TECHNISCHE FAKULTÄT DER CHRISTIAN-ALBRECHTS-UNIVERSITÄT ZU KIEL

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almanach 11

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Christian-Albrechts-Universität zu Kiel

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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Preface

Dear Reader,

In the last year, the Faculty of Engineering (TF) continued to strive for excellence in research and teaching. In the eponymous Excellence Initiative, the application for a third Cluster of Excellence in "Materials for Life", in which the faculty is the leading applicant (Prof. Quandt is in charge of the conception), reached the final round in the application procedure as one of four universities in Germany in the field. This is already a major success. During his inaugural visit to Schleswig Holstein, the former President of the Federal Republic of Germany, Christian Wulff, together with the Prime Minister of Schleswig Holstein, Peter Harry Carstensen, visited the Nano-Laboratory of the Christian Albrechts University at the TF. Professor Quandt introduced the Nano-Laboratory as one of the most advanced laboratories of the University and as the experimental core of the research planned in the Cluster of Excellence "Materials for Life". President Wulff commented that he was impressed and appreciated the scien-tific merits in nanotechnology research at the CAU.

Two new Heisenberg Professors joined the faculty, at the Institute of Materials Science as well as the Institute of Computer Science in 2011: Prof. Jeffrey McCord for "Nanoscale Magnetic Materials" and Prof. Dirk Nowotka for "Dependable Systems. Heisenberg professorships are assigned and financed via the German Research Foundation in a very competitive process and have a high reputation in science. Prof. Christine Selhuber-Unkel received a Professorship for "Biocompatible Nanomaterials" after she was financed as a Junior-Professor via a prestigious Emmy-Noether-Award.

The International Microscopy Conference 2011 was held at the University of Kiel. The Conference was chaired by Prof. Wolfgang Jäger, who holds the professorship of Microanalysis of Materials in our faculty. Scientists and manufacturers met at the Bay of Kiel for 6 days, from August 28th to September 2nd, 2011, in order to discuss and exchange the latest developments in Instrumentation and Methods and current topics in Materials Science and Life Science.

Considering its teaching the TF was once more again very successfull as it was demonstrated by the enquiry of the bachelor students in 2011. The study courses at the TF were evaluated by the students and came within the top positions of the overall list of the university.

In contrast to the excellent scientific situation and successful teaching, the year 2010 ended for the Faculty of Engineering (TF) with highly disagreeable circumstances: a financial problem became obvious which was due to the fact that fixed costs have been permanently increasing (personnel, energy, location…), whereas the total budget has been limited for several years. As a consequence, the faculty had to undergo various structural changes and adaptations. Expenditures for 2011 had to be regulated in a revised manner, which allowed the budget at the end of the year to be kept and a part of the outstanding debts which had occurred during 2010 to be redeemed. Financial affairs are now seriously monitored, and, although painful financial changes could not be avoided, future financing is well under control. Nevertheless, it must be stated that the Faculty of Engineering - like the rest of the Christian-Albrechts University - is severely underfinanced, which is problematic in view of e.g. exploding energy costs and the demands in research and teaching.

On a note of sadness, Prof. Anton Heuberger, who held a professorship in Semiconductor Technology at the TF and was the director of ISIT, Itzehoe, for many years, passed away February 3, 2011.

Happier news are that Dipl.-Ing. Johannes von Hoyningen-Huene received the prestigious Alumni-Award, which was given by the Alumni-Club of the CAU for the first time.

Finally the year 2011 brought the decision, that major parts of the Technical Faculty, namely Materials Research and Electrical and Information Engineering, will definitely and permanently remain at the location in Kiel Gaarden, where they have been situated since the foundation in 1990. Time will tell if this decision, which was postponed from year to year for more than two decades, will be appropriate to fulfill the demands of the future. At least it is clear that major financial investments will be inescapable.

Department of Computer Science

The Department of Computer Science (Institut für Informatik) of the Christian-Albrechts-Universität zu Kiel was founded in 1971 as one of the first computer science departments in Germany. The research topics, which are described in detail in the subsequent pages, range from theoretical, practical, and technical computer science to applied computer science and applied mathematics.

Results

In 2011, we welcomed **Dr. Dirk Nowotka**, who since November has been Heisenberg-Professor for Dependable Systems in our department.

As of January 2011, a **KoSSE** (*Kompetenzverbund Software Systems Engineering, KoSSE*) office has been established based on a collaboration agreement between CAU, the University of Lübeck and the WTSH GmbH. On June 11th, the second KoSSE day took place in Lübeck with more than 100 participants. Prof. Wilhelm Hasselbring and Prof. Reinhard Koch were awarded a transfer award *Transferprämie* for the transfer of knowledge in KoSSE, by the Innovation Foundation (Innovationsstiftung) Schleswig-Holstein.

In April, a Memorandum of Understanding on the exchange of (doctoral) students in the area of semantic technologies was signed with the Malaysian Institute of Microelectronic Systems, on the initiative of Prof. Norbert Luttenberger.

Among the activities to attract students to computer science was the **Software Challenge**, led by Prof. Manfred Schimmler, where school pupils compete in a series of programming contests. After six contests restricted to Schleswig-Holstein, the contest 2011/12 which started in August 2011, is the first national one. The project's „innovative tutorial concept" was awarded with the *Innovationspreis des Allgemeinen Fakultätentages Informatik* in August.

Also at the *Fakultätentag Informatik*, Prof. Michael Hanus was elected onto its board for 2012-2014, where he will be involved in future developments of the CS curriculum at German universities.

Fig. 1: Prof. Dr. Manfred Schimmler (left) receives the award certificate for the project Software-Challenge-Germany from Prof. Dr. Hans-Ulrich Heiß, chairman of the *Fakultätentag Informatik*.

Movingart, led by Prof. Thomas Wilke, is a project to develop computer science skills among school children. Almost 400

pupils from 14 schools all over Schleswig-Holstein took part in the first contest in 2011 and used the Scratch software for designing computer animations. In both projects the participating classes are supported by staff from the department. To establish computer science as a subject in all schools, the department takes part in the instruction of teachers. Together with the Institute for Quality Development of Schools in Schleswig-Holstein (IQSH), the Institute participated in revising the annual training course for teachers who want to teach computer science as an additional subject.

50 pupils visited the one-week introductory programming course „Schnupperstudium" offered during their autumn holidays by Prof. Thomas Wilke and PD Frank Huch.

To attract women into computer science is the aim of several activities of the department, such as activities at the nationwide **Girls' Day** where female students visit the department from many schools around Schleswig-Holstein. Six members of the department took part in the establishment of the Projekt tasteMINT in the Faculty. After training for one week they were certified as observers for tasteMINT and applied their knowledge during the two tasteMINT events at the Faculty in 2011.

These activities seem to bear fruit because the steady increase of first year students in Computer Science also continued in the year 2011. Compared to 2010, the number of first year students increased by 30%. At the end of 2011, almost 1200 students were enrolled in Computer Science being 55% of all students in the Faculty of Engineering. Despite the resulting rather high student-staff ratio, currently at 85:1 in CS, one of the strengths of the department is certainly the good relationship between students and lecturers. There is a substantial, continued effort to provide a high-quality education, reflected for example in the teaching report (*Lehrbericht*) accessible to students and department members, which is jointly edited by lecturers and students. Conversely, for the fourth time the student representatives *(Fachschaft)* presented in 2011 the annual „Best Prof. Awards" that honour lecturers of the department. This year, members of the department received the „Best Prof Award" not only in the category „computer science" but also in the category „mathematics" . To further guide the improvement process of the CS degree programmes, a *Studienkommission* has been incorporated in 2011 where faculty members, other lecturers and students are involved in improving the degree programmes further.

Fig. 2: Prof. Dr. R. von Hanxleden, Prof. Dr. T. Wilke, PD Dr. F. Huch, and Dr. B. Langfeld received their Best-Prof. Award certificates at the annual award ceremony during the student-organized summer barbecue [Photo credit: *Institut für Informatik*].

One aim of this continuous improvement is to increase the number of graduates and to decrease the average duration of studies. In computer science, this is a notoriously difficult issue, as many students enter the field with false expectations and an insufficient background in mathematics. On average there were about 30 graduates in the years 2000 - 2009, well below half of the number of beginners. In 2010, the department set itself the goal of reaching 100 graduates

(bachelor & master) within five years. In 2011 there were 83 graduates in total, including 43 single-subject bachelors, of which 21 completed in six semesters and 10 in seven semesters. That means that roughly three quarters of the bachelors completed within one semester of the nominal duration of this degree programme. This is certainly a very positive trend, but considering the number of beginners (with CS and Business Information Technology over 200 in 2011) it is still not satisfactory. The majority of students still do not reach the goal of obtaining a degree in one of our programmes, and of those who fail, many realize this only very late in their studies. To help sufficiently qualified and motivated students to successfully complete their studies, and to help others to quickly re-orient themselves, will remain a challenge that we have to address.

On November 22nd the 3rd Kieler Business Information Technology Day took place at the CAU. This, by now established, event was organized by Prof. Andreas Speck, and took place in cooperation with the Kiel University of Applied Sciences and the *Berufsakademie der Wirtschaftsakademie Schleswig Holstein*.

Also in November, as an example of the publication awards received by members of the department, Prof. Klaus Tochtermann and co-authors Dr. Anna Köck and Birgit Fingerle received the Best Science Management Publication Prize for a paper on the future of libraries, in a competition among 1300 publications in that area. The same group also received the LIBER Award for Library Innovation 2011.

On December 2nd our traditional computer science day (Tag der Informatik) took place, which is a joint event with the „Winterfest" of the Faculty of Engineering. This event, organized by the group of Prof. Norbert Luttenberger, is now an established annual gathering of colleagues, students, employees, alumni, company representatives and friends of our department. This is reflected by the high and still rising attendance, (more than 250 participants now), as well as the continued support of our industrial supporters. For the first time, the event included handing over the awards of the Prof. Dr. Werner Petersen-Stiftung, and a newly established b+m-Prize in Software- and Systems-Engineering.

2011 concluded also with the launch of the **Kiel Computer Science Series** (KCSS). The scope of this series includes dissertations, habilitation theses, and text books in computer science. The KCSS is an open access publication, where the copyright of the publications remains with the authors and is not transferred to a publisher. The KCSS issues are freely available as electronic downloads (www.informatik.uni-kiel.de/kcss/), but can also be purchased via a print-on-demand publisher.

Personnel

Head of the group: Prof. Dr. R. von Hanxleden;
Technical Staff: C. Dort

Staff:

A. Bock	01.06.-31.12.2011	(50%)	CAU
Computer Science and Business Information Technology Examination office			
F. Lorenz	01.01.-31.12.2011	(50%)	CAU
Computer Science and Business Information Technology Examination office			
B. Scheidemann	01.01.-31.12.2011	(50%)	CAU
Computer Science and Business Information Technology Examination office			
Ä. Straßner	01.01.-31.12.2011		CAU
Computer Science Department's Office			

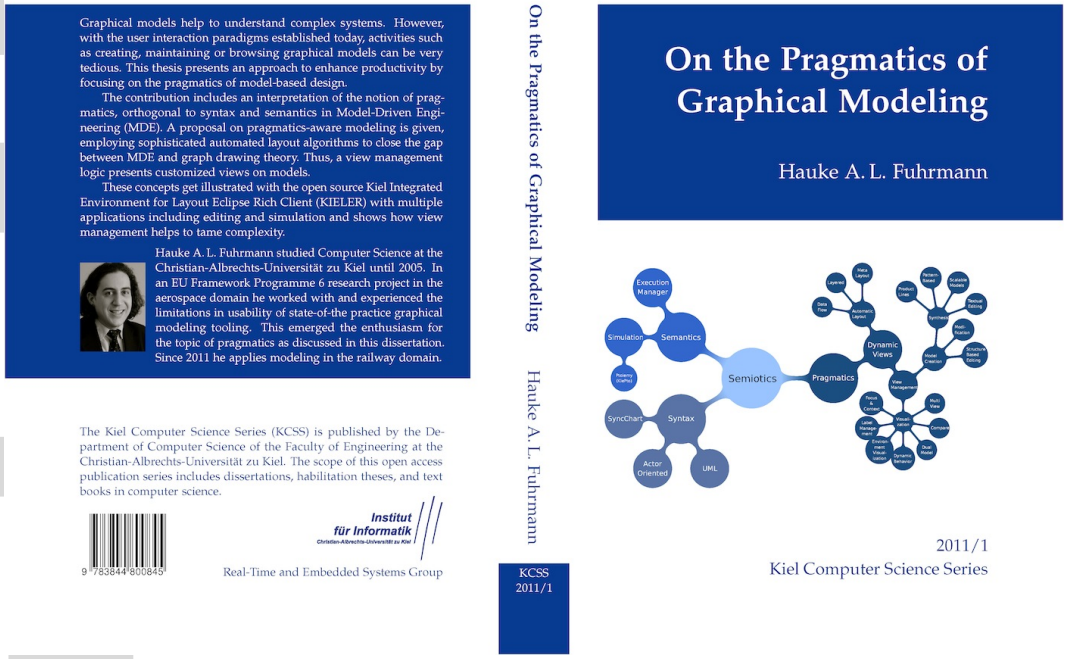


Fig. 3: The first issue of the Kiel Computer Science Series (KCSS).

Scientific Staff:

W. Burmeister	01.01.-31.12.2011	CAU
Computer Sciences Technic- Service		
PD Dr. F. Huch	01.01.-31.12.2011	CAU
Computer Science and Business Information Technology Examination office		
H. Krasemann	01.04.-30.09.2011	Lecturer
Privacy Protection		
D. Kähler	01.04.-31.12.2011	Lecturer
Computer Science Education		
Dr. H. Lindhorst	01.04.-30.09.2011	Lecturer
IT Law		
Dr. M. Margraf	01.10.-31.12.2011	Lecturer
IT Security		
Dr. I. Pfannschmidt	01.01.-31.12.2011	CAU
Computer Science Department's Office		
P. Pichol	01.01.-31.12.2011	CAU
Computer Sciences Technic- Service		
Dr. A. Salski	01.01.-31.12.2011	Lecturer
KI		

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

MS0306: Nebenläufige und verteilte Programmierung, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
F. Huch (+ B. Peemöller, K.-O. Kürtz)

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

Inf-FD1: Grundlagen fachbezogenen Lehrens und Lernens im Fach Informatik, 2 hrs Seminar/Week,
L. Willert

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

Summer 2011

Inf-FortProg: Fortgeschrittene Programmierung, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
F. Huch (+ T. Wilke, F. Reck, B. Peemöller)

Inf-FD3: Fachunterricht - Konzeption und Gestaltung im Fach Informatik, 2 (+ 2) hrs Seminar (+ Exercises)/Week,
D. Kähler (+ L. Willert)

TEF-info-FD1: Grundlagen fachbezogenen Lehrens und Lernens im Fach Informatik, 2 hrs Seminar/Week,
L. Willert

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

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

MS0507: Künstliche Intelligenz, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
A. Salski (+ A. Salski)

Winter 2011/2012

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

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

Inf-FD4: Fachdidaktisches Urteilen und Forschen sowie Weiterentwicklung von Unterrichtspraxis, 2 (+ 2) hrs Seminar (+ Exercises)/Week,
L. Willert (+ L. Willert)

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

Inf-FD2: Planung, Durchführung und Analyse von Unterricht im Fach Informatik, 2 hrs Seminar/Week,
D. Kähler

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

Further Activities and Events

A. Salski

Editorial board member (since 2005):

The International Journal „Ecological Informatics“ , Elsevier.

Member of programme committee:

The 8th International Conference on Ecological Informatics (ISEI8), August 20-22, 2012, Brasilia (Brazil).

Algorithmic Optimal Control - CO2 Uptake of the Ocean

The main goal of our working group is the use of methods of mathematical optimization, high performance computing, and uncertainty analysis, to validate and improve models and simulations of CO_2 uptake.

The amount of CO_2 in the ocean is mainly determined by ocean currents and biogeochemical processes. The simulation of these processes is important, for example, to investigate the future behaviour of the ocean as a CO_2 buffer for the increasing emissions into the atmosphere. Models of CO_2 uptake consist of equations for different tracers such as nutrients, phyto- and zooplankton. These models use many parameters that are fitted to measurement data. For this purpose, methods of mathematical optimization, high performance computing, and uncertainty analysis are used. Main challenges are the huge computational effort to spin up 3-D models to steady seasonal cycles in order to optimize them. Among other different optimization techniques, the algorithmic generation of sensitivities, and Newton-like methods for the computation of periodic states are used in the project.

The role of CO_2 in the ocean

CO_2 is a main topic in the discussion about climate change and climate protection strategies. It is one of the main greenhouse gases, i.e. it holds back a part of the radiation reflected from the earth's surface into the atmosphere. Thus, on the one hand, CO_2 is responsible for the comfortable warm climate on earth allowing us to survive at all, but on the other hand, the increase of CO_2 emissions in the last 200 years has caused a temperature rise with all its consequences such as sea ice melting, changes in vegetation etc. Climate model simulations indicate that these effects, summarized as global warming, will continue and even become stronger. Even though the atmospheric CO_2 is most discussed, its amount in the oceans is also very important. In fact, much more of this gas is dissolved in the oceans, and two thirds of the emitted CO_2 is taken up from the atmosphere via the sea surface. This effect thus mitigates the greenhouse effect, but, naturally, it also changes the chemical composition of the ocean water, leading for example to acidification. Moreover it is unclear how this mitigation property will change in the future due to global warming.

Modelling the CO_2 Uptake

The amount and distribution of CO_2 in the ocean is determined by the water circulation, by biochemical processes, namely the assimilation of CO_2 by phytoplankton (algae) and its mineralization by zooplankton (animals), and sedimentation. A well-accepted theory describes the relation of the amounts of CO_2 and nutrients that are converted to biomass by photosynthesis. Thus the CO_2 uptake is usually modelled in a system of transport (or advection-diffusion) equations for so-called tracers. The coupling relations between the tracers in these models are more or less empirical, i.e. it is not very clear what the coupling terms look like mathematically, and moreover, how many tracers have to be taken into account. Many model parameters are used: they are chosen such that the model results remain feasible (i.e. tracer concentrations remain non-negative) and that given measurement data are matched by the model output.

Results

The Consequences of Fukushima The software METOS3D enabled our group to easily simulate the distribution of radioactive water released into the Pacific from Fukushima in March 2011. It can be observed in these simulations that traces of iodine-131 vanish quickly and are not going to be distributed widely into the ocean. On the other hand, caesium-137 will take a couple of years to arrive at the North American coastline.

Surrogate-Based Optimization for Marine Ecosystem Models

The applicability of a marine ecosystem model for prognostic simulations crucially depends on its ability to resemble the actually observed physical and bio-geochemical processes. An assessment of the quality of a given model is typically based on its calibration against observed quantities. This calibration or optimization process is intrinsically linked to an adjustment of typically poorly known model parameters. Straightforward calibration attempts by direct adjustment of

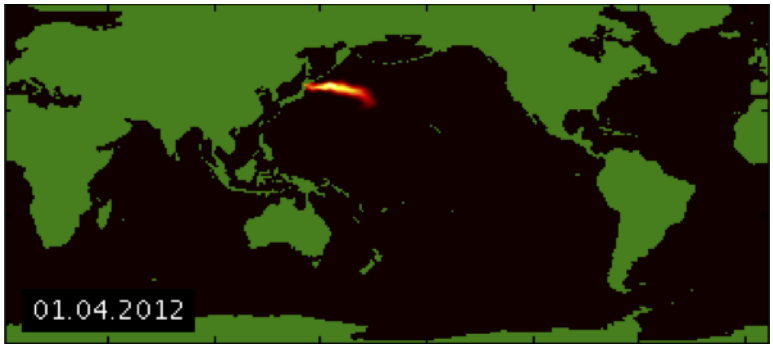


Fig. 1: Example for the calculated distribution of radioactive water released at the beginning of April, 2012.

the model parameters using conventional optimization algorithms are often tedious or even beyond the capabilities of modern computer power as they normally require a large number of simulations. This typically results in prohibitively high computational cost, particularly if already a single model evaluation involves time-consuming computer simulations.

The optimization of coupled hydrodynamical marine ecosystem models simulating biogeochemical processes in the ocean is a representative example. Computing times of hours up to several days for just a single model evaluation are not uncommon. A computationally efficient optimization of expensive simulation models can be realized, for example, using surrogate-based optimization (SBO). Therein, the optimization of the expensive, so-called high-fidelity (or fine) model is carried out by means of a surrogate, a fast but yet reasonably accurate representation of the fine model.

A multiplicative response correction approach turned out to be very suitable for the marine ecosystem models considered. It could be shown that a reliable surrogate can be obtained. Exploiting the latter in a surrogate-based optimization algorithm, a computationally cheap but yet accurate solution could be achieved. The optimization costs could be significantly reduced compared to a direct optimization of the expensive fine model (cf. Figure 2). Investigated models comprised both, a one- and a three-dimensional marine ecosystem model.

The proposed methodologies, particularly the multiplicative response correction approach, serve as initial parts of a set of tools for a computationally efficient calibration of marine ecosystem models. The investigation of further enhancements of the algorithms presented, as well as other promising approaches in the framework of surrogate-based optimization, will be highly valuable.

Personnel

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

Scientific Staff:

Dipl.-Math. M. El Jarbi Cluster Future Ocean A3	01.01.-31.12.2011		DFG
Dipl.-Math. A. Heinle Cluster Future Ocean A3	01.01.-31.12.2011		DFG
Dipl.-Math. C. Kratzenstein SPP 1253	01.01.-31.12.2011		DFG
Dr. H. Mütze Cluster Future Ocean A3	01.01.-31.12.2011	(50%)	DFG

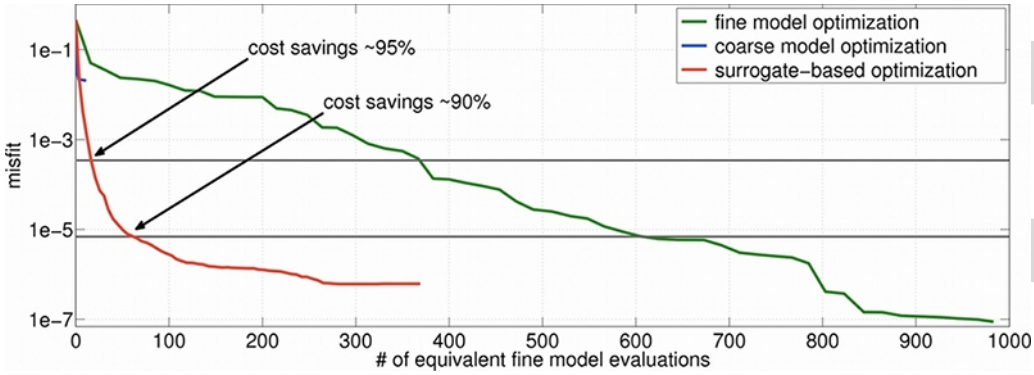


Fig. 2: Convergence of the misfit (least squares difference of the model response and the measurement data) of an illustrative SBO run for the calibration of a one-dimensional marine ecosystem model. Corresponding optimization costs for the SBO are significantly lower compared to a direct fine model optimization. The direct coarse model optimization is cheap but its solution is rather inaccurate (corresponding to a large misfit). Using SBO, achieved savings in the optimization costs amount to 90-95% (depending on the required accuracy of the solution). Optimization costs are measured in „equivalent" number of fine model evaluations, which comprise both the pure fine model as well as the cheaper coarse model evaluations involved in the SBO run.

Dipl.-Math. J. Piwonski Cluster Future Ocean A3	01.01.-31.12.2011		DFG
Dipl.-Phys. M. Prieß Cluster Future Ocean A3	01.01.-31.12.2011		DFG
J. Reimer CAU, Cluster Future Ocean	15.05.-31.12.2011	(50%)	CAU, DFG
Dipl.-Math. J. Rückelt Cluster Future Ocean A3	01.01.-31.12.2011		DFG

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

Numerische Mathematik und Optimierung, 2 hrs Seminar/Week,
T. Slawig (+ S. Börm, J. Burmeister)

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

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

Optimierung und Informatik in Meeres- und Klimaforschung, 2 hrs Projektmodul/Week,
T. Slawig

Optimierung und Informatik in Meeres- und Klimaforschung, 2 hrs Praktikum/Week,
T. Slawig

Algorithmische Optimale Steuerung/Klimasimulationen, 2 hrs Masterprojekt/Week,
T. Slawig

Summer 2011

Programmierpraktikum, 3 hrs Lab/Week,
T. Slawig (+ J. Piwonski, S. Schulmeister)

Programmierpraktikum für Mathematiker, 3 hrs Lab/Week,
T. Slawig (+ J. Piwonski, S. Schulmeister)

Optimierung und Informatik in Meeres- und Klimaforschung, 2 hrs Projektmodul/Week,
T. Slawig

Optimierung und Informatik in Meeres- und Klimaforschung, 2 hrs Praktikum/Week,
T. Slawig

Algorithmische Optimale Steuerung/Klimasimulationen, 2 hrs Masterprojekt/Week,
T. Slawig

ISOS Course: Introduction to Scientific Programming, 2 hrs Seminar/Week,
T. Slawig

Mathematik und Informatik in Klimamodellen, 2 hrs Seminar/Week,
T. Slawig

NIchtlineare Optimierung und Datenassimilation, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
J. Piwonski

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

Third-Party Funds

DFG SPP 1253, *Personal/Sachmittel,* 01.01.-31.12.2011 (47167 EUR)
DFG Cluster Future Ocean, *Personal/Sachmittel,* 01.01.-31.12.2011 (251384 EUR)

Further Cooperation, Consulting, and Technology Transfer

Prof. Dr. Andreas Oschlies, **IfM Geomar**, Kiel
Dr. Iris Kiest, **IfM Geomar**, Kiel
Prof. Dr. Anand Srivastav, **Institut für Informatik**, Kiel
Prof. Dr. Andreas Griewank, **MATHEON** and **Humboldt-Universität zu Berlin**, Berlin
Prof. Dr. Nicolas Gauger, **DLR Braunschweig** and **Humboldt-Universität zu Berlin**, Braunschweig/Berlin
Dr. Ira Neitzel, **Technische Universität Berlin**, Berlin
Dr. Uwe Prüfert, **TU Bergakademie Freiberg**, Freiberg
Prof. Dr. Slawomir Koziel, **Reykjavik University**, Reykjavik (Iceland)

Diploma, Bachelor and Master Theses

J. Reimer, *Entwicklung einer Toolbox mit Algorithmen zur optimalen Versuchsplanung am Beispiel von Überflutungsszenarien*, 25.02.2011
S. Mahmens, *Implementierung von 3D-Simulationsalgorithmen auf Grafikkarten*, 30.09.2011
B. Holst, *Visualisierung von 4D Ozeandaten*, 30.09.2011
X. Xu, *Restrukturierung und Weiterentwicklung eines Legacy-Codes für ein Klimamodell*, 31.03.2011
C. Roschat, *Lösung von Optimalsteuerproblemen unter Verwendung Greenscher Funktionen*, 31.07.2011

Publications

Published in 2011

M. Prieß, S. Koziel, T. Slawig, *Surrogate-Based Optimization of Climate Model Parameters Using Response Correction*, Journal of Computational Science, **2**, 335 - 344 (2011)
J. Reimer, *Die Experimental Design Toolbox zur optimalen Versuchsplanung*, Technische Berichte des Instituts für Informatik, Christian-Albrechts-Universität zu Kiel, **tr1106**, (2011)
I. Neitzel, U. Prüfert, T. Slawig, *A Smooth Regularization of the Projection Formula for Constrained Parabolic Optimal Control Problems*, Numerical Functional Analysis and Optimization, **32 (12)**, 1283 - 1315 (2011)
T. Slawig, U. Prüfert, *Mathematics-based Optimization in the COMSOL Multiphyscis Framework*, Proceeding of the COMSOL Conference Stuttgart 2011, (2011)
M. Prieß, S. Koziel, T. Slawig, *Improved Surrogate-Based Optimization of Climate Model Parameters Using Response Correction*, Conference Proceedings, Int. Conf. Simulation and Modeling Methodologies, Technologies and Appl., SIMULTECH 2011, 449 - 457 (2011)

Presentations

M. Prieß, *Surrogate-Based Optimization of Climate Model Parameters*, Workshop on Numerical Methods for Optimal Control and Inverse Problems, Garching, 14.-16.03.2011
C. Kratzenstein, *Parameter Identification in Ocean Modeling via Oneshot Optimization*, Workshop on Numerical Methods for Optimal Control and Inverse Problems, Garching, 14.-16.03.2011
T. Slawig, *Surrogate-based Optimization of Parameters in a Marine Ecosystem Model (Poster)*, EGU General Assembly 201, Vienna, Austria, 03.-08.04.2011
M. Prieß, *Surrogate-Based Optimization of Climate Model Parameters*, SIAM Conference on Optimization, Darmstadt, 16.-19.05.2011
T. Slawig, *Mathematik, Informatik und Klimaforschung*, Schleswig-Holsteinische Universitäts-Gesellschaft, Kiel, 30.06.2011
T. Slawig, *Automatic differentiation in Simulation and Optimal Control*, Virtuhcon-Seminar am Institut für Energieverfahrenstechnik der Technischen Universität Bergakademie Freiberg, Freiberg, 01.08.2011
M. Prieß, *Surrogate-Based Optimization of Climate Model Parameters*, International Workshop on Advances in Simulation-Driven Optimization and Modeling, Reykjavik, Island, 13.-14.08.2011
T. Slawig, *Optimization in Climate Models*, International Workshop on Advances in Simulation-Driven Optimization and Modeling, Reykjavik, Island, 13.-14.08.2011
T. Slawig, *Methods of Optimization and Control in Marine Science*, 25th IFIP TC 7 Conference on System Modeling and Optimization, Berlin, 12.-16.09.2011
A. Heinle, *Theoretical analysis and optimization of nonlinear ODE systems for marine ecosystem models*, 25th IFIP TC 7 Conference on System Modeling and Optimization, Berlin, 12.-16.09.2011
U. Prüfert, T. Slawig, *Mathematics-based Optimization in the COMSOL Multiphyscis Framework*, COMSOL Conference,

Stuttgart, 26.-28.10.2011

M. Prieß, *Surrogate-Based Optimization for Validation of Marine Ecosystem Models*, Group Meeting, IFM-GEOMAR, Kiel, 21.11.2011

Further Activities and Events

Joscha Reimer won the **Preis des Fördervereins der Technischen Fakultät** for his excellent master's thesis *Entwicklung einer Toolbox mit Algorithmen zur optimalen Versuchsplanung am Beispiel von Überflutungsszenarien*.

Anna Heinle participated as a tutor in „Girls' Day 2011" (" Der Ozean der Zukunft - Wie Modelle ihn darstellen").

Thomas Slawig co-organized a mini-symposium (" Surrogate-based Optimization in Engineering and Climate Science") during the SIAM Conference on Optimization in Darmstadt (16-19 May 2011).

Thomas Slawig organized a mini-symposium (" Parameter Optimization and Model Improvement") during the 25th IFIP TC 7 Conference on System Modelling and Optimization (12-16 September 2011).

Business Information Technology

The main focus of the working group is the support of systems development and integration by improved generation and validation concepts. Besides the development of systems, integration is a major problem in business information systems. Almost all of the commercial systems are composites, for example an ERP system is connected to an e-commerce system in order to realize a web shop.

The working group provides courses for the various computer science courses (bachelor's, master's and diploma). Moreover, the establishment of the new course in business information systems is supported by the working group.

Results

Innovative concepts for system generation support flexible generation. This facilitates an increased degree of re-use. For instance, this new concept may be applied in systems integration and the realization of systems communication.

Standard models (business processes) have been enhanced in order to improve the checkability of these models. The new model languages may be used to express both the model to be validated as well as the specification of the basis of the validation.

A current intention of our work in the domain of business process validation is enabling non checking experts (e.g. business domain experts) to use the checking concept in order to validate their processes.

Personnel

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

Scientific Staff:

Dipl.-Wirt.-Inf. Harm Brandt User Driven Innovation	01.01.-31.12.2011	(50%)	Interreg 4A
Dipl.-Wirt.-Inf. Harm Brandt	01.10.-31.12.2011	(50%)	HSP
Dipl.-Wirt.-Inf. Sven Feja	01.01.-31.12.2011		
Dipl.Inf. Aneta Lotycz	01.01.-31.12.2011	(50%)	
MBA Andreas Rusnjak	01.01.-30.09.2011		
Dipl.-Ing. Sören Witt	01.01.-31.12.2011	(50%)	
Dipl.Ing. Sören Witt	01.01.-31.12.2011	(50%)	

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

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

MS0703:-Qualitätssicherungsmanagement, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
A. Speck (+ S. Feja)

S5.1:-Seminar - Architekturen betrieblicher Systeme, 2 hrs Seminar/Week,
A. Speck

WBA5.1:- Projektvorbereitung - Modellierung und Entwicklung, 3 (+ 3) hrs Lecture (+ Exercises)/Week,
A. Speck (+ S. Feja, A. Rusnjak)

WWIa:-Bertriebliche Standardsoftware, 4 (+ 3) hrs Lecture (+ Exercises)/Week,
A. Speck (+ A. Rusnjak)

Summer 2011

WG2.2:-Grundlagen Wirtschaftsinformatik II, 3 (+ 1) hrs Lecture (+ Exercises)/Week,
A. Speck (+ S. Feja)

WA4.3:-Proseminar/ Projekt, 3 hrs Seminar/Week,
A. Speck

eCommerce Systeme, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
A.s Speck (+ S. Feja)

Marktorientierte und betriebliche Anwendungssysteme, 2 hrs Lecture/Week,
A. Speck (+ S. Feja, A. Rusnjak)

Winter 2011/2012

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

MS0703:-Qualitätssicherungsmanagement, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
A. Speck (+ S. Feja)

S5.1:-Seminar - Architekturen betrieblicher Systeme, 2 hrs Seminar/Week,
A. Speck

WBA5.1:- Projektvorbereitung - Modellierung und Entwicklung, 3 (+ 3) hrs Lecture (+ Exercises)/Week,
A. Speck (+ S. Feja, A. Rusnjak)

WWIa:-Bertriebliche Standardsoftware, 4 (+ 3) hrs Lecture (+ Exercises)/Week,
A. Speck (+ A. Rusnjak)

Third-Party Funds

EU Interreg 4A, *User Driven Innovation*, 01.01.-31.12.2011 (222460 EUR)

Diploma, Bachelor and Master Theses

B. Lebrecht, *Verifikation statischer Abhängigkeiten in MultiView basierten Prozessmodellen*, 30.09.2011

T. Sochart, *Konzipierung und Implementierung einer Webanwendung zur Administration einer LDAP-basierten Zugangsverwaltung für heterogene Anwendungssysteme*, 29.09.2011

T. Borreck, *Anwendung modernre Paradigmen und Techniken für den Entwurf und die Implementierung einer Rich Internet Application mit Ruby on Rails*, 12.10.2011

S. Masog, *Evaluation gängiger Ansätze zur Modellierung von Geschäftsprozessen hinsichtlich Konketisierung von Requirements aus der Business Modell Sicht*, 28.09.2011

A. Lange, *Evaluation ausgewählter Business Modell/Frameworks zur kreativen / informellen Erfassung von Requirements mit Blick auf Schnittstellen zu Geschäftsprozessen*, 30.09.2011

F. Grobosch, *System Dynamics-basierte Analyse einer Infrastruktur zur Vermeidung von E-Mail-Spam*, 30.09.2011
I. Michak, *Kennzahlen orientierte Datenschutzsicherung in Geschäftsprozessen*, 30.09.2011
C. Eggeling, *Verkaufsoptimierung durch Bedarfsanalyse und Einkaufsmengenoptimierung*, 29.09.2011
M. Lange, *Modellierung und Validierung von Datenschutz-Schutzzielen in Prozessmodellen*, 30.09.2011
B. Peters, *Mobile Couponing- Entwicklung eines Validierungssystems für die mobile Gutscheinverifikation*, 29.03.2011
D. Rath, *Der Einsatz von Social-Media-Instrumenten aus Sicht der Vater Unternehmensgruppe am Beispiel der Personalrecruiting*, 01.12.2011
H. Gerken, *Early Requirements Engineering als Managementaufgabe in technologiebasierten Unternehmen*, 30.06.2011
A. Asseily, *Agiler Entwicklungsprozess für Anwendungssoftware auf Smartphones*, 19.08.2011
S. August, *Validierung von Webservice basierten Sicherheitsmodellen und deren Transformation in Web Service Security Policy*, 30.09.2011

Publications

Published in 2011

A. Speck, S. Feja, E. Pulvermüller, M. Schulz, *Verification of e-Commerce Business Processes*, Electronic Business Interoperability: Concepts, Opportunities and Challenges, (2011)
A. Speck, S. Feja, S. Witt, E. Pulvermüller, A. Lotycz, *Framework for Business Process Verification*, 14th International Conference on Business Information Systems (BIS 2011), 50 - 60 (2011)
E. Pulvermüller, A. Speck, S. Feja, S. Witt, *Component Composition Validation*, The 10th International Conference on Software Methodologies, Tools and Techniques (SoMeT 2011), 5 - 19 (2011)
S. Feja, S. Witt, A. Speck, *BAM: A Requirements Validation and Verification Framework for Business Process Models*, 11th International Conference On Quality Software (QSIC 2011), 186 - 191 (2011)
A. Speck, S. Feja, S. Witt, E. Pulvermüller, M. Schulz, *Formalizing Business Process Specifiations*, Computer Science and Information Systems Journal (ComSIS), **8 (2)**, 427 - 446 (2011)
A. Speck, S. Feja, S. Witt, *Description of Protocol Rules*, INFORMATIK 2011 Informatik schafft Communities Proceedings der 41. GI Jahrestagung, (2011)
A. Rusnjak, M. Pohle, S. Krause, *Speed Creation Session: A way to increase the productivity of experts in projects and assure quality requirements*, Workshop on Requirements Prioritization for customer-oriented Software-Development (RePriCo'11), (2011)
A. Rusnjak, *Improving IT-Strategy-Alignment with a multidimensional business value*, 17th International Working Conference on Requirements Engineering: Foundation for Software Quality (RefsQ2011), (2011)

Presentations

A. Rusnjak, *Speed Creation Session: A way to increase the productivity of experts in projects and assure quality requirements*, Workshop on Requirements Prioritization for customer-oriented Software-Development (RePriCo'11, Essen, Deutschland, 30.03.2011
A. Rusnjak, *Improving IT-Strategy-Alignment with a multidimensional business value*, 17th International Working Conference on Requirements Engineering: Foundation for Software Quality (RefsQ2011), Essen, Deutschland, 31.03.2011
A. Speck, *Framework for Business Process Verification*, 14th International Conference on Business Information Systems (BIS 2011), Poznan, Polen, 16.06.2011
S. Witt, *BAM: A Requirements Validation and Verification Framework for Business Process Models*, QSIC 2011, Madrid, Spanien, 13.-14.07.2011
A. Speck, *Component Composition Validation*, The 10th International Conference on Software Methodologies, Tools and Techniques (SoMeT 2011), St.Petersburg, Russland, 29.09.2011

Co-Organisation for the Workshop „Protokoll-basierte Modellierung von Geschäftsinteraktionen (PMBI 2011)“ at GI Informatik 2011, Berlin

Cognitive Systems

The head of the cognitive systems group, Professor Dr. Gerald Sommer, retired in March. Some research is being continued by Oliver Fleischmann. He is investigating low level signal models suitable for image processing and their geometric properties using group theory methods. He is concerned also with the automatic scale selection of low level image structures. The applications of his methods include the detection of interest points in images and consequently the construction of versatile interest point descriptors.

Personnel

Head of the group: Prof. Dr.-Ing. G. Sommer;
Technical Staff: Dipl.-Ing. (FH) H. Schmidt (50%)

Scientific Staff:

Dipl.Inf. O. Fleischmann	01.01.-31.12.2011	CAU
GENHIL		

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

MS1201: Signaltheoretische Grundlagen der Bildverarbeitung, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
G. Sommer (+ O. Fleischmann)

MSS1201: Seminar - Robot Vision (Computer Vision), 2 hrs Seminar/Week,
G. Sommer (+ O. Fleischmann)

Oberseminar - Kognitive Systeme, 2 hrs Seminar/Week,
G. Sommer

Publications

Published in 2011

O. Fleischmann, L. Wietzke, G. Sommer, *Image Analysis by Conformal Embedding*, in Journal of Mathematical Imaging and Vision, Volume 40, Number 3, Pages 305-325, 2011, Springer Netherlands, DOI: 10.1007/s10851-011-0263-5., (2011)

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. The AG ComSys performs research work in four different application-oriented areas. These areas will be introduced in the following.

Results

1. Computer science support for marine research

In the context of the European-funded Network of Excellence ESONET (standing for European Sea Floor Observatory Network) AG ComSys closely cooperated with oceanographers from MARUM in Bremen. AG ComSys contributed to the following sub-projects of ESONET: (1) standardization of sensor communication protocols (IEEE 1451), (2) manpower support during the cruise of the research vessel Merian for scientific drilling with the sea floor drill rig MeBo (Elefsina - Valletta, 05.06.2010-04.07.2010). Most mentionable is that ComSys staff member Jesper Zedlitz was appointed to a position on the IEEE 1451 standards committee.

2. Verification of Railway Infrastructures

In close co-operation with Funkwerk IT GmbH, Kiel, an ontology-based verifier for railway infrastructures was designed and implemented. In 2010, the focus was on the formalization of railway infrastructure design rules in SWRL language (Semantic Web Rule Language) and on gaining practical experience with this new methodology.

3. Parallel Processing on Graphics Cards

This project was set up to research enhanced parallel processing methods for XML-coded documents on commercially available and cheap parallel processors, namely high-performance graphics cards. We focused on NVIDIA's GTX series of cards, because these cards come with a programming environment (called CUDA), which enables the programmer to develop general purpose programs that can run on a graphics card. We enhanced our previous work by concentrating on parallel algorithms for the XML-related technologies XPath and XSLT.

Personnel

Head of the group: Prof. Dr.-Ing. Norbert Luttenberger; Secretary: Nicole Mard-Azad (50%)
Technical Staff: Matthias Westphal (50%)

Scientific Staff:

MSc. Michael Lodemann Railway infrastructure verification	01.01.-31.12.2011	ISH-HWT
Dipl.-Inf. Hagen Peters Massive parallel processing	01.01.-15.10.2011	Land SH
Dipl.-Inf. Jesper Zedlitz MaWiFo	01.02.-31.12.2011	ZBW

Lectures, Seminars, and Laboratory Course Offers

Summer 2011

Organisation und Architektur von Rechnern, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
Norbert Luttenberger (+ Miro Spönemann)

Kommunikationssysteme, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Norbert Luttenberger

Winter 2011/2012

XML in Communication Systems, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Norbert Luttenberger (+ Jesper Zedlitz)

Third-Party Funds

ISH-HWT, *RTVE/ITIS*, 01.01.-31.12.2011 (60000 EUR)
ESONET (via MARUM Bremen), *CS Support for Marine Research*, 01.-31.01.2011 (5000 EUR)
ZBW, *MaWiFo*, 01.02.-31.12.2011 (55000 EUR)

Further Cooperation, Consulting, and Technology Transfer

Our close cooperation partners were MARUM Bremen, Funkwerk IT GmbH Kiel, and ZBW - Deutsche Zentralbibliothek für Wirtschaftswissenschaften Leibniz-Informationszentrum Wirtschaft.

Diploma, Bachelor and Master Theses

Jingjing Lang, *Transformation von OWL2-Ontologien in UML2-Klassendiagramme*, 07.07.2011
Arne Marti Klemenz, *Machine Understanding of Scientific Texts for Generation of Keywords for Covered Primary Research Data*, 04.02.2011
Jonas Bötel, *Auswertung von XPath-Ausdrücken auf der Basis von CUDA*, 08.09.2011
Christian Hoffmann, *A CUDA-based XSLT Implementation*, 26.05.2011
Stephan Knauer, *Eine Browser-basierte Benutzerschnittstelle für das CUDA OS*, 23.08.2011
Martin Köper, *Design and Implementation of a CUDA OS-based Library for XML Security*, 19.03.2011
Ole Schulz-Hildebrandt, *Vergleichsbasierte GPU-Sortieralgorithmen: Analyse und Verbesserungen*, 29.11.2011

Publications

Published in 2011

Hagen Peters, Ole Schulz-Hildebrandt, Norbert Luttenberger, *Fast in-place, comparison-based sorting with CUDA: a study with bitonic sort*, Journal Concurrency and Computation, **23**, **7**, (2011)
Michael Lodemann, Rita Marnau, Norbert Luttenberger, *Using Semantic Constraints for Verification*, STAKE 2011 - 3rd Semantic Technology And Knowledge Engineering Conference, (2011)
Jesper Zedlitz, Jan Jörke, Norbert Luttenberger, *From UML to OWL2*, STAKE 2011 - 3rd Semantic Technology And Knowledge Engineering Conference, (2011)
Norbert Luttenberger, Hagen Peters, *17th GI/ITG Conference on Communication in Distributed Systems*, OpenAccess Series in Informatics (OASIcs), **17**, (2011)
Hagen Peters, Ole Schulz-Hildebrandt, *Comparison-based in-place sorting with CUDA*, GPU Computing Gems Jade Edition, (2011)
Nils Gruschka, Meiko Jensen, Luigi Lo Iacono, Norbert Luttenberger, *Server-Side Streaming Processing of WS-Security*, IEEE Transactions on Services Computing, **4**, **4**, (2011)

Further Activities and Events

AG ComSys organized the 17th GI/ITG Conference on Communication in Distributed Systems (KiVS 2011) in Kiel in March 2011.

Computer-Aided Program Development

For many years the main research topics of the research group have been as follows: the fundamentals of programming languages and formal methods for problem specification and program development, the use of relation-algebraic and relation-like methods in mathematics and computer science, the application of graphs as a modelling tool and the formal development of declarative and relational algorithms on them, and the investigation of computational problems from Social Choice Theory and the theory of cooperative games. All this always has been done in view of computer support and led to the development of several tools: RelView for the manipulation and visualization of relations and graphs and for relation-algebraic prototyping and programming, Sloth for the test of Haskell programs to be minimally strict, and many BDD-based algorithms for game-theory problems. All tools are freely available and are placed at general disposal via the group's Web sites and Web sites concerning Haskell.

Results

With regard to the fundamentals of programming languages, in the last year we have concentrated mainly on the semantic foundations of minimally strict sequential functions in the context of the functional programming language Haskell. We have finished the development of a new technique that allows us to test whether a sequential function exists that is less strict than a given one. The technique has been implemented and led to the already mentioned Haskell-based tool Sloth. We also have carried out many case studies, including binary arithmetic and the well-known Haskell-library Split. In all cases the tool allowed the refinement of investigated programs with regard to strictness. The new versions use less memory than the original ones; in some cases the refinement even led to a drastic reduction of memory consumption.

For many years there have been different approaches and proposals for the implementation of graph algorithms in a functional programming language. The main difficulties that arise when dealing with graphs in such a language are caused by two facts, viz: graphs are not freely generated structures like lists and trees, and furthermore, many algorithms on them use node- or edge-marking strategies, i.e., states. In the last year we have investigated a new approach to functional graph algorithms that combines algebraic techniques, especially in the context of relation algebra and semi rings, with classical programming techniques like unfold-fold, data refinement and the use of higher order functions. Using this new approach, we have demonstrated how to develop formally and systematically a purely functional version of Warshall's well-known algorithm for computing transitive closures. Based on the so-called relation algebraic star-decomposition rule, we have devised a generic rectangle-based functional algorithm for reflexive-transitive closures. All these algorithms use an implementation of relations by lists of lists and have a cubic runtime complexity. We also have demonstrated how they can be re-used as components in other functional algorithms.

Following this approach we have used the representation of graphs by lists of lists in Haskell. This representation has then been generalized to specific container types that support efficient merging operations. In many cases these merging operations are well-suited as a replacement for constant-time access to vertices and edges in a graph. In this setting we have developed a purely functional version of the bipartite-maximum-matching algorithm, which is based upon the well-known theorem of Berge and its restatement in relation algebra. This algorithm has a cubic running time complexity, which is similar to the one in the imperative case for dense graphs. Also, the merging operations allow the use of arbitrary edge values, especially semi ring elements. The representation of graphs by semi ring matrices is well-studied and provides algebraic means to reason about graph properties. We have used this approach to derive a prototype implementation of the Edmonds-Karp algorithm for finding maximum flows in asymmetrical graphs, again with a similar running time complexity as in the imperative case.

Concerning the use of relation algebra and the tool RelView, we have continued our work on computational problems from Social Choice Theory and cooperative Game Theory. We have investigated the notions of prestige, centrality and influence in social networks. We also have shown how to model simple games relations algebraically, how to translate one relation algebraic model into another, and how to solve important computational problems on simple games using

relation algebra and RelView. The latter include, for example, the identification of key players having different power, the computation of interesting classes of coalitions, the detection of certain game properties, and to test whether a player (a coalition) is at least as desirable as another one.

Besides Social Choice Theory and Game Theory, we have applied relation algebra and RelView to solve combinatorial problems on chessboards. A classical problem here is the so-called n-queens problem. It asks for the number of possibilities to place n non-attacking queens on a chessboard with n rows and columns. The computing technique we have developed to solve such problems is very flexible and especially appropriate for experimentation. We have applied it to solve independence and domination problems on rectangular chessboards, but it can easily be applied to other chessboard problems and topologies.

Finally, we continued our studies in the application of binary decision diagrams (BDDs) to problems in the context of simple games and weighted voting games. Quasi-reduced and ordered binary decision diagrams (QOBDDs), which are a class of BDDs, are well suited to represent these games. For instance, we were able to show that homogeneous n-player simple games have polynomial size QOBDD-representations in n for specific orderings of the players (variables), and we were also able to improve the worst-case upper bound for the size of QOBDDs representing general weighted voting games. Regarding the existence of weighted representations of simple games, we have developed a novel test to decide if such a representation exists based on linear programming. Our new method significantly outruns existing methods based on linear programming in many relevant cases.

Personnel

Head of the group: Prof. Dr. Rudolf Berghammer; Secretary: Ulrike Pollakowski

Scientific Staff:

Dipl.-Inf. Stefan Bolus 01.01.-31.12.2011 DFG
SOCIAL SOFTWARE for elections, the allocation of tenders and coalition/alliance formation (SSEAC)

Dr. phil. Bernd Braßel 01.01.2010-31.03.2011
Semantics of functional-logic programs and methods for debugging

Dipl.-Inf. Jan Christiansen 01.01.2010-30.09.2011
Investigations concerning strictness and non-strictness in functional languages

Dipl.-Math. Nikita Danilenko 01.04.-31.12.2011
Functional algorithms for discrete problems

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

Arbeitsgemeinschft Informatik, Logik und Mathematik, 2 hrs Seminar/Week,
Rudolf Berghammer (+ Michael Hanus)

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

Inf-Math-A: Mathematik für Informatiker A - Grundlagen und Diskrete Strukturen, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Rudolf Berghammer (+ Barbara Langfeld, Christina Robenek, M. El Ouali)

Summer 2011

Inf-SemPS: Semantik von Programmiersprachen, 4 (+ 2) hrs Lecture (+ Exercises)/Week,

Rudolf Berghammer (+ Jan Christiansen)

Arbeitsgemeinschaft Informatik, Logik und Mathematik, 2 hrs Seminar/Week,
Rudolf Berghammer (+ Michael Hanus)

MS0402: Ordnungen und Verbände, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Rudolf Berghammer (+ Nikita Danilenko)

Winter 2011/2012

Arbeitsgemeinschft Informatik, Logik und Mathematik, 2 hrs Seminar/Week,
Rudolf Berghammer (+ Michael Hanus)

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

Inf-Math-A: Mathematik für Informatiker A - Grundlagen und Diskrete Strukturen, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Rudolf Berghammer (+ Nikita Danilenko, Barbara Langfeld)

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

Third-Party Funds

DFG, *LogiCCC: SOCIAL SOFTWARE for elections, the allocation of tenders and coalition/alliance formation (SSEAC)*, 01.01.-31.12.2011 (47.604,99 EUR)
Reisekostenzuschuss, *LogiCCC Conference, Berlin*, 15.-18.09.2011 (195,20)
Reisekostenzuschuss, *Delhi Logic Week*, 05.-11.01.2011 (889,77)

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.

Diploma, Bachelor and Master Theses

M. Annageldyev, *Entwicklung und Implementierung einer Sprache für derivate Finanzprodukte*, 30.05.2011
M. Pal, *Untersuchung von Approximationsalgorithmen für das Bin Packing Problem*, 30.09.2011

Publications

Published in 2011

R. Berghammer, *Relational modelling and solution of chessboard problems*, In: de Swart H. (ed.), Relational and Algebraic Methods in Computer Science, LNCS, Springer, **6663**, 92 - 108 (2011)
R. Berghammer, *A functional, successor list based version of Warshall's algorithm*, In: de Swart H. (ed.), Relational and Algebraic Methods in Computer Science, LNCS, Springer, **6663**, 109 - 124 (2011)

R. Berghammer, S. Bolus, A. Rusinowska, H. de Swart, *A relation-algebraic approach to simple games,* European Journal of Operational Research, **210**, 68 - 80 (2011)

R. Berghammer, A. Jaoua, B. Möller, *Special issue on Relations and Kleene Algebra in Computer Science,* Journal on Logic and Algebraic Programming, **80**, (2011)

R. Berghammer, A. Rusinowska, H. de Swart, *Computations on simple games using* RelView, In: Gerdt V.P., Koeps W., Mayr E.W., Vorozhtsov E.V. (eds.), Computer Algebra in Scientific Computing, LNCS, Springer, **6885**, 49 - 60 (2011)

S. Bolus, *Power indices of simple games and vector-weighted majority games by means of binary decision diagrams,* European Journal of Operational Research, **210**, 258 - 272 (2011)

B. Braßel, M. Hanus, B. Peemöller, F. Reck, *KiCS2: A new compiler from Curry to Haskell,* In: Kuchen H. (ed.), Functional and Constraint Logic Programming, LNCS, Springer, **6816**, 1 - 18 (2011)

J. Christiansen, *Sloth – A tool for checking minimal strictness,* In: Rocha R., Launchbury J. (eds.), Practical Aspects of Declarative Languages, LNCS, Springer, **6539**, 160 - 174 (2011)

J. Christiansen, D. Seidel, *Minimally strict polymorphic functions,* In: Schneider-Kamp P., Hanus M. (eds.), Proceedings of the 13th International ACM SIGPLAN Conference on Principles and Practice of Declarative Programming, July 20-22, 2011, Odense, Denmark. ACM, 53 - 64 (2011)

A. Rusinowska, R. Berghammer, H. de Swart, M. Grabisch, *Social networks: Prestige, centrality and influence,* In: de Swart, H. (ed.), Relational and Algebraic Methods in Computer Science, LNCS, Springer, **6663**, 22 - 39 (2011)

G. Schmidt, R. Berghammer, *Contact, closure, topology and the linking of row and column types of relations,* Journal on Logic and Algebraic Programming, **80**, 339 - 361 (2011)

Presentations

R. Berghammer, *On the use of BDDs for solving problems on simple games,* Workshop "LogICCC meets India", Delhi, India, 07.-08.01.2011

R. Berghammer, *Relational modelling and solution of chessboard problems,* Conference "Relational and Algebraic Methods in Computer Science", Rotterdam, The Netherlands, 30.05.-03.06.2011

R. Berghammer, *A functional, successor list based version of Warshall's algorithm,* Conference "Relational and Algebraic Methods in Computer Science", Rotterdam, The Netherlands, 30.05.-03.06.2011

R. Berghammer, S. Bolus, *Demonstration of* RelView *with applications to social choice,* Conference "Relational and Algebraic Methods in Computer Science", Rotterdam, The Netherlands, 30.05.-03.06.2011

R. Berghammer, A. Rusinowska, H. de Swart, *Computations on simple games using* RelView, Workshop "Computer Algebra in Scientific Computing", Kassel, Germany, 05.-09.09.2011

R. Berghammer, *Simple games and the use of BDDs for problem solving,* LogICCC Final Conference, Berlin, Germany, 15.-19.09.2011

B. Braßel, M. Hanus, B. Peemöller, F. Reck, *KiCS2: A new compiler from Curry to Haskell,* Workshop "Functional and Constraint Logic Programming", Odense, Denmark, 19.-19.07.2011

J. Christiansen, *Sloth – A tool for checking minimal strictness,* Symposium "Practical Aspects of Declarative Languages", Austin, USA, 24.-25.01.2011

J. Christiansen, D. Seidel, *Minimally strict polymorphic functions,* SIGPLAN Conference "Principles and Practice of Declarative Programming", Odense, Denmark, 20.-22.07.2011

N. Danilenko, *A functional algorithm for finding maximum matchings in bipartite graphs,* Kolloqium Programmiersprachen und Grundlagen der Programmierung (KPS'11), Raesfeld, Germany, 26.-28.09.2011

A. Rusinowska, R. Berghammer, H. de Swart, M. Grabisch, *Social networks: Prestige, centrality and influence,* Conference "Relational and Algebraic Methods in Computer Science", Rotterdam, The Netherlands, 30.05.-03.06.2011

R. Berghammer, S. Bolus, and J. Christiansen worked as reviewers for 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 2011 he was a member of the programme committee of RAMiCS 12, that took place in May/June 2011 in Rotterdam (The Netherlands). At present he is a member of the programme committee of RAMiCs 13, that will be held in September 2012 in Cambridge (UK), and of the 10th Workshop on Boolean Problems, that will be held 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 2011: Vladimig Gerdt (Dubna, Russia) March 21, 2011.

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

Dependable Systems

The Dependable Systems Group, newly established in November 2011, investigates formal methods for the discovery and prevention of hard- and software bugs. In particular, we work in the field of formal specification and verification, model-checking, the satisfiability problem of certain logics, and combinatorial problems of sequential structures.

Personnel

Head of the group: Prof. Dr. D. Nowotka;

Scientific Staff:

Dr. Florin Manea	01.11.-31.12.2011
Dipl.-Inf. Mike Müller	01.11.-31.12.2011

Lectures, Seminars, and Laboratory Course Offers

Winter 2011/2012

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

Übung zu: Grundlagen der Softwarezuverlässigkeit, 2 hrs Exercise/Week,
D. Nowotka

Third-Party Funds

DFG, *Heisenbergprofessur*, 15.11.2011-14.11.2014 (324800 EUR)
DFG, *Kombinatorische Aspekte von Wörtern und deren Anwendungen*, 01.05.2011-31.10.2014 (365000 EUR)

Further Cooperation, Consulting, and Technology Transfer

The Dependable Systems group cooperates with Daimler (R&D), the University of Stuttgart (Prof. Dr. Erhard Plödereder), the Charles University of Prague(Prof. Dr. Dr. Stepan Holub), Czech Republic, the Turku University (Prof. Dr. Tero Harju, Prof. Dr. Juhani Karhumäki), Finland, the University of Winnipeg (Prof. Dr. James Currie), Canada, and the University of Waterloo (Prof. Dr. Jeffrey Shallit), Canada.

Further Activities and Events

D. Nowotka served as a member of the programme committee of TIME 2012.

D. Nowotka served as a member of the programme committee of WORDS 2012.

D. Nowotka has organized a Dagstuhl seminar together with Maxime Crochemore (Kings College, UK), Lila Kari (University of Western Ontario, CA), and Mehryar Mori (New York University, US). Title: *Combinatorial and Algorithmic Aspects of Sequence Processing.*

Discrete Optimization

Discrete or combinatorial optimization is a branch of mathematical optimization. It is concerned with solving discrete, finite optimization problems efficiently.

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. Particular topics are as follows: 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 clusters of excellence „The Future Ocean“ and (upcoming) „Materials for Life“ , and also on projects with industrial partners.

Results

The group ist part of several highly competitive research clusters. Among them are the DFG priority program 1307 Algorithm Engineering and the clusters fo excellence mentioned above.

Personnel

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

Scientific Staff:

Dipl. Inf. D. Ehlers	01.03.-31.12.2011	(50%)	DFG
Engineering randomisierter Algorithmen für Optimierungsprobleme in Hypergraphen			
Dipl. Math. M. El Ouali	01.01.-31.12.2011	(50%)	CAU / DFG
Engineering randomisierter Algorithmen für Optimierungsprobleme in Hypergraphen			
Priv.-Doz. Dr. M. Gnewuch	01.01.-31.12.2011		DFG
Hochdimensionale numerische Integration			
Priv.-Doz. Dr. G. Jäger	01.01.-31.12.2011		DFG
Exzellenzcluster Future Ocean			
Dr. L. Kliemann	01.01.-31.12.2011		CAU
Algorithm Engineering, Game Theory			
M.A. O. Kliemann	01.01.-31.05.2011		DFG
Engineering randomisierter Algorithmen für Optimierungsprobleme in Hypergraphen			
M.A. O. Kliemann	01.10.-31.12.2011		DFG
Engineering randomisierter Algorithmen für Optimierungsprobleme in Hypergraphen			
Dr. B. Langfeld	01.01.-30.09.2011		CAU
Graph Theory and Discrete Tomography			
Dipl. Math. P. Munstermann	15.03.-31.12.2011	(50%)	DFG
Engineering randomisierter Algorithmen für Optimierungsprobleme in Hypergraphen			

Dipl. Math. V. Sauerland	01.01.-31.10.2011	CAU / HWT
Automatische Lehrgangsplanung (Kooperation mit der MINT GmbH, Kiel)		
G. Wittig-Srivastav	01.01.-31.10.2011	CAU
Projektkoordination		

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

Kombinatorische Optimierung - Approximation und Randomisierung, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
A. Srivastav (+ B. Langfeld)

Monte-Carlo- und Quasi-Monte-Carlo-Methoden, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
M. Gnewuch

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

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

Masterabschlussseminar, 2 hrs Seminar/Week,
A. Srivastav (+ B. Langfeld)

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

Summer 2011

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

Kombinatorische Optimierung, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
A. Srivastav (+ B. Langfeld)

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

Masterabschlussseminar, 2 hrs Seminar/Week,
A. Srivastav (+ B. Langfeld)

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

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

Monte-Carlo- und Quasi-Monte-Carlo-Methoden, 4 (+ 2) hrs Seminar (+ Exercises)/Week,
M. Gnewuch (+ J. Peter)

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

Third-Party Funds

DFG SPP 1307 Phase 1, *Engineering randomisierter Algorithmen für Optimierungsprobleme in Hypergraphen,* 01.10.2007-31.12.2012 (134600 Euro)
DFG SPP 1307 Phase 2, *Engineering randomisierter Algorithmen für Optimierungsprobleme in Hypergraphen,* 01.10.2009-30.06.2012 (136000 Euro)
DFG, *Exzellenzcluster The Future Ocean - Numerische Simulation,* 01.01.2009-30.09.2011 (47300 Euro)
DFG, *Hochdimensionale numerische Integration,* 01.04.2009-31.03.2012 (117000 Euro)
ISH, *Entwurf effizienter Algorithmen für die Lehrgangsplanung bei Fluggesellschaften,* 01.11.2009-28.02.2011 (71988 Euro)
DFG SPP 1307 Phase 3, *Engineering von Matching- und Überdeckungsalgorithmen in großen Graphen und Hypergraphen,* 25.08.2011-24.08.2013 (177650 Euro)

Further Cooperation, Consulting, and Technology Transfer

Cooperation with:

G. Averkov, Universität Magdeburg. Project: Discrete Covariograms

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

J. Dick, University of New South Wales, Sydney, Australia. Project: Fractional discrepancy and numerical integration

B. Doerr, M. Wahlström, Max-Planck-Institut für Informatik, Saarbrücken. Project: Algorithms to construct small discrepancy samples

S. Ghorpade, Department of Mathematics, Indian Institute of Technology, Bombay, India

P. Gritzmann, Technische Universität München. Project: Discrete Tomography

R. Möhring, W. Höhn, Technische Universität Berlin. Project: Genetic Algorithms for Sequencing and Scheduling

C. Patvardhan, Faculty of Engineering, Dayalbagh Educational Institute, Deemed University, Agra, India

F.-A. Siebert, Universitätsklinikum Kiel. Project: Optimizing therapy planning in particle therapy

H. Wozniakowski, Columbia University New York, USA, and Department of Applied Mathematics, University of Warsaw, Poland. Project: Tractability of multivariate problems and high dimensional numerical integration

Diploma, Bachelor and Master Theses

D. Ehlers, *Algorithms for Combinatorial Auctions and Matching on Hypergraphs with Multiplicity via Duality Theory,* 10.02.2011
K. Land, *Diskrepanz von arithmetischen Progressionen in endlichen, zyklischen Gruppen,* 18.12.2011
P. Munstermann, *Bipartite Matching in the Semi-Stream-Model,* 25.05.2011
F. Kumm, *Der Nutzen von Adaptivität bei Stochastic-Set-Cover,* 05.10.2011
J. Kollmann, *Lineare Diskrepanz und polyedrische Integralität von k-regulären Matrizen,* 06.10.2011

A. Tiemann, *Diskrepanz Quadratischer Arithmetischer Progressionen,* 18.11.2011

Publications

Published in 2011

M. Gnewuch, H. Wozniakowski, *Quasi-Polynomial Tractability,* Journal of Compexity, **Vol.27**, 312 - 330 (2011)

P. Gritzmann, B. Langfeld, W. Wiegelmann, *Uniqueness in Discrete Tomography,* SIAM Journal on Discrete Math (SIDMA), **Vol.25**, 1589 - 1599 (2011)

L. Kliemann, *Matching in Bipartite Graph Streams in a small number of passes (extended abstract),* Proceedings of the 10th International Symposium on Experimental Algorithms, 254 - 266 (2011)

L. Kliemann, *The Price of Anarchy for Network Formation in an Adversary Model,* Games, **Vol.2**, 302 - 332 (2011)

S. Eggert, L. Kliemann, P. Munstermann, A. Srivastav, *Bipartite Matching in the Semi-Stream-Model,* Algorithmica, **Vol.63**, 490 - 508 (2011)

M. El Ouali, A. Fretwurst, A. Srivastav, *Inapproximability of b-Matching in k-uniform Hypergraphs,* Proceedings of the 5th International Workshop on Algorithms and Computation, 57 - 69 (2011)

N. Hebbinghaus, A. Srivastav, *Discrepancy of Centered Arithmetic Progressions ...,* Proceedings of the 6th European Conference on Combinatorics (Eurocomb 2011), 449 - 456 (2011)

Presentations

L. Kliemann, *Matching in Bipartite Graph Streams in a small number of passes,* 10th Intl. Symposium on Experimental Algorithms, Chania, Greece, 06.05.2011

B. Langfeld, *On the reconstruction of panar lattice-convex sets from covariogram,* Oberseminarvortrag des DFG-Sonderforschungsbereiches 701, Fakultät Mathematik der Universität Bielefeld, Bielefeld, Deutschland, 26.01.2011

B. Langfeld, *Are planar lattice-convex sets determined by their covariogram?,* Oberseminar des Lehrstuhls Angewandte Geometrie und Diskrete Mathematik, Technische Universität München, München, Deutschland, 01.04.2011

B. Langfeld, *Are planar lattice-convex sets determined by their covariogram?,* DMV Jahrestagung 2011, Universität zu Köln, Köln, Deutschland, 20.09.2011

M. Gnewuch, *A Randomized Algorithm to Approximate the Star Discrepancy Based on Threshold Accepting,* 8th IMACS Seminar on Monte Carlo Methods (MCM 2011), Borovets, Bulgaria, 29.08.2011

M. Gnewuch, *Infinite-Dimensional Numerical Integration,* 7th International Congress on Industrial and Applied Mathematics (ICIAM 2011), Vancouver, Canada, 18.07.2011

M. Gnewuch, *Multilevel Algorithms for Infinite-Dimensional Integration,* Foundations of Computational Mathematics (FoCM 2011), Workshop on Information-Based Complexity, Budapest, Hungary, 05.07.2011

M. Gnewuch, *Infinite-Dimensional Numerical Integration,* 4th Workshop on High-Dimensional Approximation (HDA 2011), Bonn, Germany, 27.06.2011

M. Gnewuch, *When are Multivariate and Infinite-Dimensional Integration on Reproducing Kernel Hilbert Spaces Related to Geometric Discrepancy?,* Workshop on Theoretical Aspects of High-Dimensional Problems and Information-Based Complexity, Hausdorff Research Institute for Mathematics, Bonn, Germany, 21.06.2011

M. Gnewuch, *Relation between (Weighted) Geometric Discrepancy and (Weighted) Numerical Discrepancy,* University of New South Wales, Computational Mathematics Seminar, Sydney, Australia, 22.02.2011

M. Gnewuch, *(Quasi-)Monte-Carlo-Methoden,* Antrittsvorlesung, Faculty of Mathematics and Natural Sciences, CAU Kiel, Kiel, Germany, 18.01.2011

A. Srivastav, *Algorithm Engineering for Evolutionary Algorithms,* Faculty of Science, Dayalbagh Educational Institute, Demeed University, Agra, India, 20.02.2011

A. Srivastav, *Algorithm Engineering in India, DFG SPP 1399,* „Algorithm Engineering", Annual Symposium, Free

University of Berlin, Berlin, Germany, 27.05.2011

A. Srivastav, *Discrete Optimization in Kiel,* Odense University, Odense, Denmark, 05.05.2011

A. Srivastav, *Discrepancy of Arithmetic Progressions,* European Symposium on Combinatorics, Hungarian Academy of Science, Budapest, Hungary, 29.08.2011

A. Srivastav, *Indo-German Science Relation,* Annual Meeting of the German-Indian Society, Dresden, Germany, 23.09.2011

Further Activities and Events

M. Gnewuch was invited by Josef Dick (University of New South Wales, Sydney) to a research stay in Sydney from Feb. 9 to March 10 2011.

M. Gnewuch: Organization of the Minisymposium „Discrepancy Theory and Applications to High-Dimensional Integration" at the 7th International Congress on Industrial and Applied Mathematics (ICIAM 2011) in Vancouver, Canada.

M. Gnewuch: Reviewer for „Discrete and Computational Geometry" , „Journal of Complexity" , Proceedings of „Monte Carlo and Quasi-Monte Carlo Methods 2010" and „AMS Reviews" .

B. Langfeld is joint project leader in the EU-Project „MaP Mathematik mit Perspektive" (Förderperiode 31.08.2010 - 31.03.2014).

B. Langfeld, 06/2011: Awarded the Best-Prof-Award 2011 (1. Platz, Kategorie Mathematik) der Fachschaften Mathematik und Informatik der Christian-Albrechts-Universität zu Kiel.

A. Srivastav: Initiated Extension of the DFG SPP 1307 „Algorithm Engineering" to India (DFG-DST Call Computational Algorithmics with Special focus on Algorithm Engineering, 2011)

Information Systems Engineering

Research and teaching in the department of Information Systems Engineering concentrates 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

A knowledge based system for detecting and classifying piracy attacks

The goal of the project PITAS (Pirate and Terrorist Aversion System) is the development of a system aimed at the online assessment of risks caused by pirate and terrorist attacks and the taking of appropriate countermeasures. For that purpose, data provided by novel sensors from the field of sonar and radar technology are collected, fused and analyzed. To accomplish the task of detecting and classifying pirate attacks, we developed an information system storing formal descriptions of scenarios representing attacks. The system applies techniques from the field of mining of moving objects, thus being able to match a set of trajectories to instances of most probable scenarios.

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 developed based on the development of a complete formalization of BPMN 1.0 and 1.1 developed over the last few years in an international collaboration. 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 is structured into 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 at 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.

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 can 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 computations in any databases: 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 the 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

Based on the representation of models of crystal structures by so-called polyhedra graphs new interfaces for the formulation of queries against inorganic crystallographic databases are developed. These interfaces allow the combination of textual and graphical input in queries. Evaluation of queries is supported by the use of a special form of index in combination with the query interface of a relational database system.

A crystal-chemical approach to high-temperature superconductivity based upon the notion of structural valency has been developed further, now including the analysis of bond paths. The hypothesis is that systems of structurally distinguished periodic bond paths have to exist in every unconventional superconductor. This could be shown for large sets of cuprates as well as transition-element chalcogenides and pignides. The approach is applied in a systematic search for potential superconductors.

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 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 can easily assimilate them to perform their tasks in juristical environments.

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 the data itself, the intension behind the data, the usage of data and the origin of data on the same level.

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 whereas 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 that 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: M. Sc. S. Gaede

Scientific Staff:

Dipl.-Inf. K. Jannaschk	01.01.-31.12.2011	CAU
apl.-Prof. Dr. H.-J. Klein	01.01.-31.12.2011	CAU

M. Sc. R. Noack	01.01.-30.09.2011	(50%)	HSP
M. Sc. R. Noack	01.10.-31.12.2012		CAU
Dipl.-Inf. T. Polomski	01.01.-31.12.2011		BMWI
Verbundprojekt: PITAS - Piraterie- und Terrorabwehr auf Seeschiffen			
Dipl.-Inf. O. Sörensen	01.01.-31.12.2011		CAU

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

Inf-DBTech: Datenbanktechnologie, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
H.-J. Klein (+ H.-J. Klein)

MS0503: Intelligent Information Systems, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
B. Thalheim (+ K. Jannaschk)

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

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

WInf-Proj: Business Information Systems Project, 4 hrs Lecture/Week,
B. Thalheim (+ R. Noack)

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

MSP0501: Masterprojekt - Datenbankprogrammierung (FopraDBII), 4 hrs Exercise/Week,
K. Jannaschk + O. Sörensen

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

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

Summer 2011

Inf-IS: Informationssysteme (DB), 4 (+ 2) hrs Lecture (+ Exercises)/Week,
H.-J. Klein (+ Ch. Robenek, J. Schönborm, Ch. Starke)

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

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

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

A5.3.11: Fortgeschrittenenpraktikum, 4 hrs Exercise/Week,
H.-J. Klein

BA6.11: Projektmodul - Datenbanktechnologie, 6 hrs Exercise/Week,
H.-J. Klein (+ T. Polomski)

WInf-BAppE: Selected Topics in Business Application Engineering, 2 hrs Lecture/Week,
B. Thalheim

WInf-DBProg: Datenbankprogrammierung, 2 (+1) hrs Lecture (+ Exercises)/Week,
B. Thalheim (+ O. Sörensen)

WInf-InfSysIME: IS Integration, Migration and Evolution, 2 (+1) hrs Lecture (+ Exercises)/Week,
B. Thalheim (+ K. Jannaschk)

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

Informations- und Wissensmanagement, 2 hrs Exercise/Week,
R. Noack

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)

Third-Party Funds

DAAD, *Projektbezogener Personenaustausch mit Japan : Knowledge Technology for Next Generation Web*, 01.01.-31.12.2011 (27.850,00 EUR)
DAAD, *Projektbezogener Personenaustausch mit Finnland - PPP Finnland*, 01.01.-31.12.2011 (12.697,00 EUR)
BMWI, *A knowledge based system for detecting and classifying piracy attacks using scenario descriptions and sensor data (within project PITAS)*, 01.01.-31.12.2011 (160.740,00 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),

Georgia College and State University (Ajantha Dahanayake),

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),

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),

University of Otago, Dunedin (Qing Wang),

University of Vermont (X. Sean Wang),

Universita di Pisa (Egon Börger),

Victoria University, Wellington (Hui Ma, Sebastian Link),

KEIO University Tokyo (Yasushi Kiyoki),

NICT Institut Kyoto (Koji Zettsu).

Diploma, Bachelor and Master Theses

M. Böhm, *Integration von Informationen zu Piratenangriffen aus heterogenen Internetquellen mit einer Text-Mining Komponente*, 22.09.2011
P. Broman, *DBFeed - ein System für lernende Datenextraktion*, 16.12.2010
A. Eichmeier, *Verhalten von virtuellen Gemeinschaften im Web*, 30.09.2011
S. Fourati, *Grundlagen der Kollaboration im webbasierten Lernsystem*, 30.09.2011
P. Hafner, *Dienstorientierte Softwarearchitekturen im Rahmen der wissenschaftlichen Datenerfassung*, 30.09.2011
A. Jaworska, *Informationsextraktion, -transformation und -integration*, 20.10.2011
F. Kramer, *Debugging von BPMN Prozessen*, 17.03.2011
S. Zieger, *REST im Codesign Prozess*, 30.09.2011
W. Zorgati, *Entwurf und Umsetzung eines Steuerungssystems für die wissenschaftliche Datenerfassung*, 30.09.2011

Dissertations / Postdoctoral Lecture Qualifications

M. Skusa, *Semantische Kohärenz in der Softwareentwicklung*, 08.07.2011

Publications

Published in 2011

D.-W. Embley, B. Thalheim, *Handbook of Conceptual Modeling Handbook of Conceptual Modeling Theory, Practice, and Research Challenges,* Springer, (2011)

E. Börger, O. Sörensen, *BPMN Core Modeling Concepts: Inheritance-Based Execution Semantics,* Handbook of Conceptual Modeling: Theory, Practice and Research Challenges, Springer, 287 - 332 (2011)

P. Broman, B. Thalheim, *Data Extraction from Semi-Structured Text Using Weighted Finite Automata,* Proc. of the 21th European - Japanese Conference on Information Modelling and Knowledge Bases, **1**, 9 - 27 (2011)

A. Dahanayake, B. Thalheim, *Enriching Conceptual Modelling Practices through Design Science,* BMMDS/EMMSAD, Lecture Notes in Business Information Processing, Springer, **81**, 497 - 510 (2011)

D. Fleischer, K. Jannaschk, *A path to filled archives,* Nature Geoscience, **4**, 575 - 576 (2011)

F. Förster, B. Thalheim, *Data and Information Management for Humanist Researchers (Text and Things). /Conference Poster,* Supporting Digital Humanities 2011, University of Copenhagen, (2011)

H. Jaakkola, E. Karttunen, Y. Kidawara, B. Thalheim, K. Zettsu, *Future Directions of Knowledge Systems Environments for Web 3.0,* Information Modelling and Knowledge Bases XXII, IOS Press, 413 - 446 (2011)

H. Jaakkola, B. Thalheim, *Architecture-Driven Modelling Methodologies,* Information Modelling and Knowledge Bases XXII, LOS Press BV, 97 - 116 (2011)

K. Jannaschk, T. Polomski, *Cluster Analysis Systematisation for Data, Model, and Knowledge Management,* Proc. of the 21th European - Japanese Conference on Information Modelling and Knowledge Bases, **2**, 40 - 59 (2011)

K. Jannaschk, C.A. Rathje, B. Thalheim, *A Generic Database Schema for CIDOC-CRM Data Management,* ADBIS 2011 Research Communications, **2**, 127 - 136 (2011)

H.-J. Klein, *Graphical Query Interfaces for Inorganic Crystallographic Databases. XXII Congress of the Intern. Union of Crystallography, Madrid, Spain,* Acta Cryst., **A67**, **C72**, (2011)

M. Klettke, B. Thalheim, *Evolution and Migration of Information Systems,* Handbook of Conceptual Modeling: Theory, Practice and Research Challenges, Springer, 381 - 420 (2011)

F. Liebau, H.-J. Klein, X. Wang, *A crystal chemical approach to superconductivity. I. A bond-valence sum analysis of inorganic compounds.,* Zeitschrift für Kristallographie, **226**, 309 - 318 (2011)

H. Ma, K.-D. Schewe, B. Thalheim, W. Qing, *Cloud Warehousing,* Journal of Universal Computer Science,Volume17,, **8**, 1183 - 1201 (2011)

B. Neumayr, M. Schrefl, B. Thalheim, *Modeling Techniques for Multi-level Abstraction,* The Evolution of Conceptual Modeling, Lecture Notes in Computer Science, Springer, **6520**, 68 - 92 (2011)

K.-D. Schewe, B. Thalheim, *About Semantics,* Semantics in Data and Knowledge Bases,LNCS, Springer, **6834**, 1 - 22 (2011)

K.-D. Schewe, B. Thalheim, *Web Information Systems Portfolio: (A) Contribution to Pragmatics,* , Lecture Notes in Business Information Processing, Springer, **75**, 147 - 161 (2011)

K.-D. Schewe, B. Thalheim, *Null Value Algebras and Logics,* Information Modelling and Knowledge Bases XXII, LOS Press BV, 354 - 367 (2011)

B. Thalheim, *The Art of Conceptual Modelling,* Proc. of the 21th European - Japanese Conference on Information Modelling and Knowledge Bases, **1**, 203 - 222 (2011)

B. Thalheim, *The Science of Conceptual Modelling,* Database and Expert Systems Applications, DEXA 2011, Springer, **1**, 12 - 26 (2011)

B. Thalheim, *Interdisciplinary Advances in Adaptive and Intelligent Assistent Systems,* Information Science Reference, Hershey,, 1 - 25 (2011)

B. Thalheim, *The theory of conceptual models, the theory of conceptual modelling and foundations of conceptual modelling.,* The Handbook of Conceptual Modeling: Its Usage and Its Challenges, chapter 17, Springer, 547 - 580

(2011)

B. Thalheim, *The Evolution of Conceptual Modeling From a Historical Perspective towards the Future of Conceptual Modeling,* Lecture Notes in Computer Science, Springer, **6520**, (2011)

B. Thalheim, *The Enhancecd Entity-Relationship Model,* Handbook of Conceptual Modeling: Theory, Practice and Research Challenges, Springer, 165 - 208 (2011)

B. Thalheim, *The Theory of Conceptual Models, the Theory of Conceptual Modelling and Foundations of Conceptual Modellling,* Handbook of Conceptual Modeling: Theory, Practice and Research Challenges, Springer, 543 - 578 (2011)

B. Thalheim, *The Culture and Art of Conceptual Modelling,* Anwendungsorientierte Organisationsgestaltung, baar, Hamburg, 127 - 144 (2011)

B. Thalheim, M. Tropmann, *Performance Forecasting for Performance Critical Huge Databases,* Information Modelling and Knowledge Bases XXII, LOS Press BV, 206 - 225 (2011)

B. Thalheim, Q. Wang, *Towards a Theory of Refinement for Data Migration,* ER, Lecture Notes in Computer Science, Springer, **6998**, 318 - 331 (2011)

Presentations

K. Jannaschk, *A Systematic Approach To Cluster Analysis Within A Data Mining Design Framework,* 21th European - Japanese Conference on Information Modelling and Knowledge Bases, Tallinn, Estonia, 09.06.2011

K. Jannaschk, *An Universal Database for CIDOC-CRM Data Management,* DAMA Workshop, Kiel, Germany, 08.07.2011

K. Jannaschk, *A Generic Database Schema for CIDOC-CRM Data Management,* 15th East European Conference on Advances in Databases and Information Systems, Vienna, Austria, 22.09.2011

H.-J. Klein, *Graphical query interfaces for inorganic crystallographic databases,* XXII Congress and General Assembly of the Intern. Union of Crystallography, Madrid, Spain, 22.-27.08.2011

B. Thalheim, *A theory of model, to model and modelling,* Modellierung 2011, Kerkrade, Netherlands, 02.03.2011

B. Thalheim, *Model Suites: Systematic Multi-Facetted Modelling,* Colloqium, ETH, Zurich, Switzerland, 23.05.2011

B. Thalheim, *The Art of Conceptual Modelling,* EJC 2011, Tallinn, Estonia, 07.06.2011

B. Thalheim, *Data Extraction from Semi-Structured Text Using Weighted Finite Automat,* EJC 2011, Tallinn, Estonia, 06.07.2011

B. Thalheim, *Infrastructures for Knowledge Systems Environments and Digital Sciences,* EJC 2011, Tallinn, Estonia, 08.07.2011

B. Thalheim, *Revisiting the Theory of Integrity Constraints,* SDKB 2011, Zurich, Switzerland, 03.07.2011

B. Thalheim, *Science and Art of conceptual modelling,* DEXA 2011, Toulouse, France, 31.08.2211

B. Thalheim, *Web Information Systems: Foundations and Research Issues,* ESF Workshop, Linz, Austria, 29.09.2011

B. Thalheim, *Refinement for Data Migration,* ER 2011, Brussels, Belgium, 02.11.2011

B. Thalheim, *Modelling for Future Internet,* ER 2011, Brussels, Belgium, 03.11.2011

B. Thalheim, *Wann Webdaten zu Informationen und Wissen werden.,* Night of the Profs, Christian-Albrechts-University,, Kiel, Germany, 19.11.2011

B. Thalheim, *The Data Mining Framework: The Background for Guided Intelligent Data Analysis and Mining for Concepts,* Colloquium, Keio, Japan, 02.12.2011

B. Thalheim, *A algebra for incremental construction of complex models (in Russian),* Kolmogorow-Lecture, Lomonossow-University, Moscow, Russia, 28.12.2011

B. Thalheim, *Evolving algebraic structures,* Kolmogorow-Lecture, Lomonossow-University, Moscow, Russia, 29.12.2011

B. Thalheim, *A model of the mathematical model (in Russian),* Kolmogorow-Lecture, Lomonossow-University, Moscow, Russia, 30.12.2011

Further Activities and Events

Programme Committees:

- SSDBM: 23rd Intern. Conf. on Scientific and Statistical Database Management, Portland, USA, July 2011.

Co-Chair:

- Microsymposium 'Topological correlations and crystal structure interconnections', XXII Congress and General Assembly of the Intern. Union of Crystallography, Madrid, Spain, 2011.

R. Noack

Member of programme committee:

-SDKB 2011 5th International Workshop on Semantics in Data and Knowledge Bases, July, 2011, Zurich, Switzerland,
-ETheCoM 2011 2nd International Workshop on Evolving Theories of Conceptual Modelling, September, 2011, Milan, Italy,
-GeoDBIS 2011 1st International Workshop on Geometric Objects in Databases and Information Systems, September, 2011, Vienna, Austria.

B. Thalheim

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

Member of programme committee:

ADBIS 2011, September 2011,
BIS 2011, June 2011,
BIR 2011, October 2011,
CAiSE 11, June 2011,
CMM 2011, June 2011,
CMS 2011, August 2011,
DEXA 2011, September 2011,
EJC 2011, June 2011,
EMMSAA201, June 2011,
ER 11 November 2011,
Ethecom 2011, September 2011,
FP-UML 2011, November 2011,
GeoDBIS Workshop (ADBIS 2011 workshop), September 2011,
IN2SP (CAiSE workshop),
ITSM 2011 (DEXA Workshop), September 2011,
NLDB 2011, June 2011,
SDH 2011, November 2011,
SDKB 2011, July 2011,
UNISCON 2011, September 2011,
WEBIST 2011, July 2011,
WI 2011, February. 2011,
WISM 2011, November 2011.

Member of steering committees of international conferences:

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

Co-Chairman of conferences:

FoIKS.

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:

ADBIS 2011 Handbook of conceptual modelling, Springer 2011,
Post-Proceedings of the conference Semantics in Databases and Knowledge Bases 2010, LNCS 6824, Springer 2011,
Special issue of IJKBO, 2011,
Special issue von JUCS 2011.

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.

Co-Chairman of workshops:

CMS 2011, Milan.

Member of the Scientific Advisory Board: with Dataport.

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.

Member of Committees:

Berufungsausschuß Wirtschaftsinformatik Christian-Albrechts-University Kiel, Germany.

Reviewer of doctoral theses:

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

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.

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 2011, 12 scientific researchers were involved in 10 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 2011. Not all activities of MIP in 2011 can be discussed here so we highlight some of the more important research achievements.

DeCSMedia: In 2011, previously successful work on 3D-TV systems (supported by EU project 3D4YOU) led to the start of a new research subgroup DeCSMedia within MIP, supported by the BMWi EXIST technology transfer programme. In that group, a novel 3D-TV system will be developed with the goal of technology transfer towards a future Spin-off company in 2013. Three researchers are currently working full-time in this enterprise.

KoSSE: As part of the competence centre Software Systems Engineering KoSSE, MIP worked on developing modular computer vision systems, together with the company IBAK. The key issue of the subproject MoSeS is development of modular, reusable computer vision components for fast prototyping. Application areas are autonomous navigation and sewer pipe inspection systems. Two researchers are currently 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-localization 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. The role of MIP involves 3D-Data capture and modelling of deformable objects in real-time. Two researchers are currently 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 are being investigated, currently by one researcher. In addition, there is a close collaboration between the archaeology diving team of the CAU and MIP on underwater archaeology.

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 conservation of all information, combination of 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 that will permit 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 camera will be built in the future; the necessary funding has been supplied by the Professor Petersen Foundation.

Arts and Computer Science: some examples of bug art 2011

There are many links between arts and computer science. One example is the project *movingart*, initiated by a colleague Professor Thomas Wilke from Theoretical Computer Science, as a collaboration between art classes in schools, and computer

science. There are, however, also other links between these disciplines. MIP as a research group produces a lot of computer code, especially for the tasks of computer vision, graphics, and image processing. Often, the process of finding program errors, called debugging, is tedious and time consuming. If one error is found, it is commonly called a bug, which means an error. Since our area is visual data processing, the bugs are also of visual quality. Often, however, they exhibit a certain beauty, due to some regular or irregular pattern.

The following visual results are unwanted effects of bugs in the programs, causing some spectacular patterns to evolve. They were collected by Robert Wulff from our group. Please find enclosed his Bug Art with explanations.

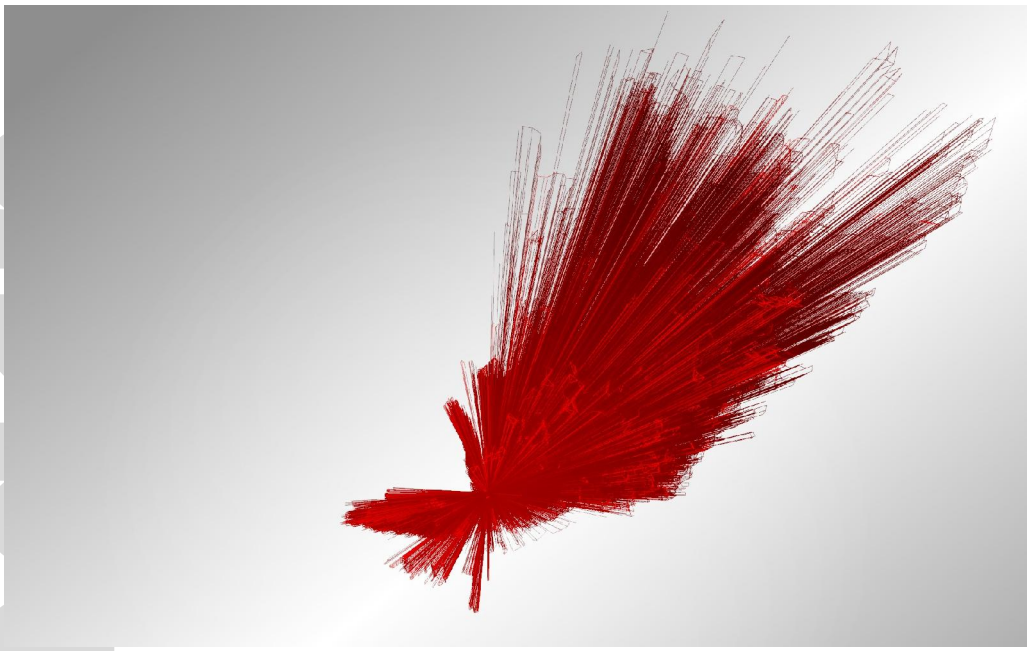


Fig. 1: Explosion. Typically, surfaces are represented through triangle meshes, where the topology (mesh connectivity) is connected with the geometry (3D points) by indexed lists. Here, the index list was corrupted, causing the very irregular geometrical structure.

Personnel

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

Scientific Staff:

B. Bartczak	01.01.-31.08.2011	EU/EU/DFG
Interreg/3D4YOU/3DPoseMapII		
D. Chen	01.03.-31.12.2011	Chinese Research Council
S. Esquivel	01.01.-31.12.2011	CAU
Land		
Markus Franke	01.05.-31.12.2011	ISH
Modulare Dezentrale Schiffsüberwachungstechnik		
A. Frick	01.01.-31.12.2011	EU/EXIST
3D4You, DeCSMedia		

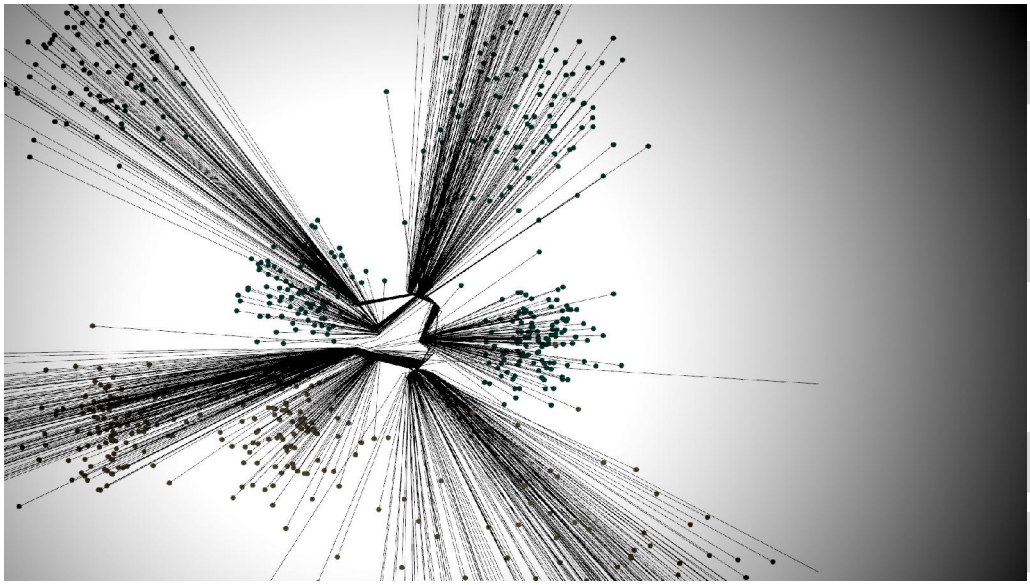


Fig. 2: Singularity. 3D clustering algorithms like the Mean-Shift-Algorithm are used to find high density 3D point cloud clusters by iterative steepest descent. Each ray shows the direction of the descent. Here, each step was wrongly normalized, causing all points to converge towards the unit sphere.

A. Jordt 3D4You/Interreg	01.01.-31.12.2011	EU
D. Jung InnoNet/Land	01.01.-31.12.2011	BMWi/CAU
F. Kellner InnoNet/Interreg, DeCSMedia	01.01.-31.12.2011	BMWi/EU/EXIST
A. Petersen Land/KoSSE	01.01.-31.12.2011	CAU/EU
I. Schiller KoSSE, DeCSMedia	01.01.-31.12.2011	EU/EXIST
A. Sedlazeck Modelling of Seafloor Structures, InterReg	01.01.-31.12.2011	DFG/EU
R. Wulff Graduiertenkolleg Human Landscapes	01.01.-31.12.2011	DFG
L. Zhang	01.01.-31.12.2011	Chinese Research Council

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

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

MS0601 Masterprojekt - Vertiefende Übung Visuelle Modellierung, 4 hrs Exercise/Week,

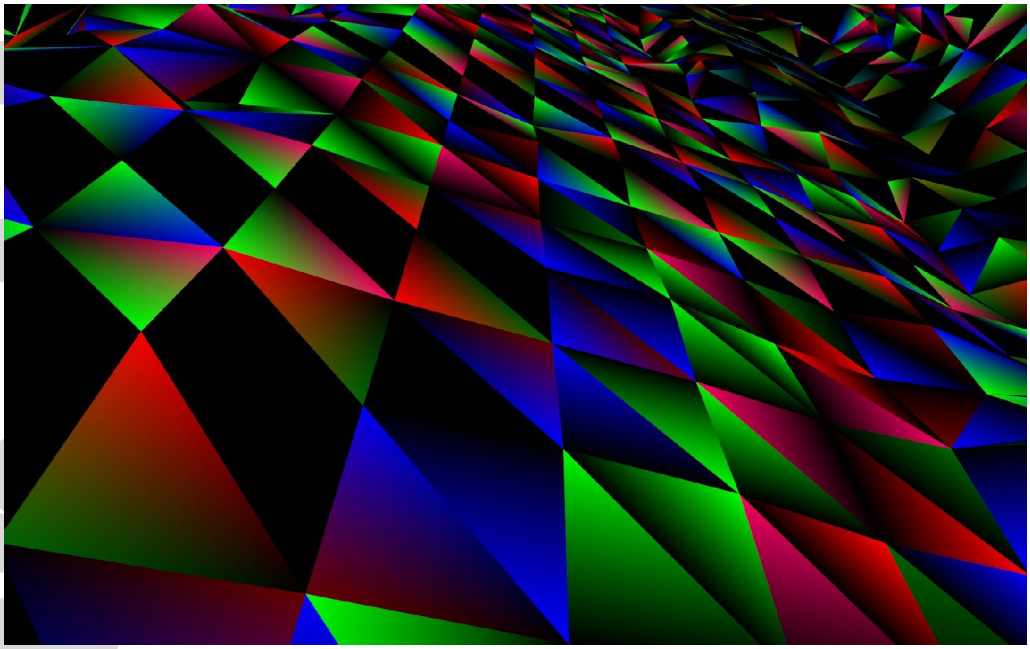


Fig. 3: Kaleidoscope. During the initialization of a triangle mesh, colour values are set at the triangle borders. The colours are then interpolated. Here, the colour values were not set properly and show arbitrary values.

R. Koch (+ D. Jung, F. Kellner, A. Frick)

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

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

A 5.3.9 Fortgeschrittenenenpraktikum - Multimediale Informationsverarbeitung, 4 hrs Exercise/Week,
R. Koch (+ D. Jung, F. Kellner, A. Frick)

BA 6.7 Projektmodul Computer Graphik/Computer Vision, 6 hrs Bachelorarbeit/Week,
R. Koch (+ S. Esquivel)

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

Summer 2011

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)

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)

Third-Party Funds

EU, *3D4YOU*, 01.02.2008-31.01.2011 (438.100 EUR)
DFG, *Seafloor modeling*, 01.09.2009-31.08.2011 (150.000 EUR)
EU, *InterReg*, 01.09.2009-31.07.2012 (273.000 EUR)
EU, *KoSSE*, 01.08.2009-31.08.2012 (330.000 EUR)
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*, 01.03.-31.08.2011 (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, *2 Stipends*, 01.09.2009-31.08.2013 (93.000,00)
VW, *Optical See-Through*, 01.07.-30.09.2011 (6.000,00)
BMWi, *EXIST*, 01.09.2011-28.02.2013 (466.532,00)

Further Cooperation, Consulting, and Technology Transfer

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

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

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

Diploma, Bachelor and Master Theses

L. Husvogt, *Simulation of a Kinect Depth Camera from 2D Environmental Maps for Offline Evaluation of a Mobile Robot System*, 28.09.2011

A. Timpl, *Einsetzbarkeit der Sonarsensorik zur Kollisionsvermeidung und Mikro-navigation der Roboterplattform PowerBot,* 28.09.2011
C. Zelenka, *Analyse von Verfahren zur Merkmalsverfolgung in Stereo-Bildpaaren,* 26.09.2011
J. Nupnau, *Kalibrierung einer Thermalkamera und Objektdetektion in Kombination mit Farbkamera,* 26.09.2011
K. Ott, *Untersuchung der Kinect-Kamera als berührungsloses Eingabegerät,* 26.09.2011
S. Möller, *Implementierung eines globalen Alpha-Matting Verfahrens auf GPU,* 26.09.2011
J. Bracker, *Analyse der Genauigkeit der Sonarsensorik der mobilen Roboterplattform PowerBot,* 28.09.2011
R.-T. Diekert, *Poseschätzung aus Multi-Sensordaten für ein mobiles Robotersystem,* 28.09.2011
L. Langenhop, *Visuelle Schätzung der Fahrtrichtung eines Mobilen Robotersystems,* 28.09.2011
D. Wolters, *Analyse der Einsetzbarkeit von Kinect Tiefensensoren auf mobilen Roboterplattformen,* 28.09.2011
Ch.-W. Reimer, *Kontinuierliche Erfassung von Umgebungsinformationen für ein mobiles robotersystem mit Tiefenkamera,* 28.09.2011
V. Behrends, *Beste nächste Ansicht für die Exploration mittels mobiler Robotersysteme,* 28.09.2011
M. Ide, *Modulares Design einer graphischen Benutzeroberfläche zur Steuerung und Überwachung mobiler Robotersysteme,* 28.09.2011

Dissertations / Postdoctoral Lecture Qualifications

I. Schiller, *Dynamic 3D Scene Analysis and Modeling with a Time-of-Flight Camera,* 17.05.2011
C. Rabe, *Detection of Moving Objects by Spatio-Temporal Motion Analysis,* 18.02.2011

Publications

Published in 2011

D. Jung, R. Koch, *A Best-Next-View Selection Algorithm for Multi-View Rendering,* Proceedings of 3D Imaging, Modeling, Processing, Visualization and Transmission (3DIMPVT), (2011)
I. Schiller, R. Koch, *Improved Video Segmentation by Adaptive Combination of Depth Keying and Mixture-of-Gaussians,* Proceedings of SCIA 2011, Springer Verlag, **LNCS 6688**, 59 - 68 (2011)
C. Rabe, U. Franke, R. Koch, *Dense 3D Motion Field Estimation from a Moving Observer in Real-Time,* 5th Biennial Workshop on DSP for In-vehicle Systems, (2011)
C. Menk, E. Jundt, R. Koch, *Visualisation Techniques for Using Spatial Augmented Reality in the Design Process of a Car.,* Computer Graphics Forum 2011, (2011)
R. Koch, F. Huang, *(Eds.) Computer Vision - ACCV 2010 Workshops.,* Selected and revised papers of eight ACCV workshops,, (2011)
A. Petersen, M.-A. Beyer, *Partitioned Covariance Intersection,* Proceedings of ISIS 2011, (2011)
A. Jordt, R. Koch, *Fast Tracking of Deformable Objects in Depth and Colour Video,* Proceedings of the British Machine Conference, (2011)
A. Jordt, A. Fugl, L. Bodenhagen, M. Willatzen, R. Koch, H. Petersen, K. Andersen, M. Olsen, N. Krueger, *an Outline for an intelligen System performing Peg-in-Hole Actions with flexible Objects,* Proceedings of the International Conference on Intelligent Robotics and Applications, (2011)
Ch. Menk, R. Koch, *Interactive Visualization Technique for Truthful Color Reproduction in Spatial Augmented Reality Applications.,* Proceedings of 10th International Conference on Mixed and Augmented Reality ISMAR11, (2011)
L. Zhang, R. Koch, *Hand-held Monocular SLAM Based on Line Segments,* Proceedings of IMVIP 2011, 8 - 15 (2011)
A. Frick, M. Franke, R. Koch, *Time-Consistent Foreground Segmentation of Dynamic Content from Color and Depth Video,* Proceedings of DAGM 2011 Springer Verlag LNCS, **6835**, 462 - 467 (2011)
A. Frick, R. Koch, *Improving Depth Discontinuities For Depth-Based 3DTV Production,* 3DTV-Con: The True Vision - Capture, Transmission and Display of 3D Video (3DTV-CON), (2011)

M. Franke, *Color Image Segmentation Based on an Iterative Graph Cut Algorithm Using Time-of-Flight Cameras,* Proceedings of DAGM 2011, Springer Verlag LNCS, **6835**, 462 - 467 (2011)

B. Bartczak, P. Vandewalle, O. Grau, G. Briand, J. Fournier, P. Kerbiriou, M. Murdoch, M. Müller, R. Goris, R. Koch, R. van der Vleuten, *Display Independent 3D-TV Production and Delivery using the Layered Depth Video Format.,* IEEE Transactions on Broadcasting: Special Issue on 3D Horizon Vol., **57 (2)**, 477 - 490 (2011)

A. Sedlazeck, R. Koch, *Simulating Deep Sea Underwater Images Using Physical models for Light Attenuation, Scattering, and Refraction,* Proceedings of the Workshop on Vision, Modelling and Visualization VMV, (2011)

A. Sedlazeck, R. Koch, *Calibration of Housing Parameters for Underwater Stereo-Camera Rigs,* BMVC Proceedings of the British Machine Vision Conference., (2011)

R. Wulff, R. Koch, *Towards a System for Semantic Image-Based 3D Documentation of Archaeological Trenches,* Proceedings of Computer Applications and Quantitative Methods in Archaeology CAA 2011, (2011)

I Schiller, *Dynamic 3D Scene Analysis and Modeling with a Time-of-Flight Camera PhD Thesis,* BoD Verlag, 2011, ISBN 978-3842371897, (2011)

D. Jung, R. Koch, *Efficient Rendering of Light Field Images,* Cremers D. et al. in Video Processing and Computational Video Springer LNCS, **7082**, 184 - 211 (2011)

Presentations

D. Jung, *A Best-Next-View Selection Algorithm for Multi-View Rendering,* 3D Imaging, Modeling, Processing, Visualization and Transmission, 17.03.2011

I. Schiller, *Improved Video Segmentation by Adaptive Combination of Depth Keying and Mixture-of-Gaussians,* SCIA 2011, Ystad, Schweden, 24.05.2011

C. Rabe, *Dense 3D Motion Field Estimation from a Moving Observer in Real-Time,* 5th Biennial workshop on DSP for In-vehicle Systems, Kiel, Deutschland, 05.09.2011

A. Petersen, *Partitioned Covariance Intersection,* Digital Ship, Hamburg, Deutschland, 18.09.2011

A. Jordt, *Fast Tracking of Deformable Objects in Depth and Colour Video,* British Machine Conference 2011, Dundee, Großbritannien, 31.08.2011

C. Menk, *Interactive Visualization Technique for Truthful Color Reproduction in Spatial Augmented Reality Applications.,* ISMAR 2011, Basel, Schweiz, 29.10.2011

L. Zhang, *Hand-held Monocular SLAM Based on Line Segments,* IMVIP 2011, Dublin, Irland, 08.09.2011

A. Frick, *Time-Consistent Foreground Segmentation of Dynamic Content from Color and Depth Video,* DAGM 2011, Frankfurt/M, Deutschland, 01.09.2011

A. Frick, *Improving Depth Discontinuities For Depth-Based 3DTV Production,* 3DTV-Con, Antalya, Türkei, 17.05.2011

M. Franke, *Color Image Segmentation Based on an Iterative Graph Cut Algorithm Using Time-of-Flight Cameras,* DAGM 2011, Frankfurt/M, Deutschland, 01.09.2011

A. Sedlazeck, *Simulating Deep Sea Underwater Images Using Physical models for Light Attenuation, Scattering, and Refraction,* VMV 2011, Berlin, Deutschland, 04.10.2011

A. Sedlazeck, *Calibration of Housing Parameters for Underwater Stereo-Camera Rigs,* British Machine Conference 2011, Dundee, Großbritannien, 30.08.2011

R. Wulff, *Towards a System for Semantic Image-Based 3D Documentation of Archaeological Trenches,* CAA 2011 Computer Applications and Quantitative Methods in Archaeology, Beijing, China, 14.04.2011

R. Koch, *Time-of-Flight-Range and Color Camera Systems for 3D-TV and Augmented Reality,* Workshop on 3D Imaging, Stanford, USA, 22.01.2011

R. Koch, *3D in Kino und Wohnzimmer,* Kinder- und Schüleruni 2011, Kiel, Deutschland, 07.12.2011

R. Koch, *Potential von Augmented Reality und Multimedialer Bildverarbeitung für die Schifffahrt,* Maritime IT 2011, Rendsburg, Deutschland, 29.09.2011

R. Koch, *3D in Kino und Fernsehen - was ist heute technisch möglich,* BOD Dreiländertagung der Orthoptistinnen 2011,

Nürnberg, Deutschland, 19.11.2011

Further Activities and Events

Prof. Dr.-Ing. Reinhard Koch was invited to give a talk and a poster presentation at a workshop on 3D imaging, Stanford, CA., USA, Jan. 22th, 2011. The title of the talk was *Time-of-Flight-Range and Colour Camera Systems for 3D-TV and Augmented Reality*. The title of the poster was *3D4YOU: A 3D-TV Camera System for Layered Depth Video*.

As last year, **Prof. Dr.-Ing. Reinhard Koch** received the **Transferprämie** , donated by the ISH Schleswig-Holstein, for his achievements in knowledge transfer. The fund was endowed with 20,000 Euros.

Markus Franke's diploma thesis, *Colour Image Segmentation Based on an Iterative Graph Cut Algorithm using Time-of-Flight Cameras*, was accepted for presentation at the **DAGM Symposium 2011** and was named **outstanding thesis** by the **Young Researcher's Forum in Frankfurt**.

Markus Franke's diploma thesis, *Colour Image Segmentation Based on an Iterative Graph Cut Algorithm using Time-of-Flight Cameras*, was also awarded a prize: the **Professor Dr. Werner Petersen-Preis der Technik**.

Dr.-Ing. Uwe Franke (speaker), Dr. rer. nat. Stefan Gehrig und Dr.-Ing. Clemens Rabe were nominated for the **Deutschen Zukunfspreis** in recognition of their project *6D-Vision - Gefahren schneller erkennen als der Mensch*.

Children from 12 to 16 years were enthralled by *3D in Kino und Wohnzimmer* a talk given by **Prof. Dr.-Ing. Reinhard Koch** for the **Kinder- und Schüleruni Kiel 2011**.

During his one week stay **Prof. Yoav Y. Schechner** from **Technion the Israel Institute of Technology** gave a paper *Clear Underwater Vision - Improvement of underwater visual capabilities*.

Modern Information and Communication Technology was the topic of **Maritime IT 2011** and **Prof. Dr.-Ing. Reinhard Koch** gave a paper with the title *Potential von Augmented Reality und Multimedialer Bildverarbeitung für die Schifffahrt*.

Awakening the curiosity of young people for informatics was the aim of the **Schnupperstudium**. **Prof. Dr.-Ing. Reinhard Koch** gave a lecture on the topic *3D Fernsehen* and our **powerbot mobile robot** gave an impressive demonstration of what it does.

Saturday morning Physics featured *3D-Technologie für Kino und Wohnzimmer* by **Prof. Dr.-Ing. Reinhard Koch** on November 26th 2011. A similar talk was given at the Naturwissenschaftlicher Verein Kiel on November 23rd and on the Kieler Woche 2011.

ISIT and TF, two institutions from Schleswig-Holstein on the road to success: the concept was presented on October 28th in Kiel and **Dr. Ingo Schiller** spoke about *Ein innovatives Aufnahmesystem für die tiefenbasierte 3D Filmproduktion*.

Possibilities and limits of processing underwater 3D images were sounded by **Anne Sedlazeck** with a paper *Dem Ocean auf den Grund gegangen* held at the **Day of Informatics** on December 2nd.

Christoffer Menk's paper on *Interactive Visualisation Technique for Truthful Colour Reproduction in spatial Augmented Reality Applications* was awarded **Best S & T Student Paper** on ISMAR 2011 in Basel Switzerland.

3D in Kino und Fernsehen - was ist heute technisch möglich was the title of the keynote speech given by **Prof. Dr.-Ing. Reinhard Koch** at the conference of the BOD, a three-country-conference for orthoptics in Nuremberg in November 2011.

Reviews

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

- 3DTV-Con,

- 3DimPVT 2011,
- CVMP 2011,
- DAGM 2011,
- EG 2011,
- ICCV 2011,
- IC 3D 2011,
- ICME 2011,
- VMV 2011.
- 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, partially in collaboration with the Portland State University (Oregon, USA), new research results related to the 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 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.

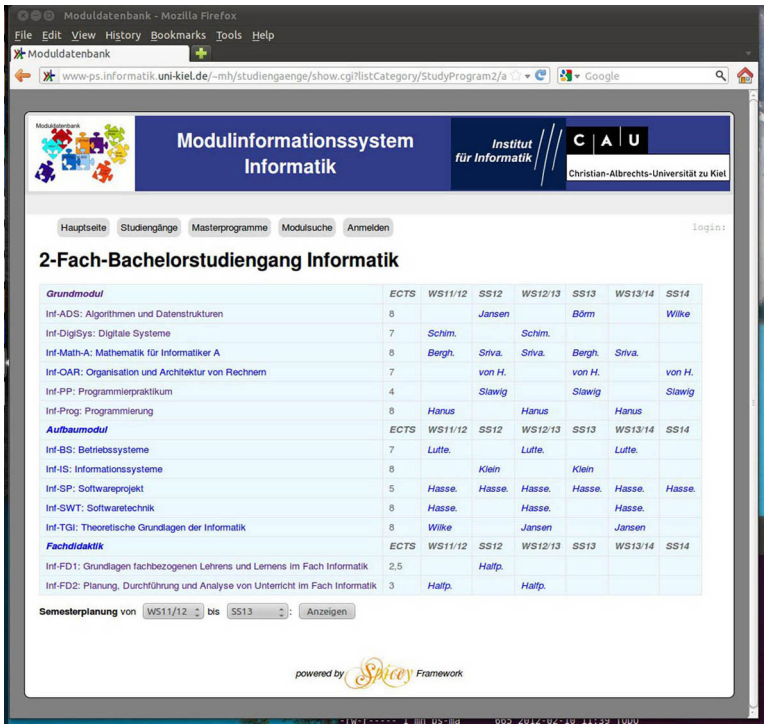


Fig. 1: The interface to the module database of the Institute of Computer Science

Related to the *application* of declarative languages, we worked on the design and implementation of a new web framework, called Spicey. Using Spicey, it is possible to generate a complete web application from a specification of the underlying complex data model in a few minutes. Since the generated implementation is a high-level declarative program, it is easy to adapt this to various customer requirements. In contrast to other web frameworks, ours 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.

Another application of declarative languages has been implemented together with Steffen Mazanek from the Universität der Bundeswehr (Munich). We developed a bidirectional transformation between BPMN (Business Process Modelling and Notation) and BPEL (Business Process Execution Language), two formalisms to deal with the management of business processes. Since our transformation from BPMN to BPEL is implemented in a functional logic language, the backward transformation from BPEL to BPMN is also obtained, so that one can work on both representations of business processes with automatic synchronization.

The application of functional logic languages has resulted in new design and programming patterns which exploit specific features of such languages. Hence, these patterns are not applicable to other kinds of programming languages. In order to support a systematic classification of such patterns, we collaborated with Prof. Antoy, Portland State University (Oregon, USA). We proposed a catalogue of design patterns together with typical application scenarios.

One of these design patterns has been exploited to provide a high-level processing of semistructured data that is frequently available as web data (in XML format). Due to the use of a modern multi-paradigm declarative language, it is possible to provide a framework to query and process such data in a few lines of code. Actually, the complete implementation is part of the corresponding scientific paper describing this approach, i.e. the source code of the publication is, at the same time, the program code used to perform such processing tasks. The code itself is not just a toy example but is used to integrate UnivIS data (from the XML-interface of the lecture information system of the university) into the module database of the institute.

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), Curry 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, a more efficient one ca be developed, 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 support 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 developed a new implementation of Curry 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 the form of a search space. This provides for the application of various search strategies (depth-first, breadth-first, iterative deepening, parallel) to explore the search space. In addition to this flexibility, purely functional parts of declarative programs are compiled into Haskell programs almost without any overhead. Our first benchmarks show that this new implementation (KiCS2) is much faster than other existing Curry implementations for deterministic programs. For non-deterministic programs, KiCS2 can compete with or outperform other existing implementations of Curry. This implementation raised also some interest in the logic programming community so that we could present it as an invited talk at the 11th International Colloquium on Implementation of Constraint and Logic Programming Systems in Lexington (Kentucky, USA).

Personnel

Head of the group: Prof. Dr. Michael Hanus; Secretary: Ulrike Pollakowski
Technical Staff: Dipl.-Ing. (FH) Thomas Heß

Fig. 2: Beginner students of the winter term 2011 (photo by Th. Wilke)

Scientific Staff:

M. SC. Björn Peemöller	01.01.-31.12.2011	CAU
Dipl.-Inf. Fabian Reck	01.01.-31.12.2011	CAU
Dr. Friedemann Simon	01.01.-31.12.2011	CAU

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

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

Arbeitsgemeinschaft Informatik, Logik und Mathematik, 2 hrs Seminar/Week,
Michael Hanus (+ Rudolf Berghammer)

Inf-Prog: Programmierung, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Michael Hanus (+ Fabian Reck, Lars Prädel)

MS0303: Deklarative Programmiersprachen, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Michael Hanus (+ Björn Peemöller)

MS0306: Nebenläufige und verteilte Programmierung, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Frank Huch (+ Björn Peemöller, K. O. Kürtz)

Inf-ObjPro:Objektorientierte Programmierung, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
Friedemann Simon

Inf-ObjProNF: Objektorientierte Programmierung (für Nebenfächler), 2 (+ 2) hrs Lecture (+ Exercises)/Week,
Friedemann Simon

Summer 2011

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

Arbeitsgemeinschaft Informatik, Logik und Mathematik, 2 hrs Seminar/Week,
Michael Hanus (+ Rudolf Berghammer)

Inf-FortProg: Fortgeschrittene Programmierung, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
F. Huch (+ Fabian Reck, Björn Peemöller, Th. Wilke)

NF-Inf-2: Systematisches Programmieren, 2 (+ 4) hrs Lecture (+ Exercises)/Week,
Friedemann Simon

NF-Inf-2-Phys: Systematisches Programmieren für Physiker, 2 hrs Lecture/Week,
Friedemann Simon

Winter 2011/2012

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

Arbeitsgemeinschaft Informatik, Logik und Mathematik, 2 hrs Seminar/Week,
Michael Hanus (+ Rudolf Berghammer)

Inf-Prog: Programmierung, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Michael Hanus (+ Fabian Reck, Lars Prädel)

MS0302: Übersetzerbau, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Michael Hanus (+ Fabian Reck)

MS0304: Funktionale Programmierung, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Frank Huch (+ Björn Peemöller)

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

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

Further Cooperation, Consulting, and Technology Transfer

The research group collaborated with Portland State University (Sergio Antoy) and Universität der Bundeswehr (Steffen Mazanek) during the reported period.

Diploma, Bachelor and Master Theses

Catherine Antoniou, *A Client-Server Solution for Database Integration,* 01.02.2011
R. Gudschun, *Design-Aid for Graphical User Interfaces in Declarative Programming Languages,* 25.02.2011
J. Beck, *Transferbasierte Übersetzung vom Schwedischen ins Deutsche - implementiert in Prolog,* 30.09.2011

Dissertations / Postdoctoral Lecture Qualifications

B. Braßel, *Implementing Functional Logic Programs by Translation into Purely Functional Programs,* 20.10.2011

Publications

Published in 2011

S. Antoy, S. Hanus, *Contracts and Specifications for Functional Logic Programming,* Proceedings of the 21st Workshop on Logic-based Methods in Programming Environments (WLPE 2011), 47 - 61 (2011)
S. Antoy, M. Hanus, *New Functional Logic Design Patterns,* Proceedings of the 20th International Workshop on Functional and (Constraint) Logic Programming (WFLP 2011), **Springer LNCS 6816**, 19 - 34 (2011)
B. Braßel, S. Fischer, M. Hanus, F. Reck, *Transforming Functional Logic Programs into Monadic Functional Programs,* Functional and Constraint Logic Programming, **Springer LNCS 6559**, 30 - 47 (2011)

B. Braßel, M. Hanus, B. Peemöller, F. Reck, *KiCS2: A New Compiler from Curry to Haskell,* Functional and Constraint Logic Programming, **Springer LNCS 6816**, 1 - 18 (2011)

B. Braßel, M. Hanus, B. Peemöller, F. Reck, *Haskell for Logic Programmers: Compiling Functional Logic Programs to Haskell,* Proc. 11th International Colloquium on Implementation of Constraint and Logic Programming Systems (CICLOPS 2011), 1 - 18 (2011)

M. Braßel, M. Hanus, B. Peemöller, F. Reck, *Implementing Equational Constraints in a Functional Language,* Proc. 19th International Conference on Applications of Declarative Programming and Knowledge Management (INAP 2011) and 25th Workshop on Logic Programming (WLP 2011), 22 - 33 (2011)

M. Hanus, *Lazy and Enforceable Assertions for Functional Logic Programs,* Functional and Constraint Logic Programming, **Springer LNCS 6559**, 84 - 100 (2011)

M. Hanus, *Declarative Processing of Semistructured Web Data,* Technical Communications of the 27th International Conference on Logic Programming (ICLP 2011), **LIPIcs Vol. 11**, 198 - 208 (2011)

M. Hanus, P. Scheider-Kamp, *Principles and Practice of Declarative Programming,* ACM Press, (2011)

M. Hanus, *Declarative Processing of Semistructured Web Data,* IfI, CAU Kiel, **Research Report 1103**, (2011)

M. Hanus, S. Koschnicke, *An ER-based Framework for Declarative Web Programming,* CoRR, **abs/1103.4133**, (2011)

S. Mazanek, M. Hanus, *Constructing a Bidirectional Transformation between BPMN and BPEL with a Functional Logic Programming Language,* Journal of Visual Languages and Computing, **Vol. 22**, **No. 1**, 66 - 89 (2011)

B. Braßel, S. Fischer, *From Functional Logic Programs to Purely Functional Programs Preserving Laziness,* 20th International Symposium on Implementation and Application of Functional Languages, **Springer LNCS 5836**, 25 - 42 (2011)

Presentations

M. Hanus, *From Haskell to Curry and back to Haskell,* Portland State University, Portland, Oregon (USA), 28.04.2011

Björn Peemöller, *KiCS2: A New Compiler from Curry to Haskell,* 28. Workshop GI-FG Programmiersprachen und Rechenkonzepte, Bad Honnef, 04.05.2011

M. Hanus, *KiCS2: A New Compiler from Curry to Haskell,* pdxfunc meeting, Portland, Oregon (USA), 13.06.2011

M. Hanus, *Declarative Processing of Semistructured Web Data,* 27th International Conference on Logic Programming, Lexington, Kentucky (USA), 09.07.2011

M. Hanus, *Haskell for Logic Programmers: Compiling Functional Logic Programs to Haskell,* 11th International Colloquium on Implementation of Constraint and Logic Programming Systems (invited talk), Lexington, Kentucky (USA), 10.07.2011

M. Hanus, *Contracts and Specifications for Functional Logic Programming,* 21st Workshop on Logic-based Methods in Programming Environments, Lexington, Kentucky (USA), 10.07.2011

B. Peemöller, *KiCS2: A New Compiler from Curry to Haskell,* 20th International Workshop on Functional and (Constraint) Logic Programming, Odense, Denmark, 19.07.2011

M. Hanus, *New Functional Logic Design Patterns,* 20th International Workshop on Functional and (Constraint) Logic Programming, Odense, Denmark, 19.07.2011

Fabian Reck, *Implementing Equational Constraints in a Functional Language,* 16. Kolloquium Programmiersprachen und Grundlagen der Programmierung (KPS'11), Raesfeld Castle, Germany, 27.09.2011

M. Hanus, *Implementing Equational Constraints in a Functional Language,* 19th International Conference on Applications of Declarative Programming and Knowledge Management and 25th Workshop on Logic Programming, Vienna, Austria, 28.09.2011

Further Activities and Events

M. Hanus:

programme committee member of TFP 2011 (12th International Symposium on Trends in Functional Programming), Madrid (Spain), May 2011,

programme committee member of the CICLOPS 2011 (11th International Colloquium on Implementation of Constraint and Logic Programming Systems), Lexington (Kentucky, USA), July 2011,

programme committee member of WFLP 2011 (20th Workshop on Functional and (Constraint) Logic Programming), Odense (Denmark), July 2011,

programme committee chair of PPDP 2011 (13th International Symposium on Principles and Practice of Declarative Programming) Odense (Denmark), July 2011,

programme committee member of WLP 2011 (25th Workshop on (Constraint) Logic Programming), Vienna (Austria), September 2011,

member of the Editorial Board of the Journal of Functional and Logic Programming,

member of the steering committee of the Symposia on Logic-based Program Synthesis and Transformation,

member of the steering committee of the ACM SIGPLAN Symposia on Principles and Practice of Declarative Programming,

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),

member of the advisory board of the GLP (Gesellschaft für Logische Programmierung), German-speaking branch of the Association for Logic Programming (ALP),

member of the selection committee of the DAAD (German Academic Exchange Service) for the project-related support to scientific cooperation with Spain and Portugal,

member of the advisory board of the „Berufsakademie an der Wirtschaftsakademie Schleswig-Holstein" ,

chair of the examinations board of computer science studies, University of Kiel,

member of the Senate Curriculum Committee, University of Kiel,

vice-member of the Senate Equal Opportunities Committee, University of Kiel,

research sabbatical at Portland State University (Oregon, USA) with Prof. Sergio Antoy, March-June 2011,

invited talk at CICLOPS 2011 (11th International Colloquium on Implementation of Constraint and Logic Programming Systems), Lexington (Kentucky, USA), July 2011.

F. Huch:

programme committee member of TFP 2011 (12th International Symposium on Trends in Functional Programming), Madrid (Spain), May 2011,

programme committee member of LOPSTR 2011 (21st International Symposium on Logic-Based Program Synthesis and Transformation), Odense (Denmark), July 2011,

organization of the 28th Workshop of the GI-Fachgruppe Programmiersprachen und Rechenkonzepte, Bad Honnef (Germany), May 2011,

member of the Steering Committee of Symposia on Implementation and Application of Functional Languages (IFL),

chair of the executive committee of the Fachgruppe „Programmiersprachen und Rechenkonzepte" of the Gesellschaft für Informatik e.V.

B. Peemöller:

research stay at the National Institute of Informatics, Tokio, Japan, September 12-25, 2011,

attendance and administrative support of the International Conference on Functional Programming (ICFP 2011) and related workshops (WGP, Haskell Symposium, Haskell Implementor's Workshop, CUFP), Tokio, Japan, September 2011.

F. Simon:

participation in seminars for students planning professional careers, „Computer Museum" , representative of the Faculty of Engineering in the board of control.

Results

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

- the model-based design of complex reactive systems,
- deterministic concurrency and synchronous languages.

The activities on the **model-based design of complex reactive systems** concentrate on the *modelling pragmatics*, that is, the practical aspects of creating, maintaining and visualizing graphical system models. 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 2011 include the reimplementation of the main automatic layout algorithm and improvement of the concept for processing port constraints, the extension of the layer-based approach for the layout of compound graphs, and a web service for graph layout and graph format conversion. Also, KIELER's layout capabilities within UC Berkeley's Ptolemy system have been improved.

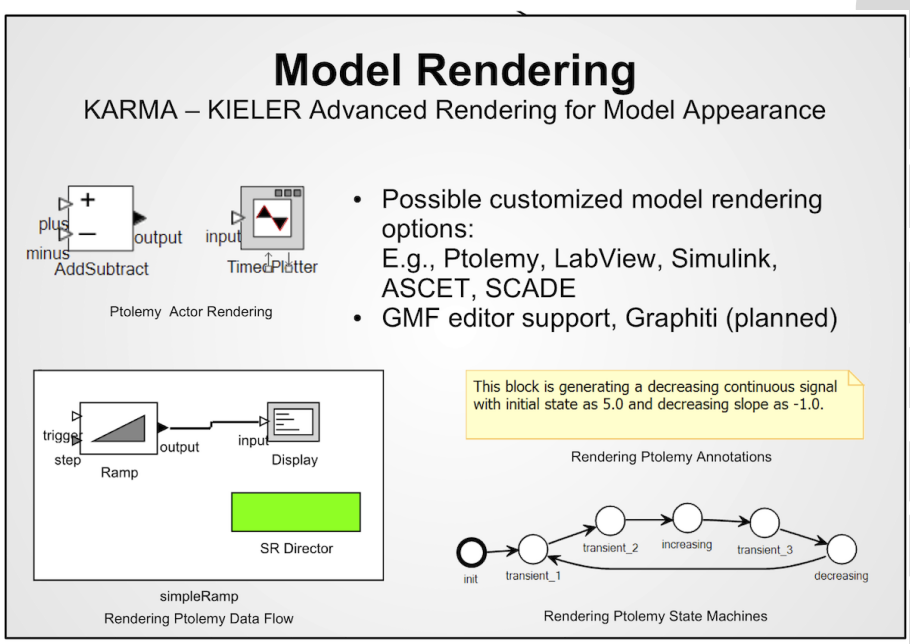
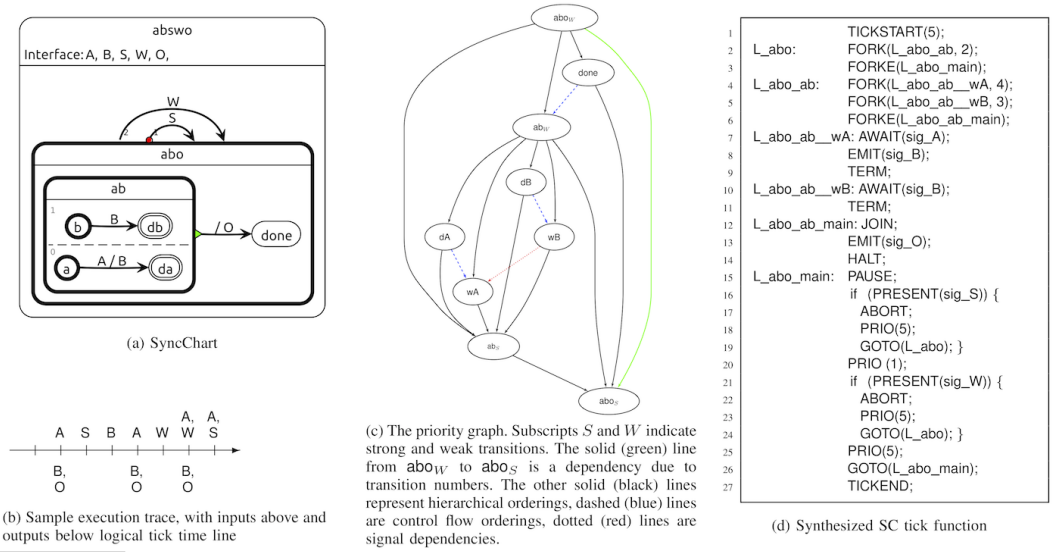


Fig. 1: KARMA in KIELER (from [Motika, Spönemann et al. 2011]).

The major result in the area **deterministic concurrency and synchronous languages** is the development of *Synchronous C (SC)* and *Synchronous Java (SJ)*, which are light-weight mechanisms to embed deterministic concurrency in C and Java. SC and SJ are inspired by the reactive processing paradigm, but are implemented as macros/classes expressed in standard C/Java, available as open-source code. In 2011, the main developments were improvements in SJ and an adaption for Lego Mindstorms NXT.



(a) SyncChart

(b) Sample execution trace, with inputs above and outputs below logical tick time line

(c) The priority graph. Subscripts S and W indicate strong and weak transitions. The solid (green) line from abo_W to abo_S is a dependency due to transition numbers. The other solid (black) lines represent hierarchical orderings, dashed (blue) lines are control flow orderings, dotted (red) lines are signal dependencies.

(d) Synthesized SC tick function

Fig. 2: Example Synthesis of Synchronous C (SC) Code from a SyncChart (from [Traulsen, Amende and von Hanxleden 2011]).

Personnel

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

Scientific Staff:

Dipl.-Inf. H. Fuhrmann MENGES	01.01.-30.04.2011	EU
Dipl.-Inf. C. Motika	01.01.-31.12.2011	Land
Dipl.-Inf. C. Schneider MENGES	01.03.-31.12.2011	EU
Dipl.-Inf. C. D. Schulze MENGES	01.09.-31.10.2011	EU
Dipl.-Inf. C. D. Schulze	01.11.-31.12.2011	Land
Dipl.-Inf. J. Schönborn	01.01.-30.09.2011	Land
Dipl.-Inf. M. Spönemann	01.01.-31.12.2011	Land

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

Inf-BS: Betriebssysteme, 3 hrs Lecture/Week,
R. von Hanxleden

Übung zu: Betriebssysteme, 2 hrs Exercise/Week,
R. von Hanxleden (+ H. Peters, C. Motika)

Fig. 3: The RTSYS group at a climbing excursion in Eckernförde (11.07.).

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

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

MSP1101: Masterprojekt - Echtzeitsysteme/Eingebettete Systeme, 4 hrs Exercise/Week,
R. von Hanxleden (+ M. Spönemann, C. Motika, H. Fuhrmann)

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

Oberseminar - Echtzeitsysteme und Eingebettete Systeme, 2 hrs Seminar/Week,
R. von Hanxleden

Summer 2011

Inf-EntEinSys: Entwurf eingebetteter Echtzeitsysteme, 4 hrs Lecture/Week,
R. von Hanxleden

Übung zu: Entwurf eingebetteter Echtzeitsysteme, 2 hrs Exercise/Week,
R. von Hanxleden (+ C. Motika)

Inf-EmSysDes: Embedded System Design, 4 hrs Lecture/Week,
R. von Hanxleden

Übung zu: Embedded System Design, 2 hrs Exercise/Week,
R. von Hanxleden (+ C. Motika)

A5.3.3: Fortgeschrittenenpraktikum - Echtzeitsysteme/Eingebettete Systeme (Modellierung in Eclipse), 4 hrs Exercise/Week,
R. von Hanxleden (+ M. Spönemann)

MSP1101: Masterprojekt - Echtzeitsysteme/Eingebettete Systeme (Modellierung in Eclipse), 4 hrs Exercise/Week,
R. von Hanxleden (+ M. Spönemann)

BA6.1: Projektmodul - Echtzeitsysteme/Eingebettete Systeme, 6 hrs Exercise/Week,
R. von Hanxleden (+ M. Spönemann)

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

MSS1101: Seminar - Echtzeitsysteme / Eingebettete Systeme (Modellierung Nebenläufiger Systeme), 2 hrs Seminar/Week,
R. von Hanxleden (+ R. Berghammer)

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

Winter 2011/2012

MS1102: Synchrone Sprachen, 4 hrs Lecture/Week,
R. von Hanxleden

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

MSP1101: Masterprojekt - Echtzeitsysteme / Eingebettete Systeme, 4 hrs Exercise/Week,
R. von Hanxleden (+ C. Motika)

BA6.1: Projektmodul - Echtzeitsysteme / Eingebettete Systeme, 6 hrs Exercise/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

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, *Model Engineering und Predictable Processing*, 01.01.2010-31.12.2011 (15.318 EUR)

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

Diploma, Bachelor and Master Theses

C. Schneider, *(Diploma Thesis) On the Pragmatics of Graphical Modeling*, 05.05.2011
U. Rüegg, *(Bachelor Thesis) Interactive Transformations for Visual Models*, 28.03.2011
H. Wree, *(Bachelor Thesis) Ein Gleisplaneditor basierend auf Graphiti*, 31.03.2011
C. D. Schulze, *(Diploma Thesis) Optimizing Automatic Layout for Data Flow Diagrams*, 28.07.2011
S. Wersig, *(Diploma Thesis) Ein Web Service für das automatische Layout von Graphen*, 31.10.2011

Dissertations / Postdoctoral Lecture Qualifications

H. Fuhrmann, *On the Pragmatics of Graphical Modeling*, 05.05.2011

Publications

Published in 2011

C. Motika, M. Spönemann, H. Fuhrmann, C. Krüger, J. Carstens, R. von Hanxleden, *KIELER Actor Oriented Modeling (KAOM)*, Poster presented at 9th Biennial Ptolemy Miniconference (PTCONF'11), Berkeley, CA, USA, (2011)

C. Traulsen, T. Amende, R. von Hanxleden, *Compiling SyncCharts to Synchronous C*, In Proceedings of the Design, Automation and Test in Europe Conference (DATE'11), Grenoble, France, IEEE, 563 - 566 (2011)

R. von Hanxleden, H. Fuhrmann, M. Spönemann, *KIELER-The KIEL Integrated Environment for Layout Eclipse Rich Client*, n Proceedings of the Design, Automation and Test in Europe University Booth (DATE 11), Grenoble, France, (2011)

R. von Hanxleden, N. Holsti, B. Lisper, E. Ploedereder, R. Wilhelm, A. Bonenfant, H. Casse, S. Bünte, W. Fellger, S. Gepperth, J. Gustafsson, B. Huber, N. M. Islam, D. Kästner, R. Kirner, L. Kovacs, F. Krause, M. de Michiel, M. C. Olesen, A. Prantl, W. Puffitsch, C. Rochange, M. Schoeberl, S. Wegener, M. Zolda, J. Zwirchmayr, *WCET Tool Challenge 2011: Report*, In Proceedings of the 11th International Workshop on Worst-Case Execution Time (WCET) Analysis, Porto, Portugal, (2011)

C. Bachmaier, F. J. Brandenburg, P. Effinger, C. Gutwenger, J. Katajainen, K. Klein, M. Spönemann, M. Stegmaier, M. Wybrow, *The Open Graph Archive: A Community-Driven Effort*, Poster at the 19th International Symposium on Graph Drawing, Technische Universiteit Eindhoven, Netherlands, (2011)

U. Rüegg, C. Motika, R. von Hanxleden, *Interactive Transformations for Visual Models*, In 3rd Workshop Methodische Entwicklung von Modellierungswerkzeugen (MEMWe 2011) at conference INFORMATIK 2011, GI-Edition - Lecture Notes in Informatics (LNI) Berlin, Germany, Bonner Köllen Verlag, (2011)

C. Motika, *Interactive Esterel to SyncCharts Transformation for executing Esterel with Ptolemy*, Presentation at the 18th International Open Workshop on Synchronous Programming (SYNCHRON 11), Dammarie-les-Lys, France, (2011)

M. Chimani, C. Gutwenger, P. Mutzel, M. Spönemann, H.M. Wong, *Crossing Minimization and Layouts of Directed Hypergraphs with Port Constraints*, In Proceedings of the 18th International Symposium on Graph Drawing (GD 10), volume 6502 of LNCS, 141 - 152 (2011)

R. von Hanxleden, *Synchronous C + WCRT Algebra 101*, Presentation at the 18th International Open Workshop on Synchronous Programming (SYNCHRON'11), Dammarie-les-Lys, France, (2011)

Presentations

C. Motika, M. Spönemann, H. Fuhrmann, C. Krüger, J. J. Carstens, R. von Hanxleden, *KIELER Actor Oriented Modeling (KAOM)*, Poster presented at 9th Biennial Ptolemy Miniconference (PTCONF 11), Berkeley, CA, USA, 16.02.2011

C. Traulsen, T. Amende, R. von Hanxleden, *Compiling SyncCharts to Synchronous C In Proceedings of the Design*, Automation and Test in Europe Conference (DATE 11), Grenoble, France, 14.-18.03.2011

R. von Hanxleden, H. Fuhrmann, M. Spönemann, *KIELER-The KIEL Integrated Environment for Layout Eclipse Rich Client In Proceedings of the Design*, Automation and Test in Europe University Booth (DATE 11), Grenoble, France, 14.-18.03.2011

R. von Hanxleden, *Taming Graphical Modeling - On the Pragmatics for the Model-Based Design of Complex Systems*, Innovation Forum Embedded Systems 2011, Munich, 08.04.2011

M. Spönemann, *Model-Based Engineering of Embedded Systems*, Invited talk at Irkutsk State University Supported by the International Center, Irkutsk, Russia, 08.09.2011

M. Spönemann, *Graph Drawing - The Layered Approach*, Talk at the weekly Ptolemy project meeting, EECS Department, University of California at Berkeley, Berkeley, CA, USA, 28.09.2011

U: Rüegg, C. Motika, R. von Hanxleden, *Interactive Transformations for Visual Models In 3rd Workshop Methodische Entwicklung von Modellierungswerkzeugen (MEMWe 2011)*, at conference INFORMATIK 2011, GI-Edition - Lecture Notes in Informatics (LNI) Bonner Köllen Verlag, Berlin, Germany, 06.10.2011

R. Jung, C. Schneider, *Tipps und Tricks für das Arbeiten mit Eclipse*, Kompetenzverbund Software Systems Engineering (KoSSE) Workshop, Kiel, 23.11.2011

R. von Hanxleden, *Synchronous C + WCRT Algebra 101*, Presentation at the 18th International Open Workshop on Synchronous Programming (SYNCHRON 11), Dammarie-les-Lys, France, 28.11.-02.12.2011

C. Motika, *Interactive Esterel to SyncCharts Transformation for executing Esterel with PtolemyInteractive Esterel to SyncCharts Transformation for executing Esterel with Ptolemy*, Presentation at the 18th International Open Workshop on Synchronous Programming (SYNCHRON 11), Dammarie-les-Lys, France, 28.11.-02.12.2011

Further Activities and Events

C. Motika, C. Schneider:

demonstration of the Model-Railway, Girls'Day 2011 (14.04.) and the Schnupperstudium (18./19.10.).

H. Fuhrmann, C. Motika, C. Schneider, M. Spönemann:

reviewers for the *International Conference on Embedded Software* (EMSOFT).

R. von Hanxleden:

Chair of the Department of Computer Science,

member of the *ArtistDesign European Network of Excellence on Embedded System Design*,

Programme Committee member for the *International Conference on Embedded Software (EMSOFT)*, the *Embedded System Design (ESD) Track at the International Symposium on Electronic System Design (ISED) 2011*, and the *Methodische Entwicklung von Modellierungswerkzeugen (MEMWe2011) Workshop* at the *GI-Jahrestagung INFORMATIK 2011*,

reviewer for the *ACM Transactions on Embedded Computing Systems*, the *EURASIP Journal on Embedded Systems*, and the *ACM SIGPLAN/SIGBED Conference on Languages, Compilers, Tools and Theory for Embedded Systems (LCTES) 2011*.

C. Schneider, J. Schoenborn:

reviewers for the *Embedded System Design (ESD) Track at the International Symposium on Electronic System Design (ISED) 2011*.

C. Motika, C. D. Schulze, M. Spönemann:

reviewers for the *Methodische Entwicklung von Modellierungswerkzeugen (MEMWe2011) Workshop* at the *GI-Jahrestagung INFORMATIK 2011*.

Scientific Computing

The group focuses on developing fast solvers for mathematical problems. This task includes several aspects:

1. the mathematical problem has to be translated into a form that can be handled by a computer (typically by approximation and discretization),

2. the relevant data has to be represented as efficiently as possible (using suitable compression techniques),

3. the solution has to be computed by a fast method (we currently focus on hierarchical matrices and multigrid iterations), and

4. the algorithms have to be implemented in a way that takes advantage of the properties of the computer architecture that will be used to solve them (e.g., preparing them for parallelization or vectorization).

Current research topics are the method of hierarchical matrices for treating non-local phenomena and fast solvers for partial differential equations. ns.

Results

A new hybrid approximation technique for integral equations yields promising experimental results (DFG project BO 3289/2-1).

A new adaptive compression algorithm for H^2 - matrices provides the basis for significantly improving the efficiency of construction and preconditioning of dense matrices.

Personnel

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

Scientific Staff:

Dipl.-Math N. Albrecht	21.10.-31.12.2011	(50%)	CAU
Dipl.-Math D. Boysen	01.01.-31.12.2011	(50%)	CAU
Dipl.-Math J. Burmeister	01.01.-31.12.2011		CAU
Dipl.-Math J. Gördes	01.01.-31.12.2011		DFG
Separation der Fundamentallösungen elliptischer Differentialgleichungen mit Hilfe von Quadraturverfahren			
Dipl.-Math K. Reimer	01.01.-31.12.2011		CAU

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

Absolventen-Seminar Scientific Computing, 2 hrs Seminar/Week,
S. Börm (+ J. Burmeister)

Analysis 3, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
S. Börm (+ J. Burmeister)

Elementare numerische Methoden der Mathematik und ihre Implementierung I, 2 hrs Lecture/Week,
S. Börm (+ J. Burmeister)

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

Seminar - Numerische Mathematik und Optimierung, 2 hrs Seminar/Week,
S. Börm (+ J. Burmeister, Th. Slawig)

Summer 2011

Absolventen-Seminar Scientific Computing, 2 hrs Seminar/Week,
S. Börm (+ J. Burmeister)

Analysis 4, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
S. Börm (+ K. Reimer)

Numerik von Eigenwertproblemen (Mathematisches Praktikum), 4 (+ 2) hrs Lecture (+ Exercises)/Week,
S. Börm (+ J. Burmeister)

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

Elementare numerische Methoden der Mathematik und ihre Implementierung II, 2 hrs Lecture/Week,
J. Burmeister (+ S. Börm)

Winter 2011/2012

Absolventen-Seminar Scientific Computing, 2 hrs Seminar/Week,
S. Börm (+ J. Burmeister, K. Reimer)

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

Elementare numerische Methoden der Mathematik und ihre Implementierung I, 2 hrs Lecture/Week,
S. Börm (+ J. Burmeister)

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

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

Third-Party Funds

Deutsche Forschungsgesellschaft, *Separation der Fundamentallösungen elliptischer Differentialgleichungen mit Hilfe von Quadraturverfahren,* 01.02.2010-31.01.2013 (170.500 EUR)

Further Cooperation, Consulting, and Technology Transfer

Cluster „ Future Ocean“ .

Diploma, Bachelor and Master Theses

M. Mordhorst, *Numerische Behandlung der Darcy-Gleichung,* 23.06.2011
T. Greggers, *Adaptives Finite-Element-Verfahren zur Lösung elliptischer Eigenwertprobleme,* 26.07.2011
N. Albrecht, *Ein Eigenwertmehrgitterverfahren für elliptische Differentialgleichungen,* 25.08.2011

Presentations

S. Börm, *Wissenschaftliches Rechnen,* Symposium Schule - Hochschule - Beruf, Kiel, 03.02.2011
S. Börm, *Wissenschaftliches Rechnen,* MNU-Campus 2011 Schleswig Holstein, Kiel, 21.09.2011
S. Börm, *Mathematischer Blick in die Zukunft: Numerische Simulation,* Night of the Profs, Kiel, 18.11.2011
S. Börm, *H^2-Matrix Methods for Matrix Equations,* ETH Zürich, Zürich, 10.-12.10.2011
S. Börm, *Weighted hierarchical compression of boundary element matrices,* IABEM 2011, Brescia, Italien, 05.-08.08.2011
K. Reimer, *H^2-matrix preconditioners for boundary element matrices,* IABEM 2011, Brescia, Italien, 05.-08.08.2011
J. Gördes, *Low-rank approximation of integral operators by using the second Green formula and quadrature,* IABEM 2011, Brescia, Italien, 05.-08.08.2011
D. Boysen, *Numerical treatment of a transmission problem with H-matrices,* IABEM 2011, Brescia, Italien, 05.-08.08.2011

Further Activities and Events

Prof. Börm is working for a second term as „Associate Editor" for the SIAM Journal Scientific Computing.

Course „Grafikprogrammierung für die Schule" for the IQSH on 22.2.2011 in Kiel, 22.3.2011 in Flensburg, and 18.5.2011 in Bargteheide.

Software Engineering

The 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 to continuously 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 is 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 2011, the KoSSE projects MENGES and Xbase were running: project DynaMod (Dynamic Analysis for Model-Driven Modernization) started. Prof. Hasselbring received the **ISH -Transferprämie 2011**.

We contribute to several **research data management** activities, for instance in the Excellence Cluster Future Ocean. In 2011, two projects started: project MaWiFo on research data management in economics (with the ZBW, Leibniz-Informationszentrum Wirtschaft), and 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**.

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 the 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 monitoring 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 with a telecommunication customer self-service and a digital photo submission service. Kieker is available as open-source software. For more information on Kieker, refer to http://www.kieker-monitoring.net

SPEC Research Group opens a repository of peer-reviewed tools for quantitative system evaluation and analysis.

A repository of peer-reviewed tools for quantitative system evaluation and analysis is now available at the SPEC RG website. As a contribution to the community, SPEC RG addresses the need for a collection of tools that have undergone a thorough review process, by many independent experts, to ensure high quality and relevance. The review process covers important quality factors, including maturity, availability and usability. The repository is intended to have a broad scope, covering system evaluation and analysis with respect to both classical performance metrics, such as response time, throughput, scalability and efficiency, as well as other non-functional system properties included under the term dependability, e.g. availability, reliability, and security. In particular, tools for measurement, profiling, workload characterization, load testing, stress testing and resilience testing are solicited.

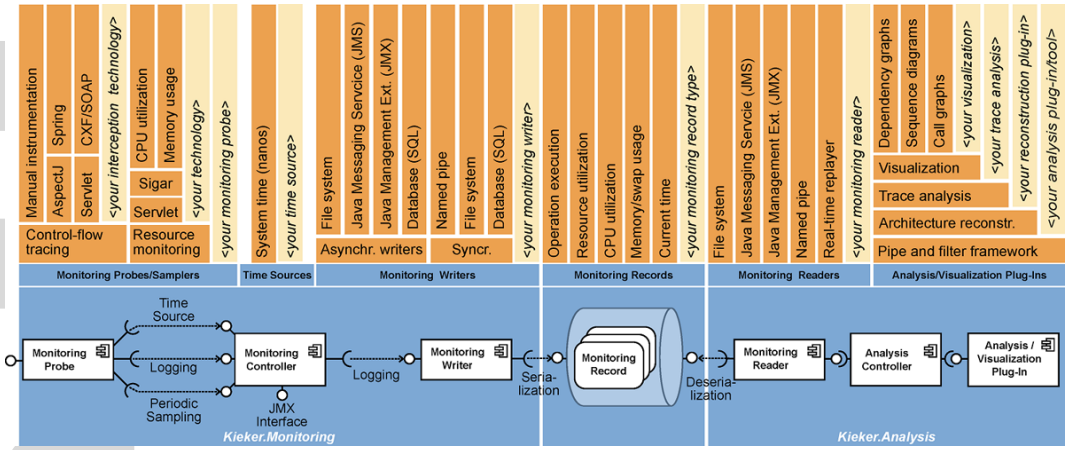


Fig. 1: Kieker Architecture and Reusable Components

Open And Growing: Among the first tools to pass the review process was Kieker, (see above). More tools are currently under review and further submissions are encouraged. After a careful review process, the tools are published on the SPEC RG website. The tools are redistributed without modification and the submitter retains the associated rights and responsibilities. As part of the acceptance process, SPEC RG may ask the authors to make changes or enhance certain features or aspects but SPEC RG itself does not make any changes.

Mature, Available, Usable The members of SPEC RG review the submitted tools using a wide spectrum of criteria starting with code-related requirements such as source structure and documentation, and ending with practical issues including licensing and support. Thus, the tools are expected to perform as advertised in most configurations. The goal of the review process is to deliver tools that are robust and result in a productive experience for those that commit resources to use them. Further information is available at http://research.spec.org/projects/tools.html and http://research.spec.org/news/single-view/article/repository-of-peer-reviewed-tools-launched.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 started at the beginning of 2011, has 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.

In 2011, the project and initial results have already been presented at scientific and professional conferences and workshops, including MDSM Workshop (Oldenburg), WSR (Bad Honnef), SEACON (Hamburg), and KoSSE-Tag and KoSSE-Workshop (Lübeck and Kiel respectively). 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 will last to December 2012.

In the first project year, the research focused on engineering the application domain of electronic railway control centres, the

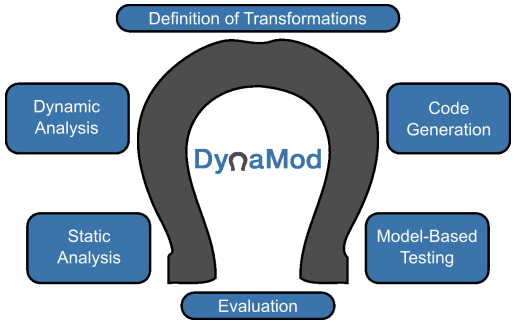


Fig. 2: Work Packages in DynaMod

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. Furthermore, different techniques of DSL coupling were explored and the findings have been presented to the research community at various conferences and workshops (SEACON, KoSSE-Tag Kiel, Transportforum, MDD-RW Karlsruhe, KoSSE-Workshop) in 2010. 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 will last until 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 started at the beginning of 2011 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, whereby 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 by so-called scientific workflows in the domain of fisheries. 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 about the workflows from institutional archives towards archival and publication of research 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.

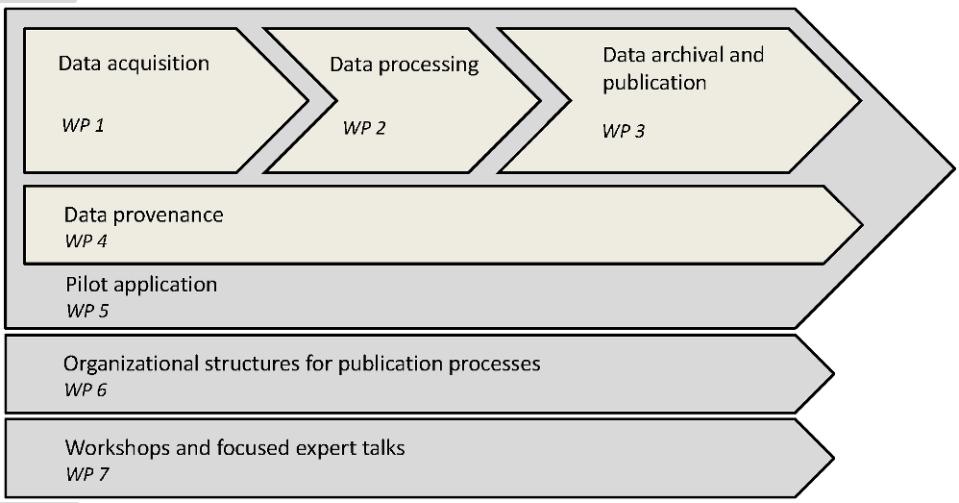


Fig. 3: Work Packages in PubFlow

Personnel

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

Staff:

Prof. Dr. W.-P. de Roever	01.01.-31.12.2011	retired

Scientific Staff:

Dipl.-Inf. P. Brauer PubFlow	01.08.-31.12.2011	DFG
Dipl.-Wirt.-Inf. J. Ehlers Kieker	01.01.-31.12.2011	CAU
M.Sc. S. Frey CloudMIG, Kieker	01.01.-31.12.2011	CAU
Dipl.-Inform. S. Gudenkauf ProCol, SCOPE	01.01.-31.12.2011	OFFIS
Dipl.-Inform. R. Jung MENGES, Kieker	01.01.-31.12.2011	ZPW / EFRE
Dipl.-Inform. G. Scherp MaWiFo	01.01.-31.12.2011	ZBW
Dipl.-Inform. A. van Hoorn DynaMod, Kieker	01.01.-31.12.2011	BMBF
Dipl.-Inform. R. von Massow Xbase	01.01.-31.12.2011	BMBF
Dipl.-Inf. J. Waller Kieker	01.01.-31.12.2011	CAU

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

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)

Summer 2011

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

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

Masterseminar - Empirical Methods in Software Engineering Research, 2 hrs Seminar/Week,
W. Hasselbring

Software Engineering für parallele und verteilte Systeme, 4 (+ 2) hrs Lecture (+ Exercises)/Week,

W. Hasselbring (+ S. Frey, J. Waller)

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, A. van Hoorn, S. Frey)

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

Third-Party Funds

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)

CAU, *eProject - Einführung von Kooperationswerkzeugen für Softwareprojekte in der Lehre,* 01.06.2010-30.05.2011 (4.622 EUR)

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

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

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

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

Further Cooperation, Consulting, and Technology Transfer

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

In eProject, we cooperate with eLK.Medien, the CAU service centre for e-learning.

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

In Kieker, we cooperate with XING AG and with researchers from 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), with the group for Communication Systems (Prof. Dr. Norbert Luttenberger), and the group on environmental, resource and ecological economics (Prof. Dr. Martin Quaas).

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.

Diploma, Bachelor and Master Theses

S. Fenner, *Migration of Software Systems to Platform as a Service Based Cloud Environments*, 31.10.2011
T. Frotscher, *Prognoseverfahren für das Antwortzeitverhalten von Software-Komponenten*, 31.03.2011
N. Günther, *Modellbasierte Laufzeit-Performance-Vorhersage für komponentenbasierte Softwarearchitekturen*, 16.11.2011
L. Kroll, *Performance Monitoring for a Web-based Information System*, 30.06.2011
P. Löffler, *Migration von Softwaresystemen auf IaaS-basierte Cloud Umgebungen*, 31.03.2011
F. Magedanz, *Dynamic Analysis of .NET Appliccations for Architecture-Based Model Extraction and Test Generation*, 31.10.2011
B. Weißenfels, *Multidimensionale Performance-Analyse komponentenbasierter Softwaresysteme*, 30.09.2011

Dissertations / Postdoctoral Lecture Qualifications

N. Streekmann, *Clustering-Based Support for Software Architecture Restructuring*, 30.09.2011

Publications

Published in 2011

S. Efftinge, S. Frey, W. Hasselbring, J. Köhnlein, *Einsatz domänenspezifischer Sprachen zur Migration von Datenbankanwendungen*, Datenbanksysteme für Business, Technologie und Web (BTW 2011), **Lecture Notes in Informatics**, 554 - 573 (2011)
J. Ehlers, A. van Hoorn, J. Waller, W. Hasselbring, *Self-Adaptive Software System Monitoring for Performance Anomaly Localization*, Proceedings of the 8th IEEE/ACM International Conference on Autonomic Computing (ICAC 2011), 197 - 200 (2011)
J. Ehlers, W. Hasselbring, *Self-Adaptive Software Performance Monitoring (Best Paper Award)*, Software Engineering 2011, 51 - 62 (2011)
J Ehlers, W. Hasselbring, *A Self-Adaptive Monitoring Framework for Component-Based Software Systems*, 5th European Conference on Software Architecture (ECSA '11), **Lecture Notes in Computer Sci.**, 278 - 286 (2011)
S. Frey, W. Hasselbring, *The CloudMIG Approach: Model-Based Migration of Software Systems to Cloud-Optimized Applications*, International Journal on Advances in Software, **4**, 3 - 4 (2011)
S. Frey, A. van Hoorn, R. Jung, W. Hasselbring, B. Kiel, *MAMBA: A Measurement Architecture for Model-Based Analysis*, Institut für Informatik, Universität Kiel, **TR-1112**, (2011)
S. Frey, W. Hasselbring, *An Extensible Architecture for Detecting Violations of a Cloud Environment's Constraints During Legacy Software System Migration*, Proceedings of the 15th European Conference on Software Maintenance and Reengineering (CSMR 2011), 269 - 278 (2011)
A. Fuhr, W. Hasselbring, V. Riediger, M. Bruntnik, K. Kontogiannis, *Joint Proceedings of the First International Workshop*

on Model-Driven Software Migration (MDSM 2011) and the Fifth International Workshop on Software Quality and Maintainability (SQM 2011), **708**, (2011)

S. Gudenkauf, W. Hasselbring, *Space-Based Multi-Core Programming in Java*, Proceedings of the 9th International Conference on the Principles and Practice of Programming in Java (PPPJ 2011), 41 - 50 (2011)

W. Hasselbring, V. Gruhn, *ECSA Companion Volume*, Software Architecture, 5th European Conference, ECSA 2011. Companion Volume, (2011)

A. van Hoorn, *Online Capacity Management for Increased Resource Efficiency of C-B Software Systems*, Proceedings of the Joint Workshop of the German Research Training Groups in Computer Science, GITO-Verlag, **48**, (2011)

A. van Hoorn, S. Frey, W. Goerigk, W. Hasselbring, S. Köster, H. Krause, M. Porembski, T. Stahl, M. Steinkamp, N. Wittmüss, *DynaMod Project: Dynamic Analysis for Model-Driven Software Modernization*, Joint Proceedings of the 1st International Workshop on Model-Driven Software Migration (MDSM 2011) and the 5th International Workshop on Software Quality and Maintainability (SQM 2011), **CEUR Workshop Proceedings 708**, 12 - 13 (2011)

A. van Hoorn, H. Knoche, W. Goerigk, W. Hasselbring, *Model-Driven Instrumentation for Dynamic Analysis of Legacy Software Systems*, Proceedings of the 13. Workshop Software-Reengineering (WSR 2011), 26 - 27 (2011)

R. von Massow, A. van Hoorn, W. Hasselbring, *Performance Simulation of Runtime Reconfigurable Component-Based Software Architectures*, 5th European Conference on Software Architecture (ECSA '11), **Lecture Notes in Computer Sci.**, 43 - 58 (2011)

D. Okanovic, A. van Hoorn, Z. Konjovic, M. Vidakovic, *Towards Adaptive Monitoring of Java EE Applications*, Proceedings of the 5th International Conference on Information Technology (ICIT 2011), (2011)

G. Scherp, W. Hasselbring, *Interoperability of the BIS-Grid Workflow Engine with Globus Toolkit 4*, Proceedings of the Grid Workflow Workshop 2011, **CEUR 826**, 1 - 6 (2011)

N. Streekmann, *Clustering-Based Support for Software Architecture Restructuring*, Vieweg-Teubner Verlag, (2011)

M. Wasilewski, W. Hasselbring, *A formal and pragmatic approach to engineering safety-critical rail vehicle control software*, Software Engineering 2011: Fachtagung des GI-Fachbereichs Softwaretechnik, **Lecture Notes in Informatics**, 99 - 110 (2011)

Presentations

J. Ehlers, *Self-Adaptive Software Performance Monitoring*, Software Engineering 2011, Karlsruhe, 24.02.2011

J. Ehlers, *Self-Adaptive Software System Monitoring for Performance Anomaly Localization*, 8th IEEE/ACM International Conference on Autonomic Computing (ICAC 2011), Karlsruhe, 16.06.2011

J. Ehlers, *A Self-Adaptive Monitoring Framework for Component-Based Software Systems*, 5th European Conference on Software Architecture (ECSA 2011), Essen, 14.09.2011

W. Hasselbring, A. van Hoorn, *Architecture reconstruction via dynamic analysis*, SEACON 2011, Architekturtag, Hamburg, Germany, 29.06.2011

W. Hasselbring, *Einsatz domänenspezifischer Sprachen zur Migration von Datenbankanwendungen*, BTW 2011, Kaiserslautern, Germany, 04.03.2011

W. Hasselbring, *Analyse des Laufzeitverhaltens von IT-Systemen zur Bewertung der IT-Architekturen*, Computer Science and Transport Symposium (CSTS), Kiel, Germany, 11.05.2011

W. Hasselbring, *Dynamische Analyse zur quantitativen Bewertung von Softwarearchitekturen*, Softwareforen, Leipzig, Germany, 30.05.2011

W. Hasselbring, *Domänenspezifische Sprachen zur Migration von Datenbankanwendungen*, 2. KoSSE-Tag, Lübeck, Germany, 08.06.2011

W. Hasselbring, *Towards Publication Workflows: Data Aquisition, Processing and Archival*, SimTech 2011, Stuttgart, Germany, 15.06.2011

W. Hasselbring, *Modellbasierter Entwurf SPS-basierter elektronischer Stellwerke*, Software-Architektur 2011, Hamburg, Germany, 20.07.2011

W. Hasselbring, *Reverse Engineering of Dependency Graphs via Dynamic Analysis (Invited talk)*, 5th European Conference on Software Architecture (ECSA 2011), Essen, Germany, 13.09.2011

W. Hasselbring, *Reverse Engineering von Softwarearchitekturen durch dynamische Analyse*, Kundenforum Architektur von Capgemini, Hamburg, Germany, 17.11.2011

W. Hasselbring, *Dynamische Softwarearchitekturanalyse*, HSH, Kiel, Germany, 21.10.2011

W. Hasselbring, *Reverse Engineering durch dynamische Analyse*, Universität Bremen, Bremen, Germany, 15.12.2011

W. Hasselbring, *PubFlow: Publication processes for research data*, Knowledge Exchange workshop on Primary Research Management, DFG, Bonn, 14.11.2011

A. van Hoorn, *Kieker: Continuous monitoring and analysis of software systems*, DynaMod-Workshop, Dataport, Altenholz, Germany, 17.02.2011

A. van Hoorn, *DynaMod project: Dynamic analysis for model-driven software modernization*, International Workshop on Model-Driven Software Migration (MDSM 2011), co-located with 15th European Conference on Software Maintenance and Reengineering (CSMR 2011), Oldenburg, Germany, 01.03.2011

A. van Hoorn, *Brief presentation of Kieker and Markov4JMeter*, SPEC Research Group face-to-face meeting, co-located with 2nd ACM/SPEC International Conference on Performance Engineering (ICPE 2011), Karlsruhe, Germany, 15.03.2011

A. van Hoorn, *Model-driven instrumentation for dynamic analysis of legacy software systems*, 13. Workshop Software-Reengineering (WSR 2011), Bad Honnef, Germany, 03.05.2011

A. van Hoorn, H. Knoche, *DynaMod: Dynamische Analyse für modellgetriebene Software-Modernisierung*, 2. KoSSE-Tag, Lübeck, Germany, 08.06.2011

A. van Hoorn, *Utilizing PCM for online capacity management of component-based software systems*, Palladio Days 2011, Karlsruhe, Germany, 18.11.2011

R. von Massow, A. van Hoorn, *Performance simulation of runtime reconfigurable component-based software architectures*, 5th European Conference on Software Architecture (ECSA 2011), Essen, Germany, 14.09.2011

G. Scherp, *The BIS-Grid Workflow Engine: Orchestrating Grid services with standard WS-BPEL*, Grid Workflow Workshop 2011, Köln, Germany, 04.03.2011

M. Wasilewski, *A formal and pragmatic approach to engineering safety-critical rail vehicle control software*, Tagung Software Engineering 2011, Karlsruhe, 24.02.2011

Further Activities and Events

S. Frey:

- member of the programme committee of the following conferences:

  CGC 2011: International Conference on Cloud and Green Computing

  CLOUD COMPUTING 2011: The Second International Conference on Cloud Computing, GRIDs, and Virtualization

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.
- reviewer for the following funding agencies:
  - Deutsche Forschungsgemeinschaft (DFG),
  - Natural Sciences and Engineering Research Council of Canada (NSERC).
- Editorial Board of the following journals:
  - Advances in Software Engineering,
  - Datenbank-Spektrum, Special Section "Programmierung von Datenbankanwendungen",
  - 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:
  - dpunkt Verlag,
  - Computer Science – Research and Development,
  - IEEE Software,
  - IEEE Transactions of Software Engineering,
  - Journal of Software and System Modelling,
  - Vieweg + Teubner Verlag.
- member of the programme committee for various conferences and workshops such as:

SE 2011: GI-Fachtagung Software Engineering ,

WI 2011: Development/Architecture of IS track,

IMETI 2010: 3rd International Multi-Conference on Engineering and Technological Innovation,

ESoSyM 2011: Evolutionäre Software- und Systementwicklung - Methoden und Erfahrungen,

CSMR 2011: 15th European Conference on Software Maintenance and Reengineering,

SQMB 2011: workshop zur Software - Qualitätsmodellierung und- bewertung,

DFF 2011: 3nd Workshop Design for Future,

GWW 2011: Vierter Grid Workflow Workshop,

TEAR 2011: Trends on Enterprise Architecture Research Workshop,

Informatik 2011: workshop Datenmanagement und Interoperabilität im Gesundheitswesen,

ESEC/FSE 2011: European Software Engineering Conference and the ACM SIGSOFT Symposium on the Foundations of Software Engineering Industrial Track,

TDSA2011: workshop on Traceability, Dependencies, and Software Architecture,

EMISA 2011: International Workshop on Enterprise Modelling and Information Systems, Architecture

CSMR 2012: 16th European Conference on Software Maintenance and Reengineering,

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).

- Organization of:
  - KoSSE-Tag 2011,
  - workshop Model-Driven Software Migration (MDSM 2011),
  - ECSA 2011 – Tutorial and Workshop Chair.

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 lies on massively parallel systems: particularly systems that can speed up computer intensive operations by the use of special purpose hardware architectures. The activities during 2011 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

Next Generation COPACOBANA

Many problems in scientific computing and crypto analysis are currently intractable due to the limitations of standard pc architectures or clusters of those. Solutions for that lack of performance are problem specific architectures like 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 COPACOBANA. The project COPACOBANA, the Cost Optimized COde Breaker and ANAlyser is as yet the only known affordable hardware for breaking DES (data encryption standard). It was developed in collaboration with the University of Bochum between 2005 and 2007.

In order to meet the requirements of modern bio-informatics, a number of additional features for COPACOBANA were desired. In a HWT2-project funded by the ISH (Innovation Society Schleswig-Holstein), the architecture RIVYERA has been designed for this purpose. During 2009 to 2011 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 will be ready to operate in 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, to solve problems in size that are unfeasible for standard PCs and even GPU-based systems or small computer clusters. Major topics include biological sequence alignment and de-novo assembly of genome sequences including read error correction.

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 solved was the implementation of the NCBI BLASTp algorithm for the RIVYERA architecture [ICCS2011]. BLASTp efficiently processes inexact searches for protein database queries, i.e. identifying similar sequences in a protein sequence database corresponding to the query. Perfectly integrated in the environment of the original NCBI BLASTp application a more than 200-fold increase in speed is reached compared to a standard PC. This project is being further developed still to improve speed and alignment quality. Currently, the original increase has already been doubled. The implementation of BLASTp was also introduced at the 3rd Workshop on Theoretical Biology of the Max-Planck-Institute in Plön.

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 (~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 usual 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. A running project focuses on the implementation of the Burrows-Wheeler based aligner „BWA" on the RIVYERA architecture. However, to fit the hardware structure of the internal FPGAs, a complete restructuring of the algorithm is required. The expected speedup will be about 200 and, as in BLASTp, the algorithm will be integrated in the environment of the original BWA application.

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 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 percent 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.

All projects considering short read alignment and de-novo assembly are done in close collaboration with the Institute of Clinical Molecular Biology at the UKSH and the SciEngines GmbH (manufacturer of the RIVYERA). A more medical related project considering SNP detection with the help of optimal short read alignment is currently in its completion phase.

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 2011 we developed a number of parallel financial mathematics algorithms for the architecture. These algorithms have been implemented in VHDL. The received results are impressive in terms of runtime and energy efficiency. In 2011, these results found their way into a commercial application with the company ISAVISION GmbH.

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. A universal client must therefore integrate different task models and must 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 will be funded until September 2012.

Personnel

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

Scientific Staff:

M. Sc. A. Abbas	01.01.-31.10.2011	University Aleppo

M. Sc. S. Koschnicke	01.01.-31.12.2011	Land SH
M. Sc. F. Schatz	01.01.-31.12.2011	Getdigital
Dipl.-Inf. Ch. Starke	01.01.-31.12.2011	KoSSE
Dipl-Inf. L. Wienbrandt	01.01.-31.12.2011	Land SH
M. Sc. C. Yeo	01.01.-31.12.2011	Land SH

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

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

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

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

Algorithmen der Bioinformatik, 2 hrs Seminar/Week,
M. Schimmler

Summer 2011

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

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

FPGA-Entwurf mit VHDL, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
M. Schimmler (+ M. Schimmler)

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. Yeo)

Winter 2011/2012

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

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

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

Third-Party Funds

University of Aleppo, *Stipendium Ayman Abbas,* 01.01.-31.10.2011 (9.245,00 EUR)
Ministerium für Wissenschaft, Wirtschaft und Verkehr, *BLK-Modellversuch,* 01.09.2010-30.08.2011 (30.000,00 EUR)
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 EUR)
ESN, *Universeller Aufgabenclient zur Unterstützung des technischen Betriebsmanagements bei verteilter Datenhaltung,* 01.10.2009-30.09.2012 (20.264,36 EUR)
GISWORK, *Universeller Aufgabenclient zur Unterstützung des technischen Betriebsmanagements bei verteilter Datenhaltung,* 01.10.2009-30.09.2012 (2.251,60 EUR)
Prof. Dr. Werner Petersen-Stiftung, *scholarshop Software-Challenge,* 01.08.2011 (18.000,00 EUR)
Dataport, *scholarship Software-Challenge,* 15.12.2011 (3.600,00 EUR)
Digitale Wirtschaft Schleswig-Holstein, *Software-Challenge,* 29.06.2011 (2.726,05 EUR)
ESN, *Software-Challenge,* 26.02.2011 (7.000,00 EUR)
Ministerium für Wissenschaft, Wirtschaft und Verkehr, *BLK-Modellversuch,* 01.01.2011-30.06.2012 (50.000,00 EUR)
Innovationsstiftung Schleswig-Holstein, *scholarship Software-Challenge,* 01.10.2011-30.09.2012 (14.400,00 EUR)

Diploma, Bachelor and Master Theses

F. Grohmann, *Fehlerkorrektur von Short Reads unter Verwendung von Suffixbäumen,* 12.08.2011
S. Möller, *Short-Read-Alignment unter Verwendung von Hash-Maps,* 16.08.2011

Publications

Published in 2011

F. Schatz, S. Koschnicke, N. Paulsen, Ch. Starke, M. Schimmler, *MPI Performance Analysis of Amazon EC2 Cloud Services for High Performance Computing Advances in Computing and Communications,* Communications in Computer and Information Science, **190**, 371 - 381 (2011)
L. Wienbrandt, S. Baumgart, J. Bissel, F. Schatz, M. Schimmler, *Massively parallel FPGA-based implementation of BLASTp with the two-hit method,* Proceedings of the International Conference on Computational Science, ICCS, **4**, 1967 - 1976 (2011)
F. Schatz, S. Möller, M. Schimmler, *Smarti - A fast short read alignment algorithm, Research in Computational Molecular Biology,* 15th Annual International Conference, RECOMB, Vancouver, Kanada, (2011)
L. Wienbrandt, *Hardware implementation and massive parallelization of BLAST,* Workshop on Theoretical Biology, Max-Planck-Institute for Evolutionary Biology, Plön, (2011)
S. Koschnicke, Ch. Starke, M. Schimmler, *Mobiler Aufgabenclient Plattformunabhängige Mobilisierung von bestehender Software zur Disposition,* Workshop Software Engineering 2011, Software Engineering Forum der Informatik-Transferinstitute, Karlsruhe, (2011)

Theoretical Computer Science

The theory group specializes in logic in computer science, automata theory and formal languages, verification, computational complexity, cryptographic protocols, and computing education.

Results

Information flow security. As the internet has become one of the major means of communication and interaction in our society, it is most important to ensure that communication over it is carried out in a secure fashion. This calls for: (1) mechanisms for secure communication, and (2) methods for proving systems using these mechanisms securely. Unfortunately, standard methods for (2) are not really modular: they do not support hierarchical approaches, and neither do they work well with abstraction, which means complex systems can hardly be proved secure at all. According to Rushby, a solution may be to analyze the information flow between individual components of a system. In fact, the notion of „information flow security" tries to capture this idea formally and may be a good starting point in this regard. One of the main results of the theory group in 2011 was a complete classification of different notions of information flow security proposed in the literature, in terms of their computational complexity.

Cryptography. In recent years, the theory group has built up expertise on cryptography, both in research and teaching. One of the major objectives in teaching is to convey that IT systems need not only be designed so as to ensure security but also rigorously proved to be secure (see above). There had been no textbook in German advocating this view until last year, when the theory group, together with a group at Trier University, concluded its work on the first, entitled „Moderne Kryptographie" .

Automata theory. Automata, basic models of computation, are applied in many areas of computer science. One particular automaton model, often used in verification of non-terminating computation processes, is a finite-state device called „Büchi automaton" . Over the last years, the theory group has contributed regularly to the study of Büchi automata. In 2011, in joint work with colleagues from the US and Israel, a result was obtained regarding complementation of Büchi automata, one of the major technical problems when dealing with such automata.

Propositional Logic. Continuing the research about constraint-related problems from propositional logic, the theory group studied the minimization problem for propositional formulas. In addition to its relevance for complexity theory (a variant of this problem led to the definition of the polynomial hierarchy), this problem has highly practical relevance in artificial intelligence, for example in the „compression" of knowledge bases. The group, in joint work with a colleague from the US, obtained very broad classification results showing in which cases formulas can be minimized efficiently. Unlike similar problems in the literature, the complexity of the minimization problem is not determined by the usual algebraic characterizations.

Modal Logic. In joint work with a colleague from the US, the theory group continued their research on complexity of the modal satisfiability problem. This year the main result is that there is a very „simple" modal logic that is undecidable, namely one which is obtained by restricting the allowed models to those satisfying a universal first-order formula (without equality). This result complements earlier work of the group about the complexity of the modal satisfiability problem where the class of allowed models was restricted to universal Horn formulas.

Computing education. In 2011, the theory group continued its work on the „Scratch project" . Its objective is to find out to which extent it is possible to convey basic programming and algorithmic skills, by (simply) using a specifically designed tool for designing computer animations and computer games in art courses. The tool used is Scratch, which was developed at MIT. First findings had shown that, in contrast to our assumptions, it is easier for children to use message passing (for structuring a distributed program) than to use loops (as a means of abstraction). In a new project, the theory group is investigating why the Annual „Software Challenge" , a programming contest for high school students organized by the group lead by Professor Schimmler and aimed at attracting talented students, has been such a success in recent years.

Personnel

Head of the group: Prof. Dr. Th. Wilke; Secretary: H. Capell (15 percent), F. Lorenz, D. Patz (15 percent)
Technical Staff: Th. Heß (50%)

Scientific Staff:

Dipl.-Math. S. Eggert	01.01.-31.12.2011		CAU
M.Sc. I. Khan	01.01.-31.07.2011		DAAD
Dr. rer. nat. K. O. Kürtz	01.01.-31.03.2011		CAU
Dipl.-Math. S. Preugschat	01.01.-31.12.2011	(50%)	CAU
Dipl.-Math. T. Radtke (75 percent)	01.01.-31.12.2011		ISH
Dr. H. Schnoor	01.01.-31.12.2011		CAU
StR S. Schulmeister	01.01.-31.12.2011	(50%)	CAU

Lectures, Seminars, and Laboratory Course Offers

Summer 2011

Inf-LogInf: Logik in der Informatik, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Th. Wilke (+ S. Preugschat)

MS0101: Kryptographie, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Th. Wilke, H. Schnoor (+ H. Schnoor, S. Eggert)

Inf-PP: Programmierpraktikum, 3 hrs Exercise/Week,
Th. Slawig (+ H. Schnoor, S. Schulmeister)

Inf-FortProg: Fortgeschrittene Programmierung, 3 (+ 2) hrs Exercise (+ Exercises)/Week,
F. Huch (+ Th. Wilke, F. Reck, B. Peemöller)

Winter 2011/2012

Inf-EinfPP: Einführendes Programmierpraktikum, 2 hrs Exercise/Week,
H. Schnoor (+ O. Fleischmann, S. Schulmeister, M. Spönemann)

Inf-TGI: Theoretische Grundlagen der Informatik, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Th. Wilke (+ S. Eggert, Th. Wilke)

MS0102: Automaten, Logiken, Spiele, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Th. Wilke (+ S. Preugschat)

Third-Party Funds

DAAD, *A/06/90283*, 01.03.-31.07.2011 (4.697,50 EUR)
Innovationsstiftung Schleswig-Holstein, *Wenn Bilder laufen lernen, ist Informatik nicht weit!*, 16.06.2010-30.04.2012 (133080 EUR)
b+m Informatik AG, *Schnupperstudium Informatik*, 17.-21.10.2011 (476,00 EUR)
DiWiSH, *Wenn Bilder laufen lernen, ist Informatik nicht weit!*, 01.01.-31.12.2011 (1.074,85 EUR)
ESN, *Wenn Bilder laufen lernen, ist Informatik nicht weit!*, 01.01.-31.12.2011 (1.190,00 EUR)

Further Cooperation, Consulting, and Technology Transfer

Cooperation with other groups:

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 and Master Theses

A. Mattal, *Kompakte Darstellung von Spielen,* 20.08.2011
K. Balzer, *Unmöglichkeitsresultate zur Wahlmanipulation in der Praxis,* 30.09.2011
H. Georg, *Fotoverschlüsselung in Browsern,* 30.09.2011
Th. J. Jensen, *Verteilter Abgleich und verteilte Sicherung von Daten,* 28.09.2011
A. Koch, *Ein Mittelsmannangriff auf ein digitales Signiergerät,* 17.09.2011
C. K. Liebchen, *Fuzzing für PDF-Betrachter,* 26.09.2011
S. Pfreundschuh, *Identity-Based Cryptography in Haskell,* 10.10.2011

Publications

Published in 2011

R. Küsters, Th. Wilke, *Moderne Kryptographie. Eine Einführung,* Vieweg + Teubner, (2011)
S. Fogarty, O. Kupferman, M.Y. Vardi, Th. Wilke, *Unifying Büchi Complementation Constructions,* CSL 2011, 248 - 263 (2011)
S. Eggert, R. van der Meyden, H. Schnoor, Th. Wilke, *The Complexity of Intransitive Noninterference,* Security and Privacy 2011, 196 - 2011 (2011)
E. Hemaspaandra, H. Schnoor, *Minimization for Generalized Boolean Formulas,* IJCAI 2011, 566 - 571 (2011)
E. Hemaspaandra, H. Schnoor, *A Universally Defined Undecidable Unimodal Logic,* MFCS 2011, 364 - 375 (2011)
M. Bauland, M. Mundhenk, T. Schneider, H. Schnoor, I. Schnoor, H. Vollmer, *The tractability of model checking for LTL: The good, the bad, and the ugly fragments,* ACM Transactions on Computational Logic, **12**, 1301 - 1328 (2011)

Presentations

Th. Wilke, *Functional Programs for Regular Expression Matching (invited talk),* Developments in Language Theory, Mailand, Italy, 19.-22.07.2011
Th. Wilke, *Prophetic Automata (invited talk),* Games Workshop, Paris, France, 31.08.-03.09.2011
H. Schnoor, *Epistemic, Strategic ATL* with Explicit Strategies,* Dagstuhl-Seminar, Wadern, Deutschland, 06.-11.03.2011

E. Hemaspaandra, H. Schnoor, *Minimization for Generalized Boolean Formulas,* IJCAI 2011, Barcelona, Spanien, 16.-22.07.2011

E. Hemaspaandra, H. Schnoor, *A Universally Defined Undecidable Unimodal Logic,* MFCS 2011, Warschau, Polen, 22.-26.08.2011

S. Eggert, R. van der Meyden, H. Schnoor, Th. Wilke, *The Complexity of Intransitive Noninterference,* Security and Privacy 2011, Oakland, USA, 22.-25.05.2011

Further Activities and Events

» Th. Wilke has been a member of the Council of the European Association for Theoretical Computer Science.

» Th. Wilke has been vice speaker of the division Grundlagen of the Gesellschaft für Informatik .

» Th. Wilke has been a member of the editorial boards of the following journals and series: Fundamenta Informaticae, Formal Methods in System Design, Lecture Notes in Logic.

» Th. Wilke was co-chair of the programme committee of STACS 2012.

» Th. Wilke served on an evaluation panel for the INRIA theme „Programs, Verification and Proofs“ .

» Th. Wilke consulted for the curriculum „Kunst und Informatik“ .

» Th. Wilke was member of the jury for „Bundeswettbewerb Informatik“ .

» Organization of several workshops for computer science and art teachers.

» Organization of one week Schnupperstudium Informatik.

» Organization of 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 for medical care).

Personnel

Head of the group: Prof. Dr. K. Jansen; Secretary: U. Iaquinto (50%)
Technical Staff: P. Karimi Massouleh (50%)

Scientific Staff:

K.-M. Klein	01.01.-31.12.2011		CAU
S. Kraft	01.01.-31.12.2011		DFG
L. Prädel	01.01.-31.12.2011	(50%)	DFG
L. Prädel Hochschulpakt 20/20	01.01.-31.12.2011	(50%)	CAU
C. Robenek Hochschulpakt 20/20	01.01.-31.12.2011	(50%)	CAU
C. Robenek	01.01.-31.12.2011	(50%)	DFG
Dr. I. Schnoor 3/4 Stelle	01.01.-31.03.2011		CAU
Dr. I. Schnoor	01.04.-31.07.2011	(50%)	CAU

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

Vorlesung - Lineare Optimierung und ganzzahlinge Optimierung, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
K. Jansen (+ K.-M. Klein)

Vorlesung - Approximative Algorithmen, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
K. Jansen

Fortgeschrittenen Praktikum - Effiziente Algorithmen, 4 hrs Lab/Week,
K. Jansen (+ S. Kraft)

Seminar - Theoretische Informatik (Ressourcenbeschränkte Algorithmen), 2 hrs Seminar/Week,
K. Jansen (+ K.-M. Klein, S. Kraft)

Seminar - Approximative Algorithmen, 2 hrs Seminar/Week,
K. Jansen

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

Summer 2011

Vorlesung - Algorithmen und Datenstrukturen, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
K. Jansen (+ C. Robenek, L. Prädel, I. Schnoor, K.-M. Klein)

Seminar - Approximative Algorithmen, 2 hrs Seminar/Week,
K. Jansen

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

Masterprojekt - Effiziente Algorithmen, 4 hrs Practical/Week,
K. Jansen (+ S. Kraft, K.-M. Klein)

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)

Third-Party Funds

DFG-Projekt, Entwicklung und Analyse von approximativen Algorithmen für zwei- und dreidimensionale Packungsprobleme, *Personal, travel, and aquisition,* 01.10.2008-30.09.2011 (203.280 EUR)
Fortsetzung DFG-Projekt, Entwicklung und Analyse von approximativen Algorithmen für zwei- und dreidimensionale Packungsprobleme, *Personal, travel, and aquisition,* 01.10.2011-30.04.2013 (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 Max-Planck-Institut für Informatik in Saarbrücken with the researcher Rob van Stee and 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.

Diploma, Bachelor and Master Theses

L. C. Balaj, *Approximation Algorithms for Scheduling Problems,* 01.09.2011

Publications

Published in 2011

K. Jansen, L. Prädel, U. Schwarz, O. Svensson, *Faster Approximation Algorithms for Scheduling with Fixed Jobs,* The 17th CATS symposium, (2011)

R. Harren, K. Jansen, L. Prädel, R. van Stee, *A $(5/3+\varepsilon)$-Approximation for Strip Packing,* Algorithms and Data Structures Symposium - WADS 2011, (2011)

M. Bougeret, P.-F. Dutot, K. Jansen, C. Robenek, D. Trystram, *Approximation algorithms for multiple strip packing and scheduling parallel jobs in platforms,* Discrete Mathematics, Algorithms and Applications, (2011)

K. Jansen, R. Solis-Oba, *A Polynomial Time OPT+1 algorithm for the cutting stock problem with a constant number of object lengths,* Mathematics of Operations Research, (2011)

K. Jansen, R. Solis-Oba, *A simple OPT+1 algorithm for cutting stock under the modified integer round-up property assumption,* Information Processing Letters, (2011)

M. Bougeret, P.-F. Dutot, K. Jansen, C. Robenek, D. Trystram, *Scheduling jobs on heterogeneous platforms,* 17th Annual International Computing and Combinatorics Conference (COCOON'11), (2011)

K. Jansen, C. Robenek, *Scheduling jobs on identical and uniform processors revisited,* 9th Workshop on Approximation and Online Algorithms (WAOA 2011), (2011)

L. A. Goldberg, K. Jansen, R. Ravi, J. D. P. Rolim, *Journal of the 14th International Workshops on Approximation Algorithms for Combinatorial Optimization Problems and the 15th International Workshop on Randomization and Approximation Techniques in Computer Science (APPROX '11 and RANDOM'10),* LNCS, **6845**, (2011)

Presentations

K. Jansen, *Approximation algorithms for scheduling and packing problems,* Colloquium of the Department of Computer Science of the University of Paderborn, Paderborn, Germany, 11.01.2011

K. Jansen, R. Solis-Oba, *A Polynomial Time OPT+1 algorithm for the cutting stock problem with a constant number of object lengths,* Dagstuhl Seminar 11091 on Packing and Scheduling Algorithms for Information and Communication Services, Dagstuhl, Germany, 27.02.-04.03.2011

K. Jansen, *A fast approximation scheme for the multiple knapsack problem,* 8th ESICUP Meeting, Copenhagen, Danmark, 19.-21.05.2011

K. Jansen, L. Prädel, U. Schwarz, O. Svensson, *Faster Approximation Algorithms for Scheduling with Fixed Jobs,* Workshop on Approximation and Online Algorithms (WAOA 2011), Nymburk, Czech Republic, 19.-24.06.2011

K. Jansen, *Approximation algorithms for scheduling and packing problems,* 9th Workshop on Approximation and Online Algorithms (WAOA 2011), Saarbrücken, Germany, 08.-09.09.2011

K. Jansen, L. Prädel, U. Schwarz, O. Svensson, *Faster Approximation Algorithms for Scheduling with Fixed Jobs,* Tagung der GOR-Arbeitsgruppe Projektmanagement and Scheduling, Berlin, Germany, 11.11.2011

K. Jansen, L. Prädel, U. Schwarz, O. Svensson, *Faster Approximation Algorithms for Scheduling with Fixed Jobs,* The 17th Conference of Computing: The Australasian Theory Symposium (CATS), Perth, Australia, 17.-20.01.2011

R. Harren, K. Jansen, L. Prädel, R. van Stee, *A $(5/3+\varepsilon)$-Approximation for Strip Packing,* Dagstuhl Seminar 11241, Dagstuhl, Germany, 13.-17.06.2011

R. Harren, K. Jansen, L. Prädel, R. van Stee, *A $(5/3+\varepsilon)$-Approximation for Strip Packing,* Algorithms and Data Structures Symposium - WADS 2011, New York, USA, 15.-17.08.2011

M. Bougeret, P.-F. Dutot, K. Jansen, C. Robenek, D. Trystram, *Scheduling jobs on heterogeneous platforms,* 17th Annual International Computing and Combinatorics Conference (COCOON'11), Dallas, USA, 14.-16.08.2011

K. Jansen, C. Robenek, *Scheduling jobs on identical and uniform processors revisited,* 9th Workshop on Approximation and Online Algorithms (WAOA 2011), Saarbrücken, Germany, 08.-09.09.2011

Further Activities and Events

Prof. Jansen was involved in the organization of the following conferences. As an invited speaker at the *Workshop on Approximation and Online Algorithms, WAOA 2011*, in Saarbrücken, he gave a talk on approximation algorithms for scheduling and packing problems. He was a workshop Co-Chair of the *Workshop on Approximation Algorithms for Combinatorial Optimization Problems (APPROX 2011)* and of the *Workshop on Randomization and Approximation Techniques in Computer Science (RANDOM 2011)* taking place in Princeton, USA. In addition he organized (with Clair Mathieu, Hadas Shachnai and Neal E. Young) the *Dagstuhl Seminar Packing and Scheduling Algorithms for Information and Communication Service* taking place in February. Prof. Jansen was a programme committee member of the *Workshop on Scheduling for Parallel Processing (SPC 2011)* in Torun, Poland, the *Workshop on Approximation and Online Algorithms (WAOA 2011)* in Saarbrücken, and of the conference *International Parallel and Distributed Processing Symposium (IPDPS 2011)* in Anchorage, Alaska, USA.

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 in 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 planning of the Cluster of Excellence *Materials for Life* (the final decision on funding will be announced in June 2012), in the *Computational Sciences Centre* of the CAU, and in the regional research network *CEwind - Centre of Competence in Wind Energy*.

As of December 2011, ET&IT consists of 11 professorships including the external professorship held by Prof. Dr.-Ing. Wolfgang Benecke, who also is the Managing Director of the Institut für Siliziumtechnologie (ISIT) in Itzehoe. At the end of 2011, three commissions were created to recruit to ET&IT professorships: Prof. Dr.-Ing. Helmut Röck (*Automation and Control Engineering*) will retire at the end of March 2012 and Prof. Dr.-Ing. Friedrich W. Fuchs (*Power Electronics and Electrical Drives*) will retire at the end of March 2013. The third professorship where a commission has been created is dedicated to the area of *Electrical Circuits*.

Beginning in the summer semester 2011, ET&IT has been offering two new master's programmes in *Electrical and Information Engineering* and in *Electrical and Information Engineering and Business Management*. These programmes consecutively follow the corresponding 7-term bachelor's programmes and each consists of two semesters for courses individually chosen from a module catalogue and of one semester for the master's thesis. Of course, these master's programmes are also open for graduates from other Universities. The master's programmes have been successfully accredited by the ASIIN until 2016.

For the winter semester 2011/2012 a total of 250 new students enrolled in academic courses offered by ET&IT. In detail, 105 students started the bachelor's programme *Electrical and Information Engineering* and 111 enrolled in the bachelor's programme *Electrical and Information Engineering and Business Management*. In the corresponding master's programmes 21 students took up their studies, and 13 new students enrolled in the international 4-semester master's programme *Digital Communications* where all courses are offered in English.

In 2011, ET&IT again was very active in the promotion of young talent. In particular, the Institute successfully participated in the events *tasteMINT*, *Girls Day*, *Schul-AG Technik* (engineering labs for pupils), and *Power Girls & Boys*. Finally, ET&IT again organized a project week on *Mobile Communications* for a partner school in Schleswig-Holstein and participated in the projects *lüttIng* and *Stadt der jungen Forscher*.

Automation and Control Engineering

The research activities of the group Automation and Control Engineering are in the areas of model-based measurement, modelling and control in biotechnology, and nonlinear and adaptive control of micromechanical systems.

The Automation and Control Engineering group is a member of the AHMT Workshop for measurement engineering and the GMA Workshop on Advanced Methods in Control (Theoretische Verfahren der Regelungstechnik).

Teaching activities are in the areas of state space methods, digital control and identification, optimal and robust control, together with two labs in control basics and advanced control.

Results

Coriolis Mass Flow Meter (Felix Koschmieder)

Due to a direct measurement principle Coriolis-Mass-Flow-Meters (CMFM) achieve a low measurement uncertainty of typically $\pm 0.05\%$. In order to guarantee low measurement uncertainties independent of the operating conditions, such as highly viscous fluids, system pressure or temperature gradients, a model based correction of sensitivity and zero point is essential.

A mechanical lumped parameter model describes the oscillation of the measuring pipe in the first and second eigenmode. Using the Euler-Lagrange-Formalism leads to a pair of coupled 2nd order differential equations. The structure of the model is depicted in fig. 1. Asymmetries in the mechanical design e.g. differences in damping of the inlet and outlet section of the pipe, which causes a drift of the zero point, are also considered. For detection of changes in sensitivity and zero point the CMFM has to operate in a cyclic measurement procedure.

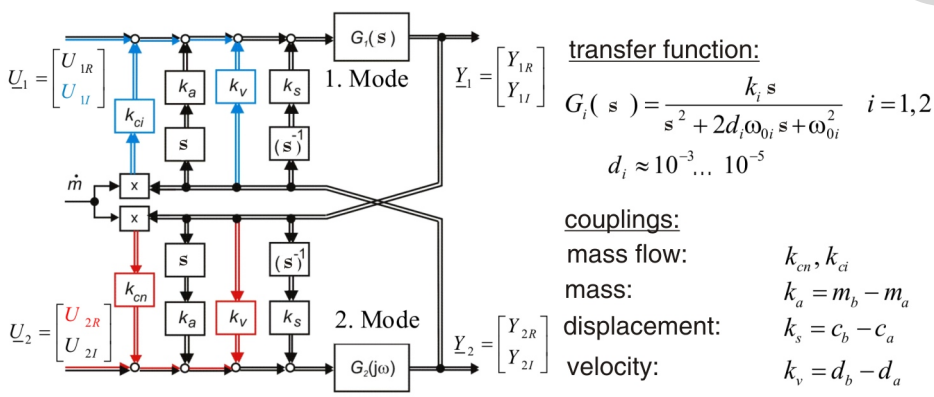


Fig. 1: Structure of the CMFM-Modell

A newly designed nonlinear phasor control allows the operating mode to be changed in only 5–6 periods of oscillation of the pipe on a real CMFM (cp. fig. 2); this is very fast if one takes into account the high quality factors of about 5000 of the oscillating pipe. The settling time is now limited in practice by the maximum available actuating force. The improvement of control performance is achieved by describing the oscillation with phasors for time varying excitation frequencies. A Kalman-Filter estimates the phasor from the sinusoidal time signal.

Cyclic changes of the operating mode can be avoided by separating the measurements in frequency domain. But by describing the oscillation at two excitation frequencies the number of states of the phasor model doubles and the model has now an order of 16. Therefore considerable calculation power is required for real-time implementation of the Kalman-Filter. The complexity is justifiable, because simulation results show an equal performance of the controller as well as the results

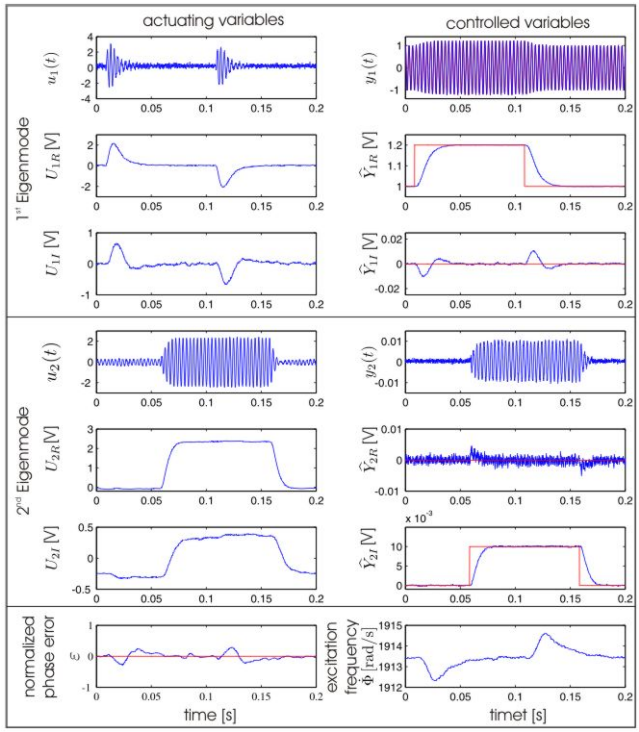


Fig. 2: Step change in amplitude of the oscillations in the 1st and 2nd eigenmode

presented here for one excitation frequency.

Control in Biotechnology (Eduard Peter)

Streptococcus thermophilus is one of the most important lactic acid bacteria in the dairy industry since it is extensively used as a starter culture for the manufacture of several dairy products such as yoghurt or cheese. One of the main roles of Streptococcus thermophilus in milk fermentation is acidifying the milk by metabolizing the substrate lactose into lactate, as well as preserving the product and adding aroma compounds.

In the industrial production of the starter culture the bacteria are cultivated in a batch reactor and harvested when the maximum activity is reached thus guaranteeing high yield and constant quality of the starter culture. Prediction of the optimal harvesting time is of great interest as the downstream process following the cultivation of the bacteria has to be started promptly. To predict the harvesting time we developed a soft-sensing technique based on artificial neural networks (ANN) that is currently being tested in the dairy industry.

When combining artificial knowledge together with exact process modelling the error in predicting the harvesting time for the biomass can be further reduced. The mathematical model of the batch fermentation process used was developed in a prior thesis and 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 on-line. Unfortunately the state variables cannot be measured on-line due to the lack of appropriate hardware sensors. For that reason, hardware sensors have to be replaced by software sensors based on the process model and exploiting on-line measurements of pH value and the chemical base added to keep the pH constant during batch fermentation.

The estimation of lactate is done using both the dynamic model developed by D. Barth and a newly developed static model derived from material balances together with an electroneutrality condition describing the impact of added base, lactate

and other chemicals to the equilibrium pH in the actual fermentation process.

As the culture medium is rather complex and the chemicals present in the medium are not known exactly, fictitious acids and bases with suitably chosen concentrations and dissociation constants have to be introduced to exactly represent the measurements of the pH value. This approach is currently being tested and compared to the ANN based technique for predicting the optimal harvesting time for the biomass.

Control of a Micro Mechanical Mirror (Thomas von Wantoch)

In order to develop a method enabling the controlled deflection of a laser beam with a gimbal-mounted 2D-scanner, in a first step, the harmonic oscillation around one axis has been investigated thoroughly. As a result a promising strategy for simultaneously controlling the frequency and the amplitude of the sinusoidal vibration has been designed and successfully tested in simulation. The mechanical part of the examined MEMS mirror is modelled as two coupled forced

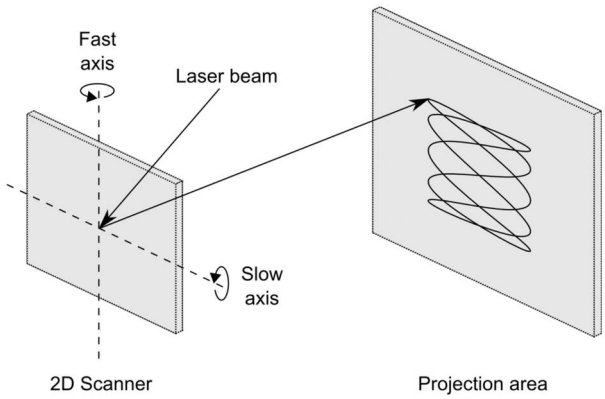


Fig. 3: Optical setup of a laser projection system with a single 2D scanner

oscillators with a cubic restoring force leading to a nonlinear second order differential equation for each axis of oscillation. Due to tolerances in the manufacturing process as well as environmental changes such as temperature fluctuations the characteristic parameters of the scanner are time-variant and not exactly known. Taking this into account an adaptive control strategy is utilized allowing on-line identification of the system parameters during operation.

To accomplish low power consumption and high mechanical angles the mirror is packaged in vacuum and must be driven in resonant mode. Controlling the frequency and amplitude of the oscillation is realized employing the phasor control approach that has been developed and applied to the Coriolis Mass Flow Meter at ART. In addition, the nonlinear dynamics of the microscanner are compensated for by feedback control resulting in a linear harmonic oscillation.

The excellent performance of the proposed algorithm with regard to dynamical response and robustness against disturbances in system parameters could already be shown in simulation.

In the next step, it is intended to implement and investigate the suggested control strategy realized by means of a FPGA-based DSP development system on an experimental set-up. For this purpose the nonlinear characteristic of the electrostatic actuation as well as the capacitive position measurement have to be considered. Furthermore, it is necessary to compensate the coupling between both of the perpendicular oscillations.

Personnel

Head of the group: 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.-31.12.2011		CAU
Prof. Dr. E. Pawluk Nonlinear Control	01.01.-31.12.2011		Guest
Dipl.-Wirtsch.-Ing. E. Peter Process Control in the Dairy Industry	01.01.-31.12.2011		CAU
Dipl.-Ing. Thomas von Wantoch Control of a Micro Mechanical Mirror	01.01.-31.12.2011		CAU
Dr. Wei Zhong Underactuated Systems	01.07.-31.12.2011		Guest
Dr. Wei Zhong Process Control in the Dairy Industry	01.01.-30.06.2011	(50%)	Ind.

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

Praktikum Leistungselektronik und Regelungstechnik, 4 hrs Lab/Week,
H. Röck (+ F. Koschmieder, E. Peter, T. von Wantoch)

Digitale Regelung, 2 (+1) hrs Lecture (+ Exercises)/Week,
H. Röck (+ E. Peter)

Regelungstechnik III, 2 (+1) hrs Lecture (+ Exercises)/Week,
H. Röck (+ F. Koschmieder)

Regelungstechnik I, 3 (+2) hrs Lecture (+ Exercises)/Week,
H. Röck (+ T. von Wantoch)

Ausgewählte Kapitel der Regelgungstechnik, 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)

Praktikum Regelungstechnik I, 4 hrs Lab/Week,
H. Röck (+ F. Koschmieder, E. Peter, T. von Wantoch)

Summer 2011

Praktikum Leistungselelktronik und Regelungstechnik, 4 hrs Lab/Week,
H., F. Röck, Fuchs (+ F. Koschmieder, Thomas von Wantoch, E. Peter)

Ausgewählte Kapitel der Regelungstechnik, 2 hrs Lecture/Week,
H. Röck (+ F. Koschmieder, E. Peter, Thomas von Wantoch)

Anleitung zum wissenschaftlichen Arbeiten, 1 hrs Seminar/Week,
H. Röck (+ E. Peter, F. Koschmieder, Thomas von Wantoch)

Einführung in die digitale Regelung, 3 (+1) hrs Lecture (+ Exercises)/Week,
H. Röck (+ T. von Wantoch)

Regelungstechnik II, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
H. Röck (+ E. Peter)

Optimale Regelung, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
H. Röck (+ F. Koschmieder)

Masterpraktikum Regelungstechnik, 4 hrs Lab/Week,
H. Röck (+ E. Peter, F. Koschmieder, T. von Wantoch)

Masterpraktikum Leistungselektronik und Regelungstechnik, 4 hrs Lab/Week,
H. Röck (+ E. Peter, F. Koschmieder, T. von Wantoch)

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 Regelgungstechnik, 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)

Third-Party Funds

Industrie, *Coriolis Mass Flow Measurement*, 01.01.-31.12.2011 (15.000,00)

Diploma, Bachelor and Master Theses

Arne Trost, *Erprobung und Weiterentwicklung eines nichtlinearen Zeiger- Regelkonzeptes für einen Coriolis-Massendurchflussmesser mit geradem Messrohr*, 17.01.2011

Christian Erlhofer, *Realisierung und Erprobung einer nichtlinearen Phasoren - Regelung für den Coriolis-Massendurchflussmesser, basierend auf einem Algorithmus mit zwei Zeitskalen*, 16.05.2011

Andreas Kater, *Entwurf einer nichtlinearen Mehrgrößenregelung für den Praktikumsversuch Drei-Tank-System*, 29.04.2011

Felix Rützel, *Entwurf und praktische Erprobung der Regelung für eine Verladebrücke*, 30.08.2011

Christian Mallas, *Realisierung eines adaptiven Minimal-Varianz-Reglers und Erprobung an einem analogen Regelstreckenmodell*, 26.04.2011

Dissertations / Postdoctoral Lecture Qualifications

Dorothee Barth, *Mathematische Analyse eines biotechnologischen Prozesses am Beispiel der Fermentation von Streptococcus thermophilus als Starterkultur*, 18.02.2011

Publications

Published in 2011

H. Röck, F. Koschmieder, *Compensation Method Applied to Coriolis Mass Flow Metering, Flomeko 2010, Taipeh, Taiwan,* 15th International Flow Measurement Conference Flomeko2010, CDROM ISBN 978-986-264-062-3, Taipei, Taiwan, (2010)

H. Röck, F. Koschmieder, *Operating a Coriolis Mass Flow-Meter at two different Frequencies simultaneously using Phasor Control,* 10th International Symposium on Measurement Technology and Intelligent Instruments (ISMTII-2011); Daejeon, S. Korea 29.06.-02.07.2011, (2011)

Further Activities and Events

Honorary positions of Prof. Röck:

member of the ISMTII 2011 organizing committee, Daejeon Kaist, Korea,

member of the „Tönnis Kommission" ,

member of the GMA Workshop Advanced Methods in Control (GMA Arbeitskreis Theoretische Verfahren der Regelungstechnik),

member of the AHMT (Arbeitskreis der Hochschullehrer für Messtechnik),

Head of Engineering Branch Library (Fachbibliothek Ingenieurwissenschaften),

member of Examination Committee Industrial Engineering,

member of the advisory board for Prof. Petersen Preis.

Communications

Research Activities:

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

Polarization multiplexing

Polarization multiplexing (Polmux), which transmits two channels of an identical wavelength in orthogonal states of polarization, can double the spectral efficiency of fibre-optic communication systems. Higher-order optical modulation formats such as square 16QAM combined with coherent detection is a promising technology for achieving a 100Gbit/s Ethernet. However, some impairment may happen during Polmux transmission, which limits the performance of optical communication. One of the critical challenges is polarization mode dispersion (PMD), which causes random pulse spreading and signal distortions as the signal propagates through the fibre. The other is the random phase noise induced by the non-zero laser linewidth. Therefore, in order to overcome these challenges, we need digital-signal-processing (DSP) at the receiver side to overcome the channel impairments, so that later data can be reconstructed properly. A fractionally spaced equalizer (FSE) with constant modulus algorithm (CMA) is a well-known blind equalizer and is used widely. It enables the compensation of linear optical impairments namely chromatic dispersion (CD) and PMD in the electrical domain. While the CMA error criterion is optimal for PSK signals, it is not optimal for 16QAM signals, since the errors do not go to zero when the equalizer has fully converged. After FSE the received signal is demultiplexed and equalized, but the constellation points are rotated to a random phase angle. The random phase noise has to be estimated by using carrier phase recovery. In contrast to PSK modulation where the phases are equally spaced, the phase distances for square 16QAM are not equal. The 112-Gb/s Polmux-QPSK has been reviewed and investigated by simulation. The CMA algorithm can compensate 1000-ps/nm CD and 100-ps DGD. The research challenges are to overcome the impairments for higher-order modulation formats namely 16QAM using DSP.

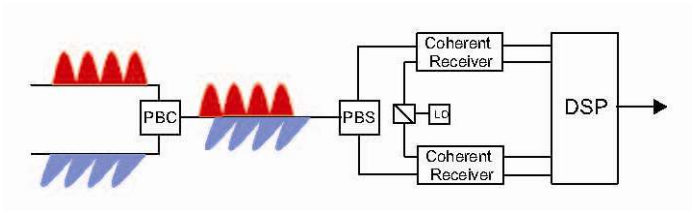


Fig. 2: Fig.: Polmux transmission with coherent detection.

OFDM over MMF Short Links

After having conquered the long and medium-range networks, optical solutions are nowadays rapidly penetrating into short-range data communication scenarios. The challenge is to offer cost-effective and robust optical solutions within relatively short ($\leq$ 1 km) transmission distances, where multimode fibres (MMF) that feature low costs and easy handling are more suitable than traditional single-mode fibres for long-haul transmission systems. However, the capacity of MMF is severely constrained by intermodal dispersion. Orthogonal frequency-division multiplexing (OFDM) with high spectrum efficiency and resistance to linear dispersion has been widely incorporated in commercial copper-based digital subscriber line (DSL) systems, and now is being considered as a strong candidate for MMF-based short links. An OFDM signal consists

of a number of closely spaced modulated carriers. The data to be transmitted on an OFDM signal is spread across the carriers of the signal, each carrier taking part of the payload. This reduces the data rate taken by each carrier. The lower data rate has the advantage of enhanced tolerance to linear dispersion. Adding a guard band time or guard interval can further enhance the tolerance to linear dispersion. Analysis and simulations show that it is possible to remove any frequency gap in the optical OFDM signal generated by a directly modulated laser (DML). Even direct detection is applied at the receiver, leading to significantly increased spectral efficiency and substantially reduced bandwidth of DML, receiver and DAC/ADC. Preliminary simulation results confirm that it is possible to transmit a frequency gap-free 10-Gb/s optical 16-QAM OFDM signal over a 250-m MMF with an original bandwidth-distance product of 495-MHz-km, under overfilled launch (OFL). By using restricted mode launch (RML), the transmission distance can be further extended to 500 m.

Passive optical networks (continued)

Passive optical networks (PON) are one of the most likely candidates to replace the currently installed copper based access networks. We are currently investigating different multiple access techniques in a PON. Promising candidates are wavelength division multiple access (WDMA), to share different wavelengths, and orthogonal frequency division multiple access (OFDMA) to share one wavelength in the frequency domain. Until recently, high speed point-to-multipoint transmission (PON-Upstream scenario) could only be simulated. However, with the newly acquired arbitrary waveform generator (AWG) with a maximum sampling rate of 24 GSamples/second we have the possibility to validate different high speed simulations in the lab (diagram below). With the help of offline processing the data is generated on the PC via Matlab and sent to the two AWGs. The data is then converted into the analog domain using 1x24GS/s or 2x12GS/s outputs of the new AWG and 1x 20GS/s or 2x10GS/s using the outputs of the older AWG. These data can then be added and transmitted over a fibre. After using a photodiode to convert the signal from the optical to the electrical domain the signal is sampled and digitized by a 50GHz/s real time scope. Using offline processing the data can be extracted.

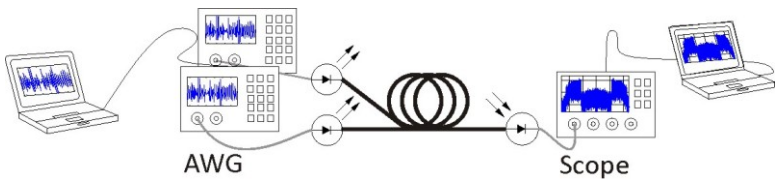


Fig. 3:

Therefore we are now able to investigate the upstream scenario in the lab as well, which is currently considered the Achilles' heel of OFDMA PONs.

Mitigation of nonlinear impairments in optical fibre transmission

Transmission at high optical launch-power levels can be very advantageous, e.g. in order to increase the transmission distance over a fibre, or in order to improve the spectral efficiency by means of multi-level modulation schemes. Unfortunately, this action will result in nonlinear effects throughout transmission, which distort the propagating optical signal, and degrade the system's performance. Therefore, equalization of nonlinear impairments in fibre-optic transmission systems is becoming more and more crucial for future system design. In order to be able to *optimally* compensate the nonlinear as well as linear impairments of the system, it is necessary to do it in conjunction with coherent detection, since it allows the detection of the electrical field of the received optical signal, which contains the information of the amplitude and phase. Thanks to the progressive research to develop faster and faster electronic circuits, coherent detection can be incorporated with a digital signal processing (DSP) unit, which allows the use of sophisticated algorithms for the equalization process. One of the leading electronic equalization methods is the so-called digital back-propagation (DBP), which compensates *jointly* for linear and nonlinear fibre impairments. DBP creates a mirror image of the transmission link by replacing amplifiers with attenuators and transmission fibres with fibres, whose transfer function is the exact inverse of the transmission fibres transfer function. This mirror image is implemented on a digital signal processing (DSP) unit by solving numerically the nonlinear Schrödinger equation (NLSE) with the help of the split-step Fourier method (SSFM).

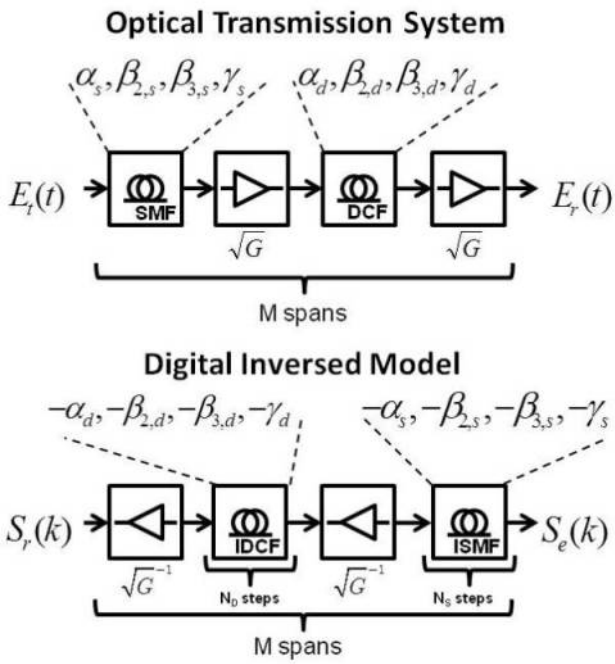


Fig. 1:

A block diagram of a transmission link: optical forward-propagation vs. digital back-propagation. S_r and S_e denote the received and equalized digital signals, respectively.

Personnel

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.-31.12.2011	Industry
M.Sc. Abdulamir Ali Orthogonale Frequenzmultiplextechnik (OFDM)	01.01.-31.12.2011	Land
Dipl.-Ing. Annika Dochhan Modulationsverfahren	01.01.-31.12.2011	CAU
Dr.-Ing. Jochen Leibrich OFDM und Simulationswerkzeuge	01.01.-31.12.2011	CAU
M.Sc. Roi Rath Kanalentzerrung	01.08.-31.12.2011	Industry
Dipl.-Ing. Christian Ruprecht OFDM-Konzepte für das optische Zugangsnetz	01.10.-31.12.2011	BMBF
Dipl.-Ing. Johannes von Hoyningen-Huene OFDM-Konzepte für das optische Zugangsnetz	01.08.-31.12.2011	BMBF

Dr. Jing Xu	01.08.-31.12.2011	BMBF
OFDM-Konzepte für das optische Zugangsnetz		
Dipl.-Ing. Jiani Zhao	15.04.-31.12.2011	CAU
Optical Communication		

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

Numerische Simulation analoger und digitaler Nachrichtensysteme, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
J. Leibrich (+ J. Leibrich)

Optische Kommunikationstechnik II (Hochgeschwindigkeitssysteme und Netze), 2 (+ 1) hrs Lecture (+ Exercises)/Week,
W. Rosenkranz (+ J. Leibrich)

Seminar über ausgewählte Kapitel der Nachrichtentechnik, 3 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

Communications Lab, 4 hrs Lab/Week,
W. Rosenkranz und Mitarbeiter

Digital Communications, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
W. Rosenkranz (+ A. Ali)

High-Speed Systems and Networks, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
W. Rosenkranz (+ J. Leibrich)

Advanced Topics Lab (Projekt), 4 hrs Projekt/Week,
W. Rosenkranz

Summer 2011

Nachrichtenübertragung, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
W. Rosenkranz (+ A. Dochhan)

Bachelorpraktikum Nachrichten- und Informationstechnik, 4 hrs Lab/Week,
W. Rosenkranz (+ C. Ruprecht)

Anleitung zum wissenschaftlichen Arbeiten für Studierende der Elektrotechnik und Informatonstechnik, 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

Optical Communicatons, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
W. Rosenkranz (+ J. Leibrich)

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)

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

Third-Party Funds

BMBF, *OFDM-Konzepte für das optische Zugangsnetz*, 01.01.-31.12.2011 (168.318)
Industry, *ADVAntage-PON*, 01.01.-31.12.2011 (89.250)
Industry, -, 01.01.-31.12.2011 (92.225)
Professor Dr. Werner Petersen-Stiftung, *Zuschuss für Gastprofessur*, 15.04.-19.06.2011 (6.000)

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.

Herr Prof. Dr.-Ing. N. Hanik, TU München, war als Gastprofessor im Rahmen der Exzellenzinitiative für den Aufenthalt exzellenter Wissenschaftler der Professor Dr. Werner Petersen-Stiftung in der Zeit vom 15.04.-19.06.2011 am Lehrstuhl tätig.

Diploma, Bachelor and Master Theses

Roi Rath, *Electronic Equalization of Nonlinear Impaiments in Fiber-Optic Transmission Systems*, 03.04.2011
Semjon Schaefer, *Numerische Simulation eines direkt modulierten Lasers zur Nachrichtentechnik*, 08.04.2011
Dennis Clausen, *Untersuchung und Anpassung der Zugangstechnik DMT auf den optischen Zugangsbereich*, 30.12.2011

Tim Claussen, *Effiziente Implementierung der Split-Step-Methode unter Berücksichtigung neuester Rechnertechnologie*, 30.12.2011

Sebastian Klein, *Parallelisierung eines MATLAB-basierten Softwarepaketes zur numerischen Simulation optischer Übertragungsstrecken*, 14.12.2011

Publications

Published in 2011

B. Inan, O. Karakaya, P. Kainzmaier, S. Adhikari, S. Calabro, V.A.J.M. Sleiffer, N. Hanik, S.L. Jansen, *Realization of a 23.9 Gb/s Real Time Optical-OFDM Transmitter with a 1024 Point IFFT*, OFC, **OMS2**, (2011)

A. Lobato, B. Inan, S. Adhikari, S.L. Jansen, *On the efficiency of RF-Pilot-based nonlinearity compensation for CO-OFDM*, OFC, **OThF2**, (2011)

J. von Hoyningen-Huene, J. Leibrich, A. Ali, W. Rosenkranz, *Constant Envelope Optical OFDM for Improved Nonlinear and Phase Noise Tolerance*, OFC, **OWE3**, (2011)

A. Dochhan, W. Rosenkranz, *A Systematic Approach to Investigate the Tolerance of 53.5 GBaud 33%-RZ-DQPSK towards Optical Filtering and Residual Chromatic Dispersion based on Experiments*, OFC, **OMI1**, (2011)

R. Ryf, C. Bolle, J. von Hoyningen-Huene, *Optical coupling components for spatial multiplexing in multi-mode fibers*, ECOC, **We.10.P1.79**, (2011)

S. Adhikari, B. Inan, O. Karakaya, W. Rosenkranz, S.L. Jansen, *FFT Optimization in Presence of DAC Imperfections*, ECOC, **We.10.P1.25**, (2011)

A. Dochhan, R. Rath, C. Hebebrand, J. Leibrich, W. Rosenkranz, *Evaluation of Digital Back-propagation Performance Dependent on Stepsize and ADC Sampling Rate for Coherent NRZ- and RZ-DQPSK Experimental Data*, ECOC, **We10.P1.79**, (2011)

J. Leibrich, A. Ali, W. Rosenkranz, *Decision feedback compensation of transmitter/receiver nonlinearity for DD-OFDM*, ECOC, **We.8.A.5**, (2011)

B. Inan, S. Adhikari, O. Karakaya, P. Kainzmaier, M. Mocker, H. von Kirchbauer, N. Hanik, S.L. Jansen, *Realization of a Real-Time 93.8-Gb/s Polarization-Multiplexed OFDM Transmitter with 1024-Point IFFT*, ECOC, **We.9.A.7**, (2011)

Presentations

S.L. Jansen, A. Lobato, S. Adhikari, B. Inan, D. van den Borne, *OFDM for ultra-high capacity long-haul transmission applications*, ONDM 2011, Bologna, Italy, 08.02.2011-10.02.2012

C. Ruprecht, J. von Hoyningen-Huene, A. Ali, W. Rosenkranz, *Untersuchung verschiedener Konzepte für OFDMA-PON im Zugangsbereich*, Workshop der ITG Fachgruppe 5.3.1, Modellierung photonischer Komponenten und Systeme, Dortmund, Deutschland, 14.-15.02.2011

B. Inan, O. Karakaya, P. Kainzmaier, S. Adhikari, S. Calabro, V.A.J.M. Sleiffer, N. Hanik, S.L. Jansen, *Realization of a 23.9 Gb/s Real Time Optical-OFDM Transmitter with a 1024 Point IFFT*, OFC 2011, paper OMS2, Los Angeles, USA, 06.-10.03.2011

A. Lobato, B. Inan, S. Adhikari, S.L. Jansen, *On the efficiency of RF-Pilot-based nonlinearity compensation for CO-OFDM*, OFC 2011, paper OThF2, Los Angeles, USA, 06.-10.03.2011

J. von Hoyningen-Huene, J. Leibrich, A. Ali, W. Rosenkranz, *Constant Envelope Optical OFDM for Improved Nonlinear and Phase Noise Tolerance*, OFC 2011, paper OWE3, Los Angeles, USA, 06.-10.03.2011

A. Dochhan, W. Rosenkranz, *A Systematic Approach to Investigate the Tolerance of 53.5 GBaud 33%-RZ-DQPSK towards Optical Filtering and Residual Chromatic Dispersion based on Experiments*, OFC 2011, paper OMI1, Los Angeles, USA, 06.-10.03.2011

S. Adhikari, S.L. Jansen, M. Alfiad, B. Inan, A. Lobato, V.A.J.M. Sleiffer, W. Rosenkranz, *Self-Coherent Optical OFDM, an interesting alternative to direct or coherent detection*, ICTON 2011, Stockholm, Schweden, 26.-30.06.2011

R. Ryf, C. Bolle, J. von Hoyningen-Huene, *Optical coupling components for spatial multiplexing in multi-mode fibers,* ECOC 2011, paper We.10.P1.79, Geneva, Switzerland, 18.-22.09.2011

S. Adhikari, B. Inan, O. Karakaya, W. Rosenkranz, S.L. Jansen, *FFT Optimization in Presence of DAC Imperfections,* ECOC 2011, paper We.10.P1.25, Geneva, Switzerland, 18.-22.09.2011

A. Dochhan, R. Rath, C. Hebebrand, J. Leibrich, W. Rosenkranz, *Evaluation of Digital Back-propagation Performance Dependent on Stepsize and ADC Sampling Rate for Coherent NRZ- and RZ-DQPSK Experimental Data,* ECOC 2011, paper We.10.P1.79, Geneva, Switzerland, 18.-22.09.2011

J. Leibrich, A. Ali, W. Rosenkranz, *Decision feedback copmpensation of transmitter/receiver nnlinearity for DD-OFDM,* ECOC 2011, paper We.8.A.5, Geneva, Switzerland, 18.-22.09.2011

B. Inan, S. Adhikari, O. Karakaya, P. Kainzmaier, M. Mocker, H. von Kirchbauer, N. Hanik, S.L. Jansen, *Realization of a Real-Time 93.8-Gb/s Polarization-Multiplexed OFDM Transmitter with 1024-Point IFFT,* ECOC 2011, paper We.9.A.7, Geneva, Switzerland, 18.-22.09.2011

R. Rath, A. Dochhan, J. Leibrich, W. Rosenkranz, *Electronic Equalization of Nonlinear Fibre Impairments with the Digital Backpropagation Method,* Workshop der ITG Fachgruppe 5.3.1, Modellierung photonischer Komponenten und Systeme, Karlsruhe, Deutschland, 24.-25.11.2011

Further Activities and Events

Mitgliedschaft von Prof. Rosenkranz in folgenden Gremien:

* 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)"*

LNT-Mitarbeiter wirken mit im „Arbeitskreis Übertragungstechnik" im Rahmen des BMBF Verbundprojektes „100GET" .

Herr Dr. Jochen Leibrich hat an der Ausbildung zum tasteMint Assessor teilgenommen. Ferner hat Herr Leibrich als Beobachter bei der Durchführung von tasteMint im März und Spetember teilgenommen.

Awards

Das Drittmittelprojekt 100GET wurde mit dem Celtic Excellance Award in Gold 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 (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 (and acoustic) fields using series expansions. It is an orthogonal decomposition of the field into the (canonical) dipole, quadrupole, octopole (etc.) fields with respect to a chosen origin. The method has been successfully employed to solve several classical boundary value problems in the frequency domain. Applications of spherical symmetry include diffraction at a perfectly conducting or dielectric sphere (Mie solution) and diffraction at a perfectly conducting cone. This DFG-sponsored project uses the extraordinary features of multipole analysis to evaluate and post-process numerically obtained near-fields. Within the FDTD-method, a near-field far-field transformation utilizes an equivalence principle: the sources of the field are replaced by electrical and magnetic currents on a closed surface surrounding all actual 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 expansion of the far-field obtained allows an enhancement of the numerically obtained results using a spatial frequency low-pass filter.

In this research project a novel technique has been developed that is perfectly adjusted to the problem: it allows a very efficient calculation of the Legendre polynomials needed. As an application of this technique the far-fields of UWB antennas for an entire frequency range have been calculated by just one single FDTD-run. The promising multipole interface for computational electromagnetics is still being developed and extended. In particular the efficiency of numerical convolution in the time-domain is to be improved.

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 mechanical constraints and on the frequency range of the anticipated disturbances. A quantitative measure of a shield's impact on electrical and magnetic disturbances at low frequencies is the electrical and magnetic shielding effectiveness. However, these measures are not applicable for high frequency or pulsed (transient) disturbances.

This research project concentrates on the evaluation of the adequacy of definitions regarding shielding effectiveness. This is done by simulated and experimental examination of specific shielding enclosures. We are particularly interested in the results of a near-field source of interference as compared to incoming plane waves.

c) Statistical EMC

Statistical EMC is an important part of statistical electromagnetics, as many variables and parameters in EMC (frequency, amplitude, waveform, geometry) are known only by means of their statistics. They might be given in terms of the first few statistical moments of their distributions. The special direction of this research is the combination with a spherical-multipole expansion of the electromagnetic field where only the amplitudes are described through statistical moments.

d) Multipole analysis of diffraction coefficients

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.

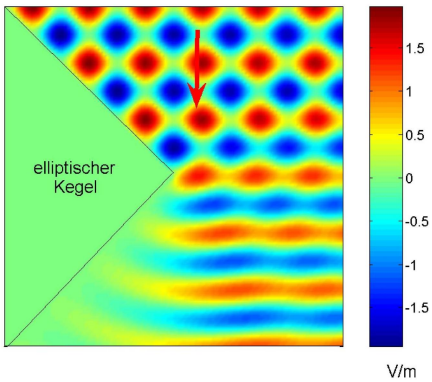


Fig. 1: Snapshot of the electric field strength in the plane of symmetry of a semi-infinite elliptic cone with a plane wave incoming from above. Interference in the region of reflection can be identified, as well as an almost undisturbed plane wave in the region of transmission and a spherical-wave-like diffracted field in the shadow region.

In this DFG sponsored research project we managed to determine diffraction coefficients from solutions for the sector and the elliptical cone. These structures have peaks and the associated diffraction coefficients are to be obtained. This is done by numerical evaluation of a series expansion of the field in elliptic conical coordinates using series transformations for improved convergence. Possible applications may include more precise calculations of the fields scattered by airport constructions, to improve instrument landing systems.

e) Multipole antennas

Antennas are renowned as key elements in wireless digital communications. In multipath propagation scenarios, as in the field of mobile devices, multiple antennas (MIMO systems) could improve crucial parameters such as SNR or channel capacity. In this project a novel approach to implement such systems in small devices (e.g. mobile phones) is to be examined. Instead of the usual approach of several separate antennas, only one antenna is fed through N inputs. By feeding different currents, N virtual antennas with orthogonal directional characteristics (multi-modes) can be achieved.

f) 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.

g) Modelling and localization of cardiomagnetic sources

The project is part of the Collaborative Research Centre (SFB) 855 on „Magnetoelectric Composites - Future Biomagnetic Interfaces“ funded 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	01.03.-31.12.2011	DFG
SFB855 - D1: Multipole-based reconstruction schemes		
Dipl.-Phys. F. Argin	01.04.-31.12.2010	DFG
SFB855 - D1: Multipole-based reconstruction schemes		
Dipl.-Ing. M. Kijowski	01.01.-31.12.2011	DFG
Scattering by semi-infinite structures		
Dipl.-Phys. K. Körber	01.01.-31.12.2011	CAU
Statistical EMC		
Dr.-Ing. V. Motrescu	15.03.-31.12.2011	DFG
SFB 855 -D4: Magnetocardiographic modelling and localization		

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

Elektromagnetische Felder 2, 2 (+1) hrs Lecture (+ Exercises)/Week,
L. Klinkenbusch (+ K. Körber)

Felder und Wellen in biologischen Systemen, 2 (+1) hrs Lecture (+ Exercises)/Week,
L. Klinkenbusch (+ K. Körber)

Intensivübung Elektromagnetische Felder, 1 hrs Exercise/Week,
L. Klinkenbusch (+ C. Argin, K. Körber, M. Kijowski)

Projekt, 3 hrs Lecture/Week,
L. Klinkenbusch (+ K. Körber)

Summer 2011

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 (+ M. Kijowski)

Projekt, 3 hrs Exercise/Week,
L. Klinkenbusch (+ K. Körber)

Felder und Wellen in biologischen Systemen, 2 (+1) hrs Lecture (+ Exercises)/Week,
L. Klinkenbusch (+ H. Ahrens)

Winter 2011/2012

Elektromagnetische Felder 2, 3 (+1) hrs Lecture (+ Exercises)/Week,
L. Klinkenbusch (+ F. Argin)

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

Third-Party Funds

DFG, *Semi-infinite Strukturen*, 01.01.-31.12.2011 (1/1 E13 + 1 WiMi + Sachmittel)
DFG, *1st German-Israeli Workshop on Advances in Electromagnetics*, 30.03.-02.04.2011 (11828)
DFG, *SFB 855 TP D1*, 01.01.-31.12.2011 (2 E13 + Sachmittel)
DFG, *SFB 855 TP D4*, 01.01.-31.12.2011 (1 E13 + Sachmittel)

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, ERSASMUS partnership

3. Prof. Dr. E. Cardelli, University Perugia (Italy), ERASMUS partnership

4. Prof. Dr. Paul Urbach, TU Delft und Philips Eindhoven (Netherlands), Subject: Scattering theory, FDTD-Simulationen

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), ERASMUS partnership

Diploma, Bachelor and Master Theses

H. Brüns, *Aufbau und Test eines FDTD-Programms zur Untersuchung des Kantenfeldes bei Schirmaperturen*, 18.04.2011

Dissertations / Postdoctoral Lecture Qualifications

C. Möller, *Analytische und numerische Untersuchungen zur Schirmdämpfung bei impulsförmigen elektromagnetischen Feldern*, 09.05.2011

Publications

Published in 2011

M. Kijowski, L. Klinkenbusch, *Eigenmode Analysis of the Electromagnetic Field Scattered by an Elliptic Cone*, Advances in Radio Science, **9 (doi:10.5194/ars-9-31-2011)**, 31 - 37 (2011)

L. Klinkenbusch, *Time-Domain Near-Field to Near-Field Transformation Using a Spherical-Multipole Approach (invited)*, Radio Science, **doi:10.1029/2011RS004670**, (2011)

L. Klinkenbusch, M. Kijowski, *Spherical-Multipole Analysis of Electromagnetic Scattering by an Elliptic Cone*, Proc. 16th International Symposium on Theoretical Electrical Engineering (ISTET11), Klagenfurt, Austria, **doi: 10.1109/INDS.2011.6024793**, 105 - 111 (2011)

K. Körber, L. Klinkenbusch, *Statistical Description of Shielding Problems Using Multipole Analysis (invited)*, URSI General Assembly (GASS), Istanbul, Turkey, **doi: 10.1109/URSIGASS.2011.605**, (2011)

C. Möller, L. Klinkenbusch, *Shielding Effectiveness for Transient Near-Field Sources (invited)*, Proc. 2011 International Conference on Electromagnetics in Advanced Applications (ICEAA 11), Torino, Italy, **doi: 10.1109/ICEAA.2011.604638**, (2011)

Presentations

M. Kijowski, L. Klinkenbusch, *Spherical-Multipole Analysis of Electromagnetic Scattering by an Elliptic Cone*, 16th International Symposium on Theoretical Electrical Engineering, Klagenfurt, Austria, 25.-27.07.2011

K. Körber, L. Klinkenbusch, *Statistical Description of Shielding Problems Using Multipole Analysis (invited)*, URSI General Assemby, Istanbul, Turkey, 13.-20.08.2011

C. Möller, L. Klinkenbusch, *Shielding Effectiveness for Transient Near-Field Sources (invited)*, 2011 International Conference on Electromagnetics in Advanced Applications, Torino, Italy, 12.-17.09.2011

V. Motrescu, L. Klinkenbusch, *Simulations of magnetocardiographic signals using realistic geometry models of the heart and torso*, Kleinheubacher Tagung 2011, Miltenberg, Germany, 26.-28.09.2011

K. Körber, L. Klinkenbusch, *Statistical Multipole Formulations for Shielding Problems*, Kleinheubacher Tagung 2011, Miltenberg, Germany, 26.-28.09.2011

F. Argin, H. Ahrens, L. Klinkenbusch, *Improved measurement surface for MEG using magnetic-dipole sources and a spherical-multipole expansion*, Kleinheubacher Tagung 2011, Miltenberg, Germany, 26.-28.09.2011

H. Ahrens, F. Argin, L. Klinkenbusch, *A Comparison of minimum norm and MUSIC for a combined MEG/EEG sensor array*, Kleinheubacher Tagung 2011, Miltenberg, Germany, 26.-28.09.2011

L. Klinkenbusch, *Time-Domain Spherical-Multipole Expansion of Radiated Fields*, 1st German-Israeli Workshop on Advances in Electromagnetics, Yad Hashmona, Israel, 30.03.-02.04.2011

Further Activities and Events

Prof. Klinkenbusch co-organized the 1st German-Israeli Workshop on Advances in Electromagnetics, successfully held in Yad Hashmona (Israel) on March 30 - April 2, 2011. Since 2009 he has been a Committee member of the German Academic Exchange Service (DAAD) for the region Near-East/ North Africa. Since October 2010, Prof. Klinkenbusch has served as the Managing Director of the Institute of Electrical and Information Engineering. He is also a representative for the Faculty of Engineering in the Schleswig-Holsteinische Universitätsgesellschaft.

Prof. Klinkenbusch is a member of VDE, elected member of URSI Commission B, and a Fellow of IEEE. He serves on the IEEE Antennas and Propagation Education Committee. In 2011, he served as a Guest Editor for the ISTET'09 special issue of COMPEL and as Associate Editor of RADIO SCIENCE for the special issue of EMTS 2010.

Digital Signal Processing and System Theory

The group now called "Digital Signal Processing and System Theory", (DSS), has been in existence since October 1993, formerly with the abbreviation LNS, for "Lehrstuhl für Netzwerk- und Systemtheorie", i.e. Chair of Circuit and System Theory. The new name was adopted with the appointment of a new professor: in 2010, Dr.-Ing. Gerhard Schmidt took over from Dr.-Ing. Ulrich Heute, who, however, is still actively involved in several projects of DSS.

At the beginning of 2011 there were nine scientific co-workers: three paid by the state, six on a project-funding basis, plus the Head of the group and his predecessor, with a secretary and a technician (both also working for the group for Information & Coding Theory (ICT) of Prof. Dr.-Ing. P. Höher). In addition, several students helped us, on a short-time job basis, with the everyday work in teaching, research, and administration.

During the year, two more positions with project funding were filled, one on a short-time basis, and one with a promotion perspective. At the end of the year, one of the team members finalized her dissertation and left the group, while a successor took over immediately. So, ten researchers are active now with the two professors. In addition, seven external research scientists are part of the DSS team.

Our cooperation with the Neurology Department of the University Clinics Kiel and with the Federal-Navy Research Institute for Under-Water Acoustics and Geophysics (FWG) continued with very good success, the latter still based on two BMV-funded projects, and the former 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.

At the end of 2010, another large project had been started. It is funded by BMWi, is termed PITAS, and 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. Furthermore, the cooperative work with the Telecom laboratories at TU Berlin was continued, based on a DFG-funded research project.

Speech and audio processing continue to be important research topics of the department. To be more precise, the investigation of so-called in-car communication systems (systems that support speech communication in passenger compartments) has been continued in 2011 and a car was equipped with various real-time signal processing capabilities in order to verify our theoretical approaches in real automotive environments. Furthermore, we started to investigate automatic evaluation schemes for in-car communication systems.

In addition to that, research on the (real-time) simulation of acoustic environments continued and led to the first promising results. With this approach, it is possible to simulate the acoustic properties of any location in a semi-anechoic chamber or even in an arbitrary, yet silent location. While the approach of wave field synthesis demands expensive equipment, our goal is to minimize the amount of channels needed.

Also in 2011 we started to investigate signal enhancement schemes for breathing masks as used by fire fighters. The first results (mainly the automatic suppression of breathing noise and automatic equalization) have been very promising and we will continue in this interesting field of research.

Results

On-going work led to numerous publications and presentations. Prof. Heute was invited to present an overview of the current work on instrumental speech-quality estimation at TU Vienna / Austrian Telecom Research Institute in May.

In September the DSS team organized an international workshop in Kiel about signal processing for in-vehicle systems (DSP in Vehicles 2011). Participants from all over the world joined the workshop and we had four very interesting days filled with talks, panels, and demonstrations.

Fig. 1: DSP in Vehicle workshop: A short visit to the plenary hall during the welcome reception in the Landeshaus.

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. Christoph Norrenbrock presented results at four conferences in Aachen, Düsseldorf, Turin and Florence, Italy.
- Medical signal processing: EEGs and, in the future, MEGs, are analyzed by Abdul Rauf Anwar, cooperating closely with our post-doc Muthuraman Muthuraman who has been a member of the Neurology group at Kiel's University Clinics since 2010. The aim is to find new hints to the sources of tremor diseases and the information flow inside the brain. The results led to various publications, both in journals and at conferences.
- Medical signal processing: Noise and artefact reduction in 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 Leck and Sankelmark, in March and September 2011, as well as at two international conferences in Siena, Italy, and Shanghai, PR China.
- Sonar-Signal Processing: Kathrin Wilkens continued to work for an FWG-BMV funded project on active-sonar DSP, with a focus on tracking by means of variants of Kalman filters. The state of the work was presented at four international conferences and workshops, and a dissertation was finalized.
- Sonar signal processing: Dennis Küter works with the PITAS system and, especially, with novel concepts of sonar sensors. His first ideas were published at DAGA 2011 in Düsseldorf.
- Sonar 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 work is documented in two project reports and in a contribution to an international conference in Berlin.
- 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.
- Real-time audio processing: Christian Lüke, Gerhard Schmidt, Anne Theiß, and Jochen Withopf continued with the development of the "KiRAT" soft- and hardware combination. "KiRAT" stands for Kiel Real-Time Audio Toolkit, and is the basis for the audio and speech research at the institute.

- Real-time audio processing: Jochen Withopf finished a first real-time version of an in-car communication system which improves the communication between front and rear passengers of a vehicle. His first results were published in a conference contribution.

- Real-time audio processing: Anne Theiß started to investigate automatic evaluation procedures for in-car communication systems. In addition, she worked on signal processing for enhancing the speech communication of fire fighters.

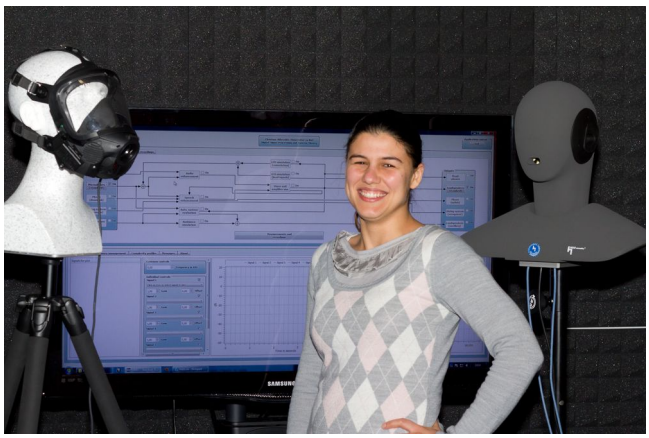


Fig. 2: Signal processing for enhancing the speech communication among fire fighters (presented by L. Jassoume).

- Real-time audio processing: Christian Lüke continued to implement an acoustic environment simulation, allowing for reliable and reproducible testing of speech and audio equipment in nearly real environments.

- Real-time audio processing: Vasudev Kandade Rajan started to work on multi-channel speech enhancement systems for automotive applications.

Signal processing, either for medical, underwater, or speech and audio applications, is a very interesting research discipline that led in 2011 to very interesting results : apart from which, we had a lot of fun with our research (see Fig. 3).

Fig. 3: Since the end of 2011 real-time processing can be tested also in our new research car.

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.-31.12.2011	Lecturer and PhD supervisor
Dr.-Ing. T. Ludwig	01.01.-31.12.2011	Lecturer

Scientific Staff:

M. Sc. A. R. Anwar	01.01.-31.12.2011	DAAD / PhD student
Dipl.-Wirtsch.-Ing. Jan. Bajorat	01.08.-31.12.2011	PhD student
M. Sc. H. Bakkari	01.10.-31.12.2011	External PhD student
Dipl.-Ing. M. Christoph	01.01.-31.12.2011	External PhD student
M.Sc. M. Haide	01.01.-31.12.2011	External PhD student
M.Sc. P. Hannon	01.01.-31.12.2011	External PhD student
M.Sc. V. Kandade Rajan	15.11.-31.12.2011	PhD student
Dipl.-Ing. R. Kreimeyer	01.01.-31.12.2011	FWG / PhD student
Dipl.-Phys. D. Küter	01.01.-31.12.2011	PITAS / PhD student
Dipl.-Phys. C. Lüke	01.01.-31.12.2011	PhD student
Dipl.-Wirtsch.-Ing. D. Nguyen	01.01.-31.12.2011	PITAS / PhD student
Dipl.-Ing. C. Norrenbrock	01.01.-31.12.2011	DFG / PhD student
M.Sc. A. Santillán Guzmán	01.01.-31.12.2011	DFG SFB / PhD student
M.Sc. Sebastian Stenzel	01.01.-31.12.2011	External PhD student
M.Sc. A. Theiß	01.02.-31.12.2011	PhD student
Dipl.-Wirtsch.-Ing. K. Wilkens	01.01.-31.12.2011	FWG / PhD student
Dipl.-Ing. J. Withopf	01.01.-31.12.2011	PhD student
M.Sc. A. Wolf	01.01.-31.12.2011	External PhD student
Dr.-Ing. H. Özer	01.-31.01.2011	Postdoc

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

Advanced Digital Signal Processing, 2 (+1) hrs Lecture (+ Exercises)/Week,
G. Schmidt (+ C. Lüke)

Advanced Signals and Systems, 3 (+2) hrs Lecture (+ Exercises)/Week,
U. Heute (+ H. Özer)

Digital Speech Signal Processing, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
U. Heute (+ C. Norrenbrock)

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 2011

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)

Statistical Signal Processing, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
T. Ludwig

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)

Winter 2011/2012

Advanced Digital Signal Processing, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
G. Schmidt (+ J. Bajorat)

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)

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 of Small Moving Targets under Water by DSP*, 01.01.-31.12.2011 (71 800 EUR)

Bundesamt für Wehrtechnik und Beschaffung (BMV), *Detection and Classification of Marine Mammals by means of Speaker-Recognition Methods,* 01.01.-31.12.2011 (60 000 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.-31.12.2011 (68 000 EUR)
BMWi, *PITAS,* 01.01.-31.12.2011 (170 000 EUR)
DAAD, *Brain Source Analysis,* 01.01.-31.12.2011 (18 000 EUR)

Diploma, Bachelor and Master Theses

L. Jassoume, *Speech Enhancement for Non-Stationary Distortions,* 31.12.2011
J. Puls, *Real-Time Implementation of a Binaural Simulation,* 31.12.2011
L. Torres, *Active Noise Control,* 30.11.2011
M. Nahrwold, *Species/Speaker Recognition with Gaussian Mixture Models - Model Based Marine Mammal Classification,* 31.10.2011
V. Kandade Rajan, *Multi-channel Speech Quality Improvement for Automotive Applications,* 30.09.2011
H. Xu, *Automatic Identification and Suppression of Artifacts in EEG data using ICA and Statistical Thresholding,* 30.09.2011
F. Heydasch, *Nicht-intrusive Qualitätsschätzung synthetisierter Sprachsignale mittels Vokaltraktapproximation,* 30.08.2011
J. Bajorat, *Implementierung eines Sprachverbesserungssystemes mit mehreren Mikrofonen,* 31.07.2011
C. Bude, *Comparison of Two Beamforming Algorithms,* 30.05.2011

Publications

Published in 2011

A. Santillán Guzmán, A. Galka, U. Heute, U. Stephani, *Application of State-Space Modeling to Instantaneous Independent Component Analysis,* Proc. IEEE International Conference on Biomedical Engineering and Informatics, (2011)
J. Withopf, C. Lüke, H. Özer, G. Schmidt, A. Theiß, *Signal Processing for In-Car Communication Systems,* DSP Workshop for In-Vehicle Systems, (2011)
M. Krini, G. Schmidt, B. Iser, *Generalized Spectral Refinement and its Applications,* DSP Workshop for In-Vehicle Systems, (2011)
K. Wilkens, D. Nguyen, U. Heute, *Adaptive Clutter Density in Multi-Hypothesis Tracking,* Proc. IEEE ISIF GI Workshop Sensor Data Fusion, (2011)
C. Norrenbrock, F. Hinterleitner, U. Heute, S. Möller, *Towards a better Understanding of TTS Synthesis: Subjective Quality and its Instrumental Assessment,* Proc. ESSV, (2011)
F. Hinterleitner, S. Möller, C. Norrenbrock, *An Evaluation Protocol for the Subjective Assessment of Text-to-Speech in Audiobook Reading Tasks,* Proc. Blizzard Challenge, (2011)
C. Norrenbrock, U. Heute, F. Hinterleitner, S. Möller, *Aperiodicity Analysis for Quality Estimation of Text-to-Speech Signals,* Proc. Interspeech, (2011)
F. Hinterleitner, S. Möller, C. Norrenbrock, U. Heute, *Perceptual Quality Dimensions of Text-to-Speech Systems,* Proc. Interspeech, (2011)
M. Muthuraman, A. Hossen, U. Heute, G. Deuschl, J. Raethjen, *A New Diagnostic Test to Distinguish Tremulous Parkinson's Disease from Advanced Essential Tremor,* Movement Disorders, (2011)
K. Wilkens, T. Ludwig, H. Schmaljohann, *New Developments for Multi-Hypothesis Tracking in Anti-Submarine Warfare,* UDT Europe, (2011)
A. Schulz, H. Schmaljohann, K. Wilkens, I. Nissen, C. Kubaczyk, W. Jans, *Systems and Concepts for Networked ASW,* Underwater Acoustics Measurements UAM, (2011)

K. Wilkens, M. Daun, *A Gaussian Mixture Motion Model and Contact Fusion Applied to the Metron Data Set*, Proc. International Conference on Information Fusion, (2011)
D. Küter, U. Heute, *Aktive Sonardetektion mit einem selbstausrichtenden Array*, Proc. DAGA, (2011)
C. Norrenbrock, U. Heute, F. Hinterleitner, S. Möller, *Quality Estimation of Text-To-Speech Signals*, Proc. DAGA, (2011)
F. Hinterleitner, S. Möller, C. Norrenbrock, U. Heute, *Comparison of Approaches for Instrumentally Predicting the Quality of Text-to-Speech Systems: Data from the Blizzard Challenge 2010*, Proc. DAGA, (2011)
A. N. Hossen, U. Heute, *Different Zoom Approaches for Improving Spectral Resolution with Applications in Radar Signal Processing*, J. Eng. Research, **8 / 1**, 1 - 11 (2011)
A. Santillán Guzmán, U. Heute, U. Stephani, A. Galka, *Digital Processing of EEG / MEG Signals*, Proc. Int. Summer School IEEE / EMB Biomed. Sig. Process., (2011)

Presentations

U. Heute, *Instrumental Estimation of Synthetic-Speech Quality*, Telecommunication Forum FTW, Vienna, Austria, 05.-07.05.2011

Further Activities and Events

Memberships and activities of U. Heute

* Editorial Board of the CAU university journal „Christiana Albertina“ ,

* Advisory Committee, European Association for Signal, Speech, and Image Processing (EURASIP),

* Scientific Committee, European Signal Processing Conference (EUSIPCO), Barcelona, 2011

* Reviewer for various international journals (EURASIP, IEEE, IEE)

* Head of the Kiel Section of „Schleswig-Holsteinische Universitäts- Gesellschaft“

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 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 multiuser 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, synchronisation, interference rejection). Among the applications are cellular radio systems (GSM and UMTS enhancements, WLAN, LTE, LTE-Advanced), underwater communications, in-body communications, satellite radio, and terrestrial broadcasting systems.

Concerning **teaching**, we offer lectures and exercises on channel coding, information theory, wireless communications and advanced wireless communications with the emphasis on digital signal processing, partly in English within the international master's course on ''Digital Communications''. A lecture on system identification (with a focus on underwater communications) and a lecture on time series analysis (with a focus on medical applications) are offered in the form of teaching assignments. 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, and 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, 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, new coding schemes have been investigated to further improve the system performance. With sophisticated channel coding, we are less than 1dB 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 system concept based on multi-layer interleave-division multiple access (ML-IDMA). 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, like the Levenberg-Marquardt method, particle swarm optimization, and simulated annealing, have been applied. In addition to finding the global optimum of the nonlinear metric, one major task has been to obtain soft information concerning the parameter estimates. Soft information corresponds to the variance of a parameter estimate and is a measure of reliability. The soft information can be exploited in a weighted positioning algorithm in order to improve the positioning accuracy. Different methods to obtain soft information were proposed and analyzed.

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.

In 2011, 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 significantly be improved to support higher-order modulation formats. The improved receiver supports a larger variety of channel codes and can cope even 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, in 2011 ICT proposed an advanced signal design for diver detection that is able to discriminate between moving objects (like divers) and stationary objects (like the sea bed).

Underwater Communications (Ivor Nissen, Christian Schroeder). In contrast to wireless RF communications, in underwater communications electromagnetic waves are rarely used. This is because of the strong absorption of EM-waves in water. In order to serve reasonable distances, acoustic communication is state-of-the-art.

In 2011, a research project was finished where two system approaches designed for different kinds of application have been investigated. The first system is based on a multi-carrier approach with non-orthogonal pulse shaping. It is suitable for medium to high data rates. The second system is designed for command & control links to underwater vessels. This system employs short bursts utilizing the entire transponder bandwidth. The benefit is the mitigation of inter-symbol interference due to the short burst duration and the small payload. This concept might in future be used to deploy an underwater network.

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.

Personnel

Head of the group: Prof. Dr.-Ing. P. A. Höher; Secretary: S. Schuchardt (50%)
Technical Staff: Dipl.-Ing. T. Rabsch

Scientific Staff:

Dipl.-Ing. R. Adam Joint Navigation and Communication	01.04.2009-31.12.2011	DFG
Dr. rer. nat. A. Galka Time Series Analysis	01.06.2009-31.12.2011	Lecturer
Dipl.-Ing. M. Gregory Free-space Optical MIMO Communications	01.01.2010-31.12.2011	External PhD Student
M.Sc. Dapeng Hao Interleave-Division Multiplexing (IDM), PITAS	01.01.2007-31.12.2011	DFG
Dipl.-Ing. Ch. Knievel 3GPP LTE-A	15.03.2009-31.12.2011	CAU
Dr. rer. nat. I. Nissen Acoustical Underwater Communications	01.10.2008-31.12.2011	Lecturer
M.Sc. M. Noemm Pirate defence (PITAS project)	01.06.2009-31.12.2011	BMWi
Dipl.-Ing. K. Schmeink Joint Navigation and Communication	01.04.2007-31.12.2011	CAU
Dipl.-Ing. Ch. Schröder Accoustical Underwater Communications	01.10.2008-30.06.2011	FWG
M.Sc. Z. Shi 3GPP LTE-A	01.01.2009-31.12.2010	Industry
Dipl.-Ing. V. Zeiger Underwater Navigation	01.01.2010-31.12.2011	External PhD Student

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

Grundlagen der Kanalcodierung, 2 (+1) hrs Vorlesung (+ Exercises)/Week,
P.A. Höher (+ und Mitarbeiter)

Information Theory and Coding I, 2 (+1) hrs Vorlesung (+ Exercises)/Week,
P.A. Höher (+ und Mitarbeiter)

Advanced Wireless Communications (DSP), 2 (+1) hrs Vorlesung (+ Exercises)/Week,
P.A. Höher (+ und Mitarbeiter)

System Identification, 2 (+1) hrs Vorlesung (+ Exercises)/Week,
I. Nissen

Communications Lab, 4 hrs Practical/Week,
P.A. Höher (+ W. Rosenkranz, G. Schmidt, und Mitarbeiter)

Advanced Topics Lab, 4 hrs Praktikum/Week,
P.A. Höher (+ W. Rosenkranz, G. Schmidt, und Mitarbeiter)

Informationstechnik und Codierung, 1 hrs Seminar/Week,
P.A. Höher

Summer 2011

Theoretische Grundlagen der Informationstechnik, 2 (+1) hrs Vorlesung (+ Exercises)/Week,
P.A. Höher (+ und Mitarbeiter)

Information Theory and Coding II, 2 (+1) hrs Vorlesung (+ Exercises)/Week,
P.A. Höher (+ und Mitarbeiter)

Wireless Communications (DSP), 2 (+1) hrs Vorlesung (+ Exercises)/Week,
P.A. Höher (+ und Mitarbeiter)

Real-time Signal Processing Lab, 4 hrs Practical/Week,
P.A. Höher (+ W. Rosenkranz, G. Schmidt, und Mitarbeiter)

Informationstechnik und Codierung, 1 hrs Seminar/Week,
P.A. Höher

Time Series Analysis, 2 (+1) hrs Lecture (+ Exercises)/Week,
A. Galka

Projekt, 3 hrs Seminar/Week,
P.A. Höher (+ und Kollegen)

Winter 2011/2012

Grundlagen der Kanalcodierung, 2 (+1) hrs Vorlesung (+ Exercises)/Week,
P.A. Höher (+ und Mitarbeiter)

Information Theory and Coding I, 2 (+1) hrs Vorlesung (+ Exercises)/Week,
P.A. Höher (+ und Mitarbeiter)

Advanced Wireless Communications (DSP), 2 (+1) hrs Vorlesung (+ Exercises)/Week,
P.A. Höher (+ und Mitarbeiter)

System Identification, 2 (+1) hrs Vorlesung (+ Exercises)/Week,
I. Nissen

Communications Lab, 4 hrs Practical/Week,
P.A. Höher (+ W. Rosenkranz, G. Schmidt, und Mitarbeiter)

Advanced Topics Lab, 4 hrs Practical/Week,
P.A. Höher (+ U. Heute, W. Rosenkranz, und Mitarbeiter)

Informationstechnik und Codierung, 1 hrs Seminar/Week,
P.A. Höher

Third-Party Funds

DFG, *Joint Navigation and Communication based on Interleave-Division Multiple Access (HO 2226/11-1)*,
15.03.2009-14.03.2012 (1x E13+Material and Traveling Expenses)

DFG, *Superposition Mapping: Theory and Applications (HO 2226/12-1)*, 01.10.2010-30.09.2012 (1x E13 + Material and Traveling Expenses)
FWG (WTD-71), *Acoustical Underwater Communications*, 01.07.2008-30.06.2011 (270835 EUR)
Industry, *3GPP LTE-A Channel Estimation*, 01.10.2008-30.09.2010 (NDA)
Industry, *3GPP LTE-A Interference Cancellation*, 01.10.2010-30.09.2012 (NDA)
Industry, *Interleave-Division Multiplexing*, 01.11.2009-31.01.2011 (NDA)
BMWi, *PITAS (Pirate Defense)*, 01.09.2010-31.08.2013 (ca. 240000 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,
- L-3 Communications ELAC Nautik GmbH, Kiel,
- Raytheon Anschütz, Kiel,
- Research Institute of the Armed Forces on Underwater Sound and Geophysics (FWG), Kiel,
- Huawei Technologies, Shanghai.

Diploma, Bachelor and Master Theses

R. Shashishekar, *A-priori Information for Cognitive Underwater Communication Systems*, 03.01.2011
E. Majeed, *Graph-Based Interference Cancellation for 3GPP DARP Phase II*, 14.02.2011
A.A. Saed, *Graph-Based Soft Channel Estimation and Symbol Detection for Superposition Mapping in MIMO Systems*, 23.02.2011
K.A. Jessen, *Kanalmodellierung für ein gemeinsames Kommunikations- und Navigationssystem*, 28.03.2011
B. Koosha, *Dynamic Infrastructure Management of Wireless Access Network In Home and Office Environment*, 15.08.2011
Y. Liu, *Channel Coding for an Optical MIMO Free-Space Link*, 24.08.2011
M.J. Sastre Torres, *State Estimator for Position Estimation via Received Signal Strength of WiFi and GPS Pseudo Ranges*, 01.11.2011
L. Gao, *Superposition Mapping for OFDM*, 09.12.2011
J. Chi, *Channel Coding for Superposition Mapping with Grouped Power Allocation*, 12.12.2011
W. Hao, *Soft Interference Cancellation for Wireless Networks*, 19.12.2011
B. Nikfar, *Adaptive Modulation and Coding for MIMO OFDM Systems*, 20.12.2011

Dissertations / Postdoctoral Lecture Qualifications

T. Wo, *Superposition Mapping & Related Coding Techniques*, 20.05.2011

Publications

Published in 2011

P.A. Höher, *Grundlagen der digitalen Informationsuebertragung: Von der Theorie zu Mobilfunkanwendungen*, Vieweg + Teubner Verlag, ISBN 3834808806, (2011)

P.A. Hoeher, *OFDM Data Detection and Channel Estimation,* H. Rohling (Ed.): OFDM, Concepts for Future Communication Systems, Springer-Verlag, ISBN 9783642174957, (2011)

P.A. Hoeher, T. Wo, *Superposition modulation: Myths and facts,* IEEE Communications Magazin, (2011)

K. Schmeink, R. Adam, P.A. Hoeher, *Joint communication and positioning based on soft channel parameter estimation,* EURASIP Journal on Wireless Communications and Networking, (2011)

H. Wu, T. Haustein, E. Jorswiek, P.A. Hoeher, *Sum rate optimization by spatial precoding for a multi-user MIMO DFT-precoded OFDM uplink,* EURASIP Journal on Advances in Signal Processing, 2011, (2011)

M. Noemm, N. ul Hassan, P.A. Hoeher, *Channel coding for IDM: High-rate convolutional code concatenated with irregular repetition code,* IEEE GLOBECOM, Houston, (2011)

Ch. Knievel, M. Noemm, P.A. Hoeher, *Low-Complexity Receiver for Large-MIMO Space-Time Coded Systems,* IEEE Vehicular Technology Conference, San Francisco, (2011)

Ch. Knievel, P.A. Hoeher, A. Tyrell, G. Auer, *Particle swarm enhanced graph-based channel estimation for MIMO-OFDM,* IEEE Vehicular Technology Conference, Budapest, (2011)

M. Noemm, P.A. Hoeher, Y. Wang, *Phase allocation aspects of interleave-division multiplexing from PAPR prospective,* IEEE Vehicular Technology Conference, Budapest, (2011)

K. Schmeink, R. Adam, P.A. Hoeher, *Influence of oversampling on channel parameter estimation for joint communication and positioning,* Workshop on Positioning, Navigation and Communication (WPNC), Dresden, (2011)

M. Gregory, P.A. Hoeher, *Adaptive channel coding for maritime FSO channels with RF feedback link,* IEEE Int. Conference on Space Optical Systems and Applications (ICSOS '11), Santa Monica, (2011)

D. Manteuffel, P.A. Hoeher, M. Mehdorf, *Evaluation of RF localization for deep brain implants,* 5th Europ. Conf. on Antennas & Propagation, Rome, Italy, (2011)

Patent Applications

Ch. Knievel, P.A. Hoeher, and further inventors, *Apparatus and Method for Estimating a Channel Coefficient of a Data Subchannel of a Radio Channel,* European Patent Office, 05.08.2011, 11176717.4-2415

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. He is heading an appointments committee on Control Theory.

Dipl.-Ing. Rebecca Adam is on leave at UCLA, Los Angeles.

Dipl.-Ing. Christopher Knievel is 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.

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. A highlight in 2011 in the area of nanostructured organic light emitting diodes (OLEDs) was the successful demonstration of multiperiod gratings. In the area of lab-on-a-chip systems we determined the refractive index of fluids with a simple integrated optoelectronic chip. We demonstrated a thermally-tuned active beam alignment system for optical interconnects. In the area of microscopy we developed a new microscopy method for three-dimensional imaging of cells based on nanostructured microscopy slides. Finally, we programmed a comprehensive modelling suite to analyze the behaviour of magnetoelectric sensors using analytic as well as numeric approaches. All of the above are just a few highlights of the year 2011. Details on the research results are presented below.

Results

Nanostructured organic light emitting diodes (OLEDs)

Organic light emitting diodes (OLEDs) have shown great potential for general lighting applications. Even now, 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. In 2011 we continued to investigate light extraction schemes using nanotechnological approaches. While nanostructures with a single frequency are a common technique to extract guided modes, they can lead to an undesired colour impression. In order to extract guided modes from OLEDs with reduced angular colour impressions, we are investigating compound Bragg gratings composed of multiple superimposed periods (see Fig. 1 a/b).

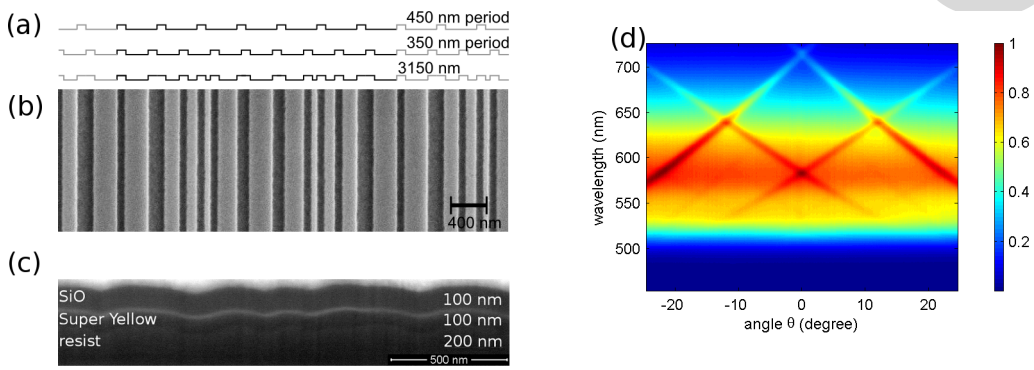


Fig. 1: (a) Superposition of multiple binary gratings to form a compound grating. (b) Scanning electron microscope (SEM) image of the two-period compound grating structure in a nickel shim. (c) SEM image of a photoluminescence sample. The grating cross section, the „Super Yellow" organic emission layer and a silicon monoxide (SiO) passivation layer are visible. (d) Angularly and spectrally resolved intensity measurement of the emission for a sample with a two-period compound grating.

In cooperation with the Karlsruhe Nano and Micro Facility (KNMF) a master shim with a range of period combinations has been designed and fabricated. In our laboratories we replicated the structures by nano imprint lithography (NIL) and fabricated OLED-like samples with organic emitters for photoluminescence measurements (Fig. 1c). We could show that two outcoupling features per period component arise for a single guided mode (Fig. 1d), which shows the great potential of this approach to enhance outcoupling with a minimized colour impression in OLEDs.

In order to increase the outcoupling efficiency of the grating between the OLED structure und the substrate, the refractive index difference between the grating layer and the OLED anode polymer needs to be maximized. We experimented with

different polymer grating layers. Introducing TiO2 nanoparticles into the nanostructured polymer allows an increase of the refractive index of the grating layer. In photoluminescence measurements we demonstrated the viability of this approach

Lab-on-a-chip

The possibility to integrate organic light-emitting diodes (OLEDs) and organic photo detectors (OPDs) on a single substrate opens the door for applications such as chemical sensors or biosensors. We integrated wet-processed OLEDs and OPDs on a single substrate in a lateral set-up. Hence, it is feasible to utilize the opposite side of the substrate for refractometric measurements of liquids. The part of the light guided through the glass substrate due to total internal reflection is detected at the OPD. The intensity of the OPD signal depends on the refractive index of the surrounding medium. We use a flow cell to change the refractive index on the opposite side of the substrate. The flow-cell is formed by squeezing an o-ring between the OLED-OPD substrate covered with a regular glass lid. Two butterfly cannulas pierced into the o-ring are used for in- and outflow of the liquid.

Ramping the OLED voltage with a triangular signal between 0 and 5V the light intensity of the OLED is changed. At higher voltages than the OLED threshold voltage (~2.3V) the light intensity increases exponentially. Therefore the detected OPD signal exhibits an exponential increase. The photo current measured at the OPD depends on the refractive index of the liquid in the flow cell. Higher refractive indices result in a lower photo current. To demonstrate this dependency, three different refractive indices were used: an empty flow cell (air, n=1), water (n=1.33), and a blend of water and glycerol (glycerol: n=1.47; 1:1 blend: n=1.4). As shown in Figure 2c), a decreasing signal is obtained with an increase of the refractive index in the flow cell.

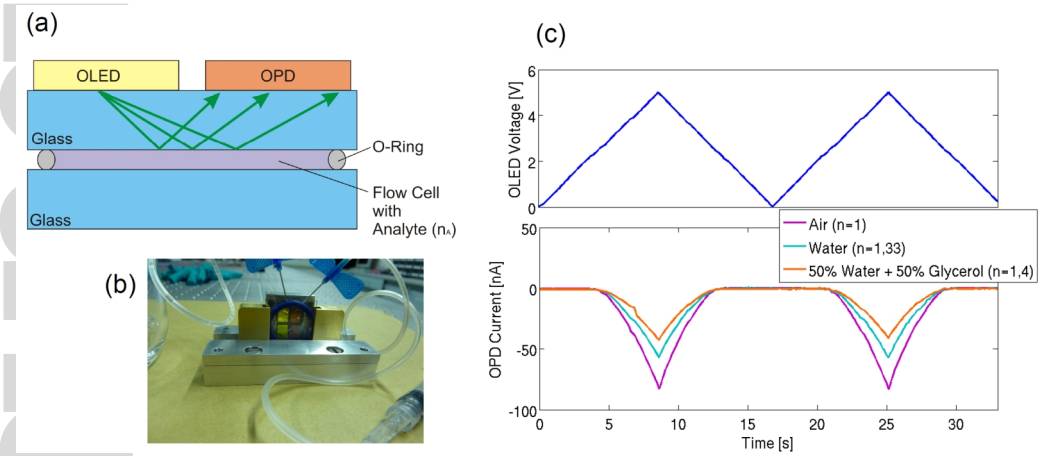


Fig. 2: (a) Schematic diagram of the measurement system consisting of the OLED-OPD substrate, a flow cell and a regular glass substrate. (b) Photograph of the measurement system. (c) OLED voltage (top) and experimentally obtained OPD current (bottom) as a function of time for three different liquids in the flow cell.

3D imaging based on photonic crystal slabs

3D microscopy of small objects, such as cells, always has been a challenging issue. However, the knowledge of the 3D shape of cells delivers crucial information such as cell type and cell cycle. In our research we developed a material-based method for 3D microscopy which is based on photonic crystal slabs. In contrast to conventional methods our approach uses the nano-optics inherent in the photonic crystal slab, and hence can be used with simple light microscopes.

Photonic crystal slabs are slab waveguides with a periodic nanostructure. These structures provide spectrally limited optical modes referred to as guided-mode resonances (GMRs), which can be excited both in transmission or reflection. Looking at the mode profile of GMRs we observe an evanescent part, which typically extends a few hundred nm out of the photonic crystal slab and can interact with objects on the surface. Hence, the object's optical thickness will affect the GMR's spectral position and quality factor and can be recalculated from these parameters. To demonstrate this method we scanned

a photonic crystal slab with fibroblast cells on its surface and determined the spectral position of the GMRs. Using a calibration curve, which was obtained by numerical calculations, we could calculate the optical thickness of the cells.

Integrated optics

In 2011 we continued our work on spatially dispersive tuneable thin-film structures. Reflective Gires-Tournois resonators, consisting of a polydimethylsiloxane (PDMS) layer sandwiched between two semi-transparent silver layers on right angle glass prisms were produced and investigated. Using Joule heating of the top silver layer, a thermal expansion of the resonator is achieved enabling a tuning of dispersion effects. The spatial shift of a Gaussian beam (He-Ne wavelength 633 nm) focused through the prism was analyzed. These devices allow for active beam alignment in optical interconnects, e.g., source-to-fibre coupling applications using their beam shift capabilities. An effective resonator cavity thickness change of 0.65% corresponding to a temperature increase of 26K was obtained using Joule heating actuation. At a time constant of 0.5-1 seconds a dynamic 12 microns beam actuation was achieved being in the order of magnitude of the beam waist.

Furthermore, grating structures and thin-film resonators on self-supporting PDMS membranes were successfully produced and thermally actuated. Using electrostatic actuation, membrane based active micro optics promises faster response times and larger effects, while strain constraints by the substrate are avoided. These structures are still subject to optimization of design and fabrication.

Modelling of magnetoelectric sensors

Within the framework of the SFB 855 we are designing magnetoelectric (ME) sensor structures. In 2011 we modelled the low-frequency performance of magnetic field sensors containing layers of piezoelectric materials and magnetostrictive materials on a silicon cantilever structure. Fig. 3 a) shows an example of a cantilever model structure.

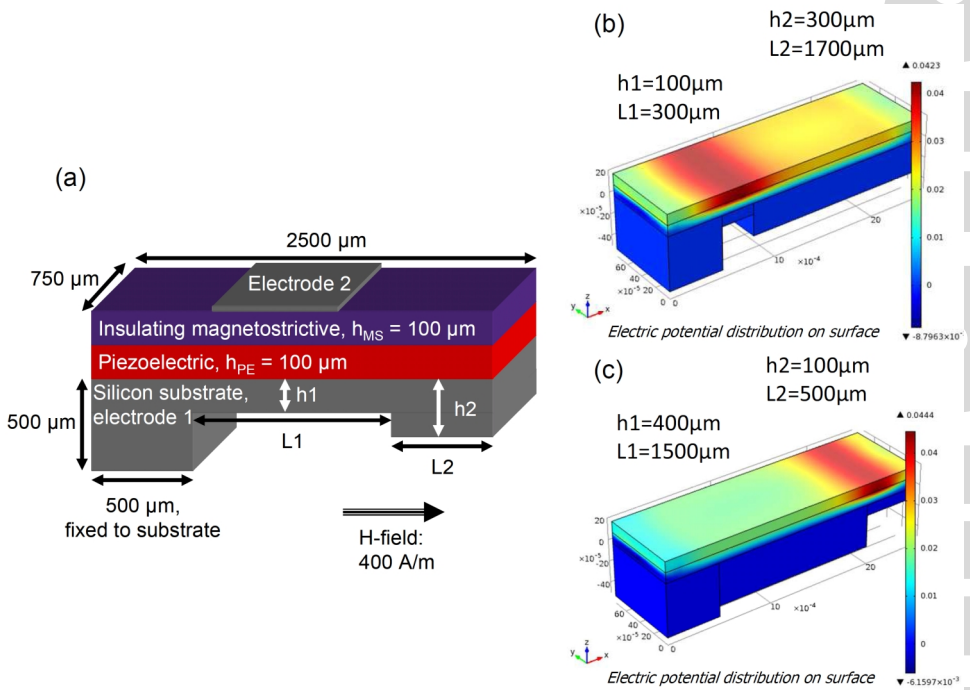


Fig. 3: (a) Schematic diagram of a cantilever magnetoelectric sensor. Finite-element-method simulation (FEM) of electric potential distribution on the surface for a cantilever with (b) a stress concentrator region in the middle and (c) a stress concentrator region at the tip of the cantilever.

Considering a fixed 100-micron thickness of magnetostrictive and piezoelectric layer, the cantilever design was varied and the best position for electrode 2 was evaluated. 3D numeric simulations were carried out with COMSOL Multiphysics (finite

element method, FEM) employing a linear model with ideal interface coupling. Figures 3 b) and c) show examples of the induced voltage as a function of position for two different cantilever structures. In both cases the highest voltage is induced above the region with a substrate thickness of 100 microns. Thus, electrode 2 should be placed above this region.

The induced voltage is influenced strongly by the neutral plane position. Therefore, scaling of the magnetostrictive and piezoelectric layer to smaller thicknesses requires a thinning of the substrate as well for maximum performance. When considering conductive magnetostrictive materials, this layer should be limited to the region where the highest voltage is produced to avoid charge averaging with lower response areas. Alternatively, an insulating layer should be used between the piezoelectric material and the magnetostrictive material.

Personnel

Head of the group: Prof. Dr. M. Gerken, Priv. Doz. Dr.-Ing. T. Mussenbrock; Secretary: S. Thielbörger (50%)
Technical Staff: Dipl.-Ing. J. Buschmann (50%), J. Greve

Scientific Staff:

M.Sc. A. Abdollahinia Magneto-electric sensors	01.-31.01.2011	DFG
Dr.-Ing. J. Adam Design and modelling	01.01.-31.03.2011	BMBF
Dr.-Ing. U. B. Bala Magneto-electric sensors	01.01.-30.09.2011	DFG
Dipl.-Phys. J. Hauss Organic light emitting diodes	01.01.-28.02.2011	BMBF
Dipl.-Ing. C. Kluge Lab-on-a-chip	01.01.-31.12.2011	CAU
Dr. M.C. Krantz Thin-film devices/Magneto-electric sensors	01.01.-31.12.2011	BMBF/DFG
Dipl.-Ing. P. Metz Microoptical systems	01.01.-31.12.2011	CAU
Dr.-Ing. Y. Nazirizadeh Nanostructures for analysis and imaging	01.01.-31.12.2011	BMBF/ISH
M.Sc. A. Pradana Nanostructured organic optoelectronics	01.01.-31.12.2011	CAU
Dipl.-Phys., MPhys. B. Riedel Organic light emitting diodes	01.01.-28.02.2011	BMBF
Dr. M. Rädler Lab-on-a-chip	01.01.-31.12.2011	BMBF
Dipl.-Wi.-Ing. D. Threm Lab-on-a-chip	01.01.-31.12.2011	BMBF

Winter 2010/2011

Grundgebiete der Elektrotechnik I, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
T. Mussenbrock (+ staff and student tutors)

Grundlagen der Elektrotechnik, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
T. Mussenbrock (+ A. Dochhan)

Seminar Integrierte Systeme und Photonik, 2 hrs Seminar/Week,
T. Mussenbrock

Praktikum Optoelektronik, 4 hrs Exercise/Week,
Scientific staff

Summer 2011

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 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

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)

Diploma, Bachelor and Master Theses

L. Gugat, *Optimierung von OLEDs für Chiplabore,* 03.02.2011
M. Bremer, *Herstellung, Charakterisierung und Optimierung nanostrukturierter Spincoat-OLEDs,* 11.04.2011
B. Ripke, *Empfindlichkeit und Detektionsgrenze von Chiplaboren für optische Brechungsindexmessungen,* 05.08.2011
A. Zaman, *Optimierung der dynamischen Eigenschaften von aktiven Mikrooptiken auf Basis von dielektrischen Elastomeren,* 15.08.2011
T. Karrock, *Optische Druckmessung mittels nanostrukturierter Oberflächen,* 01.12.2011

Publications

Published in 2011

J. Hauss, T. Bocksrocker, B. Riedel, U. Geyer, U. Lemmer, M. Gerken, *Metallic Bragg-gratings for light management in organic light-emitting devices,* Appl. Phys. Lett., **99**, 103303 (2011)
J. Hauss, T. Bocksrocker, B. Riedel, U. Lemmer, M. Gerken, *On the interplay of waveguide modes and leaky modes in corrugated OLEDs,* Optics Express, **19**, 851 - 858 (2011)
Z. Wang, J. Hauss, C. Vannahme, U. Bog, S. Klinkhammer, D. Zhao, M. Gerken, T. Mappes, U. Lemmer, *Nanograting transfer for light extraction in organic light-emitting devices,* Appl. Phys. Lett., **98**, 143105 (2011)
B. Riedel, Y. Shen, J. Hauss, M. Aichholz, X. Tang, U. Lemmer, M. Gerken, *Tailored Highly Transparent Composite Hole-Injection Layer Consisting of Pedot:PSS and SiO2 Nanoparticles for Efficient Polymer Light-Emitting Diodes,* Advanced Materials, **23**, 740 (2011)
J. Hauss, B. Riedel, S. Gleiss, U. Geyer, U. Lemmer, M. Gerken, *Periodic nanostructuring for guided mode extraction in organic light-emitting diodes,* J. Photon. Energy, **1**, 011012 (2011)
B. Riedel, J. Hauss, Y. Shen, M. Aichholz, U. Lemmer, M. Gerken, *Polymer light-emitting diodes with inorganic nanocomposite interlayers for efficiency enhancement,* J. Photon. Energy, 011012 (2011)

Patent Applications

Y. Nazirizadeh, M. Gerken, *Verfahren zur Bestimmung der Dicke von Objekten mit Hilfe eines Licht-Mikroskops,* Deutsche Patentanmeldung, 16.11.2011, DE 10 2011 118 641.0

Presentations

M.C. Krantz, P. Metz, S. Peters, F. Glöckler, U. Lemmer, M. Gerken, *Optical beam positioning with PDMS thin film resonators for thermal drift compensation in free-space optical interconnects,* IEEE Winter Topicals, Keystone, CO, USA, 10.-12.01.2011
Y. Nazirizadeh, U. Lemmer, M. Gerken, *Surface contrast microscopy,* Optics in the Life Sciences: OSA Optics and Photonics Congress, Monterey, CA, USA, 04.-06.04.2011
P. Metz, M.C. Krantz, M. Gerken, *Wavelength and polarization effects in actively tunable thin film resonators for thermal drift compensation,* 13th International Conference on Transparent Optical Networks ICTON 2011, Stockholm, Sweden, 26.-30.06.2011
D. Threm, Y. Nazirizadeh, A. Pradana, M. Raedler, J. Mikat, M. Gerken, *Integrated organic optoelectronic system for refractometric measurements,* 16th International Conference on Optical MEMS and Nanophotonics - OMN 2011, Istanbul, Turkey, 07.-11.08.2011
Y. Nazirizadeh, J.F. Reverey, C. Selhuber-Unkel, M. Gerken, *3D imaging of cells with nanostructured microscope slides,*

Microscopy Conference MC 2011, Kiel, Germany, 28.08.-02.09.2011

P. Metz, M.C. Krantz, M. Gerken, *Tunable thin film resonator for efficient VCSEL-to-fiber coupling*, 4th EOS Topical Meeting on Optical Microsystems, Capri, Italy, 26.-28.09.2011

C. Kluge, P. Metz, B. Ripke, Y. Nazirizadeh, M. Gerken, *Integrated refractometer design with directional light source*, IEEE Photonics 2011 (IPC11), Arlington, VA, USA, 09.-13.10.2011

A. Pradana, C. Kluge, M. Bremer, M. Raedler, M. Gerken, *Multiperiod gratings in a high refractive index material for enhanced OLED outcoupling*, Renewable Energy and the Environment Congress, Austin, TX, USA, 02.-03.11.2011

U.B. Bala, M.C. Krantz, M. Gerken, *Design of Electrode Positions in Cantilever Magnetoelectric Sensors*, 2011 MRS Fall Meeting and Exhibit, Boston, MA, USA, 28.11.-02.12.2011

M.C. Krantz, U.B. Bala, M. Gerken, *Analytic Modeling of 2-2 Nanocomposite Magnetoelectric Sensors for Low Frequency Applications*, 2011 MRS Fall Meeting and Exhibit, Boston, MA, USA, 28.11.-02.12.2011

Microwave Laboratory

The **Microwave Laboratory** of the Christian Albrechts University of Kiel (CAU) has continued research in the areas of **ultra-wideband technology (UWB)**, **power amplifiers for communication systems**, 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 which 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 microwave sensors is an area, 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, for example aerosols, on other radar sensors and on sensors for medical applications. In addition, a novel density independent measurement method was enhanced which 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 the materials research at Kiel, and to low noise electronic circuits for interrogating such devices.

The working area **Materials and high frequency components** is focused on various characterization methods for the determination of the permeability of magnetic nanocomposites at frequencies up to several GHz. The materials are then applied in components such as inductors or balun transformers at microwave frequencies. Close cooperation exists in this area with the materials research at CAU Kiel.

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

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, for example, the water content of bulk materials and other process variables. There is a strong correlation between many of those quantities and the dielectric properties. Therefore, dielectric measurements are well-suited for material characterization. Existing methods for such measurements require that the samples are regular in shape. They also require that the material under test fills the entire cross section of the electromagnetic field. The method under development is not subject to this restriction. Contrary to 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 proved successfully with simulations and measurements of dielectric objects that the use of multivariate analysis methods allows the determination of an object's dielectric properties independently of shape, size and orientation. It was also shown that related properties, like 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. Dedicated hardware was built in order to demonstrate the system performance and accuracy under practical conditions. The use of a specially tailored miniaturized sampling oscilloscope capable of transmitting and receiving UWB-signals with several gigahertz of bandwidth leads to very promising results.

Further investigations are focused on the improvement of the whole measurement set-up and individual components in order to achieve better accuracy. Signal processing and multivariate calibration procedures are also subject to further studies.

UWB Through-Wall-Radar

An application of UWB radar system using a breath simulator, for remote measurement of the position and respiration of hidden persons in varying positions and angles, has been finished. The result is that only at certain angles can the imitated breath frequency for each point be detected. The angles extend beyond both sides of the transmitting and reflecting angle (TRA) area. The greater the distance, the smaller are both the angles available to detect breath frequency and the TRA. The best results are obtained with angles where the object person is facing the line connecting the transmitting and receiving antenna. In every row parallel to this line, the highest relative amplitude is in its middle (TRA) area. The peak amplitude also becomes smaller with larger distances.

Microwave Moisture Measurement

The effective measurement of high moisture content solid matter (up to 50%) is performed by exploiting multiple (at least double) resonances of stray field resonators. Due to the fact that in this method the resonant frequencies should be widely separated, suitable resonators have to be conceived and designed. Our investigations show that implementing appropriate methods for the excitation of dielectric stray field ring resonators results in resonances which are sufficiently separated. Appropriate coupling positions for these kinds of resonators were adjusted to realize wide-band operation. In addition, dielectric ring resonators were analyzed theoretically and experimentally. The theoretically determined resonator parameters (resonance frequency and quality factor) agree well with simulations and measurements. The applied method allows fast estimation of the resonance frequency and quality factor for different dimensions of the resonator. A lumped element (RLC) model for multiple resonances also was developed. This model facilitates the estimation of the complex permittivity of various materials.

Multiple-Utilized Microwave Resonators for Materials Characterization

In industrial processes it is important to know the composition and state of raw materials. Especially in the food industry the water and salt content are important quality variables. In general the water content of natural materials can be measured precisely with microwave resonators because they are very sensitive to small changes of the permittivity; water dominates the complex permittivity of food stuffs. With increasing water content of the material under test (MUT) the resonator is increasingly loaded by the dielectric loss of the water. Furthermore the resonance frequency is detuned by permittivity changes. Finally the electrical field of the microwave resonator interacts with the permittivity of the MUT. The magnetic field can be used equally well for measuring the conductivity of the MUT. Due to ions in solution the conductivity is directly correlated to the salt content of a MUT. When penetrating a conducting MUT the magnetic field generates eddy currents which depend on the conductivity. The eddy currents in turn generate magnetic fields opposing the original fields of the resonator. Thus the resonator is increasingly loaded with increasing conductivity of the MUT. In order to separate the influence of the two constituents, namely water and salt, on the resonance, the electrical and/or the magnetic field of the resonator have to sufficiently penetrate the MUT. Various structures are conceivable to fulfil this requirement. As an example, a ring resonator is shown in figure 1: an aperture is placed between the ring resonator and the MUT in order to separate the field components, which can be altered by switching the excitation. When the localization of the feed port is altered to another position, the fringe field at the aperture changes from predominantly electric to magnetic. Using these two operation modes, the same sensor can separate rapidly and non-destructively permittivity changes caused by water and conductivity changes caused by salt content.

PITAS

The PITAS-project is a common activity of the maritime cluster in Kiel and the groups ''Circuit- and System Theory, (Prof. Heute)'', ''Information and Coding theory, (Prof. Höher)'', and ''Microwave, (Prof. Knöchel)'' from the Institute of Electrical

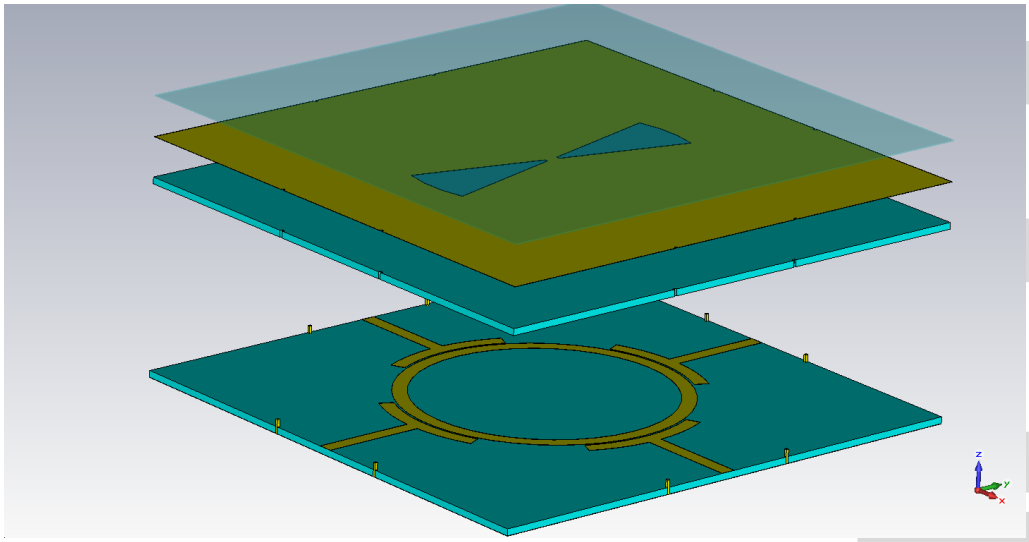


Fig. 1: Ring resonator for dual mode operation. The field penetrating the material under test is selected via the feeding port and an aperture.

Engineering and Information Theory, along with ''Information Systems Engineering, (Prof. Klein)'' from the Institute of Computer Science. The goal of the subproject ''Radar and Tracking'' is detection of small targets like rubber boats within one mile around ships for the identification of possible threats such as pirates. Several concepts have been investigated. Detailed analysis of possible radar signals was undertaken. On the basis of the results obtained a coherent pulse radar system was designed. The newly designed system has advantages in detecting small targets on rough sea over the radar systems currently used. The new system is now under test in this laboratory.

Rotary Joint for the Near-Range Radar (PITAS)

A rotary joint facilitates the scanning of an antenna beam in the horizontal plane at constant radiated power in the whole range of scanning angles. Such a wave-guide component has been designed using propagation mode conversion from the rectangular wave-guide H01 mode to the circular wave-guide H11 mode. A polarization rotation section is formed by an elliptical waveguide. Such a configuration of the rotary joint provides high power transmission, which is limited by the properties of the rectangular waveguide. The insertion loss of the device developed does not exceed 0.3 dB at a voltage standing wave ratio (VSWR) of less than 1.2 in a bandwidth of 4%.

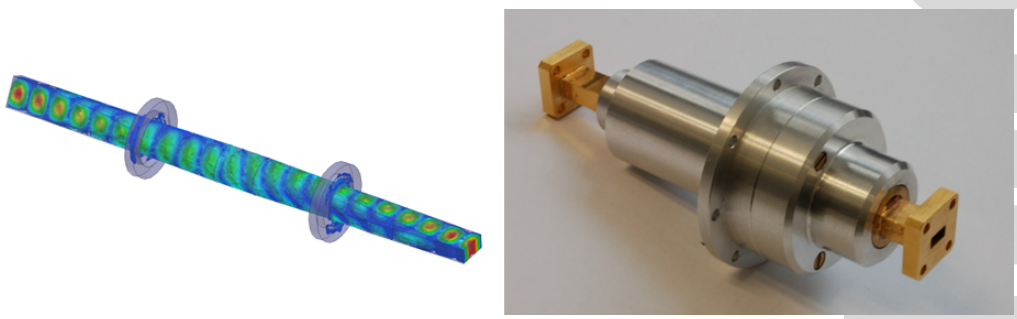


Fig. 2: Rotary Joint

Collaborative Research Centre SFB 855 ''Magnetoelectric Composite Materials - Biomagnetic Interfaces of the Future''
Subproject C3: Sensor Modelling and Electronic Signal Processing

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. For this reason the ME modulation technique was developed further. Thus it was possible to improve the sensor sensitivity for a 1 Hz magnetic input signal by a factor of 1000. This technique also allows broadband measurements, which are necessary for biomagnetic measurements. Currently, additional Barkhausen noise impairs the achievement of the same sensitivity as in resonance. Work is in progress to reduce the influence of this noise source. Together with the Multicomponent Materials group of the Institute for Materials Science, a frequency modulation approach for cantilever based magnetic field sensors was developed and investigated. Furthermore, noise calculations and measurements have been carried out for MEMS based ME sensors from the Fraunhofer Institute for Silicon Technology (ISIT). Results show that despite their small size of below 1 mm^2 these sensors achieve a sensitivity level of 100 $pT/\sqrt{Hz}$. Finally an optically based test setup (fig 3) for ME cantilevers was developed to achieve the full characterization of the sensor's equivalent circuit.

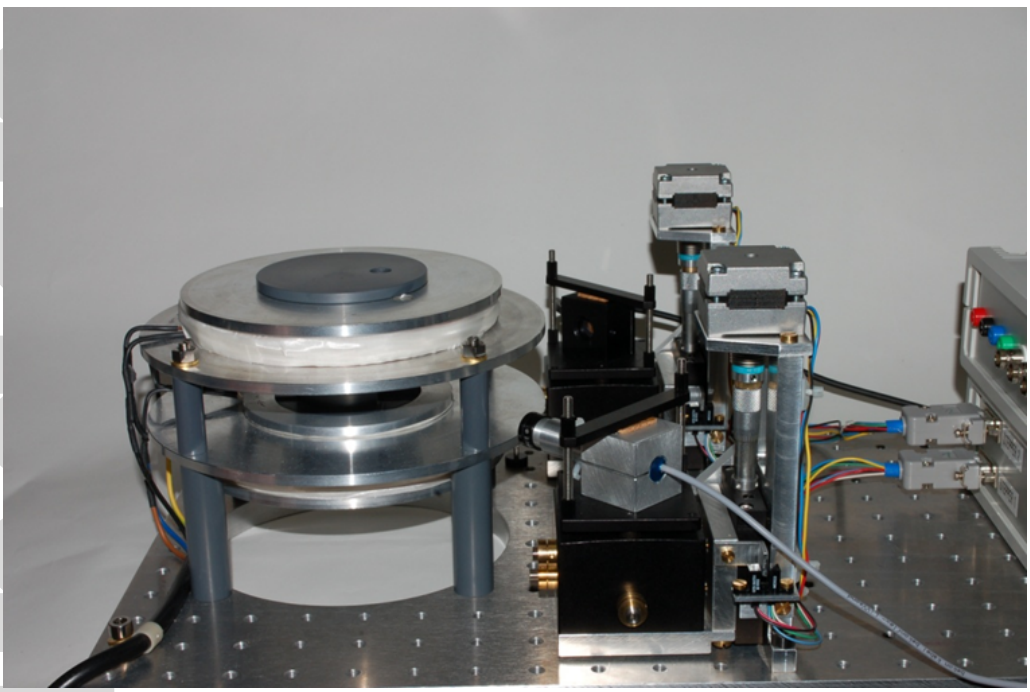


Fig. 3: Optical based test setup for ME sensor characterization

Application of metamaterials in microwave resonators and slow wave structures

The aim of the project is the consideration of metamaterials applications in microwave resonators and slow wave structures. In this regard, and based on rigorous analytical formulations, the ability of different metamaterial layers in realizing miniaturized metamaterial loaded resonators, filters, and sensors has been investigated; examples of miniaturized resonators and filters have been designed, simulated and constructed. On the other hand, analytical investigations show that metamaterials are able to realize optimized slow wave structures for spatial harmonic magnetrons, which are currently suffering from low efficiency and output power. Due to the fact that the operation of these magnetrons has not been fully investigated, we have developed a fully realistic model using a CST-PIC simulator and we have considered the very particular conditions governing their operation. The simulation results based on this model show very good agreement with measurement. This agreement confirms the accuracy of the model. In the following this model operation was applied to several optimized anode structures. The geometrical characteristics of these optimized structures are determined by formulating a criterion for increasing output power.

Microstrip Filter Design with Fuzzy Logic

The main goal of this research plan is focused on the development of a fuzzy based approach that enables a designer to

relate physical parameters of the filter to the required electrical characteristics. In order to provide such a useful design tool that accelerates the filter design process, we completed the following steps last year. In order to complete the modelling process in a wider variation range of independent variables, the number of membership functions was increased. In order to increase the accuracy of the model, the conventional IDS pattern, was modified. This modification improves the accuracy when there is not enough initial data. In the next step, we developed our fuzzy model in order to support, simultaneously, three modelling parameters. The completed model was applied to model coupling and external quality factor in the case of square open loop resonators and triangular open loop resonators. Results were compared with those extracted by full wave calculations: they were in good agreement. Based on the extracted fuzzy-based surfaces, three different filters were designed, fabricated and tested. Using the proposed approach coupling and external quality factors were modelled for other kinds of resonators, such as spiral resonators and split ring resonators. For the case of split ring resonators, four different independent parameters were modelled simultaneously. Accuracy of the extracted surfaces was confirmed by the full wave approach. Two different filters were designed, fabricated and tested based on the extracted surfaces. A good agreement between the measurement and simulation results confirms the accuracy of the proposed fuzzy-based filter design approach. The validity of the approach was also confirmed for a novel proposed metamaterial filter for which measured and simulated results were also in good agreement. The method has been applied to different kinds of resonators with different modelling parameters with the same simplicity and unique approach. It should be mentioned that it is consistently fast and accurate in comparison with the common full wave-based approach. In the last year 3 conference papers and 2 journal papers were published and one journal paper was accepted for publication.

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 of $\leq$ 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 of $\leq$ 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 (0,1 m/m 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 (Nizhnii Novgorod) spectra of the HCCCN (propene cyanide), 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 with accuracies $\leq$ 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 Through wall radar	01.01.-31.12.2010	externally funded

Dr.-Ing. F. Daschner	01.01.-31.12.2011		CAU
Resonant stents / Microwave sensors / Heterotopic bone induction			
Dipl.-Ing. R. El Korch	01.04.-31.12.2011		BMWi / CAU
High level moisture measurement with microwave resonators			
Dipl.-Ing. F. Hettstedt	01.01.-30.04.2011		DFG
Magnetic nanocomposites for RF-applications			
Dipl.-Ing. R. Jahns	01.01.-31.12.2011		DFG
Magnetoelectric sensors			
Dr.-Ing. T. Lehmann	01.01.-31.12.2011		Guest researcher
Lüttlng			
Dipl.-Ing. H. Mextorf	01.01.-31.12.2011		DFG
Non-contacting characterisation of irregular shaped objects			
M.Sc. N. Nasresfahani	01.01.-31.12.2011		DAAD
Metamaterials in microwave structures			
M.Sc. P. Rezaee	01.01.-31.12.2011		DAAD
Microwave filter design with fuzzy logic			
Dipl.-Ing. W. Stellmach	01.03.-31.12.2011	(50%)	BMWi
M.Sc. O. Teplyuk	01.01.-31.12.2011		CAU
Radar-sensor			

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

Leitungstheorie, 2 (+1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ R. Jahns)

Nichtlineare Schaltungen, 2 (+1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ F. Hettstedt)

Radar, 2 (+1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ F. Hettstedt)

Hochfrequenz-Messtechnik, 2 (+1) hrs Lecture (+ Exercises)/Week,
F. Daschner (+ F. Daschner)

Praktikum Hochfrequenztechnik, 4 hrs Practical/Week,
R. Knöchel (+ F. Daschner, F. Hettstedt, H. Mextorf, O. Teplyuk)

Seminar Hochfrequenztechnik, 2 hrs Seminar/Week,
R. Knöchel

Summer 2011

Radar, 2 (+1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ F. Daschner)

Hochfrequenzschaltungen für Mobil- und Satellitenfunk, 2 (+1) hrs Lecture (+ Exercises)/Week,

R. Knöchel (+ H. Mextorf)

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,
R. Knöchel (+ 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 2011/2012

Leitungstheorie, 2 (+1) hrs Lecture (+ Exercises)/Week,
F. Daschner (+ R. El Korch)

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 (+ W. Stellmach)

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

Third-Party Funds

Deutsche Forschungsgemeinschaft, *Magnetic nanocomposites for rf applications in mobile communication (Folgeprojekt)*, 01.10.2008-31.01.2011 (91400 EUR)

Deutsche Forschungsgemeinschaft, *Kontaktlose Bestimmung der dielektrischen Eigenschaften unregelmäßig geformter Objekte (ISOPerm)*, 01.10.2008-31.01.2011 (122300 EUR)

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*, 01.10.2008-31.03.2012 (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*, 01.07.2010-30.06.2013 (1029711 EUR)

Innovationsstiftung Schleswig-Holstein, *''lüttIng.'' - Schüler-Technik- Akademie*, 25.05.2010-22.08.2012 (26140 EUR)

Deutscher Akademischer Austauschdienst, *Leonhard-Euler-Projekt, Zielland: Ukraine,* 01.09.2010-31.08.2011 (7280 EUR)
Deutscher Akademischer Austauschdienst, *Leonhard-Euler-Projekt, Zielland: Ukraine,* 01.09.2011-31.08.2012 (7380)

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 ''Inorganic functional materials'' 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,

Baker Hughes INTEQ GmbH, Celle in the area of high frequency sensors.

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)** and 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)**.

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 and Master Theses

B. Stolze, *Aufbau und Untersuchung eines retrodirektiven Radarsystems,* 13.01.2011
S. Zhenyu, *Untersuchung von modulierten resonanten Stents,* 31.03.2011
M. Falb, *Entwicklung eines magnetoelektrischen Messverfahrens mit Effektmodulation,* 18.05.2011
L. Welsch, *Entwicklung einer digitalen Auswerteelektronik für magnetoelektrische Sensoren,* 06.06.2011
D. Reese, *Rekonfigurierbare Takterzeugung für ein Abtastoszilloskop,* 07.06.2011
J. M. Grimm, *Entwicklung eines Mikrowellenoszillators mit Streufeldresonator,* 19.08.2011
G. Davtjan, *Untersuchung eines Ringresonators zur Materialcharakterisierung mit multivariater Signalverarbeitung,* 23.09.2011

M. Grischan, *Zweimodiger Mikrowellen-Ringresonator zur Feuchtigkeits- und Leitfähigkeitsmessung,* 21.11.2011

Dissertations / Postdoctoral Lecture Qualifications

F. Hettstedt, *Weichmagnetische Nanokomposite und deren Anwendungen in der Hochfrequenztechnik,* 14.07.2011

Publications

Published in 2011

H. Mextorf, F. Daschner, M. Kent, R. Knöchel, *UWB free-space characterization and shape recognition of dielectric objects using statistical methods,* IEEE Trans. Instrum. Meas., **60**, 1389 - 1396 (2011)

H. Mextorf, T. Lehmann, R. Knöchel, *Compact cascaded directional couplers with continuously tuneable coupling ratios,* Proc. German Microwave Conference, 1 - 4 (2011)

F. Daschner, R. El Korch, R. Knöchel, *A Stray Field Ring Resonator for Quantitative Permittivity Determination,* Proceedings of the 9th International Conference on Electromagnetic Wave Interaction with Water and Moist Substances, 119 - 126 (2011)

H. Mextorf, F. Daschner, M. Kent, R. Knöchel, *Free-spaced prediction of the water content of irregularly shaped bodies filled with water-ethanol mixtures,* Proceedings of the 9th International Conference on Electromagnetic Wave Interaction with Water and Moist Substances, 162 - 169 (2011)

H. Mextorf, F. Daschner, M. Kent, R. Knöchel, *New UWB Free-Space Method for the Classification and Characterization of Dielectric Objects,* Proc. ICUWB, 410 - 414 (2011)

H. Mextorf, F. Daschner, M. Kent, R. Knöchel, *Performance of Multivariate Calibration Methods for the UWB Characterization of Dielectric Objects,* Innovative Feuchtemessung in Forschung und Praxis, **6**, 105 - 112 (2011)

F. Daschner, S. Hoffmann, R. Knöchel, M. Jerosch-Herold, C. Rickers, *Resonant Stents for Non-Invasive Monitoring of Restenosis,* Proceedings of the 41st European Microwave Conference, 972 - 975 (2011)

R. Jahns, H. Greve, E. Woltermann, E. Lage, E. Quandt, R. Knöchel, *Magnetoelectric Sensors for Biomagnetic Measurements,* Medical Measurements and Application Proceedings (MeMeA), 107 - 110 (2011)

B. Gojdka, R. Jahns, K. Meurisch, H. Greve, R. Adelung, E. Quandt, R. Knöchel, F. Faupel, *Fully integrable magnetic field sensor based on delta-E effect,* Appl. Phys. Lett., **99**, 223502 (2011)

R. Jahns, H. Greve, E. Woltermann, E. Quandt, R. Knöchel, *Noise Performance of Magnetometers with Resonant Thin Film Magnetoelectric Sensors,* IEEE Transactions on Instrumentation and Measurements, **60 (8)**, 2995 - 3001 (2011)

R. Knöchel, A. Teplyuk, G. Khlopov, K. Schünemann, *Millimeter wave range sensor for protection of outdoor areas,* Proceedings of the 6th Future Security Conference, 468 - 471 (2011)

N. Nasresfahani, P. Rezaee, K. Schünemann, R. Knöchel, M. Tayarani, *Miniaturized Coaxial Cylindrical Cavity Filters Based on Sub-Wavelength Metamaterial Loaded Resonator,* Proceedings of the International Conference on Electromagnetics in Advanced Applications, 1086 - 1089 (2011)

N. Nasresfahani, P. Rezaee, M. Tayarani, *Application of Metamaterials in Microwave Humidity Sensors,* Proceedings of the 25th International Symposium on Microwave and Optical Technology, 143 - 146 (2011)

N. Nasresfahani, K. Schünemann, *Modifying Humidity Sensors Through the Use of Metamaterial Structures,* Theoretical and Methodical Problems of Radio Engineering Systems Effective Functioning, 103 - 110 (2011)

P. Rezaee, N. Nasresfahani, R. Knöchel, M. Tayarani, *Active Learning Method for External Q Computation,* Proceedings of the 6th German Microwave Conference, 1 - 4 (2011)

P. Rezaee, N. Nasresfahani, R. Knöchel, M. Tayarani, *Using Active Learning Method for designing Miniaturized Microstrip Metamaterial Bandpass Filters,* Proceedings of the 25th International Symposium on Microwave and Optical Technology, 257 - 260 (2011)

P. Rezaee, N. Nasresfahani, R. Knöchel, M. Tayarani, *Active Learning Method for Designing Miniaturized Waveguide Filters Loaded by Broadside-Coupled Split Ring Resonator,* Proceedings of the 13th International Conference on

Electromagnetics in Advanced Applications, 1074 - 1077 (2011)

P. Rezaee, M. Tayarani, R. Knöchel, *Active Learning Method for the Determination of Coupling Factor and External Q in Microstrip Filter Design,* Progress in Electromagnetics Research, **120**, 459 - 479 (2011)

P. Rezaee, M. Tayarani, R. Knöchel, *Miniaturized Microstrip Filter Design Using Active Learning Method,* Radioengineering Journal, **20**, **4**, 857 - 865 (2011)

Patent Applications

F. Daschner, R. Knöchel, M. Jerosch-Herold, C. Rickers, *Hochfrequenz-resonante Stents für das nichtinvasive restenose Monitoring,* Deutsches Patentamt, 07.03.2011, 102011013308.9-35

M. Gorek, G. B. Itskovich, A. N. Bespalov, F. Daschner, R. Knöchel, *Concentric Buttons of Different Sizes for Imaging and Standoff Correction,* United States Patent Office, 18.08.2011, 13/212,624

Presentations

H. Mextorf, R. Knöchel, *Kontaktlose Charakterisierung dielektrischer Objekte mittels multivariater Analysemethoden,* UKoLoS Berichtskolloquium, Karlsruhe, Germany, 28.02.-01.03.2011

Further Activities and Events

Prof. Knöchel served as a Vice-Dean until the beginning of July 2010 and thereafter 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 leading 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 have to be controlled on an 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, spin transport, or a combination of both 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 and novel transistors with enhanced functionalities and performance. The department of Nanoelectronics is focusing on medium term and long-term tasks, on emerging far-reaching concepts, and on issues of physics and technology well ahead of the main stream development of the nanoelectronics industry. The research area of the AG Nanoelectronic is built on three main pillars: (1) new device concepts based on quantum phenomena, (2) interfacial studies, and (3) novel fabrication routes. For example, we explore multiferroic tunnel junctions based on complex oxide materials, superconducting junctions for quantum bits and lateral tunnel junctions (Nanogaps). A considerable technological and metrological infrastructure is an essential precondition for being competitive in science and technology on an international level. Part of the equipment required, 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, magnetoresistance set-ups and ferroelectric thin films analyzers for a temperature range between 4.2 K and 300 K are part of our laboratory. 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

Nanogap Devices (Mirko Hansen, Martin Ziegler) To address structural, electrical, and chemical properties at the atomistic scale nanogap separated electrodes are fundamental building blocks. In the last decade, several device structures have been realized, ranging from molecular and carbon nanotube transistors, to fast DNA sequencing techniques. The aim of this project is to get access to the relevant physical phenomena at the atomistic scale important for the engineering of resistance switching devices, which are potential candidates for future non-volatile random access memories. Currently, the implementation of resistance switching based devices in the market is hindered by several obstacles, whereas the understanding of relevant effects for the resistive switching phenomena on the atomistic and mesoscopic scale is still under debate. Since nanogap resistive switching devices are highly scalable, they may offer in this respect advantages in comparison to parallel plate geometries. By using two different archetypical oxides as substrate materials for our nanogap junctions, we were able to observe the contribution of the substrate oxide film to the resistive switching behaviour at the nanometre scale.

In order to fabricate nanogap devices new high resolution lithography techniques are of interest in our current research. Owing to the high resolution, small feature size, and fast and low cost, capillary force assistant imprint lithography has attracted much attention. But, the effect of capillarity as the driving force for the lithography process can lead to complex nonlinear dynamic effects, where simultaneous patterning of high quality features consisting of rather different length scales (from nm to m) is one of the critical parts during the CFL process. In collaboration with Dr. M. Rädler and A. Pradana (ISP, AG Gerken) we were able to develop a capillary force based lithography process for a multiscale system, containing connected 250 nm wide bridges and 8-20 μm wiring, as shown in Fig. 1.

Magnetoelectric Hetrostructures (Adrian Petraru, Neele Hoeft, Soni Rohit and Nikolay Pertsev) A significant enhancement of the magnetoelectric coefficients up to 100 V Oe^{-1} cm^{-1} at strain-induced transitions between different ferroelectric phases was theoretically predicted for epitaxial $Pb(Zr_{1-x}Ti_x)O_3$ (PZT) layers.* To observe this large ME coefficient experimentally, a careful strain engineering of the PZT films is essential because the misfit strain has to be adjusted on

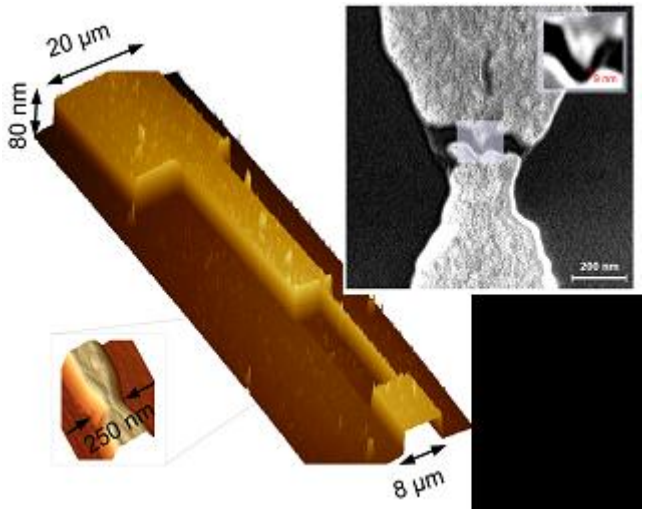


Fig. 1: AFM images of a multiscale system, containing connected 250 nm wide nanobridges and 8-20 μm wide supply conductors. Inset: SEM image of an electromigration formed nanogap junction on SiO_2 substrate.

an accuracy level of less than 0.05%. According to the in-plane lattice parameter of the substrate, the thickness and the composition of the PZT film can be used, in principle, to reach this condition. Nonetheless, any method which allows a post-fabricated fine tuning of the misfit strain is desirable. Due to their high piezoelectric coefficients in the order of 2500 pm/V, PMN-PT substrates can be used and the strain in the PZT films can be varied via an external electric bias field applied to the substrate. Epitaxial magnetoelectric $CoFe_2O_4/Pb(Zr_{1-x}Ti_x)O_3$ (PZT)/$SrRuO_3$ composite thin films were deposited on polished 150 micrometre thick PMN-PT single crystal substrates by pulsed-laser deposition and high pressure sputtering. The X-ray analysis showed that additional to the initial misfit strain of PZT film due to film growth, a strain tuning in the range of 0.2 percent was observed when a bias voltage of 300 V was applied.

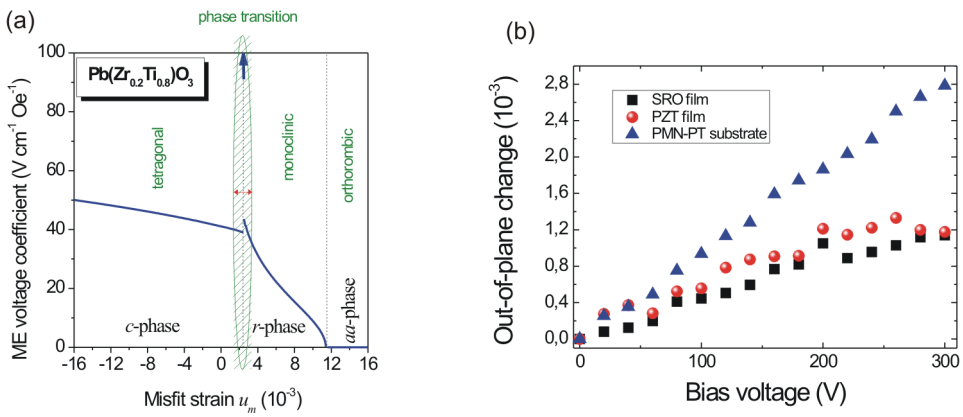


Fig. 2: (a) *Calculated Magnetoelectric voltage coefficient α_{E33} at room temperature for a hybrid heterostructure involving the Terfenol-D substrate and the single-domain epitaxial $Pb(Zr_{0.2}Ti_{0.8})O_3$ film subjected to the isotropic biaxial in-plane strain u_m. (b) Tuning of the superimposed strain in epitaxial $SrRuO_3$ and PZT films grown on PMN-PT substrate via external voltage applied to the substrate.

Strain dependent magnetoelectric properties of these heterostructures are investigated for several compositions of the PZT films: $Pb(Zr_{0.2}Ti_{0.8})O_3$, $Pb(Zr_{0.52}Ti_{0.48})O_3$, $Pb(Zr_{0.3}Ti_{0.7})O_3$ and for $BaTiO_3$ films. An experimental magnetoelectric measurement setup was developed, where the strain dependent magnetoelectric properties are investigated. Furthermore,

epitaxial magnetoelectric heterostructures grown on $SrTiO_3$ buffered Si substrates are being investigated. This approach might offer interesting perspectives for CMOS compatible magnetoelectric devices based on epitaxial complex oxides.

*N.A. Pertsev et al., PRB 80, 054102 (2009)

Personnel

Head of the group: Prof. Dr. H. Kohlstedt; Secretary: T. Bittner (50%)
Technical Staff: Dipl.Ing.(FH) N. Röschmann

Scientific Staff:

Dr. habil. N. Pertsev Mercator Professur	01.01.-28.02.2011	DFG
Dr. A. Petraru	01.01.-31.12.2011	CAU
N. Ruppelt KO 1953/11-1, BA 521	01.01.-31.12.2011	DFG
Dr. R. Soni SFB 855	01.01.-31.12.2011	DFG
Dr. O. Vavra	01.01.-31.12.2011	CAU
Dr. M. Ziegler	01.01.-31.12.2011	CAU

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

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 (+ H. Kohlstedt)

Digital Electronics-Non-volatile RAMs, 2 (+1) hrs Lecture (+ Exercises)/Week,
H. Kohlstedt (+ A. Petraru)

Summer 2011

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 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 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

Third-Party Funds

DFG, SFB 855, Teilprojekt A4, *Magnetoelektrische Verbundwerkstoffe - biomagnetische Schnittstellen der Zukunft,* 01.01.2009-31.12.2013 (268300 EUR)
DFG, *Mercator Gastprofessur,* 01.03.2010-28.02.2011 (115600 EUR)
DFG, *Materials World Network: Transport, Switching and Size Effects in the lead-free ferroelectric, BiFeO3,* 01.05.2010-31.01.2011 (54445)
DFG, *Semifluxons in ferromagnetic Josephson junctions,* 01.12.2010-30.11.2013 (211450)

Further Cooperation, Consulting, and Technology Transfer

University of Tuebingen, Germany, Experimentalphysik II and Centre for Collective Quantum Phenomena: Josephson junctions for quantum bits.

A.F. Ioffe Physico-Technical Institute, St. Petersburg, Russia: Landau-theory on strain effects in magnetoelectric heterostructures.

University of California, Berkeley, USA, Materials Science Division: multiferroic BiFeO3

Fa. Oerlikon, Leybold, Germany, Cologne: development of thin film processes.

RWTH Aachen, Germany, Inst. für Werkstoffe der Elektrotechnik II: multiferroic BiFeO3.

Texas State University, USA, Department of Physics: development of epitaxial Si-SrTiO3 wafers for magnetoelectric sensors.

Research Centre Juelich, Institute for Bio-and Nanotechnology: Rutherford backscattering spectrometry for complex oxides.

Diploma, Bachelor and Master Theses

A. Groß, *Ferroelektrische Josephson-Kontakte,* 02.03.2011
M. Ignatov, *Simulationen von Memristoren in MOSFET-Schaltungen,* 24.06.2011
F. Mattes, *Metallische Tunnelkontakte mit ionischen Festkörperleiter für Memristoren,* 11.07.2011
N. Hoeft, *Entwicklung epitaktischer magneto-elektrischer Sensoren,* 12.08.2011
M. Bubolz, *Ermittlung von potenzialen zur Kostenreduzierung eines Linearwegsensors,* 28.10.2011
M. Oberländer, *EEPROM-Zellen als Alternative zu Memristoren in lernfähigen Schaltungen,* 23.12.2011
T. Patelzyk, *Entwicklung einer analogen Schaltmatrix zur wahlfreien Selektion festkörperionischer Bauelemente, ihrer Formierung und elektrischen Charakterisierung,* 03.08.2011

Publications

Published in 2011

N.A: Pertsev, H. Kohlstedt, R. Knöchel, *Ferromagnetic resonance in epitaxial films: Effects of lattice strains and voltage control via ferroelectric substrate*, Phys. Rev. B., **014423**, (2011)

A. Piorra, A. Petraru, H. Kohlstedt, M. Wuttig, E. Quandt, *Piezoelectric properties of 0.5($Ba_{0.7}Ca_{0.3}TiO_3$)-0.5[$Ba(Zr_{0.2}Ti_{0.8}O_3$] ferroelectric lead-free laser deposited thin films*, J. of Appl. Phys., **104101**, (2011)

D.S. Jeong, B. Cheong, H. Kohlstedt, *Pt/Ti/Al_2O_3/Al tunnel junctions exhibiting electroforming-free bipolar resistive switching behavior*, Sol. Stat. Elec., **63**, 1 - 4 (2011)

R. Soni, P. Meuffels, G. Staikov, R Weng, C. Kuegeler, A. Petraru, M. Hambe, R. Waser, H. Kohlstedt, *On the stochastic nature of resistive switching in Cu doped $Ge_{0.3}Se_{0.3}$ based memory devices*, J. of Appl. Phys., **054509**, (2011)

K. Zabel, K. Westerholt, H. Kohlstedt, *The mating of electrons:triplet superconductivity first demonstrated experimentally*, Int. J. of Mat. Res., **102**, 232 - 234 (2011)

Presentations

D. Gedamu, T. Behrendt, H. Kohlstedt, O. Vavra, A. Petraru, R. Adelung, *Electrical properties of an Al-NWFET fabricated under different gate oxide layers*, DPG Frühjahrstagung, Dresden, Deutschland, 13.-18.03.2011

A. Quer, E. Kröger, M. Kalläne, A. Petraru, R. Soni, H. Kohlstedt, L. Kipp, K. Rossnagel, *Angle-resolved photoelectron spectroscopy of strained $SrRuO_3$ thin films*, DPG Frühjahrstagung, Dresden, Deutschland, 13.-18.03.2011

E. Kröger, M. Kalläne, A. Quer, A. Petraru, R. Soni, H. Kohlstedt, L. Kipp, K. Rossnagel, *Lattice-strain induced changes in the electronic structure of $SrRuO_3$ investigated by angle-resolved photoelectron spectroscopy*, DPG Frühjahrstagung, Dresden, Deutschland, 13.-18.03.2011

S. Scharinger, C. Gürlich, R.G. Mints, M. Weides, H. Kohlstedt, E. Goldobin, D. Koelle, R. Kleiner, *Anomalous features in Ic(H)-patterns of multifacet Josephson junctions*, DPG Frühjahrstagung, Dresden, Deutschland, 13.-18.03.2011

Further Activities and Events

Membership and activities of H. Kohlstedt in the following functions:

General Chairman : *Drei Königstreffen* Wilhelm und Else Heraeus-Stiftung, WE-Heraeus Physics School (05 to 07 January 2011) at the Physikzentrum Bad Honnef (Germany): entitled *Functional Magnetoelectric Oxide Heterostructures* (organization of the conference together with Dr. Marian Alexe (MPI Halle) and Mrs. T. Bittner (TF, CAU Kiel),

representative of CAU Kiel for the *Fakultätentag der Elektrotechnik und Informationstechnik* (FTEI),

organization of the FTEI Plenary Meeting which will be held from May 7th to May 9th 2012 at the CAU Kiel (together with Mrs. T. Bittner),

member of the international advisor board of the CIMTEC 2012 - 4th International Conference *Smart Materials, Structures and Systems*.

Power Electronics and Electrical Drives

As in the previous year our institute was able to work under quite positive circumstances in 2011. Due to the necessity for economy measures within the faculty the budget from the university was reduced considerably, but because of third party funded projects we were able to keep research and education, salary and material expenses at a solid level.

Our research activities are focused on three fields which the following headlines describe quite well:

-electromobility and electric drives for vehicles,

-renewable energy conversion,

-grid integration of decentralized energy sources,

-modern control in power electronics.

Very good results in research and education have been obtained from the work of our strong team, presenting in total 19 publications in conferences and journals, and 2 doctoral theses. We have enhanced our research cooperation with companies and universities and were able to gain some new companies for such cooperation. Technology transfer is still an important aspect in this matter. We are still engaged in the competence centres of CEwind e.G. and KLSH (power electronics). One of the visible highlights in 2011 at the final seminar of the joint research project „inverter for electric vehicle" was the presentation and demonstration of a lifting truck with a new inverter, developed in cooperation with three other universities and one institute under the supervision of three industrial partners. With respect to infrastructure our laboratory has been further improved towards grid integration. The grid impedance emulator developed completes our compilation of devices for investigation such as grid voltage emulator, voltage sag generator, FACTS converter and grid impedance analyser. Concerning our teaching activities we have launched some new courses for the master's study program, e.g. „Renewable Energy Systems I and II" (wind energy and photovoltaic, each with lecture and exercise), a master's laboratory course and a seminar in power electronics. This has entailed a lot of effort for us. Similar to the final thesis the master's laboratory course is characterized by the self-contained working of the students. The other teaching courses took place as usual with good attendance. The lecture „Power Electronic Generator Systems for Wind Turbines" in the framework of the CEwind study course Master of Wind-Engineering took place for the fourth time, with approximately 30 attendants. The interest of the students for our subject is still high, which is reflected by teaching courses and final theses (35 in 2011), but also the emerging workload of the team. The number of first-year students (bachelor) in electrical and information engineering is a record, with 222 students (study courses: Electrical and Information Engineering, Industrial Engineering, master's in Digital Communication). For some years the team has engaged in supervision of first-year students (organization: weekly supervising groups, one day seminar „Study Right"). The study course Electrical and Information Engineering, which has been shifted to the bachelor/master-system, is running satisfactorily, and the first bachelor theses have been finished. The master's study course started also according to plan. Due to the small groups involved so far there is an intensive study atmosphere. The free choice of subjects has been well approved. Some team members have left the institute after successfully completing their work: we wish Messrs Franke, Lohde, Mühlfeld, Wessels and Wittig a good start in industry. At the beginning of 2012 some new team members will begin their work at the institute.

Results

Optimization of Inverters (5kW, 24V) (Wittig)

For the optimization of battery fed inverters for automotive application a modern converter concept has been designed and is being constructed. This converter has to be distinguished by a small volume, a high efficiency and a simple method of power multiplication. For these goals it is important to optimize the power losses. The research work is being executed by a project team with up to six members. In the first part of the project the main focus was on the overall design concept and the electrical dimensioning of the converter, the capacitor bank connection and the development of a driver circuit

for control of the power semiconductors. MOSFET chips, newly developed for this project, and modules combined with an optimized power module layout and short switching times are the measures adopted to improve converter efficiency. A detailed calculation of converter efficiency for different layout variants was performed. In the second part the main focus was on the control of the semiconductor power devices. Besides the development of a suitable driver circuit further additional driver circuits were analyzed to achieve an optimal switching behaviour. Finally in the third part the converter is put into actual operation and a small series of prototypes fabricated and tested in the laboratory.

Fig. 1: Project members at the final project seminar with fork lift including the developed converter

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 2011 the comparison and analysis of different five level topologies have begun. Experimental investigations on these systems will be done in 2012. Another research field is the analysis and application of modern power semiconductors. These new technologies can further increase the efficiency of power electronic systems. Beside 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, e.g., for photovoltaic applications.

Condition Monitoring and Fault Tolerance for Power Electronic Converters in Wind Energy Applications (Böttcher)

Wind turbines are increasingly installed in areas which are difficult to access, especially due to the rising number of off-shore applications. Thus maintenance is much more difficult to accomplish and defects can cause breakdowns for a

long time, if they are not rectified quickly. In this project different strategies to increase the availability of the power electronic converter are investigated. The project is especially focused on fault-tolerant operation as well as on condition monitoring and prognosis methods for the most important components of the power electronic converter, which are the power semiconductors and the DC link capacitors. Different fault-tolerant converter topologies have been compared and a laboratory test bench with one suitable topology was put into operation and investigated. In addition, another laboratory test bench used for accelerated ageing of IGBT-modules and measurement of possible indicators for state of ageing detection was developed and different modules have been investigated.

EMC Optimization of Inverters (5kW, 24V) (Mühlfeld)

The optimization of inverters in terms of stray inductance and electromagnetic compatibility is another crucial task in the joint project of the „Competence Centre for Power Electronics" . A low inductive inverter layout is one of the basic necessities for operating power modules with short switching times economically and to obtain high efficiency of the power semiconductors. Different inverter hardware setups and power module layouts have been analyzed and compared regarding their overall efficiency, their thermal properties, and their fabrication constraints. The simulations allowed the determination of the setup with the best trade-off for the given requirements. Additionally, EMC of inverters is investigated and optimized by simulations and measurement as the inverter has to comply with common standards. The inverter has been fabricated in two power levels: 5 kW and 15 kW. It is now being tested in the laboratory to validate simulation results.

Battery Buffer and Power management for Electric Vehicles (Schröder)

During strong acceleration, the battery in electric vehicles has to deliver high peak currents. Thus, due to the internal serial resistance, the battery voltage drops under high load conditions. 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. This system is able to save the regenerative braking energy with higher efficiency than the battery can during the electrochemical energy transfer. The energy is transferred back to the system during high load conditions. Thus the maximum battery power is reduced; battery downsizing or lifetime extension is possible. Furthermore, the buffer system stabilizes the on-board voltage. In this project, the hardware design and the control of such a battery buffer system is designed. The focus is set on the development of a highly efficient and compact dc-dc-converter.

Modern Control of Induction Machines with Torsional Load and Gearbox (Thomsen)

Adjustable speed drive systems which are widespread in industrial applications include mechanical transmission elements between the driving motor and the load, such as couplings, gears, and shafts. These elements have non-ideal transmission behaviours. Drive shafts, for instance, have a finite stiffness and can develop unwanted torsional oscillations. These oscillations can cause a reduced control performance, high stress on the mechanical parts and therefore a reduced lifetime of the drive system. Furthermore, backlash effects can occur if gearboxes or clutches are located in the drive system and yield to high torque impulses. For a high dynamic speed control and the reduction of torsional oscillations, the dynamic of the shaft torsion has to be considered in the control synthesis. Conventional control structures with a PI-based feedback controller are not able to reduce torsional oscillations effectively. The aim of this research work is a high dynamic speed control with active damping of torsional oscillations, and limiting the influence of backlash. The DFG-funded project was continued in 2011. Different control methods have been designed, analyzed and compared for various drive configurations. The dynamic behaviour can be improved significantly using a state space control method. A very high dynamic speed control can be achieved if a flatness based feed-forward control is combined with a state space feedback control. Furthermore, the influence of backlash can be reduced.

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, e.g. in windmill or photovoltaic applications, are used to generate and feed electrical power to the mains, conforming to international standards. The capacity of the mains is dependent on the line-impedance. The mains line-impedance is usually non constant, and 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. Basically, the line-impedance is inductive with a resistive part but due to additional capacitors connected to the mains the line-impedance can be capacitive and resonate at certain frequencies. 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 in a frequency range up to 10 kHz and lead to a reduction, or elimination, of current harmonics in the lower-frequency range (Active-Filter functionality), a compensation of reactive power components as well as grid-voltage and current unbalances, all in addition to the fundamental power feed-in. Furthermore, the grid-adaptive PWM converter control and hardware should be designed to rid the feed-in of higher-frequency harmonic current components. The research project has been successfully continued in 2011. Key research results have been published at international conferences and the work was honoured with an IEEE ECCE 2011 student presentation award. The project will be continued through 2012 where the grid-impedance estimation based on an extended Kalman-Filter and a grid-adaptive PI-based state-space control of a grid-connected PWM-converter with LCL-Filter will be core research areas.

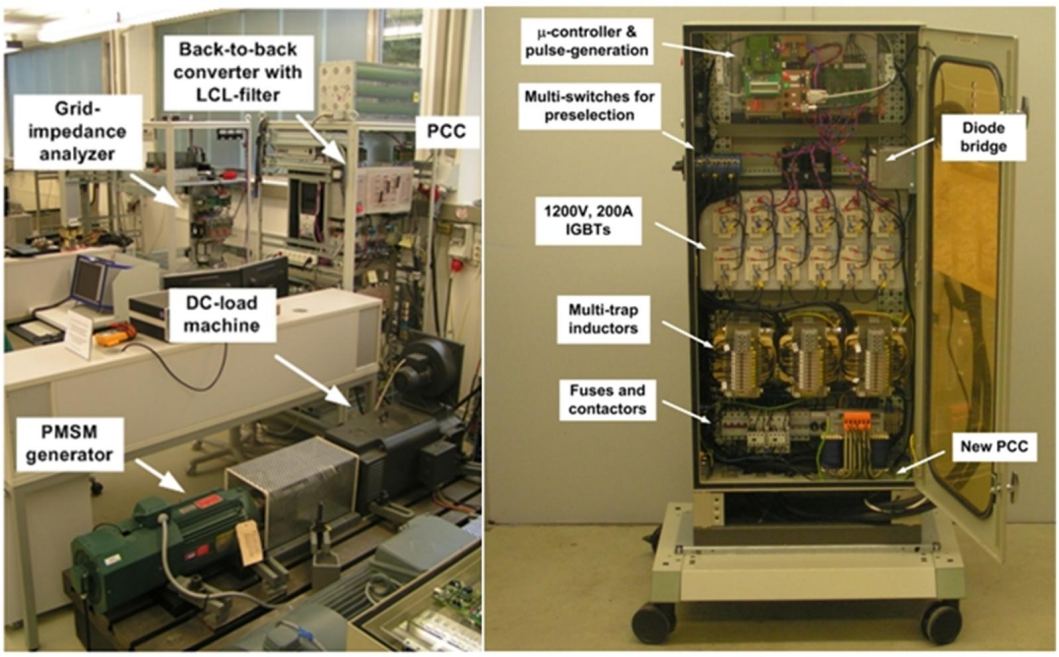


Fig. 2: Laboratory setup for grid-integration active front-end used in renewable energy applications: (left) Power-converter and adjustable speed drive-system, (right) emulator to create variable grid-impedance conditions

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 increasing and therefore the influence of each inverter on other active loads increases as well. As the voltage quality and the 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 transient grid faults. Conventional and modern control methods for voltage source inverters will be compared. In figure 1(a) a possible setup of such a microgrid is shown. It includes different units, like energy sources, loads or storage systems, which are connected by impedances in parallel to the grid connection point. In figure 1(b) the general structure of one active load with inverter is illustrated.

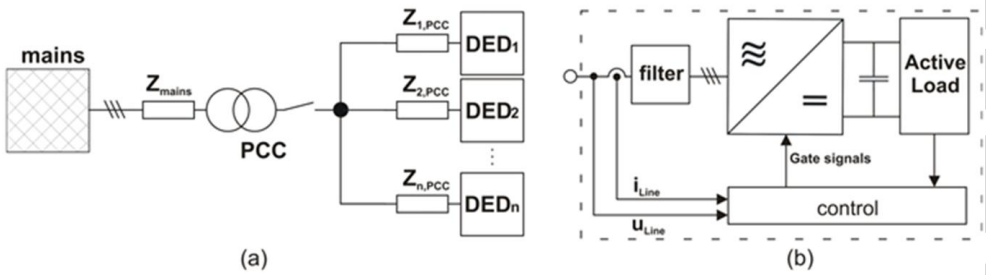


Fig. 3: (a): Structure of an autonomously controlled microgrid, (b) equivalent circuit diagram of a single active load

In 2012 control methods for parallel acting inverters will be investigated in the laboratory to verify the analytic results.

Connection of WT with ESS to Weak Grids (Grunau)

The amount of injected power to the mains from regenerative energy sources like wind turbines (WT) is increasing steadily. It can be foreseen that in some parts of the electrical grid the main part of injected energy will come from WT in the future. These decentralized feeders normally supply their energy by means of frequency converters to the grid. As a negative consequence unwanted effects in the grid occur, like high harmonics, but favourable ones also occur, as for example control of the fed in power. The reactive power especially can be controlled to stabilize the grid voltage, and by the use of energy storage systems (ESS) the active power can be fed in independently from the fluctuations of the wind, as far as the ESS and the converter rating allows. The grid codes (GC) contain the requirements for grid connection of WT. A problem of decentralized generation is that the points of common coupling (PCC) are located far away from the energy consumption centres. At these points typically weak grids can be found. Investigations will be carried out as to how energy storage systems can help to establish a secure and profitable connection of wind turbines at such weak grid connection points.

Personnel

Head of the group: Prof. Dr.-Ing. F.W. Fuchs; Secretary: P. Bekendorf, M. Marter
Technical Staff: B. Doneit

Scientific Staff:

Dipl.-Ing. M. Böttcher 01.01.-31.12.2011 Zukunftsprogramm SH/ WTSH

CEwind - Kompetenzzentrum Windenergie S-H Phase II: Condition Monitoring für Frequenzumrichter und Regelung an Generatoren in Windenergieanlagen

Dipl.-Ing. T. Franke	01.01.-15.02.2011	CAU/Stipendium
Investigation of modern Silicon-Carbide semiconductors for high efficient converters for solar applications		
Dipl.-Ing. F. Gebhardt	01.01.-31.12.2011	CAU
Analysis of Multilevel Inverters and New Power Semiconductors for Solar Applications		
Dipl. Wirtsch.-Ing. S. Grunau	01.01.-31.12.2011	CAU
Wind Turbines and Energy Storage Systems		
Dipl. Ing. N. Hoffmann	01.01.-31.12.2011	Zukunftsprogramm S-H/ WTSH
CEwind - Kompetenzzentrum Windenergie S-H Phase II: Netzadaptive Führung der Betriebsverhaltens und der Aktiv-Filter Funktionalität von Netzpulsstromrichtern in Windenergieanlagen		
Dipl.-Ing. R. Lohde	01.01.-31.03.2011	ESF/Land SH/Industry
CEWind Phase I: Power electronics generator systems in wind turbines and its grid behaviour		
Dipl.-Physiker O. Mühlfeld	01.01.-31.12.2011	Frauenhofer ISIT/Land SH
Electromagnetic compatibility of future battery-fed low-voltage converters		
Dipl. Wirtsch.-Ing. J. Reese	01.01.-31.12.2011	CAU
Investigation on autonomous controlled inverters in microgrids		
Dipl.-Ing. J. Schröder	01.01.-31.12.2011	Frauenhofer ISIT/Land SH
Battery Buffer System and Power Management		
Dipl.-Ing. S. Thomsen	01.01.-31.12.2011	DFG
Modern control of electrical drives with oscillatory mechanical loads		
Dipl.-Ing. Ch. Wessels	01.01.-14.09.2011	ESF/Land SH
Power electronics generator systems in wind turbines and their grid behaviour		
Dipl.-Ing. B. Wittig	01.01.-30.09.2011	Frauenhofer ISIT/Land SH
Electrical design and development of future battery-fed low-voltage converters		

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

Power Electronics I- Basics, 2 (+1) hrs Lecture (+ Exercises)/Week,
F.W. Fuchs (+ J. Reese)

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, 4 hrs Lab/Week,
F. W. Fuchs (+ S. Thomsen, C. Wessels, O. Mühlfeld, F. Gebhardt, J. Schröder, N. Hoffmann, M. Böttcher)

Seminar on Power Electronics, 2 hrs Seminar/Week,
F.W. Fuchs

Power Electronics - excursion, 1 hrs excursion/Week,
F.W. Fuchs (+ J. Reese, F. Gebhardt)

Power Electronic Generator Systems for Wind Turbines, 3 (+1) hrs Master Studycourse Wind Enegineering in CEwind (+ Exercises)/Week,
F.W. Fuchs (+ T. Franke, C. Wessels, F. Gebhardt, R. Lohde)

Summer 2011

Basics of electrical energy systems and power engineering, 3 (+2) hrs Lecture (+ Exercises)/Week,
F.W. Fuchs (+ S. Grunau, N. Hoffmann, J. Schröder, F. Gebhardt)

Power Electronics II - Advanced, 3 (+1) hrs Lecture (+ Exercises)/Week,
F.W. Fuchs (+ J. Schröder)

Renewable Energy Systems I, 2 (+1) hrs Lecture (+ Exercises)/Week,
F.W. Fuchs (+ M. Böttcher)

Power Electronics - laboratory course, Bachelor, 4 hrs Lab/Week,
F.W. Fuchs (+ B. Wittig, S. Thomsen, F. Gebhardt, S. Grunau, J. Schröder, N. Hoffmann, O. Mühlfeld, M. Böttcher)

Seminar on Power Electronics, 2 hrs Seminar/Week,
F.W. Fuchs

Power Electronics - excursion, 1 hrs excursion/Week,
F. W. Fuchs (+ J. Reese)

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, 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 Master Studycourse 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)

Third-Party Funds

DFG, *Regelung elektrischer Antriebe mit aktiver Dämpfung mechanischer Schwingungen und Adaption unbekannter Parameter*, 01.02.2009-31.01.2012 (219.715 EUR)

EU / State SH (CE wind), *Condition Monitoring for frequency converters at wind turbine generators*, 01.10.2008-31.12.2011 (100.000 EUR)

EU / State SH (CE wind), *Grid adapive control of the performance and active filtering ability of active rectifiers in wind turbine generators*, 01.10.2008-31.12.2012 (361.978 EUR)

Frauenhofer ISIT/Land SH, *Power Circuit development and optimization for new converter concepts for battery fed drives*, 01.04.2008-31.12.2011 (541.000EUR + MWSt)

Frauenhofer ISIT/Land SH, *Battery back up for Battery fed drives*, 01.04.2008-31.12.2011 (151.250 EUR + MWSt)

Industry, *Auslegung und Optimierung eines LCL-Filters und der PWM zur Netzanbindung eines Mittelspannungsumrichters*, 15.01.-31.05.2011 (14.600 EUR + MWSt)

Industry, *Grid Adaptive Control of Active Rectifiers*, 01.04.2011-31.03.2013 (9.000 EUR + MWSt)

Industry, *Control Systems for Power Converters*, 01.07.2011-29.02.2012 (18.173 EUR)

Industry, *Netzadaptive Regelung des Netzpulsstromrichters für Windenergieanlagen*, 15.09.2011-31.12.2012 (5.000 EUR + MWSt)

Industry, *Batteriestützung für Elektrofahrzeuge*, 01.01.2011 (15.900 EUR + MWSt)

Industry, *Double Update for dSpace Board 1103*, 01.02.-31.05.2011 (10.500 EUR + MWSt)

Industry, *Schulung zu E-Maschinen, Regelung Drehstromantriebe, Sicherheit bei Laborarbeit*, 01.09.-31.12.2011 (9.600 EUR + MWSt)

Diploma, Bachelor and Master Theses

T. Endres, *Vergleich von Verfahren zur Reduzierung der Schaltverluste in mehrphasigen DC/DC Wandlern*, 08.03.2011

H. Vach, *Untersuchung und Implementierung von Verfahren zur Minimierung der Leckströme bei der transformatorlosen Einspeisung von Solarenergie ins Netz*, 22.03.2011

O. Freitag, *Online Identifikation der äquivalenten Netzimpedanz für eine netzadaptive Regelung eines Netzpulsstromrichters in Windenergieanlagen*, 23.02.2011

A. Sarach, *Einfluss einer Aktiv-Filter-Funktionalität auf das Betriebsverhalten und die elektrischen Bauteilkomonenten von Windenergieanlagen*, 21.04.2011

F. Lukoschus, *Spannungsorientierte Regelung eines Netzpulsstromrichters*, 02.05.2011

S. Brüske, *Regelung eines elektro-mechanischen Antriebssystems mit dem Internen Modell Prinzip*, 09.05.2011

M. Andresen, *Modellbasierte prädiktive Stromregelung unter direkter Berücksichtigung des schaltenden Charakters eines Netzpulsstromrichters für Windenergieanwendungen*, 24.05.2011

L. Wunderlich, *Entwicklung eines Verfahrens zur frequenzvariablen Steuerung eines Tiefsetzstellers zum Betrieb an der Lückgrenze*, 03.06.2011

K. Genzmer, *Simulative Untersuchung eines Solar-Wechselrichters mit PI basierter Regelung*, 10.06.2011

J. Owczarzak, *Inbetriebnahme eines Solar-Wechselrichters mit LCL-Filter und Untersuchung von parallel betriebenen Umrichtern bei oberschwingungsbehafteter Netzspannung*, 28.06.2011

S. Leowski, *Entwurf, Aufbau, Inbetriebnahme und Untersuchung eines Batterie-Emulators*, 30.06.2011

M. Paulsen, *Untersuchung von Verfahren zur Fehlerfrüherkennung und Restlaufzeitbestimmung von IGBT-Modulen auf Grundlage unterschiedlicher Alterungsmechanismen*, 13.07.2011

M. Hempel, *Verbesserung des Regelverhaltens von Netzpulsstromrichtern mit Aktiv-Filter-Funktionalität durch Störgrößenbeobachter und Adaption der Netzimpedanz mit LCL-Filter in Windenergieanwendungen*, 19.07.2011

H. Jedtberg, *Optimierung der Regelung eines StatCom-Umrichters zum Einsatz an Windenergieanlagen unter Berücksichtigung verschiedener Regelziele unter unsymmetrischen Netzfehlerbedingungen*, 06.08.2011

T. Plöhn, *Untersuchung und Vergleich von Verfahren zur messtechnischen Analyse des Verhaltens von Mittelspannungsnetzen*, 16.08.2011

P. Kühn, *Auslegung, Aufbau, Inbetriebnahme und Untersuchung eines fehlertoleranten dreistufigen NPC-basierten Umrichters*, 22.08.2011

B. Reese, *Untersuchung von Verfahren zur Netzimpedanzbestimmung*, 29.08.2011

C. Rocneanu, *Untersuchung und Modellierung von modernsten Siliziumcarbid Leistungshalbleitern*, 30.08.2011

M. Ciesielski, *Identifikation und adaptive Regelung eines Antriebssystems mit schwingungsfähiger Last*, 01.09.2011

E. Diez Perez, *Aktive Inselnetzerkennung in Solarwechselrichtern und Untersuchung von Regelungsverfahren in einem isoliert betriebenen Microgrid*, 01.09.2011

R. Kühne, *Untersuchung von Windenergieanlagen mit Kurzzeit- Energiespeichersystemen zur Steigerung der Effizienz, Vergleichmäßigung der Leistung und Erfüllung von Netzanschlussregeln*, 10.10.2011

D. Janning, *Entwurf, Implementierung, Inbetriebnahme und messtechnische Untersuchung einer Feldorientierten Regelung für eine 5 kW - Asynchronmaschine*, 25.10.2011

S. Schubotz, *Untersuchung von Offline- und Online-Verfahren zur Detektion des Alterungszustandes von Kondensatoren im Spannungszwischenkreis von Umrichtern*, 28.10.2011

D. Schauer, *Herstellen einer CAN basierten Kommunikationsstruktur für Microcontroller und Vergleich von kontinuierlichen und diskontinuierlichen PWM-Verfahren*, 06.12.2011

S. Adamovic, *Detaillierte Charakterisierung und empirische Modellerstellung von Ultrakondensatoren*, 15.12.2011

A. Schröder, *Aktive Dämpfungsverfahren unter Berücksichtigung variierender Netzimpedanzen für die Regelung eines Netzpulsstromrichters mit LCL-Filter in Windenergieanwendungen*, 15.12.2011

K. Buchert, *Vergleich von Multilevelumrichtern für Windenergieanlagen im MultiMW-Bereich mit Leistungshalbleitern verschiedener Spannungs- und Leistungsklassen*, 20.12.2011

S. Brüske, *Untersuchung von Verfahren zur Fehlerdiagnose für einen fehlertoleranten dreistufigen NPC-basierten Umrichter für den Einsatz in Windenergieanlagen*, 30.12.2011

S. Baresel, *Untersuchung von Snubber- und Clamping- Beschaltungen für Low Voltage Power MOSFETs*, 27.04.2011

M. Fox, *Implementierung und Untersuchung eines direkten Regelverfahrens für das DASG in WEA am Laborversuchsstand*, 27.01.2011

H. Günther, *Aufbau, Inbetriebnahme und Test einer Treiberschaltung mit zweistufiger Ansteuerung der Leistungs-MOSFETs eines B6-Umrichters*, 17.01.2011

K.. Helbig, *Vergleich von fehlertoleranten NOC-basierten Umrichtertopologien für den Einsatz in Offshore-Windenergieanlagen*, 11.03.2011

J. Krüger, *Elektrische und thermische Charakterisierung eines Leistungsmoduls für batteriegespeiste Umrichter*, 09.02.2011

A. Tawfek, *Reactive Powercontrol and Capabilities of Modern Wind Turbines and the Impact of the Power System*, 25.06.2011

B. Zhao, *Modelling of a Wind Farm with Multi-Pole Permanent Magnet Synchronous Generator Wind Turbines for Grid Support and Uninterrupted Operation during Grid Fault*, 02.04.2011

Dissertations / Postdoctoral Lecture Qualifications

M. Mohr, *Stromrichtersysteme zur Einspeisung elektrischer Energie aus Brennstoffzellen*, 04.03.2011

K. Rothenhagen, *Fehlertolerante Regelung der doppeltgespeisten Asynchronmaschine bei Sensorfehlern*, 27.05.2011

Publications

Published in 2011

M. Böttcher, F.W. Fuchs, *Power Electronic Converters in Wind Energy Systems - Considerations of Reliability and Strategies for Increasing Availability*, EPE Joint Wind Energy and T+D Chapters Seminar 2011, Trondheim, Norway, (2011)

J. Dannehl, M. Liserre, F.W. Fuchs, *Filter-Based Active Damping of Voltage Source Converters With LCL Filter*, IEEE Transactions on Industrial Electronics, **vol.58, no. 8**, (2011)

N. Hoffmann, F.W. Fuchs, J. Dannehl, *Models and effects of different updating and sampling concepts to the control of grid-connected PWM converters - A study based on discrete time domain analysis*, Power Electronics and

Applications (EPE 2011), Proceedings of the 2011-14th European Conference on, (2011)
N. Hoffmann, L. Asiminoaei, F.W. Fuchs, *Online Grid-Adaptive Control and Active-Filter Functionality of PWM-Converters to Mitigate Voltage- Unbalances and Voltage-Harmonics - A Control Concept Based on Grid-Impedance Measurement,* In Proc. of IEEE Energy Conversion Congress and Exposition, Phoenix, USA, 3067 - 3074 (2011)
N. Hoffmann, R. Lohde, M. Fischer, L. Asiminoaei, P.B. Thoegersen, F.W. Fuchs, *A Review on Fundamental Grid-Voltage Detection Methods under Highly Distorted Conditions in Distributed Power- Generation Networks,* In Proc. of IEEE Energy Conversion Congress and Exposition, Phoenix, USA, 3045 - 3052 (2011)
M. Mohr, *Stromrichtersysteme zur Einspeisung elektrischer Energie aus Brennstoffzellen,* Dissertation, Christian-Albrechts-Universität zu Kiel, (2011)
O. Mühlfeld, B. Wittig, F.W. Fuchs, *Development of an Optimized Power Section for a 5 kW Low Voltage Traction Inverter,* EPE ECCE 2011, (2011)
J. Reese, R. Lohde, F.W. Fuchs, *FRT Capability of Direct Power Controlled Converters connected by an Actively Damped LCL-Filter for Wind Power Applications,* EPE ECCE 2011, (2011)
J. Reese, R. Lohde, F.W. Fuchs, *Investigations on the Fault Ride Through Capability of Direct Power Controlled Converters Connected with LCL-Filter for Wind Power Applications,* EPE Joint Wind Energy and T+D Chapters Seminar 2011, (2011)
K. Rothenhagen, *Fehlertolerante Regelung der doppeltgespeisten Asynchronmaschine bei Sensorfehlern,* Dissertation, Christian-Albrechts-Universität zu Kiel, (2011)
J.C. Schroeder, F.W. Fuchs, *Design of a power management for a battery buffer system in an electric lift truck by means of fuzzy control and genetic algorithm,* Power Electronics and Applications (EPE 2011), Proceedings of the 2011-14th European Conference on, 1 - 10 (2011)
S. Thomsen, F.W. Fuchs, *Design and Analysis of a Flatness-Based Control Approach for Speed Control of Drive Systems with Elastic Couplings and Uncertain Loads,* Power Electronics and Applications (EPE 2011), Proceedings of the 2011-14th European Conference on, (2011)
S. Thomsen, N. Hoffmann, F.W. Fuchs, *PI Control, PI-Based State Space Control, and Model-Based Predictive Control for Drive Systems With Elastically Coupled Loads - A Comparative Study,* Industrial Electronics, IEEE Transactions on, **vol. 58, no. 8**, 3647 - 3657 (2011)
Ch. Wessels, F.W. Fuchs, M. Molinas, *Voltage Control of a StatCom at a Fixed Speed Wind Farm under Unbalanced Grid Faults,* IECON 2011, (2011)
Ch. Wessels, S. Grunau, F.W. Fuchs, *Current Injection Targets for a StatCom under Unbalanced Grid Voltage Condition and the Impact on the PCC Voltage,* EPE Joint Wind Energy and T+D Chapters Seminar 2011, (2011)
Ch. Wessels, F. Gebhardt, F.W. Fuchs, *Fault Ride-Through of a DFIG Wind Turbine Using a Dynamic Voltage Restorer During Symmetrical and Asymmetrical Grid Faults,* Power Electronics, IEEE Transactions on, **vol.26, no.3**, 807 - 815 (2011)
Ch. Wessels, N. Hoffmann, F.W. Fuchs, *Regelung der negativen Spannungssequenz durch Windenergieanlagen,* In Proc. of ETG Kongress, Fachtagung 3: Leistungselektronik in Netzen, (2011)
B. Wittig, O. Mühlfeld, F.W. Fuchs, *Adaption of MOSFETs Current Slope by Systematic Adjustment of Common Source Stray Inductance and Gate Resistance,* EPE ECCE 2011, (2011)
B. Wittig, F.W. Fuchs, *Analysis and Comparison of Turn-Off Active Gate Control Methods for Low Voltage Power MOSFETs with High Current Ratings,* IEEE Transactions on Power Electronics, accepted and in press for publication, (2011)
B. Wittig, O. Mühlfeld, F.W. Fuchs, *Methoden zur Effizienssteigerung von Niedrigspannungs - Umrichtern mit hohen Lastströmen,* ETG - Kongress, Würzburg, (2011)
B. Wittig, O. Mühlfeld, F.W. Fuchs, J. Rudzki, *High Efficient Power Converter for Low Voltage Traction Applications with Power Multiplication,* Bodo's Power Systems, (2011)

M. Böttcher, *Fortschritte in der Leistungselektronik - Leistungshalbleiter und Stromrichterschaltungen,* Industrieseminar, 20.01.2011

M. Böttcher, *Fehlertolerante Umrichtertopologien für WEA / Forcierte Alterung von IGBT-Modulen,* Mitarbeiterseminar, 25.03.2012

M. Böttcher, *Power Electronic Converters in Wind Energy Systems - Considerations of Reliability and Strategies for Increasing Availability,* EPE Joint Wind Energy and T+D Chapters Seminar 2011, Trondheim, 10.05.2011

M. Böttcher, *Condition Monitoring und fehlertoleranter Betrieb - Aktuelle und geplante Arbeiten,* Mitarbeiterseminar, 13.07.2011

M. Böttcher, *Fehlertoleranter Umrichter: Durchgeführte und geplante Laborarbeiten,* Mitarbeiterseminar, 09.12.2011

F. Gebhardt, *Fortschritte in der Leistungselektronik - Leistungshalbleiter und Stromrichterschaltungen,* Industrieseminar, 20.01.2011

F. Gebhardt, *Systemoptimierung von Solar-Wechselrichtern und Analyse von modernsten Leistungshalbleitern,* Mitarbeiterseminar, 25.03.2011

F. Gebhardt, *Implementierung des PWM double updates auf einem dSpace ds1103 System,* Mitarbeiterseminar, 13.07.2011

F. Gebhardt, *Analysis of Multilevel Inverters and New Power Semiconductors for Solar Applications,* Inustrie, 27.10.2012

F. Gebhardt, *Berechnung der Leistungshalbleiterverluste für einen 5-Level Wechselrichter,* Mitarbeiterseminar, 09.12.2011

S. Grunau, *Forschungsthemen im Bereich Windenergie an LEA,* Mitarbeiterseminar, 25.03.2011

S. Grunau, *Investigations on the Fault Ride Through Capability of Direct Power Controlled Converters Connected with LCL-Filter for Wind Power Applications,* EPE Joint Wind Energy and T+D Chapters Seminar 2011, Trondheim, 10.05.2011

S. Grunau, *Überblick zu Forschungsthemen im Bereich HGÜ und Offshore,* Mitarbeiterseminar, 13.07.2011

S. Grunau, *Schülerprojekte an LEA, Runder Tisch zum Thema,* Lehrstuhl, 08.09.2011

S. Grunau, *Regelung der negativen Spannungssequenz durch Windenergieanlagen, Negative sequence voltage control for wind turbines,* ETG Fachkonferenz Würzburg, 09.11.2011

S. Grunau, *Windenergieanlagen und Energiespeichersysteme,* Mitarbeiterseminar, 09.12.2011

N. Hoffmann, *Aktuelle Forschungs- und Anwendungstrends in der Regelung von Leistungselektronik und elektrischen Antrieben,* Industrieseminar, 20.01.2011

N. Hoffmann, *Grid-adaptive Control and Active-Filter Functionality of grid-connected PWM-inverters in Wind-Energy applications,* Industrie, 12.01.2011

N. Hoffmann, *Netzadaptive Führung des Betriebsverhaltens und der Aktiv-Filter-Funktionalität von Netzpulsstromrichtern in Windenergieanlagen,* Industrie, 10.02.2011

N. Hoffmann, *Review on Fundamental Grid-Voltage Detection methods under Highly Distorted Voltage-Conditions,* Mitarbeiterseminar, 25.03.2011

N. Hoffmann, *Grid-adaptive Control and Active-Filter Functionality of grid-connected PWM-inverters in Wind-Energy applications,* Industrie, 30.06.2011

N. Hoffmann, *Auslegung und Optimierung eines LCL Filters und der PWM zur Netzanbindung eines Mittelspannungsumrichters,* Industrie, 19.08.2011

N. Hoffmann, *Grid-adaptive Control and Active-Filter Functionality of grid-connected PWM-inverters in Wind-Energy applications,* Konferenz EPE ECCE 11, 18.09.2011

N. Hoffmann, *Online Grid-Adaptive Control and Active-Filter Functionality of PWM-Converters to Mitigate Voltage-Unbalances and Voltage-Harmonics - A Control Concept Based on Grid-Impedance Measurement,* Konferenz EPE ECCE 11, 18.09.2011

N. Hoffmann, *A Review on Fundamental Grid-Voltage Detection Methods under Highly Distorted Conditions in Distributed Power-Generation Networks,* Konferenz EPE ECCE 11, 18.09.2011

N. Hoffmann, *Advantages and challenges of finite-state model-based predictive control in active front-end applications - The concept of variable pulse-width model-based predictive current control,* Industrie, 14.10.2011

N. Hoffmann, *Pulse-width modulation of active front-end converters in steady-state over-modulation- challenges, solutions and implementation on a 1 MW low-voltage active front-end converter,* Industrie, 24.10.2011

R. Lohde, *Aspekte der Momentanleistungstheorie,* Mitarbeiterseminar, 25.03.2011

O. Mühlfeld, *Vergleich von Simulation und Messung beim KLSH Umrichter,* Mitarbeiterseminar, 16.05.2011

O. Mühlfeld, *Untersuchung der Steuerbarkeit der Stromsteilheit beim Schalten von Leistungs-MOSFETs durch Adaption der Common Source Induktivität,* Industrie, 25.05.2011

O. Mühlfeld, *Messtechnische Untersuchung der elektro-thermischen Wechselwirkungen innerhalb eines Leistungsmoduls,* Industrie, 13.05.2011

O. Mühlfeld, *Einfluss parasitärer Elemente auf leitungsgebundene Störungen,* Mitarbeiterseminar, 13.07.2011

O. Mühlfeld, *Optimierung eines Umrichters für Elektrofahrzeuge,* LE Nord, Bremen, 27.10.2011

J. Reese, *Fortschritte in der Leistungselektronik - Regelung von Leistungselektronik und elektrischen Antrieben,* Industrieseminar, 20.01.2011

J. Reese, *Modellierungsansätze von parallelen Umrichtern,* Mitarbeiterseminar, 25.03.2011

J. Reese, *LVRT-Fähigkeit von Windenergieanlagen mit LCL-Filter und fluktuierender Schaltfrequenz,* Mitarbeiterseminar, 13.07.2011

J. Reese, *Investigation on autonomous controlled Inverters to improve control mode of microgrids,* Industrie, 27.10.2011

J. Reese, *Methoden zur Effizienzsteigerung von Niedrigspannungs-Umrichtern mit hohen Lastströmen,* ETG Fachkonferenz Würzburg, 09.11.2011

J. Reese, *Interpretation und Auswirkungen der komplexen Netzimpedanz auf parallel arbeitenden Umrichter,* Mitarbeiterseminar, 09.12.2011

J. Reese, *FRT Capability of Direct Power Controlled Converters connected by an Actively Damped LCL-Filter for Wind Power Applications,* Konferenz EPE ECCE 11, 18.09.2011

J. Schröder, *Investigation on autonomous controlled Inverters to improve control mode of microgrids, Industrie, 10/11 Methoden zur Effizienzsteigerung von Niedrigspannungs-Umrichtern mit hohen Lastströmen, ETG Fachkonferenz Würzburg, 11/11 Interpretation und Auswir,* Kompetenzzentrum Leistungselektronik Schleswig-Holstein, 18.02.2011

J. Schröder, *Optimierung und Implementierung eines aktiven Powermanagements,* Mitarbeiterseminar, 25.03.2011

J. Schröder, *Gekoppelte Induktivitäten in mehrphasigen Gleichstromstellern,* Mitarbeiterseminar, 13.07.2011

J. Schröder, *Bestimmung des Ladezustandes einer Bleisäurebatterie mit und ohne Batteriestützung,* Kompetenzzentrum Leistungselektronik Schleswig-Holstein, 27.10.2011

J. Schröder, *Auslegung und Implementierung einer gekoppelten Induktivität,* Mitarbeiterseminar, 09.12.2011

S. Thomsen, *Flachheitsbasierte Drehzahlregelung eines Antriebssystems mit schwingungsfähiger Last,* Mitarbeiterseminar, 25.03.2011

S. Thomsen, *Models and effects of different updating and sampling concepts to the control of grid-connected PWM converters - A study based on discrete time domain analysis,* Konferenz EPE, Birmingham, 30.08.2011

S. Thomsen, *Flachheitsbasierte Regelung für Antriebssysteme mit schwingungsfähiger Last,* LE Nord, Bremen, 27.10.2011

S. Thomsen, *Vergleich von Drehzahlregelungsverfahren für Antriebssysteme mit schwingungsfähiger Last: Betrachtung variierender Antriebskonfigurationen,* Mitarbeiterseminar, 09.12.2011

Ch. Wessels, *Fault Ride Through mit Teilumrichter- und Vollumrichter-Windenergieanlagen,* Mitarbeiterseminar, 25.03.2011

B. Wittig, *Typenprüfung + Active Gate Control am NeLe-Umrichter,* Mitarbeiterseminar, 25.03.2011

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 in 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 the Master-Laboratory

- New test setup: IGBT based grid impedance emulator to reproduce step changes in the grid impedance in 30 kVA laboratory scale

- New test setup: Fault tolerant three-level neutral-point-clamped inverter

- New test setup: Forced ageing of IGBT modules with monitoring of possible ageing indicators

- Implementation of calorimetric power loss measurement of inverters

- Acquirement of an LCR device for measuring up to 2 Mhz

- Acquirement of a 10 kW DC power supply (100V / 30A)

- Acquirement of a 4-channel temperature data logger

Contribution to external representation of the Faculty of Engineering

Tech to you (industry fair Hannover, tour for pupils, guided by research assistants, April 2011)

Presentation on job information events for pupils (February 2011)

Information course for the *Kiel University Information Days*(March 2011)

Power Girls and Boys (Three days event for 10-11 year old pupils, introduction to technical experiments)

Stadt der jungen Forscher / Wissenschaftsfestival (May 2011)

Technology of Silicon-Based Micro- and Nano-Systems

Since October 2008 Prof. Dr. 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

Wireless Communications

The research of the Group of Wireless Communications (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 aim to master especially 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 designed antennas cover the frequency range from 3.1 GHz to 10.6 GHz. In the framework of a BMWi project grant, 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 surgery 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

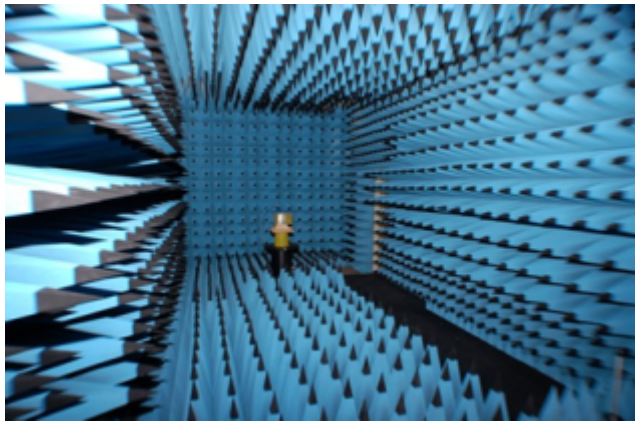


Fig. 1: Shielded absorber room for antenna measurements.

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 periphery 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.

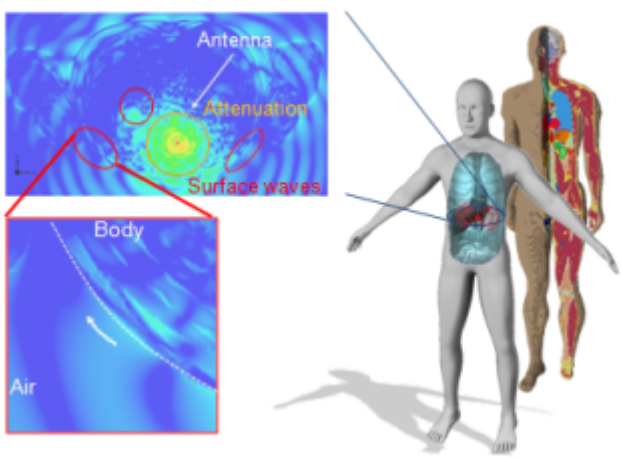


Fig. 2: In and on body radio propagation of wireless medical implants.

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	01.07.-31.12.2011	BMBF / EU
Dipl.-Ing. M. Grimm UWB BAN / EPAMO	01.10.-31.12.2011	DFG / BMBF / EU
Dipl.-Wirtsch.-Ing. R. Martens MIMO	01.01.-31.12.2011	DFG / CAU
Dipl.-Wirtsch.-Ing. F. Marx HSP2020 / Localization / EPAMO	01.01.-31.12.2011	CAU / BMBF / EU
Dipl.-Ing. E. Safin MIMO	15.08.-31.12.2011	BMBF / EU
M.Sc. Sana Salama Reconfiguable Antennas	01.10.-31.12.2011	DAAD

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

Grundgebiete der Elektrotechnik III, 3 (+2) hrs Lecture (+ Exercises)/Week,
D. Manteuffel (+ R. Martens, D. Manteuffel)

Advanced Topics Lab, 6 hrs Practical/Week,
D. Manteuffel

Summer 2011

Wireless Communication (RF), 2 (+1) hrs Lecture (+ Exercises)/Week,
D. Manteuffel (+ R. Martens)

Hochfrequenztechnik, 2 (+1) hrs Lecture (+ Exercises)/Week,
D. Manteuffel (+ R. Martens)

Seminar EM Modelling, 3 hrs Seminar/Week,
D. Manteuffel

Projekt, 3 hrs Practical/Week,
D. Manteuffel

Winter 2011/2012

Grundgebiete der Elektrotechnik III, 3 (+2) hrs Lecture (+ Exercises)/Week,
D. Manteuffel (+ E. Safin, F. Marx)

Antennas, 2 (+1) hrs Lecture (+ Exercises)/Week,
D. Manteuffel (+ D. Manteuffel)

Funkbasierte Kommunikation und Sensorik in der Medizintechnik, 2 (+1) hrs Lecture (+ Exercises)/Week,
D. Manteuffel (+ D. Manteuffel)

Projekt, 3 hrs Practical/Week,
D. Manteuffel

Masterpraktikum Mikrowellen und EMV, 4 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)*, 01.10.2010-30.09.2012 (124960 EUR)
Deutsche Forschungsgemeinschaft, *Integration von Mehrantennensystemen in kleinen mobilen Endgeräten auf Basis der Theorie der Charakteristischen Moden*, 01.12.2010-30.11.2011 (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)
Industry Cooperation, *Multiple collaborations with local industry and SMEs*, 01.01.-31.12.2011 (non-disclosed)
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 and Master Theses

Ralf Andersen, *Entwicklung eines Speisungskonzeptes für ultra-breitbandige dual-polarisierte Hornantennen*, 01.02.2011
Eugen Safin, *Rekonstruktion der modalen Quellenverteilungen auf planaren Antennen auf Basis des abgestrahlten Fernfeldes zur Analyse von MIMO Systemen*, 28.03.2011
Denis Baron, *Entwicklung einer breitbandigen Antenne zur Kanalcharakterisierung*, 01.06.2011
Sarah Schauer, *Raytracing-Untersuchung von Indoor-Kanälen*, 01.06.2011
Yiming Huang, *Analyse und Bewertung der Kanalmodelle körpergebundener Funknetzwerksysteme (BAN)*, 10.06.2011

Publications

Published in 2011

D. Manteuffel, R. Martens, *A Concept for MIMO Antennas on Small Terminals Based on Characteristic Modes*, IWAT 2011 - International Workshop of Antenna Technology, (2011)
R. Martens, E. Safin, D. Manteuffel, *Selective Excitation of Characteristic Modes and Small Terminals*, EuCAP 2011 - European Conference on Antennas and Propagation, (2011)
D. Manteuffel, P. Höher, M. Mehdorn, *Evaluation of RF Localization for Deep Brain Implants*, EuCAP 2011 - European Conference on Antennas and Propagation, (2011)
M. Grimm, D. Manteuffel, *Characterization of Electromagnetic Propagation Effects in the Human Head and its Application to Deep Brain Implants*, International Conference on Electromagnetics in Advanced Applications - Antennas and Propagation in Wireless Communications 2011, (2011)
R. Martens, E. Safin, D. Manteuffel, *Inductive and Capacitive Excitation of the Characteristic Modes of Small Terminals*, LAPC 2011 - Loughborough Antennas and Propagation Conference, (2011)

Presentations

D. Manteuffel, *Industrial Antenna Design*, ESoA Course, Germany, 01.05.2011

D. Manteuffel, *Compact Antennas*, ESoA Course, Spain, 01.07.2011
D. Manteuffel, *EM Modelling*, Technik der Antennen, Germany, 01.10.2011
D. Manteuffel, *Mobile Communication Antennas*, Technik der Antennen, Germany, 01.10.2011
D. Manteuffel, *Intelligente Antennensysteme*, Carl-Crantz-Gesellschaft, Germany, 01.10.2011

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 2011 Prof. Manteuffel served on the TPC of the following international conferences: EuCAP 2011 - European Antennas and Propagation Conference, LAPC 2011 - Loughborough Antennas and Propagation Conference, iWAT 2011 - International Workshop on Antenna Technology.

Results

In the 2011 the Institute for Materials Science gained significant public interest particularly due to scientific activities linked to the Nanolab with its clean room facilities, and the labs for nanoanalytics. The relevance of the highly sophisticated infrastructure became visible by the inaugural visit of the former federal president of Germany (C. Wulff) to Schleswig-Holstein. Together with the state premier of Schleswig-Holstein (H. P. Carstensen) and the mayor of Kiel (T. Albig) Wulff visited the Nanolab and showed particular interest in the nano-bio topics.

Fig. 1: The former federal president and the state premier of Schleswig-Holstein enjoy a demonstration by Prof. Dr. Quandt and Dr. Lima de Miranda in the clean room facilities

Prof. W. Jäger acted as Conference Chair of the very successful International Microscopy Conference MC2011 in Kiel: 930 delegates from all over the world were present, among those 140 student participants. The scientific program covered the current developments in Instrumentation and Methods, Materials Science and Life Sciences, with more than 25 scientific symposia and workshops. More than 500 scientific contributions were received from 44 countries from within as well as outside Europe, including Japan, China, Israel, South Africa, USA, and others. 50 manufacturers of microscopes and suppliers of equipment and products in all fields of microscopy and related techniques contributed to the success of the conference. The enclosed event report tries to convey to you some impressions of the conference. The congress was inaugurated with addresses of welcome by Professor Gerhard Fouquet (President of the Christian-Albrechts-University), Dr. Cordelia Andreßen (Secretary of State of the Ministry of Science, Economic Affairs, and Transport for the Federal State of Schleswig-Holstein), and by Cathy Kietzer (President of the City Council Kiel). We would like to express cordially our sincere gratitude for this important support.

The Institute for Materials Science contributes considerably to the interdisciplinary activities at Christian-Albrechts-University, particularly within the research foci of ''Kiel Nano Sciences''. Two highlights with respect to third-party funding are of particular importance. Firstly, the approval of the second funding period of the collaborative research centre ''Function

by Switching'' (SFB 677, speaker: Prof. Herges) by the German Research Foundation (DFG). Four contributions of the Institute by Prof. Adelung, Prof. Selhuber-Unkel, Prof. Faupel, and Prof. Elbahri underline the close connection between materials science, chemistry, physics, and biology. Secondly, the initial proposal for the cluster of excellence ''Materials for Life'' (speaker: Prof. Quandt) was positively evaluated. As a result, the contributing investigators were invited to submit the full proposal, which was defended in January 2012. The report of the referees will be published in June; thus we still have time to keep our fingers crossed!

Further progress is indicated by the continued growth of the scientific infrastructure of the institute. A new state of the art high resolution field emission scanning electron microscope from the Zeiss company could be purchased and installed. The microscope was bought with financial support from the institute and the university, the DFG, and the ''Prof. Dr. Werner Petersen Stiftung der Technik''. To acknowledge this latter sponsorship, the microscope was named the Werner Petersen microscope.

The scientific expertise of the institute directors is also indicated by honours, prizes, and invitations to join scientific committees. For instance, Prof. Quandt was elected as a member of the research council 406 (Material Science) of the German Research Foundation. Moreover, Prof. Adelung received a prize from the Innovationsstiftung Schleswig-Holstein (''ISH Transferprämie''), given in cooperation with the Ministry of Science, Economic Affairs and Transport, for dedicated cooperation with companies in Schleswig-Holstein. Prof. Wolfgang Jäger has been elected as a member of the Executive Committee of the European Materials Research Society.

The former junior professor, Mrs. Selhuber-Unkel (group ''Biocompatible Nanomaterials''), received an offer for a W2 professorship from the RWTH Aachen. Fortunately, with the highly appreciated help of the president and dean, she decided to decline the offer and stay in Kiel, also as W2 full professor. A new (the third!) Heisenberg-professorship awarded to Prof. Jeffrey McCord in January 2011 strengthens the expertise in magnetic materials research at the Institute. Prof. McCord´s group ''Nanoscale Magnetic Materials - Magnetic Domains'' focuses on magnetic domain formation and its dynamics in magnetic materials of numerous kinds, the understanding of which is necessary for the development of various proposed applications. The current SFB 855 ''Magnetoelectric Composites - Future Biomagnetic Interfaces'' will instantly benefit from this expertise on nanostructured magnetic thin films.

The Institute successfully certified their study course Master in Materials Science and Engineering as accredited by the ASIIN. The study course Bachelor in Materials Science was successfully evaluated and will be recertified in 07/12. The Institute engaged in the program TasteMINT, guided by the equal opportunity commissioner of the Faculty of Engineering. The project was conducted with 24 young women in order to assess their potential aptitude for studying a subject from the fields of mathematics, computer science, natural sciences, and technology.

The Institute is still improving the quality of work in the examination office - for the students as well as for the employees. One basic point deals with the introduction of the online portal for report status and appointment information (ProSTi) for all lab courses offered by the Institutes of Materials Science and Electronics / Information Engineering. It allows online registration and control of lab courses by the students and supervisors. The quality of administration and teaching is again highlighted by the excellent evaluation results accorded to the study quality in a university-wide bachelor survey.

Finally, the administration of the institute has changed. After many years with Prof. Föll as the executive director, Prof. Kienle was elected to the post in November 2011. The new executive director would like to give thanks to his predecessor for his excellent work during his incumbency.

Biocompatible Nanomaterials

The department „Biocompatible nanomaterials" focuses on investigating cell-material interactions with an interdisciplinary approach, by combining methods from physics, chemistry and biology. Currently, the members of the group are materials scientists, physicists and biologists. In the long run, we want to be able to control living cells with nanostructures and to characterize quantitative parameters. This particularly includes experiments with force microscopy techniques that allow cell adhesion studies from the single-cell level down to the single molecule level.

In the following we discuss recent results from our different projects.

Results

Diffusional motion in living cells

Understanding the intracellular motion of particles is not only essential for controlling drug delivery processes, but also for investigating the influence of materials on intracellular processes. By combining single particle tracking microscopy data of endogenous lipid granules in living fission yeast cells, with analytical results and simulations, we have shown that in the intracellular space anomalous diffusion dominates particle transport.

The most remarkable result was the observation that for cellular diffusion processes time average is not equal to ensemble average, a phenomenon known as ergodicity breaking. Ergodicity breaking is also associated with ageing phenomena, which we clearly observe in our cells. This result was achieved in close collaboration with Prof. Ralf Metzler (University of Potsdam) and Lene Oddershede (University of Copenhagen). The work received the publication award 2011 from the Centre for NanoSciences (CeNS), Munich.

This project is financially supported by the „German Academy of Sciences Leopoldina" .

Jeon, J.-H., Tejedor, V., Burov, S., Barkai, E., Selhuber-Unkel, C., Berg-Sørensen, K., Oddershede, L., and Metzler, R. In vivo anomalous diffusion and weak ergodicity breaking of lipid granules. Physical Review Letters (2011), 106, 048103.

Target-cell contact reactions in parasitic amoebae

Acanthamoeba Castellanii are free living, pathogenic amoebae. They destroy target cells by an extracellular killing mechanism that is induced by the formation of a close contact between amoeba and target cell. Subsequently, granules that contain membrane-active proteins are transported to the contact site between amoeba and target cell. Therefore, the intra-amoebic motion of granules plays an essential role for the pathogenicity of the amoebae. The movement of small lipid granula (diameter about 200 nm) as well as the motion of vacuoles (several μm in diameter) inside the amoebae was observed by recording sequences of living *Acanthamoeba* using phase contrast microscopy in combination with a high speed camera (figure 1). The intracellular particles are automatically tracked and the time averaged mean square displacement is calculated. From these data the rheological exponent α can be determined, which gives important information about the type of motion of the particle. It was found that in amoebae particles are mostly actively transported either by molecular motors or intracellular convection.

Furthermore the contact formation between amoebae and nerve cells was explored by recording sequences of co-cultures of amoebae and target cells using phase contrast microscopy. *Acanthamoeba* attack nerve cells at extensions like dendrites or axons. It could be observed that amoebae pull nerve cells from the surface, which shows that they can exert large forces in the μN regime. For comparison, a single molecular motor can typically exert only several pN. This will be further studied using force microscopy, which allows for a detailed quantification of cellular forces.

This project is funded by an Emmy Noether grant from the DFG.

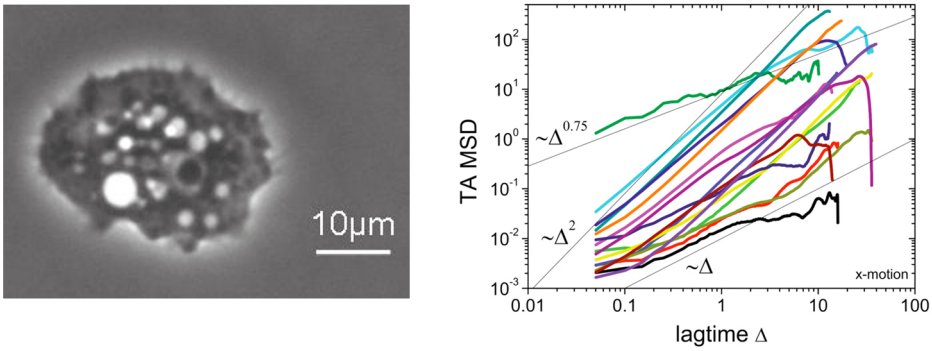


Fig. 1: Figure 1 Left: *Acanthamoeba comandoni* adhering to a glass surface. The white circles are intracellular vacuoles, which are transported inside the cell. Right: Mean squared displacements of granules in the amoeba. Many different types of motion are observed, from subdiffusion (exponent 0.75) to Brownian motion (exponent 1) to superdiffusion (exponent 2).

Switchable cell adhesion

For a large variety of applications it would be very advantageous to switch the adhesive properties of surfaces for cell adhesion. Examples include cell culture dishes, because the techniques typically used to detach cells from such surfaces are very harmful to the cells. We aim at switching the adhesion of eukaryotic and prokaryotic cells in a spatially and temporally defined way by developing photo-switchable functional surfaces. One approach is to switch cell adhesion independently from addressing any adhesion receptors by using azobenzene molecules. We are also combining this method with nanostructured surfaces (figure 2), in order to control the density and spatial distribution of azobenzene molecules. On these surfaces nanometer sized gold dots (5-8 nm in diameter) are prepared in hexagonal patterns using block-copolymer micelle nanolithography (BCMN). Azobenzene molecules can be covalently coupled to these surfaces by thiol-linkers; the area between the gold dots is covered with a polyethylene glycol.

This project is funded by the SFB 677 „Function by Switching“ (Project B11).

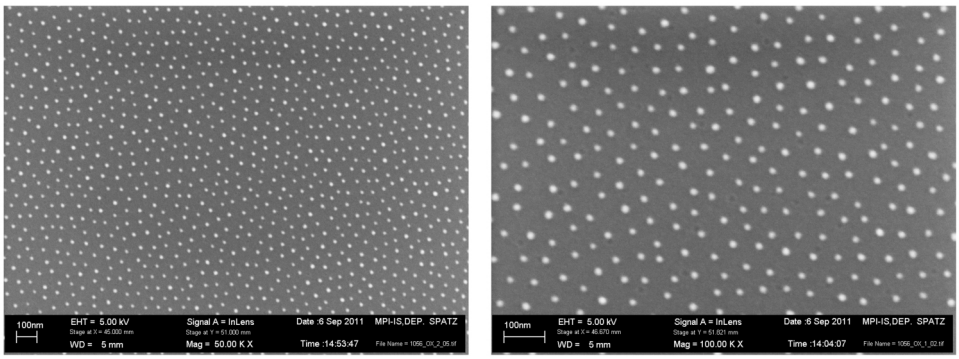


Fig. 2: Scanning electron microscopy images of surfaces fabricated with block-copolymer micelle nanolithography. Gold dots are placed on the surface in a quasi-hexagonal pattern by a self-assembly process.

Personnel

Head of the group: Prof. Dr. C. Selhuber-Unkel; Secretary: E. Riemer (50%)

Scientific Staff:

M.Sc. L. Kadem	01.08.-31.12.2011	DFG
SFB 677, Teilprojekt B11		
M.Sc. J. Reverey	01.01.-31.12.2011	DFG
A nanobiophysical approach to elucidate target-cell killing by amoebic parasites		
Dr. S. Viebig	01.09.-31.12.2011	CAU

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

Cell Mechanics, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
C. Selhuber-Unkel (+ C. Selhuber-Unkel)

Biokompatible Nanomaterialien, 2 hrs Seminar/Week,
C. Selhuber-Unkel

Summer 2011

Grundlagen der Optik und Lichtmikroskopie, 2 hrs Lecture/Week,
C. Selhuber-Unkel

Biokompatible Nanomaterialien, 2 hrs Seminar/Week,
C. Selhuber-Unkel

Winter 2011/2012

Advanced Materials A: Polymers, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
C. Selhuber-Unkel (+ C. Selhuber-Unkel)

Cell Mechanics, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
C. Selhuber-Unkel (+ 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, *Funktion durch Schalten: SFB 677/1-2007 Pauschale Mittel für Selhuber-Unkel,* 01.06.2010-30.06.2011 (17.000 Euro)
DFG, *Schaltbare Zelladhäsion: SFB 677/B11*, 01.07.2011-30.06.2015 (237.600 Euro)
Deutsche Akademie der Naturforscher Leopoldina, *Reisekostenzuschuss,* 20.-24.02.2011 (3.200 Euro)

Further Cooperation, Consulting, and Technology Transfer

Prof. E. Quandt, Universität Kiel, Lehrstuhl für Anorganische Funktionsmaterialien, PDMS pillar structures from photolithography, SAW
Prof. R. Herges, Prof. Th. K. Lindhorst, Universität Kiel, Otto-Diels-Institut, Switchable cell adhesion (SFB „Function by switching“)
Prof. S. Gorb, Universität Kiel, Zoologisches Institut, common projects on investigating adhesion with AFM
Prof. M. Leippe, Universität Kiel, Zoologisches Institut, Characterizing biophysical properties of amoebae
Dr. C. Röhl, UKSH, Toxikologie, and Prof. J. Spatz, MPI for Metal Research, Stuttgart, Toxicity of silver nanoparticles
Prof. R. Metzler, TU München, Diffusion and aging in cells
Assoc. Prof. Lene Oddershede, Niels Bohr Institute, University of Copenhagen, Optical tweezers
Prof. M. Gerken, Universität Kiel, Lehrstuhl für Integrierte Systeme und Photonik, Cell adhesion on photonic crystals

Diploma, Bachelor and Master Theses

Emre Kizilkan, *Production and Characterization of Polyacrylamide Microbeads for Bead Deformation Assays,* 15.09.2011

Publications

Published in 2011

N. S. Rossen, A. J. Hansen, C. Selhuber-Unkel, L. B. Oddershede, *Arachidonic Acid Randomizes Endothelial Cell Migration and Regulates Adhesion and Migration,* PLoS ONE, **6(9)**, 25196 (2011)
J. Deeg, I. Louban, D. Aydin, C. Selhuber-Unkel, H. Kessler, J. Spatz, *Impact of local versus global ligand density on cellular adhesion,* Nano Letters, **11(4)**, 1469 - 1476 (2011)
J.-H. Jeon, V. Tejedor, S. Burov, E. Barkai, C. Selhuber-Unkel, K. Berg-Sørensen, L. Oddershede, R. Metzler, *In vivo anomalous diffusion and weak ergodicity breaking of lipid granules,* Physical Review Letters, **048103**, 106 (2011)
M. Benoit, C. Selhuber-Unkel, *Measuring cell adhesion forces: theory and principles,* Methods in molecular biology (Clifton, N. J.), **736**, 355 - 77 (2011)
A. Sandelin, H. R. Hansen, S. Baldursdottir, A. S. Kristensen, L. K. Bak, F. V. Christiansen, C. Selhuber-Unkel, *The Value of Example Solutions in Pharmacy Education: The role of seniority and gender,* Pharmacy Education, **11(1)**, 32 - 37 (2011)

Presentations

C. Selhuber-Unkel, *Quantifying cell-nanomaterial interactions with force microscopy (Invited),* Symposium Zelluläre Maschinen, Dresden, Germany, 04.01.2011
C. Selhuber-Unkel, *Quantifying cell adhesion forces with AFM,* Advanced Atomic Force Microscopy Techniques, KIT, Karlsruhe, Germany, 28.02.2011
C. Selhuber-Unkel, P. Yde, J.-H. Jeon, V. Tejedor, K. Berg-Sørensen, L. B. Oddershede, *Anomalous diffusion of intracellular lipid granules,* DPG-Frühjahrstagung, Dresden, Germany, 17.03.2011
C. Selhuber-Unkel, *Controlling cells with functional nanomaterials, (Invited),* Workshop, Kiel, Germany, 18.04.2011
C. Selhuber-Unkel, *Biologische Effekte im Nano-Reich,* Nanotage der Phänomenta Flensburg, Flensburg, Germany, 02.05.2011
C. Selhuber-Unkel, *Self-assembly of gold nanostructures for controlling cell adhesion (Invited),* Chinese-German Symposium, Berlin, Germany, 29.05.-01.06.2011
C. Selhuber-Unkel, J. Reverey, *Bio-inspired nanomaterials for controlling cell functions,* International Materials Research Congress, Cancun, Mexico, 14.-19.08.2011

C. Selhuber-Unkel, P. Yde, L. B. Oddershede, K. Berg-Sørensen, J.-H. Jeon, V. Tejedor, R. Metzler, *Investigating intracellular motion with nano-scopic techniques,* International Materials Research Congress, Cancun, Mexico, 14.-19.08.2011

J. Reverey, M. Leippe, C. Selhuber-Unkel, *Contact formation between Acanthamoebae and target alls,* International Summer School Cellular Systems 2011, Heidelberg, Germany, 24.-30.08.2011

C. Selhuber-Unkel, M. López-Garciá, H. Kessler, J. P. Spatz, *Advanced force microscopy techniques for investigating cell-nanostructure interactions,* Microscopy Conference MC 2011, Kiel, Germany, 28.08.-02.09.2011

C. Selhuber-Unkel, *Cell adhesion,* SFB 677, Integriertes Graduiertenkolleg, Schleswig, Germany, 04.10.2011

C. Selhuber-Unkel, *Investigating cellular contact reactions with force microscopy (Invited)*, Institutskolloquium des Instituts für Physiologie, University of Kiel, Kiel, Germany, 18.10.2011

C. Selhuber-Unkel, J. Reverey, J. Deeg, I. Louban, H. Kessler, J. Spatz, *Biofunctionalized gold nanostructures for controlling cell adhesion,* MRS Fall Meeting, Boston, USA, 28.11.-04.12.2011

Further Activities and Events

C. Selhuber-Unkel: Member of the jury (Chemistry) of the „Bundeswettbewerb Jugend forscht“ .

Computational Mechanics

Prof. Dr.-Ing. habil. Jörn Mosler, Head of Department, Simulation of Solids and Structures, Helmholtz-Zentrum Geesthacht.

Prof. Mosler became professor of the Faculty of Engineering in 2008. Information about his scientific work is available on the Website of Helmholtz-Zentrum Geesthacht: http://www.hzg.de/.

Functional Nanomaterials

The group ''Functional Nanomaterials'' carries out research in the field of nanoscience and nanotechnology. Typically the group is involved in both basic and applied research projects, often with interdisciplinary character, which is typical for research on the nanoscale. Due to the expansion of the group in 2010, the growth in terms of establishing additional research projects and equipment has been continued in 2011. In the framework of the collaborative research initiative SFB 855 ''Magnetoelectric Composites - Future Biomagnetic Interfaces'' funded by the ''Deutsche Forschungsgemeinschaft''(DFG), a special deposition chamber was designed and constructed. The ultra-high vacuum chamber is equipped with two sputter sources in such a manner that samples mounted perpendicularly on the holder can be coated with a spiral of two different materials rolled into each other. This geometry has the advantage that multilayer coatings can be formed in a continuous manner. For example, piezoelectric materials can be equipped with different magnetic materials formed like a Swiss roll. Further synthesis procedures have been set up, for example, a computer controlled tube furnace for the vapour-liquid-solid growth method, or a method similar to the already reported flame transport synthesis to produce metal oxide nanostructures. This ultra-rapid method allows the production of metal nanostructures in a few milliseconds. With the experimental setup on the laboratory scale complex nanostructures in the kilogram/minute scale can be formed. On the analytic side a combined optical, scanning Raman and atomic force microscope from the Witec company has been installed. The Raman spectrometer allows the detection of vibrational modes in the analyzed sample, e.g. molecular vibrations. The installed instrument can carry out Raman spectroscopy with high spatial resolution below a micrometre. As the instrument is additionally equipped with an atomic force microscope, it is possible to correlate the local chemistry determined by the vibrational modes with the structural aspects of a sample. Another instrument of great utility for nanoscopic analytics is the new Zeiss field emission scanning electron microscope. This instrument belongs to the Institute of Materials Science and was in half financed by the DFG based on a joint proposal by members of the institute, which received funding in 2011. This instrument was also partly funded by CAU Kiel and the Prof. Dr. Werner Petersen-Stiftung. In terms of projects, two further project proposals received funding in 2011. The first is in the framework of a further collaborative research initiative funded by the ''Deutsche Forschungsgemeinschaft'': the SFB 677 ''Function by switching''. In this joint proposal with Prof. Gorb from the biology department and Prof. Staubitz from chemistry the amazing ability of geckos and insects to walk on walls should be utilized to develop a switchable adhesive. In this biomimetic approach for the adhesive structure flexible nano ceramics should be utilized as a tool for tuning the mechanical properties of the structure. A novel inorganic / organic photoswitchable polymer should introduce functional switching properties to the structure, leading to the bio-inspired switchable dry adhesives. The BMBF (Federal ministry of Education and Research) project in cooperation with the company Nanoproofed has passed the midterm evaluation. So the funding of the BMBF continued and in 2011 trials have been started. The second is an EU-funded Interreg project called Technet Nano. This is a network including universities, research institutes and companies in the Baltic Sea region to exchange knowledge, to utilize clean rooms, and to attract and inform small and medium sized enterprises (SMEs) to carry out their high tech research using such clean rooms. The applied research projects of the group with SMEs in Schleswig Holstein was awarded a so called ''Transferprämie'', by the ISH technology foundation. This is an award of 5000 Euro third party funds given in cooperation with the ''The Ministry of Science, Economic Affairs and Transport'', for dedicated cooperation with companies in Schleswig-Holstein. With regard to teaching at the University, the interdisciplinary seminar together with Priv. Doz. Dr. Phil. Werner Theobald from the Centre for Ethics was continued in 2011. The experiment was successful in terms of visiting students. With an interested smaller group of participants some of the aspects from the summer semester seminar were published in the book „Menschenbilder'' from Lit (Berlin) publishers. Besides the invited talks given at other Universities (see list below), talks for a broader audience in the framework of the SHUG and the University were given. These include a talk at the „Night of the Profs'' and at the Kieler Woche. Furthermore the group was also involved in the preparation of workshops and an international conference, which was the SPIE nanotechnology conference in Prague, where the group leader was the conference chair. This conference series is held every 2 years and will be continued in 2013. </latex>

Results

Nano-Micro Integration of Semiconductor Nanowires on Si Chips:

The interesting electronic properties of nanowire- or rod-like structures from semiconductors or metals can only be utilized if they can be formed reproducibly as well as being mass producible. In order to reach these goals, the fabrication of semiconducting 1D nano- and mesostructures between microstructured contacts formed directly on a silicon chip, either by a thin film fracture, or by methods from the family of the vapour-liquid-solid (VLS) approaches, have been investigated. In principle, both methods can be integrated into wafer-level fabrication processes. The fracture approach was already reported earlier for the fabrication of metal nanowires. This template method starts with a microstructured photoresist film. This film is subjected to stress leading to thin film cracks that follow the orientation determined by the microstructure. The crack openings are on the nanoscale and connected with the microstructured parts on the chip surface. The whole setup can now act as a template to deposit materials, which form nanowires as well as contact areas connected by those nanowires. While metal wires have already been deposited and studied for several years, semiconducting nanowires have not yet been examined by this technique. Figure 1a-d shows an example for the functionality of such a semiconducting ZnO nanowire. The wire consists of a chain of clusters. This chain can be linked by additional heating. The post annealing step effects a crystal growth of the clusters bringing them in contact with each other. Thus a higher conductivity through the wire is achieved. This effect is shown schematically in figures 1a and b. Figure 1c shows the I-V measurement before and after annealing. After annealing a widely ohmic behaviour can be observed. ZnO is sensitive to many different gases and can be used as UV-detector due to its wide band gap. By tuning the distance between the clusters, a very fast switching of the nanowire sensor can be effected, (see figure 1d). Nanorod structures can be grown in various forms and width. Typical examples are vapour-liquid-solid structures. By utilizing the newly developed computer-controlled tube furnace setup, these can be grown under various atmospheric and gas conditions, leading to rods of different diameters and shapes. Besides the tube furnace setup, growth was also performed by flame transport synthesis as introduced last year. This patented approach allows also a direct coating of the Si microchip structures under moderate temperatures. Figure 1e shows a scanning electron micrograph with semiconducting nanorods grown directly on the circuit lines of the microchip. By interpenetration, these rod structures form conducting bridges with a high surface to volume ratio. In a microstructured chip, these can be used also as sensor elements. Figure 1f shows the response to UV-light as well. Interestingly, this setup is much less responsive than that in figures 1a-d. The reason is that the rod like structures are of higher crystalline quality, which leads to a slower response with a smaller signal. It has been shown that the higher the polycrystallinity, the larger the effect.

The flame transport approach was utilized in various ways for the production of ZnO crystals. In a collaboration, within the framework of the SFB 855, with Dr. Murphy from the physics group of Prof. Magnussen it has been shown by using the microfocus beamline at the synchrotron in Hamburg that millimetre sized crystals grown in this manner are of high crystal quality, which is important for the piezoelectric properties of the crystal. Furthermore, three dimensional ZnO networks were used as templates, in collaboration with the group of Prof. Schulte at the TUHH, to form novel carbon nanostructures. This carbon nanostructure material has fascinating properties: it is mechanically robust, conductive, and with 0.2 mg/cm^3 is the most lightweight material known so far.

Nanostructure assisted composite materials

Another main motivation for the further exploration of the applications of ZnO nano- and microstructured crystals is the above mentioned SFB 677 project. In this collaboration with the group of Prof. Staubitz from chemistry and Prof. Gorb from Biology ZnO tetrapods were used as powerful facilitators for adhesion of classically non-adhesive polymers like Teflon and Silicone. A strong adhesion between polymers is a very important challenge in materials engineering. In a layered composite, individual polymers might provide a certain desired functionality which should be used in combination. For the above mentioned SFB project to provide materials with switchable adhesion, a light switchable polymer, which is typically not very robust, and a robust but non switchable polymer should be combined. By simply using ZnO tetrapods for

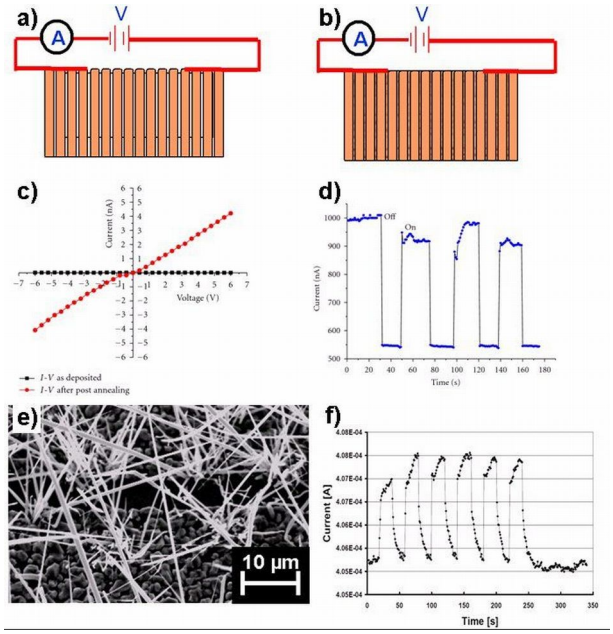


Fig. 1: Contacted nanowires and -rods and their functionality: a) schematic of a sputtered nanowire consisting of a chain of clusters with low conductivity, b) schematic of the same wire as in a) after an annealing process: the clusters have grown together leading to higher conductivity, c) IV-curve of a sputtered nanowire before and after annealing, d) UV-response of a sputtered nanowire after annealing, e) SEM-image directly grown on a microchip bridging the gap between the circuit lines and f) UV response of these bridging nanorods

mechanical interlocking, sufficient adhesion could be realized. With the special peel test machines in the Gorb group, the adhesion force of the polymer film was stronger than the force that is necessary for cohesive failure, meaning that the film is destroyed before it becomes delaminated. Figure 2 shows the concept of the interlocking adhesion: tetrapod crystals are mixed in the interface between both polymers to link them together. Even though there is only weak adhesion between the polymer and the tetrapod surface, the shape of the tetrapods forces much material movement of the polymer if it should be pulled out. In this case adhesive strength is gained from cohesive strength. Consequently, even mechanical failure in the ZnO can be observed including broken tetrapods.

Biomedical projects

With the concentration on biomedical research within the nano science focus of the university more activities in the functional nanomaterials group are shifted towards this issue.

For some years, research in the group has been on various shapes of micro and nanostructures on the basis of ZnO. In joint experiments with colleagues from the Institute of Toxicology, University of Kiel, the University of Illinois in Chicago, the Western University of Health Sciences, Pomona, and the Midwestern University, Downers Grove, it turned out that ZnO in the form of filopodia-like micro-nanoparticles possess a high virostatic potential against the herpes virus HSV-1. The micro nanoparticles (see figure 3a) were formed in a way that they have a large surface area and possess a microscopic core typically equipped with nanoscopic spikes. ZnO nanostructures are known for their polar facets and can be equipped with a variety of oxygen vacancies on the surface. These vacancies are created during growth and can be affected afterwards by UV-illumination at ambient atmosphere. In vitro tests showed now that the HSV-1 virus is bound to the surface of the ZnO, even though cells are present as well, meaning that this is an effective way to block entry to the cell. Furthermore, even if cells were already attacked by the virus, the viruses become caught during their next replication cycle by the ZnO surface and are thus hindered in spreading further. To utilize this novel mechanism in terms of a therapy an important point is the cell toxicity. Examinations by Claudia Röhl from the toxicology department in Kiel showed that the effective dose of ZnO

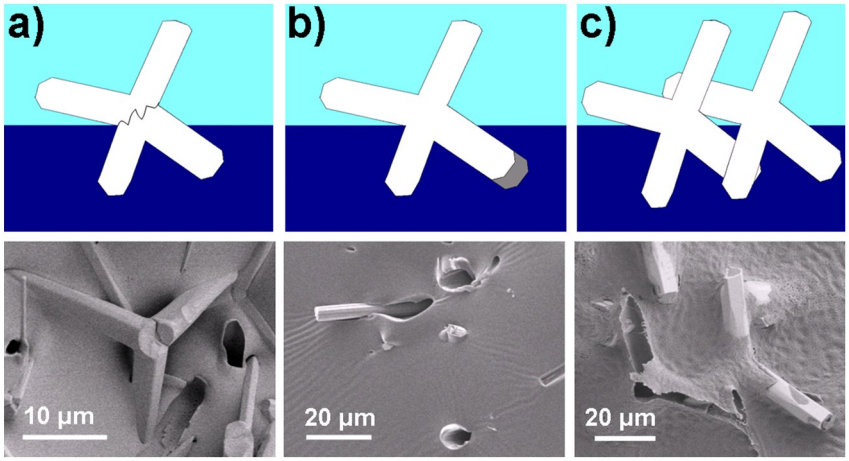


Fig. 2: Concept of the interlocking adhesion between two polymers and their failure modes: light blue and marine blue layers are interlocked by tetrapods. Illustration of the failure modes is combined with scanning electron micrographs of the peeled polymer surface: a) cohesive failure of a tetrapod b) pull out c) entanglement

particles does not show any cytotoxic effects. These experiments indicate another interesting effect: ZnO becomes more cell compatible and toxic levels are shifted to higher concentrations if illuminated before with UV-light. At the same time, the virostatic potential is increased significantly, which indicates that the oxygen vacancies act as binding sites for the virus. This virus contains glycoprotein groups with polar ends which could interact with the negatively charged oxygen vacancies. Usually the glycoprotein groups trigger the cell entry; here they are the anchors that trap the particle on the ZnO surface. Figure 3b illustrates this behaviour.

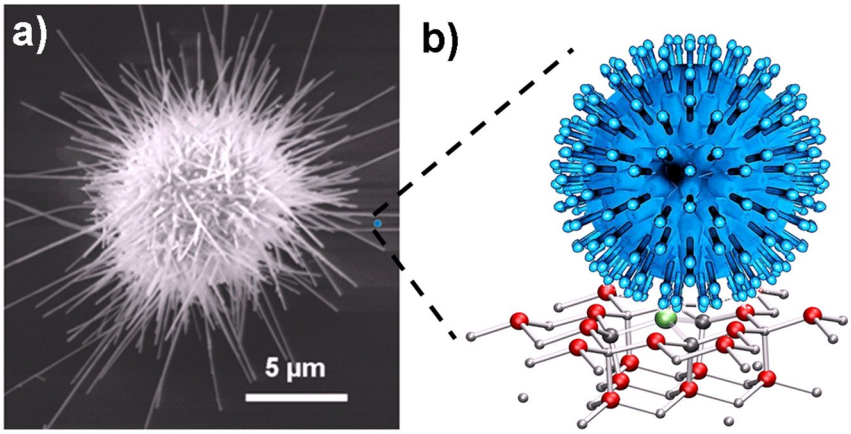


Fig. 3: Illustration of the virostatic behaviour of ZnO. a) Scanning electron micrograph of a core spike particle b) sketch of the binding of a glycoprotein group to an oxygen vacancy on the nanospike surface. Please note that the image is out of scale, a HSV-1 viron is around 150nm in diameter.

Further experiments focus on collaborations with the dental clinic. One challenge was the development of a dental implant model for in vivo tests. A dental implant could be designed on the basis of a modified root canal drill. A series of implantations was successfully carried out in the dental clinic in the group of Prof. Wildfang with the implants prepared at the TF. Multilayered material combinations were also developed in the framework of a second project dealing with dental implants. With Prof. Dr. Größner-Schreiber, ceramic coatings deposited on etched medical grade titanium are developed with the goal to reduce bacterial and increase focal adhesion. In a special sputter deposition setup, ultra-thin ceramic films with different surface morphologies were formed. Subsequent cell adhesion tests are planned to be carried out in 2012 in

cooperation with the cell adhesion expert group of Prof. Selhuber-Unkel.

Personnel

Head of the group: Prof. Dr. R. Adelung; Secretary: Dipl.-Geol. B. Minten (50%)
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.-31.12.2011	DFG, CAU
M.Sc. X. Jin Piezo composites	01.01.-31.12.2011	SFB 855, SFB 677, CAU
Dipl.-Ing. S. Kaps Piezomaterials	01.01.-31.12.2011	SFB 855, CAU
M.Sc. Harminder Kaur Biocompatibility of ZnO	01.01.-31.03.2011	Grant CAU
Dr. Y.K. Mishra Nanowires and nanostructures	01.01.-31.12.2011	CAU, AvH Grand
M.Sc. I. Paulowicz Synthesis and characterization of nanostructures	01.10.-31.12.2011	CAU
M.Sc. A. Schuchardt Aeromaterials and electrical properties	01.10.-31.12.2011	CAU
Dr. S. Wille Anti-fouling	01.01.-31.12.2011	BMBF
M.Sc. C. Wolpert Pharmaceutical materials	01.10.-31.12.2011	Grant CAU
M.Sc. E.S.E.S.A. Zarie Drug evaporation	01.01.-31.12.2011	Grant Government Egypt, CAU

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

Biomaterials, 2 hrs Lecture/Week,
R. Adelung

mawi-102: Mathematik für Materialwissenschaftler I, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
R. Adelung (+ S. Wille, B. Gojdka)

Solid State Physics I, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Y.K. Mishra (+ A. Schuchardt)

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)

Summer 2011

Mathematik für Materialwissenschaftler II, 4 (+2) hrs Lecture (+ Exercises)/Week,
R. Adelung (+ S. Harms, T. Strunskus)

Solid State Physics II, 2 (+1) hrs Lecture (+ Exercises)/Week,
Y.K. Mishra (+ A. Schuchardt)

Voraussetzungen und Auswirkungen Nanotechnologie, 2 hrs Lecture/Week,
R. Adelung

Voraussetzungen und Auswirkungen Nanotechnologie, 1 hrs Seminar/Week,
R. Adelung

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

Third-Party Funds

DFG, *Einfluss der Verhinderung der Kollagen-Degradation durch MMPs auf den Dentin-Klebeverbund,* 04.10.2007-31.01.2011 (25544 EUR)

DFG (SFB 677/1-2007 PM02), *Funktion durch Schalten: Anschubfinanzierung für Projekt,* 01.01.2009-30.06.2011 (14080 Euro)

AvH, *Hildegard Maier Forschungsstipendium Mishra,* 01.02.2009-31.01.2011 (73200 EUR)

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)

ISH, *Förderprogramm Transferprämie: Nanostrukturierte Oberflächen in der Medizintechnik,* 01.07.-31.12.2011 (5000 EURO)

DFG (SFB 677/2 2011 C10), *Funktion durch Schalten: Photoaschaltbare Adhäsive,* 01.07.2012-30.06.2015 (474240 EURO)

Wöhlk-contact-linsen GmbH, *Untersuchungen von zwei Kontaktlinsen mittels AFM,* 24.11.2011 (191 EURO)

nanoproofed GbR, *Prüfbericht zur Funktionsprüfung und Robustheit für das Produkt nanoproofed®protection Solar Photokat,* 24.11.2011 (169 EURO)

EU (Interreg-Projekt), *Technet Nano,* 29.12.2011-28.03.2014 (112925 EURO)

Further Cooperation, Consulting, and Technology Transfer

University:

Dr. D. K. Avasthi, Materials Science Group, Nuclear Science 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 - Synthesis 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. U. Kunzendorf, Universitätsklinikum Schleswig-Holstein, CAU Kiel, Nanostructured materials for dialysis

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, Pamona 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

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, Gleschendorf, BMBF-Projekt Anti-fouling, Photocatalytic substances

Wöhlk, Schönkirchen, Examination of contact lenses

Diploma, Bachelor and Master Theses

R.E. Benavides Noriega, *Characterization of zinc oxide (ZnO) nanostructures for a development of a gas sensor for N_2, CH_4, O_2 and CO_2*, 22.02.2011

A. Beckstedt, *Determination of material constants using laser ultrasound*, 05.04.2011

F. Schütt, *Herstellung von ein- und mehrkomponentigen, oxidischen Nanopartikeln nach dem Emulsionspolymerisationsverfahren*, 02.09.2011

A.W. Fischer, *Characterization of aerographite*, 28.09.2011

C. Wolpert, *Nano and micro structured vacuum deposited thin films of active and non-active pharmaceutical layers*, 30.09.2011

J. Gröttrup, *Herstellung und Vergleich von ZnO-Nanostrukturen unter Anwendung des VLS-Mechanismus und der Flammentransportsynthese*, 04.10.2011

A. Omelcenko, *Characterisation of aerographite and its suitability as electrode material for double layer capacitors*, 14.10.2011

A. Engel, *Synthese und Adhäsion von ZnO Nanostrukturen unter Anwendung des Pulver-Flammspritzverfahren*, 19.12.2011

N.O. Urs, *Direct synthesis and characterization of 1-Dimensional iron oxide nanostructures for microchip integration*, 20.12.2011

Publications

Published in 2011

Y.K. Mishra, R. Adelung, C. Röhl, D. Shukla, F. Spors, V. Tiwari, *Virostatic potential of micro-nano filopodia-like ZnO structures against herpes simplex virus-1*, Antiviral Research, **92**, 305 - 312 (2011)

S. Wille, Y.K. Mishra, D. Gedamu, S. Kaps, X. Jin, T. Koschine, A. Bhatnagar, R. Adelung, *ZnO core spike particles and nano-networks and their wide range of applications*, Proc. SPIE doi:10.1117/12.886963, **8068 806816**, (2011)

B. Gojdka, R. Jahns, K. Meurisch, H. Greve, R. Adelung, E. Quandt, R. Knöchel, F. Faupel, *Fully integrable magnetic field sensor based on delta-E effect*, Appl. Phys. Lett., **99**, 223502 (2011)

S. Wille, Y.K. Mishra, D. Gedamu, I. Paulowicz, X. Jin, R. Adelung, *Zinc oxide micro- and nanostructures as multifunctional materials*, SPIE Newsroom, **doi: 10.1117/2.1201111.003944**, (2011)

M. Tiwary, N.K. Singh, S. Annapoorni, D.C. Agarwal, D.K. Avasthi, Y.K. Mishra, P. Mazzoldi, G. Mattei, C. Sada, E. Trave, G. Battaglin, *Enhancement of photoluminescence in Er-doped Ag-SiO(2) nanocomposite thin films: A post annealing study*, Vacuum Volume, DOI: 10.1016/j.vacuum.2010.12.002, **85**, **8**, 806 - 809 (2011)

A. Kaur, A. Dhillon, G.B.V.S. Lakshmi, Y.K. Mishra, D.K. Avasthi, *Modifications induced in poly (3-hexylthiophene) due to swift heavy ion beam of 100 MeV silver (Ag(8+))*, Materials Chemistry and Physics, DOI: 10.1016/j.matchemphys.2011.10.001, **131**, **1-2**, 436 - 442 (2011)

Patent Applications

R. Adelung, M. Claus, S. Kaps, Y.K. Mishra, C. Wolpert, T. Preuße, *Elast. Material mit einem auf Partikelebene durch Nanobrücken zw. Partikeln überbrücktem Porenraum*, PCT-Nachanmeldung, Europäisches Patentamt, 18.03.2011, PCT/DE 2011/000282

Presentations

D. Gedamu, T. Behrendt, H. Kohlstedt, O. Vavra, A. Petraru, R. Adelung, *Electrical properties of an Al-NWFET fabricated under different gate oxide layers (talk)*, DPG-Frühjahrstagung, Dresden, 13.-18.03.2011

X. Jin, X. Zhu, S. Wille, Y.K. Mishra, R. Adelung, *Fabrication, characterization of multifunctional tetrapod-ZnO/Polymer composites for biospired applications (talk)*, DPG-Frühjahrstagung, Dresden, 13.-18.03.2011

S. Kaps, A. Schuchardt, Y.K. Mishra, R. Adelung, *Synthesis and characterization of micro scaled free standing c-oriented piezoelectrid ZnO needles (talk)*, DPG-Frühjahrstagung, Dresden, 13.-18.03.2011

Y.K. Mishra, S. Kaps, X. Jin, D. Gedamu, I. Paulowicz, S. Wille, R. Adelung, *Synthesis of functional nano-micro structural materials by a simple transport approach (talk)*, DPG-Frühjahrstagung, Dresden, 13.-18.03.2011

I. Paulowicz, Y.K. Mishra, A. Schuchardt, V. Hrkac, L. Kienle, R. Adelung, *Synthesis and characterization of tin oxide nanowires and nanobelts (talk)*, DPG-Frühjahrstagung, Dresden, 13.-18.03.2011

A. Schuchardt, S. Kaps, Y.K. Mishra, I. Paulowicz, R. Adelung, *Electrical properties of 1D to 3D ZnO nanostructures synthesized by flame transport synthesis approach (talk)*, DPG-Frühjahrstagung, Dresden, 13.-18.03.2011

S. Wille, T. Koschine, S. Chluba, S. Freitag, Y.K. Mishra, R. Adelung, *Synthesis of ZnO core spike particles as composite fillers with a high throughput method (poster)*, DPG-Frühjahrstagung, Dresden, 13.-18.03.2011

R. Adelung, *Fabrication and characterization of self-healing and self-reporting intepenetrating phase composites (invited talk)*, Kolloquium zum SPP 1568 Univertität Jena, Jena, 21.-21.03.2011

R. Adelung, *Nanotechnology (Chairman)*, SPIE Microtechnologies, Prag, Czech Republic, 17.-20.04.2011

S. Wille, Y.K. Mishra, S. Kaps, X. Jin, R. Adelung, *ZnO core spike particles and nano-networks and their wide range of applications (talk)*, SPIE Microtechnologies, Prag, Czech Republic, 17.-20.04.2011

R. Adelung, *Nanotechnologie: Gestern, Heute, Morgen (invited talk)*, Kieler uni live 2011, Kiel, 21.06.2011

R. Adelung, *Two simple examples for the micro-nano integration of nanowires as electronic device elements (invited talk)*, ICNBME-2011, Chisinau, Moldavia, 07.-09.07.2011

R. Adelung, *Functional Nanomaterials (invited talk)*, Universistät Ulm, Ulm, 27.-28.07.2011

R. Adelung, *Grundlagen, Stand der Technik und Perspektiven für Anwendungen mit nanobasierten Beschichtungen (invited talk)*, Netzwerktreffen für gem. ZIM-NEMO-Projekt NanoMarin - Innovative Produkte und Verfahren durch Nanobeschichtung im marinen Bereich, Wismar, 26.09.2011

R. Adelung, *Nanotechnologie in Lebensmitteln (talk)*, Seminar zu aktuellen Themen (Modul 375), Agrar- und Ernährungswiss. Fakultät , CAU Kiel, Kiel, 07.11.2011

R. Adelung, *Photokatalyse zur Schadstoffzersetzung - eine Option für Schiffsemissionen (talk)*, Kieler Marktplatz, Kiel, 15.11.2011

R. Adelung, *Zukunftsmedizin: Virenfrei durch Nano-Halbleiter im Menschen? (talk)*, Night of the Profs, CAU Kiel, Kiel, 18.11.2011

Y.K. Mishra, S. Kaps, R. Adelung, *High aspect ratio free standing ZnO-Magnetostrictive mesoscale cylindrical magnetoelectric core shell composites (talk)*, MRS Tagung 2011, Boston, USA, 28.11.-02.12.2011

M. Abes, C.T. Koops, S. Hrkac, O.M. Magnussen, B.M Murphy, E. Woltermann, H. Greve, E. Quandt, S. Kaps, R. Adelung, *Strain profile of complex magnetoelectric composite systems by x-ray diffraction methods (talk)*, MRS Tagung

2011, Boston, USA, 28.11.-02.12.2011

Y.K. Mishra, *Putting the basic building blocks together? Flame transport synthesis (invited talk)*, University of Illinois, Dep. of Microbiology and Immunology, Chicago, USA, 03.-06.12.2011

The end is nigh (retirement of Prof. Föll in 2014) and research activities have been wound down accordingly as Prof. Adelung, the successor of Prof. Föll, is phased in.

The projects ''Thermoelectricity'' and ''Si Solar cell technology'' have been successfully finished; however, the solar cell project might be continued (a proposal, together with the ISFH Hameln has been submitted). A third year for the DFG funded CELLO project has been granted; work on this project started early in 2012. As a new project, ''Mold Nanonet'', an EU funded partnership with the Technical University of Moldova was granted late in 2011.

The Si nanowire anode for high capacity Li ion batteries project (in collaboration with two FhG institutes) was running well, as were the solar cell projects (SolarWinS), the work for the SFB 855, and the (small) activities with SHALUM (''SHAded LUMinescence''). In cooperation with Prof. Wagner (ISIT), a master's thesis concerning the use of the large-area etching equipment developed by AMAT for large area galvanics has been successfully concluded.

Small exploratory projects with three companies (IMEC, Inficon, Centrosolar) have been successfully started; the work will continue into 2012, as does the running cooperation with Bosch.

Results

New projects started in 2011:

First exploratory work, for producing a porous substrate with a certain airflow resistance and a closed thin layer of some proprietary detector material on top of the substrate, was started in cooperation with Inficon. The specifications of Inficon could be met; the work will continue.

Centrosolar supplied some solar test modules that suffered from a degradation phenomenon known as ''Potential induced degradation'' (PID). CELLO proved to be a powerful tool to study PID; the results have already helped to develop a model for the chain of events that need to occur for the slow (and reversible) production of local short circuits. The work will continue.

IMEC, a large R&D organisation in Belgium, started tests of our large area electrochemical processing cell for solar cell research.

Galvanic deposition of thin metal layers on 200 mm Si wafers has been used for some time in microelectronics and MEMS. The costs of running experiments for R&D in 200 mm production equipment, however, are prohibitive in the case of noble metal deposition, since large amounts of electrolyte are needed. In preliminary exploratory experiments, our large-area processing cell proved to be principally suited for galvanics. The possibilities are presently explored by the ISIT (Prof. Wagner) in cooperation with AMAT.

The ''pore profile engineering'' used for making anodes for Li ion batteries can also be used for producing large quantities of ''silicon micro needles'', i.e. Si rods with diameters in the sub-μm range and defined length from a few to several μm. These micro needles are of interest for bio- and medical applications and cooperation with Prof. Selhuber-Unkel will start early in 2012.

Cooperation projects running in 2011:

Work for the on-going BMBF ''SolarWinS'' project (successor of the ''SolarFocus'' project) continued smoothly and will carry forward into 2012. The cooperation with Bosch intensifies. Besides the PhD work done in Stuttgart with a CELLO unit in-situ, an extensive study of so-called a-Si/c-Si tandem solar cells was done in Kiel. The results are likely to be published in 2012.

In this context, the CELLO technique was further improved on the base of a DFG project. A third year for this project was granted in Dec. 2011.

Work on the Si nanowire anode for Li ion batteries, in cooperation with the Fraunhofer Institutes for Chemical Technology (ICT) and Material and Beam Technology (IWS) and as part of the Alka-SuSi project (BMBF), has started and is running on schedule. However, minor but time consuming problems with clean room equipment hampers progress. It is hoped that the establishment of the planned but delayed ''competence centre'' staff will alleviate these problems.

The BMU funded project ''Macroporous Si for ultra-thin single-crystalline wafer based photovoltaics'' (MacPSI; together with the ''Institute for Solar Energy Research GmbH'', Hameln/Emmerthal (ISFH)) was finished on time and with good results. A proposal for a continuation has been submitted.

The BMBF project ''Porous Si as a thermoelectric material'' (PoSiTeM; together with the MPI ''Microstructure Physics'' in Halle) was finished. While AMAT could meet its milestones and deadlines, the project did not fully reach its intended goal since the ''figure of merit'' of the thermoelectric devices produced was about one order of magnitude too small. This was unavoidable, however, since it transpired that the thermal conductivity of Si nanowires is in fact one order of magnitude larger than the values published in ''Science'' that served as the basis of the project.

The experimental work concerning the SFB 855 (magneto-electric compound materials) has focused on the optimized production of macroporous InP membranes using only (photo-) electrochemical and purely chemical processing steps. Up to 9 membranes per week can now be produced with well-defined geometries. This is important because the optimization of the deposition parameters for galvanic filling of the pores with Ni and other magnetostrictive metal (alloys) needs many samples.

The galvanic filling of porous alumina oxide membranes with Ni has been investigated in parallel to the processing of InP membranes, since the surface of the pores in InP might eventually be covered with a thin layer of Al_2O_3 by atomic layer deposition (ALD). 100 % filling of commercially available porous alumina oxide wafers with Ni has been achieved. The deposition parameters are expected to be transferable to the filling of the porous InP membranes with and/or without ALD coating of the InP pore walls with alumina. This is the last step that needs to be implemented before sensors can be produced.

Internal project An internal project was focused on SHALUM (''SHAded LUMinescence'') and involved FFT studies of pore etching on p-type substrates, as far as research is concerned, and on the preparation of a new large Hyperscript intended for the general public. On the surface, the Hyperscript deals with ''Iron, Steel and Swords'' but sneaks in the essentials of Materials Science at a quite fundamental level.

Research Details

The full production process of anodes for lithium ion batteries based on Si microwire arrays has been developed in the last two years. 2011 has been a crucial year for the improvement of the capacity and reliability of the anodes produced. The improvement is mainly due to the optimization of the geometry and the dimensions of the wires. The latest wires have 1 μm in diameter, and are 70 μm long (Fig. 1a). The walls of the wires are flat, and their diameter is constant in depth (no oscillations are present), making the wires very stable. The stability is reinforced with two *in-situ* prepared stabilizing layers. With these properties, it is possible to embed the top of the wires in an electro-chemically deposited Cu layer (see Fig. 1b), which allows electrical contact to the anodes.

The production process is reproducible, and has the potential to be scaled to large areas (e.g. 6 inch wafers). The anodes produced perform well when employed in half-battery cells, exhibiting a capacity of around 2350 mAh/gr, more than 6 times larger than the standard graphite anodes. The capacity remains constant even after 60 charge-discharge cycles.

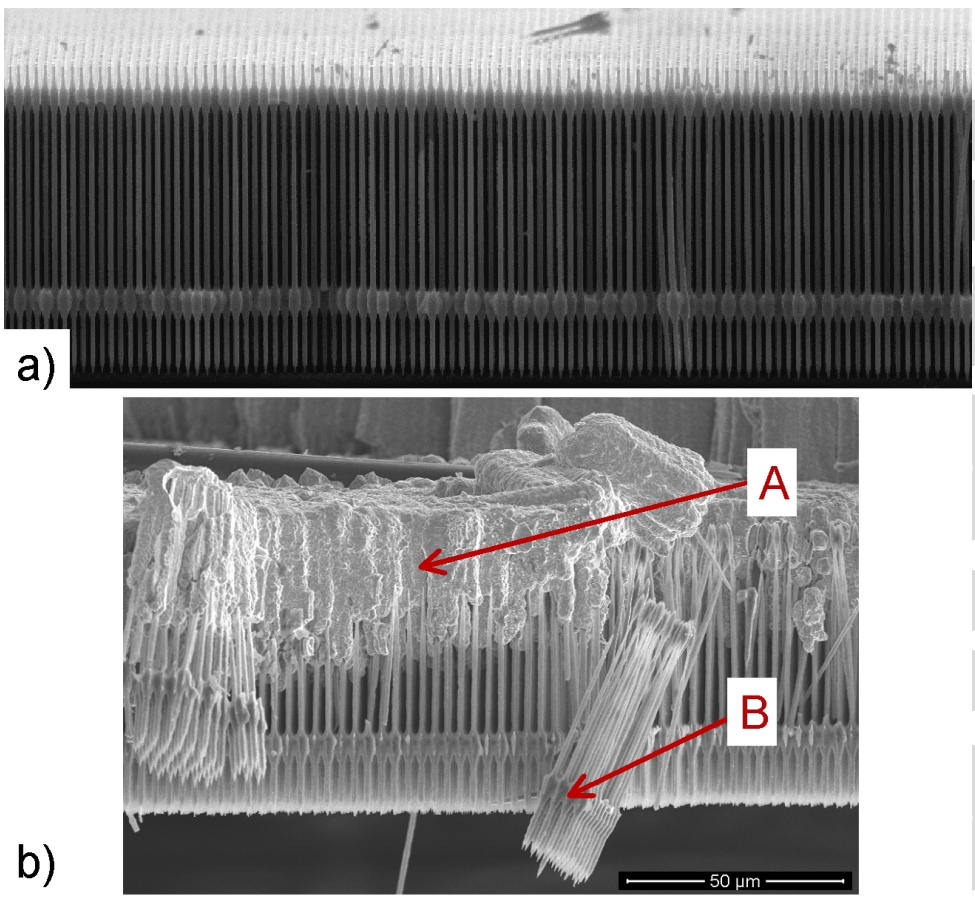


Fig. 1: a) View of the Si wire array, with wires of 1 μm diameter; as can be observed, the array is homogeneous over large areas (over the full anode area, e.g. 1 cm^2). b) View of the wire arrays contacted with an electrochemically deposited Cu layer. Two important characteristics are indicated by A and B: A: The Si wires are embedded in Cu, making a mechanically stable contact, B: The stabilizing layer of the array makes it very stable, even if the anodes are intentionally broken.

Work within the SFB 855 continues successfully but is still hampered by the lack of the atomic layer deposition tool (ALD). This is to change in early 2012; ALD equipment could finally be ordered after a long delay. Results are shown and explained in the next figure (Fig. 2).

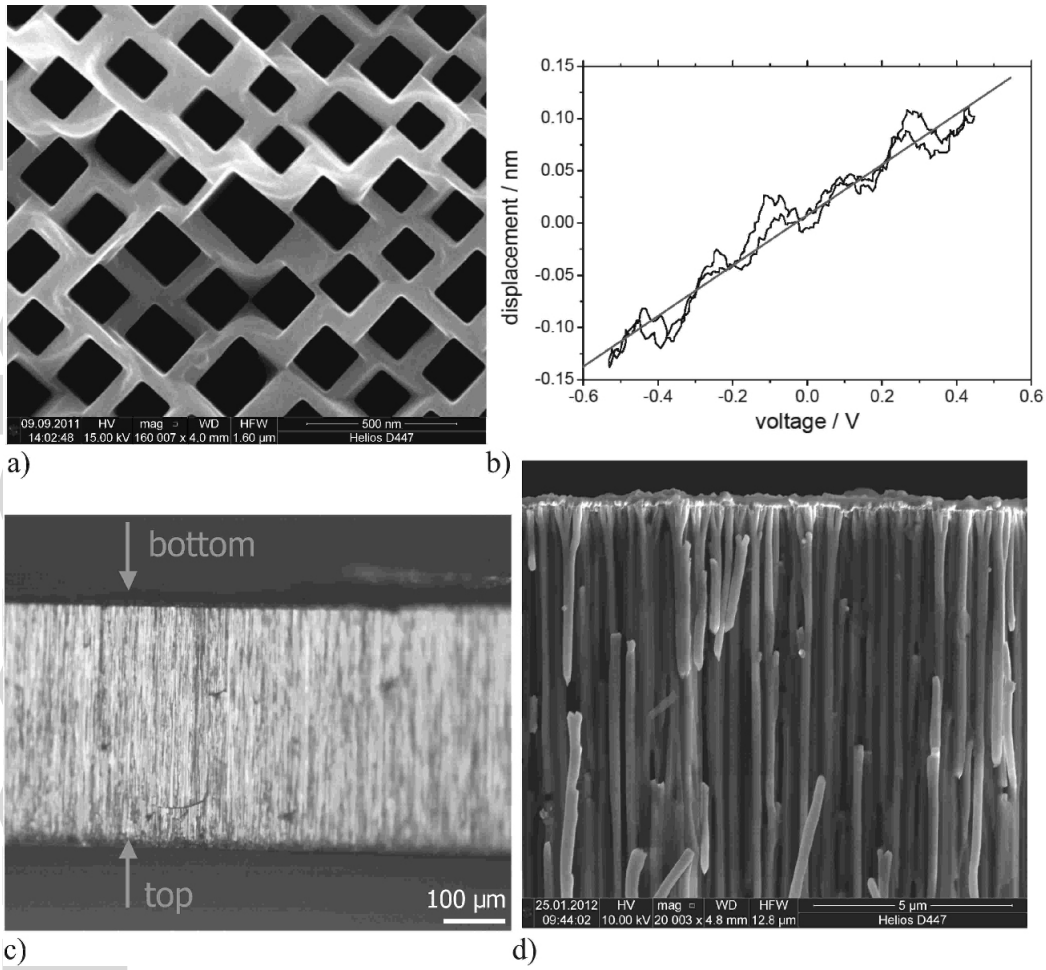


Fig. 2: a) InP pore structure after anodic pore formation in HCl plus subsequent purely chemical post-etching of the InP membrane in organic/anorganic electrolyte under cathodic bias (∼-1V). b) Piezoelectric response on application of electric field for InP pore structure after purely chemical post-etching (measured with double beam laser interferometer), 30 times larger than that of bulk InP, c) InP membrane structure using a combination of electro- and (photo)chemical etching to fabricate a porous membrane structure with a thickness of ∼470 μm on an area of 0.25 cm^2, d) electro-chemical pore filling with Ni of anodically etched Al_2O_3 membranes as a step for galvanic membrane filling in InP membranes lined with Al_2O_3.

Personnel

Head of the group: Prof. Dr. Helmut Föll; Secretary: Katrin Brandenburg (50%)
Technical Staff: Dipl.-Ing. (FH) Jörg Bahr

Staff:

Christine Ripka Edle von Röthlin	01.-30.09.2011	Third party funds

Scientific Staff:

Dr. Jürgen Carstensen	01.01.-31.12.2011	CAU
Theory, software development, supervision of teaching		
Dr. Ala Cojocaru	01.01.-30.06.2011	BMBF
Porous Si and SiGe for thermoelectrics		
M.Sc. Mark-D. Gerngroß	01.01.-31.12.2011	DFG
SFB 855 Magnetoelectric Composites - Future Biomagnetic Interfaces		
Dipl.-Ing. Malte Leisner	01.01.-16.05.2011	CAU
Modelling pore growth in semiconductors		
Dr. Yogendra Mishra	01.07.-31.12.2011	CAU
M.Sc. Emmanuel Ossei-Wusu	01.01.-31.12.2011	BMBF
Macroporous Si for solar cell uses; optimization of pore etching		
Dr. Enrique Quiroga-González	01.01.-31.12.2011	BMBF ab 01.06.2011
Si nanowire anode for Li ion battery		
Dr. Jan-Martin Wagner	01.01.-31.12.2011	CAU, DFG 01.03 - 30.04.11
Theory and development for multi-color CELLO (incl. impedance and non-linear behaviour) and for shaded luminescence techniques		

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

Quantenmechanische Aspekte in der Materialwissenschaft, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Jürgen Carstensen

Aktuelle Fragen der Forschung, 2 hrs Seminar/Week,
Helmut Föll

Materialwissenschaft I, 3 (+ 1) hrs Lecture (+ Exercises)/Week,
Helmut Föll (+ Malte Leisner)

Laboratory Course: Scientific Methods, 4 hrs Lab/Week,
Anselm Pape (+ Enrique Quiroga González, Ala Cojocaru, Andriy Lotnyk, Christiane Zamponi, Vladimir Zaporojtchenko, Dawit Gedamu, Thomas von Hofe)

Advanced Mathematics - Computational Mathematics, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
Jürgen Carstensen (+ Jan-Martin Wagner)

Basic Laboratory Course for Master Students, 4 hrs Lab/Week,
Emmanuel Ossei-Wusu (+ Mohammed Qasim Shaik, Amit Kulkarni, Sören Kaps, Marlies Schwitzke, Christina Pakula)

Halbleitertechnik und Nanoelektronik, 4 (+1) hrs Lecture (+ Exercises)/Week,
Helmut Föll (+ Rainer Adelung)

Praktikum: Analytische Methoden, 4 hrs Lab/Week,
Malte Leisner (+ Dirk Meyners, Mady Elbahri, Marlies Schwitzke, Klaus Rätzke, Dietrich Häußler)

Grundlagen der Materialwissenschaft, 3 (+2) hrs Lecture (+ Exercises)/Week,
Helmut Föll (+ Anselm Pape)

Advanced Mathematics - Mathematics for Material Science, 2 (+1) hrs Lecture (+ Exercises)/Week,
Jürgen Carstensen

Summer 2011

Materialwissenschaft II, 3 (+1) hrs Lecture (+ Exercises)/Week,
Helmut Föll (+ Jan-Martin Wagner)

Statistical Mechanics, 2 (+1) hrs Lecture (+ Exercises)/Week,
Jürgen Carstensen

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 (+ Enrique Quiroga-González)

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 (+2) hrs Lecture (+ Exercises)/Week,
Jürgen Carstensen (+ Jan-Martin Wagner)

Basic Laboratory Course for Master Students, 4 hrs Lab/Week,
Emmanuel Ossei-Wusu (+ Mohammed Qasim Shaik, Amit Kulkarni, Sören Kaps, Marlies Schwitzke, Christina Pakula)

Halbleitertechnik und Nanoelektronik, 4 (+1) hrs Lecture (+ Exercises)/Week,
Helmut Föll (+ Rainer Adelung)

Praktikum: Analytische Methoden, 4 hrs Lab/Week,
Emmanuel Ossei-Wusu (+ Dirk Meyners, Mady Elbahri, Enrique Quiroga-González)

Grundlagen der Materialwissenschaft, 3 (+2) hrs Lecture (+ Exercises)/Week,
Helmut Föll (+ Jan-Martin Wager, Mark-Danie 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,
Helmut Föll (+ Yogendra Mishra)

Third-Party Funds

DFG, *Schnelle quantitative und ortsaufgelöste Komplettcharakterisierung von Solarzellen durch Kombination von ''CELLO'' und FFT Impedanzspektroskopie*, 01.06.2008-30.04.2011 (172.000 EUR)

DFG, *Programmpauschale zu Schnelle quantitative und ortsaufgelöste Komplettcharakterisierung von Solarzellen durch Kombination von ''CELLO'' und FFT Impedanzspektroskopie*, 01.06.2008-30.04.2011 (34.400 EUR)

BMBF, *Poröses Silizium als Thermoelektrisches Material (PoSiTeM)*, 01.07.2009-30.06.2011 (165.139 EUR)

BMBF, *Projektpauschale zu: Poröses Silizium als Thermoelektrisches Material (PoSiTeM)*, 01.01.-30.06.2011 (4.376 EUR)

Alexander von Humboldt-Stiftung, *Institutspartnerschaft mit der TU Moldova*, 01.07.2010-31.12.2012 (55.000 EUR)

BMBF F+E-Vertrag mit Institut für Solarenergieforschung (ISFH) GmbH, *Macroporöses Silicium für ultradünne monokristalline Waferphotovoltaik (MacPSI) TP: Optimierung des Ätzprozesses*, 01.03.2010-31.08.2011 (107.100 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)

Further Cooperation, Consulting, and Technology Transfer

Technical University of Moldova, Chisinau, Moldova: scientific cooperation with Prof. Dr. I.M. Tiginyanu.

Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany: scientific cooperation with Dr. Breitenstein within the framework of the SolarFocus project.

CSP, Halle, Germany: scientific cooperation for the understanding of mechanical stress analysis using CELLO.

CSG, Thalheim, Germany: investigation of CSG thin film solar cells.

Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany: scientific cooperation with Dr. Schmid on ''Porous Si for thermoelectric applications''.

ISFH, Hameln/Emmerthal, Germany: cooperation within the framework of the SolarFocus / SolarWinS project and application of electrochemical pore formation for solar cell production within the MacPSI-project.

Fraunhofer-Institut für Solare Energiesysteme, Freiburg, Gelsenkirchen, Germany: scientific cooperation with Dr. Warta and Prof. Dr. Schindler within the framework of the SolarFocus / SolarWinS project; CELLO-measurements in connection with the shared supervision of a Ph.D. student.

Fraunhofer-Institut für Siliziumtechnologie, Itzehoe, Germany: investigation of large area galvanic copper deposition in a shared supervision of a master's thesis.

Dispatch Energy Innovations GmbH, Itzehoe, Germany: scientific cooperation with respect to Li-Ion Batteries.

CaliSolar, Inc., Berlin / U. S. A.: cooperation concerning interpretation and discussion of CELLO measurements.

RWE Schott Solar GmbH, Alzenau, Germany, Deutsche Solar GmbH, Freiberg, Germany, Deutsche Cell GmbH, Freiberg, Germany, Shell-Solar GmbH, München, Germany, ERSOL, Erfurt, Germany, Sunways, Konstanz: cooperation within the framework of the SolarFocus / SolarWinS project for solar cell characterization and single measurements.

Bosch AG, Stuttgart, Germany: shared supervision of bachelor's- and master's-theses and PhD-work: cooperation concerning CELLO-characterization of solar cells.

Bosch Solar Industries, Erfurt, Germany: CELLO-characterization of industrially produced solar cells and advanced solar cell concepts.

CSP, Halle, Germany: CELLO characterization of CSG solar cells.

FhGs ICT and IWS, Germany: cooperation within the ''AlKaSuSi'' project.

Q-Cells SE, Bitterfeld-Wolfen, Germany: CELLO measurements.

INFICON GmbH, Köln, Germany: optimization of Si membrane structures for helium detection.

LG Electronics Inc., Neuss, Germany: discussion about Li-ion battery concepts.

Diploma, Bachelor and Master Theses

Amanuel M. Berhane, *A comparison of novel luminescence methods for solar cells to CELLO results*, 20.05.2011
Michael Timmermann, *Optimierung der amorphen Si Schichtstruktur für hocheffiziente HIT Zellen*, 31.08.2011
Patrick Hayes, *Untersuchungen zur Herstellung von evakuierten, flächigen Glasmikrostrukturen auf Waferebene*, 01.11.2011
Aynur Gerede, *Improvement and Electrochemical Characterization of the Exhaust Gas Sensors Electrodes*, 04.11.2011
Maedeh Amirmaleki, *Synthesis of Si-Microparticles by an Electrochemical-Chemical Method*, 30.11.2011

Dissertations / Postdoctoral Lecture Qualifications

Malte Leisner, *Untersuchung und Modellierung des elektrochemischen Porenwachstums in InP mit In-situ-FFT-Impedanzspektroskopie und Monte-Carlo-Simulation*, 24.06.2011

Publications

Published in 2011

J. Carstensen, A. Schütt, G. Popkirov, H. Föll, *CELLO meaurement technique for local identification and characterization of various types of solar cell defects*, Phys. Stat. Sol. (c), **8(4)**, 1342 (2011)
H. Föll, *''Ulrich Gösele''*, Phys. Stat. Sol. (a), **208(6)**, 1371 (2011)
E. Ossei-Wusu, A. Cojocaru, H. Hartz, J. Carstensen, H. Föll, *Silicon nanowires made via macropore etching for superior Li ion batteries*, Phys. Stat. Sol. (a), **208(6)**, 1417 (2011)
M. Leisner, J. Carstensen, H. Föll, *Quantitative analysis of curro pore growth on n-type InP*, Phys. Stat. Sol. (c), **8(6)**, 1923 (2011)
M. Leisner, D. Dorow-Gerspach, J. Carstensen, H. Föll, *Influence of the doping concentration on crystallographic pore growth on n-type InP and GaAs*, Phys. Stat. Sol. (a), **208(6)**, 1378 (2011)

A. Cojocaru, M. Leisner, J. Carstensen, H. Föll, *Comparison of currentline pore growth in n-type InP and in n-type Si,* Phys. Stat. Sol. (c), **8**, 1779 (2011)

I.M. Tiginyanu, V.V. Ursaki, E. Monaico, M. Enachi, V.V. Sergentu, G. Colibaba, D.D. Nedeoglo, A. Cojocaru, H. Föll, *Quasi-ordered networks of metal nanotubes embedded in semiconductor matrices for photonic applications,* J. of Nanoelectronics and Optoelectronics, **6(4)**, 463 (2011)

E. Garralaga Rojas, J. Hensen, J. Carstensen, H. Föll, R. Brendel, *Mesoporous germanium multilayers,* Phys. Stat. Sol. (c), **8(6)**, 1731 (2011)

M.-D. Gerngroß, V. Sprincean, M. Leisner, J. Carstensen, H. Föll, I. Tiginyanu, *Porous InP as piezoelectric component in magneto-electric composite sensors,* ECS Transactions, **35(8)**, 67 - 72 (2011)

H. Föll, M. Leisner, J. Carstensen, *Modeling some ''meta'' aspects of pore growth in semiconductors,* ECS Transactions, **35(8)**, 49 (2011)

E. Quiroga González, E.K. Ossei-Wusu, J. Carstensen, H. Föll, *How to make optimized arrays of Si nanowires suitable as superior anode for Li-ion batteries,* J. Electrochem. Soc., **158(11) E**, 119 - 123 (2011)

M. Leisner, H. Föll, J. Carstensen, *A meta model for electrochemical pore growth in semiconductors,* Nanostructured Semiconductors: from basic research to applications, ed. P. Granitzer, Springer, (2011)

H. Föll, J. Carstensen, E. Ossei-Wusu, A. Cojocaru, E. Quiroga-González, G. Neumann, *Optimized Cu contacted Si nanowire anodes for Li ion batteries made in a production near process,* J. Electrochem. Soc., **158(5)A**, 580 - 584 (2011)

H. Föll, J. Carstensen, *Pattern formation during anodic etching of semiconductors,* ECS Transactions, **33(20)**, 11 (2011)

H. Föll, J. Carstensen, E. Ossei-Wusu, A. Cojocaru, E. Quiroga-González, G. Neumann, *Optimized Cu contacted Si nanowire anodes for Li ion batteries made in a production near process,* ECS Transactions, **33(27)**, 131 (2011)

A. Cojocaru, J. Carstensen, J. Boor, D.S. Kim, V. Schmidt, H. Föll, *Production and investigation of porous Si-Ge structures for thermoelectric application,* ECS Transactions, **33(16)**, 193 (2011)

H. Föll, *''Remembering Ulrich Gösele'',* ECS Transactions, **33(16)**, 3 (2011)

E. Garralaga Rojas, J. Hensen, J. Carstensen, H. Föll, R. Brendel, *Porous germanium layers by electrochemical etching for layer transfer processes of high-efficiency multi-junction solar cells,* ECS Transactions, **33(17)**, 95 (2011)

H. Föll, J. Carstensen, *Pattern formation during anodic etching of semiconductors,* J. Electrochem. Soc., **158(6)D**, 357 (2011)

J. de Boor, D.S. Kim, X. Ao, D. Hagen, A. Cojocaru, H. Föll, V. Schmidt, *Temperature and structure size dependence of the thermal conductivity of porous silicon,* European Physical Society, doi 10.1209/0295-5075/96/16001, **96**, (2011)

J.-M. Wagner, J. Carstensen, A. Berhane, A, Schütt, H. Föll, *Series resistance analysis with the shaded luminescence technique,* Proc. 26th European Photovoltaic Solar Energy Conference, Hamburg, **2BV.2.51**, (2011)

A. Schütt, J. Carstensen, G. Popkirov, H. Föll, *Mechanical stress induced effects for the characterization of large area solar cells,* Proc. 26th European Photovoltaic Solar Energy Conference, Hamburg, **2DO.3.3**, (2011)

A. Schütt, J. Carstensen, H. Föll, S. Keipert-Colberg, D. Borchert, *Evaluation of passivation schemes of large area Si solar cells: separating serial resistance from other losses by the CELLO technique,* Proc. 26th European Photovoltaic Solar Energy Conference, Hamburg, **2BV.2.39**, (2011)

C. Bohley, J.-M. Wagner, C. Pfau, P.-T. Miclea, S. Schweizer, *Raman spectra of barium halides in orthorhomic and hexagonal symmetry: An ab initio study,* Physical Review B, paper no. 024107, **83**, (2011)

H. Straube, O. Breitenstein, J.-M. Wagner, *Thermal wave propagation in thin films on substrate: the time-harmonic thermal transfer function,* Physica Status Solidi B, **248**, 2128 - 2141 (2011)

M.-D. Gerngroß, M. Leisner, J. Carstensen, H. Föll, *Porous InP as Piezoelectric Material in 1-3 Magnetoelectric Composite Sensors,* Proc. ICNBME, ISBN 978-9975-66-239-0, 16 - 19 (2011)

E. Quiroga González, E. Ossei-Wusu, J. Carstensen, H. Föll, *How to Make Optimized Arrays of Si Wires Suitable as Superior Anode for Li-Ion Batteries,* ECS Transactions, **35(34)**, 3 (2011)

Presentations

J. Carstensen, A. Schütt, G. Popkirov, J. Bahr, H. Föll, *CELLO Messungen (Solar Cell Local Characterization)*, SolarWinS Kick off Meeting, Arnstadt, Germany, 25.-26.01.2011

J. Carstensen, A. Schütt, G. Popkirov, J. Bahr, H. Föll, *CELLO investigation for local characterization and optimization of solar cells (SOLAR CELL LOCAL CHARACTERIZATION) Investigation on mono-Si Solar Cells (invited talk)*, Talk for Bosch Solar Industries, Arnstadt, Germany, 27.01.2011

J. Carstensen, A. Schütt, J.-M. Wagner, H. Föll, *CELLO investigation for local characterization and optimization of solar cells (Solar Cell Local Characterization)*, Invited talk for Q-Cells, Thalheim, Germany, 23.02.2011

J. Carstensen, J.-M. Wagner, A. Schütt, H. Föll, *CELLO investigation for local characterization and optimization of solar cells (Solar Cell Local Characterization)*, Invited talk for CSP, Halle / Saale, Germany, 24.02.2011

E. Quiroga-González, E. Ossei-Wusu, J. Carstensen, H. Föll, *Anode material for Li-ion batteries based on Si wire arrays prepared by a standard and economical electrochemical-chemical method*, Kraftwerk Batterie 2011, Aachen, Germany, 28.02.-02.03.2011

M.-D. Gerngroß, J. Carstensen, H. Föll, *Magnetoelectric 1-3 composites*, SFB 855 spring meeting, Leck, Germany, 31.03.-01.04.2011

H. Föll, M. Leisner, M.-D. Gerngroß, *Modeling some Meta Aspects of Pore Growth in Semiconductors*, Electrochemical Society spring meeting (vorgetragen von M.-D. Gerngroß), Montreal, Canada, 02.-06.05.2011

M.-D. Gerngroß, V. Sprincean, M. Leisner, J. Carstensen, H. Föll, I. Tiginyanu, *Porous InP as Piezoelectric Component in Magnetoelectric Composite Sensors*, Electrochemical Society spring meeting, Montreal, Canada, 02.-06.05.2011

E. Quiroga-González, E. Ossei-Wusu, J. Carstensen, H. Föll, *Stiction-free Si nanowire arrays with large aspect ratio as anode material for Li ion batteries*, E-MRS Meeting, Nice, France, 09.-13.05.2011

E. Quiroga-González, *Status of the preparation of Si-wire anodes in the University of Kiel*, AlKaSuSi-project meeting, Dresden, Germany, 20.05.2011

J. Carstensen, A. Schütt, J.-M. Wagner, H. Föll, *CELLO a new method for electrical characterization of solar cells (invited)*, Freiberger Siliziumtage, Freiberg, Germany, 15.-17.06.2011

J.-M. Wagner, J. Carstensen, *CELLO - ''solar cell local characterization''*, Vorlesungsreihe ''Moderne Methoden der Charakterisierung von Solarzellen und Halbleitermaterial'', MPI für Mikrostrukturphysik, Halle / Saale, Germany, 30.06.2011

M.-D. Gerngroß, M. Leisner, J. Carstensen, H. Föll, *Process Chain for the Fabrication of Magnetoelectric 1-3 Composites based on porous InP*, SFB 855 public colloquium, Kiel, Germany, 27.-28.06.2011

J. Carstensen, A. Schütt, J.-M. Wagner, H. Föll, *Improvements of CELLO*, SolarWinS Projekttreffen, Ochsenfurt, Germany, 05.-07.07.2011

M.-D. Gerngroß, M. Leisner, J. Carstensen, H. Föll, *Porous InP as Piezoelectric Matrix Material in 1-3 Magnetoelectric Composite Sensors*, International Conference on Nanotechnology and Biomedical Engineering, Chisinau, Moldova, 07.-08.07.2011

S. Keipert-Colberg, N. Barkmann, C. Streich, A. Schütt, D. Suwito, P. Schäfer, S. Müller, S. Borchert, *Investigation of a PECVD silicon oxide/silicon nitride passivation system concerning process influences*, 26th European Photovoltaic Solar Energy Conference, Hamburg, Germany, 05.-09.09.2011

A. Schütt, J. Carstensen, H. Föll, S. Keipert-Colberg, D. Borchert, *Evaluation of passivation schemes of large area Si solar cells: Separating serial resistance from other losses by the CELLO technique*, 26th European Photovoltaic Solar Energy Conference, Hamburg, Germany, 05.-09.09.2011

A. Schütt, J. Carstensen, G. Popkirov, H. Föll, *Mechanical stress induced effects for the characterization of large area solar cells*, 26th European Photovoltaic Solar Energy Conference, Hamburg, Germany, 05.-09.09.2011

J.-M. Wagner, J. Carstensen, A. Berhane, A. Schütt, H. Föll, *Serial resistance analysis with the shaded luminescence technique*, 26th European Photovoltaic Solar Energy Conference, Hamburg, Germany, 05.-09.09.2011

J. Carstensen, A. Cojocaru, A. Corduneanu, *Macropore structure for solar cell application*, MacPSI Projekttreffen, Hameln /

Emmerthal, Germany, 14.09.2011

A. Schütt, J. Carstensen, G. Popkirov, H. Föll, *Mechanical stress induced effects for the characterization of large area solar cells*, 5. Statusworkshop: Mikrostrukturelle und mechanische Fragestellungen in der Herstellung kristalliner Siliziumwafer und Solarzellen, Halle / Saale, Germany, 12.10.2011

H. Föll, *Emerging applications of electrochemically nanostructured semiconductors (invited)*, Talk at the University Hamburg, Hamburg, Germany, 26.10.2011

H. Föll, *Solarenergie für alle - funktionieren Solarzellen auf Dauer?*, Talk for Schleswig-Holsteinische Universitätsgesellschaft, Kiel, Germany, 31.10.2011

E. Quiroga-González, *Advances in the fabrication of Si-wire anodes in the University of Kiel*, AlKaSuSi-project meeting, Pfinztal, Germany, 11.11.2011

Further Activities and Events

Prof. Dr. H. Föll is the 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.

Prof. Föll was invited as guest editor of „Porous Materials 2011" Special Issue

Guest Scientists in 2011

01.01.2011 - 31.03.2011 Guest scientist: Veaceslav Sprincean, Technical University of Moldova, Chisinau, Moldova: Pore etching and pore filling.

01.02.2011 - 31.08.2011 Guest scientist: Alexandru Corduneanu, Technical University of Moldova, Chisinau, Moldova: Pore etching and pore filling.

Guests in 2011

18.04.2011 Dr.-Ing. Maciej Wiatr, GLOBALFOUNDRIES, Dresden, Colloquium of the Faculty of Engineering „Modernste Halbleitertechnologie bei GLOBALFOUNDRIES Dresden"

Inorganic Functional Materials

The group „Inorganic Functional Materials" concentrates on the 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 and sensors.

The related physical effects are magnetostriction, the piezo electric effect, or 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 which consist of piezoelectric and magnetostrictive constituents. These materials are the basis of the SFB 855 „Magnetoelectric composites - future biomagnetic interfaces" .

The Kieler Nanolabor provides thin film technology, especially magnetron sputtering, as well as photo 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

Stents

Shape memory alloys based on binary TiNi exhibit superelastic properties larger than 8 % strain. Additionally, the material is known to have an excellent biocompatibility, which allows its use for medical implants and devices. Structuring the films using wet etching technology causes some design limitations due to the isotropic behaviour of this process. A method to fabricate „thick" films (freestanding films with thickness greater than 20 μm) with very small mesh sizes was developed based on UV lithography electrodeposition of sacrificial layers and wet etching technology. Figure a shows an example of a TiNi thin film with 50 μm thickness and 30 μm structure widths.

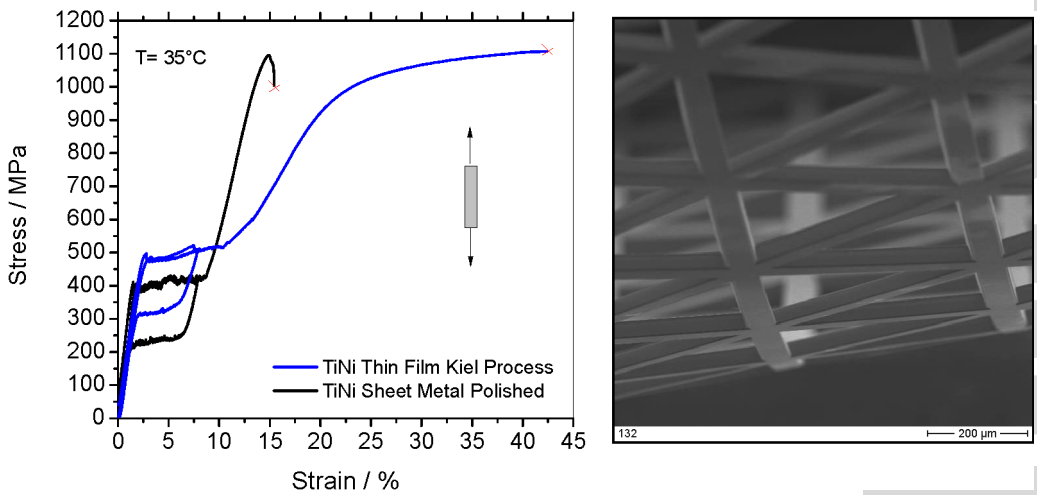


Fig. 1: a) - Example of a TiNi thin film with 50 μm thickness and 30 μm structure widths. Its excellent mechanical properties were characterized and compared to a laser structured conventional TiNi sheet as shown. b) - Tensile stress and fracture edge comparison between TiNi thin film (blue) and conventional structured (black) TiNi sheet metal.

The results demonstrate the potential of this technology as the TiNi thin film shows a yield strain up to 43 % while the

conventionally structured TiNi sheet metal shows only 16 %; both materials show a common plateau stress of between 400 and 500 MPa and an austenite finish temperature of 16 °C (thin film) and 21 °C (sheet metal).

As a consequence, this film technology can be considered to be a promising candidate for the substitution of the solid state laser technology, which is applied to micromachining NiTi tubes, once the aspect ratio of this method is comparable to the one achieved by laser technology. Major advantages are that small burrs, a heat affected zone and micro cracks, as well as possible contamination of the TiNi material with carbides, can be avoided.

Biodegradable Magnesium-Stents

Stents are small metallic devices used to scaffold or brace the inside of tubular passages or lumens. Nowadays most of the implanted stents still consist of non-degradable materials such as stainless steel or superelastic TiNi. Stents made of these materials always bear the danger of a restenosis and are a permanent source of irritation to the surrounding tissue. Additionally, the stent is no longer necessary for a number of therapies after a few months, so that the development of biodegradable stents is of special interest. Stents made from magnesium based alloys dissolve after a certain time, which can be influenced by the choice and the amount of the alloying elements used. Furthermore, with this kind of material it will be possible to implant stents into children, impossible up to now due to their continuing growth.

Due to its high corrosion rate pure magnesium unfortunately does not meet the requirements necessary for use as a stent material, so it is necessary to develop alloys that show both a low and uniform corrosion, and high ductility and stiffness. The choice of alloying elements is limited to those that are not harmful to the human metabolism, so binary and ternary systems consisting of magnesium, calcium and zinc are now under investigation. It could be shown that the solid solubility limit is significantly increased in comparison to traditionally fabricated bulk samples. This offers completely new possibilities for the alloy design, as a higher amount of alloying elements is possible without the formation of precipitates, which act as galvanic elements having a significant negative effect on the corrosion behaviour. In addition to that it is possible to create amorphous thin films by magnetron sputter deposition, which show a further improved corrosion resistance.

The mechanical behaviour of thin films consisting of the alloys Mg4Y3Nd and Mg4Y3Gd was found to be strongly dependent on the deposition conditions, namely sputtering power and chamber pressure during deposition. At optimized conditions it was possible to achieve ductile behaviour with a maximum strain of up to 16 %.

Non-contact Magnetic Sensors

In the form of interdisciplinary research (physics, materials science), the priority programme „HAUT" (SPP 1299) funded by the Deutsche Forschungsgemeinschaft (DFG) is concentrated on the development and investigation of adapting surfaces for high temperature applications. The main contribution of our research group is the development of contact-free sensors to monitor degradation, temperature or induced strain of thin hard or protective coatings by measuring their magnetic properties. For this purpose a sensing method based on frequency mixing has been developed. This technique is employed in two projects within the „HAUT" research program:

I. Nano-structured magnetic thin layer-composites for application in high temperature sensor systems

In this project, in collaboration with the Institute for Applied Materials at the Karlsruhe Institute for Technology and the Institute for Materials at the Ruhr University Bochum, new nano-structured magnetic thin film composites are developed for application as high temperature sensors in protective coatings. For the first time a combination of different thin film materials, nano-scaled wear resistant hard coatings and ferromagnetic functional films, will be integrated in new structures and used as a sensor component. Such composites exhibit a temperature-dependent magnetic hysteresis. The sensor system therefore has been adapted to include the measurement of the hysteresis. A model based on linearized magnetization curves and including variable hysteresis has been developed and used in a simulation of the sensor system. Results from simulation and from experiments have shown a linear correlation. Thus, hysteresis-sensitive analysis may allow the measurement of temperature, independent from cross-sensitivities regarding strain or degradation of the layer.

II. Depletion sensor for in-situ detection of the degradation state of protective high temperature coatings.

In this project, in collaboration with the Karl Winnacker Institute of the Dechema e.V. and the Institute of Energy and Climate Research at the Research Centre Jülich, magnetic reservoir phases are integrated into high temperature protective coatings in order to measure their degradation during use. Suitable magnetic Al- and/or Cr-rich reservoir phases for the formation of a protective oxide layer are identified and characterized, and then protective diffusion coatings containing these phases are developed. As a second concept magnetic garnets (e.g. Fe_3O_4, NiFe) are integrated in common protective coatings consisting of paramagnetic MCrAlY. The sensor system is employed to measure the magnitude of magnetic moments, and implicitly, the thickness of these coatings. Additionally, the capability of the sensor system for reconstruction of the shape of the magnetization curve has been developed. This method provides several degrees of freedom for sample parameter variation that conventional methods like VSM lack. For example, measurement of the magnetization at defined stress and strain levels has been achieved, indicating a potential for in-situ detection of magnetic properties.

Magnetoelectric Composites - Future Biomagnetic Interfaces

We contribute to the Collaborative Research Centre SFB 855 „Magnetoelectric Composites - Future Biomagnetic Interfaces" with three sub-projects (A1, C2, Z1). The major goal of these projects is the development and optimization of composites of magnetostrictive and piezoelectric material, being highly sensitive to AC magnetic fields, to tap their full potential for biomagnetic applications.

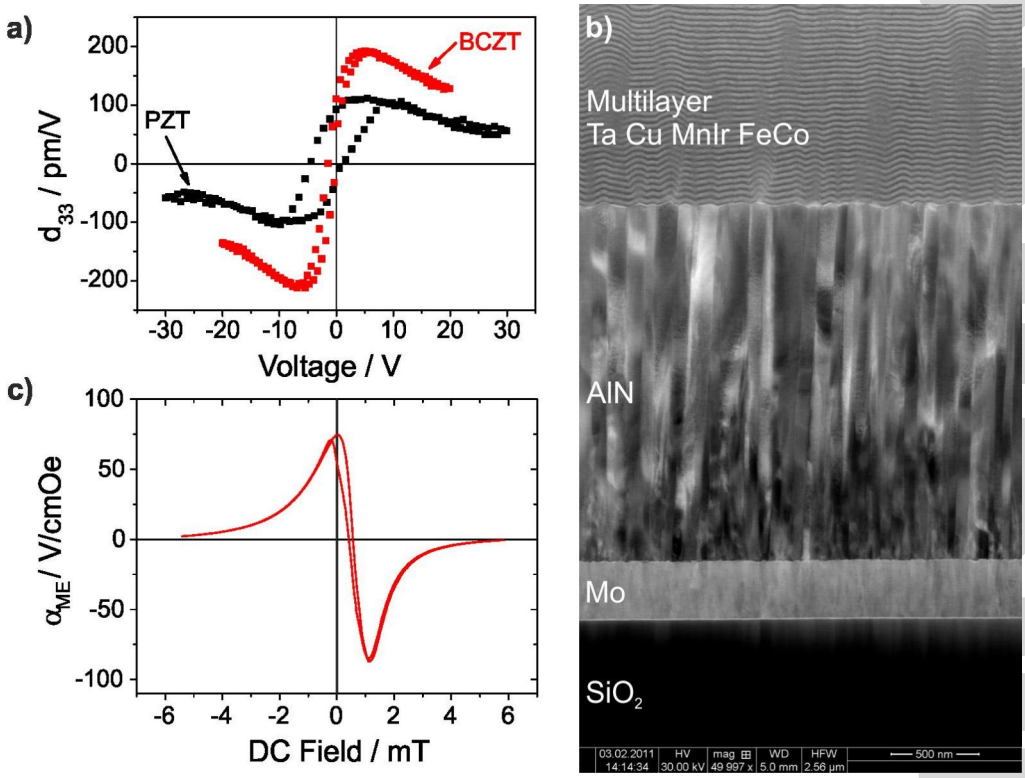


Fig. 2: a) Piezoelectric response of PZT and BCZT thin films. b) Cross-section of a magnetoelectric sensor fabricated by Focused Ion Beam technology and captured by Scanning Transmission Electron Microscopy. c) Magnetoelectric voltage coefficient of a cantilever comprising AlN and a FeCoSiB based multilayer as piezoelectric and magnetostrictive phase, respectively.1

One main research focus in 2011 was the development of lead free ferroelectric thin films. These films act as piezoelectric phase in the composites. The ferroelectric material of choice for such applications is lead zirconate titanate (PZT). However, for various reasons PZT should be replaced by alternative lead free ferroelectrics, like the very promising

material $Ba_{0.85}Ca_{0.15}(Ti_{0.9}Zr_{0.1})O_3$(BCZT). We have prepared successfully thin films of BCZT by a pulsed laser deposition process (1). The dielectric and piezoelectric properties of these thin films are comparable with thin films of PZT. The films exhibited a clamped piezoelectric response of about $d_{33,f} = 190$ pm/V and a dielectric coefficient of about $\epsilon_r = 2000$ at room temperature and are among the highest values reported for lead-free piezoelectric thin films (Fig. 1a).

One of the most remarkable results obtained in 2011 was the implementation of the exchange bias effect in magnetostrictive multilayers (Fig. 1b). The exchange bias effect refers to the shift of the magnetic hysteresis of a ferromagnetic material. It is observed in ferromagnetic - antiferromagnetic sandwich structures and arises from a magnetic exchange interaction across the ferromagnetic - antiferromagnetic interface. Thickness and angle dependency of the exchange bias field are used to tune the shift of the magnetostriction curve in such a way that the optimum working point condition of such sensors is obtained with a zero DC bias field (Fig. 1c).

Since October a magnetically shielded room provides a low noise environment for the characterization of the magnetoelectric magnetic field sensors (Fig. 2). It was supplied by Vacuumschmelze and is composed of three soft magnetic shields and a shell of aluminium yielding shielding factors of S = 1750 and 28500 at 1 Hz and 10 Hz, respectively. The DC magnetic flux measured inside the shielded room is suppressed to values below 7 nT. The inner footprint of 3.4 m by 2.4 m enables the installation of a measurement system capable of screening the magnetic field of test persons.

(1) Piorra, A.; Petraru, A., Kohlstedt, H.; Wuttig, M. and Quandt, E.: Piezoelectric properties of 0.5($Ba_{0.7}Ca_{0.3}TiO_3$) - 0.5[Ba($Zr_{0.2}Ti_{0.8}$)O_3] ferroelectric lead free laser deposited thin films, J. Appl. Phys. 109 (2011) , 104101.

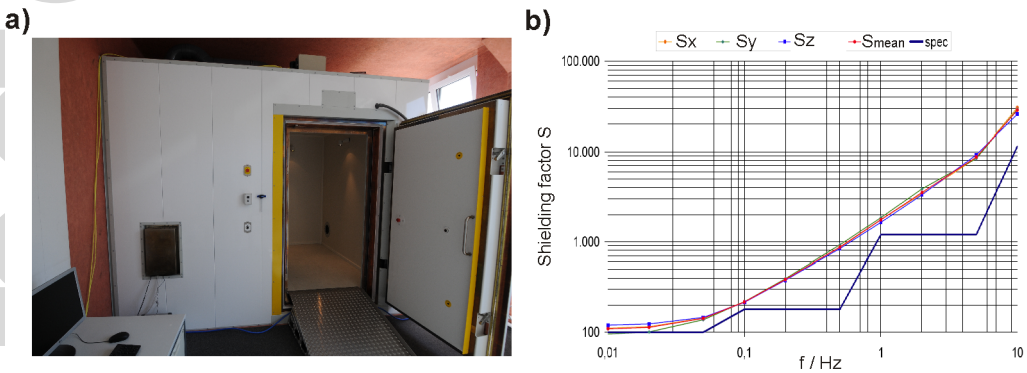


Fig. 3: a) Magnetically shielded room installed in the Kieler Nanolab. b) Shielding factor for various frequencies.

Personnel

Head of the group: Prof. Dr.-Ing. E. Quandt; Secretary: G. Schroeder
Technical Staff: Dipl.-Ing. (FH) T. Metzing, J. Ziese

Staff:

B. Gudschun	01.02.-31.12.2011		DFG
SFB 855, Z2 und IGK			
E. Riemer	01.07.-31.12.2011	(50%)	SFB 855
SFB 855 Programmpauschale			

Scientific Staff:

Dr. C. Bechtold	01.01.-31.12.2011		DFG
SPP 1239			

Dr. A. Büttner SFB 855, Z2 und IGK	01.01.-31.08.2011	CAU
Dr. Ing. S. Chemnitz SFB 677	01.01.-30.04.2011	DFG
Dr. C. Dietz Nanosecure	01.01.-28.02.2011	EU
Dr. H. Greve SFB 855 , Teilprojekt C2	01.01.-31.12.2011	DFG
M.Sc. Ch. Kirchhof SFB 855, Teilprojekt C2	16.11.-31.12.2011	DFG
Dipl.-Ing. E. Lage SFB 855, Teilprojekt Z1	01.01.-31.12.2011	DFG
Dr. R. Lima de Miranda	01.01.-31.12.2011	CAU
Dr. A. Malavé	01.01.-31.12.2011	CAU
Dr. D. Meyners	01.01.-31.12.2011	CAU
Dipl.-Ing. A. Piorra SFB 855, Teilprojekt A1	01.01.-31.12.2011	DFG
Dipl.-Ing. K. Schlüter PRO INNO II, SFB 677, SPP1239	01.01.-31.12.2011	BMWi/DFG
M.Sc. Ali Tavasollizadeh Magnetoresistive Tunnelstrukturen	01.02.-31.12.2011	DFG
Dr. I. Teliban SPP 1299	01.01.-31.12.2011	DFG
M.Sci. F. Thajudin FeGa-based Nanoelectronic Strain Sensor	01.01.-31.12.2011	ONR/NICOP
Dipl.-Phys. C. Thede SPP 1299	01.01.-31.12.2011	DFG
Dr. T. von Hofe Magnetoresistive Tunnelstrukturen	01.01.-30.09.2011	DFG
Dipl.-Ing. E. Woltermann SFB 855, Teilprojekt A1	01.10.-15.12.2011	DFG
M.Sc. E. Yarar SFB 855, Teilprojekt A1	15.11.-31.12.2011	DFG
Dr. C. Zamponi Mg Stents	01.01.-31.12.2011	DFG
MSc. A. Zayed TiNi Stents	01.07.-31.12.2011	BMWi

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

Ceramics and Glasses, 2 (+1) hrs Lecture (+ Exercises)/Week,
E. Quandt (+ A. Malavé)

Werkstoffe (Keramik), 2 hrs Lecture/Week,
H. Greve

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: Basic Lab - Praktikum, 4 hrs Lab/Week,
D. Meyners (+ K. Schlüter, E. Lage, A. Piorra, Ch. Dietz)

Laboratory Course: Analytik- Praktikum, 4 hrs Lab/Week,
D. Meyners (+ C. Zamponi)

Laboratory Course: Scientific Methods - Praktikum, 4 hrs Lab/Week,
D. Meyners (+ Th. von Hofe, C. Zamponi, F. Thajudin)

Summer 2011

Advanced Materials B, 2 (+1) hrs Lecture (+ Exercises)/Week,
E. Quandt

Anorganische Funktionsmaterialien, 2 hrs Seminar/Week,
E. Quandt

Advanced Lab Course for Master Students, 4 hrs Lab/Week,
D. Meyners (+ C. Zamponi, E. Lage, F. Thajudin, I. Teliban)

Winter 2011/2012

Werkstoffe (Keramik), 2 hrs Lecture/Week,
H. Greve (+ 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 Students, 3 hrs Lab/Week,
D. Meyners (+ A. Tavassolizadeh, E. Lage, A. Piorra, F. Thajudin)

Third-Party Funds

DFG, *SPP 1299 HAUT, Nanostrukturierte magnetische Dünnschicht-Komposite für Anwendungen in der Hochtemperatur-Sensorik*, 01.09.2010-31.08.2013 (184.143,20 EUR)

DFG, *SPP 1299 HAUT, Sensorfunktion für Hochtemperatur-Schutzschichten zur in situ Erfassung des Degradationszustands*, 01.07.2010-30.09.2012 (184.143,20 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 (236.783,00 EUR)

DFG, *SFB 677, Funktion durch Schalten, Teilprojekt C07: Komposite aus Polymermatrix und ferromagnetischen Formgedächtnis-Nanopartikeln als magnetische Schalter*, 01.07.2007-30.06.2011 (192.400 EUR)

DFG, *Magnetoresistive Tunnelstrukturen mit magnetostriktiven Elektroden als Sensor für die Rastermikroskopie*, 01.02.2011-31.01.2013 (174.969,00)

EU, *Nanosecure: Advanced nanotechnological detection and detoxification of harmful airborne substances for improved public security*, 01.01.2008-28.02.2011 (220.821,21 EUR)

BMWi, *ZIM, Entwicklung eines Implantats mit selektriver Abdeckung*, 01.07.2010-01.06.2012 (175.000,00)

Office of Naval Research (ONR,USA), NICOP, *FeGa-based Nanoelectronic Strain Sensor*, 01.07.2008-30.06.2012 (165.232 EUR)

Industrie, *Industrieprojekt Formgedächtnistechnik*, 01.09.2008-31.12.2011 (200.000 EUR)

SFB 855, *Magnetoelektrische Verbundstoffe - biomagnetische Schnittstellen d. Zukunft , Teilprojekt A 1*, 01.01.2010-31.12.2013 (603.200,00)

SFB 855, *Magnetoelektrische Verbundstoffe - biomagnetische Schnittstellen d. Zukunft, Teilprojekt C2*, 01.01.2010-31.12.2013 (289.200,00)

SFB 855, *Magnetoelektrische Verbundstoffe - biomagnetische Schnittstellen d. Zukunft, Teilprojekt Z1*, 01.01.2010-31.12.2013 (557.600,00)

SFB 855, *Magnetoelektrische Verbundstoffe - biomagnetische Schnittstellen d. Zukunft, Teilprojekt Z2*, 01.01.2010-31.12.2013 (1.185.000,00)

Further Cooperation, Consulting, and Technology Transfer

Prof. Dr. F. Faupel, CAU

Prof. Dr. H. Gatzen, Universität Hannover

Dr. H. Hölscher, KIT, Karlsruhe

Dr. N. Hort, Helmholtz-Zentrum, Geesthacht

Prof. Dr. K.U. Kainer, Helmholtz-Zentrum, Geesthacht

Prof. Dr. R. Knöchel, CAU

Prof. Dr. A. Ludwig, RUB

Prof. Dr. M. Schütze, Dechema

Dr. M. Stüber, KIT

Dr. W. J. Quadakkers, FZ Jülich

Prof. D. Viehland, Virginia Tech, USA

Prof. Dr. M. Wuttig, University of Maryland, USA

Diploma, Bachelor and Master Theses

Erdem Yarar, *Optimization of sputtered piezoelectric AlN thin films (Master Thesis)*, 30.09.2011

Christine Kirchhof, *Exchange Bias an hochmagnetostriktiven Materialien in magnetoelektrischen Kompositen (Master Thesis)*, 17.11.2011

Publications

Published in 2011

R. Jahns, H. Greve, E. Woltermann, E. Quandt, R. H. Knöchel, *Noise Performance of Magnetometers with Resonant Thin Film Magnetoelectric Sensors,* IEEE Transactions on Instrumentation & Measurement, **60 (8)**, 2995 - 30011 (2011)

A. Kulkarni, V.S.K. Chakravadhanula, V. Duppel, D. Meyners, V. Zaporojtchenko, T. Strunskus, Lorenz Kienle, E. Quandt, F. Faupel, *Morphological and magnetic properties of* $TiO_2/Fe_{50}Co_{50}$ *composit films,* Journal of Materials Science, **46**, 4638 - 4645 (2011)

F. Kahleyss, R. Lima de Miranda, T. Surmann, C. Zamponi, C. Machai, D. Biermann, E. Quandt, *Processing and Damping Properties of Sputtered NiTi Thin Films for Tools in Machining Processes,* JMEPEG, **20**, 500 - 505 (2011)

A. Piorra, A. Petraru, H. Kohlstedt, M. Wuttig, E. Quandt, *Piezoelectric properties of 0.5(*$Ba_{0.7}Ca_{0.3}TiO_3$*) - 0.5[Ba(*$Zr_{0.2}Ti_{0.8}$*)*O_3*] ferroelectric leadfree laser deposited thin films,* J. Appl. Physics, **109**, 104101 (2011)

K. Schlüter, J. Reverey, N. Hort, C. Zamponi, E. Quandt, *Mechanical behaviour and corrosion performance of thin film magnesium WE alloys,* Materials Science Forum, **690**, 286 - 289 (2011)

K. Aleksandrov, M. Schütze, I. Teliban, C. Thede, E. Quandt, *Depletion sensor for protective high temperature,* Materials and Corrosion, **62 (7)**, 706 - 712 (2011)

H. Naggert, A. Bannwarth, S. Chemnitz, T. von Hofe, E. Quandt, F. Tuczek, *First observation of light-induced spin change in vacuum deposited thin films of iron spin crossover complexes,* Dalton Trans., **40**, 6364 (2011)

B. Gojdka, R. Jahns, K. Meurisch, H. Greve, R. Adelung, E. Quandt, R Knöchel, F. Faupel, *Fully integrable magnetic field sensor based on delta-E effect,* Appl. Phys. Lett., **99**, 223502 (2011)

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 (6)**, 895 - 902 (2011)

Patent Applications

R. Jahns, R. Knöchel, E. Quandt, *Verfahren zur Magnetfeldmessung mit magnetoelektrischen Sensoren,* Europäisches Patentamt München, 18.01.2011, DE 10/2011/008866.0

E. Quandt, Chr. Bechtold, St. Chemnitz, C. Thede, J. Teliban, *Verfahren zur Bestimmung mechanischer Eigenschaften magnetostriktiver Materialien,* Internationales Patentamt, 20.07.2011, WO 2011/088823 A2

Presentations

E. Quandt, *Magnetoelectric Sensors for Biomedical Applications,* Dreikönigstreffen, Bad Honnef, 05.-07.01.2011

C. Bechtold, J. Buschbeck, B. Erkartal, A. Lotnyk, S. Fähler, L. Kienle, E. Quandt, *Tuning Magnetism by Epitaxial Strains in sputtered Fe-Pd films,* Intermag, Taipeh, China, 25.-29.04.2011

E. Quandt, *Strain Sensors based on Magnetic Tunnel Junctions,* Deutsch-Chinesischer Workshop, Berlin, 29.05.-01.06.2011

E. Lage, D. Meyners, E. Quandt, *Exchange Bias in Magnetoelectric Composites,* SFB 855 Colloquium, Kiel, 27.-27.06.2011

A. Piorra, E. Woltermann, A. Petraru, E. Yarar, H. Kohlstedt, M. Wuttig, E. Quandt, *Lead-free piezoelectric thin films of AlN and 0.5($Ba_{0.7}Ca_{0.3}TiO_3$) - 0.5[Ba($Zr_{0.2}Ti_{0.8}$)O_3] (Poster)*, SFB 855 Colloquium, Kiel, 27.-27.06.2011

H. Greve, St. Marauska, B. Wagner, E. Quandt, *ME thin film sensor prototypes*, SFB 855 Colloquium, Kiel, 28.-28.06.2011

E. Quandt, *Thin Film Smart Materials for Medical Applications*, Kolloquium MPI für Eisenforschung, Düsseldorf, 04.07.2011

K. Schlüter, J. Reverey, N. Hort, C. Zamponi, E. Quandt, *Mechanical Behaviour and Corrosion Performance of Thin Film Magnesium WE Alloys*, 5th International Light Metals Technology Conference 2011, Lüneburg, 19.-22.07.2011

H. Greve, E. Woltermann, R. Jahns, S. Marauska, B. Wagner, R. Knöchel, E. Quandt, *Giant Magnetoelectric Coefficients in* $(Fe_{90}Co_{10})_{78}Si_{12}B_{10}$*-AlN Thin Film Composites*, International Materials Research Congress, Cancun, Mexiko, 13.-20.08.2011

A. Piorra, V. Hrkac, L. Kienle, E. Quandt, *0.5($Ba_{0.7}Ca_{0.3}TiO_3$) - Lead Free Laser Deposited Thin Films of 0.5[Ba($Zr_{0.2}Ti_{0.8}$)O_3]*, 2nd International Workshop on Piezoelectric MEMS, Lausanne, Schweiz, 06.-07.09.2011

J. Teliban, j: Thede, S. Chemnitz, C. Bechtold, E. Quandt, K. Aleksandrov, M. Schütze, T. Hüttel, W. Quadakkers, *Sensor for monitoring the depletion state of high temperature protective coatings*, European Corrosion Congress, Stockholm, Schweden, 04.-08.09.2011

R. Lima de Miranda, Ch. Zamponi, E. Quandt, *NiTi Thin Film Stents*, SFB 459 Workshop, Bochum, 13.-16.09.2011

E. Lage, V. Hrkac, L. Kienle, D. Meyners, E. Quandt, *Exchange Biased Magnetostrictive Multilayer for Magnetoelectric Sensors*, Materials Research Society Fall Meeting, Boston, USA, 28.11.-02.12.2011

Dirk Meyners, E. Lage, E. Quandt, *Exchange Biased Magnetostrictive Multilayer for Magnetoelectric Sensors*, Materials Research Society Fall Meeting, Boston, USA, 28.11.-02.12.2011

H. Greve, St. Marauska, R. Jahns, E. Woltermann, R. Knoechel, B. Wagner, E. Quandt, *Giant Magnetoelectric Thin Film FeCoSiB/AlN Composites*, Materials Research Society Fall Meeting, Boston, USA, 28.11.-02.12.2011

Further Activities and Events

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.

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“ .

E. Quandt: Election to the Review Board of the DFG

March 9, 2011: Visit of the Federal President of Germany at the Faculty of Engineering of the CAU.

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

Materials Mechanics

Prof. Dr.-Ing. Wolfgang Brocks retired in 2007 but he still publishes results of his former research activities at the „Helmholtz Zentrum Geesthacht“ . These publications are listed below to demonstrate his successful work.

Publications

Published in 2011

W. Brocks, I. Scheider, *Identification of material parameters for structural analyses,* Structural Durability and Health Monitoring, **161**, 1 - 24 (2010)

D. Steglich, W. Brocks, J. Bohlen, F. Barlat, *Modelling direction-dependent hardening in magnesium sheet forming simulations,* Int. J. of Material Forming, **4**, 243 - 253 (2011)

S. Ertürk, W. Brocks, J. Bohlen, L. Letzig, D. Steglich, *A constitutive law for the thermo-mechanical modelling of magnesium alloy extrusion,* Int. J. of Material Forming, (2011)

Presentations

W. Brocks, *Coupling aspects in the simulation of hydrogen-induced stress-corrosion cracking,* IUTAM Symposium Linking Scales in Computations: From Microstructure to Macro-scale Properties, Pensacola (Florida), USA, 17.-19.05.2011

W. Brocks, I. Scheider, *Use of cohesive elements for the simulation of ductile tearing,* Russisch-französisch-deutsches Seminar ''New Trends in Mechanics of Materials'', Moskau, Russland, 26.-29.09.2011

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 (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 focussed 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 with Multi-Scan CCD Cameras, and with 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 and Research Thesis Projects: Study courses for Bachelor's and Master's degree Students (teaching languages English, German) in the subject areas Materials Science, Analytical Methods in Materials Science, and Advanced Methods of Transmission Electron Microscopy. Offers for thesis projects for Bachelor's and Master's degree students, and for Dissertation projects.

Collaboration Offers for Research and Technology: R&D collaboration with research institutions and with industry, funded project research and transfer of technology, continuing education ''Analytics of Materials for Research and Industry / Materialanalytik für Forschung und Industrie'' (Prof. W. Jäger, teaching languages German / English), www.uni-kiel.de/wiss-weiterbildung, consulting and expert advice.

Results

Conference Organisation: **International Microscopy Conference MC 2011**, 28 August - 02 September 2011, Kiel, Germany, www.mc2011.de

The Microscopy Conference MC2011 in Kiel has been a great success: 930 participants (including 140 students) from all over the world met in Kiel. The scientific programme covered, with more than 25 scientific symposia and workshops, the current developments in Instrumentation and Methods, Materials Science, and Life Sciences. More than 500 scientific contributions were received from 44 countries both from within and outside Europe, including Japan, China, Israel, South Africa, the USA, and others. 50 manufacturers of microscopes and suppliers of equipment and products in all fields of microscopy and related techniques also contributed to the success of the conference.

The scientific programme, the special sessions, the commercial exhibition, and the organisation of the conference received the highest appreciation. The offers for social activities and the manifold opportunities for lively information exchange between scientists and with representatives of the companies were considered outstanding. The positive response which we received from numerous conference participants was simply overwhelming!

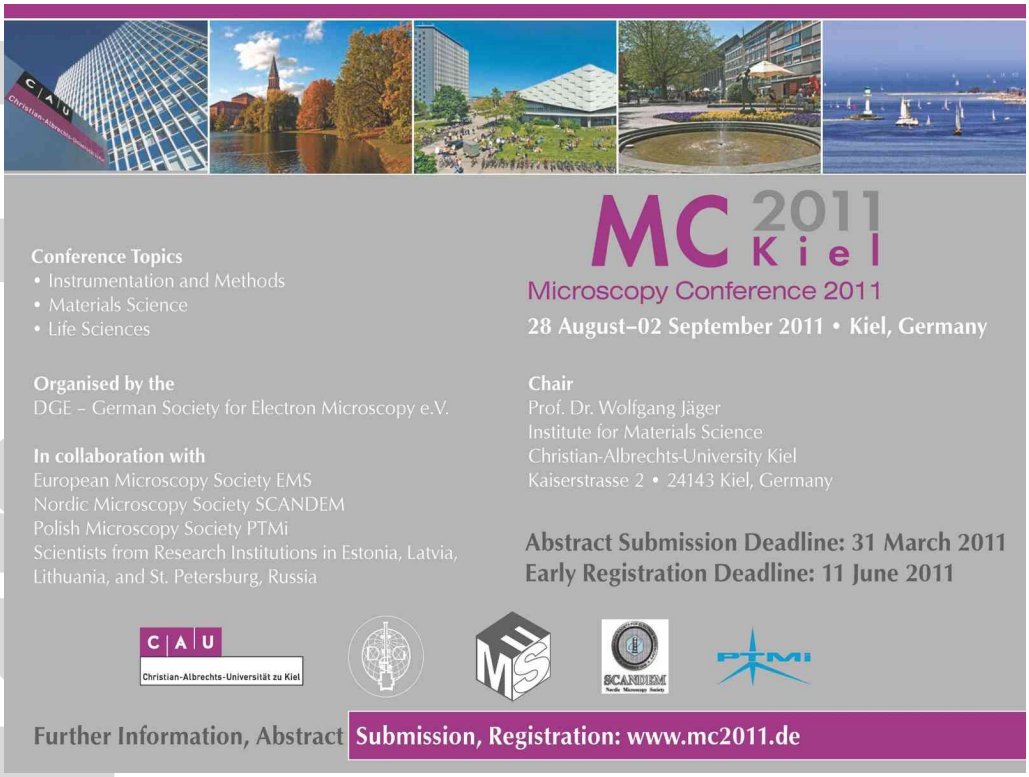


Fig. 1:

Microscopy Conference MC 2011 - Event Report

28 August - 02 September 2011, Kiel, Germany, www.mc2011.de

Scientists and manufacturers from all over the world met in Kiel, Germany for 6 days, from August 28th to September 2nd, 2011, during the international Microscopy Conference 2011 and shared a week of lively exchange about the latest developments in Instrumentation and Methods and current topics in Materials Science and Life Sciences. The congress venue was the Christian-Albrechts-Universität zu Kiel, one of the leading universities in Germany.

Fig. 2: Left: Scientists and manufacturers from all over the world met in Kiel during the international Microscopy Conference 2011. Right: Scientific exchange at its best: one of the numerous poster sessions of the MC2011. www.mc2011.de

Electron microscopy is one of the key techniques for the deeper understanding of both inanimate and living materials. Aberration-corrected electron optics brings the resolution in electron microscopy to its theoretical limits and has opened up a new dimension for materials research. Due to these developments electron microscopes are now available for research in materials science and life sciences that allow the imaging and investigation of the nanoworld around us on scales that

are not met by any other method. The present world record of image resolution in electron microscopy is 50 picometres, a distance between two objects which is inconceivably small but a handy length scale to describe the fascinating nanoworld of materials and living systems. Consequently, our colleagues Professor Maximilian Haider, now entrepreneur and Managing Director of CEOS in Heidelberg, a company that meanwhile has become the world's leading manufacturer of correctors for electron microscopes, Harald Rose, Professor at the Technical University Darmstadt, and Knut Urban, Professor at the Research Centre Jülich, received numerous awards, and quite recently have been awarded the renowned Wolf Research Prize in Physics in the Knesset. Also in 2011, the most prestigious prize of the Microscopy Society of America MSA, the Distinguished Scientist Award for Physical Sciences, has been awarded to our colleague Hannes Lichte, Professor at the TU Dresden. It is an honour and has been a particular pleasure to have our colleagues with us at the Microscopy Conference MC2011 in Kiel as speakers and as symposium organizers, together with many more distinguished fellow scientists and guests of honour.

930 participants, including 140 students, attended the conference. The congress, chaired by Prof. Wolfgang Jäger (Institute for Materials Science, Kiel University), was organized by the German Society for Electron Microscopy (DGE), for the first time in collaboration with the European Microscopy Society (EMS), the Nordic Microscopy Society (SCANDEM), the Polish Microscopy Society (PTMi), and with scientists from research Institutions in Estonia, Latvia, Lithuania, and St. Petersburg, Russia. The congress was actively supported by the Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research, by the Fraunhofer-Institute for Silicon Technology, and by Conventus Congressmanagement & Marketing GmbH (Jena, Germany) as professional conference organizer.

More than 500 scientific contributions were received from 44 countries from Europe and beyond, including Japan, China, Israel, South Africa, the USA, and others. The scientific programme, which was designed by an international panel of distinguished scientists, focused on electron microscopy and related methods and covered, with 25 scientific symposia and workshops, the current developments in Instrumentation and Methods, Materials Science, and Life Sciences. Numerous excellent contributions by scientists from universities, research institutions, and industry demonstrated convincingly the importance of electron microscopy and related methods in topical materials research and life sciences, in applications dedicated to the development of new materials, and for the advanced analysis of materials in current areas of technology. Plenary and invited talks, oral presentations as well as poster presentations, for which ample time for discussions had been reserved, proved to be a successful format for these scientific sessions. Several workshops focused on advanced methods and new developments in Cryo SEM/FIB (Chair Prof. Stanislav Gorb, Kiel), in Programming for Data Acquisition (Chair Dr. Thomas Gemming, Dresden), on Local Assessment of Magnetic and Electrical Inner Fields (Chair Prof. Klaus Leifer, Uppsala), and on Image Simulation for TEM and STEM (Chair Prof. Pierre Stadelmann, Lausanne). All workshops showed excellent attendance, bringing together invited experts, experienced scientists, and newcomers to the fields. Please consult the homepage www.mc2011.de and the proceedings [1] of the Microscopy Conference 2011 Kiel for the details on the topics of the individual sessions and workshops and on the scientific contributions.

Part of the broad spectrum of topical areas was reflected by the opening lecture and the invited plenary talks of internationally leading scientists, whose excellent contributions covered the latest developments and interdisciplinary approaches, and outlined future perspectives in topical areas of research and instrument development: 'Is there a need for further instrumental development?' (Prof. Maximilian Haider, Heidelberg, opening lecture), 'Structure determination of dynamic macromolecular complexes by single particle cryo-electron microscopy' (Prof. Holger Stark, Göttingen, EMS lecture), 'Understanding deformation mechanisms in nanoscale metals using in-situ electron microscopy' (Prof. Cynthia Volkert, Göttingen), 'Imaging systems for systems imaging in biology' (Prof. Heinrich Hohenberg, Hamburg), 'New techniques and instrumentation for the characterisation of magnetic and electrostatic fields in nanocrystals and working devices' (Prof. Rafal E. Dunin-Borkowski, Copenhagen-Lyngby and Jülich), 'Non-destructive 3D orientation maps of polycrystals on scales from 1 nm and 1 mm using transmission electron microscopy and 3D X-ray diffraction' (Prof. Henning F. Poulsen, Risoe), 'The physics and chemistry of nano-carbons explored by high-resolution electron microscopy' (Prof. Jannik C. Meyer, Vienna, EMS lecture). The lectures of Holger Stark and of Jannik Meyer were selected as 'EMS lecture', a special support awarded by the European Microscopy Society (EMS).

During the opening ceremony with numerous guests of honour and in the presence of the conference participants, the 2011 laureates of the Ernst Ruska prize, Dr. Johan Verbeeck (Physicist from Antwerp, Belgium) and Prof. David Mastronarde (Cell Biologist from Boulder, Colorado, USA) were awarded this prestigious prize, named after the Nobel prize laureate Ernst Ruska, for outstanding contributions in electron microscopy of materials science and life sciences. The lectures of the award recipients, entitled 'Electrons with a twist: topological charge effects in a TEM', and 'Software tools for tomographic reconstruction of large volumes', gave excellent insight into the methods and their importance in research for materials and life. The congress was inaugurated with addresses of welcome by the President of the Christian-Albrechts-University, Professor Gerhard Fouquet, by the Secretary of State of the Ministry of Science, Economic Affairs, and Transport (Federal State of Schleswig-Holstein), Dr. Cordelia Andreßen, and by the President of the City Council Kiel, Cathy Kietzer. We would like to express cordially our sincere gratitude for this important support. A number of further events and highlights received the highest esteem and contributed substantially to the large success of this conference. The commercial exhibition, bringing together 50 manufacturers of microscopes and suppliers of equipment and products in all fields of microscopy and related techniques, a technical session, and many lunchtime sessions provided a forum for the exchange of information and for creating opportunities for useful contacts. During a special session about 'Funding Strategies in Germany', Dr. Burkhard Jahnen from the German Science Foundation DFG and Dr. Franz Dettenwanger from the Volkswagen Foundation gave valuable insights into current research funding opportunities to a large audience of scientists. The Conference Dinner Event, also considered to be outstanding, featured the awarding of several MC2011 prizes and the greetings of the presidents and representatives of the microscopy societies (Prof. Annette Gunnaes, Oslo: SCANDEM, Prof. Aleksandra Czyrska-Filemonowicz, Cracow: PTMi, Prof. Dominique Schryvers, Antwerp: EMS, Prof. C. Barry Carter, Storrs, USA, International Federation of Societies for Microscopy IFSM, and Prof. Debbie Stokes, Cambridge: Chair of the emc2012 Manchester). Several 'MC2011 Best Poster' prizes were awarded to young graduate scientists for their outstanding research presentations, three 'MC2011 Outstanding Micrograph' prizes were selected from the MC 2011 Best Image Contest 'Art in Science', and an EMS Outstanding Paper Award 2011 was presented to Dr. Johan Verbeeck (Antwerp, Belgium). A pleasure, and not unimportant to mention, was that the catering and the evening entertainment with music and dancing found the highest appreciation!

Not only the scientific programme, the special sessions, the commercial exhibition, and the organisation of the conference received high esteem but also the offers for social activities and the manifold opportunities for lively information exchange between scientists and with representatives of the companies: all were considered outstanding. The positive response which we received from numerous conference participants was simply overwhelming!

We are grateful to all colleagues and to all participants for their invaluable support in turning Kiel into an international hub of microscopy during these days and in making the Microscopy Conference MC2011 Kiel such a great success and we are happy to have been part of it! Special thanks go to all members of the international and advisory committees, to all chairpersons and invited speakers, to all participating companies and sponsors, and, last but not least, to our congress management partners from Conventus for their excellent professional organisation. Special thanks go to the press department of the Kiel University for the valuable support in creating considerable presence through reports and interviews in the public media, for instance, in the local and regional press, regional NDR TV [2], and national German broadcasting Deutschlandfunk [3].

Prof. Dr. Wolfgang Jäger, Chairman of the MC 2011

Christian-Albrechts-Universität zu Kiel, 24143 Kiel, wj[at]tf.uni-kiel.de

Prof. Dr. Reinhard Rachel, President of the DGE German Society for Electron Microscopy

Universität Regensburg, 93053 Regensburg, Reinhard.Rachel[at]Biologie.Uni-Regensburg.de

[1] Proceedings of the Microscopy Conference MC 2011 Kiel, Germany (28 August - 02 September 2011). Vol.1 Instrumentation and Methods. Vol.2 Life Sciences. Vol.3 Materials Science. (Eds. W. Jäger, W. Kaysser, W. Benecke, W. Depmeier, S. Gorb, L. Kienle, M. Mulisch, D. Häußler, A. Lotnyk). ISBN 978-3-00-033910-3. (Copyright) 2011 DGE -

German Society for Electron Microscopy e.V. Germany.

[2] Report in NDR TV - SH Magazin (Video). 30.08.2011

http://www.ndr.de/fernsehen/sendungen/s-h_magazin/media/shmag11267.html

[3] Interviews in Deutschland-Funk (Text + Audio)

01.09.2011, http://www.dradio.de/dlf/sendungen/forschak/1544438/

14.09.2011, http://www.dradio.de/dlf/sendungen/forschak/1554838/

Collaborations - Microscopy Conference MC 2011 Kiel

The congress was jointly organized, for the first time, by the German Society for Electron Microscopy (DGE) in collaboration with the European Microscopy Society (EMS), the Nordic Microscopy Society (SCANDEM), the Polish Microscopy Society (PTMi) and with scientists from research institutions in Estonia, Latvia, Lithuania, and Russia. The conference was actively supported by the Helmholtz Zentrum Geesthacht Centre for Materials and Coastal Research and by the Fraunhofer-Institute for Silicon Technology. We are grateful to all authors, members of the international advisory and program committees, and chairpersons for their invaluable support in making the Microscopy Conference MC 2011 a successful and pleasant event.

Local Organizing Committee

Wolfgang Jager, Chairman, Materials Science, CAU, Kiel, DE: Wolfgang Kaysser, Helmholtz-Zentrum Geesthacht, DE: Wolfgang Benecke, ISiT Fraunhofer Institute for Silicon Technology, Itzehoe, DE: Wulf Depmeier, Crystallography CAU, Kiel, DE: Stanislav Gorb, Special Zoology CAU, Kiel, DE: Lorenz Kienle, Materials Science CAU, Kiel, DE: Maria Mulisch, Central Microscopy Life Science CAU, Kiel, DE: Dietrich Häussler, Materials Science CAU, Kiel, DE: Andriy Lotnyk, Materials Science CAU, Kiel, DE

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Conference Organization

Conventus Congressmanagement & Marketing GmbH, Francesca Rustler, Carl-Pulfrich-Strasse 1, 07745 Jena, DE; Phone +49 (0)3641 311 63 41, Fax +49 (0)3641 311 62 43, e-mail mc2011[at]conventus.de ; www.conventus.de

Proceedings Editors

Wolfgang Jager, Kiel, DE: Wolfgang Kaysser, Geesthacht, DE: Wolfgang Benecke, Itzehoe, DE: Wulf Depmeier, Kiel, DE: Stanislav Gorb, Kiel, DE: Lorenz Kienle, Kiel, DE: Maria Mulisch, Kiel, DE: Dietrich Hausler, Kiel, DE: Andriy Lotnyk, Kiel, DE.

Research Results:

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 hetero-epitaxial 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 GaInNAs 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.

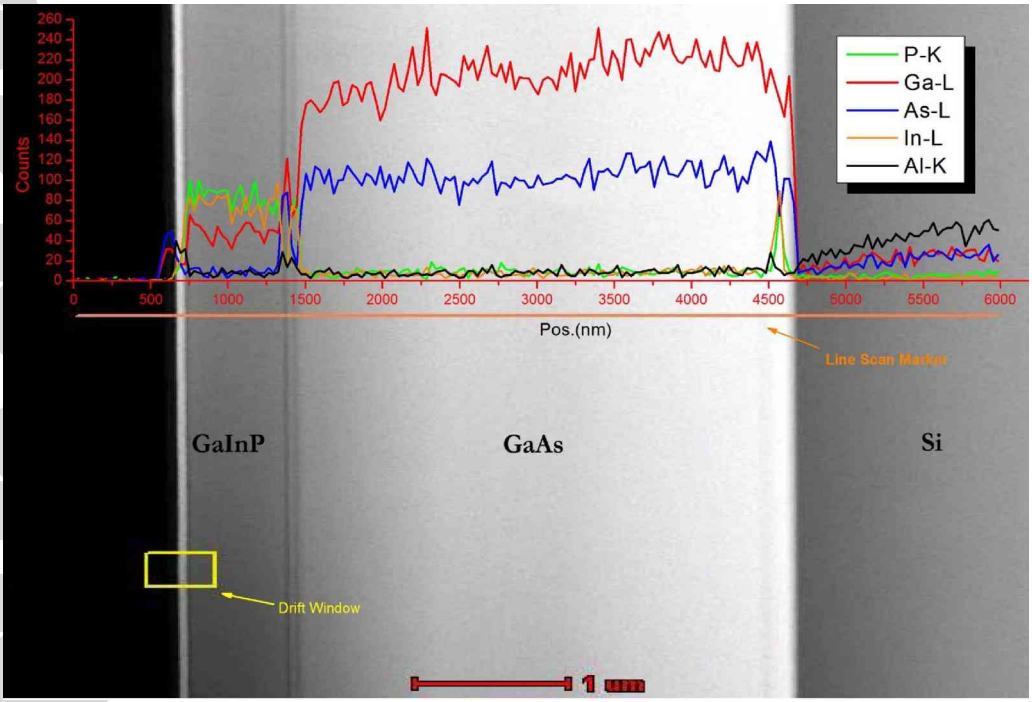

Fig. 3: Example of a high-resolution chemical analysis of a GaAs/GaInP layer system cross-section on a Si substrate. Superimposed on the HAADF-STEM cross-section image are the drift-corrected spectrum line profiles of the P-K, Ga-L, As-L, In-L and Si-K lines. (From: M. Kurttepeli, Master's Thesis 2011).

OXIDE SEMICONDUCTOR NANOMATERIALS

Advanced imaging and spectroscopic techniques of transmission electron microscopy are essential for characterizing the microstructure and the structure-property relationships of nanostructured functional materials and interfaces. We have continued the fundamental research of growth and doping phenomena and of liquid-solid interfaces for ZnO nanorod materials grown by a thermal growth method.

Dr. Dietrich Häussler CAU. Cooperation: Prof. Dr. J. Piqueras, Prof. Y. Ortega Villafuerte, Physics Department, Universidad Complutense de Madrid, Spain.

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.

Dr. D. Häußler CAU. Diploma thesis project: Ulrich Roß. Cooperations: Dr. J. Wiesmann, F. Hertlein, U. Heidorn, Incoatec GmbH, Geesthacht, 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 methods, 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 explore the potential of combining HAADF-STEM tomography with spectroscopic techniques, such as EDXS, to high-resolution analyses of nanometer-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.

Personnel

Head of the group: Prof. Dr. Wolfgang Jäger; Secretary: Katrin Brandenburg (50%)

Scientific Staff:

Dr. Dietrich Häußler 01.01.-31.12.2011 CAU
Analytical TEM of layer systems and nanomaterials

Dr. Yanicet Ortega Villafuerte 01.01.-15.02.2011 Ministerio de Ciencia e innov.
Guest scientist, Facultad de Ciencias Fisicas, UCM - Universidad Complutense Madrid, Spain

Dr. Yanicet Ortega Villafuerte 04.07.-28.10.2011 Ministerio de Ciencia e innov.
Guest scientist, Facultad de Ciencias Fisicas, UCM - Universidad Complutense Madrid, Spain

M.Sc. Burcu Ögüt 01.01.-31.12.2011
Investigations of metallic nanomaterials by energy-filter TEM (co-supervision of external Dissertation research work by Prof. W. Jäger, in collaboration with Max-Planck-Institut für Intelligente Systeme (ehem.: Metallforschung) Stuttgart, Dr. P. Van Aken)

M.Sc. V. Burak Özdöl 01.01.-25.07.2011
Transmission electron microscopy of Si-Ge heterostructures (co-supervision of external Dissertation research work by Prof. W. Jäger, in collaboration with Max-Planck-Institut für Intelligente Systeme (ehem.: Metallforschung) Stuttgart, Dr. P. Van Aken)

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

Analytics, 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

Analytische Methoden, 4 hrs Laboratory course/Week,
Dietrich Häußler (+ Dirk Meyners, Klaus Rätzke, Mady Elbahri, Malte Leisner, Dietrich Häußler, Marlies Schwitzke)

Summer 2011

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 Students, 4 hrs Laboratory Course/Week,
Dietrich Häußler (+ Oliver Riemenschneider)

Winter 2011/2012

Analytics, 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,
Marlies Schwitzke (+ Ingo Paulowics, Mehdi Keshavarz H., Dietrich Häußler)

Grundpraktikum für Ingenieure I, 3 hrs Practical/Week,
Oliver Riemenschneider (+ Dietrich Häußler)

Third-Party Funds

EU, *MACAN - Merging Atomistic and Continuum Analysis of Nanometer Length-Scale Metal-Oxide Systems for Energy and Catalysis Applications*, 01.07.2009-30.06.2013 (29.158 EUR)

DFG, *Grant for the international Microscopy Conference 2011, Kiel, 29.08.11 - 02.09.11*, 29.08.-02.09.2011 (11.620 EUR)

DFG, *Group support (Programmpauschale) granted for the international Microscopy Conference 2011, Kiel, 29.08.11 - 02.09.11*, 29.08.-02.09.2011 (2.300 EUR)

Ministerio de Ciencia e Innovacion, Madrid, Spain, *Gastwissenschaftler Aufenthalt, Dr. Yanicet Ortega Villafuerte*, 01.01.-15.02.2011 (xxx EUR)

Ministerio de Ciencia e Innovacion, Madrid, Spain, *Gastwissenschaftler Aufenthalt, Dr. Yanicet Ortega Villafuerte*, 04.07.-28.10.2011 (xxx 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, Prof. E. Weber, on the development of concepts for defect engineering for high-efficiency solar cells.

Continued collaboration with the Helmholtz-Centre Berlin for Materials and Energy, Berlin, Prof. Ch.-H. Fischer, on the application of advanced TEM methods for the development of nanoparticle materials for solar energy harvesting.

Further Collaborations with research institutions

Continued research collaboration on quantitative TEM characterisations of nanolayer systems for X-ray optics with Dr. C. Morawe, European Synchrotron Radiation Facility, Grenoble, France.

Continued research collaboration (started in 2008) with Physics Department, Universidad Complutense de Madrid, Spain, Prof. Dr. J. Piqueras, Prof. Y. Ortega Villafuerte, 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. F. Philipp, Dr. W. Sigle, on TEM characterisations of semiconductor heterostructures and of metal nanoparticles.

Diploma, Bachelor and Master Theses

Ulrich Roß, *Quantitative STEM of W-C Multilayers for X-Ray Optics*, 16.05.2011

Mert Kurttepeli, *Cross-Section TEM of Bonding Concepts for GaInP/GaAs Solar Cells on Silicon*, 31.10.2011

Dissertations / Postdoctoral Lecture Qualifications

Burak Özdöl, *Characterization of strained semiconductor structures using transmission electron microscopy (received highest rank 'opus eximium')*, 25.07.2011

Publications

Published in 2011

DGE German Society for Electron Microscopy e.V., *Proceedings of the Microscopy Conference MC 2011 Kiel, Germany, 28 August - 02 September 2011. Edited by W. Jäger, W. Kaysser, W. Benecke, W. Depmeier, S. Gorb, L. Kienle, M. Mulisch, D. Häußler, A. Lotnyk,* ISBN 978-3-00-033910-3, Vol.1 Instrumentation and Methods, Vol. 2 Life Sciences, Vol. 3 Materials Science, (2011)

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,* Proc. Microscopy Conference MC 2011, Kiel, Germany, 28.08.-02.09.2011, ISBN 978-3-00-033910-3 (Copyright) 2011 DGE - German Society for Electron Microscopy e.V. Germany, (2011)

Y. Ortega, D. Häussler, J. Piqueras, W. Jäger, P. Fernández, *Investigation of Ga-Doped ZnO Nanostructures by STEM,EDX, and HRTEM,* Proc. Microscopy Conference MC 2011, Kiel, Germany, 28.08.-02.09.2011, ISBN 978-3-00-033910-3 (Copyright) 2011 DGE - German Society for Electron Microscopy e.V. Germany, (2011)

D. Maestre, D. Häussler, A. Cremades, J. Piqueras, W. Jäger, *Transmission electron microscopy study of indium and tin oxide elongated nanostructures grown by thermal treatments,* Proc. Microscopy Conference MC 2011, Kiel, Germany, 28.08.-02.09.2011, ISBN 978-3-00-033910-3 (Copyright) 2011 DGE - German Society for Electron Microscopy e.V. Germany, (2011)

D. Häussler, B. Schaffer, F. Liu, F. Hofer, X.B. Zhang, W. Jäger, *Analytical STEM investigations of Sn-Pd nanoparticles with core-shell structures,* Proc. Microscopy Conference MC 2011, Kiel, Germany, 28.08.-02.09.2011, ISBN 978-3-00-033910-3 (Copyright) 2011 DGE - German Society for Electron Microscopy e.V. Germany, (2011)

Ch. Dieker, K. Tillmann, O.A. Williams, W. Jäger, Ch.E. Nebel, *Microscopic characterisations of diamond nanoparticles by aberration-corrected HRTEM,* Proc. Microscopy Conference MC 2011, Kiel, Germany, 28.08.-02.09.2011, ISBN 978-3-00-033910-3 (Copyright) 2011 DGE - German Society for Electron Microscopy e.V. Germany, (2011)

C. Kübel, Ch. Dieker, D. Esser, H.J. Penkalla, W. Jäger, *Electron Tomography of Nanoparticles in Zn-Doped GaAs Semiconductors,* Proc. Microscopy Conference MC 2011, Kiel, Germany, 28.08.-02.09.2011, ISBN 978-3-00-033910-3 (Copyright) 2011 DGE - German Society for Electron Microscopy e.V. Germany, (2011)

W. Jäger (Chairman MC 2011), R. Rachel (President of the DGE), *Microscopy Conference MC 2011 Kiel - Event Report,* G.I.T. Imaging and Microscopy, GIT Verlag GmbH and Co. KG, Weinheim, Germany, **4**, 14 - 15 (2011)

W. Jäger (Chairman MC 2011), R. Rachel (President of the DGE), *Microscopy Conference MC 2011 Kiel - Conference Program, Impressions, Event Reports,* Publications in the Internet: www.mc2011.de ; DGE, Helmholtzstr. 20, 01069 Dresden, (2011)

Presentations

W. Jäger, *Transmission Electron Microscopy of Interface and Defect Phenomena of Functional Materials,* Kolloquium des Instituts für Materialphysik, Universität Münster, Münster, Germany, 18.01.2011

W. Jäger, *Transmission Electron Microscopy of Interface and Defect Phenomena of Functional Materials,* Colloquium on Photovoltaics, Helmholtz Zentrum Berlin, Berlin, Germany, 03.02.2011

W. Jäger, *Hauptvortrag,* DPG Frühjahrstagung 2011, Fachverband Mikrosonde / DPG German Physical Society Spring Meeting, DPG Division Microprobes, Dresden, Germany, 13.-18.03.2011

D. Häussler, U. Ross, W. Jäger, F. Hertlein, U. Heidorn, J. Wiesmann, *A Method to Locally Determine Layer Dimensions and Interface Roughness for Multilayer Coatings with Ultimate Accuracy,* DPG Frühjahrstagung, Dresden, Germany, 13.-18.03.2011

D. Häussler, B. Schaffer, F. Liu, F. Hofer, X.B. Zhang, W. Jäger, *Analytical transmission electron microscopy investigations of Sn-Pd nanoparticles with core-shell structures,* DPG Frühjahrstagung, Dresden, Germany, 13.-18.03.2011

Ch. Fischer, Ch. Dieker, W. Jäger, *Presentation on ILGAR,* E-MRS 2011 European Materials Research Society E-MRS

Spring Meeting 2011, Symposium A MACAN11: Reconciling atomistic and continuum approaches to interfaces, Nice, France, 09.-13.05.2011

C. Kübel, Ch. Dieker, W. Jäger, *Quantitative Electron Tomography of Nanoparticles in Zn-Doped GaAs Semiconductors,* E-MRS 2011 European Materials Research Society E-MRS Spring Meeting 2011, Symposium A MACAN11: Reconciling atomistic and continuum approaches to interfaces, Nice, France, 09.-13.05.2011

Y. Ortega, Ch. Dieker, W. Jäger, J. Piqueras, P. Fernández, *Transmission Electron Microscopy of Doping Phenomena of ZnO Nanostructures,* E-MRS 2011 European Materials Research Society E-MRS Spring Meeting 2011, Symposium A MACAN11: Reconciling atomistic and continuum approaches to interfaces, Nice, France, 09.-13.05.2011

W. Jäger, *Transmission Electron Microscopy of Interface and Defect Phenomena of Functional Materials (invited lecture),* IUMAS-V 2011, 5th Congress of the International Union of Microbeam Analysis Societies, Seoul, Korea, 22.-27.05.2011

W. Jäger, *Transmission Electron Microscopy of Interface and Defect Phenomena of Functional Materials (invited lecture),* XIV International Conference on Electron Microscopy, Polish Society for Microscopy, em2011.us.edu.pl, Wisla, Poland, 26.-30.06.2011

B. Schaffer, D. Häussler, *Artificial STEM DI visualizing polycrystalline regions in high resolution images,* Microscopy and Microanalysis 2011, Nashville, Tennessee, U. S. A., 07.-11.08.2011

D. Häussler, B. Schaffer, F. Liu, F. Hofer, X.B. Zhang, W. Jäger, *Analytical STEM investigations of Sn-Pd nanoparticles with core-shell structures,* Microscopy Conference MC 2011, Kiel, Germany, 28.08.-02.09.2011

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,* Microscopy Conference MC 2011, Kiel, Germany, 28.08.-02.09.2011

Y. Ortega, D. Häussler, J. Piqueras, W. Jäger, P. Fernández, *Investigation of Ga-Doped ZnO Nanostructures by STEM, EDX, and HRTEM,* Microscopy Conference MC 2011, Kiel, Germany, 28.08.-02.09.2011

D. Maestre, D. Häussler, A. Cremades, J. Piqueras, W. Jäger, *Transmission electron microscopy study of indium and tin oxide elongated nanostructures grown by thermal treatments,* Microscopy Conference MC 2011, Kiel, Germany, 28.08.-02.09.2011

C. Kübel, Ch. Dieker, D. Esser, H.J. Penkalla, W. Jäger, *Electron Tomography of Nanoparticles in Zn-Doped GaAs Semiconductors,* Microscopy Conference MC 2011, Kiel, Germany, 28.08.-02.09.2011

Ch. Dieker, K. Tillmann, O. Williams, W. Jäger, Ch.E. Nebel, *Microscopic characterisations of diamond nanoparticles by aberration-corrected HRTEM,* Microscopy Conference MC 2011, Kiel, Germany, 28.08.-02.09.2011

W. Jäger, *Opening Adress of the International Microscopy Conference MC 2011 Kiel as Chairman of the Conference,* Microscopy Conference MC 2011, Kiel, Germany, 28.08.-02.09.2011

Y. Ortega, D. Maestre, Ch. Dieker, D. Häussler, A. Cremades, P- Fernández, J. Piqueras, W. Jäger, *Interface and Defect Phenomena of Semiconductor Oxide Nanostructures (invited lecture),* 13th Annual YUCOMAT 2011 Conference, Herceg Novi, Montenegro, 05.-09.09.2011

W. Jäger, *Transmission Electron Microscopy of Interface and Defect Phenomena of Functional Materials (invited lecture),* FEMMS 2011, 13th International Conference on Frontiers of Electron Microscopy in Materials Science, Sonoma, CA, U. S. A., 18.-23.09.2011

W. Jäger, *Transmission Electron Microscopy of Functional Nanomaterials and Solar Cells (invited lecture),* BRASONN 2011 - Brazilian School of Nanoscience and Nanotechnology, PUC-RIO, www.brasonn.com.br, Rio de Janeiro, Brazil, 07.-11.11.2011

W. Jäger, *Transmission Electron Microscopy of Functional Nanomaterials, First Alumni Seminar of Mexico-Germany Interchange on Nanostructure and Nanostructured Materials. Synthesis, Properties and Applications (plenary lecture),* Instituto Polytécnico Nacional, Escuela Superior de Física y Matemáticas, Mexico City, Mexico, 23.-25.11.2011

Further Activities and Events

Activities Prof. Wolfgang Jäger

Prof. Wolfgang Jäger has been elected as member of the Executive Committee of the European Materials Research Society.

Prof. Wolfgang Jäger acted as Conference Chair of the International Microscopy Conference MC 2011 Kiel, August 28 - September 2, 2011, organized by the DGE - German Society for Electron Microscopy e.V. in collaboration with European Microscopy Society EMS, Nordic Microscopy Society SCANDEM, Polish Microscopy Society PTMi, Scientists from Research Institutions in Estonia, Latvia, Lithuania, and Russia. Conference Topics: Instrumentation and Methods, Materials Science, Life Sciences, www.mc2011.de.

Selected Further Activities Prof. Wolfgang Jäger

Expert consultant for National Research Project Proposals for the Ministry of Science and Technological Development, Republic of Serbia, Belgrade, Serbia.

Expert consultant for research funding agencies in Germany (DFG and others) and abroad.

Guest Editor of Springer Journal of Materials Science.

Reviewer for several international scientific journals.

External reviewer and member of dissertation committees.

DPG Frühjahrstagung 2011 Dresden, March 13 - 18, 2011, session chair at TEM-Symposium (Symposium Chairpersons E. Spiecker, K. Urban) of DPG-Division Metals and Materials Physics

E-MRS 2011 European Materials Research Society E-MRS Spring Meeting 2011, Nice, France, May 9 - 13, 2011, Symposium A : MACAN11: Reconciling atomistic and continuum approaches to interfaces - member of the scientific committee and chair of symposium session. www.emrs-strasbourg.com

IUMAS-V 2011 5th Congress International Union of Microbeam Analysis Societies, Seoul, Korea, May 22 - 27, 2011, Co-organisation of Session AM5 on Thin Film Analysis. www.iumas5.org

EM2011 International Conference on Electron Microscopy of Solids, Wisla, Poland, June 26 - 30, 2011, Member of the International Advisory Committee. http://em2011.us.edu.pl

YUCOMAT 2011 13th Annual Conference of Materials Research Society Serbia, Herceg Novi, Montenegro, September 05 - 09, 2011, Member of the International Advisory Committee. www.mrs-serbia.org.rs/firstannouncement11.html

W. Jäger, Invited member of a discussion board on ''Trends in Nanoscience and Nanotechnology for Industrial and Developing Countries'' together with Prof. Dr. Siegfried Mantl (Germany), Dr. Santos Alvarado (Spain), Dr. Andreas Leson (Germany), Dr. Ramiro Pérez Campos (Humboldt Foundation), and Dr. Marcelo Lozada y Cassou (IMP Mexico) during the First Alumni Seminar of Mexico-Germany Interchange on ''Nanostructure and Nanostructured Materials. Synthesis, Properties and Applications'', National Polytechnic Institute, November 23 - 25, 2011, Mexico City, Mexico.

Guests in 2011

Prof. Dr. Roland Schindler, Fraunhofer for Sustainable Energy Systems Cambridge MA, U. S. A., Colloquium of the Faculty of Engineering ''Extending Fraunhofer Research to the US: Challenges and Opportunities'', 06.06.2011

Prof. Dr. Rafal E. Dunin-Borkowski, Centre for Electron Nanoscopy, Technical University of Denmark, Colloquium of the Faculty of Engineering ''Electron holography and environmental TEM: a unique view of magnetism and catalysis at the nanoscale'', 18.07.2011

Dr. Se Ahn Song, Advanced Materials Research Centre, Samsung Advanced Institute of Technology (SAIT), Samsung Electronics Co., Giheung, Yongin, Korea, Special colloquium of the Faculty of Engineering ''Sub-Angstrom Resolution Analysis with Electron Beam: Challenge and Prospect'', 21.10.2011

Prof. Dr. Gerhard Wilde, Institute of Material Physics, Westfälische Wilhelms-Universität Münster, Colloquium of the Faculty of Engineering ''Microstructure, atomic-level strain and atomic mobility of grain boundaries in severely deformed metals and alloys'', 24.10.2011

Presentations to the general public and for schools

Prof. Wolfgang Jäger ''Faszination Nanokosmos - Mit Elektronen zu den Grenzen des Sichtbaren'' and ''Good vibrations - mit Elektronen Musik Sehen'', SHUG Schleswig-Holsteinische Universitätsgesellschaft and CAU Program ''Uni kommt zur Schule''.

Multicomponent Materials

Currently, the Multicomponent Materials group headed by Prof. Franz Faupel (formerly Chair for Multicomponent Materials) participates actively in three Collaborative Research Centres (SFBs) and has third party funds of about 3,57 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, all of whom except one have been supported by external sources. Concerning the scientific output, more than 25 publications were published in international peer reviewed journals during the last year. Hence, only a few aspects of the present research can be discussed in the following.

Please refer to our website http://www.tf.uni-kiel.de/matwis/matv/ for further details 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.

A particularly outstanding result was the development of a new fully integrable magnetic field sensor which has been featured as a Research Highlight in ''Nature'' and numerous other 'newstickers' and journals including ''Advanced Engineering Materials'' and ''Physik Journal''. The sensor was developed within the Collaborative Research Centre SFB 855 on magneto-electric nanocomposites for medical applications together with other groups from electrical engineering (Prof. R. Knöchel) and materials science (Prof. E. Quandt and Prof. R. Adelung).

As in the year before, 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. This is why we were particularly pleased with the very positive re-evaluation of the Collaborative Research Centre SFB 677 ''Function by Switching'', which received funding for another four years with the possibility of a third extension. Our project ''Photoswitchable Metal-Polymer Nanocomposites'' received a top ranking. Many new results on the 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. The Collaborative Research Centre SFB 855 on magneto-electric nanocomposites for medical applications was already mentioned above in connection with our Research Highlight in Nature. Much research was also performed outside the three collaborative research centres, e.g. within the DFG priority program ''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 and the AIF.

The group was strongly involved in teaching and took great effort to inspire pupils for materials science and engineering in various ways including visits to schools in Schleswig-Holstein. After his deanship, Prof. Faupel took a sabbatical during WS 2010/2011.

Results

a) A fully integrable magnetic field sensing concept based on the delta-E effect

A vast range of modern technology, from cars to smartphones, is based on magnetic field sensors. To measure magnetic fields numerous principles are already known, each with its specific advantages and disadvantages. Parameters like size, weight, sensitivity and costs are of importance depending on the application of the sensor. We investigated a new sensor concept which is based on the so-called delta-E effect. This effect describes the softening of a magnetic material upon application of an external magnetic field. Such a material is for example the metallic glass FeCoSiB which is known to exhibit a high delta-E effect. To demonstrate our measurement principle, a commercial micro-cantilever made of Silicon was coated with FeCoSiB. The cantilever, which is usually utilized for atomic force microscopy, can be mechanically excited.

The resulting oscillation depends on the stiffness of the cantilever. Thus, the oscillation changes when the FeCoSiB coating softens due to the presence of a magnetic field. Accordingly, the magnetic field can be measured by monitoring the change in oscillation amplitude. This concept yields several advantages: it can detect a broad range of magnetic field frequencies, it needs no cooling since it operates at room temperature, and it is fully integrable, which makes it suitable for incorporation into existing micro-electronics. Our report on the sensor in *Applied Physics Letters* was featured by the highly renowned journal *Nature* as a research highlight due to the versatility of the concept. As mentioned above, the sensor was developed within the Collaborative Research Centre SFB 855.

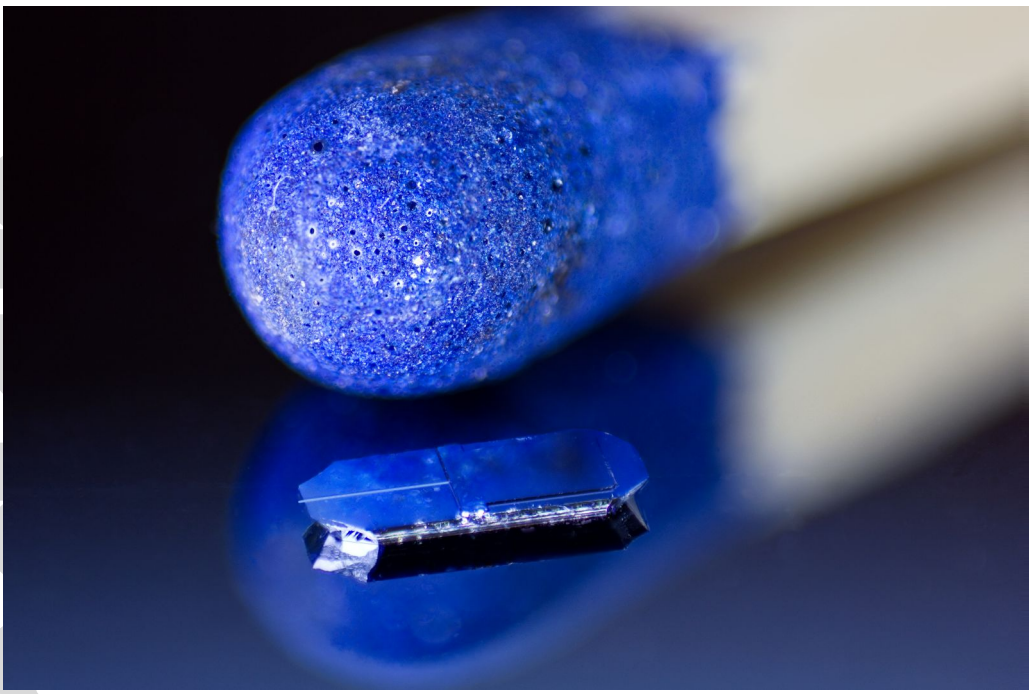

Fig. 1: The sensor is based on established MEMS technology, giving it high application potential. The 125μm long cantilever beam is barely visible on the left side of the chip.

b) Nanocomposites for functional applications

A main activity of our group during recent years has centred on 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, 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, 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 SFB TR 24. This trans regional collaborative research centre of the universities of Greifswald and Kiel addresses fundamentals of complex plasmas. As part of the 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 trans regional project. A gas aggregation cluster source (built in-house: see Almanac 2010) was used to deposit 5 nm small cobalt clusters with a very narrow size distribution. Silver clusters created by the cluster source were successfully embedded into a plasma polymer created by a RF plasma from Hexamethyldisiloxane (HMDSO) monomer. It was demonstrated that the silver clusters are not altered by the plasma process and that 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 for a joint project with Prof. Hynek Biederman from Prague University. Hosting a PhD student as a guest scientist from his group, we worked on the preparation and characterization of nanoparticles which were obtained by reactive sputtering of titanium with the gas aggregation cluster source (see Fig.2). It was observed that a small amount of oxygen is crucial for nucleation and growth of the nanoparticles. In an oxygen-rich environment, titania nanoparticles were generated that exhibited a very high photocatalytic activity. Current work now focuses on improving the mechanical stability of the coating for photocatalytic application.

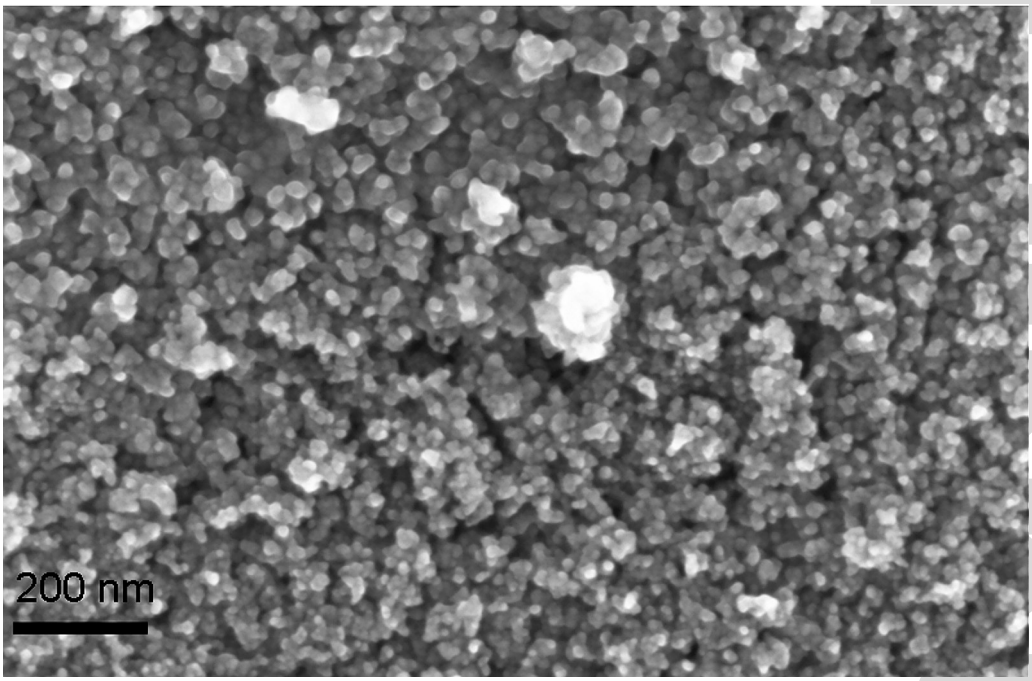

Fig. 2: Scanning electron micrograph image of titanium dioxide nanoparticle film deposited with the gas aggregation cluster source.

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 also his report) in the second funding period. Here, the nanocomposites are combined with photoswitchable molecules. These so-called chromophores change their properties 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. As described in the Almanac 2006 these resonances are collective oscillations of the conduction electrons in the electrical field vector of the electromagnetic radiation. Our recent major progress in this field is reported in many publications listed in the Almanac 2010 and below.

In several projects we explore the large specific surface area of the 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. In such coatings a high metal ion release rate is striven for because the antimicrobial activity originates from the released metal ions. This research has been supported by the World Gold Council and 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 studied in cooperation with PD Röhl from the Institute of Toxicity of the CAU. In addition, among other partners, we cooperate with Prof. Grundmeier from the Chemistry Department of the University at Paderborn in a joint DFG project.

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 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 against bacteria but non-toxic to human cells the situation is much more favourable at surfaces of silver containing nanocomposite coatings. Here, 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, were already killed at fairly low silver loadings. This, at first sight, surprising observation could be understood considering the different metabolisms of human cells and bacteria. The fast metabolism of bacteria gives rise to a significant reduction of the pH value of the surroundings. A lowered pH value leads in turn to an enhanced silver release from the coating (see Fig. 3). Thus, due to their fast and acidic metabolism bacteria themselves induce the locally increased silver release rate that finally kills them. Human cells, on the other hand, survive on a similar coating thanks to their comparatively slower metabolism. This naturally occurring larger therapeutic window is advantageous for the biocompatibility of nanocomposite coatings for implants or other medical devices.

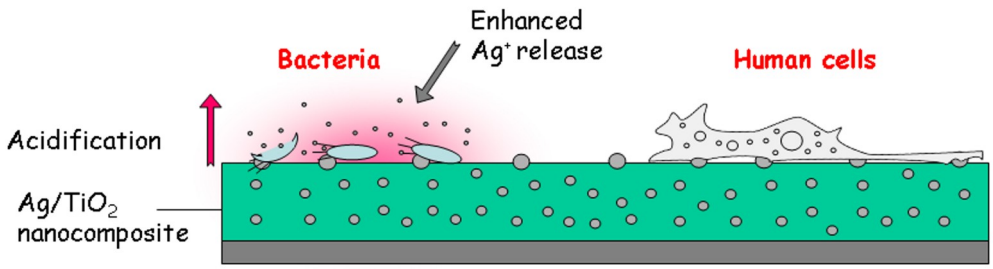

Fig. 3: Sketch of working principle of antimicrobial Ag/TiO_2 nanocomposite coating. Cells grow on the coating while the metabolism of bacteria leads to enhanced silver release and death of bacteria.

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 who initiated some exciting new applications pursued together with our group.

c) Storage stability of epoxies

Epoxies are versatile adhesives with many applications from automotive industry to hobby sailing boats. Usually, the two components of an epoxide, namely resin and hardener, are mixed immediately before use. This mixing can deteriorate the properties of an epoxy due to inclusions of air bubbles or inhomogeneous and non-stoichiometric compositions. The project "Nanomodule" funded by the Ministry of Education and Research (BMBF) aimed at the development of *one-component systems* which circumvent this problem by releasing a reaction initiator into the mixture of resin and hardener during first heating. The initiator is carried by nanoparticles, the so-called module. Suitable module/initiator combinations were tested and led to several promising cured systems which were selected for subsequent optimization. However, the mechanisms determining storage stability of non-reacted mixtures at room temperature were not understood. Within the BMBF project, among other subjects, we monitored changes in microscopic free volume during crosslinking in order to investigate the curing reaction. Based on positron annihilation lifetime spectroscopy (PALS, see Almanac 2009) we developed a method to follow the reaction in-situ at elevated temperatures. A mathematic model was introduced to extrapolate the experimental results to room temperature. Comparison with reference measurements at room temperature confirmed the reliability of our approach. Thus we could significantly contribute to the development and the understanding of one-component epoxides with improved performance.

c) Metallic glasses and glass forming undercooled metallic 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 recent years, we have 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.

d) Polymer-solid contacts

Within the DFG priority program "Polymer-solid contacts: Interfaces and Interphases", which was co-initiated by Prof. Faupel, we studied the structure and formation of interfaces between plastic and solid materials like metals and ceramics, which are important in many technical 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 Functional nanocomposites	01.01.-31.12.2011	Fellowship Iran
M.Sc. N. Alissawi Ag-ion transfer	01.01.-31.12.2011	DFG
M.Sc. S. W. Basuki Diffusion in complex melts	01.02.-31.12.2011	DFG
M.Sc. V.S.K. Chakravadhanula TEM	01.-14.07.2011	DFG
Dipl.-Phys. B. Gojdka Magneto-electric nanocomposites	01.01.-31.12.2011	SFB 855, CAU
Dipl.-Phys. S. Harms Polymer-solid interfaces	01.01.-31.12.2011	DFG SSP 1369
M.Sc. B. Henkel Functional nanocomposites	01.10.-31.12.2011	BMBF
Dipl.-Phys. T. Hrkac Functional materials	01.01.-30.11.2011	BMBF, BMWI, CAU
Dr. S. Jebril PolyMet	01.01.-30.09.2011	BMWI
M. Sc. M. Keshavarz Hedayati Optical nanocomposites	01.01.-31.12.2011	CAU, with Prof. Elbahri

M.Sc. T. Koschine Positron beam, polymers	01.01.-31.12.2011	BMBF
M.Sc. A. Kulkarni Functional nanocomposites	01.01.-31.12.2011	SFB 677, CAU
Dipl.-Ing. K. Meurisch Magneto-electric nanocomposites	01.01.-31.12.2011	CAU, SFB 855
M.Sc. C. Ohrt Polymer-Solid-Interphases	01.08.-31.12.2011	DFG SPP 1369
Dipl.-Chem. C. Pakula Functional nanocomposites	01.01.-31.10.2011	SFB 677
Dipl.-Phys. T. Peter Nanoparticles from plasmas	01.01.-31.12.2011	SFB TR24
M.Sc. O. Polonsky Nanoparticles from plasmas	01.09.-30.11.2011	SFB TR24, visiting scientist
Prof. Dr. K. Rätzke Supercooled melts, positron annihilation	01.01.-31.12.2011	CAU
M.Sc. V. Schneider Photoswitchable Nanocomposites	01.-31.12.2011	SFB 677
M.Sc. M.Q. Shaikh Free volume in epoxies	01.01.-30.03.2011	visiting scientist
Dr. T. Strunskus Functional nanocomposites	01.01.-31.12.2011	SFB 855
M.Sc. J. Xiong Functional nanocomposites	01.01.-31.12.2011	Fellowship China
Dr. V. Zaporojtchenko Functional nanocomposites	01.01.-31.12.2011	CAU

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

Werkstoffe (Metalle), 2 (+ 1) hrs Lecture (+ Exercises)/Week,
M. Keshavarz Hedayati

Advanced Organic Materials, 2 hrs Seminar/Week,
T. Strunskus

Übungen zur Physik I, 2 hrs Seminar/Week,
K. Rätzke

Advanced Materials A - Metals, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
K. Rätzke (+ N. Alissawi)

Advanced Materials A - Polymers, 2 (+ 1) hrs Lecture (+ Exercises)/Week,

T. Strunskus (+ D. Gedamu)

Thin Films II, 2 (+1) hrs Lecture (+ Exercises)/Week,
K. Rätzke (+ T. Peters)

Einführung in die Materialwissenschaft 1, 2 hrs Lecture/Week,
K. Rätzke (+ O. Riemenschneider)

Summer 2011

Advanced Solid State Physics, 2 hrs Seminar/Week,
K. Rätzke

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

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

Third-Party Funds

DFG SFB 677/1, *Funktion durch Schalten: Kombination von schaltbaren Polymeren und Nanokompositen nahe der Perkolationsschwelle,* 01.07.2007-30.06.2011 (237.600 Euro)
DFG SFB 677/1, *Funktion durch Schalten: Komposite aus Polymermatrix und ferromagnetischen Formgedächtnis-Nanopartikeln als magnetische Schalter,* 01.07.2007-30.06.2011 (211.640 Euro)
DFG, *Einfluss der Verhinderung der Kollagen-Degradation durch MMPs auf den Dentin-Klebeverbund,* 04.10.2007-31.01.2011 (25.944 Euro)
DFG, *Verteilung des Freien Volumens an Polymer-Festkörper-Grenzflächen,* 04.04.2008-04.04.2011 (245.970 Euro)
DFG, *Magnetic nanocomposites for rf applications in mobile communication,* 15.09.2008-07.10.2011 (129.566 Euro)
DFG, SFB TR24, *Grundlagen komplexer Plasmen: Plasmaprozesse zur Abscheidung von nanostrukturierten Kompositmaterialien,* 01.07.2009-30.06.2013 (287.640 Euro)
AIF, *PolyMet-Polymer-Metalloxid-Kompositschichten für flexible optische Schichtsysteme,PolyMet-Kiel: Polymer-Metalloxid-Schichtabscheidung und Charakterisierung,* 01.11.2009-31.10.2011 (175.000 Euro)
DFG SFB 855, *Magnetoelektrische Verbundwerkstoffe - biomagnetische Schnittstellen der Zukunft: Gasphasenabscheidung von magnetoelektrischen 0-3 Nanokompositen,* 01.01.2010-31.12.2013 (635.280 Euro)
DFG, *Ion transfer reactions at Ag-nanoparticle/polymer interfaces,* 17.02.2010-17.02.2012 (190.424 Euro)
BMBF, *Nano-Purification - Entwicklung fortschrittlicher Materialien und Verfahren zur Wasser- und Abwasserbehandlung mittels funktioneller Nanokomposite,* 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, *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)
AvH, *Stipendium für Prof. Dr. Amita Chandra für 1 Monat,* 26.05.-20.06.2011 (2.300 Euro)
DFG SFB 677/2, *Funktion durch Schalten: Photoschaltbare Metall-Polymer-Nanokomposite,* 01.07.2011-30.06.2015 (363.220 Euro)
KHS Plasmax GmbH, *Untersuchung diverser Beschichtungen auf PET Proben mit Hilfe der Photonenelektronenspektroskopie (ESCA),* 26.09.-24.10.2011 (1.870 Euro)
Wöhlk-contact-Linsen GmbH, *Untersuchung einer Beschichtung auf Silikonkautschuklinsen,* 18.-28.10.2011 (330 Euro)
Condias GmbH, *Analyse von NbC-Schichten,* 01.03.-30.04.2011 (500 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. 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 Technology 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, AInorganic Chemistry, Kiel University, and other partners, NEXAFS investigations at the Berlin synchrotron BESSY, Berlin

Dr. Chr. Hugenschmidt, TU Munich and FRM II, NEPOMUC

Prof. Dr. M. Kern, Dental Clinic, Kiel University, Antibacterial Coatings

Prof. R. Knöchel, Institute for Electrical Engineering and Information Technology, magnetic high frequency materials (DFG project)

Prof. Dr. P. Müller-Buschbaum, Technical University Munich, PALS-Thin Films and preparation of DFG propoposal ''Growth of sputtered metal on organic surfaces'' with Roth (DESY)

Prof. Dr. R. Podschun, Institute for Infection Medicine, Kiel University, Antibacterial Coatings

Prof. Dr. W. Possart, Saarbruecken University, BMBF project Nanomodule

Prof. Dr. E. Quandt, Inorganic Functional Materials, Faculty of Engineering, Functional magnetic 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

Dr. Y. Serfert, Food Technology, Kiel University, XPS measurements

Prof. Dr. C. Staudt, Düsseldorf, Block copolymers

Prof. Dr. F. Tuczek, Institute for Inorganic Chemistry, Kiel University,, Self-assembled monolayers

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

PD Dr. A. Hartwig, Fraunhofer Institute for Manufacturing Technology and Advanced Materials (IFAM), Bremen, PALS on functionalized nanoparticles

Prof. Dr. A. Meyer, Dr. Fan Yang, DLR, Köln, Diffusion in glass forming metallic melts

Dr. Thomas Neubert, Fraunhofer-Institute for Surface Engineering and Thin Films (IST), Braunschweig, Polymer-metal oxide composite layers for flexible optical coating systems

Dr. G. Schneider, FRZ Jülich und FRM II, silica nanocomposites

Industry:

Condias GmbH, Itzehoe, Characterisation of NbC layers

KHS Plasmax GmbH, Coatings on PET samples

Partners in AIF project Polymet:

plastic-design GmbH, Bad Salzuflen

Rolf Schäfer Beschichtungskomponenten, Münchweiler

Wohlrab Aufdampftechnik GmbH, Langenzenn

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 and Master Theses

S. Rößler, *Lichtinduzierte schaltbare Effekte in leitfähigen Polymeren*, 25.01.2011
N.C. Aslandere, *Investigation of the Silver and Cobalt Thin Films deposited by a Cluster Source*, 15.02.2011
S. Dollinger, *Positronen-Annihilations-Lebensdauer-Spektroskopie zur Bestimmung des freien Volumens in Epoxid-Silica-Nanokompositen*, 21.03.2011
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I. Kocabas, *Study of Silver Ion release from two dimensional (2D) Silver-Gold Nanoparticle Array*, 01.08.2011
B. Gothe (extern), *Synthese von langzeitstabilen, siebdruckfähigen Sol-Gel-Lacken für dekorative Kochfeldbeschichtungen*, 02.09.2011
T. Waldmann (extern), *Entwicklung eines Herstellungsprozesses für Folien aus Titan über die Pulvermetallurgische Route sowie die Analyse und Optimierung der Materialeigenschaften*, 14.11.2011
T. Jurgeleit (extern), *Chemische Reinigung von KRS-5 Kristallen durch erneutes Aufschmelzen mit Zusatzstoffen*, 14.11.2011
Y. Mekonnen, *Multi-walled Carbon Nanotube based photo-switchable sensors*, 24.11.2011
H. Cárdenas (extern), *Characterization of Thermal Cyclic Deformation Behavior of Nuclear Power Plant Components as a Contribution to Fatigue Assessment*, 12.12.2011

Dissertations / Postdoctoral Lecture Qualifications

V.S.K. Chakravadhanula, *Vapor phase deposition of functional nanocomposite thin films and their modification by ion beam irradiation*, 21.04.2011
C. Pakula, *Untersuchung Chromophore enthaltender Polymer/Metall-Nanokomposite für elektro-optische Anwendungen*, 03.11.2011
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F. Faupel, *Neue Werkstoffe durch Nanotechnologie (Invited talk)*, Johann-Heinrich-Voss-Schule, Eutin, Germany, 17.-17.01.2011
T. Strunskus, *Funktionelle Nanokomposite (Invited Talk)*, NINa 14. Schwerpunkttreffen, Itzehoe, Germany, 23.-23.02.2011
T. Peter, M. Wegner, S. Bornholdt, V. Zaporojtchenko, T. Strunskus, H. Kersten, F. Faupel, *Nanocomposite thin films prepared by plasma polymerization and high pressure magnetron sputtering (Poster)*, Plasmatechnologie PT 15, Stuttgart, Germany, 28.02.-02.03.2011
F. Faupel, A. Bartsch, K. Rätzke, A. Meyer, *Dynamic Arrest in Multicomponent Glass Forming Alloys (Invited talk)*, Internationaler Workshop ''Nonlinear Response of Soft Matter'', Konstanz, Germany, 28.02.-01.03.2011
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V. Zaporojtchenko, C. Pakula, T. Strunskus, S. W. Basuki, R. Herges, F. Faupel, *Metal-MWCNT/polymer nanocomposite thin films with reversible photoswitchable properties (Talk)*, E-MRS Spring Meeting, Nizza, France, 09.-13.05.2011

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T. Hasegawa, T. Strunskus, V. Zaporojtchenko, F. Faupel, M. Mizuhata, *Solvent effect on optical properties of solvated Nafion membrane with Ag dispersion by photoreduction (Poster)*, 59th Materials tailoring, Karuizawa, Japan, 25.-29.07.2011

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T. Strunskus, T. Peter, V. Zaporojtchenko, F. Faupel, *Preparation of nanocomposite films by cluster beam deposition and plasma polymerization (Talk)*, Internationaler Workshop des TR 24, Potsdam, Germany, 26.-28.09.2011

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M. Keshavarz Hedayati, F. Faupel, M. Elbahri, *Plasmonic metamaterials: From high transparency to complete absorption of light (Poster)*, 491. Wilhelm und Else Heraeus-Seminar, Bad Honnef, Germany, 16.-19.10.2011

S. Harms, K. Rätzke, F. Faupel, *Freies Volumen in Polymer-Festkörper Interphasen und in Nanokompositen (Invited talk)*, DGM Fachausschuß, Dautphetal, Germany, 03.-04.11.2011

T. Hrkac, V. Zaporojtchenko, T. Strunskus, R. Podschun, C. Röhl, D. Garbe-Schönberg, F. Faupel, *Evaluation der antimikrobiellen und zytotoxischen Wirksamkeit von Silber/Titandioxid-Nanokompositschichten (Poster)*, DGBM (Deutsche Gesellschaft für Biomaterialien) Jahrestagung, Gießen, Germany, 10.-12.11.2011

M. Keshavarz Hedayati, *A smart plasmonic transparent conductor with a gas sensing ability (Talk)*, Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research, Geesthacht, Germany, 11.11.2011

F. Faupel, *Neue Werkstoffe durch Nanotechnologie (Invited talk)*, SHUG, Brunsbüttel, Germany, 23.11.2011

V. Zaporojtchenko, C. Pakula, S. W. Basuki, T. Strunskus, D. Zargarani, R. Herges, F. Faupel, *Photoswitchable Polymer Nanocomposites (Talk)*, MRS Fall Meeting, Boston, United States of America, 28.11.-02.12.2011

A. Kulkarni, H. Greve, V. Zaporojtchenko, T. Strunskus, E. Quandt, F. Faupel, *Self Organized Formation of High Frequency Magnetic Nanocomposites by Vapor Phase Deposition (Poster)*, MRS Fall Meeting, Boston, United States of America, 28.11.-02.12.2011

F. Faupel, *Metal-Polymer nanocomposites for functional applications (Invited talk)*, 2nd International Conference on Advanced Nanomaterials, Guwahati, India, 08.-10.12.2011

K. Rätzke, *Diffusion und freies Volumen in amorphen Werkstoffen (Invited talk)*, Werkstoffwissenschaftliches Kolloquium, Saarbrücken, Germany, 13.12.2011

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 *encyclopedia 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 programme committee of the DFG SPP 1369 Priority Program *''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 steering committee of the CAU Focal Point of Support ''Nano and surface science'',

Member of the steering committee Quality Management of the CAU,

Member of KARE *(Kiel Alliance of Research and Education)*,

Member of the organizing committee of the German-Czech Workshop ''Formation of Nanoparticles in Plasmas'' (SFB TR24),

Member of the international advisory committee of the 5th International Conference on Electroactive Polymers: Materials and Devices (ICEP-2012),

Member of curatorship ''Holsteiner Studienpries''

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.

Highlights:

The work „Fully integrable magnetic field sensor based on delta-E effect" by B. Gojdka et al., Appl. Phys. Lett. 99, 223502 (2011), was presented as a Research Highlight in the journal Nature, 480, 155 (08 December 2011).

Nanochemistry and Nanoengineering

The Nanochemistry and Nanoengineering group 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 the environment are highly active research areas in our group. Recently, we developed new concepts for water filtration and purification using electrospun nanofibres. ''Plasmonic Nanocomposites'' as a novel concept of metamaterials for designing a transparent conducting metal and for energy harvesting applications are also being developed by us in collaboration with Prof. Faupel's research group (''Multifunctional Materials''). Also, we introduced the first photo-switchable transparent conductor with a selective photo-bleaching gas nose as a multifunctional device. Concerning achievements and publications, several patents (US and EP) have already been accepted and newly registered. Moreover, several articles have already been published in highly prestigious journals such as ''Advanced Materials'' (three articles). One of our works is featured as a frontispiece in ''Advanced Materials'' (given for outstanding results) and two invited reviews in ''Advanced Materials'' and ''Applied Physics A'' are being written by us. The PhD student ''Mehdi Keshavarz Hedayati'' won the $500 student cash prize, SPP5, Seoul National University in Seoul, Korea. This prize was awarded to him due to the high grade of his publication in plasmonics of which he was the first author. In addition, one of our researches on the topic of the nanostructured membranes carried out by Dr. Shahin Homaeigohar was selected in 2012 to be the cover page of ''Materials Today''.

Prof. Elbahri's research group has received much attention from the international community and he has been nominated for the Eni Award 2012 (Sustainable Energy). Moreover, he has been invited for several talks at reputable international conferences such as MRS (Materials Research Society) spring meeting (April 2012, San Francisco, California), META12 (the 3rd International Conference on Metamaterials, Photonic Crystals and Plasmonics) in France (the most important conference for metamaterials and Plasmonics) and Nanofair 2012 in Germany.

Results

a) Electrospun nanofibrous membranes for water filter

During the course of the last decade, efforts to achieve energy saving membranes for water treatment have increased tremendously and have recently employed solutions based on electrospun nanofibrous membranes (ENMs). Despite an extraordinary permeability, such membranes suffer from low mechanical stability, are also hydrophobic, and are usually as poorly selective as microfiltration (MF) membranes. Indeed, these membranes, owing to their micro-sized pores are able to capture only coarse suspended solids rather than nano sized substances.

Permeability and selectivity of the electrospun nanofibrous membranes (ENMs) are influenced by their structural characteristics including mechanical stability, wettability, and pore size range. Such membranes, due to a high surface area and porosity, are usually weak and non-wettable, lowering their permeability: they also possess a big pore size restricting the selectivity. In our study, the mechanically weak and low wettable electrospun nanofibrous membranes are modified, benefiting from a nanocomposite strategy using zirconia and titania nanoparticles. When using zirconia nanoparticles, the membranes show an optimum mechanical performance but not hydrophilic behaviour. Addition of titania nanoparticles through a sol-gel approach was successful in meeting both the requirements i.e. mechanical stability and high wettability. Such modifications were significantly influential on the permeability of the nanofibrous membranes.

Mechanically stable ENMs can preserve their intact porous structure during filtration. In addition, high hydrophilicity leads to a lower resistance to water flow passing through the membrane. Water flux measurements (Fig. 1a, b) show a significantly ascending trend for the zirconia reinforced PES ENMs. These results prove that addition of inorganic filler considerably enhances the permeability of the ENMs during filtration.

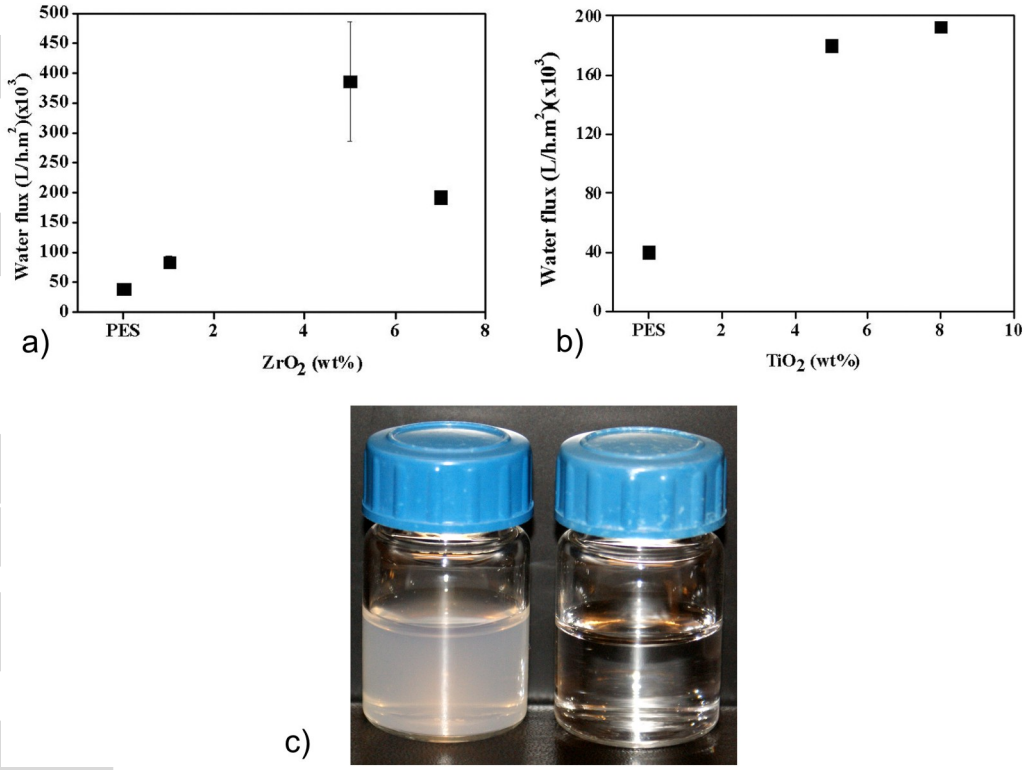


Fig. 1: a, b) Water permeability of the nanocomposite nanofibrous membranes
c) Filtration of an inorganic (titania) aqueous nanosuspension using electrospun nanofibrous membranes, (left) before filtration; (right) after filtration

In term of selectivity, the ability of the membranes was promoted from a microfiltration domain to an ultrafiltration one via a bio-functionalization approach. Indeed the applicability of electrospun nanofibrous membranes is revolutionized when they are able to perform beyond a MF membrane, capturing not only coarse suspended solids but also nanosolids much smaller than the pore size. Bio-functionalization through protein (BSA in our study) immobilization brings about such an optimum characteristic.

As a proof of the concept, 40 nm metal nanoparticles containing aqueous suspensions were filtered. While the neat PANGMA ENM is able to reject a negligible part (1.5 %) of the 40 nm Au nanoparticles, the bio-functionalized ENM rejects 72.5% of the nanoparticles of the same size. The retention efficiency for 80 nm nanoparticles is even higher, being 97%.

Electrospun nanofibrous membranes are pioneering a new generation of energy saving membranes. While, they possess an extraordinary permeability hence a very low energy consumption, they are able to separate optimally a broad range of suspended solids and solutes including inorganic micro/nano particles, microorganisms, oil, protein etc., from waste water systems. As an example shown in Fig.1 c, d, a polyethersulfone ENM developed in our group is successful in the separation of 100% of the inorganic nanoparticles from an aqueous suspension while maintaining a high water permeability.

b) Transparent conductor based on plasmonic nanocomposite

Transparent conductors (TCs), which are integral components in flat panel displays, solar cells, and smart windows, deliver electrons to, or collect them from, the active part of the device while at the same time allowing visible photons to pass through. Nowadays, ITO and other transparent conductive oxides (TCO) are mainly used. Trends to fabricate a transparent metal with conductivity greater than ITO that possesses high optical transparency seem to be tricky. Metal/polymer nanocomposites showing some interesting optical properties seem to be the worst candidates for TC development owing

to their strong absorption and reflection in the visible region. In our lab, we have recently developed an omnidirectional TCM by coating a metal film on a glass substrate with a thin layer of metal/polymer (Ag/PTFE) nanocomposite. Since the dielectric constant of polytetrafluoroethylene (PTFE) is lower than that of glass it was used as the host matrix for composite deposition. To have a high electrical conductivity, a base layer was fabricated by the sputtering of a 25-nm gold film onto fusion glass, although the film is highly reflective in the near-IR to mid-IR range. 20-nm silver/PTFE nanocomposites with different volume filling factors in the range of ~7-23%, were deposited onto the gold film by a co-sputtering deposition technique. The preparation was carried out in cooperation with the group of Prof. Faupel (see Multicomponent Materials, this Almanac). The experimental results showed that one can enhance significantly the transparency of the metal film by this coating. Figure 2a shows the transmission spectra of the stacks consisting of 20nm nanocomposite with different filling factor on a thin gold film (around 25nm thick). It was observed that the reflection drop of the stacks happens at the same wavelength of the transmission peak, which is a clear sign of evanescent coupling of plasmon resonance on both sides of the metal film. This postulation was further improved when the reflection of the sample from both sides (composite and glass substrate) was measured. Besides the interesting optical properties, electrical measurement of the system showed that the electrical conductivity of such a stack is an order of magnitude greater than that of ITO, which demonstrates its potential as a new transparent conductive metal. However, the challenge is to fabricate a composite with a condition such that its effective dielectric is similar to that of the glass substrate (requirement of evanescent coupling). This problem is difficult to overcome since small changes in deposition parameters will significantly affect the overall response of the films and indeed such difficulty recently resulted in the lack of reproducibility of our developed system. Therefore, at the moment we are dealing with this problem to facilitate the fabrication of such a composite by increasing the fabrication tolerance of the coating and reproducing the former results.

c) Plasmonic perfect absorber

In the last few years due to the great advances in nanotechnology, many reports were published trying to miniaturize the perfectly black absorber (possessing total absorption) for solar and sensoric purposes. However, so far most of the developed methods (perforated metallic films, grating structured systems, and metamaterials) are costly and suffer from a lack of flexibility. Moreover, their absorbance is restricted to a narrow spectral range, which makes their application for a broad range of frequencies impossible. In our research group, we demonstrate the design, fabrication, and characterization of a perfect plasmonic absorber in a stack of metal and nanocomposite; this shows almost 100% absorbance over a broad range of frequencies from ultraviolet to the near-infrared. Our system is composed of an ultra-thin nanocomposite and a metal film that are separated from each other by a thin dielectric layer. The composite is near percolation threshold (possessing both localized and delocalized plasmon modes) and the base film is optically thick enough to block the light passage. Figure 2b shows the schematic geometry of the black absorber realized in this work as an inset along with the absorption and reflection spectra of the device in the visible region. The structure is composed of (from bottom to the top) a glass substrate coated with an optically thick metallic film (Au) followed by a thin dielectric layer (SiO_2) acting as the spacer layer and at the very top, a thin (20 nm), nearly percolated film of nanocomposite (Au/SiO_2). Indeed, this coating can be applied onto any kind of substrate even flexible ones (see Figure 2c: Frontispiece of Advanced Materials), demonstrating the versatility and applicability of this system on any kind of substrate. It is known that anti-parallel currents will be excited in the nanoparticles (embedded within the nanocomposite) and the bottom layer. Essentially, this is called a magnetic resonance for the reason that the circulating currents result in a magnetic moment that can interact robustly with the magnetic field of the incident light. Therefore, a strong enhancement of the localized electromagnetic field is established in the spacer layer and consequently no light is reflected back. Having used a base layer with sufficiently large thickness to block the light from passing through, along with the trapping of the light and suppressing reflection, the incident light will be obstructed completely and this makes the system a perfect absorber.

Our developed structure, besides being highly light absorbent, is almost insensitive to the angle of incidence of light. Even though there is a drop in absorption up to an angle of 60°, the drop is not large and the overall absorption still remains around 90% in a broad range of the spectrum, which shows the potential use of this system as a solar absorber. The preparation was again carried out in cooperation with the group of Prof. Faupel (see Multicomponent Materials, this

Almanac).

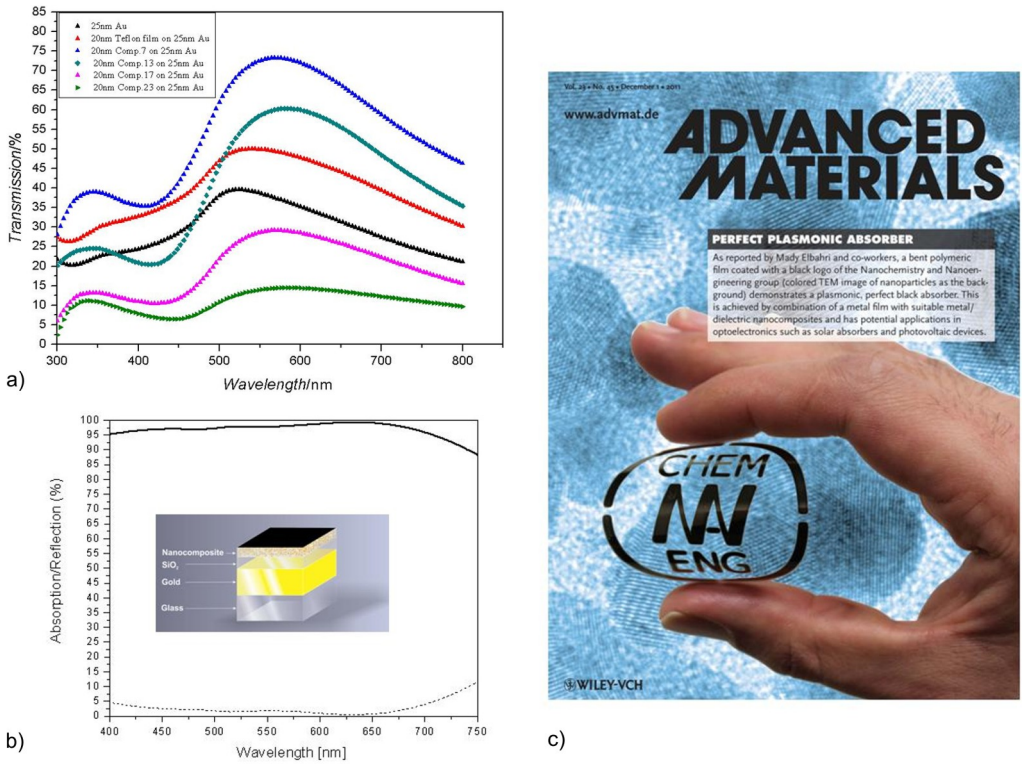


Fig. 2: a) Transmission spectra of nanocomposite with different filling factor on a 25nm gold film along with bare (black curve) and the PTFE coated (red curve) gold film.

b) Absorption (solid line) and reflection (dashed line) spectra of 20 nm Au/SiO_2 nanocomposite deposited on a 100 nm gold film with 25 nm SiO_2 spacer layer (black curves) measured at 6 degree angle of incidence. The inset represents schematically the perfect absorber structure manufactured by sputtering. The thickness of the nanocomposites, SiO_2 spacer and the gold mirror are 20, 25 and 100 nm respectively.

c) Frontispiece of Advanced Materials which featured our work in its December issue. The image is composed of two parts: the background is the TEM image of the composite, and the foreground is the demonstration of how the developed material could be coated on a flexible polymer substrate.

d) Smart photoswitchable plasmonic device

Smart materials that react to a stimulus or their surroundings to create a dynamic and reversible change in critical properties are in the focus of current research. Among numerous stimuli, photochromism is drawing great attention due to its probable applications in molecular switching, lenses, and data storage among others. Generally, photochromic molecules can turn any composite into a smart system if the host matrix is soft enough (e.g. a polymer) to let the molecule rotate upon illumination. In our group, we made use of this potential of photochromic molecules and showed the first photoswitchable transparent conductor that works via nanophotonic interaction. It is a sputtering-deposited metal film spin-coated with spirophenanthrooxazine (SPO) molecules embedded in a polymeric matrix. Transmission improvement up to 100% (relative to the intrinsic value of a thin metal film) is achieved and can be diminished upon UV light illumination. The transmission enhancement of our developed structure is attributed to the strong interaction of polarized molecules and the base metal film. The induced charged from the coating onto the mirror differs depending on the concentration of molecules. We have found that at a certain concentration, the plasmon wave vector of the film and the wave vector of the incident light match and consequently lead to a drop in reflection. Therefore, the transmission of the stacks increases while having good electrical conductivity, which demonstrates a smart transparent conductive film. Figure 3a and 3b show

the transmission and reflection of the system. Besides the transmission enhancement, the switching between high optical transparency and absorption via visible and UV irradiation demonstrate the smart functioning of our photonic device. Although the recovery time of the stacks from open form to close form normally takes almost one day, we reduced it enormously to a few seconds by exposing the device to certain organic vapours, demonstrating a photobleaching gas sensor. Figure 3c shows the photograph of our coating before and after UV irradiation showing a transparent and dark blue sample, respectively. In Figure 3d the different response times of our device to some organic vapours is shown, demonstrating the fast recovery of the system as well as the gas sensoric behaviour of device.

At the moment, we are trying to implement our idea using other metals that possess plasmon resonances at visible wavelengths, especially gold. The initial results are promising but further work is required to draw a feasible conclusion about such a system.

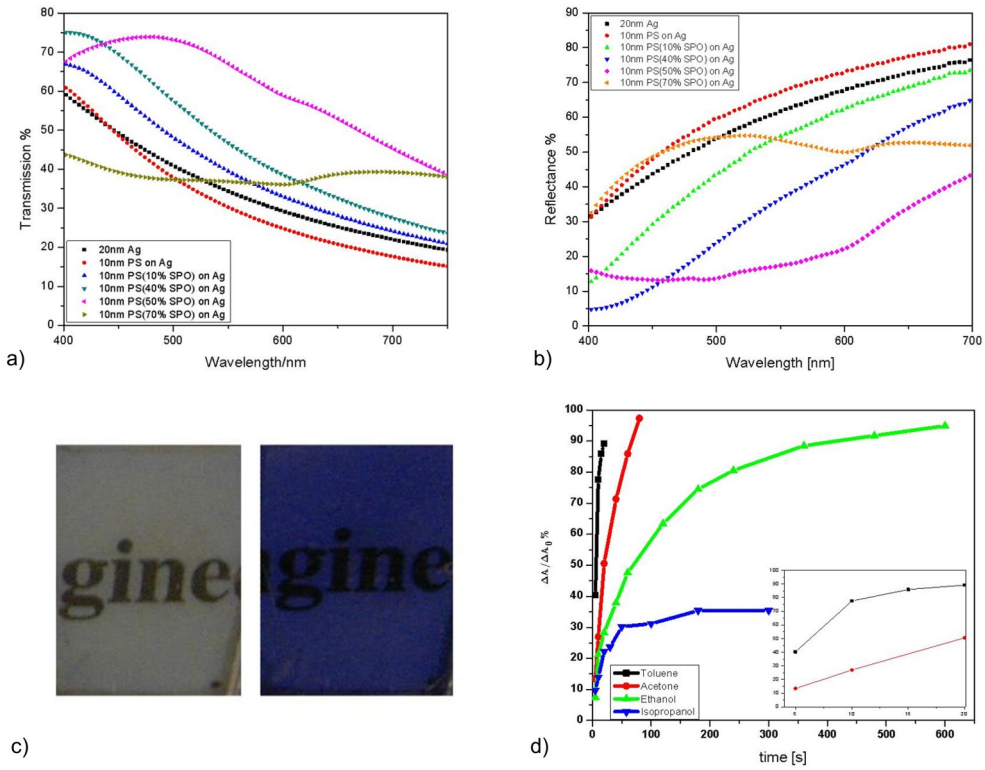


Fig. 3: a) Transmittance spectra of 20 nm silver film coated with 10 nm PS doped with 20 vol%, 50 vol%, and 70 vol% SPO. The uncoated 20 nm silver film and the 10 nm PS film coated on a 20 nm silver film are shown as references.
b) Reflectance spectra of a 20 nm silver film coated with 10 nm PS doped with 20 vol%, 50 vol%, and 70 vol% SPO. The uncoated 20 nm silver film and the 10 nm PS film coated on a 20 nm silver film are shown as references.
c) Photos of the 20nm silver film coated with 10nm PS (50 vol% SPO) before UV illumination (left) and after UV illumination (right).
d) Photobleaching of a sample containing 50% SPO in the presence of different chemical vapours. ΔA is the difference between maximum absorption and absorption at time t, $\Delta A0$ is the difference between maximum absorption and initial state. Inset shows the magnification of the graph of Toluene (black) and Acetone (red)

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.-31.12.2011	SFB 677, CAU Grant
M.Sc. D. Disci Nanofabrication for Bio.	01.01.-31.12.2011	DFG, SFB 677
Dr. K. Ganesan Smart Materials	01.01.-14.03.2011	CAU, SFB 677
Dr. S.S. Homaeigohar Nanofibers for Filtration	01.01.-31.12.2011	HZG, DAAD, HGF
M.Sc. M. Keshavarz Hedayati Plasmonic materials	01.01.-31.12.2011	DFG, CAU
Dr. M. Rakib Polymeric optoelectronic	01.04.-31.12.2010	HGF, HZG
M.Sc. J. Worley Bionanotechnology	01.01.-31.12.2011	HGF
M.Sc. A.U. Zillohu Photonic nanomaterials	01.04.-31.12.2010	HZG, DAAD, HGF

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

Nanochemistry for Nanoengineering, 2 hrs Lecture/Week,
M. Elbahri

Nanochemistry for Nanoengineering - Seminar, 1 hrs Seminar/Week,
M. Elbahri

Werkstoffe (Metalle), 2 hrs Lecture/Week,
M. Keshavarz Hedayati

Winter 2011/2012

Nanochemistry for Nanoengineering, 2 hrs Lecture/Week,
M. Elbahri

Nanochemistry for Nanoengineering - 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-Plat''*, 01.08.2009-27.09.2012 (280.370 Euro)
Uni Kiel, *Verlängerung Promotionsstipendium für Ramzy Abdelaziz für 1 Jahr*, 01.08.2010-31.07.2011 (13.200 Euro)
DAAD, *Stipendium zur Promotion für Ahnaf Usman Zillohu*, 01.04.2010-01.04.2011 (12.096 Euro)

DFG SFB 677, *Funktion durch Schalten: Anschubfinanzierung für Projekt ''Photoschaltbare multifunktionale Nanofaser''*, 01.07.-31.12.2010 (35.600 Euro)
DAAD, *Verlängerung Stipendium zur Promotion für Ahnaf Usman Zillohu für 1 Jahr,* 01.04.2011-31.03.2012 (12.096 Euro)
DFG SFB 677, *Funktion durch Schalten: Photoschaltbare Metall-Polymer-Nanokomposite,* 01.07.2011-30.06.2015 (228.470 Euro)
DFG SFB 677, *Funktion durch Schalten: Multifunktionale photoschaltbare Polymerfasern,* 01.07.2011-30.06.2015 (255.720)

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 with 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

Diploma, Bachelor and Master Theses

N. Ahmad, *Wet Chemical Systhesis of Zinc Oxide Nanoparicles for Photocatalytic Applications,* 15.02.2011
B. Mozooni, *Perfect absorber plasmonic metamaterial based nanocomposite,* 16.12.2011

Dissertations / Postdoctoral Lecture Qualifications

S. Homaeigohar, *Functional Electrospun Nanofibrous Membranes for water filtration,* 16.12.2011

Publications

Published in 2011

S.S. Homaeigohar, H. Mahdavi, M. Elbahri, *Extraordinarily water permeable sol-gel formed nanocomposite nanofibrous membranes,* Journal of Colloid and Interface Science, DOI: 10.1016/j.jcis.2011.09.042, **366 (1)**, 51 - 56 (2011)
M. Keshavarz Hedayati, M. Javaherirahim, B. Moyzooni, R. Abdelaziz, A. Tavassolizadeh, V.S.K. Chakravadhanula, V. Zaporojtchenko, T. Strunskus, F. Faupel, M. Elbahri, *Design of a Perfect Black Absorber at Visible Frequencies UsingPlasmonic Metamaterials,* Advanced Materials (also Frontispiece), **23**, 5410 - 5414 (2011)

H.T. Beyene, V.S.K. Chakravadhanula, C. Hanisch, T. Strunskus, V. Zaporojtchenko, M. Elbahri, F. Faupel, *Vapor Phase Deposition, Structure, and Plasmonic Properties of Polymer-Based Composites Containing Ag-Cu Bimetallic Nanoparticles,* Plasmonics, 1 - 8 (2011)

M. Jamali, M. Keshavarz Hedayati, A.U. Zillohu, M. Elbahri, *Photoresponsive Transparent Conductive Metal with a Photobleaching Nose,* Advanced Materials, **23 (37)**, 4243 - 4247 (2011)

M. Elbahri, M. Keshavarz Hedayati, V.S.K. Chakravadhanula, M. Jamali, T. Strunskus, V. Zaporojtchenko, F. Faupel, *An Omnidirectional Transparent Conducting-Metal-Based Plasmonic Nanocomposite,* Advanced Materials, **23 (17)**, 1993 - 1997 (2011)

T. Dai, N. Miletic, K. Loos, M. Elbahri, V. Abetz, *Electrospinning of Poly(acrylonitrile-co-glycidyl methacrylate) Nanofibrous Mats for the Immobilizatio of Candida antarctica Lipase B,* Macromolecular Chemistry and Physics, **212 (4)**, 319 - 327 (2011)

Patent Applications

M. Elbahri, F. Faupel, R. Adelung, *Verfahren zur Nanostrukturerzeugung mittels spinodaler Entnetzung,* European Patent Office, 25.10.2011, PVA 7060 / 08 0847 695.7 - 1215

M. Elbahri, M. Keshavarz Hedayati, V. Zaporojtchenko, T. Strunkus, F. Faupel, *Absorberschicht für den VIS- und/oder NIR-Spektralbereich,* German Patent and Trade Mark Office (GTPO), 19.09.2011, DE 10 2011113 571.9

M. Elbahri, S. S. Homaeigohar, *Microfiltration Membrane,* European Patent Office (EPO), 24.01.2011, EP11153217.2

M. Elbahri, S. S. Homaeigohar, T. Dai, R. Abdelaziz, *Biofunctionalized ultrafiltration Membrane,* European Patent Office (EPO), 14.06.2011, EP 11169818.9

M. Elbahri, M. Keshavarz Hedayati, V.S.K. Chakravadhanula, V. Zaporojtchenko, T. Strunkus, F. Faupel, *Metall-Komposit-Beschichtung mit hoher optischer Transmissivität im visuellen Spektrum,* German Patent and Trade Mark Office (GTPO), 27.10.2011, PCT/DE 2011/001902

M. Elbahri, R. Adelung, D. Paretkar, *Methods for producing nanostructures on substrate,* United States of America Patent and Trademark Offi, 29.03.2011, US 7914850

M. Elbahri, K. Hirmas, F. Faupel, R. Adelung, *Method for producing nanostructures by means of spinodal decrosslinking,* United States of America Patent and Trademark Offi, 24.11.2011, US 20110287181

Presentations

M. Keshavarz Hedayati, M. Jamali, T. Strunskus, V. Zaporojtchenko, F. Faupel, M. Elbahri, *New transparent conductive metal based on polymer composite (Talk),* DPG-Frühjahrstagung 2011, Dresden, Germany, 13.-18.03.2011

R. Abdelaziz, J. Worley, R. Podschun, C. Röhl, M. Elbahri, *Biomedical Applications of Zinc Peroxide Nanoparticles Fabricated by Shock Synthesis Using the Leidenfrost Phenomenon (Poster),* Euro BioMat 2011 (European Symposium on Biomaterials and related Areas, Jena, Germany, 13.-14.04.2011

M. Keshavarz Hedayati, M. Elbahri, T. Strunskus, V. Zaporojtchenko, F. Faupel, *Perfect plasmonic absorber at visible frequencies (Talk),* SPP 5 (The fifth international conference of surface plasmon photonics), Busan, South Korea, 15.-20.05.2011

M. Elbahri, *Nanochemistry: from synthesis to nanodevices and bionanotechnology (Invited talk),* Chinesisch-Deutsches Symposium, Berlin, Germany, 30.05.-01.06.2011

M. Elbahri, S.Sh. Homaeigohar, T. Dai, R. Khalil, R. Abdelaziz, *Nanofluid Filtration using Electrospun Nanofibers (Talk),* ICOM 2011, Amsterdam, Netherlands, 24.-29.07.2011

S.Sh. Homaeigohar, M. Elbahri, *Ceramic nanoparticles doped Polymeric nanofibrous membranes; An electrospun nanocomposite mat for water filtration (Poster),* ICOM 2011, Amsterdam, Netherlands, 24.-29.07.2011

M. Elbahri, *Plasmonic Matamaterials (Invited talk),* Nanoworkshop 2011 (5th Workshop on Polymer/Metal Nanoconposites), Bari, Italy, 20.-22.09.2011

M. Keshavarz Hedayati, *Multifunctional Photoswitchable Polymer Fibers (Talk),* SFB 677 Tagung, Schleswig, Germany,

07.-07.10.2011

M. Keshavarz Hedayati, *Photoswitchable polymer/metal nanocomposite (Talk)*, SFB 677 Tagung, Schleswig, Germany, 07.-07.10.2011

M. Keshavarz Hedayati, F. Faupel, M. Elbahri, *Plasmonic metamaterials: From high transparency to complete absorption of light (Poster)*, 491. Wilhelm und Else Heraeus-Seminar, Bad Honnef, Germany, 16.-19.10.2011

M. Keshavarz Hedayati, *A smart plasmonic transparent conductor with a gas sensing ability (Talk)*, Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research, Geesthacht, Germany, 11.-11.11.2011

M. Elbahri, *Plasmonische Nanokomposite: Von leitfähigen transparenten Metallen zu schwarzen Absorbern (Invited talk)*, Fachtagung Transparent leitfähige Schichten (TCO), Ulm, Germany, 28.-30.11.2011

Further Activities and Events

Distinctions gained by Prof. Elbahri's group:

Frontispiece in ''Advanced Materials'' in recognition of its excellence (2011)

Cover page in ''Materials Today''

Invitations to Prof. Elbahri:

Review article ''Plasmonic Nanocomposites'' in Advanced Materials (2012)

Programme committee of the 2nd International Conference on Manipulation, Manufacturing and Measurement on the Nanoscale - 3M-NANO 2012 in China (2012)

Award:

Dr. Mehdi Keshavarz Hedayati received the $500 student cash prize, SPP5, Seoul National University in Seoul, Korea. This award is based upon the high grades his paper has received: he was first author of these papers.

Nanoscale Magnetic Materials - Magnetic Domains

The department of „Nanoscale Magnetic Materials - Magnetic Domains“ was newly 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 by different methods is used to modify the magnetic microstructure enabling us to build artificial magnetic materials. Their effective magnetic properties are tuned using various magnetic interaction effects. A special emphasis lies on the understanding and optimization of the magnetic domain structure, also for various applications. Magnetic properties are probed on fast time-scales down to the picosecond range. Another major task within the department is therefore the methodical advancement of optical magnetic domain investigation tools with high temporal and lateral resolution.

Results

Since the group was only recently established at the CAU Kiel no new results (obtained at the CAU Kiel) exist so far. Current research activities of the newly founded department „Nanoscale Magnetic Materials - Magnetic Domains“ are concentrated on the domain behaviour of functional magnetic materials.

To a great extent the functionalities of magnetic materials are determined by their domain structure. This is reflected in the magnetic hysteresis and noise behaviour, which then affects the functional performance of the magnetic devices. Therefore the control of the magnetic microstructure is essential for the development of magnetic materials. Thus the comprehension of the magnetic domain behaviour and the associated magnetization processes is of fundamental importance. However, the magnetic domain structure can usually only be predicted for idealized small magnetic elements. A detailed experimental analysis is in most cases indispensable.

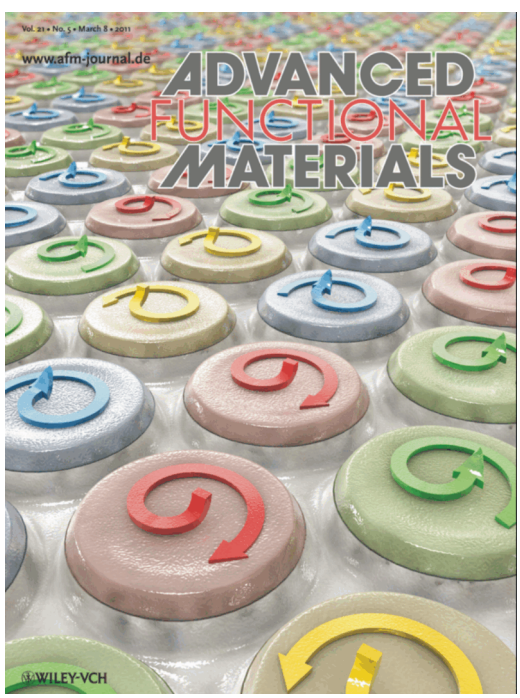


Fig. 1: Artistic view of a magnetic vortex arrangement generated by nanosphere lithography (Advanced Functional Materials 21, 801 (2011))

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 will be illuminated from a fundamental point of view as well as 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. One objective is the generation of modified large-scale structures by which novel nanoscale magnetic media will be created. The effective magnetic properties should be selectively adjustable through variable magnetization configurations. One option to achieve that goal relies on artificially generated magnetic domains and domain wall configurations. Future chances will arise in the field of magnetic sensors and for magneto-dynamic applications with optimized, as well as tuned, magnetic nanostructures.

The methodological focus 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 is intended to be developed with picosecond temporal resolution. The development of these methods is essential for achieving the intended research goals.

Personnel

Head of the group: Prof. Dr. J. McCord; Secretary: E. Riemer, G. Schroeder

Scientific Staff:

Dr. M. Kustov	01.11.-31.12.2011	DFG
SPP 1239 - Domain Structures and Dynamics in Ferromagnetic Shape Memory Materials		
M.Sc. B. Mozooni	15.11.-31.12.2011	DFG
SPP 1239 - Domain Structures and Dynamics in Ferromagnetic Shape Memory Materials		
Dr. T. von Hofe	01.10.-31.12.2011	DFG
Einstellbarkeit und schaltbare Hochfrequenzeigenschaften		

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

Third-Party Funds

DFG, *Heisenberg-Professur*, 01.07.2011-30.06.2014 (189.000,00)
DFG, *Einstellbare und schaltbare Hochfrequenzeigenschaften - Domänenkonfiguration und Beobachtung von Magnetisierungsdynamik*, 01.10.2011-30.09.2014 (311.231,20)
DFG, *Hybride Magnetische Materialien - mikroskopische Modifikationen, makroskopische Wirkungen*, 15.02.2012-14.06.2015 (184.870,00)
DFG, *SPP 1239 - Änderung von Mikrostruktur und Form fester Werkstoffe durch äußere Magnetfelder*, 01.11.2011-31.10.2013 (163.500,00)

DAAD, *PROCOPE*, 01.01.2011-31.12.2013 (5.910,00)

Further Cooperation, Consulting, and Technology Transfer

Dr. Peter Fischer, Lawrence Berkeley National Laboratory

Prof. Jürgen Faßbender, Helmholtz-Zentrum Dresden-Rossendorf

Dr. Jörg Grenzer, Helmholtz-Zentrum Dresden-Rossendorf

Prof. Lorenz Kienle, CAU Kiel

Prof. Stephane Mangin, Institut Jean Lamour - University Nancy

Dr. Roland Mattheis, IPHT Jena

Prof. Andrzej Maziewski, University of Bialystok

Dr. Guido Meier, Univerity Hamburg

Dr. Ingolf Mönch, IFW Dresden

Dr. Christian Patak, Bosch AG Reutlingen

Prof. Eckhard Quandt, CAU Kiel

Dr. Rudolf Schäfer, IFW Dresden

Publications

Published in 2011

K. Mok, C. Scarlat, G.J. Kovács, V. Zviagin, J. McCord, M. Helm, H. Schmidt, *Thickness independent magneto-optical coupling constant of nickel films in the visible spectral range,* Journal of Applied Physics, **110**, 123110 (2011)

S. Wintz, T. Strache, M. Körner, M. Fritzsche, D. Marko, I. Mönch, R. Mattheis, J. Raabe, C. Quitmann, J. McCord, A. Erbe, J. Fassbender, *Direct observation of antiferromagnetically oriented spin vortex states in magnetic multilayer elements,* Applied Physics Letters, **98**, 232511 (2011)

K. Mok, J. Kovacs, J. McCord, L. Li, M. Helm, H. Schmidt, *Magneto-optical coupling in ferromagnetic thin films investigated by vector-magneto-optical generalized ellipsometry,* Physical Review B, **84**, 094413 (2011)

J. McCord, T. Strache, I. Mönch, R. Mattheis, J. Fassbender, *Spatial manipulation of magnetic damping in ferromagnetic-antiferromagnetic films by ion irradiation,* Physical Review B, **83**, 224407 (2011)

A. Vogel, S. Wintz, T. Gerhardt, L. Bocklage, T. Strache, M.Y. Im, P. Fischer, J. Fassbender, J. McCord, G. Meier, *Field- and current-induced domain-wall motion in permalloy nanowires with magnetic soft spots,* Applied Physics Letters, **98**, 20250 (2011)

N. Martin, I. Mönch, R. Schäfer, J. Fassbender, L. Schultz, J. McCord, *Influence of dipolar energy on the magnetization reversal in magnetization-modulated thin film systems: Model and experiment,* Physical Review B, **83**, 174423 (2011)

M. Wolf, C. Patschureck, R. Schäfer, I. Mönch, L. Schultz, J. McCord, *Array anisotropy in structured thin film arrays: Influence on the magnetodynamics,* Journal of Magnetism and Magnetic Materials, **323**, 1703 (2011)

M. Jaafar, R. Sanz, J. McCord, J. Jensen, R. Schäfer, M. Vazquez, A. Asenjo, *Pattern-induced magnetic anisotropy in FePt thin films by ion irradiation,* Physical Review B, **83**, 094422 (2011)

N. Martin, N.C. Bigall, I. Mönch, T. Gemming, A. Eychmüller, R. Mattheis, R. Schäfer, L. Schultz, J. McCord, *Enhanced Nucleation of Vortices in Soft Magnetic Materials Prepared by Silica Nanosphere Lithography,* Advanced Functional Materials, **21**, 891 - 896 (2011)

S. Haindl, T. Thersleff, T. Shapoval, Y.W. Lai, J. McCord, L. Schultz, B. Holzapfel, *Advanced Nb/FePt L1(0) hybrid thin films,* Superconductor Science and Technology, **24**, 024002 (2011)

Presentations

J. McCord, *Aspects of magnetic heterostructures-statics, dynamics, and magnetic domains (invited talk),* Seminar of the SFB 668, Hamburg, 01.02.2011

J. McCord, *Magnetic properties of mixed property magnetic thin films prepared by selective ion irradiation (invited talk),* International conference on Ion-Beam Induced Nanopatterning of Materials, Bhubaneswar, Indien, 06.-10.02.2011

M.O. Liedke, M. Körner, K. Lenz, T. Strache, J. McCord, M. Ranjan, S. Facsko, J. Fassbender, *Magnetic anisotropy investigations in single crystalline Fe films on ripple MgO templates,* 75th Annual Meeting of the DPG and DPG Spring Meeting, Dresden, 13.-18.03.2011

S. Wintz, A. Puzic, T. Strache, C. Bunce, M. Körner, T. Schönherr, A. Neubert, J. McCord, I. Mönch, R. Mattheis, J. Raabe, C. Quitmann, A. Erbe, J. Fassbender, *Vortex coupling in magnetic multilayer elements,* 75th Annual Meeting of the DPG and DPG Spring Meeting, Dresden, 13.-18.03.2011

T. Strache, J. McCord, *Layer resolved magneto-optical Kerr effect magnetometry and domain studies of polycrystalline interlayer exchange coupled NiFe-Ru-Co films,* 75th Annual Meeting of the DPG and DPG Spring Meeting, Dresden, 13.-18.03.2011

M.A. Basith, S. McVitie, T. Strache, M. Fritzsche, A. Mücklich, J. McCord, J. Fassbender, *Neel walls in magnetic hybrid structures,* 75th Annual Meeting of the DPG and DPG Spring Meeting, Dresden, 13.-18.03.2011

M. Liedke, M. Körner, K. Lenz, T. Strache, J. McCord, M. Ranjan, S. Facsko, J. Fassbender, *Magnetic anisotropy investigations in single crystalline Fe films on ripple MgO templates,* 75th Annual Meeting of the DPG and DPG Spring Meeting, Dresden, 13.-18.03.2011

N. Martin, I. Mönch, R. Schäfer, L. Schultz, J. Fassbender, J. McCord, *Competition of dipolar interactions and lateral exchange spring effect in NiFe elements,* 75th Annual Meeting of the DPG and DPG Spring Meeting, Dresden, 13.-18.03.2011

A. Neudert, J. McCord, *Magnetic domain structure evolution in NiMnGa magnetic shape memory alloys,* 75th Annual Meeting of the DPG and DPG Spring Meeting, Dresden, 13.-18.03.2011

C. Patschureck, J. McCord, R. Schäfer, K. Lenz, R. Mattheis, L. Schultz, *Magneto-dynamic properties of CoFeB thin film elements: The role of magnetic domain walls,* 75th Annual Meeting of the DPG and DPG Spring Meeting, Dresden, 13.-18.03.2011

M. Höwler, K. Bernert, J. McCord, K. Potzger, M. Fritzsche, A. Mücklich, J. Fassbender, K. Kirsch, R. Mattheis, S. Slesazeck, *Preparation and Characterization of Magnetic Tunnel Junctions with Spin Transfer Torque,* 75th Annual Meeting of the DPG and DPG Spring Meeting, Dresden, 13.-18.03.2011

J. McCord, A. Neudert, *Preparation and Characterization of Magnetic Tunnel Junctions with Spin Transfer Torque,* SPP 1239 Focus Meeting Bulk Materials and Applications, Saarbrücken, 06.-07.04.2011

S. Wintz, A. Puzic, T. Strache, C. Bunce, M. Körner, M. Liedke, A. Banholzer, M. Buhl, K. Bernert, I. Mönch, R. Mattheis, J. McCord, J. Raabe, C. Quitmann, A. Erbe, J. Fassbender, *Interlayer Coupled Magnetic Vortices,* IEEE International Magnetics Conference, Taipeh, Taiwan, 25.-29.04.2011

A. Vogel, S. Wintz, T. Gerhardt, L. Bocklage, T. Strache, M. Im, P. Fischer, J. Fassbender, J. McCord, G. Meier, *Domain-wall motion in permalloy nanowires with magnetic soft spots,* IEEE International Magnetics Conference, Taipeh, Taiwan, 25.-29.04.2011

A. Berger, S. Mangin, J. McCord, O. Hellwig, E.E. Fullerton, *Cumulative Minor Loop Growth in Co/Pt- and Co/Pd-Multilayers,* IEEE International Magnetics Conference, Taipeh, Taiwan, 25.-29.04.2011

M.O. Liedke, M. Körner, K. Lenz, T. Strache, J. McCord, M. Ranjan, S. Facsko, J. Fassbender, *Magnetic anisotropy investigations in single crystalline Fe films on ripple MgO templates,* IEEE International Magnetics Conference, Taipeh, Taiwan, 25.-29.04.2011

J. McCord, T. Strache, J. Fassbender, I. Mönch, R. Mattheis, *Spatial manipulation of magnetic damping in ferromagnetic-antiferromagnetic films by ion irradiation,* IEEE International Magnetics Conference, Taipeh, Taiwan, 25.-29.04.2011

C. Hamann, I. Mönch, T. Strache, L. Schultz, J. Fassbender, R. Mattheis, J. McCord, *Tuning of the permeability spectra by imprinting artificial domain states in exchange bias modulated films,* IEEE International Magnetics Conference, Taipeh, Taiwan, 25.-29.04.2011

J. McCord, C. Hamann, T. Strache, I. Mönch, J. Fassbender, *Mixed property magnetic thin films prepared by selective ion irradiation (invited talk),* Seminar at the Institute for Nanostructural Research and Nanotechnology, Saarbrücken, 24.05.2011

J. McCord, *Aspects of magnetic heterostructures (invited talk),* Kolloquium SFB 855, Kiel, 27.-28.06.2011

M. Liedke, H. Körner, K. Lenz, A. Shalimov, T. Strache, M. Ranjan, S. Facsko, J. McCord, J. Fassbender, *Magnetic anisotropy modications of single crystalline rippled Fe,* The European Conference Physics of magnetism 2011, Poznan, Polen, 27.06.-01.07.2011

J. McCord, A. Neudert, *Twin boundary motion and magnetic domain distribution investigated by optical polarization microscopy (invited talk),* 3rd International Conference on Ferromagnetic Shape Memory Alloys, Dresden, 18.-22.07.2011

J. McCord, *Imaging magnetic domains by magneto-optical wide field microscopy (invited talk),* Workshop Seminar, Sehlendorf, 28.-30.09.2011

O. Roshchupkina, J. Grenzer, T. Strache, J. McCord, M. Fritzsche, A. Muecklich, C. Baehtz, J. Fassbender, *Structural modifications induced by FIB implantation in magnetic thin films,* 8th Autumn School on X-ray Scattering from Surfaces and Thin Layers, Smolenice, Slovakia, 04.-07.10.2011

G. Meier, A. Vogel, S. Wintz, T. Gerhardt, L. Bocklage, T. Strache, M.-Y. Im, P. Fischer, J. Fassbender, J. McCord, *Field- and current-induced domain-wall motion in permalloy nanowires with magnetic soft spots,* 56th Annual Conference on Magnetism and Magnetic Materials, Scottsdale, USA, 30.10.-03.11.2011

J. McCord, *Magnetic domains in magnetic heterostructures,* Antrittsvorlesung Technische Fakultät, CAU, Kiel, 31.10.2011

Polymerbased Multicomponents Materials

Prof. Dr. Volker Abetz, Director of the Centre for Membranes and Structured Materials, Helmholtz-Zentrum Geesthacht.

Prof. Abetz became professor of the Faculty of Engineering in 2004. Information about his scientific work is available on the Website of Helmholtz-Zentrum Geesthacht: http://www.hzg.de/.

Synthesis and Real Structures

In 2011 the research of the group "Synthesis and Real Structure" (SRS) focused on the microstructural aspects of sensors, Li-ion conductors, catalysts, and energy materials. Recent highlights are well documented in a series of 13 full papers and several conference contributions. Moreover (and very recently) positive evaluation reports by the German Research Foundation prove the development potential of our scientific field. Particular emphasis is on nanostructural research of complex chalcogenide-based nanomaterials for phase change and thermoelectric applications. In close collaboration with partners from the Fraunhofer Institute IPM interesting real-structure property relationships were demonstrated which are expected to boost considerably the thermoelectric performance of multilayer devices. Another scientific breakthrough supported by the microstructural analysis is expected in the field of multinary nanoparticles for the economically very important hydrodesulphurization reaction. This project represents only one of the strong links to the Inorganic Chemistry Department of the Christian-Albrechts-University. Other links to microscopy centres with excellent instrumentation, e.g. the Karlsruhe Institute of Technology (KIT), the Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons (ER-C) (Jülich), the Electron Microscopy Lab at UC Berkeley (EM-Lab), and the Max-Planck-Institute for Solid State Research (Stuttgart) highlight the importance of methodical development for the structural research on functional materials.

Prof. Kienle, in his dual role as group leader of SRS and head of the TEM centre at the Nanolab, serves as the contact person for many interdisciplinary projects. Consequently, he was nominated as principle investigator of the Graduate school "Human Developments in Landscapes". Moreover, he joined efforts to enhance the nanoanalytical infrastructure at the Institute. Supported by initial funding of the scheduled cluster of excellence "Materials for Life" a joint proposal for the acquirement of a new transmission electron microscope was submitted to the German Research Foundation.

Results

Electron microscopy techniques represent essential tools for analyzing structure and composition of inhomogeneous crystals composed of domains. In particular, the diffraction and imaging information from submicron sized areas available via transmission electron microscopy (TEM) considerably reduce averaging effects. This allows the identification of domains, characterization of their structures, and the determination of reliable information about their chemical composition.

a) Discoveries by transmission electron microscopy - the showcase of noble metal polychalcogenidehalides from synthetic and mineral samples (in cooperation with: T. Nilges (LMU Munich), S. Britvin (University St. Petersburg), V. Duppel (MPI-FKF Stuttgart))

In the frame of this cooperation mineral samples of the noble metal chalcogenides were studied by applying TEM. These minerals are well known for their complex real structures affected by intergrowth. Using electron diffraction and Fourier transform analyses of high resolution micrographs, the metrics of a first component are consistent with those reported for the rare mineral Kurilite. As a rule, Kurilite forms micron-sized grains, which are found next to other components, e.g. Hessite-type domains. The composition of the grains with Kurilite-type structure was determined by a combined approach of electron diffraction and EDX nanoprobe analyses. The average of 13 quantitative analyses gave $Ag_{7.9}Au_{0.1}Te_{2.9}Se_{1.0}$, which agrees within experimental errors to the expected composition of ca. Ag_8Te_3Se.

Surprisingly, some of the EDX nanoprobe analyses performed sequentially in different selected areas of the particles display the presence of extended domains of noble metal polychalcogenidehalides with a composition close to $Ag_5(Te,Se)_2Cl$. The precession electron diffraction (PED) patterns obtained in the course of tilting experiments could not be indexed assuming the metrics of any known mineral structure. Consequently, the quest for suitable structure candidates was extended to synthetic materials. Simulated PED patterns based on the bimorphic structure of Ag_5Te_2Cl convincingly match the experimental data: cf. examples in Fig. 1a and 1b for the monoclinic and tetragonal polymorph, respectively. The polymorphs show coherent intergrowth as depicted by the HRTEM micrograph and the attached Fourier transforms of Fig. 1c. To the best of our knowledge, Ag_5Te_2Cl-type domains were observed for the first time in a mineral sample.

The discovery of hitherto unknown components stimulated detailed analyses of the domain crystals, and finally led to the identification of two more phases. Their compositions with regard to Ag, Au, Te, and Se equate with Kurilite, however, marginal chlorine content was analytically determined for both phases. Thus the phases were assigned to the noble metal polychalcogenidehalides. Actually, one component crystallizes in a structure type known from synthetic noble metal polychalcogenidehalides, namely that of $Ag_{23}Te_{12}X$ (X = Cl, Br). Based on such a structure model the electron diffraction patterns can be indexed and experimental HRTEM micrographs recorded with different defocus (Fig. 2) can be reproduced by simulations.

The unexpected stability of the noble metal polychalcogenidehalides against electron beam impact, as observed for the mineral samples, serves as the motivation for in-depth TEM examinations of the synthetic materials that are known for their unique structure-property relations. The main focus is on the tetramorphic $Ag_{10}Te_4Br_3$, which represents a semiconductor capable of switching electrical properties by changing temperature.

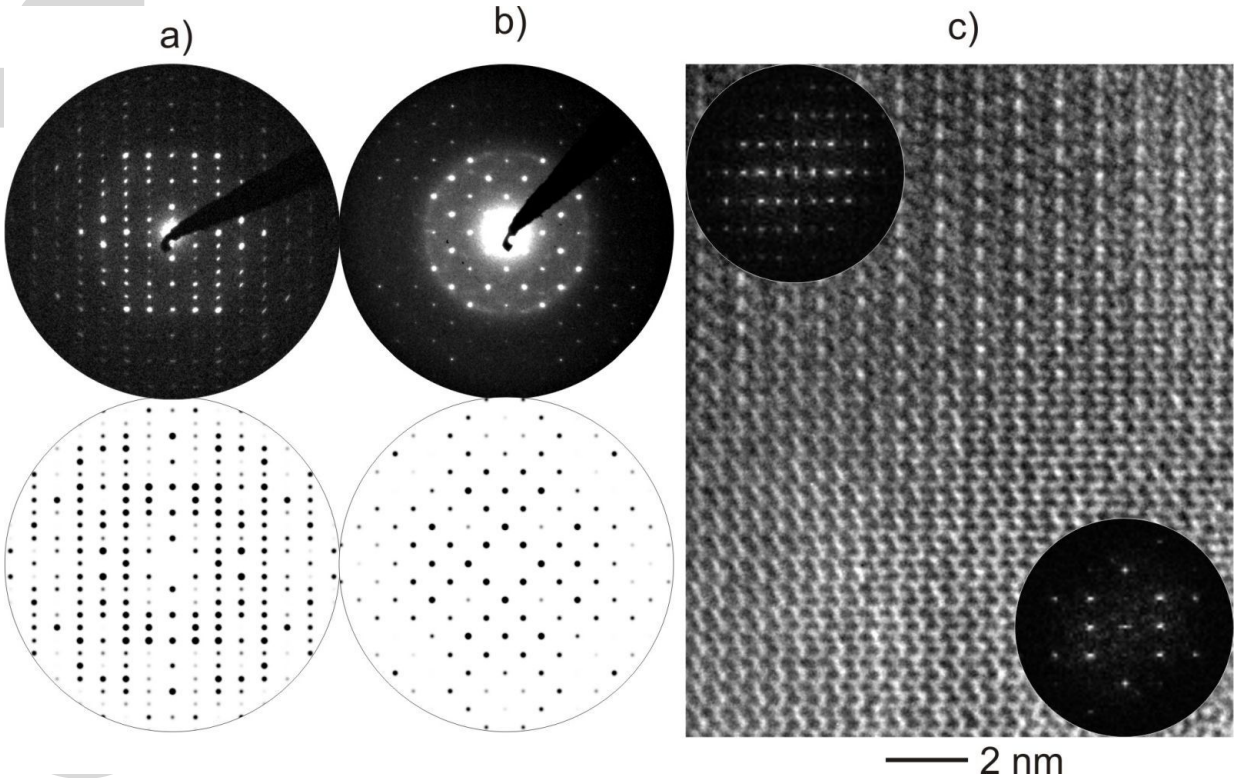


Fig. 1: Experimental (each top) and simulated (each bottom) PED patterns (thickness: 100 nm, precession angle: 3°) for Ag_5Te_2Cl-type domains. a) Monoclinic polymorph, [100]. b) Tetragonal polymorph, [001]. c) HRTEM micrograph displaying bimorphic intergrowth by the attached Fourier transforms, zone axes [021] (monoclinic, top) and [011] (tetragonal, bottom).

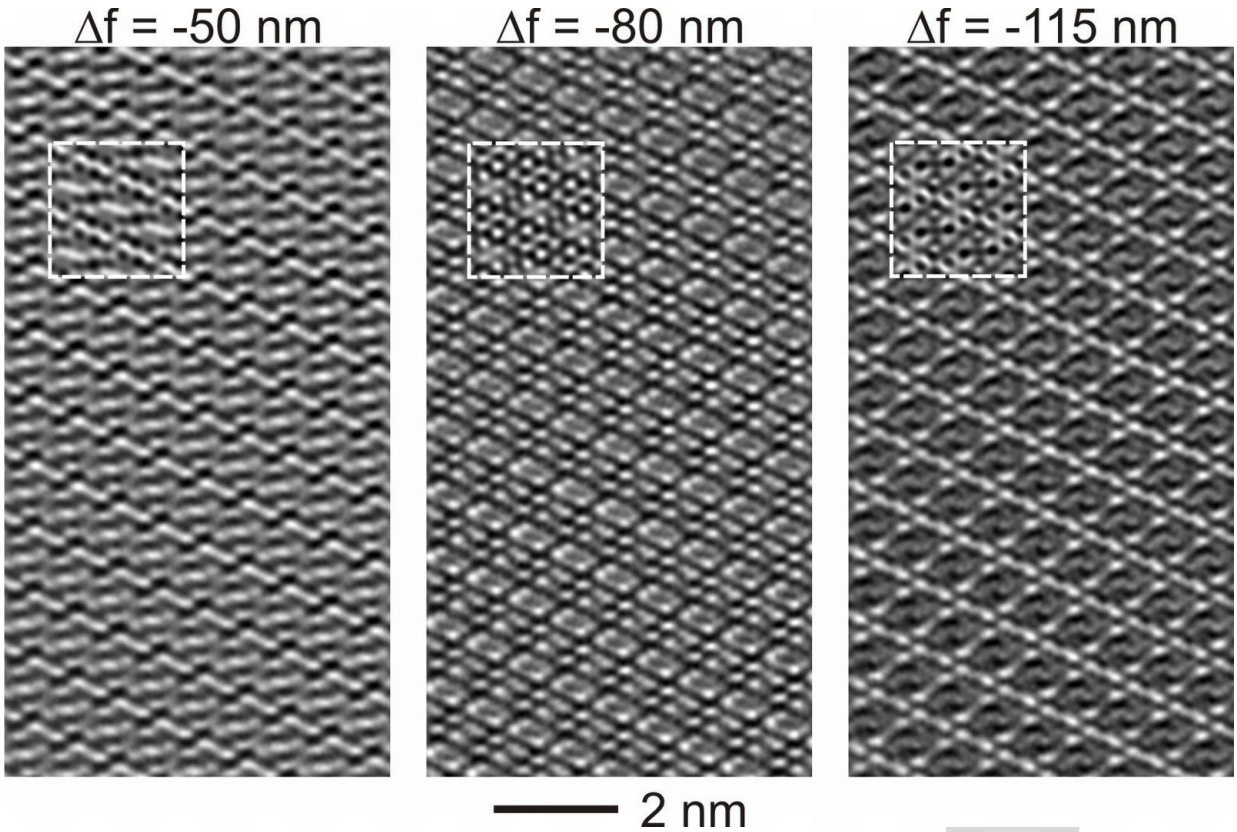


Fig. 2: Series of HRTEM micrographs and inserted simulations based on the structure type of $Ag_{23}Te_{12}X$ (X = Cl, Br) [4]. Zone axis [211], thickness: 4.8 nm.

b) In-situ TEM heating experiments on thermoelectric multilayers (in cooperation with Prof. Bensch, CAU Kiel and Fraunhofer Institute IPM, Freiburg)

Due to theoretical predictions that the thermoelectric efficiency could be enhanced significantly by nanostructural engineering the field of thermoelectrics is again receiving high attention after a long intermission of about twenty years. Venkatasubramanian et al. reported a ZT value of $\sim$2.4 respectively $\sim$1.7 for p/n-V_2VI_3-superlattices. Although this work was groundbreaking for the field of thermoelectrics no verification of these data can be found. In our work, the impact of heat treatment on the real structure of Bi_2Te_3/Sb_2Te_3 multilayers was investigated. FIB lamellae of the material were heated in-situ in the Transmission Electron Microscope (TEM) after preparation of these layers with the so called nanoalloying deposition technique via molecular beam epitaxy (MBE) equipment at the Fraunhofer Institute IPM in Freiburg. EDX elemental mapping and HAADF-STEM were performed to monitor changes of the morphology and interdiffusion phenomena after heating up to 250 °C. Grain growth started during heating and although the chemical layer structure was partly smeared out, it remained in several grains and was found to be adjusted parallel to a major lattice plane in a crystallite. First results indicate for the thermoelectric properties of these materials that the thermal conductivity is not significantly reduced by the type of nanostructuring used: firstly due to the thermal interdiffusion in terms of ''softened'' nanostructures with no sharp interfaces, and secondly, to the lack of thermal stability at the reduced period lengths, which are necessary for an efficient phonon scattering. After annealing the chemical layer the structure remains stable across large areas, as evidenced by HAADF-STEM, and the chemical structure aligns itself to the crystal lattice. These results give hints that a complete and temperature stable superlattice can be obtained by an epitaxial and exclusively c-textured growth of the Bi_2Te_3/Sb_2Te_3 multilayer system leading to enhanced thermoelectric properties. Additionally, twin boundaries were observed in HRTEM micrographs inside several grains analogous to the basal twin boundary reported in literature for Bi_2Te_3.

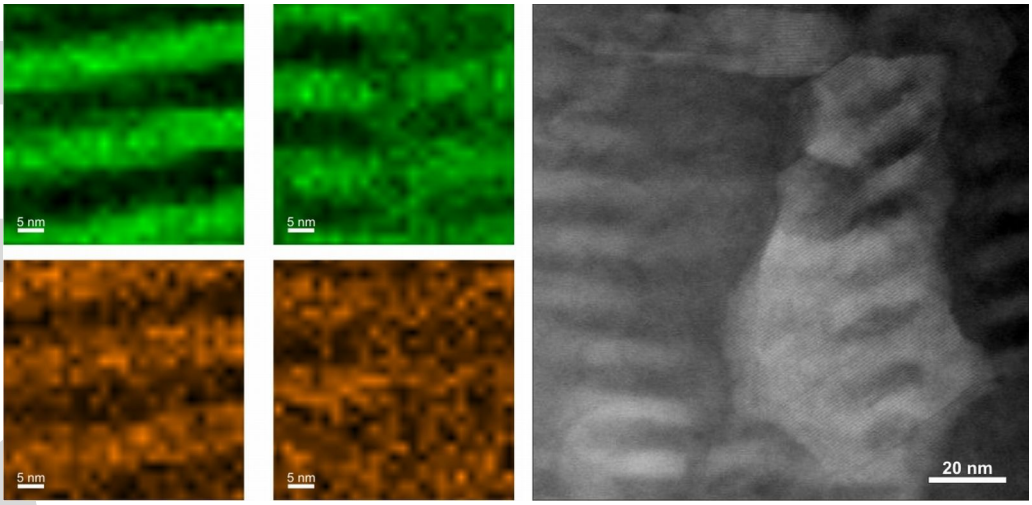


Fig. 3: (left) EDX elemental mapping (top: green areas display Bi M-line, bottom: orange areas display Sb K-line, left: pristine, right: after in-situ heating to 250 °C); (right) section of the multilayer after in-situ heating to 250 °C (HAADF-STEM image) with remaining chemical layer structure aligned to the crystal lattice.

c) Structural characterization of lead-free ferroelectric 0.5($Ba_{0.7}Ca_{0.3}TiO_3$)-0.5[$Ba(Zr_{0.2}Ti_{0.8})O_3$] (in cooperation with: Prof. Quandt, CAU Kiel)

In the framework of the SFB 855 magnetoelectric materials are developed as piezoelectric-magnetostrictive composites for sensor applications. These sensors are subjected to a variety of strict specifications as they serve as a biomagnetic interface between human and electronic data processing. In order to achieve the aim of accurate cerebral- and cardiac-magnetic field measurements health compatibility and high sensitivity to these magnetic fields becomes mandatory. A suitable candidate was found with the lead-free ferroelectric 0.5($Ba_{0.7}Ca_{0.3}TiO_3$)-0.5[$Ba(Zr_{0.2}Ti_{0.8})O_3$] (BCZT), which is distinguished by a piezoelectric constant of approximately 80 pm/V. Therefore, BCZT emerges as an appropriate alternative to lead-zirconate-titanates. Despite the excellent properties of BCZT there is a significant lack of in-depth structural characterization for bulk, and in particular, for columnar grown layer systems. TEM investigations were carried out to close this gap and a high defect density was observed within the single columnar areas. The observation of this defect density and its variable presence in the real structure could be directly assigned to properties of the material. Piezoelectric measurements revealed a strong variance of the piezoelectric constant for different samples. Moreover, the presence of modulated structures in nanodomains is a remarkable feature. These components show coherent intergrowth with highly symmetric phases characterized by cubic or pseudocubic structures. Crystallographic group theory delivers reliable candidates for model structures in order to account for these peculiarities.

d) TEM investigations on Fe-Pd-X ferromagnetic shape memory alloys (in cooperation with Prof. Ludwig, Ruhr-Universität Bochum)

Fe-Pd-X alloys were investigated by advanced transmission electron microscopy (TEM) techniques within the framework of the DFG priority programme SPP 1239. Especially in sensor and actuator technologies there is a rising interest for the development of new Fe-Pd based ferromagnetic shape memory alloys (FSMA). These FSMA should exhibit improved intrinsic properties, i.e. martensitic and ferromagnetic transition temperatures above room temperature, as well as a high magnetic anisotropy and saturation magnetization. For this purpose, Fe-Pd-X (X = Pt, Mn, Cu) alloys were produced with the combinatorial thin films deposition method. Here we focus on TEM investigations of these films, including in-situ cooling experiments. Electron diffraction analyses show that there are distinct regions containing various phases. For a Fe-Pd-Pt sample FCT, FCC and BCC structures are superimposed mostly. The presence of different phases is correlated with the chemical composition of the alloy at the nanoscale via STEM-EDX elemental analyses. Regions exhibiting single crystalline BCC structure are observed showing no indication of inhomogeneities. The TEM in-situ cooling investigations

did not show any phase transition of the FCC to the FCT phase, which might be related to small temperature differences between TEM holder and lamella at the sample position. Further cooling experiment will be performed on samples with lower martensitic transformation temperature. Moreover HRTEM micrographs and related Fast Fourier Transformation (FFT) patterns confirmed (111) macro-twins having FCC structure. Similar investigations also have been performed for Fe-Pd-Mn and Fe-Pd-Cu thin films and structural and chemical analyses are being carried out at the nanoscale via TEM.

Personnel

Head of the group: Prof. Dr. Lorenz Kienle; Secretary: Katrin Brandenburg (50%)
Technical Staff: Christin Szillus

Scientific Staff:

Dr. V.S. Kiran Chakravadhanula 01.01.-30.06.2011 DFG

Elektronenmikroskopische Untersuchung der Mikrostruktur und der lokalen chemischen Zusammensetzung im Rahmen des Paketantrags PAK 19

M.Sc. R. Burak Erkartal 01.01.-31.12.2011 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.-31.12.2011 DFG

SFB 855 Magnetoelektrische Verbundwerkstoffe - biomagnetische Schnittstellen der Zukunft, TP Z1 Hochauflösende Transmissionselektronenmikroskopie und magnetoelektrische Materialcharakterisierung

Dr. Andriy Lotnyk 01.01.-31.08.2011 CAU

Dr. Ulrich Schürmann 01.01.-31.12.2011 DFG , CAU

DFG 01.01-31.08.2011 Comprehensive clarification of the physical background of the breakthrough of ZT-2.4/1.7 for p/n-V2V13-Superlattices, CAU 01.09.-31.12.2011 TEM-Zentrum

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

Thermodynamics and Kinetics I, 2 (+1) hrs Lecture (+ Exercises)/Week,
L. Kienle

Practical TEM, 2 (+1) hrs Lecture (+ Exercises)/Week,
A. Lotnyk

Solid State Chemistry, 3 (+1) hrs Lecture (+ Exercises)/Week,
L. Kienle

Application of TEM for the Characterization of Inorganic Materials, 2 hrs Lecture/Week,
L. Kienle

Seminar Synthese und Realstruktur, 2 hrs Seminar/Week,
L. Kienle

Biomaterials, 2 hrs Lecture/Week,
L. Kienle (+ R. Adelung)

Laboratory Course: Scientific Methods, 4 hrs Lab Course/Week,
A. Lotnyk (+ C. Zamponi, A. Cojocaru, A. Pape, D. Gedamu, T. von Hofe, V. Zaporojtchenko)

Cluster 3: Mobility, Innovation and Change, 1 hrs Seminar/Week,
L. Kienle (+ A. Lotnyk)

Summer 2011

Fundamentals of Solids, 3 (+1) hrs Lecture (+ Exercises)/Week,
L. Kienle

Thermodynamics and Kinetics, 2 (+1) hrs Lecture (+ Exercises)/Week,
L. Kienle

Hochauflösende Transmissionselektronenmikroskopie: Prinzipien und Anwendungen, 2 hrs Lecture/Week,
L. Kienle

Mikro- und Nanocharakterisierung von Festkörpern mittels TEM, 2 hrs Lecture/Week,
A. Lotnyk

Praktische Aspekte der Mikro- und Nanocharakterisierung von Festkörpern mittels TEM, 1 hrs Practical Work/Week,
A. Lotnyk

Seminar Synthese und Realstruktur, 2 hrs Seminar/Week,
L. Kienle

Winter 2011/2012

Thermodynamics and Kinetics I, 2 (+1) hrs Lecture (+ Exercises)/Week,
L. Kienle (+ U. Schürmann)

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 Lab Course/Week,
U. Schürmann (+ C. Zamponi, D. Gedamu, T. von Hofe, V. Zaporojtchenko)

Crystallography, 1 hrs Seminar/Week,
U. Schürmann

Electron Microscopy, 3 (+2) hrs Lecture (+ Exercises)/Week,
L. Kienle

Third-Party Funds

DFG, *Elektronenmikroskopische Untersuchung der Mikrostruktur und der lokalen chemischen Zusammensetzung,* 01.04.2008-31.03.2011 (117.800 EUR)

DFG, *Fortführung der Heisenbergprofessur zum Thema: Synthese und Analytik von Festkörpern mit ungewöhnlichen Realstrukturen,* 01.02.2009-31.01.2011 (163.200 EUR)

DFG, *Programmpauschale zu: Fortführung der Heisenbergprofessur zum Thema: Synthese und Analytik von Festkörpern mit ungewöhnlichen Realstrukturen,* 01.02.2009-31.01.2011 (32.600 EUR)

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)*, 15.07.2010-14.07.2012 (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)*, 15.07.2010-14.07.2012 (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*, 16.12.2011-15.12.2014 (144.401 EUR)

DFG, *Programmpauschale zu Synthese und Realstruktur-Eigenschaftsbeziehungen von katalytisch aktiven Nanoteilchen auf der Basis von Übergangsmetallsulfiden*, 16.12.2011-15.12.2014 (28.900 EUR)

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.
- Inorganic Chemistry - Prof. Dr. W. Bensch, CAU Kiel.
- Institute of Physical and Theoretical Chemistry - Prof. Dr. W. Kunz, University of Regensburg.
- Thermoelektrische Systeme - Dr. H. Böttner, Fraunhofer Institut für Physikalische Messtechnik, IPM Freiburg.
- Quantentheorie des Festkörpers - 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.
- Geochemistry Division - Dr. M. Chakravadhanula, National Geophysical Research Institute, India.
- Inorganic Materials - Dr. T. Söhnel, University of Auckland, New Zealand.
- Inorganic Chemistry - Prof. Dr. Deiseroth, University of Siegen.
- Materials Science Division - Dr. D. K. Avasthi, Inter University Accelerator Centre, India.
- 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.
- Institut für Chemie und Biochemie - Prof. Dr. S. Schlecht, Freie Universität Berlin, Berlin.
- Electron Microscope and Elemental Analysis - Prof. Dr. Dr. h. c. M. Jansen, MPI for Solid State Research, Stuttgart.

- Crystallography - Prof. Dr. Dr. h. c. W. Depmeier, CAU Kiel.

- Crystallography - Dr. S. N. Britvin, CAU Kiel.

- Nanoelektronik - Prof. Dr. H. Kohlstedt, CAU Kiel.

- Superconducting Materials - Dr. S. Fähler, IFW Dresden.

- Magnetism and Superconductivity - PD Dr.-Ing O. Gutfleisch, IFW Dresden.

- Nanomagnetism - Prof. Dr. J. McCord, CAU Kiel.

- Werkstoffe der Mikrotechnik - Prof. Dr.-Ing. A. Ludwig, Ruhr-Universität Bochum.

- Angewandte Wissenschaften, Prof. Dr. S. Jendrzejewski, FH Lübeck.

Diploma, Bachelor and Master Theses

Alireza Basir Parsa, *Investigation of Silver Nanoparticles produced by Plasma-Electrochemical Deposition via HRTEM*, 10.05.2011

Jan-H. Pöhls, *Physical Properties of a Cabon-Nanotube-Tape*, 26.09.2011

Ekin Simsek, *Characterization of Fe-Pd-Pt Ferromagnetic Shape Memory Alloys via Transmission Electron Microscopy*, 27.10.2011

Gero Neubüser, *Spannungs- und Relaxationsverhalten von Aluminium-Gusslegierungen*, 28.10.2011

Publications

Published in 2011

H. Buschmann, J. Doelle, S. Berendts, A. Kuhn, P. Bottke, M. Wilkening, P. Heitjans, A. Senyshyn, H. Ehrenberg, A. Lotnyk, V. Duppel, L. Kienle, J. Janek, *Structure and dynamics of the fast lithium ion conductor ''Li(7)La(3)Zr(2)O(12)''*, PHYSICAL CHEMISTRY CHEMICAL PHYSICS, DOI 10.1039/c1cp22108f, **13(43)**, 19378 - 19392 (2011)

J. Jakobi, A. Menendez-Manjon, V.S.K. Chakravadhanula, L. Kienle, P. Wagener, S. Barcikowski, *Stoichiometry of alloy nanoparticles from laser ablation of PtIr in acetone and their electrophoretic deposition on PtIr electrodes*, NANOTECHNOLOGY, Article Number 145601, DOI 10.1088/0957-4484/22/14/145601, **22(14)**, (2011)

J.D. Koenig, M. Winkler, S. Buller, W. Bensch, U. Schuermann, L. Kienle, H. Boettner, *Bi_2Te_3-Sb_2Te_3 Superlattices Grown by Nanoalloying*, JOURNAL OF ELECTRONIC MATERIALS, DOI 10.1007/s11664-011-1578-0, **40(5)**, 1266 - 1270 (2011)

V. Todorova, A. Leienweber, L. Kienle, et al., *On AgRhO(2), and the new quaternary delafossites AgLi(1/3)M(2/3)O(2), syntheses and analyses of real structures*, JOURNAL OF SOLID STATE CHEMISTRY, DOI 10.1016/j.jssc.2011.03.014, **184(5)**, 1112 - 1119 (2011)

U. Schuermann, V. Duppel, S. Buller, W. Bensch, L. Kienle, *Precession Electron Diffraction - a versatile tool for the characterization of Phase Change Materials*, CRYSTAL RESEARCH AND TECHNOLOGY, DOI 10.1002/crat.201000516, **46(6)**, 561 - 568 (2011)

L. Kienle, V. Duppel, B. Mogwitz, et al., *Synthesis-Real Structure-Property: The Showcase of Silver-Rich Ag(2)Se*, CRYSTAL GROWTH AND DESIGN, DOI 10.1021/cg200167j, **11(6)**, 2412 - 2421 (2011)

V.S.K. Chakravadhanula, T. Hrkac, V. Zaporojtchenko, R. Podschun, V.G. Kotnur, A. Kulkarni, T. Strunskus, L. Kienle, F. Faupel, *Nanostructural and Functional Properties of Ag-TiO(2) Coatings Prepared by Co-Sputtering Deposition Technique*, JOURNAL OF NANOSCIENCE AND NANOTECHNOLOGY, DOI 10.1166/jnn.2011.3881, **11(6)**, 4893 - 4899 (2011)

S.N. Britvin, A. Lotnyk, L. Kienle, S.V. Krivovichev, W. Depmeier, *Layered Hydrazinium Titanate: Advanced Reductive Adsorbent and Chemical Toolkit for Design of Titanium Dioxide Nanomaterials*, JOURNAL OF THE AMERICAN

CHEMICAL SOCIETY, DOI 10.1021/ja202053q, **133(24)**, 9516 - 9525 (2011)

A. Kulkarni, V.S.K. Chakravadhanula, V. Duppel, D. Meyners, V. Zaporojtchenko, T. Strunskus, L. Kienle, E. Quandt, F. Faupel, *Morphological and magnetic properties of TiO(2)/Fe(50)Co(50) composite films,* JOURNAL OF MATERIALS SCIENCE, DOI 10.1007/s10853-011-5366-2, **46(13)**, 4638 - 4645 (2011)

M.C. Schaloske, L. Kienle, H. Mattausch, et al., *Disorder in Rare Earth Metal Halide Carbide Nitrides,* EUROPEAN JOURNAL OF INORGANIC CHEMISTRY, DOI 10.1002/ejic.201100201, **26**, 4049 - 4056 (2011)

J. Tomforde, W. Bensch, L. Kienle, et al., *Thin Films of Ge-Sb-Te-Based Phase Change Materials: Microstructure and in Situ Transformation,* CHEMISTRY OF MATERIALS, DOI 10.1021/cm200835a, **23(17)**, 3871 - 3878 (2011)

B. Gojdka, V. Hrkac, T. Strunskus, V. Zaporojtchenko, L. Kienle, F. Faupel, *Study of cobalt clusters with very narrow size distribution deposited by high-rate cluster source,* NANOTECHNOLOGY, Article Number 465704, DOI 10.1088/0957-4484/22/46/465704, **22(46)**, (2011)

U. Schürmann, M. Winkler, J.D. König, L. Xi, V. Duppel, W. Bensch, H. Böttner, L. Kienle, *In-situ TEM Investigations on Thermoelectric Bi_2Te_3/Sb_2Te_3 Multilayers,* Advanced Engineering (published online), (2011)

R.B. Erkartal, A. Lotnyk, C. Bechthold, C. Zamponi, E. Quandt, L. Kienle, *Transmission Electron Microscopy Investigations on $Fe_{70}Pd_{30}$ Ferromagnetic Shape Memory Alloys,* International Conference on Ferromagnetic Shape Memory Alloys 2011, Programme and Abstracts, 63 - 64 (2011)

L. Kienle, T. Nilges, S.N. Britvon, V. Duppel, *Discoveries by Transmission Electron Microscopy - the Showcase of Noble Metal Polychalkogenidehalides from Synthetic and Mineral Samples,* Microscopy Conference MC 2011, Proc., ISBN 978-3-00-033910-3, M6.P613, (2011)

R.B. Erkartal, A. Lotnyk, V. Duppel, R. Niemann, L. Schultz, S. Fähler, L. Kienle, *TEM Investigations of NiMnInCo Metamagnetic Shape Memory Alloys,* Microscopy Conference MC 2011, Proc., ISBN 978-3-00-033910-3, M2.P533, (2011)

A. Lotnyk, C. Bechthold, R.B. Erkartal, C. Szillus, L. Kienle, E. Quandt, *Behavior of different FIB protection layers during in situ heating in TEM,* Microscopy Conference MC 2011, Proc., ISBN 978-3-00-033910-3, IM7.P213, (2011)

A. Lotnyk, V. Duppel, H. Buschmann, J. Janek, L. Kienle, *Application of precession electron diffraction for pase distinction - The solid electrolyte $Li_7La_3Zr_2O_{12}$ as an example,* Microscopy Conference MC 2011, Proc., ISBN 978-3-00-033910-3, IM4.P518, (2011)

U. Schürmann, M. Winkler, J.D. König, L. Xi, V. Duppel, W. Bensch, L. Kienle, *In-situ TEM Investigations on Thermoelectric Bi_2Te_3/Sb_2Te_3 Multilayers,* Microscopy Conference MC 2011, Proc., ISBN 978-3-00-033910-3, M2.P531, (2011)

V. Hrkac, S. Kaps, Y.K. Mishra, V. Duppel, R. Adelung, L. Kienle, *Quantitative Structure Analysis of Superposition Twinning supported by a Nanospike Texture of ZnO,* Microscopy Conference MC 2011, Proc., ISBN 978-3-00-033910-3, M2.P532, (2011)

Presentations

L. Kienle, *TEM in Material Science,* Invited talk at Mads Clausen Institute, NanoSYD, University of Southern Denmark, Sonderborg, Denmark, 10.03.2011

R.B. Erkartal, A. Lotnyk, V. Duppel, R. Niemann, C. Bechthold, C. Zamponi, C. Szillus, S. Fähler, L. Schultz, E. Quandt, L. Kienle, *TEM Investigations of NiMnInCo and $Fe_{70}Pd_{30}$, Ferromagnetic Shape Memory Alloys,* 75th Annual Meeting of the DPG and DPG Spring Meeting, Dresden, Germany, 13.-18.03.2011

A. Lotnyk, C. Bechthold, R.B. Erkartal, C. Zamponi, L. Kienle, E. Quandt, *Characterization of ex-situ heated $Fe_{70}Pd_{30}$ thick films using TEM and STEM techniques,* 75th Annual Meeting of the DPG and DPG Spring Meeting, Dresden, Germany, 13.-18.03.2011

U. Schürmann, V. Duppel, S. Buller, W. Bensch, L. Kienle, *Characterization of Complex Structures by means of Precession Electron Diffraction,* 75th Annual Meeting of the DPG and DPG Spring Meeting, Dresden, Germany, 13.-18.03.2011

V. Hrkac, S. Kaps, Y.K. Mishra, V. Duppel, R. Adelung, L. Kienle, *Quantitative Structure Analysis of Superposition Twinning supported by a Nanospike Texture of ZnO,* 75th Annual Meeting of the DPG and DPG Spring Meeting,

Dresden, Germany, 13.-18.03.2011

B. Gojdka, S. Rehders, V. Hrkac, T. Strunskus, V. Zaporojtchenko, F. Faupel, *Study of cobalt cluster films deposited by high-rate cluster source*, 75th Annual Meeting of the DPG and DPG Spring Meeting, Dresden, Germany, 13.-18.03.2011

V. Hrkac, *Z1 - Structural Characterization of Thin Films using TEM*, SFB 855 Spring meeting 2011, Leck, Germany, 31.03.-01.04.2011

R.B. Erkartal, L. Kienle, *Real and magnetic structure investigation of ferromagnetic shape memory alloys with the aid of transmission electron microscopy*, SPP 1239 Focus Meeting C, Mainz, Germany, 04.-05.04.2011

L. Kienle, *Nanoscale characterization*, Presentation at DAAD event (invited talk), Bento Concalves, Brazil, 07.06.2011

L. Kienle, *Non-conventional crystal chemistry*, Trilateral seminar "Advances in Inorganic Crystal Chemistry - Non-Cenventional Approaches, New Techniques, Structure Modelling and Prediction, St. Petersburg, Russia, 23.-26.06.2011

V. Hrkac, L. Kienle, *Z1 - Current Progress in the SFB 855*, Public colloquium of the SFB 855, Kiel, Germany, 27.-28.06.2011

L. Kienle, *Materialwissenschaft, Kristallographie und Elektronenmikroskopie*, Invited talk at Universität Freiburg, Freiburg i. Br., Germany, 29.06.2011

H. Böttner, W. Bensch, L. Kienle, *Break*, SPP 1386 Statustreffen, Wittenberg, Germany, 04.07.2011

R.B. Erkartal, A. Lotnyk, C. Bechthold, C. Zamponi, E. Quandt, L. Kienle, *Transmission Electron Microscopy Investigations on $Fe_{70}Pd_{30}$ Ferromagnetic Shape Memory Alloys*, International Conference on Ferromagnetic Shape Memory Alloys, Dresden, Germany, 18.-22.07.2011

L. Kienle, T. Nilges, S.N. Britvon, V. Duppel, *Discoveries by Transmission Electron Microscopy - the Showcase of Noble Metal Polychalkogenidehalides from Synthetic and Mineral Samples*, Microscopy Conference MC 2011, Kiel, Germany, 28.08.-02.09.2011

R.B. Erkartal, A. Lotnyk, V. Duppel, R. Niemann, L. Schultz, S. Fähler, L. Kienle, *TEM Investigations of NiMnInCo Metamagnetic Shape Memory Alloys*, Microscopy Conference MC 2011, Kiel, Germany, 28.08.-02.09.2011

A. Lotnyk, C. Bechthold, R.B. Erkartal, C. Szillus, L. Kienle, E. Quandt, *Behavior of different FIB protection layers during in situ heating in TEM*, Microscopy Conference MC 2011, Kiel, Germany, 28.08.-02.09.2011

A. Lotnyk, V. Duppel, H. Buschmann, J. Janek, L. Kienle, *Application of precession electron diffraction for pase distinction - The solid electrolyte $Li_7La_3Zr_2O_{12}$ as an example*, Microscopy Conference MC 2011, Kiel, Germany, 28.08.-02.09.2011

U. Schürmann, M. Winkler, J.D. König, L. Xi, V. Duppel, W. Bensch, L. Kienle, *In-situ TEM Investigations on Thermoelectric Bi_2Te_3/Sb_2Te_3 Multilayers*, Microscopy Conference MC 2011, Kiel, Germany, 28.08.-02.09.2011

V. Hrkac, S. Kaps, Y.K. Mishra, V. Duppel, R. Adelung, L. Kienle, *Quantitative Structure Analysis of Superposition Twinning supported by a Nanospike Texture of ZnO*, Microscopy Conference MC 2011, Kiel, Germany, 28.08.-02.09.2011

A. Piorra, V. Hrkac, L. Kienle, E. Quandt, *Lead Free Laser Deposited Thin Films of 0.5(Ba0.7Ca0.3TiO3)-0.5(Ba(Zr0.2Ti0.8)O3)*, 2nd International Workshop on Piezoelectric MEMS, Lausanne, Switzerland, 06.-07.09.2011

V. Hrkac, L. Kienle, *Z1 - Structural Characterization of Thin Films using TEM*, SFB 855 Herbstworkshop und Sommerschule des Integrierten Graduiertenkollegs, Sankelmark, Germany, 21.-23.09.2011

L. Kienle, *Discoveries by Transmission Electron Microscopy (invited talk)*, International Conference "How science spies on and technology imitates nature?", Gdansk, Poland, 25.-28.09.2011

H. Böttner, W. Bensch, L. Kienle, *Beak and Beyond*, SPP 1386 Network meeting, Düsseldorf, Germany, 07.10.2011

L. Kienle, *TEM for the characterization of ferroic materials*, SPP 1599 Workshop, Dresden, Germany, 20.10.2011

L. Kienle, *Project results*, AiF-Meeting "Magnetischer Nanolack", Kiel, Germany, 04.11.2011

L. Kienle, *TEM for fundamental research and material science*, Invited talk at LMU München, München, Germany, 24.11.2011

E. Lage, V. Hrkac, L. Kienle, D. Meyners, E. Quandt, *Exchange Biased Magnetostrictive Multilayer for Magnetoelectric*

Sensors, MRS Fall Meeting 2011, Boston, U. S. A., 29.11.2011

L. Kienle, *TEM for fundamental research and material science*, Invited talk GdCh colloquium, TU München, München, Germany, 13.12.2011

Further Activities and Events

Prof. Kienle is elected executive director of the Institute for Materials Science.

Prof. Kienle is elected member of the KNMF user committee.

Prof. Kienle was the Chairman of the Session ''New trends in instrumentation'' at the Microscopy Conference MC 2011 in Kiel.

Prof. Kienle was nominated as principle investigator of the Graduate school ''Human Developments in Landscapes''

Guests in 2011

24.01.2011 Prof. Dr. Jürgen Janek, Justus-Liebig-Universität Gießen, Physikalisch-Chemisches Institut, Laboratorium für Materialforschung, Colloquium of the Faculty of Engineering „Electrochemistry for Energy transformation and storage: Stable Electrolytes, reversible Electrodes and durable Cells?"

28.11.2011 Prof. Dr. Bettina Lotsch, Max-Planck-Institut für Festkörperforschung, Stuttgart, und Department Chemie, LMU München, Colloquium of the Faculty of Engineering „Rational Material Design based on (Sub-)Nanoscale Building Blocks, and Emerging Applications"

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.

Within the Institute for Materials Science the groups and chairs possess advanced equipment for preparation and analysis including electron microscopy, photoelectron spectroscopy and 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, like 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, master 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.-31.12.2011	(50%)

Lectures, Seminars, and Laboratory Course Offers

Winter 2010/2011

Tutorium for Junior Students, 1 hrs Seminar/Week,
O. Riemenschneider

Tutorium for Senior Students, 1 hrs Seminar/Week,
O. Riemenschneider

Basic Lab Course, 3 hrs Lab/Week,
O. Riemenschneider (+ M. Schwitzke, A. Kulkarni, C. Pakula, M.Q. Shaikh, S. Kaps, Emmanuel Ossei-Wusu)

Einführung in die Materialwissenschaft I, 2 hrs Lecture/Week,
O. Riemenschneider (+ K. Rätzke)

Lab Course Scientific Methods, 3 hrs Lab/Week,
O. Riemenschneider (+ Th. von Hofe, A. Cojocaru, V. Zaporojtchenko, A. Pape, A. Lotnyk, C. Zamponi, D. Gedamu, E.Q. González)

Tutorium für Bachelorstudierende, 1 hrs Seminar/Week,
O. Riemenschneider

Grundpraktikum für Ingenieure I, Dienstagskurs, 3 hrs Lab/Week,
K. Scholz (+ O. Riemenschneider, L. Wienbrandt)

Grundpraktikum für Ingenieure I,Mittwochskurs, 3 hrs Lab/Week,
O. Riemenschneider (+ K. Scholz, L. Wienbrandt)

Summer 2011

Grundpraktikum für Ingenieure II, Dienstagskurs, 3 hrs Lab/Week,
K. Scholz (+ L. Wienbrandt, O. Riemenschneider)

Einführung in die Materialwissenschaft II, 3 hrs Lecture/Week,
K. Rätzke (+ O. Riemenschneider)

Lab Course: Functional Materials, 3 hrs Lab/Week,
O. Riemenschneider (+ scientific staff of the Inst. f. Materials Science)

Tutorium for Junior Students, 1 hrs Seminar/Week,
O. Riemenschneider

Tutorium for Senior Students, 1 hrs Seminar/Week,
O. Riemenschneider

Grundpraktikum für Ingenieure II, Mittwochskurs, 3 hrs Lab/Week,
K. Scholz (+ L. Wienbrandt, O. Riemenschneider)

Tutorium für Bachelorstudierende, 1 hrs Seminar/Week,
O. Riemenschneider

Grundpraktikum für Ingenieure II, Montagskurs, 3 hrs Lab/Week,
K. Scholz (+ L. Wienbrandt, O. Riemenschneider)

Übungen Physikalische Chemie 1 für Materialwissenschaftler, 2 hrs Exercise/Week,
O. Riemenschneider

Winter 2011/2012

Tutorium for Junior Students, 1 hrs Seminar/Week,
O. Riemenschneider

Tutorium 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)

Materialanalytik Praktikum, 4 hrs Lab/Week,
O. Riemenschneider (+ M. Schwitzke, I. Paulowicz, M. Keshavarz Hedayati, Dietrich Häußler)

Tutorium für Bachelorstudierende, 1 hrs Seminar/Week,
O. Riemenschneider

Grundpraktikum für Ingenieure I, Dienstagskurs, 3 hrs Lab/Week,
K. Scholz (+ O. Riemenschneider, L. Wienbrandt, Kirstin Scholz)

Grundpraktikum für Ingenieure I,Mittwochskurs, 3 hrs Lab/Week,
O. Riemenschneider (+ K. Scholz, L. Wienbrandt)

Third-Party Funds

contract work, *maintenance and expansion of equipment,* 01.01.-31.12.2011 (6.245,16 EUR)

Further Cooperation, Consulting, and Technology Transfer

Cooperation with Industry:

1. CP Kelco Germany GmbH, Großenbrode,

2. N+K Etiketten- u. Drucksysteme, Rheine,

3. HDW, Thyssen Krupp, Kiel,

4. Condias GmbH, Itzehoe,

5. Morpho Cards GmbH, Flintbek,

Cooperation with Institutes:

1. Institute of Inorganic Chemistry,

2. Rheologie.

Industrial and Academic cooperation includes:

- 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.

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 17 persons in the Dean's office. In 2011 the deanship was led by Prof. Dr.-Ing. Reinhard Knöchel. Prof. Dr. Franz Faupel was one of the Vicedeans; Vicedean Prof. Dr. Manfred Schimmler abdicated the position of a Vicedean in the summer of 2011.

The year 2011 was strongly affected by financial problems that forced the dean to some crucial decisions. Nevertheless this did not affect the continuing, substantial output of the staff.

An important highlight for the faculty in 2011 was the inaugural visit to Schleswig-Holstein of the Federal President Christian Wulff. The President was our honoured guest, accompanied by Peter Harry Carstensen the Prime Minster of Schleswig-Holstein; they visited the Faculty of Engineering at the beginning of March. Accompanied by Prof. Gerhardt Fouquet, the President of our University, President Wulff was introduced to the scientific work of materials science by Prof. Eckard Quandt. Furthermore he was able to inspect the clean room of the faculty. Thus, the scientific work of the Faculty of Engineering was appreciated at the highest political level.

Fig. 1: The Federal President Christian Wulff and the Prime Minister Peter Harry Carstensen visit the faculty. He was welcomed by the President of the university Prof. Dr. Gerhard Fouquet. (Copyright CAU, Fotograf Michael August)

Worth mentioning are the successful negotiations with several newly appointed professors. In 2011 Dr. Christine Selhuber-Unkel, Dr. Jeffrey McCord and Dr. Dirk Nowotka became professors of the faculty. All three demonstrate the excellent quality of research in the Faculty of Engineering.

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 the faculty signed in 2010 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 visited by 22 girls. Both events were arranged and chaired by Dr. Ina Pfannschmidt, the equal opportunity 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.

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 Trainee	01.01.-31.12.2011	
M. Hacker Secretary of Budget Department	01.01.-31.12.2011	
S. Johnsen Employee of the Mechanical Workshop	01.01.-31.12.2011	
S. Keller Trainee	01.08.-31.12.2011	
M. Kulling Employee of the Mechanical Workshop	01.01.-31.12.2011	
C. Martin Administrator Deans Office	01.01.-31.12.2011	
S. Moeller Secretary of Staff Department	01.01.-31.12.2011	
B. Neumann Vice Devision Manager of the Mechanical Workshop	01.01.-31.12.2011	
C. Newe Administrator Computer Service Department	01.01.-31.12.2011	
M. Quedens Electrician	01.03.-31.12.2011	
T. Wengler Aministrator Deans Office	01.01.-31.12.2011	(50%)

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. Figure 1 illustrates the integration of the Service Centre into the organizational structure of the Faculty of Engineering. 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.

In 2011 the Service Centre dealt with more than 870 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 work time of the employee in the examination office for Materials Science was increased from half-time to $\frac{3}{4}$ of a full position. The increase, with duration until March 2012 , is financed by the Praesidium of the Christian-Albrechts-University.

The mean proportion of female students is still in the range of about 18 %. To gain a higher proportion both institutes participated in the program tasteMINT guided by the equal opportunity 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 were 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 courses in Materials Science and Engineering the Service Centre evaluated 143 applications from foreign students and 19 from national students. For these master's courses 37 of them were accepted and 32 started their studies in October 2011.

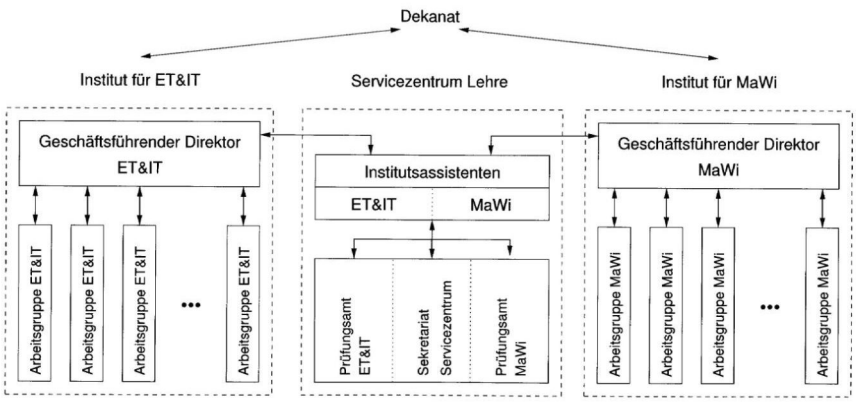


Fig. 1: Integration of the Service Centre into the organizational structure of the faculty

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.-31.12.2011	(50%)
Christiane Otte-Hüls	01.01.-31.12.2011	(50%)
Lars Struwe	01.01.-31.12.2011	

Scientific Staff:

Dipl.-Min. Marlies Schwitzke	01.01.-31.12.2011	(50%)

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.

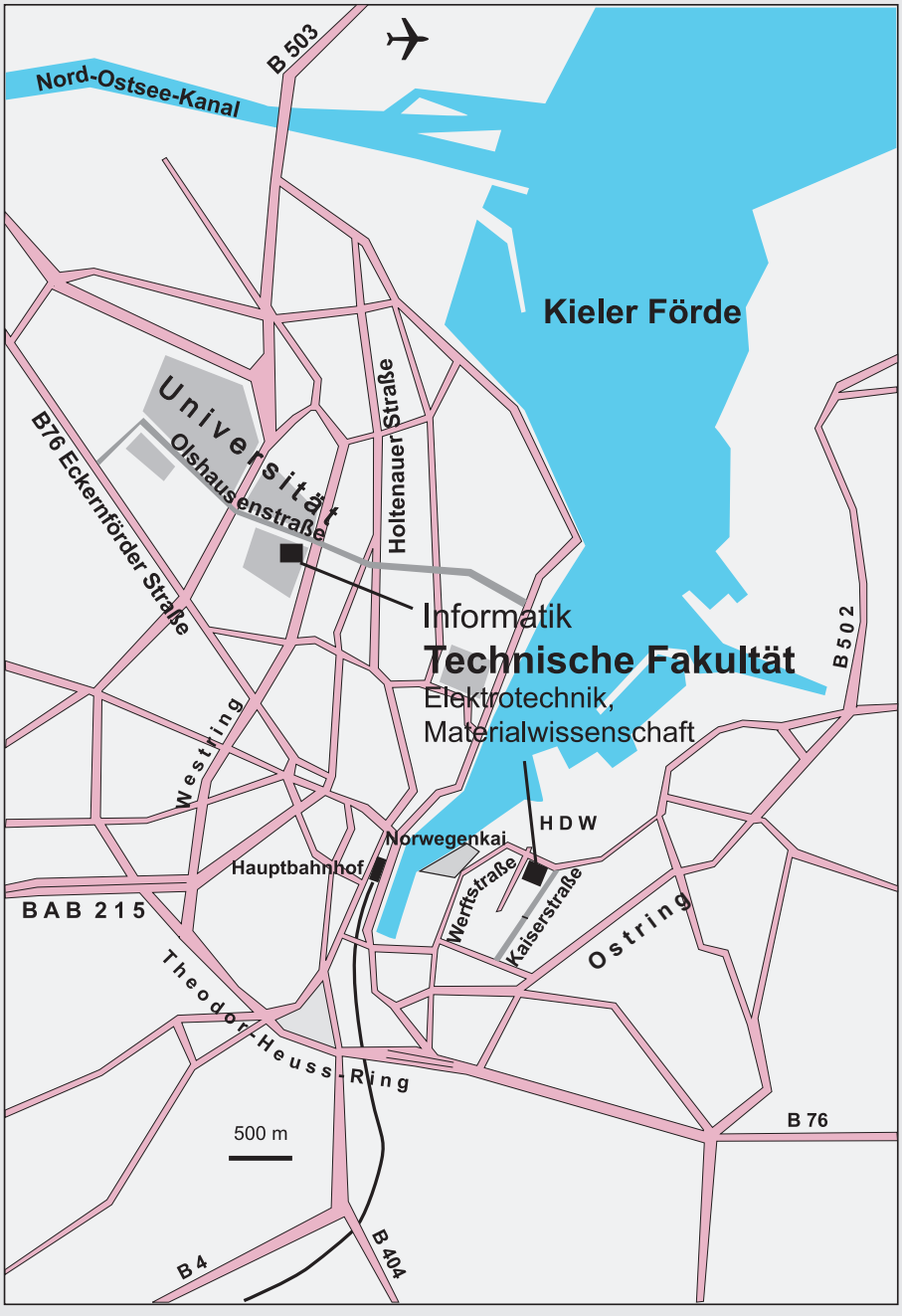
Members are companies, institutions and persons who support and encourage the faculty with its aims and its tasks.''

During 2011 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, master 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, the ''Hanover fair'', of organizing the ´Girls' day´ and many other activities of the faculty´s students. Also festivities like the „Sommerfest" and the „Winterfest" were made possible by the help of the Friends of the Faculty.

Fig. 1: Dr. Jörn Biel, M.Sc. Jan Hendrik Pöhls, B.Sc. Matthias Böhm, B.Sc. Alexander Martin Hinz, B.Sc. Fabian Schütt

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.

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