve system.

During the first period of this project a process was developed to produce a free standing TiNi thin film based on magnetron sputtering and wet etching. In order to shape this film in leaflet geometry, as shown Fig.1, a mould with the desired leaflet geometry was developed and used during the film heat treatment.

A preliminary test was carried out to investigate the transvalvular pressure gradient and the opening and closure behaviour in a hydrodynamic environment of the first heart valve design produced. Based on these first results and a future computer simulation, the design of the heart valve will be further improved.

Magnetoelectric Composites- Future Biomagnetic Interfaces

Our group contributes to the Collaborative Research Centre ''SFB 855 Magnetoelectric Composites - Future biomagnetic Interfaces'' with the three sub-projects A1, C2 and Z1. The major goal of these projects is the development and optimization of composites of magnetostrictive and piezoelectric materials. These thin-film composites show very high sensitivities to AC magnetic fields in regimes required for biomagnetic applications.

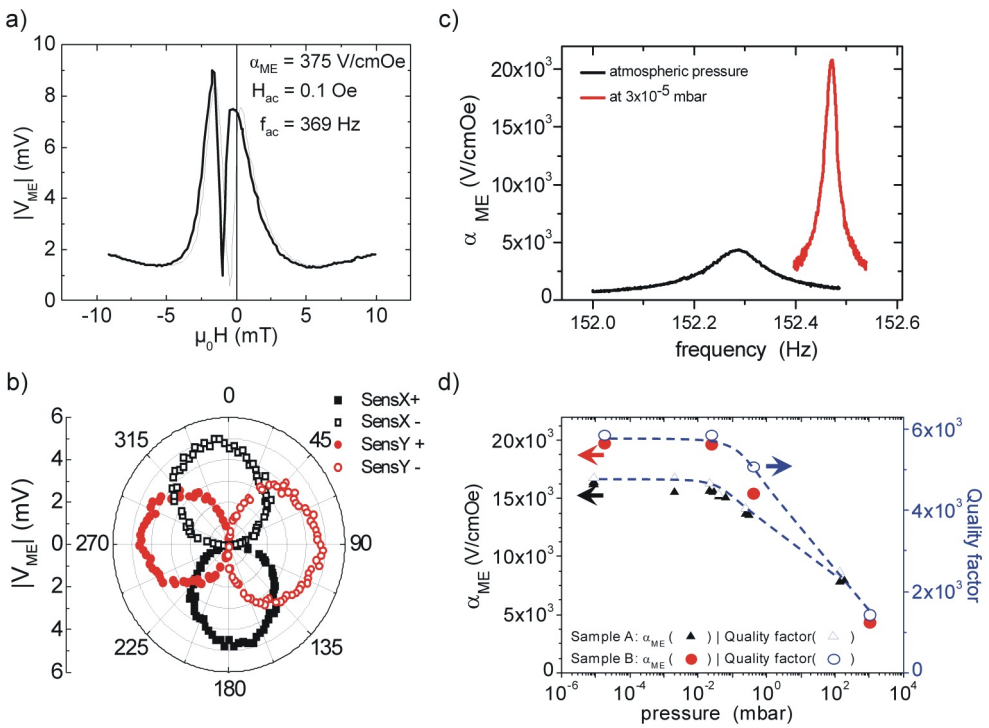


Fig. 2: Magnetoelectric (ME) measurement results: a) shows a shifted ME curve with a maximum response at zero field, b) depicts the angular dependency of two combined unidirectionally biased sensors, c) illustrates the impact of ambient pressure on quality factor and resonance frequency of a ME cantilever sensor, d) clarifies that a vacuum of 10^2 mbar is needed to avoid any air damping of the cantilevers.

One remarkable result, published in Nature Materials, is the self-biasing of such composites by utilization of the exchange-bias effect. The exchange coupling between an antiferromagnetic layer and the ferromagnetic magnetostrictive was tuned in such a way as to obtain a maximum sensor output at zero magnetic fields (Fig. 1a). This implementation of the bias field within the magnetostrictive component opens the path to highly miniaturized sensors, increasing the spatial

resolution. In addition the unidirectional character of the exchange bias allows the identification of the direction of the magnetic field with respect to an arrangement of such biased sensors (Fig 1b).

A new record in the magnetoelectric coefficient, the figure of merit in our research, has been achieved by operating our sensors in vacuum. By elimination of air damping and better sample preparation, 20 kV/cmOe at a resonance frequency of 152 Hz has been achieved (Fig. 1c). The sensor consists of 2 μm piezoelectric AlN and 2 μm magnetostrictive FeCoSiB on a silicon cantilever. The low resonance frequency is achieved by just partially thinning the cantilever to 90 μm, thus having a frequency lowering mass at the end of the cantilever.

Elastocaloric TiNi based Films

Refrigeration has a large share of the global electric energy consumption, and due to the use of FCKW containing cooling agents, is a major reason for global warming. The SPP 1599 project is aiming at the investigation of an environmentally friendly and highly efficient cooling alternative, based on solid state phase transitions which can be induced by external driving forces like magnetic, electrical, or mechanical stress fields.

In Kiel, the elastocaloric effect of NiTi based alloys which is characterized by a temperature change under adiabatic conditions due to stress induced phase transformations will be studied. For an efficient cooling device, fatigue behaviour and effect size, determined by the latent heat and the transforming volume, are the major parameters. The first part of the project is the optimization of these parameters by altering crystal lattice and microstructure using different alloy compositions and preparation methods. The characterization of the elastocaloric effect is carried out by infrared temperature measurements during tensile loading.

The second part of the project is the development of a micro cooling device prototype in cooperation with the KIT Karlsruhe, by using the optimized elastocaloric material. Such microcooling devices are potential candidates for the heat removal of microelectronics which enables higher computing capacity. In Karlsruhe the material and device simulation will be performed and a prototype will be realized by combining thin film and conventional construction technologies. Also a ''monolithic'' preparation process is envisaged which will be developed in Kiel.

Biodegradable Magnesium Stents

Stents are small devices, mostly made of metallic materials, used to scaffold or brace the inside of tubular passages or lumens. Today mostly non-degradable stents are implanted which consist of stainless steel or superelastic TiNi for example, although these permanent stents always bear the danger of a restenosis and are a potential source of irritation to the surrounding tissue. Due to these facts, and because in many therapies the stent is no longer needed after a few months, recent research focuses on the development of biodegradable materials for the use as stent material and especially on magnesium based alloys. These alloys have the advantageous property that they dissolve in the human body after a certain time, which can be influenced by the choice and the amount of the alloying elements used. However, despite the research that has already been done in recent years more work needs to be carried out to find alloys that show both an adequately low and uniform corrosion as well as high ductility and stiffness at the same time. Additionally, in the case of biomaterials, it has to be taken into account that the field of possible alloying elements is further limited, as none of the components used should have a harmful effect on the human metabolism.

The investigations of thin films made of binary Mg-Y, Mg-Gd and Mg-Ca alloys as well as ternary Mg-Y-Gd, Mg-Y-Nd and Mg-Zn-Ca alloys could show that the microstructure of most of the investigated alloys shows a columnar grain growth that does not depend on the deposition parameters. Despite this strongly textured microstructure, elongations at fracture of up to 20 % could be achieved for ternary magnesium-yttrium-rare earth alloys when applying suitable deposition parameters. Only for Mg-Zn-Ca alloys with a zinc content larger than 30 wt. % could a remarkable influence of the deposition parameters on the resulting microstructure be observed. For these alloys it was also possible to produce amorphous films that showed greatly improved corrosion behaviour. Unfortunately they exhibited unsuitable mechanical properties, as they showed very little ductility and are thus not suitable for the application as stent material. For thin films consisting

of binary magnesium alloys having a microstructure composed of a supersaturated solid solution it was observed that the corrosion rate and the tensile strength are improved with increasing amount of the corresponding alloying element, whereas the elongation at fracture decreases. While the Mg-Ca alloys investigated have proven to be too brittle for the desired application, there exist suitable alloys in the systems Mg-Gd and Mg-Y which meet the requirements for both the mechanical properties as well as the corrosion behaviour necessary for the application as a biodegradable implant material.

Personnel

Head of the group: Prof. Dr.-Ing. E. Quandt; Secretary: E. Riemer (50%), G. Schroeder
Technical Staff: Dipl.-Ing. (FH) T. Metzing, J. Ziese

Staff:

Stefanie Braunreuther-Rix SFB 855, Z2 und IGK	01.07.-31.12.2012	DFG
B. Gudschun SFB 855, Z2 und IGK	01.02.-31.12.2012	DFG

Scientific Staff:

Dr. C. Bechtold SPP 1239	01.01.-31.12.2012	DFG
Dr. A. Büttner SFB 855, Z2 und IGK	01.01.-31.08.2012	CAU
M.Sc. Christoph Chluba Elastocaloric Ti-Ni based Films and Devices - Materials	15.-31.12.2012	DFG
M.Sc. Ch. Kirchhof SFB 855, Teilprojekt C2	16.11.-31.12.2012	DFG
Dipl.-Ing. E. Lage SFB 855, Teilprojekt Z1	01.01.-31.12.2012	DFG
Dr. R. Lima de Miranda	01.01.-31.12.2012	CAU
Dr. A. Malavé	01.01.-31.12.2012	CAU
Dr. D. Meyners	01.01.-31.12.2012	CAU
Dipl.-Ing. A. Piorra SFB 855, Teilprojekt A1	01.01.-31.12.2012	DFG
M.Sc. Volker Röbisch SFB 855	01.-31.12.2012	DFG
Dipl.-Ing. K. Schlüter PRO INNO II, SFB 677, SPP1239	01.01.-31.12.2012	BMWi/DFG
M.Sc. Ali Tavasollizadeh Magnetoresistive Tunnelstrukturen	01.02.-31.12.2012	DFG
Dr. I. Teliban SPP 1299	01.01.-30.09.2012	DFG

M.Sc. F. Thajudin FeGa-based Nanoelectronic Strain Sensor	01.01.-30.06.2012	ONR/NICOP
Dipl.-Phys. C. Thede SPP 1299	01.01.-31.12.2012	DFG
M.Sc. E. Yarar SFB 855, Teilprojekt A1	15.11.-31.12.2012	DFG
Dr. C. Zamponi Mg Stents	01.01.-31.12.2012	DFG
MSc. A. Zayed TiNi Stents	01.07.-31.12.2012	BMWi

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

Werkstoffe (Keramik), 2 hrs Lecture/Week,
E. Quandt (+ A. Piorra)

Smart Materials, 2 (+1) hrs Lecture (+ Exercises)/Week,
E. Quandt

Anorganische Funktionsmaterialien, 2 hrs Seminar/Week,
E. Quandt

Micro/Nanosystems Technology and Processes, 2 (+1) hrs Lecture (+ Exercises)/Week,
D. Meyners

Laboratory Course: Materialanalytik 2, 4 hrs Lab/Week,
D. Meyners (+ C. Zamponi)

Laboratory Course: Basic Lab Course for Master´s Students, 3 hrs Lab/Week,
D. Meyners (+ A. Tavassolizadeh, E. Lage, A. Piorra, F. Thajudin)

Summer 2012

Advanced Materials B, 2 (+1) hrs Lecture (+ Exercises)/Week,
E. Quandt (+ A. Malavé)

Anorganische Funktionsmaterialien, 2 hrs Seminar/Week,
E. Quandt

Advanced Lab Course for Master´s Students, 4 hrs Lab/Week,
D. Meyners (+ C. Bechtold, Ch. Kirchhof, Ali Tavasollizadeh)

Grundpraktikum II, 3 hrs Practical/Week,
D. Meyners

Winter 2012/2013

Werkstoffe (Keramik), 2 hrs Lecture/Week,
E. Quandt (+ A. Piorra)

Smart Materials, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
E. Quandt

Anorganische Funktionsmaterialien, 2 hrs Seminar/Week,
E. Quandt

Micro/Nanosystems Technology and Processes, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
D. Meyners

Laboratory Course: Analytik, 4 hrs Lab/Week,
D. Meyners (+ E. Lage)

Laboratory Course: Basic Lab Course for Master´s Students, 3 hrs Lab/Week,
D. Meyners (+ A. Zayed, C. Thede, A. Piorra)

Grundpraktikum I, 3 hrs Practical/Week,
D. Meyners

Third-Party Funds

DFG, *Herstellung von bioresorbierbaren Dünnschicht Gefäßstützen (Stents) aus Magnesiumlegierungen durch Magnetron-Sputter-Technolgogie*, 09.11.2012-08.11.2015 (231.214 EUR)
DFG, *SPP 1599 - Elastocaloric Ti-Ni based Films and Devices - Materials*, 15.11.2012-14.11.2015 (281.234 EUR)
DFG, *TiNi Dünnschicht-Herzklappen*, 01.02.2012-31.01.2015 (239.748 EUR)
DFG, *SPP 1299 HAUT, Nanostrukturierte magnetische Dünnschicht-Komposite für Anwendungen in der Hochtemperatur-Sensorik*, 01.09.2010-31.08.2013 (184.143 EUR)
DFG, *SPP 1299 HAUT, Sensorfunktion für Hochtemperatur-Schutzschichten zur in situ Erfassung des Degradationszustands*, 01.07.2010-30.09.2012 (184.143 EUR)
DFG, *SPP 1239, Änderung von Mikrostruktur und Form fester Werkstoffe durch äußere Magnetfelder, Teilprojekt: Exploitation and Transfer of Results of the SPP 1239*, 15.07.2010-30.06.2012 (100.900 EUR)
DFG, *SPP1239: Fe-Pd-X Thin Film-Polymer Composites for Sensor Applications*, 01.01.2011-31.12.2012 (144.020,00 EUR)
DFG, *Herstellung v. bioresorbierbar. Dünnschicht Gefäßstützen (Stents) aus Magnesiumlegierungen durch Magnetron-Sputter-Technologie*, 15.09.2009-14.09.2012 (236.783 EUR)
DFG, *Magnetoresistive Tunnelstrukturen mit magnetostriktiven Elektroden als Sensor für die Rastermikroskopie*, 01.02.2011-31.01.2013 (174.969 EUR)
BMWi, *ZIM, Entwicklung eines Implantats mit selektriver Abdeckung*, 01.07.2010-01.06.2012 (175.000 EUR)
Office of Naval Research (ONR,USA), NICOP, *FeGa-based Nanoelectronic Strain Sensor*, 01.07.2008-30.06.2012 (165.232 EUR)
SFB 855, *Magnetoelektrische Verbundstoffe - biomagnetische Schnittstellen d. Zukunft , Teilprojekt A 1*, 01.01.2010-31.12.2013 (603.200 EUR)
SFB 855, *Magnetoelektrische Verbundstoffe - biomagnetische Schnittstellen d. Zukunft, Teilprojekt C2*, 01.01.2010-31.12.2013 (289.200 EUR)
SFB 855, *Magnetoelektrische Verbundstoffe - biomagnetische Schnittstellen d. Zukunft, Teilprojekt Z1*, 01.01.2010-31.12.2013 (557.600 EUR)
SFB 855, *Magnetoelektrische Verbundstoffe - biomagnetische Schnittstellen d. Zukunft, Teilprojekt Z2*, 01.01.2010-31.12.2013 (1.185.000 EUR)
Industrie, *Forschungs- und Entwicklungsvertrag*, 01.09.2012-31.08.2015 (180.000 EUR)

Further Cooperation, Consulting, and Technology Transfer

Prof. Dr. F. Faupel, CAU

Dr. H. Hölscher, KIT, Karlsruhe

Dr. N. Hort, Helmholtz-Zentrum, Geesthacht

Prof. Dr. K.U. Kainer, Helmholtz-Zentrum, Geesthacht

Prof. Dr. R. Knöchel, CAU

PD Dr. M. Kohl, KIT, Karlsruhe

Prof. Dr. A. Ludwig, RUB, Bochum

Prof. G. Lutter, UKSH

Prof. J. McCord, CAU

Dr. W. J. Quadakkers, FZ Jülich

Prof. Dr. M. Schütze, Dechema, Frankfurt

Prof. C. Selhuber-Unkel,CAU

Dr. M. Stüber, KIT, Karlsruhe

Prof. Dr. F. Tuczek, CAU

Prof. B. Wagner, FHI ISIT

Prof. Dr. M. Wuttig, University of Maryland, USA

Diploma, Bachelor's and Master's Theses

Volker Röbisch, *Magnetoelektrische 2-2 Komposite auf Basis von PZT und CFO hergestellt mittels gepulster Laserabscheidung,* 13.12.2012

Christoph Chluba, *Investigation of the elastocaloric effect in sputtered TiNiCu shape memory films,* 21.12.2012

Dissertations / Postdoctoral Lecture Qualifications

F. Thajudin, *FeGa based tunnelling magnetoresistance junctions and strain sensors,* 14.12.2012

K. Schlüter, *Untersuchung von biodegradierbaren Dünnschicht-Magnesiumlegierungen,* 20.12.2012

Publications

Published in 2012

K. Schlüter, C. Zamponi, J. Hapke, N. Hort, K.-U. Kainer, E. Quandt, *Mechanical properties and corrosion behaviour of freestanding, precipitate-free magnesium WE43 thin films,* Int. J. Mat. Res., **103**, 1 - 7 (2012)

C. Bechtold, C. Chluba, R. Lima de Miranda, E. Quandt, *High cyclic stability of the elastocaloric effect in sputtered TiNiCu shape memory films,* Applied Physics Letters, **101**, 091903 (2012)

C. Bechtold, A. Lotnyk, B. Erkartal, L. Kienle, E. Quandt, *Structural Characterization of Sputtered $Fe_{70}Pd_{30}$ Thin Films During Ex Situ and In Situ TEM Heating,* Advanced Engineering Materials, **14**, 716 - 723 (2012)

T. Habijan, R. Lima de Miranda, C. Zamponi, E. Quandt, C. Greulich, T.A. Schildhauer, M. Köller, *The biocompatibility and mechanical properties of cylindrical NiTi thin films produced by magnetron sputtering,* Material Science & Engineering C-Materials, **32**, 2523 - 2528 (2012)

A. Kukarni, B. Henkel, C. Bechtold, V. Zaporojtchenko, T. Strunskus, E. Quandt, *Monitoring magnetostriction by a quantum tunnelling strain sensor,* Sensors and Actuators A: Physical, **183**, 28 - 33 (2012)

R. Jahns, H. Greve, E. Woltermann, E. Quandt, R. Knöchel, B. Wagner, *Sensitivity enhancement of magnetoelectric sensors through frequency-conversion,* Sensors and Actuators A: Physical, **183**, 16 - 21 (2012)

K. Schlüter, C. Zamponi, N. Hort, K.U. Kainer, E. Quandt, *Polycrystalline and amorphous MgZnCa thin films,* Corrosion Science, **63**, 234 - 238 (2012)

St. Marauska, R. Jahns, H. Greve, E. Quandt, R. Knöchel, *MEMS magnetic field sensor based on magnetoelectric composites,* Microchem. Microeng, **22**, 065024 (2012)

E. Lage, C. Kirchhof, V. Hrkac, R. Jahns, R. Knöchel, E. Quandt, D. Meyners, *Exchange biasing of magnetoelectric composites,* Nature Materials, **11**, 523 - 529 (2012)

C. Thede, S. Chemnitz, I. Teliban, C. Bechtold, C. Klever, M. Stüber, E. Quandt, *Non-contact temperature determination of embedded magnetic phases of hard coatings by exploitation of the magnetic hysteresis,* Sensors and Actuators A, **178**, 104 - 109 (2012)

S. Fähler, U. Rößler, O. Kastner, J. Eckert, E. Eggeler, H. Emmerich, P. Entel, St. Müller, E. Quandt, K. Albe, *Caloric effects in ferroic materials: New concepts for cooling,* Advanced Engineering Materials, **14**, 10 - 19 (2012)

J. Teliban, St. Chemnitz, C. Thede, C. Bechtold, B. Moozoni, H.-J. Krause, E. Quandt, *M(H) shape reconstruction using magnetic spectroscopy,* J. Magn. Magn. Mat., **324**, 895 - 902 (2012)

Patent Applications

E. Lage, D. Meyners, E. Quandt, *Verbundwerkstoff mit magnetoelektrischem Effekt im Nullfeld,* PVA-SH, 25.04.2012, 1

E. Quandt, C. Selhuber-Unkel, *NiTi-basierte Mikrokraftsensoren,* PVA-SH, 30.11.2012, pva Co84

E. Quandt, A. Piorra, *Neuartige Anordnung der sensitiven Schichten bei magnetoelektrischen Sensoren für die Verwendung ...,* PVA-SH, 04.10.2012, 3

Presentations

E. Quandt, *Technik für den Blick in den Körper: Neue Magnetsensoren für Signale,* Vortrag Universitätsgesellschaft Schleswig-Holstein, Rathaus Kiel, 17.-17.01.2012

C. Thede, I. Teliban, C. Bechtold, S. Chemnitz, E. Quandt, *Magnetische Charakterisierung durch Erweiterung des Frequenzmischverfahrens (poster),* Edgar-Lüscher-Seminar, Klosters, Schweiz, 04.-10.02.2012

C. Thede, I. Teliban, S. Chemnitz, C. Bechtold, B. Mozooni, H. J. Krause, E. Quandt, *Reconstruction of magnetization curve using magnetic spectroscopy,* Int. Workshop on Magnetic Particle Imaging, Lübeck, 15.-16.03.2012

C. Thede, I. Teliban, S. Chemnitz, c. Bechtold, C. Klever, M. Stüber, E. Quandt, *Phase-sensitive frequency mixing for sensing magnetic hysteresis,* Intermag, Vancouver, Canada, 07.-11.05.2012

E. Quandt, E. Lage, C. Kirchhof, D. Meyners, *Exchange Biasing of Magnetoelectric Thin Film Composites,* CIMTEC Conference, Montecatini Terme, Italy, 10.-15.06.2012

E. Quandt, C. Bechtold, R. Lima de Miranda, M. Wuttig, *Elastocaloric Properties of Sputtered Ti-Ni-X Thin Films,* CIMTEC Conference, Montecatini Terme, Italy, 10.-15.06.2012

C. Zamponi, K. Schlüter, E. Quandt, , *Influence of the Ca amount on the corrosion behaviour of Mg-Ca thin films,* 9th International Conference on Magnesium Allyos & Applications, Vancouver, Canada, 08.-12.07.2012

K. Schlüter, C. Zamponi, E. Quandt, *Amorphous thin films consisting of ternary MgZnCa-alloys,* 9th International Conference on Magnesium Allyos & Applications, Vancouver, Canada, 08.-12.07.2012

A. Zayed, R. Lima de Miranda, E. Quandt, *Investigating Fatigue Life for Equiatomic TiNi thin films,* Euromat 2012, Lausanne, Switzwerland, 23.-27.07.2012

E. Quandt, E. Lage, C. Kirchhof, D. Meyners, *Giant Magnetoelectric Effect in Exchange Biased Thin Film Composites*, XXI International Materials Research Congress, Cancun, Mexico, 11.-21.08.2012

E. Lage, D. Meyners, C. Kirchhof, E. Quandt, *Bias Field Integration in Magnetoelectric Composites by Exchange Bias*, Materials Science and Engineering, Darmstadt, 25.-27.09.2012

D. Meyners, E. Lage, C. Kirchhof, R. Jahns, H. Runkowske, R. Knöchel, E. Quandt, *Magnetoelectric thin film sensor for biomagnetic sensing*, Materials Science and Engineering, Darmstadt, 25.-27.09.2012

A. Piorra, V., Röbisch, E. Quandt, *Ferroelectric lead-free 0.5($Ba_{0.7}Ca_{0.3}TiO_3$) - 0.5[Ba($Zr_{0.2}Ti_{0.8}$)O_3]: From bulk to laser deposited thin films for magnetoelectric applications*, Materials Science and Engineering, Darmstadt, 25.-27.09.2012

C. Kirchhof, R. Jahns, D. Meyners, R. Knöchel, E. Quandt, *Enhancement of magnetoelectric effect by operation in vacuum (poster)*, Materials Science and Engineering, Darmstadt, 25.-27.09.2012

Erdem Yarar, A. Piorra, D. Meyners, E. Quandt, *Magnetoelectric 2-2 Thin Film Composites (poster)*, Materials Science and Engineering, Darmstadt, 25.-27.09.2012

E. Quandt, E. Lage, A. Piorra, C. Kirchhof, E. Yarar, D. Meyners, *Giant Magnetoelectric Effect in Thin Film Composites*, ECS Meeting Prime 2012, Honolulu, USA, 06.-22.10.2012

D. Meyners, E. Quandt, *Giant magnetoelectric effect in thin film composites*, International Scientific CNRS Fall School 2012, Branville, France, 22.-26.10.2012

K. Schlüter, C. Zamponi, A. Piorra, U. Schürmann, L. Kienle, E. Quandt, *Dünne biokorrodierende Schichten auf Basis von MgZnCa Legierungen*, Jahrestagung der Deutschen Gesellschaft für Biomaterialien, Hamburg, 01.-03.11.2012

Further Activities and Events

E. Quandt: Vice Dean of the Faculty of Engineering (since July 2012).

E. Quandt: Speaker of the DFG Collaborative Research Centre (SFB 855) ''Magnetoelectric Composites - Biomagnetic Interfaces of the Future''.

E. Quandt: Member of the Materials Science and Engineering Expert Committee (MatSEEC) of the European Science Foundation (ESF).

E. Quandt: Speaker of the Research Focus ''Kiel Nano Science'' of the Christian-Albrechts-University of Kiel, (until October 2012).

E. Quandt: Member of the Executive Board and spokesperson of the Advisory Board of the Deutsche Gesellschaft für Materialkunde (DGM).

E. Quandt: Member of the Scientific Advisory Board of the Acandis GmbH and Co. KG, Pfinztal.

E. Quandt: Coordinator of the Proposal for a Cluster of Excellence ''Materials for Life'' (until June 2012).

E. Quandt: Member of the Review Board of the DFG

R. Lima de Miranda, E. Quandt: Co-Founder of the company Acquandas GmbH, Kiel.

E. Quandt: Speaker of the Advisory Board of the Fraunhofer Institute ISIT

Materials and Processes for Nanosystem Technologies

Prof. Dr. Bernhard Wagner is the Deputy Director of the Fraunhofer-Institute für Siliziumtechnologie (ISIT) in Itzehoe.

Fraunhofer ISIT develops and manufactures components in microelectronics and microsystems technology, from the design phase, (including system simulation) through prototyping and fabrication of samples, up to series production. Even though components manufactured at Fraunhofer ISIT, such as acceleration sensors, valves, and deflection mirrors, often measure just a fraction of a millimetre in size, there is a wide range of applications: the devices are implemented in areas like medical care, environmental and traffic engineering, communication systems, automotive industry, and mechanical engineering. Working under contract, ISIT develops these types of components in accordance with customer requirements, also creating the application specific integrated circuits (ASICs) needed for the operation of sensors and actuators. Included in this service is system integration using miniaturized assembly and interconnection technology.

Together with Vishay Siliconix Itzehoe GmbH, the institute operates a professional semiconductor production line which is up-to-date in all required quality certifications (e. g. ISO 9001, TS 16949). This line is used in parallel for PowerMOS and microsystem production and for R&D projects developing new devices and technological processes.

Other fields of activity at ISIT focus on assembly and packaging techniques for microsystems, analysis of the quality and reliability of electronic components, and development of advanced power-supply components for electronic systems.

The institute employs a staff of around 150 people

Further information about Fraunhofer ISIT is available on the web: www.isit.fraunhofer.de.

In addition the Institute publishes an Annual Report which can be ordered at ISIT.

Fraunhofer-Institut für Siliziumtechnologie,
Managing Director: Professor Dr. Wolfgang Benecke
Fraunhoferstr. 1
D-25524 Itzehoe
Tel. + 49(0)4821/17-4211 (Secretary)
Fax + 49(0)4821/17-4250
Email info@isit.fraunhofer.de
Internet www.isit.fraunhofer.de

Microanalysis of Materials

Research Focus and Methods: Our research projects aim at the understanding of microstructure-property relationships of functional materials and the synthesis of fundamental research, quantitative methodological approaches, and their applications in technology-oriented material developments. Particular emphasis is put on:

- microstructure research of thin film systems, interfaces, defects, and nanomaterials,

- quantitative methods of high-resolution and analytical transmission electron microscopy, and

- nanoanalytics with electrons in materials and surface science.

The Centre of Materials Analysis (CMA) and the ''Kieler Nanolabor'' of the CAU Kiel (see TF almanac 2008) provide access to numerous methods for the nanoanalysis of materials. Techniques predominantly used in our research projects are the advanced high-resolution imaging (HRTEM, STEM/HAADF, EFTEM) and spectroscopic (EELS/ELNES, EDXS) methods of transmission electron microscopy (TEM), state-of-the-art image simulation,and digital image analysis methods as well as dual-beam FIB / SEM / EDX methods for focused ion beam (FIB) TEM specimen preparation. The central instrument of the TEM laboratory is a FEI TECNAI F30 analytical transmission electron microscope, equipped with a GATAN GIF / TRIDIEM 863 Imaging Energy Filter; it has Multi-Scan CCD Cameras and specimen holders for temperature control and electron tomography for 3D object reconstruction. Software packages for state-of-the-art image simulation, digital image analyses, spectral data analyses, and exit-wave reconstruction from focal series assist in the evaluation of the experimental data.

Course Teaching, Offers for Research Schools, Research Thesis Projects: CMA runs study course lectures for bachelor´s and master´s students (teaching languages English and German) on the principles of materials science, analytical methods in materials science, and advanced methods of electron microscopy. It offers thesis projects for bachelor´s and master´s course students, and for dissertation projects. It also offers research schools in microstructure research with methods of advanced electron microscopy.

Collaboration Offers for Research and Technology: We offer consulting and expert advice, R&D collaboration with research institutions and industry, funded project research and transfer of technology. Continuing education is offered in the course''Analytics of Materials for Research and Industry / Materialanalytik für Forschung und Industrie'' (Prof. W. Jäger, teaching languages German and English).

Results

Conference Organisation

E-MRS 2012 European Materials Research Society Spring Meeting, Symposium X: ''Quantitative microscopy of energy materials, Strasbourg, France, May 14 - 18, 2012. Chairpersons: Aicha Hessler-Wysser, EPFL Lausanne, Switzerland, Thomas Höche, Fraunhofer IWM Halle, Germany, Wolfgang Jäger, CAU Kiel, Germany, Hugo Bender, IMEC Leuven, Belgium. www.european-mrs.com

Meeting Report

Thomas Höche, Aicha Hessler-Wyser, Hugo Bender, Wolfgang Jäger

A symposium on ''Quantitative microscopy of energy materials'' was held during the E-MRS 2012 Spring Meeting in Strasbourg, France, May 14-18, 2012. The symposium was organized by Thomas Höche, Fraunhofer Institute for Mechanics of Materials IWM, Halle, Germany, Aicha Hessler-Wyser, EPFL, Lausanne, Switzerland, Wolfgang Jäger, Kiel University, Germany and Hugo Bender, imec, Belgium. It was a successor to the symposium on ''Quantitative electron microscopy for research and industry'' organized at the E-MRS 2010 Spring Meeting.

The symposium gave a forum to researchers interested in quantitative application of different advanced microscopy methods, including atomic force microscopy, transmission electron microscopy and spectroscopy, and scanning electron microscopy, to different fields of energy-related materials, such as hydrogen production and storage, fuel cells, batteries, reactors, and photovoltaics. This symposium had more than 60 contributions received from 23 countries from within Europe as well as from China, Israel, Japan, Korea and the US. The symposium was one of several symposia on materials for energy at the E-MRS conference.

The topical areas are reflected by the contributions of the invited speakers and addressed a wide range of methods and application aspects in this important field: quantitative electron tomography (Paul Midgley, Cambridge University, UK), nanometric defects in materials in transmission electron microscopy (Robin Schäublin, EPFL Lausanne and Paul Scherrer Institute, Villigen, Switzerland), quantitative characterization of deformation and transformation of microstructures of advanced steels using electron diffraction techniques in the SEM (Stefan Zaefferer, Max-Planck Institute for Iron Research, Düsseldorf, Germany), effect of interfaces on the ionic conductivity of SOFC materials (David McComb, Ohio State University, Columbus, USA), on the help of microscopies in the understanding of degradation mechanisms observed on materials in pressurized water reactor (Laurent Legras, EDF, France), designing semiconductor photocatalyst/metal cocatalyst composites for water splitting (Rik Brydson, University of Leeds, UK), electron energy-loss spectroscopy of dopant concentration profiles and optical absorption in thin film silicon solar cells (Rafal Dunin-Borkowski, Forschungszentrum Jülich, Germany), microscopy study of thin-film polycrystalline silicon solar cells: where optical, electrical and structural material characterizations in the sub-micron range meet each other (Dries Van Gestel, imec, Belgium), materials science for high-efficiency III-V solar cells (Frank Dimroth, Fraunhofer Institute for Solar Energy Systems ISE, Freiburg, Germany), investigation of aged organic solar cell stacks by cross-sectional transmission electron microscopy coupled with elemental analysis (Paola Favia, imec, Belgium), advances in spectroscopic nano-scale characterization in electron-optical instruments (Nestor Zaluzec, Argonne National Laboratory, USA), HAADF-STEM of layered structures in materials for photonics, thermoelectronics and photovoltaics (Miran Ceh, Jozef Stefan Institute, Ljubljana, Slovenia), nanostructured reactive hydride composites for hydrogen storage (Thomas Klassen, Helmholtz-Zentrum, Geesthacht, Germany).

The graduate student award for the best paper submitted to the symposium went to Panagiotis Karagiannidis from the Laboratory for Thin Films, Nanosystems and Nanometrology, Physics Department of the Aristotle University of Thessalonika, Greece, for his presentation on ''Impact of thermal annealing on the morphology and interfacial composition of bulk heterojunction organic solar cells''. Two best poster awards were granted in the categories ''materials'' and ''techniques'' to András Kovács and co-workers from the Ernst Ruska-Centre, Jülich, Germany for the poster on ''Resolving the surface structure of iron-silicide alloy nanocrystals'' and to Kjetil Valset and coworkers from the Department of Physics, University of Oslo for the poster on ''Quantitative study of structure factors at large reciprocal vectors using convergent beam electron diffraction: application to anharmonicity of the thermal motion in Mg_2Si''. Full papers of the symposium contributions will be published in a special volume of Journal of Materials Science.

End of Meeting Report

We have applied advanced high-resolution imaging and spectroscopic techniques of transmission electron microscopy (conventional and aberration-corrected high-resolution TEM, electron diffraction, high-resolution STEM, and spectroscopic EDXS and EELS analyses) in comprehensive and quantitative research on interfaces, surfaces, and nanomaterials. The topics were as follows:

TEM FOR IMPROVED HIGH-EFFICIENCY SOLAR CELLS

Our microstructure research of compound semiconductor layer materials aims at the development of new concepts for defect engineering and at the control of strain in heteroepitaxial crystal layer growth for high-efficiency solar cells. The focus of recent efforts is on concepts of defect engineering with buffer layer systems based on GaAsP layers and on GaInP layers.

Dr. Dietrich Häussler CAU. Cooperation: Dr. F. Dimroth, Dr. A. Bett, Fraunhofer Institute for Solar Energy Systems FhG-ISE Freiburg.

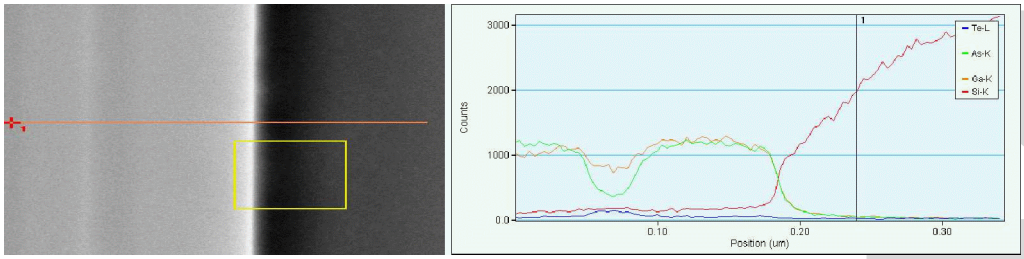


Fig. 1: STEM investigations of interface properties in high-efficiency solar cells: example of measurements near bonding interface of GaInP/GaAs/Si solar cell. The figure depicts the STEM high-angle annular dark field contrast image and the EDXS line profile distribution of some elements indicated as examples.

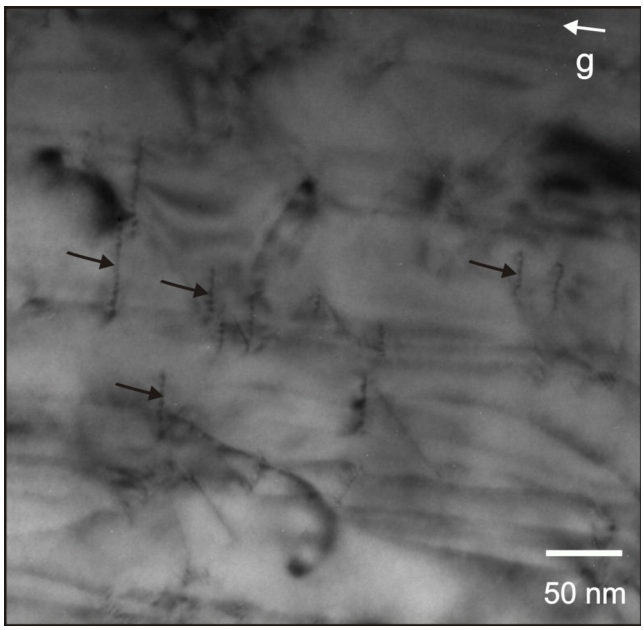


Fig. 2: TEM analyses of buffer system concepts for high-efficiency solar cells. Example of layer cross-section analysis of dislocations in a step-graded metamorphic $GaAs_xP_{1-x}$ buffer system on a Si (001) substrate.

In methodologically oriented investigations, we explored the potential of combining HAADF-STEM with spectroscopic techniques, such as EDXS and EELS, to give high-resolution analyses of interfaces in solar cells on Si substrates. The investigations continue using probe-corrected STEM instruments (ER-C Jülich).

Dr. D. Häussler, CAU Kiel. Cooperation: Dr. L. Houben, Prof. Rafal Dunin-Borkowski, Ernst-Ruska Center, Research Centre Juelich, Germany.

QUANTITATIVE STEM OF MULTILAYERS FOR COMMERCIAL SYNCHROTRON OPTICS

The methodological development is oriented towards technology support and focuses on high-angle annular dark-field scanning TEM (HAADF-STEM) for cross-section imaging of periodic and aperiodic multilayer systems and their interfaces and the quantitative assessment of reflectivity properties. The investigations are continued using probe-corrected STEM instruments (ER-C Jülich).

Dr. D. Häussler, CAU Kiel. Cooperations: Dr. J. Wiesmann, F. Hertlein, U. Heidorn, Incoatec GmbH, Geesthacht, Germany. Dr. L. Houben, Prof. Rafal Dunin-Borkowski, Ernst-Ruska Centre, Research Centre Juelich, Germany.

TEM OF NANOPARTICLE MATERIALS

Quantitative analyses of structure and composition of polycrystalline core-shell nanoparticles, which are of potential interest for applications in catalysis and as data storage, have been extended further by applying STEM-based imaging and diffraction methods with spectroscopic methods.

Dr. D. Häußler CAU. Cooperation: Dr. B. Schaffer, Dr. F. Hofer, Institute for Electron Microscopy, Graz University of Technology, Graz, Austria and SuperSTEM Facility Daresbury, UK.

In methodologically oriented investigations, we explored the potential of combining HAADF-STEM tomography with spectroscopic techniques, such as EDXS, to give high-resolution analyses of nanometre-scale particles and inclusions formed by diffusion doping in III-V compound semiconductor materials. Essential for such investigations are specimens fabricated by focused ion beam (FIB) preparation techniques.

Cooperation: Dr. Ch. Kübel, Group Leader Transmission Electron Microscopy, Karlsruhe Institute of Technology (KIT), Institute of Nanotechnology (INT). Dr. Peter Ercius, Dr. U. Dahmen, NCEM National Center for Electron Microscopy, LBL Berkeley, CA, USA.

TEM OF NANOSCALE PHENOMENA IN MAGNETIC Cu-Co MULTILAYER AND Cu-Co ALLOY SYSTEMS

TEM diffraction contrast imaging and STEM-based EDXS analyses are performed on melt-spun magnetic Cu-Co alloys and on Cu-Co multilayer systems which exhibit oscillatory behaviour of the giant magnetoresistance (GMR) upon changing microstructure parameters. In order to gain quantitative understanding of the microstructure-property relationships, TEM methods are applied in systematic studies of interfaces and microstructure.

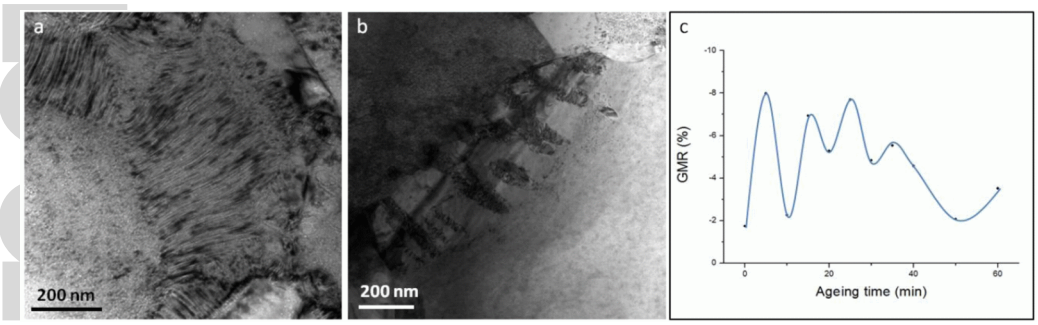


Fig. 3: TEM characterisations of microstructure phenomena for the structure-property relationship of Cu-Co alloys depicting giant magnetoresistance (GMR). Colonies of discontinuous precipitation (a) and discontinuous coarsening (b) of a sample aged at 550 °C for 60min. (c) GMR ratios as a function of ageing time at 550 °C. Funded by MACAN.

Dr. D. Häußler CAU. Cooperation: Professor Guillermo Solórzano, Natasha M. Suguihiro, M.Sc., PhD student, Department of Materials Science and Metallurgy, PUC-Rio Pontifícia Universidade Católica do Rio de Janeiro, Rio de Janeiro, Brazil.

Personnel

Head of the group: Prof. Dr. Wolfgang Jäger; Secretary: Katrin Brandenburg (50%)

Scientific Staff:

Dr. Dietrich Häußler 01.01.-31.12.2012 CAU
Analytical TEM of layer systems and nanomaterials

M.Sc. Burcu Ögüt 01.01.-31.12.2012 MPI Stuttgart
Investigations of surface plasmon resonances of metallic nanomaterials by energy-filtering TEM (co-supervision of external dissertation, in collaboration with Max-Planck-Inst. f. Intelligente Systeme, Stuttgart, Prof. Dr. P. Van Aken, Dr. W. Sigle

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

Analytics I, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Wolfgang Jäger

Transmission Electron Microscopy I, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Wolfgang Jäger

Analytical Methods in Materials Research, 2 hrs Seminar/Week,
Wolfgang Jäger

Materialwissenschaft III, 3 (+ 1) hrs Lecture (+ Exercises)/Week,
Wolfgang Jäger

Materialanalytik 2, 4 hrs Practical/Week,
Dietrich Häußler (+ et al.)

Summer 2012

Analytics II, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Wolfgang Jäger

Transmission Electron Microscopy II, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Wolfgang Jäger

Microstructure Research of Thin Films and Nanostructures, 2 hrs Seminar/Week,
Wolfgang Jäger

Einführung in die Materialanalytik, 2 hrs Lecture/Week,
Wolfgang Jäger

Advanced Laboratory Course for Master´s Students, 4 hrs Practical/Week,
Dietrich Häußler (+ et al.)

Winter 2012/2013

Analytics I, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Wolfgang Jäger

Transmission Electron Microscopy I, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Wolfgang Jäger

Analytical Methods in Materials Research, 2 hrs Seminar/Week,
Wolfgang Jäger

Materialwissenschaft III, 3 (+ 1) hrs Lecture (+ Exercises)/Week,
Wolfgang Jäger

Materialanalytik 2, 4 hrs Practical/Week,
Dietrich Häußler (+ et al.)

Third-Party Funds

EU, *MACAN - Merging Atomistic and Continuum Analysis of Nanometre Length-Scale Metal-Oxide Systems for Energy and Catalysis Applications,* 01.07.2009-30.06.2013 (29.158 EUR)

Further Cooperation, Consulting, and Technology Transfer

Technology-oriented collaborations with industry and external research institutes.

Continued collaboration with the Helmholtz Zentrum Geesthacht, Dept. Nanotechnology, Dr. M. Dornheim, Prof. Th. Klassen, on the application of advanced TEM methods for the development of nanomaterials for high-capacity hydrogen storage.

Continued collaboration with the Fraunhofer Institute for Solar Energy Systems ISE, Dr. F. Dimroth, Dr. A. Bett, and Prof. E. Weber, on the development of concepts for defect engineering for high-efficiency solar cells.

Collaboration with the Ernst Ruska Centre for Microscopy and Spectroscopy with Electrons, Research Centre Juelich GmbH, Prof. R. Dunin-Borkowski, Prof. J. Mayer, and Dr. L. Houben on aberration-corrected electron microscopy including EELS investigations of wafer-bonded tandem solar cells.

Further collaborations with research institutions

Continued research collaboration (started in 2008) with the Physics Department, Universidad Complutense de Madrid, Spain, Prof. Dr. J. Piqueras, Prof. Y. Ortega Villafuerte, and Dr. D. Maestre Varea on TEM characterisations of oxide semiconductor nanomaterials.

Collaborations with universities

Co-supervision (Prof. W. Jäger) of PhD theses research work at the Max-Planck-Institute for Metal Research, Stuttgart, Germany (Stuttgart Centre for Electron Microscopy, Dr. P. van Aken, Dr. W. Sigle) on TEM characterisations of plasmonic properties of metal nanoparticles.

Research collaboration with Department of Materials Science and Metallurgy, PUC-Rio Pontifícia Universidade Católica do Rio de Janeiro, Rio de Janeiro, Brazil (Professor Guillermo Solórzano) on TEM investigations of microstructure-property relationships of Cu-Co alloy and multilayer systems showing giant magnetoresistance behaviour.

Diploma, Bachelor's and Master's Theses

Marisa Hernández Pavón, *Cross-Section TEM for Bonding Concepts for GaAsP/GaAs Solar Cells on Silicium*, 31.10.2012

Laura Beines, *Korrelation zwischen den rheologischen Eigenschaften und dem sensorischen Empfinden von kosmetischen Basiscremeformulierungen. Experimental thesis work with Kuhs Cosmetics GmbH, Leichlingen Germany*, 22.10.2012

Alessandra Kummerow, *Einfluss des Härtungszyklus auf die Druckeigenschaften von Faserverbunden. Experimental thesis work with Deutsches Zentrum für Luft- und Raumfahrt eV., Braunschweig, Germany*, 30.09.2012

Cai Müller, *Materialographische Charakterisierung von potentiell magnetischen Eisen-Seltenerd-X-Diffusionssystemen. Experimental thesis work with Robert Bosch GmbH, Stuttgart, Germany*, 28.08.2012

Publications

Published in 2012

Y. Ortega, D. Häussler, J. Piqueras, P. Fernández, W. Jäger, *Complex hierarchical arrangements of stacked nanoplates in Al-doped ZnO*, Phys. Status Solidi A, **209**, 1487 - 1492 (2012)

W. Jäger, *Contribution to Report on Research and Technology Transfer 2012 Faculty of Engineering CAU Kiel / Beitrag zu Forschungs- und Transfer Bericht 2012 Technische Fakultät CAU Kiel*, Edited by: EKSH Gesellschaft für Energie- und Klimaschutz Schleswig Holstein GmbH, Kiel, Germany, www.eksh.org, (2012)

D. Häussler, B. Schaffer, F. Hofer, W. Jäger, *Quantitative STEM of Sn-Pd Nanoparticles with Core-Shell Structures,* Proc. Annual Conference of the DPG German Physical Society / DPG-Jahrestagung, Berlin, Germany, March 25 - 30, 2012, (2012)

D. Häussler, M. Kurttepeli, S. Essig, K. Derendorf, F. Dimroth, W. Jäger, *Cross-Section STEM Study of Bonding Concepts for Solar Cells,* Proc. Annual Conference of the DPG German Physical Society / DPG-Jahrestagung, Berlin, Germany, March 25 - 30, 2012, (2012)

C.-H. Fischer, Y. Fu, S. Gledhill, T. Köhler, M. Krüger, R. Sàez Araoz, M. Lux-Steiner, D. Abou-Ras, C. Dieker, W. Jäger, *Monodisperse ZnS nanodot films by Spray-ILGAR - process, growth mechanism and application for highly efficient thin film solar cells,* (Extended Abstract), Proc. Nanofair 2012 - 9TH INTERNATIONAL NANOTECHNOLOGY SYMPOSIUM - NEW IDEAS FOR INDUSTRY, Dresden, Germany, June 12 - 13, 2012, (2012)

D. Häussler, B. Schaffer, F. Hofer, W. Jäger, *Analytical STEM Investigations of Sn-Pd Nanoparticles with Core-Shell Structures,* (Extended Abstract), Proc. Nanofair 2012 - 9TH INTERNATIONAL NANOTECHNOLOGY SYMPOSIUM - NEW IDEAS FOR INDUSTRY, Dresden, Germany, June 12 - 13, 2012, (2012)

D. Häussler, U. Ross, W. Jäger, F. Hertlein, U. Heidorn, J. Wiesmann, *Nano-Scaled Aperiodic Multilayer Systems for X-ray Optics: Quantitative Layer Thickness Determination by HAADF-STEM,* (Extended Abstract), Proc. Nanofair 2012 - 9TH INTERNATIONAL NANOTECHNOLOGY SYMPOSIUM - NEW IDEAS FOR INDUSTRY, Dresden, Germany, June 12 - 13, 2012, (2012)

L. Liu, U. Hernandez, Y. Xing, N. Suguihiro, W. Jäger, D. Häussler, E. Baggio-Saitovitch, I.G. Solórzano-Naranjo, *Effect of Interface Roughness on the Superconducting Properties of Nb/Co Multilayers,* (Abstract, Topic: Defects and Microstructure Complexity in Materials), Proc. 2012 MRS Materials Research Society Fall Meeting, Boston USA, Nov. 25 - 30, 2012, (2012)

D. Häussler, U. Ross, W. Jäger, F. Hertlein, U. Heidorn, J. Wiesmann, *Quantitative HAADF STEM analyses of layer dimension and interface roughness of multilayer coatings with ultrathin layers,* EMC2012 - Vol. 1: Physical Sciences: Applications, Proc. 15th European Microscopy Congress, Sept. 16 - 21, 2012, Manchester UK, Eds. D.J. Stokes, W.M. Rainforth, ISBN 978-0-9502463-5-2, The Royal Microscopical Society 2012, 79 (2012)

D. Häussler, B. Schaffer, F. Hofer, W. Jäger, *Aberration-corrected STEM of Sn-Pd nanoparticles with core-shell structures,* EMC2012 - Vol. 1: Physical Sciences: Applications, Proc. 15th European Microscopy Congress, Sept. 16 - 21, 2012, Manchester UK, Eds. D.J. Stokes, W.M. Rainforth, ISBN 978-0-9502463-5-2, The Royal Microscopical Society 2012, 81 (2012)

D. Häussler, M. Kurttepeli, S. Essig, K. Derendorf, F. Dimroth, W. Jäger, *Cross-section STEM study of bonding concepts for solar cells,* EMC2012 - Vol. 1: Physical Sciences: Applications, Proc. 15th European Microscopy Congress, Sept. 16 - 21, 2012, Manchester UK, Eds. D.J. Stokes, W.M. Rainforth, ISBN 978-0-9502463-5-2, The Royal Microscopical Society 2012, 95 (2012)

Presentations

W. Jäger, *Transmission Electron Microscopy of Nanostructured Semiconductor Materials (Invited Lecture),* APMC10 2012 Asia-Pacific Microscopy Conference, Perth, Australia, 05.-09.02.2012

D. Häussler, M. Kurttepeli, S. Essig, K. Derendorf, F. Dimroth, W. Jäger, *Cross-section STEM study of bonding concepts for solar cells,* PICO 2012 Inauguration of the ER-C Annexe and Commissioning of the PICO Microscope and Symposium on Frontiers of Aberration Corrected Electron Microscopy, Juelich Research Centre, Jülich, Germany, 29.02.-02.03.2012

D. Häussler, U. Ross, W. Jäger, F. Hertlein, U. Heidorn, J. Wiesmann, *HAADF-STEM determination of layer dimensions and interface roughness of multilayer coatings with ultrathin layers,* PICO 2012 Inauguration of the ER-C Annexe and Commissioning of the PICO Microscope and Symposium on Frontiers of Aberration Corrected Electron Microscopy, Juelich Research Centre, Jülich, Germany, 29.02.-02.03.2012

Y. Ortega, W. Jäger, J. Piqueras, D. Häussler, P. Fernández, *Analytical STEM and in situ TEM Studies of ZnO Nanotubes*

with Sn Cores, 7th Int. Conference on High Temperature Capillarity, Eilat, Israel, 18.-22.03.2012

D. Häussler, B. Schaffer, F. Hofer, W. Jäger, *Quantitative STEM of Sn-Pd Nanoparticles with Core-Shell Structures*, Annual Conference of the DPG German Physical Society / DPG-Jahrestagung, Berlin, Germany, 25.-30.03.2012

D. Häussler, M. Kurttepeli, S. Essig, K. Derendorf, F. Dimroth, W. Jäger, *Cross-Section STEM Study of Bonding Concepts for Solar Cells*, Annual Conference of the DPG German Physical Society / DPG-Jahrestagung, Berlin, Germany, 25.-30.03.2012

D. Häussler, M. Kurttepeli, S. Essig, K. Derendorf, F. Dimroth, W. Jäger, *Cross-Section STEM Study of Bonding Concepts for Solar Cells*, E-MRS 2012 European Materials Research Society Spring Meeting, Symposium X: Quantitative Microscopy of Energy Materials, Strasbourg, France, 14.-18.05.2012

W. Jäger, *Transmission Electron Microscopy of Nanoscale Multilayer Materials*, Nanofair 2012 - 9th INT. NANOTECHNOLOGY SYMPOSIUM - NEW IDEAS FOR INDUSTRY, Dresden, Germany, 12.-13.06.2012

D. Häussler, B. Schaffer, F. Hofer, W. Jäger, *Analytical STEM Investigations of Sn-Pd Nanoparticles with Core-Shell Structures*, Nanofair 2012 - 9th INT. NANOTECHNOLOGY SYMPOSIUM - NEW IDEAS FOR INDUSTRY, Dresden, Germany, 12.-13.06.2012

D. Häussler, U. Ross, W. Jäger, F. Hertlein, U. Heidorn, J. Wiesmann, *Nano-Scaled Aperiodic Multilayer Systems for X-ray Optics: Quantitative Layer Thickness Determination by HAADF-STEM*, Nanofair 2012 - 9th INT. NANOTECHNOLOGY SYMPOSIUM - NEW IDEAS FOR INDUSTRY, Dresden, Germany, 12.-13.06.2012

W. Jäger, *Transmission Electron Microscopy of Nanoscale Multilayer Materials (Invited Lecture)*, Advanced Materials and Nanoanalysis (Joint workshop of Institute of Metallurgy and Materials Science, Polish Academy of Sciences, and Dresden Fraunhofer Cluster Nanoanalysis), Cracow, Poland, 25.-26.06.2012

W. Jäger, *Transmission Electron Microscopy for High-Efficiency Solar Cells (Plenary Lecture)*, YUCOMAT 2012 Conference, Herceg Novi, Montenegro, 03.-07.09.2012

D. Häussler, B. Schaffer, F. Hofer, W. Jäger, *Aberration-corrected STEM of Sn-Pd nanoparticles with core-shell structures*, EMC 2012 15^{th} European Microscopy Congress, Manchester, United Kingdom, 16.-21.09.2012

D. Häussler, U. Ross, W. Jäger, F. Hertlein, U. Heidorn, J. Wiesmann, *Quantitative HAADF STEM analyses of layer dimension and interface roughness of multilayer coatings with ultrathin layers*, EMC 2012 15^{th} European Microscopy Congress, Manchester, United Kingdom, 16.-21.09.2012

D. Häussler, M. Kurttepeli, S. Essig, K. Derendorf, F. Dimroth, W. Jäger, *Cross-Section STEM Study of Bonding Concepts for Solar Cells*, EMC 2012 15^{th} European Microscopy Congress, Manchester, United Kingdom, 16.-21.09.2012

W. Jäger, *Transmission Electron Microscopy of Nanoscale Multilayer Material*, MSE Department Colloquium, Materials Science and Engineering, Stanford University, Stanford, U. S. A., 05.10.2012

M. Hernández Pavón, D. Häussler, T. Roesener, F. Dimroth, W. Jäger, *Cross-section TEM for Bonding Concepts of GaAsP/GaAs Solar Cells on Silicon*, MACAN 2012 Workshop on Thermodynamics, Sabanci University, Istanbul, Turkey, 12.-15.11.2012

N.M. Suguihiro, D. Häussler, W. Jäger, E. Baggio-Saitovitch, I.G. Solórzano, *Giant Magnetoresistance in Nanostructure Controlled Melt Spun Cu-Co Alloys*, MACAN 2012 Workshop on Thermodynamics, Sabanci University, Istanbul, Turkey, 12.-15.11.2012

Further Activities and Events

Guests in 2012

Professor Robert Sinclair, Chairman, Materials Science and Engineering, Stanford University, USA, ''Electron Microscopy of Nanoparticles for Cancer Detection'', Special Colloquium of the Faculty of Engineering, 22.06.2012

Ai-Leen Koh, PhD, Stanford Nanocharacterization Laboratory, Stanford University, USA, ''Probing Plasmon Resonances in Noble Metallic Nanostructures Using Monochromated Electron Energy-Loss Spectroscopy'', Special Colloquium of the Faculty of Engineering, 22.06.2012

Professor James Wittig, Vanderbilt University, Nashville, Tennessee, USA, ''In-Situ Phase Transformation Investigations of FePt Magnetic Nanoparticles with Z-STEM Imaging'', Special Colloquium of the Faculty of Engineering, 22.06.2012

Professor Guillermo Solórzano, Natasha M. Suguihiro, M.Sc., Department of Materials Science and Metallurgy, PUC-Rio Pontifícia Universidade Católica do Rio de Janeiro, Rio de Janeiro, Brazil, ''Giant Magnetoresistance in Nanostructure Controlled Melt Spun Cu-Co Alloys'', 13.09.2012

Professor Wayne D. Kaplan, Dean, Department of Materials Science & Engineering, Technion - Israel Institute of Technology, Haifa 32000, Israel, ''Interfacial Complexions & Thermodynamic Transitions at Interfaces'', Special Colloquium of the Faculty of Engineering, 07.12.2012

Selected activities Prof. Wolfgang Jäger

E-MRS 2012 European Materials Research Society Spring Meeting, Symposium X: Quantitative Microscopy of Energy Materials, Strasbourg, France, May 14 - 18, 2012. Organisation and chairpersons: Aïcha Hessler-Wysser, EPFL Lausanne, Switzerland, Thomas Höche, Fraunhofer IWM Halle, Germany, Wolfgang Jäger, CAU Kiel, Germany, Hugo Bender, IMEC Leuven, Belgium. www.european-mrs.com

EMC 2012 15th European Microscopy Congress, Manchester UK, September 16 - 21, 2012. Physical Sciences: Applications - Session on Functional Materials. Organisation and chairpersons: Dave McComb (Columbus OH, USA), Wolfgang Jaeger (Kiel, Germany), Etienne Snoek (Toulouse, France). www.emc2012.org.uk

Offers for the general public and for schools: ''Faszination Nanokosmos - Mit Elektronen zu den Grenzen des Sichtbaren'' and ''Good vibrations - mit Elektronen Musik sehen'', SHUG Schleswig-Holsteinische Universitätsgesellschaft and CAU Programm ''Uni kommt zur Schule'' (2012).

Reviewer for research funding bodies (Germany and abroad).

Reviewer for international scientific journals.

Member of EMS Outstanding Paper Award Committee of the European Microscopy Society.

Guest-Editor (2012-2013) of Springer Journal of Materials Science.

Elected Member of Executive Committee of European Materials Research Society. Member of advisory committees, organiser and session chair for international conferences and workshops on advanced electron microscopy in materials science.

Member of EU-funded MACAN Consortium (2008 - 2013).

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Multicomponent Materials

For several years, the Chair for Multicomponent Materials headed by Prof. Franz Faupel has participated actively in three Collaborative Research Centres (SFBs) and has third party funds of about 2,5 million euro from the German Research Foundation (DFG), the BMBF (Ministry for Education and Research), the AIF (Working Group Industrial Research), and others. The achievements presented in this report would have been impossible without the contributions of the 15 PhD students, almost all of whom were supported by external sources. Concerning the scientific output, in 2012 more than 20 publications were published in peer reviewed international journals. The work of the group continues to be highly cited: in 2012, work reported by members of the group attracted more than 500 citations in the Web of Science. Here, only a few aspects of the last year's research can be discussed.

For more details we refer to our website http://www.tf.uni-kiel.de/matwis/matv/ and the papers listed below. More information on the different research topics are also given in previous Almanac editions which can be downloaded from our website.

Looking back on 2012, two very sad events have made all other things that happened far less important. In August 2012, Dr. Vladimir Zaporojtchenko, the head of the functional nanocomposites group, unexpectedly passed away with a heart attack. He was not only a great scientist, who stimulated the work of the Chair for Multicomponent Materials enormously, but also a kind friend and colleague whom one could always rely on. His memory will always be with us. Only a few days later, Dipl.-Ing. (FH) Rainer Kloth, who was in charge of our servers, software, and electronics, had a severe stroke. Meanwhile, he has made a substantial recovery and we all hope to see him back to work in the not too distant future.

As in the previous year, working in three Collaborative Research Centres, the group strongly benefited from the joint interdisciplinary work with partners ranging from fundamental physics and organic chemistry to electrical engineering and medicine. The Collaborative Research Centre SFB 677 „Function by Switching" is now almost in the middle of the second funding period that started in 2011. There, the very successful work of the last years continues with good chances for a second extension. Many new results on formation of nanoparticles in plasmas were also obtained in our joint project „Plasma Processes for the Deposition of Nanostructured Composite Materials" within the Collaborative Research Centre SFB TR 24 on complex plasmas, together with the group of Prof. Kersten from the physics department of the CAU. Judging from the interesting results and large number of high-quality publications from all the groups participating in SFB TR24, we are optimistic with respect to its evaluation in 2013. The Collaborative Research Centre SFB 855 on magneto-electric nanocomposites for medical applications is also preparing for evaluation in 2013 and can look back to a very productive 2012. Much research of the Chair for Multicomponent Materials was also performed outside the three collaborative research centres, e.g. within the DFG priority programme „Polymer-solid contacts: Interfaces and Interphases" , and several other projects. The group also performed investigations at large scale facilities, particularly at the electron storage ring BESSY in Berlin and at the positron beam facility of the Research Reactor Garching. In addition, various projects were carried out with industry. Besides direct cooperation with companies, joint work with industry was performed within projects of the BMBF.

The group was strongly involved in teaching and took great effort to inspire schoolchildren about materials science and engineering in various ways, including visits to schools in Schleswig-Holstein.

Results

a) Nanocomposites for functional applications

A main activity of our group during the last few years centres around functional nanocomposites, which consist of metallic nanoparticles embedded in an insulating matrix, either polymeric or ceramic in nature. The size of the nanoparticles is between that of atoms and macroscopic materials and thus gives rise to new properties not observed in conventional materials and which are explored in a broad range of applications ranging from high frequency magnetic materials to antimicrobial coatings. The nanocomposites are mostly deposited as thin films by vapour phase deposition methods,

Fig. 1: (left) Dr.-Ing. Björn Gojdka, the first PhD student in the Collaborative Research Centre 855 who finished with ''summa cum laude'' (excellent), (right) Dr. Vladimir Zaporojtchenko, who stimulated the work of the Chair for Multicomponent Materials enormously, and unexpectedly passed away in August 2012.

in particular evaporation and sputtering from solid targets. During the last year, plasma polymerization and physically enhanced chemical vapour deposition (PECVD) have also been employed in a joint project of the above mentioned Collaborative Research Centre TR 24. This trans-regional collaborative research centre of the universities of Greifswald and Kiel addresses fundamentals of complex plasmas and their applications to nanoscience. As part of TR 24, our group established a joint project with Prof. Kersten from the department of physics of the CAU, focusing on the use of plasma processes for the deposition of nanostructured composite materials. Very interesting results were obtained within this project. As reported in the 2011 Almanac, a gas aggregation cluster source was used to deposit metal clusters with a very narrow size distribution. These clusters were successfully embedded into a plasma polymer created by an RF plasma from Hexamethyldisiloxane (HMDSO) monomer. It was demonstrated that by using two spatially separated plasma sources for the generation of the clusters and the deposition of the matrix, the clusters are not altered by the HMDSO plasma and their filling factor in the composite can be varied over a broad range. This opens up a new path for the generation of functional nanocomposites.

The gas aggregation cluster source was also used in a joint project with Prof. Hynek Biederman from Prague University, for the generation of TiO_2 nanoparticles, which were obtained by reactive sputtering of titanium and exhibit interesting functional properties. In these investigations, a small amount of oxygen turned out to be crucial for nucleation and growth of the nanoparticles (Almanac 2011). Recently, we could show that the cluster deposition rate can be increased by more than an order of magnitude by operating the cluster source in a pulsed directed current (DC) mode (see Fig. 2). This huge increase in deposition rate is not only interesting from the application point of view but also casts new light on the fundamental mechanisms of reactive sputtering and nucleation of clusters.

Nanocomposites also play a key role in our projects within the Collaborative Research Centre SFB 677 ''Function by Switching'', which are now carried out jointly with Prof. Elbahri (see his report also) in the second funding period. Here, the nanocomposites are combined with photoswitchable molecules. These so-called chromophores change their properties

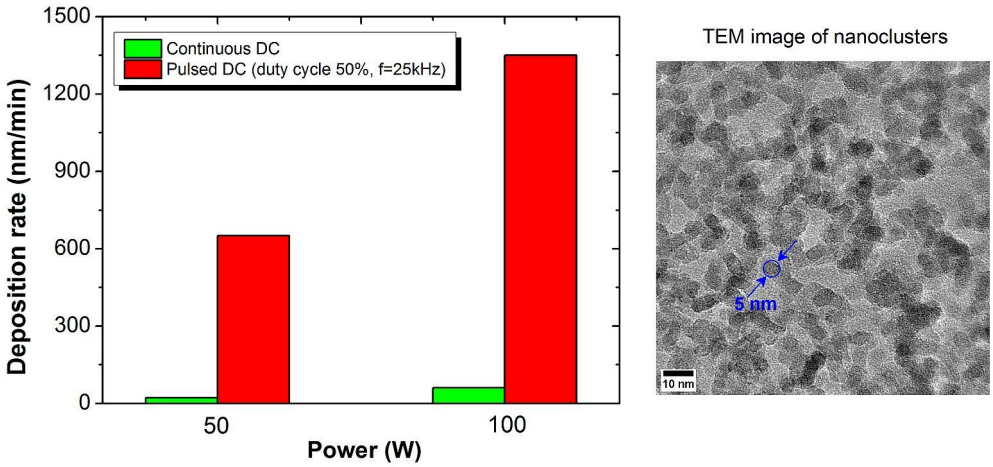


Fig. 2: (left) Comparison of the deposition rates of TiO_2 clusters generated in a gas aggregation cluster source operated in the pulsed DC reactive sputtering mode and in the DC mode. One notes a huge increase in the deposition rate for pulsed operation. (right) Transmission electron microscope image of deposited clusters.

reversibly upon irradiation with light of two different wavelengths. Very interesting new electro-optical properties arise through interactions between chromophores and the so-called surface plasmon resonance of the metallic nanoparticles. These resonances are collective oscillations of the conduction electrons in the electrical field vector of the electromagnetic radiation. Recently, new photoswitchable devices were developed which contain carbon nanotubes instead of metallic nanoparticles and allow light-induced conductivity switching. The switching mechanism is not fully understood yet but seems to be based on switchable electron transfer between the carbon nanotubes and the photoswitchable molecules such as azobenzene derivatives.

Concerning the Collaborative Research Centre SFB 855 on magneto-electric nanocomposites for medical applications, our work has shown that in this case, layered composites are much more promising than particulate composites. As reported in the 2011 Almanac, we developed a novel magnetic field sensor which was presented to a wide readership in a Nature Research Highlight. Currently, various approaches ranging from new materials, through alternative read out and operation principles, to active control are explored together with partners within SFB 855. Moreover, magnetoelectric layered composites involving piezoelectric polymers appear to show great potential.

In several projects we explore the large specific surface area of finely dispersed nanoparticles and the strong influence of the surface or interfacial energy on the material's properties. This is particularly the case in antibacterial coatings with nanoparticles of silver and other noble metals where we strive for a high metal ion release rate because the antimicrobial activity originates from the released metal ions. This research is carried out in cooperation with Prof. Podschun from the Institute of Infection Medicine of the University Hospital Schleswig-Holstein/Campus Kiel. Toxicity of nanoparticles is investigated in cooperation with PD Röhl from the Institute for Toxicology and Pharmacology for Natural Scientists of the CAU. In addition, among other partners, we cooperate with Prof. Grundmeier from the Chemistry Department of the University of Paderborn in a joint DFG project addressing fundamental issues of silver ion release from nanocomposites.

Antimicrobial nanocomposites have been studied intensively with respect to their medical applicability, for example as functional coatings for implants. For such applications understanding of the so-called therapeutic window is essential in order to achieve a therapeutic effect without inflicting undesired damage on the treated organism. In a systematic study conducted in close cooperation with PD Dr. Röhl and Prof. Podschun, much progress in the understanding of the therapeutic window in antimicrobial nanocomposites was achieved. It was found that the toxicity of silver for human cells and bacteria differs strongly for silver in solution and silver at surfaces. While in solution only a small therapeutic window exists in

which silver is sufficiently toxic to bacteria but non-toxic to human cells, the situation is much more favourable at surfaces of nanocomposite coatings containing silver. Here, as reported already in the 2011 Almanac, human cells grow essentially undisturbed up to fairly high silver loadings of the coatings and the toxicity for human cells can roughly be estimated by the measured silver release of the coating into distilled water. Bacteria, on the other hand, are already killed at fairly low silver loadings. This, at first sight, surprising observation could be understood by considering the different metabolisms of human cells and bacteria. Future work is now directed towards exploring the therapeutic window for various types of bacteria and human cells and different antibacterial surfaces. In addition, work was performed in the field of antibacterial coatings, aimed at controlling the release behaviour of nanocomposites consisting of reactively sputtered TiO_2 and silver. In this and other work carried out in the group on antibacterial coatings based on a matrix deposited by plasma-enhanced chemical vapour deposition of HMDSO, care was taken to avoid direct exposure of Ag nanoparticles to the environment. This was achieved by effective encapsulation that only releases antibacterially active silver ions but no nanoparticles.

In connection with environmental effects of Ag nanoparticles, our recent work on so-called electrochemical Ostwald ripening in aqueous solution is very interesting. Due to their high surface tension, small nanoparticles are thermodynamically less favourable than larger ones and may give rise to particle coarsening. Our investigations show that this well-known phenomenon in materials science may also take place in solution via exchange of silver ions. The effect is quite large and leads to a dissolution of the potentially more harmful smaller particles.

Reactively sputtered TiO_2 was also used in a BMBF project together with the Fraunhofer Institute Umsicht and several industrial partners for its photocatalytic properties which are here applied to water purification and waste water treatment.

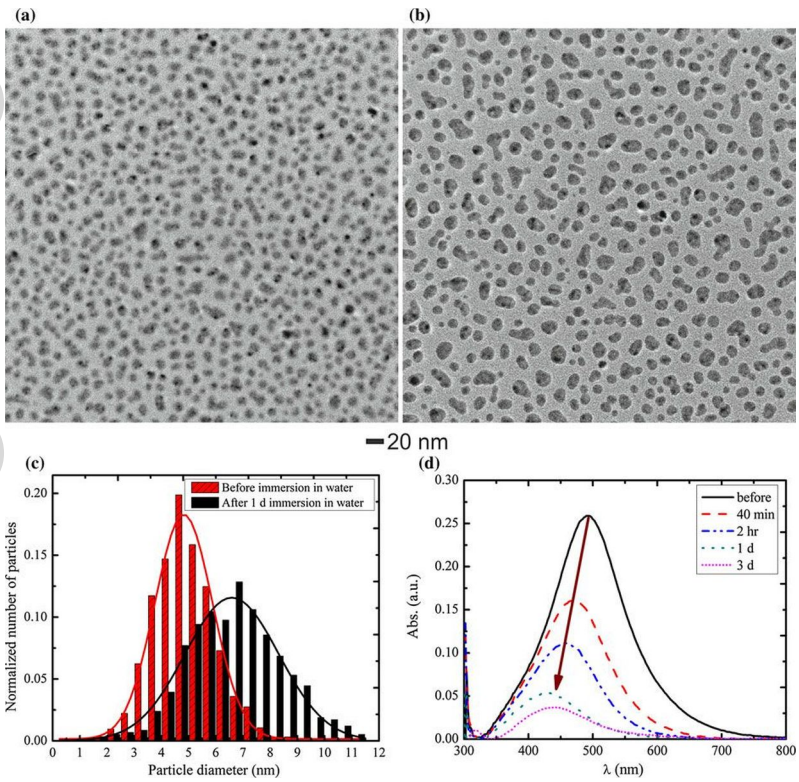


Fig. 3: Transmission electron micrographs showing the growth of Ag nanoparticles on a fluoropolymer surface before (a), and after (b) immersion in water for one day. The change in size is also seen quantitatively in the size distribution (c) and in UV-Vis spectra for different immersion times in water (d).

The group also investigates various other functional properties of nanocomposites with metallic nanoparticles and an organic or ceramic matrix. Interested readers are referred to the attached list of publications and earlier Almanac editions.

Concerning optical and plasmonic properties and so-called metamaterials, we refer to the Almanac chapter of Prof. Elbahri (see also Almanac 2011) who initiated some exciting new applications pursued together with our group.

Finally we mention that the nanoworkshop series ''Polymer-Metal-Nanocomposites'' that was initiated 2003 by Prof. Faupel in Kiel will continue in 2013 with the 6th nanoworkshop in Toulouse. With preparations being in progress Prof. Faupel has already been invited to give a plenary overview on functional nanocomposites.

b) Metallic glasses and glass forming melts

Metallic glasses are mixtures of metals and non-metals which can be employed in a vast range of applications from ultra-thin electronic housings to biodegradable implants. Although the appearance of metallic glasses resembles that of ordinary metals, their atomic structure differs completely. While the atoms in a conventional metal arrange in a periodic lattice, there is no such order in metallic glasses. This disordered state, which is similar to a frozen liquid, can be created by rapid quenching of a melt. However, only for certain mixtures of elements will the glassy state be accessible with technically reasonable cooling rates. During the last years, we investigated the diffusion behaviour, glass forming ability, and the transition from the undercooled melt to the glassy state. Details were reported in the Almanac 2010 and previous editions.

Recently, we found very interesting deviations from the Stokes-Einstein relation in glass-forming Zr-Cu-Ni-Ti-Be melts. According to the Stokes-Einstein relation, in the equilibrium melt far above the melting point all atoms are expected to participate in the Brownian motion with approximately the same mobility. In contrast, the majority component Zr, which is also the largest atom of the alloy, proved to have a much lower mobility compared to the other components. This gives important clues to the excellent glass forming ability of this (also technologically important) bulk glass forming alloy.

c) Polymer-solid contacts

Within the DFG priority programme ''Polymer-solid contacts: Interfaces and Interphases'' which was co-initiated by Prof. Faupel, we studied the structure and formation of interfaces between plastics and solid materials like metals and ceramics, which are important in many technological applications including polymer nancomposites where solid nanoparticles are embedded in a polymer matrix. We refer to the Almanac 2010, our website, and the list of publications for more information.

Personnel

Head of the group: Prof. Dr. F. Faupel; Secretary: N. Gühlke (50%), Dipl.-Chem. S. Kastaun (50%)
Technical Staff: Dipl.-Ing. (FH) R. Kloth, Techn. C. Ochmann, Dipl.-Ing. (FH) S. Rehders

Scientific Staff:

M.Sc. A. M. Ahadi Nanoparticles from plasmas	01.01.-31.12.2012	Fellowship Iran
M.Sc. N. Alissawi Ag-ion transfer	01.01.-31.12.2012	DFG
M.Sc. S. W. Basuki Diffusion in complex melts	01.01.-31.12.2012	DFG
Dipl.-Phys. B. Gojdka Magneto-electric nanocomposites	01.01.-31.12.2012	SFB 855, CAU
Dipl.-Phys. S. Harms Polymer-solid interfaces	01.01.-31.03.2012	DFG SSP 1369

M.Sc. B. Henkel Functional nanocomposites	01.01.-31.12.2012	BMBF
M. Sc. M. Keshavarz Hedayati Optical nanocomposites	01.01.-31.12.2012	CAU, with Prof. Elbahri
M.Sc. T. Koschine Positron beam, polymers	01.01.-31.12.2012	BMBF
Dr. A. Kulkarni Magneto-electric nanocomposites	01.01.-31.12.2012	SFB 855, CAU
Dipl.-Ing. K. Meurisch Magneto-electric nanocomposites	01.01.-21.02.2012	CAU, SFB 855
M.Sc. C. Ohrt Polymer-Solid-Interphases	01.08.-31.12.2012	DFG SPP 1369
Dipl.-Phys. T. Peter Nanoparticles from plasmas	01.01.-31.12.2012	SFB TR24
Dr. O. Polonsky Nanoparticles from plasmas	01.11.-31.12.2012	SFB TR24, visiting scientist
Prof. Dr. K. Rätzke Supercooled melts, positron annihilation	01.01.-31.12.2012	CAU
Dipl.-Phys. V. Schneider Photoswitchable nanocomposites	01.01.-31.12.2012	SFB 677
M.Sc. Y. M. Sisay Carbon Nanotubes	01.05.-31.07.2012	SFB 677 IGK
Dr. T. Strunskus Functional nanocomposites	01.01.-31.12.2012	SFB 855
M.Sc. J. Xiong Functional nanocomposites	01.01.-31.12.2012	Fellowship China
Dr. V. Zaporojtchenko † Functional nanocomposites	01.01.-31.08.2012	CAU

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

Einführung in die Vakuumtechnik, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
V. Zaporojtchenko †

Advanced Organic Materials, 2 hrs Seminar/Week,
F. Faupel

Übungen zur Physik I, 2 hrs Seminar/Week,
K. Rätzke

Thin Films, 4 (+ 1) hrs Lecture (+ Exercises)/Week,

K. Rätzke (+ T. Peter)

Einführung in die Materialwissenschaft 1, 2 hrs Lecture/Week,
K. Rätzke (+ O. Riemenschneider)

Werkstoffe - Metalle, 2 hrs Lecture/Week,
F. Faupel

Solid State Physics 1, 2 hrs Lecture/Week,
F. Faupel

Vakuum Technology, 2 (+1) hrs Lecture (+ Exercises)/Week,
V. Zaporojtchenko †

Seminar for Members Group for Nanocomposites, 2 hrs Seminar/Week,
V. Zaporojtchenko †

Seminar for Members Group of Rätzke, 2 hrs Seminar/Week,
K. Rätzke

Seminar for Members of the Chair for Multicomponent Materials, 2 hrs Seminar/Week,
F. Faupel

Summer 2012

Einführung in die Materialwissenschaft II, 2 hrs Lecture/Week,
K. Rätzke (+ O. Riemenschneider)

Advanced Metallic Materials, 2 hrs Seminar/Week,
F. Faupel

Functional Nanomaterials / Functional Nanocomposites, 2 hrs Seminar/Week,
V. Zaporojtchenko †

Seminar for Members of the Chair for Multicomponent Materials and interested guests, 2 hrs Seminar/Week,
F. Faupel

Übungen zur Physik II, 2 hrs Exercise/Week,
K. Rätzke

Seminar for Members Group of Rätzke, 2 hrs Seminar/Week,
K. Rätzke

Seminar for Members Group for Nanocomposites, 2 hrs Seminar/Week,
V. Zaporojtchenko †

Solid State Physics 2, 2 (+1) hrs Lecture (+ Exercises)/Week,
F. Faupel

Winter 2012/2013

Advanced Organic Materials, 2 hrs Seminar/Week,
F. Faupel

Übungen zur Physik I, 2 hrs Seminar/Week,
K. Rätzke

Thin Films, 4 (+1) hrs Lecture (+ Exercises)/Week,
K. Rätzke (+ V. Schneider)

Einführung in die Materialwissenschaft 1, 2 hrs Lecture/Week,
K. Rätzke (+ O. Riemenschneider)

Werkstoffe - Metalle, 2 hrs Lecture/Week,
F. Faupel

Solid State Physics 1, 2 (+1) hrs Lecture (+ Exercises)/Week,
F. Faupel

Advanced Materials A - Polymers, 2 (+1) hrs Lecture (+ Exercises)/Week,
F. Faupel

Seminar for Members Group of Rätzke, 2 hrs Seminar/Week,
K. Rätzke

Seminar for Members of the Chair for Multicomponent Materials, 2 hrs Seminar/Week,
F. Faupel

Third-Party Funds

DFG, SFB TR24, *Fundamentals of Complex Plasmas: Plasma processes for the deposition of nanostructured composite materials,* 01.07.2009-30.06.2013 (287.603 Euro)
DFG SFB 855, *Magnetoelectric Composites - Future Biomagnetic Interfaces: Gasphasenabscheidung von magnetoelektrischen 0-3 Nanokompositen,* 01.01.2010-31.12.2013 (635.280 Euro)
DFG, *Ion transfer reactions at Ag-nanoparticle/polymer interfaces,* 17.02.2010-31.12.2013 (190.424 Euro)
BMBF, *Development of advanced materials and methods for water and sewage treatment by means of functional nanocomposites,* 01.05.2010-30.04.2013 (221.004 Euro)
BMBF, *Verbundprojekt POSIMETHOD: Teilprojekt 5: ''Charakterisierung nanoskopischer Leerstellen in dünnen Polymerfilmen mittels Positronenlebensdauerspektroskopie'',* 01.07.2010-30.06.2013 (213.300 Euro)
China Scholarship Council, *Stipendium für Jian Xiong für 4 Jahre,* 15.11.2010-15.11.2014 (48.000 Euro)
Iran Government, *Stipendium für Amir Mohammad Ahadi für 3 Jahre,* 25.11.2010-25.03.2014 (45.000 Euro)
DFG, *Polymer-Solid contacts: Interfaces and Interphases: Verteilung des freien Volumens an Polymer-Festkörper Grenzflächen,* 25.02.2011-25.02.2014 (257.800 Euro)
DFG, *Structural Arrest in Multicomponent Glass-forming Zr-melts,* 06.04.2011-06.04.2014 (278.450 Euro)
DFG SFB 677/2, *Function by Switching: Photoswitchable Metal-Polymer Nanocomposites,* 01.07.2011-30.06.2015 (363.220 Euro)
DFG SFB 677/2 IGK, *Function by Switching: Intrgriertes Grauiertenkolleg Ziele: Untersuchungen zum Schalten der elektrischen Leitfähigkeit mit Multiwall Carbon Nanotubes (MCNT) im Projekt C01,* 01.05.-31.07.2012 (4.407 Euro)

Further Cooperation, Consulting, and Technology Transfer

University:

Prof. M. Bauer, F. Tuczek, O. Magnussen, Prof. W. Herges: Combination of switchable molecules and nanocomposites close to the percolation threshold (SFB „Function by Switching")

Dr. U. Boucher, Spain, Ageing of Nanocomposites

Dr. Peter Budd, Manchester School of Chemistry, The University of Manchester, Manchester UK, Polymer Membranes

Prof. Dr. A. Chandra, Dehli, India, Conductance and free volume in polymer electrolyte composites

Prof. Dr. G.Dollinger, Dr. W. Egger, Bundeswehr University, Munich, PLEPS at FRM II

Prof. Drusch, Food Processing Technologie and Materials Science, TU Berlin, Encapsulation of food products

Prof. Dr. M. Elbahri, Institute for Material Science: several topics with hybrid organic/inorganic materials

Prof. Dr. M. Es-Souni, FH Kiel, Characterisation of Functional Materials

Prof. Dr. G. Grundmeier, Paderborn University, Silver Release from Nanocomposites

Prof. Dr. H. Herges, Organic Chemistry, Prof. Dr. F. Tuczek, Inorganic Chemistry, Kiel University, and other partners, NEXAFS investigations at BESSY, HZB Berlin

Dr. Chr. Hugenschmidt, TU Munich and FRM II, NEPOMUC

Dr. S. James, Belfast, Porous Liquids

Prof. Dr. C. Janiak, University Düsseldorf, Mixed Matrix Membranes

Prof. Dr. M. Kern, Dental Clinic, Kiel University, Antibacterial Coatings

Prof. R. Knöchel, Institute for Electrical Engineering and Information Technology, magnetic high frequency materials

Prof. Dr. P. Müller-Buschbaum, Technical University Munich, PALS on Thin Films and preparation of DFG proposal "Growth of sputtered metal on organic surfaces" with Dr. S. Roth (DESY)

Prof. Dr. R. Podschun, Institute for Infection Medicine, Kiel University, Antibacterial Coatings

Prof. Dr. E. Quandt, Inorganic Functional Materials, Faculty of Engineering, Functional nanocomposites

PD Dr. C. Röhl, Prof. Dr. J. Sievers, Institute for Toxicology and Pharmacology for Natural Scientists, Toxilogical effects of metallic nanoparticles on human cells

Prof. Dr. C. Staudt, Düsseldorf, Block copolymers

Prof. Dr. Y. Yampolskii, A.V. Topchiev Institute of Petrochemical Synthesis, Laboratory of Membrane Gas Separation, Russian Academy of Sciences, Moscow, Positron annihilation and membrane polymers

Research Institutes:

Dr. D. K. Avasthi, Materials Science Group, Nuclear Science Centre New Delhi, India, High energy ion beam effects in polymer-metal nanocomposites

Prof. Dr. A. Meyer, Dr. Fan Yang, DLR, Köln, Diffusion in glass forming metallic melts

Dr. Thomas Neubert and Dr. Michael Vergöhl , Fraunhofer-Institute for Surface Engineering and Thin Films (IST), Braunschweig, Photocatalytically active TiO_2 coatings

Dr. G. Schneider, FRZ Jülich und FRM II, silica nanocomposites

Industry:

KHS Plasmax GmbH, Coatings on PET samples

Partners in BMBF project Nanopurification:

Fraunhofer Institute for Environmental, Safety and Energy Technology (UMSICHT), Oberhausen

Enviro Chemie GmbH, Roßdorf

Kryschi Wasserhygiene, Kaarst

Cornelsen Umwelttechnologie GmbH, Essen

Gelsenwasser AG, Gelsenkirchen

Ferdinand Braun-Institut, Berlin

Diploma, Bachelor's and Master's Theses

T. Eckert, *Untersuchung der Silberionenfreisetzung aus Silber-Gold-Nanopartikeln auf PTFE,* 07.02.2012

A. Kittmann, *Herstellung des Glasscheibenverbundes für das 'Pressure tight Bridge Display',* 12.09.2012

E. Gill, *Identifikation und Charakterisierung potentieller Verschleißstellen an der variablen Turbinengeometrie und Verstellmechanismus verschiedener Diesel-Abgasturbolader,* 15.09.2012

L. Birk, *Grundlagenuntersuchung Magnesium-Hohlprofile für den Polymere-Metall-Hybrid Leichtbau im IHU Spritzgussverfahren Verformung von stranggepressten Magnesiumknetlegierungen im Vergleich zur Aluminiumknetlegierung AW 6060,* 19.10.2012

H. Lewitz, *Optimization of Piezoelectric Properties of P(VDF-TrFE) Copolymer Thin Films for Application in Magnetoelectric Sensors,* 19.10.2012

M. Wegner, *Entwicklung eines Prozesses zur seriellen Herstellung von Bauteilen aus Rotgold über die pulvermetallurgische Route,* 30.10.2012

L. Kahle, *Optimizing Interface Properties in Polymer-Based Magnetoelectric Composites,* 16.11.2012

N. Karow, *Oberflächenbeschichtung für eine Kryosonde, die für die minimalinvasive Kryochirurgie und Kryoanalgesie zum Einsatz kommt,* 07.12.2012

R. Sieg, *Free volume and physical ageing in polystyrene gold-nanocomposites (by positron annihilation lifetime spectroscopy),* 19.12.2012

M. Steffens, *Elektrische und dielektrische Eigenschaften von TiO_2-Ag-Nanokompositen,* 21.12.2012

Dissertations / Postdoctoral Lecture Qualifications

S. Harms, *Freies Volumen an Polymer-Dünnschichten, Polymer-Festkörper-Grenzflächen und Polymer-Nanokompositen,* 06.03.2012

A. Kulkarni, *Magnetic Nanocomposites,* 16.04.2012

B. Gojdka, *New concepts for Functional 0-3 Nanocomposites and Magnetic Field Sensors,* 28.11.2012

Publications

Published in 2012

K. Meurisch, B. Gojdka, T. Strunskus, V. Zaporojtchenko †, F. Faupel, *Vapour phase deposition of highly crystalline self-poled piezoelectric nylon-11,* Journal of Physics D: Applied Physics, **Vol. 45 (5)**, 055304 (2012)

H. T. Beyene, V. S. K. Chakravadhanula, C. Hanisch, T. Strunskus, V. Zaporojtchenko †, M. Elbahri, F. Faupel, *Vapour Phase Deposition, Structure, and Plasmonic Properties of Polymer-Based Composites Containing Ag-Cu Bimetallic Nanoparticles,* Plasmonics, **Vol. 7 (1)**, 107 - 114 (2012)

A. Biswas, I. Bayer, A. Biris, T. Wang, E. Dervishi, F. Faupel, *Advances in Top-Down and Bottom-Up Nanofabrication Techniques: Applications and Future Prospects,* Advances in Colloid and Interface Science, **Vol 170, Issue 1-2**, 2 - 27 (2012)

T. Hasegawa, T. Strunskus, V. Zaporojtchenko †, F. Faupel, M. Mizuhata, *Preparation of Silver Nanoparticles-Nafion Membrane Composite by Photoreduction Process,* ESC Translations - Boston, MA, Vol. 41, Nanotechnology (General) - 220th ECS Meeting, **41**, (2012)

K. Yliniemi, B. Oskaya, N. Alissawi, V. Zaporojtchenko †, T. Strunskus, B. P. Wilson, F. Faupel, G. Grundmeier, *Combined in situ electrochemical impedance spectroscopy - UV/Vis and AFM studies of Ag nanoparticle stability in perfluorinated films,* Materials Chemistry and Physics, **134 (1)**, 302 - 308 (2012)

B. Gojdka, V. Zaporojtchenko †, V. Hrkac, J. Xiong, L. Kienle, T. Strunskus, F. Faupel, *Highly versatile concept for precise tailoring of nanogranular composites with a gas aggregation cluster source,* Applied Physics Letters, **Vol. 100 (13)**, 133104 (2012)

N. Alissawi, V. Zaporojtchenko †, T. Strunskus, T. Hrkac, I. Kocabas, B. Erkartal, V. S. K. Chakravadhanula, L. Kienle, G. Grundmeier, D. Garbe-Schönberg, F. Faupel, *Tuning of the ion release properties of silver nanoparticles buried under a hydrophobic polymer barrier,* Journal of Nanoparticle Research, **Vol. 14 (7)**, 928 (2012)

K. Rätzke, F. Faupel, *Free volume and positron annihilation in polymers and polymer electrolytes,* Electroactive Polymers, Materials and Devices, Volume IV, Macmillan Publishers, Dehli, India, eds. S. A. Hashmi, A. Chandra, R.K. Singh, A. Chandra, series editor S. Chandra, 81 - 83 (2012)

S. Harms, K. Rätzke, F. Faupel, N. Chaukura, P. M. Budd, W. Egger, L. Ravelli, *Ageing and Free Volume in a Polymer of Intrinsic Microporosity (PIM-1),* The Journal of adhesion, **88**, 608 - 619 (2012)

A. Kulkarni, B. Henkel, C. Bechtold, V. Zaporojtchenko †, T. Strunskus, E. Quandt, F. Faupel, *Monitoring magnetostriction by a quantum tunnelling strain sensor,* Sensors and Actuators A, **183**, 28 - 33 (2012)

B. Gojdka, V. Hrkac, J. Xiong, M. Gerken, L. Kienle, T. Strunskus, V. Zaporojtchenko †, F. Faupel, *A critical evaluation of the 0-3 approach for magnetoelectric nanocomposites with metallic nanoparticles,* Journal of Applied Physics, **Vol. 112 (4)**, 044303 (2012)

K. L. Kolipaka, V. Brueser, R. Schlueter, A. Quade, J. Schaefer, H. Wulff, T. Strunskus, F. Faupel, *Simple method of hybrid PVD/PECVD to prepare well dispersed cobalt-plasma polymerized hexamethyldisilazane nanocomposites,* Surface and Coatings Technology, **207**, 565 - 570 (2012)

M. Ganeva, T. Peter, S. Bornhold, H. Kersten, T. Strunskus, V. Zaporojtchenko †, F. Faupel, R. Hippler, *Mass Spectrometric Investigations of Nano-Size Cluster Ions Produced by High Pressure Magnetron Sputtering,* Contributions to Plasma Physics, **Vol. 52, Issue 10**, 881 - 889 (2012)

M. Bonitz, L. Rosenthal, K. Fujioka, V. Zaporojtchenko †, F. Faupel, H. Kersten, *Towards a particle based simulation of complex plasma driven nanocomposite formation,* Contributions to Plasma Physics, **Vol. 52, Issue 10**, 890 - 898 (2012)

M. K. Hedayati, F. Faupel, M. Elbahri, *Tunable broadband plasmonic perfect absorber at visible frequencies,* Applied Physics A, **Vol. 109, Issue 4**, 769 - 773 (2012)

N. Alissawi, L. Kienle, V. S. K. Chakravadhanula, I. Kocabas, D. Garbe-Schönberg, T. Strunskus, V. Zaporojtchenko †, F. Faupel, *Effect of gold alloying on stability of silver nanoparticles and control of silver ion release from vapour-deposited Ag-Au/polytetrafluoroethylene nanocomposites,* Gold Bulletin, **Online, DOI: 10.1007/s13404-01**, (2012)

T. Peter, O. Polonskyi, B. Gojdka, A. M. Ahadi, T. Strunskus, V. Zaporojtchenko †, H. Biedermann, F. Faupel, *Influence of reactive gas admixture on transition metal cluster nucleation in a gas aggregation cluster source,* Journal of Applied Physics, **Vol. 112, Issue 11**, 114321 (2012)

P. Diwan, S. Harms, K. Rätzke, A. Chandra, *Polymer electrolyte-graphene composites: conductivity peaks and reasons thereof,* Solid State Ionics, **217**, 13 - 18 (2012)

S. Drusch, Y. Serfert, A. Berger, M.Q. Shaikh, K. Rätzke, V. Zaporojtchenko †, K. Schwarz, *New insights into the macroencapsulation properties of sodium caseinate and hydrolysed casein,* Food Hydrocolloids, **27**, 332 - 338 (2012)

S. M. Matson, K. Rätzke, M. Q. Shaikh, E. G. Litvinova, S. M. Shishatskiy, K.-V. Peinemann, V. S. Khotimskiy, *Macrochain Configuration, Structure of Free Volume and Transport Properties of Poly (1-Trimethylsilyl-1-Propyne) and Poly (1-Trimethylgermyl-1-Propyne),* Polymer Science A, **Vol. 54, Issue 8**, 671 - 677 (2012)

V. S. K. Chakravadhanula, C. Kübel, T. Hrkac, V. Zaporojtchenko †, T. Strunskus, F. Faupel, L. Kienle, *Surface segregation in TiO_2-based nanocomposite thin films,* Nanotechnology, **Vol. 23, Issue 49**, 495701 (2012)

E. Kovacevic, J. Berndt, T. Strunskus, L. Boufendi, *Size dependent characteristics of plasma synthesized carbonaceous nanoparticles,* Journal of Applied Physics, **Vol. 112, Issue 1**, 013303 (2012)

Patent Applications

M. Elbahri, M. Keshavarz Hedayati, F. Faupel, T. Strunskus, V. Zaporojtchenko, V. S. K. Chakravadhanula, *Metal composite coating having high optical transmissivity in the visual spectrum*, German Patent and Trade Mark Office (GTPO), 19.01.2012, DE 10 2010 050 110 B3

M. Elbahri, F. Faupel, R. Adelung, K. Hirmas, *Method for the production of a nanostructure by means of spinodal decrosslinking*, European Patent Office (EPO), 04.04.2012, EP 2 206 153 B1

M. Elbahri, M. Keshavarz Hedayati, F. Faupel, T. Strunskus, V. Zaporojtchenko, V. S. K. Chakravadhanula, *Metal composite coating having high optical transmissivity in the visual spectrum*, World Intellectual Property Organization (WIPO), 03.05.2012, WO 2012/055397 A1

Presentations

T. Strunskus, *XPS and NEXAFS investigation of functionalized TATA molecules on Au(111) surfaces (Talk)*, Mitarbeiterseminar AG Magnussen (Institut für Angewandte und Experimentalphysik, CAU Kiel), Kiel, Germany, 13.01.2012

H. Kersten, C. Bornholdt, P. Sadler, T. Peter, M. Fröhlich, T. Strunskus, V. Zaporojtchenko †, F. Faupel, *Examples for related plasma diagnostics during nano-particle formation (Invited Talk)*, Third International Symposium on Plasma Nanoscience (iPlasmaNano-III), Signapur, India, 26.02.-01.03.2012

F. Faupel, *Curing and ageing of adhesives studied by positron annihilation lifetime spectroscopy (Plenary Talk)*, 35th Adhesion Society Annual Meeting and Expo, New Orleans, United States of America, 26.-29.02.2012

C. Ohrt, *Investigation of interphases and mixing rules of o-Ps lifetimes in polymer-nanocomposites (Talk)*, Treffen deutscher Positronengruppen, Dresden, Germany, 28.02.-01.03.2012

S. Harms, K. Rätzke, F. Faupel, B. Löwe, W. Egger, *Positronen-Implantation in Polymer/Festkörper-Schichtsysteme - PALS-Strahlmessungen und Simulationen (Talk)*, Treffen deutscher Positronengruppen, Dresden, Germany, 28.02.-01.03.2012

T. Koschine, S. Harms, C. Ohrt, K. Rätzke, F. Faupel, B. Löwe, L. Ravelli, U. Ackermann, W. Egger, *Entwicklungen am gepulsten Positronenstrahlsystem in München an ausgewählten Beispielen*, Treffen deutscher Positronengruppen, Dresden, Germany, 28.02.-01.03.2012

B. Henkel, T. Strunskus, V. Zaporojtchenko †, F. Faupel, *Reaktiv gesputterte photokatalytisch aktive Titandioxidschichten für die Wasseraufbereitung (Poster)*, Clustertreffen der BMBF-Fördermaßnahme NanoCare und NanoNature, Frankfurt / Main, Germany, 13.-14.03.2012

F. Faupel, *Plasma based deposition of functional nanocomposites (Invited Talk)*, DPG Frühjahrstagung der Sektion AMOP (SAMOP) (2012), Stuttgart, Germany, 15.-16.03.2012

C. Röhl, T. Hrkac, R. Podschun, V. Zaporojtchenko †, T. Strunskus, H. Papavlassopoulos, D. Garbe-Schönberg, F. Faupel, *Differential pro- and eukaryotic toxicity of silver released from nanocomposite surfaces increases the therapeutic window of silver in antibacterial treatments (Talk)*, DGPT (Deutschen Gesellschaft für Experimentelle und Klinische Pharmakologie und Toxikologie) Jahrestagung 2012, Dresden, Germany, 19.-22.03.2012

B. Henkel, T. Strunskus, V. Zaporojtchenko †, S. Rehders, F. Faupel, *Pulsed DC Magnetron Sputtered TiO_2 Layers Optimized for Photocatalytic Efficiency (Poster)*, DPG-Frühjahrstagung der Sektion Kondensierte Materie (SKM) 2012, Berlin, Germany, 25.-30.03.2012

C. Ohrt, T. Koschine, S. Harms, K. Rätzke, F. Faupel, *Investigation of interphases in polyethylenpropylene(PEP)-silsesquioxane-nanocomposites by positron annihilation lifetime spectroscopy (Poster)*, DPG-Frühjahrstagung der Sektion Kondensierte Materie (SKM) 2012, Berlin, Germany, 25.-30.03.2012

B. Gojdka, V. Zaporojtchenko †, T. Strunskus, T. Hrkac, J. Xiong, L. Kienle, F. Faupel, *New deposition concept for the precise tailoring of nanocomposites with a gas aggregation cluster source (Poster)*, DPG-Frühjahrstagung der Sektion Kondensierte Materie (SKM) 2012, Berlin, Germany, 25.-30.03.2012

T. Peter, S. Bornholdt, T. Strunskus, V. Zaporojtchenko †, H. Kersten, F. Faupel, *Gas phase aggregation cluster source for composite material deposition (Poster)*, DPG-Frühjahrstagung der Sektion Kondensierte Materie (SKM) 2012, Berlin, Germany, 25.-30.03.2012

K. Rätzke, M. Shaikh, J. Gaukler, W. Possart, F. Faupel, *Reactive epoxies with functional zeolite fillers: IR spectroscopy and PALS studies (Talk)*, DPG-Frühjahrstagung der Sektion Kondensierte Materie (SKM) 2012, Berlin, Germany, 25.-30.03.2012

C. Ohrt, T. Koschine, S. Harms, K. Rätzke, F. Faupel, G. Schneider, L. Willner, D. Richter, *Investigation of interphases in polyethylenepropylene (PEP)-silsesquioxane-nanocomposites by positron annihilation lifetime spectroscopy (Poster)*, 4 Jahrestreffen SPP 1369, Frankfurt / Main, Germany, 01.06.2012

F. Faupel, V. Zaporojtchenko †, T. Strunskus, M. Elbahri, *Polymer nanocomposites for functional applications (Invited Talk)*, 4th International conference smart materials strucures systems (CIMTEC 2012), Montecatini Terme, Tuscany, Italy, 10.-14.06.2012

V. Zaporojtchenko †, *Functional Metal-Dielectric Nanocomposite Films Prepared by Integration of a Gas Aggregation Cluster Source into a Plasma Deposition Process (Talk)*, The International Conference ISMANAM 2012, Moskau, Russia, 17.-22.06.2012

N. Alissawi, V. Zaporojtchenko †, T. Strunskus, F. Faupel, *Tuning of silver ion release properties of silver-polymer nanocomposites (Poster)*, Junior Euromat 2012, Lausanne, Switzerland, 23.-27.07.2012

F. Faupel, *Vapour phase deposition and functional properties of nanocomposite materials (Invited Talk)*, 3rd Graduate Summer Institute, South Orange, United States of America, 30.07.-03.08.2012

T. Strunskus, *Introduction to X-ray Photoelectron Spectroscopy (Talk)*, Summer school at IGK of SFB 677, Ratzeburg, Germany, 09.-10.08.2012

F. Faupel, *Neue Werkstoffe durch Nanotechnologie (Invited Talk)*, 6. Science Summer School Itzehoe, Itzehoe, Germany, 13.08.2012

K. Rätzke, S. Harms, T. Koschine, C. Ohrt, F. Faupel, W. Egger, L. Ravelli, P. Budd, *Free volume in thin polymer films and at polymer-solid interfaces (Invited Talk)*, 16th International Conference on Positron Annihilation (ICPA-16), Bristol, UK, 19.-24.08.2012

T. Koschine, S. Harms, K. Rätzke, F. Faupel, R. Konietzny, C. Staudt, *Free Volume in a polymer membrane-nanoparticle system (Poster)*, 16th International Conference on Positron Annihilation (ICPA-16), Bristol, UK, 19.-24.08.2012

T. Strunskus, *Near edge x-ray absorption fine structure as a tool for the characterization of nanoparticles obtained from dusty plasmas (Talk)*, 3rd Workshop on Diagnostic and Simulation of Dusty Plasmas (DSDP), CAU Kiel, Kiel, Germany, 26.-28.08.2012

M. Ganeva, T. Peter, S. Bornholdt, M. Fröhlich, H. Kersten, T. Strunskus, V. Zaporojtchenko †, F. Faupel, R. Hippler, *Influence of He:Ar ratio on the size distribution of cluster ionsproducedby high pressure magnetron sputtering (Poster)*, 13th International Conference on Plasma Surface Engineering (PSE 2012), Garmisch-Patenkirchen, Germany, 10.-14.09.2012

F. Faupel, *Dynamic arrest in multicomponent glass forming alloys (Invited Talk)*, International Conference on the Physics of None-Crytalline Solids (XIII PNCS), Yichang, Hubei, China, 16.-20.09.2012

F. Faupel, *Nanocomposites for Functional Applications (Invited Talk)*, Besuch Prof. Zhang, South China University, Guangzhou, China, 21.09.2012

B. Gojdka, R. Jahns, K. Meurisch, H. Grewe, R. Adelung, R. Knöchel, F. Faupel, *Fully Integrable Magnetic Field Sensor Based on Delta-E Effect (Talk)*, Materials Science Engineering (MSE 2012), Darmstadt, Germany, 25.-27.09.2012

V. Hrkac, Y.K. Mishra, S. Kaps, E. Lage, D. Meyners, B. Gojdka, S. Marauska, A. Petrau, H. Kohlstedt, B. Wagner, F. Faupel, E. Quandt, R. Adelung, L. Kienle, *TEM investigations on materials for biomagnetic sensing (Poster)*, Materials Science Engineering (MSE 2012), Darmstadt, Germany, 25.-27.09.2012

T. Strunskus, T. Peter, V. Zaporojtchenko †, A. Ahadi, B. Gojdka, J. Zabel, B. Henkel, O. Polonsky, H. Biederman, F. Faupel, *Formation of Nanoparticles for Deposition of Thin Film Coatings from a Gas Aggregation Cluster Source (Keynote Lecture)*, Materials Science Engineering (MSE 2012), Darmstadt, Germany, 25.-27.09.2012

T. Hrkac, T. Strunskus, V. Zaporojtchenko †, C. Röhl, R. Podschun, J. Xiong, H. Papavlassopoulos, D. Garbe-Schönberg, F. Faupel, *Enhancement of the therapeutic windows at the surface of silver/titania nanocomposite coatings (Poster)*, DGBM (Deutsche Gesellschaft für Biomaterialien) Jahrestagung, Hamburg, Germany, 01.-03.11.2012

F. Faupel, V. Zaporojtchenko †, T. Strunskus, *Polymer Nanocomposites for functional Applications (Invited Plenary Talk)*, Fifth International Conference on Electroactive Polymers: Materials and Devices (ICEP-2012), Varanasi, India, 04.-08.11.2012

F. Faupel, K. Rätzke, *Dynamic arrest in mulicomponent glass forming alloys (Talk)*, Deutsch-Sino Workshop, Köln, Germany, 05.-09.11.2012

S. W. Basuki, K. Rätzke, F. Faupel, F. Yang, A. Meyer, *^{57}Co and ^{95}Zr diffusion in liquid $Zr_{46.75}Be_{27.5}Ti_{8.25}Cu_{7.5}Ni_{10}$ (Talk)*, Deutsch-Sino Workshop, Köln, Germany, 05.-09.11.2012

F. Faupel, V. Zaporojtchenko †, T. Strunskus, *Polymer Nanocomposites for functional Applications (Invited Talk)*, Nuclear Science Center Delhi, Dehli, India, 09.11.2012

F. Faupel, *Thermodynamics, Solid State Reactions, and Stresses in Thin Films with Relevance for Microelectronics (Invited Talk)*, Fa. NXP Semiconductors, Hamburg, Germany, 15.-16.11.2012

F. Faupel, V. Zaporojtchenko †, T. Strunskus, *Nanocomposites for functional applications (Invited Plenary Talk)*, Composites International Forum 2012, Luxembourg, Luxembourg, 06.12.2012

K. Rätzke, F. Faupel, *Free Volume and Positron Annihilation in Polymers: Selected Examples (Talk)*, Kolloquium Universität Düsseldorf, Düsseldorf, Germany, 20.12.2012

Further Activities and Events

Selected Honorary Activities of Prof. Faupel:

Coordinator of the *North German Initiative Nanomaterials (NINa)*,

Principle Editor of the *Journal of Materials Research, edited by the Materials Research Society* (MRS),

Editor of the *encyclopaedia RÖMPP online, Thieme Chemistry*,

Member of the Advisory Board of *Diffusion and Defect Data*,

Member of the DGM Scientific Advisory Board, *German Material Research Society*,

Member of the Minerva-Weizmann Committee of the Max-Planck Society,

Member of the Programme Committee of the conference ''Euro Intelligent Materials 2013'' (DGM), Kiel 2013,

Member of the Programme Committee of the DFG SPP 1369 Priority Programme *''Polymer-Solid Interfaces, Thin Films, and Interphases - from Molecular View to Continuum''*,

Member of the managing committee of the SFB855 ''Magnetoelectric Composites - Future Biomagnetic Interfaces'',

Member of the *Societas Christiana Albertina*,

Member of the HWT (Hochschule-Wirtschaft-Transfer)-Jury of the ISH (Innovation Foundation Schleswig-Holstein),

Member of the management board of the ''Friends of the Faculty of Engineering'',

Member of the International Advisory Committee of the 5th International Conference on Electroactive Polymers: Materials and Devices (ICEP-2012),

Member of the Programme Committee of the International Conference Polymer Interphases in Research and Technology, Frankfurt (2013),

In addition to the activities listed above, Prof. Faupel was involved in many evaluations for the German Science Foundation (DFG), scientific journals, and other Institutions in Germany and abroad.

Nanochemistry and Nanoengineering

Nanochemistry and Nanoengineering is based in the Material Science Institute of the engineering faculty of the Christian Albrecht University of Kiel as well as the Institute of Polymer Research at HZG/Geesthacht, a division of the Helmholtz Association. ''Nanomaterials for energy and environment'' is a highly active research area in our group. The research of the group encompasses design and development of novel advanced nanomaterials and nanocomposites for industrial applications. The potential application domains include Membrane Technology, Functional Coatings, Plasmonics, Bionanoengineering, and Smart Materials. Bridging the gaps between several disciplines (chemistry, physics, bioscience, and materials science), the group took an important step toward the intra-disciplinarity of nanoscience. In 2012, we developed new concepts for water filtration and purification using electrospun nanofibres. In addition, ''Plasmonic Bionanocomposites'' as a novel concept of smart materials has been developed by us. In this research we bridged the gap between filtration, bioscience and plasmonics. The resultant achievements have already been published in highly prestigious journals such as ''Advanced Functional Materials'' and ''Materials Today''. One of these achievements is featured as a cover story in Materials Today, Fig. 1a, and another as an inside front cover in Advanced Functional Materials, Fig. 1b. Furthermore, we introduced the first plasmonic based heating approach for local embedding of nanoparticles in a polymeric matrix. Based on that we demonstrated a patterning, writing, defect healing, and welding approach of nanocomposites in a controlled manner. From the view of achievements, 7 publications and several patents (US and EP) have already been accepted and newly registered. As the specific highlight, Elbahri 's research group has received the special award of ''Nanotechnology'' in the competition of innovative ideas ''made in Schleswig-Holstein'' 2012, for the idea of introducing a new approach to anti-reflectors for solar cells.

Results

Fig. 1: a) Schematic illustration of the nanoparticle capturing mechanism of the biofunctionalized nanofibres
b) Nanogalaxy: a nanostructured hybrid membrane for environmental remediation

1. Functional Electrospun Nanofibres Membrane (ENM)

Nowadays, water filtration is the key solution to water scarcity all over the world. Therefore, state-of-the-art technologies

such as electrospun nanofibrous membranes for water filtration are in high demand. Especially promising are the highly interconnected porosity and tuneable pore sizes of such membranes. On the other hand, such high porosity and surface area-to-volume ratio make nanofibrous membranes more exposed to mechanical stresses and susceptible to mechanical failures (e.g. compaction) and thereby loss of permeance. In our previous studies (see Almanac 2011), the mechanically weak and low wettable electrospun nanofibrous membranes were modified through a nanocomposite strategy using zirconia and titania nanoparticles. Thus an extraordinary water permeable nanocomposite membrane with an order of magnitude higher permeability than the neat membrane has been realized.

In a new study, we aimed at investigating another approach: solvent induced interfibre adhesion through a heat treatment process. Thermal treatment at a temperature above the glass transition temperature and just below the melting temperature of the polymeric nanofibres is a well-known approach to strengthen a nanofibrous mat. Differing from such a successful technique, our approach benefited from extracting residual solvent from within the nanofibres by heating. The residual solvent can act as a glue to partially dissolve and stick the nanofibres to each other. This interfibre adhesion is believed to enhance the mechanical properties of the nanofibrous membrane without a significant change in the porous structure. The enhancement of the mechanical properties of the electrospun nanofibrous membrane was probed via tensile test and nanoindentation which clearly demonstrated a higher elastic modulus and compaction resistance respectively. The mechanically stronger membrane possesses a higher resistance against tensile disintegration which would lead to a lower water flux at high feed pressures. Through a particle challenge test, i.e. filtration of a TiO_2 aqueous nanosuspension under an incremental feed pressure of 1-2 bar, we could also show that a mechanically resistant ENM can offer an improved filtration efficiency, mainly due to its higher structural integration.

Electrospun nanofibrous membranes are usually poorly selective and generally fail to capture nano-sized substances owing to their micro-sized pores. Inspired by nature, where a carnivorous plant spreads its leaves equipped with some sticky mucilage to attract and capture small insects, we have fabricated the first biofunctionalized polymer nanofibrous membrane with tuneable morphological and conformational changes (fibres spread during filtration because of the water/protein interaction) along with an ability to stick to metal nanoparticles (owing to strong protein-metal interaction). Fig. 2a, shows the mechanism of capturing nanoparticles much smaller than the pore size of the membrane with almost 100% efficiency and without considerable feed pressure, i.e. negligible energy consumption. The result of the filtration test as performed in our group is shown in Fig 2b.

As a feature trial for our research we developed a new type of sorption filter based on a nano/micro hybrid structural membrane with tuneable properties. The work was selected as a cover story in Materials Today. The membrane possesses a multifunctionality in removal of suspended solids and oil from water and can be considered as a novel, efficient water filtration membrane.

2. Bio-based Smart and Multifunctional Materials

Smart materials that react to a stimulus or their surroundings through a dynamic and reversible change in critical properties are in the focus of our current research. Among numerous stimuli, the biological example is going to draw great attention due to its probable applications in molecular switching. Biological materials are inherently and naturally multifunctional. The knowledge about smart combinations of various functions in materials that appeared in biological evolution might inspire design of novel artificial biohybrids. For example, some colours in living organisms are due to the specific shape and distribution of nano-structures. These structural colours may change depending on environmental conditions. For example, the cuticle of the dock beetle that is shown in the picture on page 4, changes its colour depending on the hydration state owing to the conformational change of the protein and its interaction with the pigment.

Recently, we adopted this principle to bridge the gap between ''Filtration and Plasmonics'' and accordingly we connected our main research in HZG with that in Kiel. As we showed, a novel membrane consisting of polymer fibres and proteins could filter out tiny nano-scaled particles present in aqueous solutions. A nanofluid (e.g. a colloidal suspension of metal nanoparticles in water) can pass through a macroporous nanofibrous membrane unless the membrane's nanofibres are

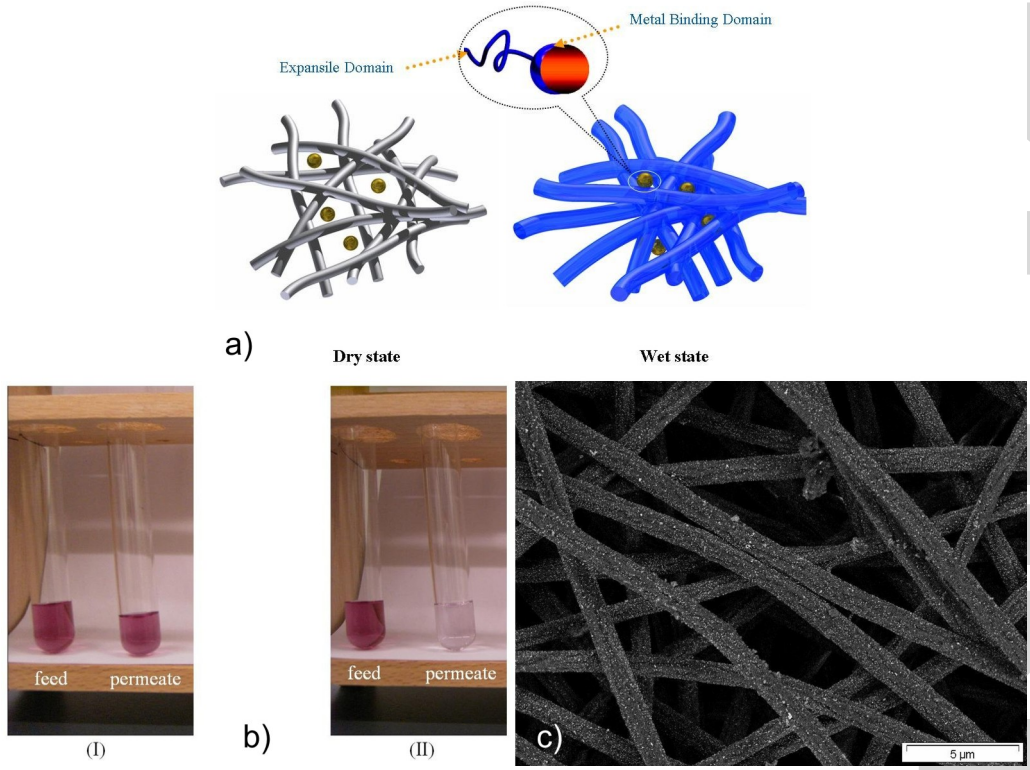


Fig. 2: a) The sketch illustrates how the swollen functionalized nanofibres capture the nanoparticles, b) Extraordinary nanofluid filterability after biofunctionalization proved via visual comparisons between the feed and permeated samples through the neat filter(I) and BSA/PANGMA ENMs (II), c) Formation of a bionanohybrid structure through adsorption of Au nanoparticles onto the BSA/PANGMA nanofibres

biofunctionalized by a protein for example. We learned that the biofunctional agent, i.e. a protein such as the conventionally used bovine serum albumin, undergoes a conformational change and captures all the metal nanoparticles during the filtration process. Thanks to the protein, the captured metal nanoparticles could be well dispersed, (Fig. 2c) and accordingly a novel method of nanocomposite fabrication was introduced. Ultimately, through this research, via benefiting from the conformational change of a protein, a smart plasmonic metal-polymer bionanocomposite, (Fig.3a) is demonstrated. It is able to act as an omnidirectional perfect black absorber. We believe that our result is a breakthrough towards the design of an operative filtration process as a new route for the fabrication of functional materials while offering commercially attractive efficiencies at a low cost.

3. Plasmonic Heat

When a metal nanoparticle is illuminated, some part of the intercepted light is scattered into the surroundings, while the other part is absorbed and ultimately dissipated as undesirable heat. We recently demonstrated the possibility of using the heat as the driving force for incorporation of nanoparticles into a polymer film. The local heating disrupts the polymer matrix and allows softening and pre-melting of the subsurface layer of the polymer foil through a photon-thermal energy conversion process by the nanoparticles. In the first proof-of-concept experiment, we showed the selective and precise embedding of Ag nanoparticles into a PVDF polymeric matrix for in-situ fabrication of nanocomposites in different forms. Indeed, patterning, writing, defect healing, and welding in a controlled manner along with crystallinity control through light irradiation were feasible, Fig.3b. Theoretical calculations and experimental data were used to estimate the amount of heat generated by the optically excited Ag nanoparticles. It was understood that this heat is sufficient to be in the range of the polymer melting temperature.

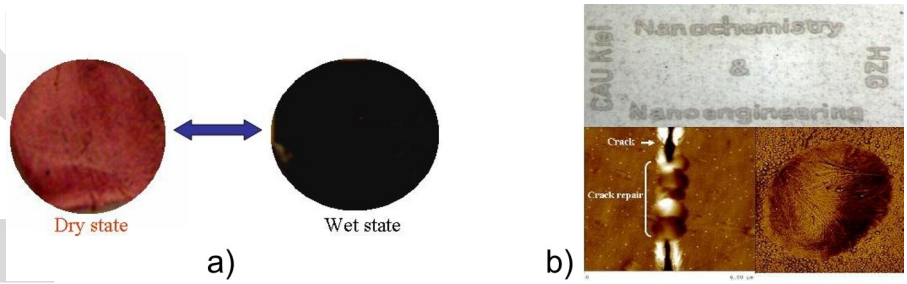


Fig. 3: a) Tuneable colouration of the surface of the membrane at dry (red) and wet (black) states, b) Plasmonic heating based nanocomposite fabrication in different forms of controlled patterning, writing (top image), defect healing (bottom-left image), and crystallinity control through light irradiation (bottom-right image)

Personnel

Head of the group: Prof. Dr. -Ing. M. Elbahri; Secretary: N. Gühlke (50%), Dipl.-Chem. S. Kastaun (50%)
Technical Staff: Dipl. -Ing. (FH) R. Kloth, Techn. C. Ochmann, Dipl.-Ing. (FH) S. Rehders

Scientific Staff:

M. Sc. R. Abdelaziz Nanofabrication	01.01.-31.12.2012	SFB 677, DFG
M.Sc. D. Disci Nanofabrication for Bio.	01.01.-31.12.2012	DFG
Dr. S.S. Homaeigohar Nanofibres for Filtration	01.01.-31.12.2012	HZG, DAAD, HGF
M.Sc. M. Keshavarz Hedayati Plasmonic materials	01.01.-31.12.2012	DFG, CAU
M.Sc. J. Worley Bionanotechnology	01.01.-31.12.2012	HGF
M.Sc. A.U. Zillohu Photonic nanomaterials	01.04.-31.12.2012	HZG, DAAD, HGF

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

Nanochemistry for Nanoengineering, 2 hrs Lecture/Week,
M. Elbahri

Nanochemistry for Nanoengineering - Seminar, 1 hrs Seminar/Week,
M. Elbahri

Summer 2012

Nanochemistry for Nanoengineering - Seminar, 2 hrs Seminar/Week,
M. Elbahri

Winter 2012/2013

Nanochemistry for Nanoengineering, 2 hrs Lecture/Week,
M. Elbahri

Nanochemistry for Nanoengineering - Seminar, 1 hrs Seminar/Week,
M. Elbahri

Werkstoffe - Polymere, 2 hrs Lecture/Week,
M. Elbahri

Polymer based Smart and Multifunctional Devices, 2 hrs Lecture/Week,
M. Elbahri

Polymer based Smart and Multifunctional Devices - Seminar, 1 hrs Seminar/Week,
M. Elbahri

Third-Party Funds

GKSS, *Einrichtung einer gemeinsamen Helmholtz-Hochschul-Nachwuchsgruppe*, 01.03.2009-28.02.2015 (2.100.000 Euro)
DFG, *Nanosynthesis and Nanopatterning based on ''Drop-on-a-hot-Plate''*, 01.08.2009-31.08.2013 (280.370 Euro)
DAAD, *1. Verlängerung Stipendium zur Promotion für Ahnaf Usman Zillohu*, 01.04.2011-31.03.2012 (12.096 Euro)
DAAD, *2. Verlängerung Verlängerung Stipendium zur Promotion für Ahnaf Usman Zillohu für 1 Jahr*, 01.04.2012-31.03.2013 (12.168 Euro)
DFG SFB 677, *Function by Switching: Photoswitchable Metal-Polymer Nanocomposites*, 01.07.2011-30.06.2015 (228.470 Euro)
DFG SFB 677, *Function by Switching: Multifunctional Photoswitchable Polymer Fibers*, 01.07.2011-30.06.2015 (261.720 Euro)

Further Cooperation, Consulting, and Technology Transfer

Prof. Dr. F. Faupel, Institute for Material Science, several topics with hybrid organic/inorganic materials

Prof. Dr. R. Adelung, Institute for Material Science, several topics nanostructures, biomaterials i.e. submitted DFG joint project for conductive polymer nanowires

Prof. Dr. Dieter Adam, Institut für Immunologie, Christian-Albrechts-Universität Kiel

Prof. Dr. L. Kienle, Institute for Material Science, Transmission electron microscopy

Prof. Dr. V. Abetz, Helmholz Zentrum Geesthacht, Zentrum für Material- und Küstenfoschung GmbH, Blockcopolymers

Prof. Dr. Eich, TU Hamburg, Photonic crystal

Prof. Dr. Martin Müller, Helmholz Zentrum Geesthacht, Zentrum für Material- und Küstenfoschung GmbH

Prof. Dr. sc.hum. Rainer Podschun, Institut für Infektionsmedizin, Christian-Albrechts-Universität Kiel

Prof. Dr. Carsten Rockstuhl, Photonik, Uni Jena

Priv.-Doz. Dr. C. Röhl, Institut für Toxikologie und Pharmakologie für Naturwissenschaftler, Christian-Albrechts-Universität

Prof. Dr. Selhuber-Unkel, Biocompatible Nanomaterials, Faculty of Engineering

Prof. Dr. rer. nat. S. N. Gorb, Spezielle Zoologie, Christian-Albrechts-Universität Kiel

Dr. Thomas Emmler, Helmholz Zentrum Geesthacht, Zentrum für Material- und Küstenfoschung GmbH

Dr. Wolfgang Reinert, Fraunhofer ISIT

Prof. Dr. Peter Müller-Buschbaum, Institute of Physics, TU München

Prof. Dr. Stefan Linden, Institute of Physics, Bonn University

Prof. Dr. Carsten Ruckstühl, Institute of Physics, Jena University

Prof. Dr. Horst-Günter Rubahn, NanoSYD, Mads Clausen Institute, Denmark

Prof. Dr. Andrei Lavrinenko, Department of Photonics, TU Denmark

Prof. Dr. Abhijit Biswas, Electrical Engineering, Notre Dame, USA

Prof. Dr. Alexander Govorov, Physics Department, Ohio University, USA

Diploma, Bachelor's and Master's Theses

M. Javaherirahim, *A new approach to design of transparent conductors based on plasmonics and photonics,* 09.01.2012
C. Tillack, *Biogenic synthesis of metal nanopaticles and metal/polymer bionanocomposites,* 13.07.2012

Publications

Published in 2012

M. Elbahri, S. Sh. Homaeigohar, R. Abdelaziz, T. Dai, R. Khalil, A. U. Zillohu, *Smart Metal-Polymer Bionanocomposites as Omnidirectional Plasmonic Black Absorbers Formed by Nanofluid Filtration.,* Advanced Functional Materials, **22**, 4771 (2012)

S. Sh. Homaeigohar, H. Mahdavi, M. Elbahri, *Extraordinarily water permeable sol-gel formed nanocomposite nanofibrous membranes,* Journal of Colloid and Interface Science, **366**, 51 (2012)

S. Sh. Homaeigohar, M. Elbahri, *Novel Compaction Resistant and Ductile Nanocomposite Nanofibrous Membranes with Superior Water Permeability,* Journal of Colloid and Interface Science, **372**, 6 (2012)

S. Sh. Homaeigohar, M. Elbahri, *Nano Galaxy - a novel electrospun nanofibrous membrane,* Winner of Cover story competition in Materials Today, (2012)

S. Sh. Homaeigohar, J. Koll, T. Lilleodden, M. Elbahri, *The solvent induced interfiber adhesion and its influence on the mechanicaland filtration properties of polyethersulfone electrospun nanofibrous microfiltration membranes,* Separation and Purification Technology, **98**, 456 (2012)

A. U. Zillohu, S. Sh. Homaeigohar, R. Abdelaziz, N. Alissawi, J. Koll, Th. Emmler, M. Elbahri, *Photoswitchiable Metallodielectric hybrid nanofibres,* J. Phys. Chem. C, **117**, 19611 (2012)

M. Keshavarz Hedayati, F. Faupel, M. Elbahri, *Design of a Perfect Black Absorber at Visible Frequencies Using Plasmonic Metamaterials,* Applied Physics A, **23**, 5410 (2012)

H. T. Beyene, V. S. K. Chakravadhanula, C. Hanisch, T. Strunskus, V. Zaporojtchenk, M. Elbahri, F. Faupel, *Vapour Phase Deposition, Structure, and Plasmonic Properties of Polymer-Based Composites Containing Ag-Cu Bimetallic Nanoparticles,* Plasmonics, **7**, 107 (2012)

A. U. Zillohu, S. Sh. Homaeigohar, R. Abdelaziz, N. Alissawi, R. Koll, Th. Emmler, M. Elbahri, *Photoswitchable Metallodielectric hybrid nanofibres,* Advanced Functional Materials adfm, **201**, 201437 (2012)

M. Keshavarz Hedayati, M. Jamali, M. Javaherirahim, A. U. Zillohu, M. Elbahri, *Smart Transparent Plasmonic Conductor,* Applied Physics A, 7344 (2012)

R. Abdelaziz, J. Worley, J.-H. Pöhls, D. Disci, K. Hirmas, A. U. Zillohu, B. Erkartal, V. K. Chakravadhanula, V. Duppel, L. Kienle, M. Elbahri, *Lab in Leidenfrost Drop: Green Chemistry and Nanofabricated Devices under Leidenfrost Condition.,* Nature Nanotechnology, **NNANO-12040490A**, (2012)

Patent Applications

F. Faupel, T. Strunskus, V. Zaporojtchenko, V. S. K. Chakravadhanula, M. Keshavarz Hedayati, M. Elbahri, *Metal composite coating having high optical transmissivity in the visual spectrum*, German Patent and Trade Mark Office (GTPO), 19.01.2012, DE 10 2010 050 110 B3

R. Adelung, M. Elbahri, *Method for Generating Oxidic Nanoparticles from a Material Forming Oxide Particles*, United States of America Patent and Trademark Offi, 06.03.2012, US 8,129,000 B2

R. Adelung, F. Faupel, K. Hirmas, M. Elbahri, *Method for the production of a nanostructure by means of spidonal decrosslinking*, European Patent Office (EPO), 04.04.2012, EP 2 206 153 B1

F. Faupel, T. Strunskus, V. Zaporojtchenko, V. S. K. Chakravadhanula, M. Keshavarz Hedayati, M. Elbahri, *Metal composite coating having high optical transmissivity in the visual spectrum*, World Intellectual Property Organization (WIPO), 03.05.2012, WO 2012/055397 A1

M. Elbahri, S. Sh. Homaeigohar, T. Dai, R. Abdelaziz, *Biofunctionalized ultrafiltration Membrane*, European Patent Office (EPO), 19.12.2012, EP 2 535 103 A1

Presentations

M. Elbahri, *Plasmonic Nanocomposites (Invited Talk)*, MRS 2012 Spring Meeting and Exhibit, San Francisco, United States of America, 09.-13.04.2012

M. Elbahri, *Plasmonic Nanocomposites (Invited Talk)*, META 12 (3rd International Conference on Metamaterials, Photonic Crystals and Plasmonics), Paris, France, 19.-22.04.2012

A. Zillohu, M. Jamali, M. Javaherirahim, B. Mozooni, M. Elbahri, F. Faupel, M. Keshavarz Hedayati, *A smart plasmonic transparent conductor with a gas sensing ability (Talk)*, META 12 (3rd International Conference on Metamaterials, Photonic Crystals and Plasmonics), Paris, France, 19.-22.04.2012

A. Zillohu, M. Jamali, M. Javaherirahim, M. Elbahri, F. Faupel, B. Mozooni, M. Keshavarz Hedayati, *Tunable Broadband Plasmonic Perfect Absorber at Visible Frequencies (Poster)*, META 12 (3rd International Conference on Metamaterials, Photonic Crystals and Plasmonics), Paris, France, 19.-22.04.2012

M. Elbahri, *Plasmonic Nanomaterials (Invited Talk)*, Times of Polymers and Composites, Ischia (Naples), Italy, 09.-11.05.2012

M. Elbahri, *(Invited Talk)*, Workshop, Sonderborg, Germany, 10.05.2012

M. Elbahri, *Plasmonic nanocomposites: from transparent conductor to perfect absorber (Invited Talk)Plasmonic nanocomposites: from transparent conductor to perfect absorber (Invited Talk)*, Nanofair 2012, Dresden, Germany, 12.-13.06.2012

M. Elbahri, *Plasmonics: from synthesis to function (Invited Talk)*, Technical University of Denmark, Copenhagen, Denmark, 24.-25.05.2012

M. Elbahri, S. Sh. Homaeigohar, J.-H. Pöhls, C. Tillack, R. Abdelaziz, D. Disci-Zayed, *Biogenic Synthesis of Smart Plasmonic Bionanocomposites (Poster)*, Nanofair 2012, Dresden, Germany, 12.-13.06.2012

M. Keshavarz Hedayati, *Photoswitchable plasmonic materials (Talk)*, Internationale SFB677-Tagung 2012,, Plön, Germany, 20.-22.08.2012

M. Elbahri, *Electrospun Nanofibrous Membrane for Water Filtration*, Materials Science and Engineering Conference 2012 (MSE 2012), Darmstadt, Germany, 25.-27.09.2012

F. Faupel, T. Strunskus, V. Zaporojtchenko, A. Zillohu, M. Jamali, M. Keshavarz Hedayati, M. Elbahri, *Plasmonic Nanocomposites: from black absorber to transparent conductor (Talk)*, Materials Science and Engineering Conference 2012 (MSE 2012), Darmstadt, Germany, 25.-27.09.2012

M. Elbahri, *Plasmonic bionanocomposites (Invited Talk)*, Ringberg Symposium, Rottach-Egern (Tegernsee), Germany, 30.09.-02.10.2012

Further Activities and Events

Nanotechnology award in Idea competition

Nomination for Eni Award

Featuring of the paper ''Smart'' as inside front cover in Advanced Functional Materials, in recognition of its excellence

Featuring of the paper ''Nano Galaxy - a novel electrospun nanofibrous membrane,'' as winner of cover story competition in Materials Today

Invitation for Review article ''Plasmonic Nanocomposites'' in Advanced Materials

Invitation for writing a book ''Plasmonic Nanocomposites'' Wiley

Invitation for writing a book ''Recent Advanced''in Elsevier

Invitation to the organizing committee of the international workshop nanocpmosdon ''Manipulation, Manufacturing and Measurement on the Nanoscale - 3M-NANO'' 2012 in China

almanac

Nanoscale Magnetic Materials - Magnetic Domains

The department of "Nanoscale Magnetic Materials - Magnetic Domains" was established in the middle of 2011 with the financial support of the DFG Heisenberg Professorship Programme. The main focus of the department is on magnetic heterostructures with tailored magnetic properties. Nanostructuring and nanolayering by various methods is used to modify the magnetic microstructure, enabling us to design artificial magnetic materials and specifically control the magnetic domains as well as applying and optimizing magnetic structures for various types of applications. The effective magnetic properties are tailored using different magnetic interaction effects. Magnetic properties are analyzed by probing the magnetic response laterally on time-scales from DC down to the picosecond range. Therefore, an additional task within the department is the methodical advancement of magnetic domain investigation tools with high temporal and lateral resolution. In general, the scientific focus of the research group is on micro- and nanostructured magnetic thin films. The magnetization behaviour of structured and layered magnetic thin films is illuminated from a fundamental point of view as well as from the perspective of application related scientific questions. We are investigating new fundamental concepts based on domain engineering for the property design of nanostructured magnetic layer systems. One central goal is to improve existing magnetic material systems with respect to their functionality. Complementary to this, the methodological emphasis of the department is on the optimization, development, and application of optical and microscopic techniques for the investigation of magnetic and ferroelectric domain behaviour with high spatial and temporal resolution. Time-resolved polarization microscopy and magneto-optical microscopy are intended to be developed with picosecond temporal resolution. The development of these methods is essential for achieving the desired research goals.

Results

Real-time magneto-optical magnetic vector imaging

The imaging of magnetic domains in magnetic thin films is essential in order to obtain an understanding of the underlying mechanism of magnetization reversal and the related processes in micro- or nanoscale magnetic devices. This promotes further development in domain imaging techniques. Despite the advances of recent years, mainly in improving lateral and temporal resolution, the necessary continuous imaging of the vector nature of magnetization is rarely performed. We were able to demonstrate for the first time real-time quantitative magneto-optical vector imaging of the spatial variation of magnetization using dual wave-length imaging. One illustrative example of magnetization reversal in a magnetic thin film, demonstrating the new method, is displayed in Figure 1. By the addition of direct vector imaging to magneto-optical Kerr microscopy, this established technique of magnetic imaging will be of even greater value for fundamental and applied research.

Magnetic domain effects in magneto-electric composite materials

From magneto-resistive sensor applications it is well known that the noise exhibited in the sensors is strongly degraded by closure domain activity and domain wall pinning effects. Magnetic domain activities in magneto-electric sensors are therefore an important factor that limits the low field sensitivity of the sensor. Hence, the aim of the project is to investigate and optimize the magnetic domain structure of magneto-electric composites and yet maintain sufficiently high sensitivity. Using spatially resolved characterization methods, we obtained an understanding of the magnetic rearrangement processes in magneto-electric thin films. From this, concepts for the control of the magnetic domain behaviour are developed with the objective of achieving the largest effective permeability and magnetostriction. The studies are supported by comparative modelling of the magnetization reversal behaviour. The investigations form the basis for the understanding of magneto-electric composite behaviour.

As an example, we could show that the effects of domain rearrangement on the sensor's noise level can be lowered significantly by laminating the magnetic layers with non-magnetic materials. Lamination with non-magnetic interlayers results in coupling between the domains and the domain walls of adjacent magnetic layers by magneto-static interactions.

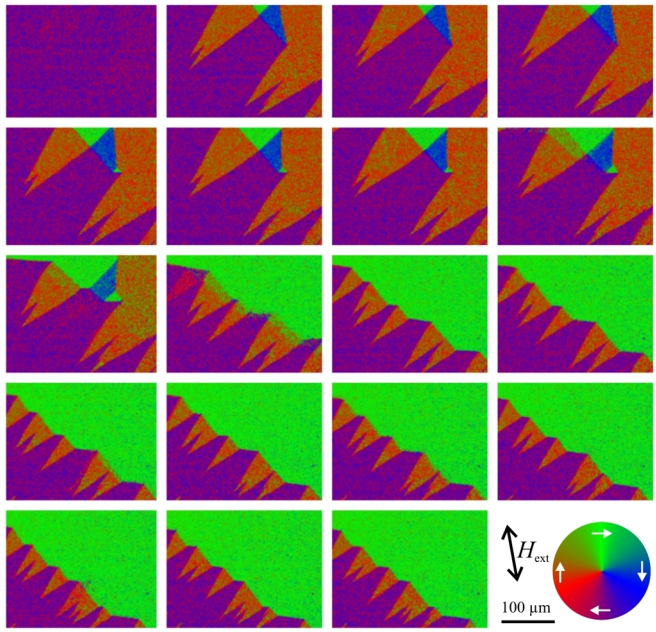


Fig. 1: Vector magnetization representation of the magnetization reversal process in an extended epitaxial Fe(100)-layer with a thickness of 50 nm (sample preparation D. Bürgler, FZ Jülich). The colour coding represents the individual directions of magnetization.

The domain walls tend to align themselves to their peers in the neighbouring layers, eliminating charges from the interior of the magnetic films. The interaction between the layers causes the domain structure to change depending on the non-magnetic and magnetic layer thicknesses.

For example, in patterned samples the magnetic closure domains display a transition from a modified spike domain to a closure domain structure, both strongly influenced by a partial anti-parallel alignment of magnetization of the individual layers. Magnetic domain rotation starts to become dominant in the magnetization reversal process. Consequently, the domain induced noise in magneto-electric sensors is reduced sharply by laminating the magnetic layers.

Hybrid magnetic materials - microscopic modifications resulting in macroscopic effects

Understanding the correlation of artificial magnetic domain configurations and effective magnetic characteristics, such as the anisotropy, exchange coupling, and interlayer exchange coupling is the main goal of the research project. Artificial magnetic structures are produced with the aid of ion irradiation techniques in order to modify magnetic characteristics on a length scale comparable to, or below, the magnetic characteristic correlation lengths. By this, completely new domain and domain wall configurations are imprinted that do not occur in conventional film systems. With the progressive reduction in structure size, materials with modified effective magnetic properties, so-called magnetic hybrid materials, are generated.

The current focus of the project is on the investigation of the functional relationship between microscopic magnetic property patterns and the integrally measured effective magnetic parameters. The scalability of the findings is examined by the comparison of different material systems with varying effective magnetic correlation lengths. As an example the tailored anisotropic magneto-resistive response of a hybrid exchange biased sensor structure is shown in Figure 2. The sensor structure is only sensitive along a single magnetic field axis and stabilized in a modulated but quasi-single domain structure.

Dynamic metallographic and magneto-optical polarization microscopy of magnetic shape memory alloy systems

Time-resolved metallographic optical microscopy techniques, together with magnetic domain imaging, are used to clarify

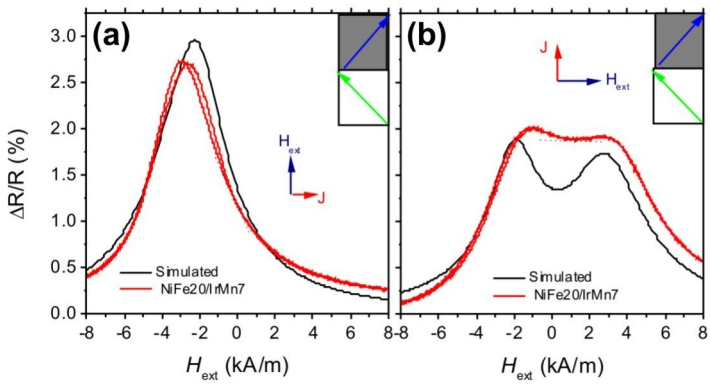


Fig. 2: Simulated and measured anisotropic magneto-resistance response for a hybrid dual-exchange biased sensor structure along two different directions.

the interaction between magnetic domains and twin boundary motion in magnetic shape memory alloy single crystals. The magnetic field and stress induced magnetic domain formation can be imaged by a magneto-optical indicator film technique. One of the main results is the discovery of magnetic field induced structural reorientations without concurrent magnetic domain wall motion. Contrariwise, for strain induced reorientation processes a complete rearrangement of the magnetic domain structure by the moving twin boundaries is observed.

As an example from dynamic actuation experiments on twin boundary motion, we find that the field induced strain increases with actuation speed, resulting in non-linear temperature dependent effects on twin boundary mobility. The findings can be interpreted as the interaction of moving twin boundaries with local non-fixed defects. The results provide key information for the understanding of the connection of magnetic and crystallographic domains in magnetic shape memory alloys, as well as for the optimization of devices for future technical applications.

Laterally resolved thermal imaging using magneto-optical indicator films

Using magneto-optical indicator films we were able to demonstrate a novel approach for imaging of lateral temperature distributions. The method involves a magneto-optical indicator film, which is placed in contact with the investigated sample in the same way as for the imaging of magnetic stray fields. Since the magneto-optical Faraday rotation is a function of the local saturation magnetization of the magnetic sensing layer and the saturation magnetization is a function of temperature, the indicator film can be exploited as a transducer of a local variation of temperature into a variation of magneto-optical contrast.

In order to obtain maximum sensitivity the critical temperature of the temperature sensing layer is chosen to be close to, but still above, the temperature range of investigation. Indicator films with planar and uniaxial magnetic anisotropy can be used for the measurement of temperature change. Relying on optics, the imaging scheme has the potential to work up to high temporal resolution, only depending on thermal conductions. Temperature changes occurring within a few microseconds can be measured with high lateral resolution. A temperature resolution of the order of 0.01K is demonstrated (Fig. 3).

Personnel

Head of the group: Prof. Dr. J. McCord; Secretary: E. Riemer, G. Schroeder
Technical Staff: Dipl.-Ing. (FH) Thomas Metzing

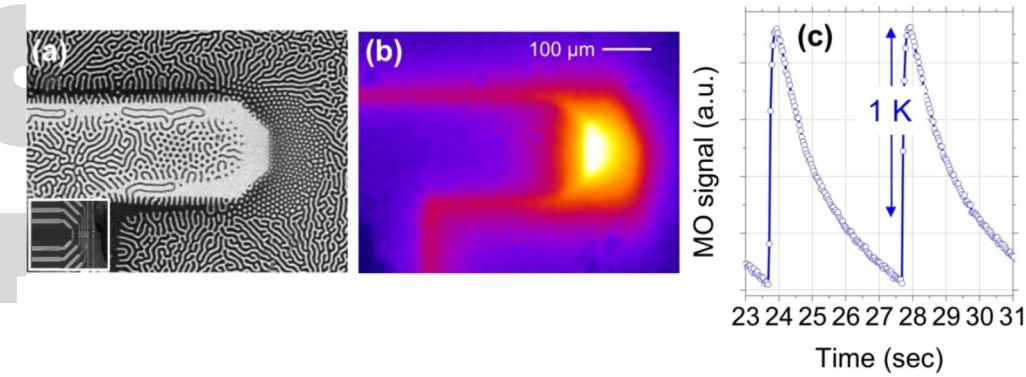


Fig. 3: (a) Effect of magnetic field and heat generated by a current flowing through a track of a printed circuit board (shown in the inset) on the domain structure of a uniaxial indicator film and (b) thermal image of the track. (c) Local change of magneto-optical signal with time due to the temperature evolution caused by a sequence of short current pulses put through a Kanthal heating wire.

Scientific Staff:

Dr. M. Kustov 01.01.-31.12.2012 DFG
SPP 1239 - Domain Structures and Dynamics in Ferromagnetic Shape Memory Materials

M.Sc. B. Mozooni 01.01.-31.12.2012 DFG
Einstellbarkeit und schaltbare Hochfrequenzeigenschaften

Dipl.-Phys. Julia Trütschler 01.02.-31.12.2012 DFG
Hybride Magnetische Materialien

M.Sc. Nedet Onur Urs 17.02.-31.12.2012 DFG
SFB 855, Magnetoelektrische Verbundwerkstoffe - biomagnetische Schnittstellen der Zukunft, Teilprojekt B05

Dr. T. von Hofe 01.01.-31.12.2012 DFG
Einstellbarkeit und schaltbare Hochfrequenzeigenschaften + SFB 855 Teilprojekt B05

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

Advanced Materials A - Metals, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
J. McCord

Magnetism and Magnetic Materials, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
J. McCord

Nanoskalige magnetische Werkstoffe, 2 hrs Seminar/Week,
J. McCord

Summer 2012

Magnetische Materialien, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
J. McCord

New Trends in Magnetism, 2 hrs Seminar/Week,
J. McCord

Nanoskalige magnetische Werkstoffe - magnetische Domänen, 2 hrs Seminar/Week,
J. McCord

Advanced Lab Course for Master´s Students, MOKE, 4 hrs Lab/Week,
J. McCord (+ N. O. Urs)

Winter 2012/2013

Advanced Materials A - Metals, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
J. McCord

Magnetism and Magnetic Materials, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
J. McCord

Magnetic Domains, 2 hrs Seminar/Week,
J. McCord

Werkstoffe - Keramiken, 2 hrs Lecture/Week,
J. McCord

Grundpraktikum I, 3 hrs Practical/Week,
J. McCord (+ J. Trütschler)

Third-Party Funds

DFG, *Heisenberg-Professur*, 01.07.2011-30.06.2014 (189.000 EUR)
DFG, *Einstellbare und schaltbare Hochfrequenzeigenschaften - Domänenkonfiguration und Beobachtung von Magnetisierungsdynamik*, 01.10.2011-30.09.2014 (311.231 EUR)
DFG, *Hybride Magnetische Materialien - mikroskopische Modifikationen, makroskopische Wirkungen*, 15.02.2012-14.06.2015 (184.870 EUR)
DFG, *SPP 1239 - Änderung von Mikrostruktur und Form fester Werkstoffe durch äußere Magnetfelder*, 01.11.2011-31.10.2013 (163.500 EUR)
DAAD, *PROCOPE*, 01.01.2011-31.12.2013 (5.910 EUR)
DFG, *SFB 855 - Magnetoelektrische Verbundwerkstoffe - biomagnetische Schnittstellen d. Zukunft, Teilprojekt B05*, 01.04.-31.12.2012 (207.100 EUR)

Further Cooperation, Consulting, and Technology Transfer

Prof. Manfred Albrecht, TU Chemnitz

Dr. Andreas Berger, CICnanoGUNE, San Sebastian, Spain

Dr. Daniel Bürgler, Forschungszentrum Jülich - Peter Grünberg Institute

Dr. Peter Fischer, Lawrence Berkeley National Laboratory, Berkeley, USA

Prof. Jürgen Faßbender, Helmholtz-Zentrum Dresden-Rossendorf

Prov. Rostislav Grechishkin, Tver State University, Russia

Dr. Jörg Grenzer, Helmholtz-Zentrum Dresden-Rossendorf

Prof. Oliver Gutfleisch, Technische Universität Darmstadt

Prof. Lorenz Kienle, CAU Kiel

Prof. Reinhard Knöchel, CAU Kiel

Prof. Stephane Mangin, Institut Jean Lamour, Nancy, France

Dr. Roland Mattheis, IPHT Jena

Prof. Andrzej Maziewski, University of Bialystok, Poland

Dr. Guido Meier, University Hamburg

Dr. Ingolf Mönch, IFW Dresden

Dr. Christian Patak, Bosch AG Reutlingen

Prof. Eckhard Quandt, CAU Kiel

Dr. Rudolf Schäfer, IFW Dresden

Dr. Heidemarie Schmidt, TU Chemnitz

Prof. L. Schultz, IFW Dresden

Prof. Nian Sun, Northeastern University, Boston, USA

Prof. Hongbin Hu, Arizona State University, Glendale, USA

Publications

Published in 2012

O. D. Roshchupkina, J. Grenzer, T. Strache, J. McCord, M. Fritzsche, A. Muecklich, C. Baehtz, J. Fassbender, *Focused ion beam induced structural modifications in thin magnetic films,* J. Appl. Phys., **112**, 033901 (2012)

A. Neudert, Y. W. Lai, R. Schäfer, M. Kustov, L. Schultz, J. McCord, *Magnetic Domains and Twin Boundary Movement of NiMnGa Magnetic Shape Memory Crystals,* Advanced Engineering Materials, **14**, 601 - 613 (2012)

C. Patschureck, K. Lenz, M. O. Liedke, M. U. Lutz, T. Strache, I. Mönch, R. Schäfer, L. Schultz, J. McCord, *Magnetization dynamics of buckling domain structures in patterned thin films,* Phys. Rev. B, **86**, 054426 (2012)

S. Wintz, T. Strache, M. Körner, C. Bunce, A. Banholzer, R. Mattheis, J. Raabe, C. Quitmann, J. McCord, *Interlayer-coupled spin vortex pairs and their response to external magnetic fields,* Phys. Rev. B, **85**, 224420 (2012)

S. Wintz, T. Strache, M. Körner, C. Bunce, A Banholzer, I. Mönch, R. Mattheis, J. Raabe, C. Quitmann, J. McCord, A. Erbe, K. Lenz, J. Fassbender, *Control of vortex pair states by post-deposition interlayer exchange coupling modification,* Phys. Rev. B, **85**, 134417 (2012)

J. Steiner, R. Schafer, H. Wieczoreck, J. McCord, F. Otto, *Formation and coarsening of the concertina magnetization pattern in elongated thin-film elements,* Phys. Rev. B, **85**, 104407 (2012)

A. Maziewski, P. Mazalski, Z. Kurant, M. O. Liedke, J. McCord, J. Fassbender, J. Ferré, A. Mougin, A. Wawro, L. T. Baczewski, A. Rogalev, F. Wilhelm, T. Gemming, *Tailoring of magnetism in Pt/Co/Pt ultrathin films by ion irradiation,* Phys. Rev. B 85, **85**, 054427 (2012)

Presentations

S. Wintz, C. Bunce, A. Banholzer, T. Strache, M. Körner, A. Gemming, A. Erbe, J. McCord, J. Raabe, C. Quitmann, J. Fassbender, *Pairs of diverging-converging spin vortices in biquadratically interlayer exchange coupled elements,* DPG Fühjahrstagung, Berlin, 25.-30.03.2012

K. Mok, C. Scarlat, G. J. Kovacs, L. Li, V. Zviagin, J. McCord, M. Helm, H. Schmidt, *Magneto-optical coupling in ferromagnetic thin films investigated by VMOGE,* DPG Fühjahrstagung, Berlin, 25.-30.03.2012

M. Langer, J. Osten, A. Neudert, M. Körner, A. Banholzer, I. Mönch, R. Mattheis, J. Fassbender, J. McCord, *Fabrication and characterization of patterned exchangecoupled trilayers,* DPG Fühjahrstagung, Berlin, 25.-30.03.2012

M. Langer, A. Neudert, J. Osten, M. Körner, I. Mönch, R. Mattheis, J. Fassbender, J. McCord, *Magnetization reversal of ferromagnetic elements surrounded by a synthetic antiferromagnet,* Intermag 2012, Vancouver, Canada, 07.-11.05.2012

J. McCord, O. Roshchupkin, B. Erkartal, J. Grenzer, L. Kienle, E. Quandt, *Magnetic stripe domains in magnetostriction free films - the role of structure,* Intermag 2012, Vancouver, Canada, 07.-11.05.2012

J. McCord, M. Kustov, Y. W. Lai, A. Neudert, R. Schäfer, L. Schultz, *Magnetic domains and twin boundary movement of NiMnGa magnetic shape memory crystals,* MSE, Darmstadt, 25.-27.09.2012

A. Vogel, S. Wintz, T. Gerhadt, L. Bocklage, T. Strache, M. Im, P. Fischer, J. Fassbender, J. McCord, G. Meier, *Domain-wall motion in permalloy nanowires with magnetic soft spots,* International Conference on Magnetism, Bexco, Busan, Korea, 08.-13.07.2012

J. Fassbender, M. Körner, K. Lenz, A. Strache, A. Banholzer, J. Grebin, J. Lindner, I. Barsukov, F. Römer, R. Meckenstock, S. Hemken To Krax, M. Farle, J. McCord, I. Mönch, R. Mattheis, *Magnonic Crystals By Means Of Patterned Ion Implantation (invited),* 18th International Conference on Ion Beam Modification of Materials (IBMM2012, Qingdao, China, 02.-07.09.2012

J. McCord, *Applied magneto-optics - magnetic domains and magnetization dynamics (invited),* Physikalisches Kolloquium der TU Chemnitz, Chemnitz, 10.10.2012

R. Adur, I. Lee, Y. Obukhov, C. Hamann, J. McCord, D. V. Pelekhov, *Scanning probe ferromagnetic resonance imaging of stripe patterned exchange bias film,* IEEE International Conference on Microwave Magnetics 2012, Kaiserslautern, 26.-29.08.2012

Synthesis and Real Structures

In 2012 the group "Synthesis and Real Structures" (SRS) focused mainly on interdisciplinary electron microscopy projects at the technical faculty. The quantitative measures of scientific development, such as third party funding and number of full papers, indicate that the group was successful as never before. Particularly, strong links to the chemistry department were substantiated via three joint projects which were positively evaluated by the German Research Foundation. To maintain this high level of activity the group is working continuously on applications with scientific and industrial partners, e.g. on thermoelectric materials, catalysts, and electrode materials for Li-ion batteries.

Meanwhile, the first two PhD students of the group (Viktor Hrkac and Burak Erkartal) are finalizing their theses; their successors have already begun their scientific work. Dr. Ulrich Schürmann, as experimental expert, became a permanent member of the group as a scientific coordinator. His duties include the installation and management of a new transmission electron microscopy lab in 2013.

Prof. Kienle, in his dual role as group leader of SRS and head of the electron microscopy centre, engaged in efforts to enhance the capabilities of nanoanalytics within the institute and beyond. The latter is demonstrated by strong links to microscopy centres with excellent instrumentation, particularly the Karlsruhe Nano Micro Facility, the Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons (Jülich), and the Max Planck Institute for Solid State Research (Stuttgart).

Results

a) Influence of element substitution on the crystallization and properties of the Blu-ray phase change material (PCM) $Ge_8Sb_2Te_{11}$ (priority programme SPP 1386, in cooperation with Prof. Bensch, CAU Kiel and Fraunhofer IPM).

Technologies for data storage are highly important as nowadays more information must be stored faster on even smaller devices. The opto-electronic properties of the Blu-ray phase change material $Ge_8Sb_2Te_{11}$ fulfil these requirements: high reflectivity contrast, cyclability, long-term stability, and fast crystallization speed. These materials can be reversibly switched between an amorphous and a crystalline phase. The different states exhibit unique physical properties, characterized by pronounced optical and electrical changes that are used as the logic values of a memory device. Crystalline and metastable PCM phases can be assigned to the cubic NaCl-type structure with Ge, Sb, and structural vacancies randomly dispersed on the cation site.

$Ge_8Sb_2Te_{11}$ and its properties were investigated and compared to partially substituted compounds such as $Ge_8Sb_2Te_6Se_5$, and $SnGe_7Sb_2Te_7Se_4$. To monitor the influence of substitution on both cation and anion sites on the properties, in $Ge_8Sb_2Te_6Se_5$, only Te was substituted by Se, while in $SnGe_7Sb_2Te_7Se_4$, Ge was also partially replaced by Sn. The partial substitution of Te by Se and Ge by Sn in the Blu-ray PCM $Ge_8Sb_2Te_{11}$ leads to distinctive changes of the structural as well as the electrical and optical properties.

In the as-deposited state the films are amorphous, as evidenced by X-ray diffraction (XRD) and transmission electron microscopy (TEM). The progress in crystallization, monitored in an in-situ heating TEM experiment, is shown in Figures 1(a)-(c). These examinations prove that the transition temperature from the amorphous to the metastable cubic state increases with the Se content, compared to the non-substituted material. After extended times of in-situ annealing the nanosized crystallites show planar defects, the so called vacancy layers, which signify the transition into a stable phase with average trigonal symmetry above the crystallization temperature (cf. stripes in Fig. 1(d)). The vacancy layers are based on a segregation of atoms and structural vacancies within layered aggregates serving for structural stabilization.

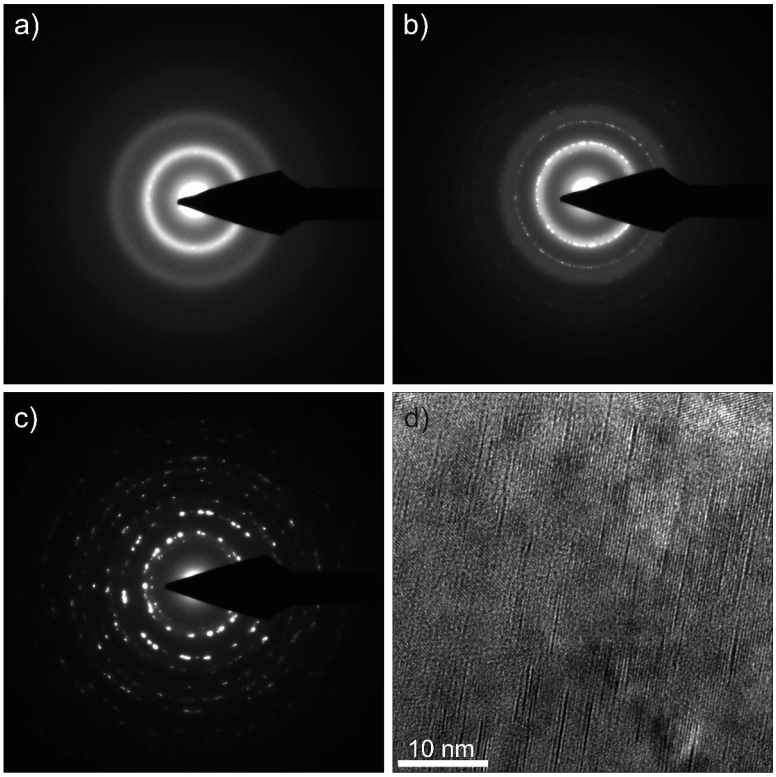


Fig. 1: Sequence of temperature- and time-dependent SAED measurements of $Ge_8Sb_2Te_6Se_5$ during in-situ heating: a) 120 °C; b) 220 °C; c) 230 °C, after 25 min; High-resolution micrographs with parallel stripes correlating with vacancy layers.

b) Characterization of elastocaloric Ni-Ti based thin films via TEM (in cooperation with Prof. Quandt, CAU Kiel).

Ni-Ti based alloys are known for their unique characteristics such as shape memory effect and pseudoelasticity. In the last decade such alloys were envisaged for ferroic cooling systems since the structural changes during the shape memory/pseudoelastic transitions are related to entropy changes. Here, we investigated fatigue mechanisms of Ni-Ti based alloys, which showed a small temperature change during mechanical cycling, via state-of-the-art TEM techniques.

In the case of binary Ni-Ti alloys, SAED and HRTEM imaging revealed that the film consists of Ni_4Ti_3 precipitates, R-Phase, and austenite. The average size of the Ni_4Ti_3 precipitates is determined to be around 20 nm and they are coherently intergrown with the austenitic matrix. The distribution of the precipitates in the austenitic matrix was analyzed via automatic texture measurements (ASTAR) in TEM for the first time. This method works quite well; however, the sizes of the precipitates represent the determining factor for quantitative evaluations. After ex-situ mechanical cycling the alloys show strong distortions of the austenitic matrix which are interrelated to residual strain accumulating during cycling. Another focus of research dealt with Cu doped Ni-Ti alloys, since the addition of Cu to the Ni-Ti system leads to decreasing martensite start temperatures. Various structures with different compositions have been detected via diffraction studies as well as ASTAR measurements accompanied by STEM-EDX nanoprobe investigations. In this case, and in contrast to the binary materials, the microstructure did not change after ex-situ mechanical cycling thus giving rise to 2000 stable pseudoelastic cycles.

c) Morphology-property relations for AlN thin films (collaborative research centre SFB 855, in cooperation with Prof. Wagner, ISIT Fraunhofer, and Prof. Kohlstedt, CAU Kiel).

In the framework of SFB 855 magnetoelectric (ME) materials are developed as strain-mediated piezoelectric-magnetostrictive nanocomposites for sensor applications. These sensors seem to be excellent candidates for biomagnetic

interfaces, enabling non-invasive medical imaging such as magneto-encephalography or cardiography (MEG, MCG). For the piezoelectric component, non-toxic III-V aluminum nitride (AlN) thin films proved their outstanding performance. The piezoelectric properties of AlN are directly associated with the crystal orientation and thus the morphology. In optimum cases the films are strongly c-textured, i.e. the film normal is parallel to the polar crystal axis [0 0 0 1]. Modern TEM techniques, particularly when introducing automated electron diffraction (ASTAR, see above), allow a detailed investigation of the morphology on different length scales ranging from nano- to micron size. The interrelation of these results with piezo-response force microscopy (PFM, Figure 2) demonstrates the relationship between morphology and property. The colour code (Fig. 2b) and the diffraction patterns of the marked areas prove columnar growth of AlN. However, several columns are misaligned from the [0 0 0 1] orientation. These morphology defects can also be identified by PFM measurements from similar regions. The topological view in Fig. 2d reveals only minor differences in altitude, nevertheless, the magnitude (Fig. 2e) and phase (Fig. 2f) signals of the piezo-response are marginal, as indicated by the dark areas. According to the strict interrelation of morphology and piezoelectric properties the dark areas should correlate with misaligned columns. Furthermore, a closer inspection of the orientation maps of Figs. 2b-d shows that the azimuthal rotation of the columns around the [0 0 0 1] direction is not subject to any restriction. Intrinsic features of the rotation at the grain boundaries and defect structures such as stacking mismatch boundaries can be analyzed quantitatively by high resolution microscopy and (precession) electron diffraction.

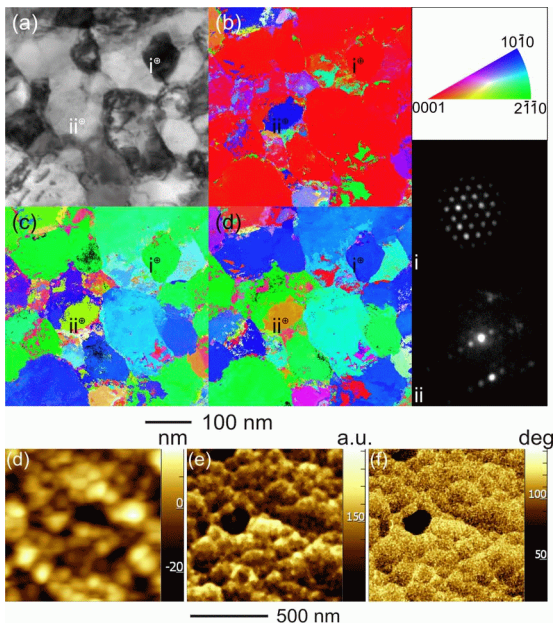


Fig. 2: Crystallite orientation mapping of AlN thin films (plane view). (a) Virtual bright field image. (b) Orientation map along the out-of-plane direction (z-direction), and for two in-plane directions (c) x-direction, (d) y-direction. (Right) Colour code of the stereographic triangle (hexagonal point group: 6mm) for all three maps. Diffraction patterns of area (i) and (ii) verifying the presence of misaligned grains. PFM measurements on an AlN thin film; (d) topographic image (e) magnitude signal (vertical) and (f) phase signal (vertical).

d) TEM Investigation of Core-Shell-Shell Ultrastructures in Inorganic Silica-Carbonate Systems (in Cooperation with Prof. W. Kunz, University of Regensburg).

Mineralization of alkaline-earth carbonates in silica-rich media at high pH leads to fascinating crystal morphologies that strongly resemble products from biomineralization, despite the absence of any organic matter. In this study, barium carbonate particles, showing a complex ultrastructure depending on the local pH-values, were precipitated under biomorphic conditions. Above a certain threshold in the silica content, rapid crystallization was prevented and amorphous nanoparticles were stabilized in solution. These self-assembled nanoparticles were characterized by high resolution transmission electron

microscopy (HRTEM), EDX mapping, and energy filtered TEM elemental mapping (EFTEM) at the nanoscale. The particles were found to be hybrids consisting of a silica core that was surrounded by a layer of amorphous barium carbonate, the latter covered by an outer shell of silica. HRTEM showed the particles were mostly amorphous for both of the silica and barium carbonate parts, but with occasional crystallizations under illumination of high-energy electron beam. A variety of EDX analyses performed in scanning TEM (STEM) mode proved that the Si/Ba signal ratio varies across the edge of particles, which indicated a barium rich layer between a silica core and a silica outer shell. In addition, EFTEM elemental mapping (Figure 3) had clearly revealed the core-shell-shell morphology of the particles.

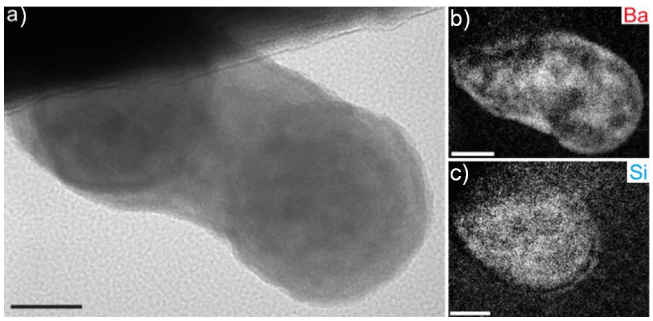


Fig. 3: Bright field TEM and element-sensitive energy filtered transmission electron microscopy (EFTEM) images of silica-carbonate-silica hybrid particles. a) TEM bright field image of the analyzed core-shell particle. b) and c) Corresponding EFTEM maps of barium and silicon reveal that barium is preferentially located on the rim and silica in the core of the particles. Note that the particles shrink slightly after long-term exposure to the electron beam without losing their composite character, which indicates this hybrid structure is robust even under a high-energy electron beam irradiation. Scale bar is 50 nm.

Personnel

Head of the group: Prof. Dr. Lorenz Kienle; Secretary: Katrin Brandenburg (50%)
Technical Staff: Christin Szillus

Scientific Staff:

M.Sc. Mao Deng 16.04.-31.12.2012 DFG
Synthese und Realstruktur-Eigenschaftsbeziehungen von katalytisch aktiven Nanoteilchen auf der Basis von Übergangsmetallsulfiden

M.Sc. R. Burak Erkartal 01.01.-31.12.2012 DFG
SPP 1239 Änderung von Mikrostruktur und Form fester Werkstoffe durch äußere Magnetfelder, TP Characterization of the micro- and nanostructure of magnetic shape memory materials by Transmission Electron Microscopy

Dipl.-Phys. Viktor Hrkac 01.01.-31.12.2012 DFG
SFB 855 Magnetoelektrische Verbundwerkstoffe - biomagnetische Schnittstellen der Zukunft, TP Z1 Hochauflösende Transmissionselektronenmikroskopie und magnetoelektrische Materialcharakterisierung

Dr. Ulrich Schürmann 01.01.-31.12.2012 CAU
TEM-Zentrum

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

Thermodynamics and Kinetics I, 2 (+ 1) hrs Lecture (+ Exercises)/Week,

L. Kienle

Solid State Chemistry, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
L. Kienle (+ U. Schürmann)

Seminar Synthese und Realstruktur, 2 hrs Seminar/Week,
L. Kienle

Biomaterials, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
L. Kienle (+ R. Adelung)

Laboratory Course: Scientific Methods, 4 hrs Practical/Week,
U. Schürmann (+ et al.)

Crystallography, 1 hrs Seminar/Week,
U. Schürmann

Electron Microscopy, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
L. Kienle

Chemistry 1, 1 hrs Exercise/Week,
Lorenz Kienle

Summer 2012

Fundamentals of Solids, 3 (+ 1) hrs Lecture (+ Exercises)/Week,
L. Kienle

Thermodynamics and Kinetics, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
L. Kienle

Mikro- und Nanocharakterisierung von Festkörpern mittels TEM, 2 hrs Lecture/Week,
L. Kienle (+ U. Schürmann)

Praktische Aspekte der Mikro- und Nanocharakterisierung von Festkörpern mittels TEM, 2 hrs Seminar/Week,
L. Kienle (+ U. Schürmann)

Seminar Synthese und Realstruktur, 2 hrs Seminar/Week,
L. Kienle

Winter 2012/2013

Thermodynamics and Kinetics I, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
L. Kienle

Solid State Chemistry, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
L. Kienle (+ U. Schürmann)

Solid State Chemistry, 1 hrs Seminar/Week,
U. Schürmann

Seminar Synthese und Realstruktur, 2 hrs Seminar/Week,
L. Kienle

Chemistry and Physics of Biomaterials, 3 (+ 1) hrs Lecture (+ Exercises)/Week,
L. Kienle (+ R. Adelung, C. Selhuber-Unkel)

Electron Microscopy, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
L. Kienle

Allgemeine Chemie, 1 hrs Exercise/Week,
L. Kienle

Third-Party Funds

DFG (SPP 1386), *Comprehensive clarification of the physical background of the breakthrough of ZT-2.4/1.7 for p/n-V_2VI_3-Superlattices (im Rahmen des SPP 1386: Nanostrukturierte Thermoelektrika: Theorie, Modellsysteme und kontrollierte Synthese)*, 01.06.2009-31.05.2012 (138.225 EUR)

DFG (SPP 1386), *Programmpauschale zu: Comprehensive clarification of the physical background of the breakthrough of ZT-2.4/1.7 for p/n-V_2VI_3-Superlattices (im Rahmen des SPP 1386: Nanostrukturierte Thermoelektrika: Theorie, Modellsysteme und kontrollierte Synthese)*, 01.06.2009-31.05.2012 (28.900 EUR)

DFG (SPP 1239), *Characterization of the micro- and nanostructure of magnetic shape memory materials by Transmission Electron Microscopy (im Rahmen des SPP 1239: Änderung der Mikrostruktur und Form fester Werkstoffe durch äußere Magnetfelder)*, 15.07.2010-31.07.2013 (144.000 EUR)

DFG (SPP 1239), *Programmpauschale zu: Characterization of the micro- and nanostructure of magnetic shape memory materials by Transmission Electron Microscopy (im Rahmen des SPP 1239: Änderung der Mikrostruktur und Form fester Werkstoffe durch äußere Magnetfelder)*, 15.07.2010-31.07.2013 (28.800 EUR)

DFG, *SFB 855, TP Z1 Hochauflösende Transmissionselektronenmikroskopie und magnetoelektrische Materialcharakterisierung*, 01.01.2010-31.12.2013 (784.000 EUR)

DFG, *Synthese und Realstruktur-Eigenschaftsbeziehungen von katalytisch aktiven Nanoteilchen auf der Basis von Übergangsmetallsulfiden*, 16.04.2012-15.04.2015 (144.501 EUR)

DFG, *Programmpauschale zu Synthese und Realstruktur-Eigenschaftsbeziehungen von katalytisch aktiven Nanoteilchen auf der Basis von Übergangsmetallsulfiden*, 16.04.2012-15.04.2015 (28.900 EUR)

DFG, *Investitionsmittel zur Beschaffung eines Großgerätes: Transmissionselektronenmikroskop*, 25.06.2012-24.06.2013 (382.509 EUR)

Land Schleswig-Holstein, *Investitionsmittel zur Beschaffung eines Großgerätes: Transmissionselektronenmikroskop*, 25.06.2012-24.06.2013 (382.509 EUR)

DFG (SPP 1386), *Synthesis, theoretical investigation and properties of nanocomposite themoelectric materials*, 19.10.2012-18.10.2015 (12.000 EUR)

DFG (SPP 1386), *Programmpauschale zu Synthesis, theoretical investigation and properties of nanocomposite themoelectric materials*, 19.10.2012-18.10.2015 (4.800 EUR)

DFG, *SPP 1386 Nanostrukturierte Thermoelektrika: Theorie, Modellsysteme und kontrollierte Synthese. Nanostructure, thermoelectric properties and transport theory of V2VI3 and V2VI3 IV-VI based superlattices*, 21.12.2012-20.12.2015 (148.800 EUR)

DFG, *Programmpauschale zu SPP 1386 Nanostrukturierte Thermoelektrika: Theorie, Modellsysteme und kontrollierte Synthese. Nanostructure, thermoelectric properties and transport theory of V2VI3 and V2VI3 IV-VI based superlattices*, 21.12.2012-20.12.2015 (29.800)

Further Cooperation, Consulting, and Technology Transfer

- Multicomponent Materials - Prof. Dr. F. Faupel, CAU Kiel. - Functional Nanomaterials - Prof. Dr. R. Adelung, CAU Kiel.

- General Materials Science - Prof Dr. H. Föll, CAU Kiel.

- Inorganic Functional Materials - Prof. E. Quandt, CAU Kiel.

- Magnetic Domains - Prof. Dr. McCord, CAU Kiel.

- Inorganic Chemistry - Prof. Dr. W. Bensch, CAU Kiel.

- Inorganic Chemistry - Prof. Dr. Johnson (Mercator Professor at CAU) University Oregon

- Institute of Physical and Theoretical Chemistry - Prof. Dr. W. Kunz, University of Regensburg.
- Thermoelectric Systems - Dr. H. Böttner, Fraunhofer Institut für Physikalische Messtechnik, IPM Freiburg.
- Theory of Solids - Prof. Dr. I. Mertig, Istitut für Physik, Martin-Luther-Universität Halle-Wittenberg.
- Institute of Polymers and Composites - Prof. Dr. K. Schulte, Technische Universität Hamburg-Harburg.
- Transmission Electron Microscopy - Institute of Nanotechnology - Dr. C. Kübel, Karlsruhe Institute of Technology.
- Inorganic Chemistry - Dr. Schlosser, University Regensburg.
- Laserzentrum Hannover e.V. - Dr. S. Barcikowski, Hannover.
- Department of Physics - Dr. A. K. Tyagi, Banaras Hindu University, India.
- NanoMEGAS SPRL - Dr. S. Nicolopulos, Brussels, Belgium.
- Physical Chemistry of Solids - Prof. Dr. J. Janek, Justus-Liebig-University, Giessen.
- Institute for Chemistry and Biochemistry - Prof. Dr. S. Schlecht, Justus-Liebig-University, Giessen.
- Electron Microscope and Elemental Analysis - Prof. Dr. Lotsch and Viola Duppel, MPI for Solid State Research, Stuttgart.
- Superconducting Materials - Dr. S. Fähler, IFW Dresden.
- MEMS Materials - Prof. Dr. A. Ludwig, Ruhr Universität, Bochum.
- Department of Chemistry - Prof. Dr. Klonkowski, University of Gdansk.
- Department of Chemistry - Prof. Dr. Kanatzidis, University Illinois.

Diploma, Bachelor's and Master's Theses

Julian Strobel, *Ferroelastische Untersuchungen an ferroelektrisch ''hart'' dotierten Pb(Zr,Ti)O_3 Keramiken*, 31.08.2012
Niklas Wolff, *Synthese und Realstruktur komplexer Telluride*, 13.09.2012

Publications

Published in 2012

M. Mecklenburg, A. Schuchardt, Y.K. Mishra, S. Kaps, R. Adelung, A. Lotnyk, L. Kienle, K. Schulte, *Aerographite: Ultra Lightweight, Flexible Nanowall, Carbon Microtube Material with Outstanding Mechanical Performance*, Adv. Mater., **24(26)**, 3486 - 3490 (2012)

F.N. Sayed, O.D. Jayakumar, R. Sasikala, R.M. Kadam, S.R. Bharadwaj, L. Kienle, U. Schürmann, S. Kaps, R. Adelung, J.P. Mittal, A.K. Tyagi, *Photochemical Hydrogen Generation Using Nitrogen-Doped TiO_2-Pd Nanoparticles: Facile Synthesis and Effect of Ti^{3+} Incorporation*, J. Phys. Chem. C, **116(23)**, 12462 - 124667 (2012)

M. Winkler, X. Liu, J.D. König, L. Kirste, H. Böttner, W. Bensch, L. Kienle, *Sputtered p-Type Sb_2Te_3/$(Bi,Sb)_2Te_3$ Soft Superlattices Created by Nanoalloying*, J. Electron. Mater., **41(6)**, 1322 - 1331 (2012)

S. Marauska, V. Hrkac, T. Dankwort, R. Jahns, H.J. Quenzer, R. Knöchel, L. Kienle, B. Wagner, *Sputtered thin film piezoelectric aluminum nitride as a functional MEMS material*, Microsyst. Technol., **18(6)**, 787 - 795 (2012)

E. Lage, C. Kirchhof, V. Hrkac, L. Kienle, R. Jahns, R. Knöchel, E. Quandt, D. Meyners, *Exchange biasing of magnetoelectric composites*, Nat. Mater., **11(6)**, 523 - 529 (2012)

B. Gojdka, V. Zaporojtchenko, V. Hrkac, J. Xiong, L. Kienle, T. Strunskus, F. Faupel, *Highly versatile concept for precise tailoring of nanogranular composites with a gas aggregation cluster source*, Appl. Phys. Lett., **100(13)**, 133104 (2012)

M. Kellermeier, E. Melero-Garcia, F. Glaab, J. Eiblmeier, L. Kienle, R. Rachel, W. Kunz, J.M. Garcia-Ruiz, *Growth Behaviour and Kinetics of Self-Assembled Silica-Carbonate Biomorphs*, Chem. Eur. J., **18(8)**, 2272 - 2282 (2012)

M. Winkler, X. Liu, J.D. König, S. Buller, U. Schürmann, L. Kienle, W. Bensch, H. Böttner, *Electrical and structural properties of Bi_2Te_3 and Sb_2Te_3 thin films grown by the nanoalloying method with different deposition patterns and compositions*, J. Mater. Chem., **22(22)**, 11323 - 11334 (2012)

X. Qiao, X. Fan, Y. Pan, A. Lotnyk, L. Kienle, *Microstructure and luminescence of Yb^{3+}-doped fluorosilicate glass ceramics*, Mater. Res. Bull., **47(1)**, 29 - 34 (2012)

Y.K. Mishra, V.S.K. Chakravadhanula, V. Hrkac, S. Jebril, D.C. Agarwal, S. Mohapatra, D.K. Avasthi, L. Kienle, R. Adelung, *Crystal growth behaviour in Au-ZnO nanocomposite under different annealing environments and photoswitchability*, J. Appl. Phys., **112(6)**, 64308 (2012)

U. Schürmann, M. Winkler, J.D. König, X. Liu, V. Duppel, W. Bensch, H. Böttner, L. Kienle, *In Situ TEM Investigations on Thermoelectric Bi_2Te_3/Sb_2Te_3 Multilayers*, Adv. Eng. Mater., **14**, 139 - 143 (2012)

N. Alissawi, V. Zaporojtchenko, T. Strunskus, T. Hrkac, I. Kocabas, B. Erkartal, V.S.K. Chakravadhanula, L. Kienle, G. Grundmeier, D. Garbe-Schonberg, F. Faupel, *Tuning of the ion release properties of silver nanoparticles buried under a hydrophobic polymer barrier*, J. Nanopart. Res., **14**, 928 (2012)

B. Erkartal, V. Duppel, R. Niemann, L. Schultz, S. Fahler, U. Schürmann, L. Kienle, *Structure and Composition of Magnetocaloric Ni-Mn-In-Co Thin Films on the Nanoscale - A TEM Study*, Adv. Eng. Mater., **14**, 710 - 715 (2012)

C. Bechthold, A. Lotnyk, B. Erkartal, L. Kienle, E. Quandt, *Structural Characterization of Sputtered $Fe_{70}Pd_{30}$ Thin Films During Ex Situ and In Situ TEM Heating*, Adv. Eng. Mater., **14**, 716 - 723 (2012)

G.M. Friederichs, I. Schellenberg, R. Pottgen, V. Duppel, L. Kienle, J.S.A. der Gueinne, D. Johrendt, *Metastable 11 K Superconductor $Na_{1-g}Fe_{2-x}As_2$*, Inorg. Chem., **51**, 8161 - 8167 (2012)

B. Gojdka, V. Hrkac, J. Xiong, M. Gerken, L. Kienle, T. Strunskus, V. Zaporojtchenko, F. Faupel, *A critical evaluation of the 0-3 approach for magnetoelectric nanocomposites with metallic nanoparticles*, J. Appl. Phys., **112**, 44303 (2012)

S. Buller, C. Koch, W. Bensch, P. Zalden, R. Sittner, S. Kremers, M. Wuttig, U. Schürmann, L. Kienle, T. Leichtweiss, J. Janek, B. Schönborn, *Influence of Partial Substitution of Te by Se and Ge by Sn on the Properties of the Blu-ray Phase-Change Material $Ge_8Sb_2Te_{11}$*, Chem. Mater., **24**, 3582 - 3590 (2012)

M. Kellermeier, D. Gebauer, E. Melero-Garcia, M. Drechsler, Y. Talmon, L. Kienle, H. Colfen, J.M. Garcia-Ruiz, W. Kunz, *Colloidal Stabilization of Calcium Carbonate Prenucleation Clusters with Silica*, Adv. Funct. Mater., **22**, 4301 - 4311 (2012)

F. Niefind, J. Cruz-Reyes, M. Del Valle, L. Kienle, A. Lotnyk, G. Alonso-Nunez, M. Armbruster, W. Bensch, *Effect of Activation Method on the HDS Activity of Unsupported CoMoS Catalysts Prepared from a Novel Precursor*, Catal. Lett., **142**, 1312 - 1320 (2012)

S.N. Britvin, O.I. Siidra, A. Lotnyk, L. Kienle, S.V. Krivovichev, W. Depmeier, *The fluoride route to Lindqvist clusters: Synthesis and crystal structure of layered hexatantalate $Na_8Ta_6O_{19}$ center dot $26H_2O$*, Inorg. Chem. Commun., **25**, 18 - 20 (2012)

M. Winkler, X. Liu, U. Schürmann, J.D. König, L. Kienle, W. Bensch, H. Böttner, *Current Status in Fabrication, Structural and Transport Property Characterization, and Theoretical Understanding of Bi_2Te_3/Sb_2Te_3 Superlattice Systems*, Z. Anorg. Allg. Chem., **638**, 2441 - 2554 (2012)

V.S.K. Chakravadhanula, C. Kübel, V. Hrkac, V. Zaporojtchenko, T. Strunskus, F. Faupel, L. Kienle, *Surface segregation in TiO_2-based nanocomposite thin films*, Nanotechnology, **23**, 495701 (2012)

Presentations

V. Hrkac, L. Kienle, *Structural Characterization of Thin Films using TEM*, Statusseminar des SFB 855 Frühjahrsworkshop, Oeversee, Germany, 07.-09.03.2012

L. Kienle, *PED for material science and fundamental research*, Electron Crystallography conference at KIT, Karlsruhe, Germany, 19.03.2012

M. Winkler, J.D. König, H. Böttner, X. Liu, W. Bensch, U. Schürmann, L. Kienle, *Sputtered p-type $Sb_2Te_3/(Bi,Sb)_2Te_3$ soft superlattices fabricated by nanoalloying with high structural and thermoelectric quality,* E-MRS Spring Meeting, Strasbourg, France, 14.-18.05.2012

L. Kienle, *Real structure of TiNi based devices,* Begutachtung SPP 1599, Dresden, Germany, 26.06.2012

M. Winkler, J.D. König, H. Böttner, X. Liu, W. Bensch, U. Schürmann, L. Kienle, *Break: Fabrication and comprehensive characterization of nanoalloyed nanostructured V_2VI_3 thin film materials,* Workshop ''Thermoelectric Properties related to nanostructure and dimensionality in Bi_2Te_3 nanomaterials'', GSI, Darmstadt, Germany, 05.-06.07.2012

H. Böttner, M. Winkler, J.-D. König, X. Liu, W. Bensch, U. Schürmann, L. Kienle, F.N. Hinsche, P. Zahn, B.Y. Yavorsky, *Some new insights for nanoalloyed thermoelectric Bi_2Te_3/Sb_2Te_3-superlattices,* ICT 31^{st} International and 10^{th} European, Aalborg, Denmark, 09.-12.07.2012

L. Kienle, *Application of TEM in Material Science,* Talk at Fraunhofer IOM Leipzig, Leipzig, Germany, 10.07.2012

B. Erkartal, S. Hamann, E. Simsek, A. Ludwig, L. Kienle, *TEM Investigations of Fe-Pd-X (X = Pt, Mn, Cu) Ferromagnetic Shape Memory Thin Films,* MSE Materials Science and Engineering Congress, Darmstadt, Germany, 24.-26.08.2012

L. Kienle, *Transmission Electron Microscopy in Fundamental Research and Materials Science,* Keynote Lecture at IUMRS, Busan, South Korea, 28.08.2012

L. Kienle, *Nanoanalytics on Memristors,* Workshop ''Memristor'', Kiel, Germany, 04.09.2012

L. Kienle, *Projekt Z1- Statusbericht und Zukunft,* SFB 855 Fall Meeting, Leck, Germany, 10.09.2012

M. Winkler, J.D. König, H. Böttner, X. Liu, W. Bensch, U. Schürmann, L. Kienle, *Energy efficiency by nanoscale thermoelectric materials,* 16. Vortragstagung der Fachgruppe Festkörperchemie und Materialforschung, Darmstadt, Germany, 17.-19.09.2012

L. Kienle, *Moderne Elektronenmikroskopie in den Materialwissenschaften,* Talk at ''Saturday Morning Physics'', Kiel, Germany, 01.12.2012

Further Activities and Events

Prof. Dr. L. Kienle is author of the Römpp encyclopaedia.

Prof. Dr. L. Kienle is board member of the KNMF user committee.

almanach 12

CMA Centre for Materialanalytics

Executive board: Prof. Dr. F. Faupel, Prof. Dr. H. Föll, Prof. Dr. B. Wagner, Prof. Dr. W. Jäger, Prof. Dr. E. Quandt, Prof. Dr. J. McCord, Prof. Dr. R. Adelung, Prof. Dr. C. Selhuber-Unkel, Prof. Dr. L. Kienle.

Within the Institute for Materials Science the various groups and chairs possess advanced equipment for preparation and analysis, including electron microscopy and photoelectron spectroscopy among others, in the recently established Nanolab.

The main tasks of the CMA include, but are not restricted to:

- support of scientific cooperation, service and consulting for industry and research institutes,
- materials characterization, e.g. structure and properties of thin films, surface topography and spectroscopy, materials testing, in particular testing of mechanical properties,
- allocation of modern equipment and scientific knowledge with respect to materials testing and analysis of modern materials for internal and external users,
- extension of the available experimental methods by resource sharing with other institutions within suitable cooperations,
- support of students (bachelor's, master's and PhD) within their respective theses,
- support during study courses by various lectures and experimental courses in modern analytical methods, materials testing and investigations with transmission electron microscopy,
- support of students during job-seeking through various contacts to (local) industry and research institutes.

Personnel

Head of the group: Dr. O. Riemenschneider; Secretary: M. Wallisch (75 percent)
Technical Staff: Dipl.-Ing. K. Rath (85 percent)

Scientific Staff:

Dipl.-Min. M. Schwitzke	01.01.-31.12.2012	(50%)

Lectures, Seminars, and Laboratory Course Offers

Summer 2012

Grundpraktikum für Ingenieure II, Dienstagskurs, 3 hrs Lab/Week,
K. Scholz (+ L. Wienbrandt, O. Riemenschneider)

Grundpraktikum für Ingenieure II, Mittwochskurs, 3 hrs Lab/Week,
K. Scholz (+ L. Wienbrandt, O. Riemenschneider)

Grundpraktikum für Ingenieure II, Donnerstagskurs, 3 hrs Lab/Week,
K. Scholz (+ L. Wienbrandt, O. Riemenschneider)

Einführung in die Materialwissenschaft II, 3 hrs Lecture/Week,
K. Rätzke (+ O. Riemenschneider)

Advanced Lab Course, 3 hrs Lab/Week,
O. Riemenschneider (+ scientific staff of the Inst. f. Materials Science)

Tutorial for Junior Students, 1 hrs Seminar/Week,
O. Riemenschneider

Tutorial for Senior Students, 1 hrs Seminar/Week,
O. Riemenschneider

Übungen Physikalische Chemie 1 für Materialwissenschaftler, 2 hrs Exercise/Week,
O. Riemenschneider

Tutorial für Bachelorstudierende Junior, 1 hrs Seminar/Week,
O. Riemenschneider

Tutorial für Bachelorstudierende Senior, 1 hrs Seminar/Week,
O. Riemenschneider

Übungen zur Chemie für Materialwissenschaftler, 1 hrs Exercise/Week,
O. Riemenschneider

Winter 2012/2013

Tutorial for Junior Students, 1 hrs Seminar/Week,
O. Riemenschneider

Tutorial for Senior Students, 1 hrs Seminar/Week,
O. Riemenschneider

Basic Lab Course, 3 hrs Lab/Week,
O. Riemenschneider (+ Emmanuel Ossei-Wusu, A. Kulkarni, E. Lage, M.Q. Shaikh, S. Kaps, M. Schwitzke)

Einführung in die Materialwissenschaft I, 2 hrs Lecture/Week,
O. Riemenschneider (+ K. Rätzke)

Tutorial für Bachelorstudierende Junior, 1 hrs Seminar/Week,
O. Riemenschneider

Tutorial für Bachelorstudierende Senior, 1 hrs Seminar/Week,
O. Riemenschneider

Grundpraktikum für Ingenieure I, Montagskurs, 3 hrs Lab/Week,
K. Scholz (+ O. Riemenschneider, L. Wienbrandt)

Grundpraktikum für Ingenieure I, Dienstagskurs, 3 hrs Lab/Week,
O. Riemenschneider (+ L. Wienbrandt)

Grundpraktikum für Ingenieure I, Mittwochskurs, 3 hrs Practical/Week,
K. Scholz (+ O. Riemenschneider, L. Wienbrandt)

Materialanalytik 2 Praktikum, 4 hrs Lab/Week,
O. Riemenschneider (+ M. Schwitzke)

Third-Party Funds

contract work, *maintenance and expansion of equipment,* 01.01.-31.12.2012 (3.846,90 EUR)

Further Cooperation, Consulting, and Technology Transfer

Cooperation with Industry:

1. Element22, Kiel,
2. Bosch GmbH, Salzgitter,
3. Fa. Anasyn, Tübingen,
4. HDW, Kiel,
5. BPB, Hamburg,

Cooperation with Institutes:

1. Graduiertenschule.

Industrial and Academic cooperation includes:

- dealing with inquiries and consulting regarding damage analysis, material selection, and surface treatment,
- general consulting,
- single and serial analysis of damage analysis of material characteristics, of compounding techniques, and material application,
- material analysis on the micro and macro scale.

Functional Morphology and Biomechanics At Zoological Institute

Prof. Dr. Stanislav Gorb is the Director at the Zoological Institute of the CAU.

The research of the department of Functional Morphology and Biomechanics includes approaches of several disciplines: zoology, botany, structural biology, biomechanics, physics, and materials science. Using a wide variety of methods, the group studies the mechanical systems and materials that have evolved in nature. The research is mainly focused on biological surfaces specialized for enhancement or reduction of frictional and/or adhesive forces. Such surfaces are composed of highly-specialized materials and bear surface structures optimized for a particular function. Some of these systems employ secretory substances that modulate forces in the contact area.

In order to show different functional principles, the group experimentally tests many different systems and tries to outline general rules of the interrelationship between structure and function. Since comparative studies on the microsculpture, ultrastructure, material properties, and attachment/detachment performances of several functional systems include a wide variety of organisms, some questions about the evolution of these systems can be resolved.

The results obtained are useful for high-tech areas, such as micro- and nanotechnology, as well as for bionics (biomimetics) of novel surface-active and composite materials.

The group employs a staff of 15 people

Further information about Department of Functional Morphology and Biomechanics is available on the web: http://www.uni-kiel.de/zoologie/gorb/topics.html

Prof. Dr. Stanislav N. Gorb
Department of Functional Morphology and Biomechanics
Zoological Institute of the University of Kiel
Am Botanischen Garten 1-9
D-24098 Kiel
Deutschland/Germany
Tel. + 49-431/880-4513
Fax + 49-431/880-1389
sgorb@zoologie.uni-kiel.de

Fig. 1:

almanach 12

Deanship

Results

The Dean's office is the administrative centre of the Faculty of Engineering and therefore responsible for managing the total budget including current costs, investments, and personnel costs. For the two institutes of the faculty that are located in Kiel-Gaarden, the Dean's office is also responsible for the computer operating services, the building services, and the mechanical workshop. The Dean's office is directed by Dr. Frank Paul the head of the administration of the faculty.

To fulfil all these tasks there are 18 persons in the Dean's office. In 2012 the deanship was led by Prof. Dr.-Ing. Reinhard Knöchel and Prof. Dr. Franz Faupel was one of the Vicedeans; Vicedean Prof. Dr. Manfred Schimmler resigned from the position of a Vicedean in the summer of 2011.

The year 2012 was strongly affected by financial problems again; the budget was low as in 2011. Nevertheless this did not affect the continuing, substantial output of the staff.

Fig. 1: Closing ceremony in Summer 2012

Worth mentioning is the successful negotiation with newly appointed professors. As one of the first three new professors of the faculty, Dr. Thomas Meurer became professor in the spring of 2012, replacing Prof. Dr.-Ing. Helmut Röck who retired.

Besides the impressive scientific work of the different groups that is reflected in this Almanac, the raising of a respectable amount of third party funding has to be mentioned.

With a view to the future development of the faculty a very important decision was taken by the President of the University and the government. The two institutes of the faculty which are located on the east side of Kiel will remain at that location for at least the next 20 years. This decision is a necessary and reliable base for the future development plans of the faculty.

To attract more female students, in 2010 the faculty signed a cooperation agreement with Life e.V., the national agency of the project tasteMINT: tasteMINT is a potential assessment method to show girls their ability for MINT-topics. On March 10 staff members of all three departments joined a one week training course and obtained certificates as observers for tasteMINT. Two assessments were offered, one in March and one in September, and were attended by 22 girls. Both events were arranged and chaired by Dr. Ina Pfannschmidt, the equal opportunities officer of the faculty. At the nationwide Girls' Day on April 14th one group from Electrical Engineering and Information Technology and five from the department of

Computer Science gave some first insights into the study programmes and work at the faculty. Altogether 80 girls from all parts of Schleswig-Holstein took the chance to visit the different projects.

The Faculty of Engineering focuses on high-quality education. A basis of the evaluation of lectures and practical courses is the anonymous students' inquiry by means of EvaSys. Every term all mandatory lectures and exercises as well as some of the other modules are evaluated. After the evaluation all results are distributed to the lecturers who discuss them with the students. Additionally, the results are sent to the three departments, where different evaluation algorithms are implemented. The acceptance of the evaluation procedure can be estimated by means of the following figures: in winter 2010/11 the students supported the evaluation with 833 evaluations in 71 modules and in summer 2011 with 767 in 67 modules.

Fig. 2: ''Gardener Kulturtage 2012''

Finally, once again the skilful organization by the Dean's office, of the contest ''Jugend forscht - Schüler experimentieren'' in Schleswig-Holstein should be noted. After participating in the regional contest about 50 young participants were guests of the Faculty of Engineering in March 2011. Later in May many members of the faculty were involved in the organization of the federal contest of Jugend forscht. In 2011 this competition was held for the first time in Schleswig-Holstein and we are proud to say that it was a big success.

Personnel

Head of the group: Dr. F. Paul (Managing Director);

Staff:

S. Anders 01.01.-31.12.2011
Head Adminstrator for Staff and Budget Department

U. Bruse 01.01.-31.12.2011
Division Manager of Building Services

M. Burmeister 01.01.-31.12.2011
Division Manager of the Mechanical Workshop

R. Doose 01.01.-31.12.2011
Caretaker

I. Erichsen	01.01.-30.11.2011	
Budget Department		
M. Firnau	01.01.-31.12.2011	
Division Manager of Computer Service Department		
S. Fischer	01.01.-31.12.2011	
Trainee		
M. Hacker	01.01.-31.12.2011	
Secretary of Budget Department		
D. Johannsen	01.06.-31.12.2012	(50%)
Secretary of Budget Department		
S. Johnsen	01.01.-31.12.2011	
Employee of the Mechanical Workshop		
S. Keller	01.08.-31.12.2011	
Trainee		
M. Kulling	01.01.-31.12.2011	
Employee of the Mechanical Workshop		
C. Martin	01.01.-31.12.2011	
Administrator Deans Office		
S. Moeller	01.01.-31.12.2011	
Secretary of Staff Department		
B. Neumann	01.01.-31.12.2011	
Vice Devision Manager of the Mechanical Workshop		
C. Newe	01.01.-31.12.2011	
Administrator Computer Service Department		
M. Quedens	01.03.-31.12.2011	
Electrician		
T. Wengler	01.01.-31.12.2011	(50%)
Aministrator Deans Office		
E. Wetendorf	01.09.-31.12.2012	
Trainee		

almanach 12

Friends of the Faculty of Engineering

Friends of the Faculty of Engineering

Executive Council:

Dr. Philipp Murmann (President),

Dr. Jörn Biel (Vice-president),

Prof. Dr. Helmut Föll (Vice-president),

Prof. Dr. Dr. Marcus Porembski (Treasurer),

Dr. Frank Paul (Secretary),

Prof. Dr.-Ing. Reinhard Knöchel (Assessor)

Prof. Dr. Franz Faupel (Assessor),

Prof. Dr. Reinhard von Hanxleden (Assessor),

Herbert Jacobs (Assessor).

Auditors: Prof. Dr. Michael Hanus, Prof. Dr.-Ing. Gerhard Schmidt.

Results

''Zweck des Vereins ist die Förderung von Wissenschaft und Forschung, Studium und Lehre durch Unterstützung der Technischen Fakultät.

Der Verein pflegt die Beziehungen zwischen der Technischen Fakultät einerseits, der Wirtschaft und ihren Organisationen, den Studierenden, den Absolventen sowie ehemaligen Fakultätsangehörigen andererseits.

Er bietet dazu ein Forum für den Gedankenaustausch zwischen den Wissenschaftsdisziplinen Technik, Naturwissenschaft, Geistes-, Sozial- und Gesellschaftswissenschaften sowie der Fakultät und der Wirtschaft.

Mitglieder des Vereins sind Unternehmen, Institutionen und Personen, die die Technische Fakultät in ihren Zielen und ihrem Wirken unterstützen und begleiten.''

''The purpose of the Friends of the Faculty is the encouragement of science and research, study, and teaching, by supporting the Faculty of Engineering.

The Friends of the Faculty network the faculty with its finances and institutions on the one hand, and with the students, graduates, and alumni on the other.

The Friends of the Faculty present a forum for the exchange of ideas between the different disciplines of technology, science, philosophy, social science, and the economy.

Members are companies, institutions, and persons who support and encourage the faculty with its aims and its tasks.''

During 2012 the Friends of the Faculty were active concerning the basic ideas above. Many different projects were supported and prizes awarded for the best diploma, bachelor´s, master´s and doctoral theses. These prizes should help the young scientists to make successful careers within the economy as well as in the scientific community.

Further activities covered the financial support of a visit by young students to the most important industrial fair in Germany if not Europe, the ''Hanover fair'', of organizing the ´Girls' day´, and many other activities of the faculty´s students. Also events like the „Sommerfest" and the „Winterfest" were made possible by the help of the Friends of the Faculty.

A very important task was the financing of the important competition ''Jugend forscht - Schüler experimentieren''. Using good contacts to different companies, donations were collected to help the faculty organize this important contest of young scientists. The intention is to cover the costs of the contest for the following years and to get more talented young students for the engineering and computer science study courses. In the recent past many former participants finished their study courses at Kiel University successfully.

The current number of members leaves room to welcome new recruits. Although some have left the Friends of the Faculty the overall number of members could be increased slightly.

Service Centre

The Service Centre at the Faculty of Engineering was launched in Spring 2009. It is a joint corporation of the Institute of Electrical and Information Engineering and the Institute for Materials Science. The Service Centre is managed by assistants from the two institutes who are subordinated to the managing directors of the institutes. In addition, the examination offices of the two institutes, with three employees and a secretariat with one employee, belong to the Centre. The task of the Service Centre is to organize centrally (as far as it is possible) all issues related to studies, teaching and laboratory courses as well as examinations for the study programmes of both institutes.

The following tasks belong to the above-named fields:

Studies:

- accreditation and re-accreditation of study courses,
- design and development of study and examination regulations,
- capacity calculation,
- public relations, e.g. information days and hosted programmes at schools, tasteMINT,
- advertisement for the different study courses,
- collecting and evaluating applications for the study courses in Materials Science,
- mentoring and supervising students, not only in topics related to study courses but also for foreign students with respect to daily life in Germany.

Teaching and laboratory courses:

- coordination of schedules for all study courses of the two institutes,
- coordination of rooms for all lectures of the two institutes,
- coordination of UnivIS entries,
- organization and administration of the joint basic laboratory courses.

Lab support:

- centralized purchasing of gas.

Examination offices:

- administration of student matters,
- administration of examination matters,
- preparation of transcripts.

The Service Centre, together with the Centre of Material Analysis, is located in building G on the East Shore Campus of the Faculty of Engineering.

Results

In 2012 the Service Centre dealt with more than 1081 students. Thus, the number of students enrolled in the study courses of both institutes increased again compared to the previous year. To take care of the records and documentation concerning this number of students the working hours of the employee in the examination office for Materials Science were increased from half-time to $\frac{3}{4}$ of a full position. The increase, with duration until March 2013, is financed by the University Board of the Christian Albrechts University.

The mean proportion of female students is still in the range of about 17 %. To gain a higher proportion both institutes participated in the programme tasteMINT, guided by the equal opportunities commissioner of the faculty.

For the past winter and summer term the Service Centre scheduled timetables of a total of 23 study terms offered by both institutes. More than 470 lectures, given by more than 40 teachers, were planned. The Service Centre has enabled an old class room to be reactivated and a second one to be enlarged at the facilities of the east side campus.

For the administration and organization of many lab courses in the study programmes offered by both institutes the Service Centre established a new online portal named ProSTi (Protokollstatus- und Termininformation). It allows the Service Centre to administrate the actual lab courses and the supervisors to enter the results of their corrections. The students have access to all this information as well as the appointments for their experiments. The tool was developed in cooperation with the Department of Computer Science.

To optimize the flow of the reports, and by this the running of the lab courses for the students, a new block of letter boxes was installed in the foyer of building G. By this means, every group has time-independent access to their corrected reports.

For the international master´s course in Materials Science and Engineering the Service Centre evaluated 160 applications from foreign students and 25 from national students. For this master´s course 77 of them were accepted and 44 started their studies in October 2012.

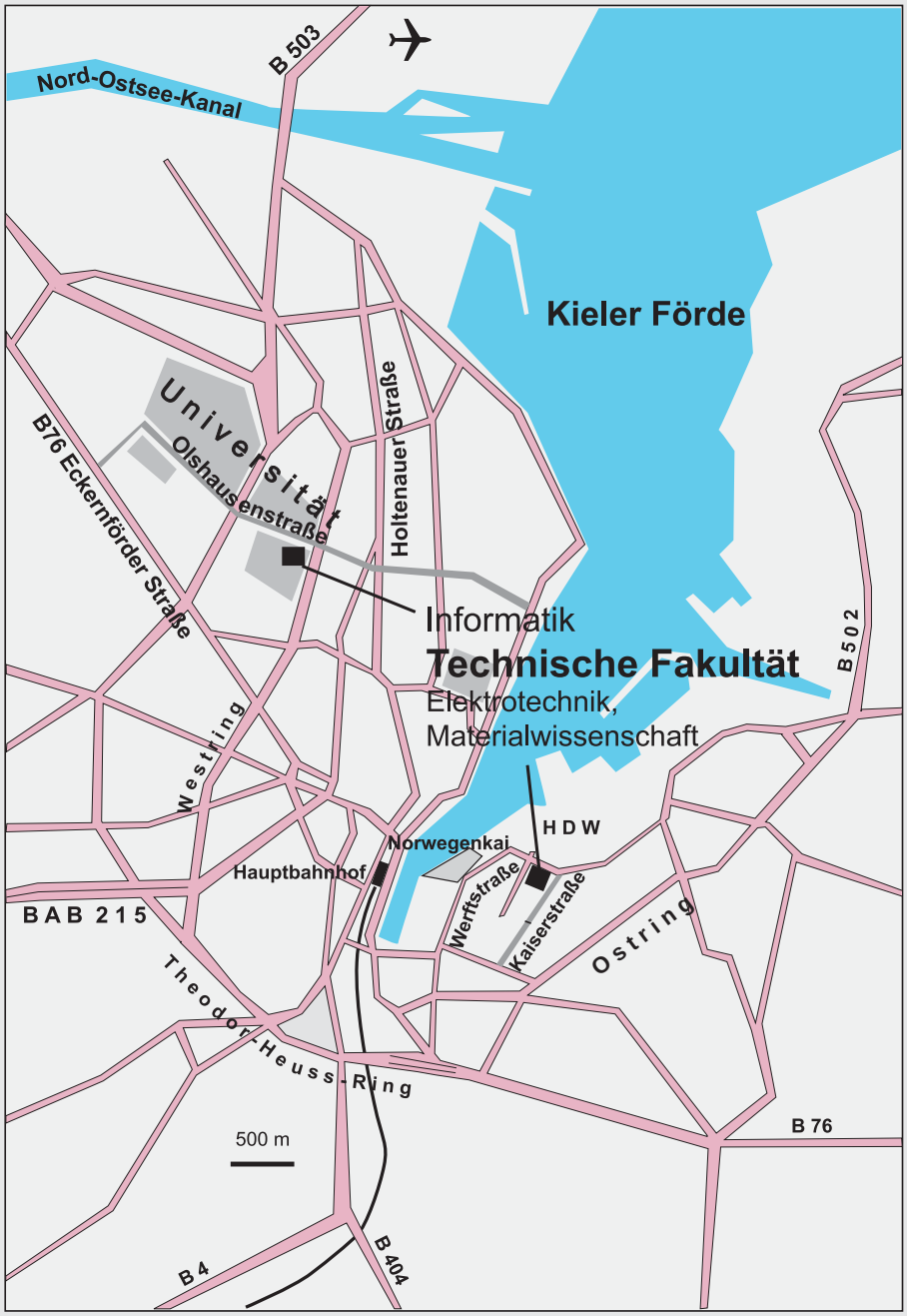
Personnel

Head of the group: Dr. Oliver Riemenschneider, Dr.-Ing. Kirstin Scholz; Secretary: Maren Wallisch (75 percent)
Technical Staff: Dipl.-Ing. (FH) Kay Rath (85 percent)

Staff:

Vera Nilsson	01.01.-31.12.2012	(50%)
Christiane Otte-Hüls	01.01.-31.12.2012	(50%)
Lars Struwe	01.01.-31.12.2012	

Scientific Staff:

Dipl.-Min. Marlies Schwitzke	01.01.-31.12.2012	(50%)

Technische Fakultät
Christian-Albrechts-Universität zu Kiel
Kaiserstr. 2, D-24143 Kiel
0431 880-6001, -6068, FAX -6003
dekanat@tf.uni-kiel.de
http://www.tf.uni-kiel.de