TECHNISCHE FAKULTÄT DER
CHRISTIAN-ALBRECHTS-UNIVERSITÄT
ZU KIEL
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Preface

Dear Reader,

last year, I emphasized that the Faculty of Engineering was/is in a very successful process of appointing new colleagues with excellent international reputation and that this has created an atmosphere of departure. The achievements of which are increasingly becoming visible. The resulting significant increase in the amount of third party funding, the number of publications and of other figures of merit is again clearly visible in 2009.

This also holds true for the huge increase in the number of students enrollment in all disciplines, exceeding 600 in total for 2009. The impressive increase in the number of female students, which exceeds 30 % in many courses is also very notable. The various measures taken during the last years to inspire pupils for engineering, such as engineering courses for pupils in the laboratories of the Faculty of Engineering, mutual visits between members of schools and of the Faculty of Engineering as well as the „Girls’ Days“ or the „Software Challenge” are now clearly showing their effect. Like in the years before, the Faculty hosted the „Jugend forscht“ competition of Schleswig-Holstein and is looking forward to the all German competition „Bundeswettbewerb Jugend forscht“ in Kiel in 2011.

The transition from the diploma courses to Bachelor and Master programs is in its final stage and went quite smoothly in the Faculty of Engineering without major problems. This is reflected in top evaluations by the students. The Bachelor course „Materialwissenschaft“ (Materials Science) was even number one among all courses offered by the Christian-Albrechts University. 61,5 % ranked the course as „very good“ or „good“. The Faculty benefits here from its long tradition with innovative programs starting with international master courses in materials science and digital communication already more than ten years ago.

A special highlight in 2009 was the approval of the Collaborative Research Center SFB 855 on magneto-electric nanocomposites for medical applications. An amount of 11,5 million euros was granted by the German Research Foundation for the first 4 years. Initiated by Prof. Quandt from the Institute of Materials Science, the SFB 855 teamed up colleagues from materials science, electrical engineering, physics, and medicine. The faculty is also involved in various other joint activities. Cooperations the clusters of excellence „Future Ocean“ and „Inflammations at Interfaces as well as in the research network CEWind Centre of Competence in Wind Energy. The Institute of Computer Science in Kiel, collaborative with our colleagues in Lübeck and the local computer science industry received a grant of 2.7 million euros by the Schleswig-Holstein Ministry of Science, Economic Affairs and Transport, to establish a competence center for software systems engineering (KoSSE). Moreover, the Faculty has further strengthened its cooperation with the Faculty of Natural Sciences and the Faculty of Medicine as well as with the Fraunhofer Institute for Silicon Technology (ISIT) and the GKSS Research Center Geestacht. For details I refer to the respective chapters in this annual report.

Prof. Franz Faupel
Dean of the Faculty of Engineering
The department of computer science of the Christian-Albrechts-University of Kiel, founded in 1971, is one of the oldest computer science departments in Germany. Currently, it consists of 15 research groups. Their 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.

In March 2009, our department organized together with the department of computer science of the University of Lübeck the first Computer Science Symposium Schleswig-Holstein (“Informatik-Symposium Schleswig-Holstein”). The various and broad research activities of both departments were presented during the two day symposium which took place in Neumünster.

Another collaboration with our colleagues in Lübeck and the local computer science industry was initiated by the end of the year 2009. The political decision about our application for a competence centre for software systems engineering (KoSSE) took a long time but had (finally) a positive outcome. On December 4, 2009, the support contracts for KoSSE were officially handed over by the Ministry of Science. The ministry supports seven computer-science-related projects with a total sum of 2.7 million euros. On the same day, our traditional computer science day (“Tag der Informatik”), took place, which is a joint event with the “Winterfest” of the Faculty of Engineering. This annual event was organized by the group of Norbert Luttenberger and was well attended by many colleagues, students, and friends of our department.

Concerning the study programmes, our department has switched to the bachelor/master system following the Bologna process a couple of years ago. Currently, we offer six study programmes (and a seventh will come soon); bachelor programmes in computer science and business information technology and master programmes in computer science and education. More than two-thirds of our students attended the new bachelor and master programmes in the winter term 2009/2010. The number of new entrant students has considerably increased during the last years. A positive development is the proportion of female students that is also steadily increasing. This could be a result of our activities to attract women into computer science, for example by organizing one-week introductory programming courses dedicated to women (“Schnupperstudium”), or the Girls’ Day where female students visit the department from many schools around Schleswig-Holstein. Further activities of our department to attract students to computer science include the “Software Challenge” where students of schools in Schleswig-Holstein compete in a series of programming contests. The final competition took place in the Sophienhof in Kiel on June 6, 2009 and was attended by officials of the university and the Ministry of Science.

In the last year our department made important decisions concerning its future structure. In order to satisfy the increasing demand for an application-oriented scientific education combining computer science and business administration, we developed a new curriculum for bachelor and master studies in business information technology. The bachelor programme is already established, whereas the master programme will start at the end of the year 2010. In order to satisfy the demand for human resources for these studies, the cognitive systems group (headed by Gerald Sommer who will resign in 2011) will be replaced by a new research group related to business information technology.
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, like 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.

In Kiel, the following topics are in the focus of research; The theory of approximation algorithms, randomized and de-randomized algorithms, algorithms for multicast-networks, combinatorial and analytical theory of discrepancy, combinatorial game theory and discrete geometry.

Results

The group has become part of several highly competitive research clusters. Among these are the DFG priority program 1307 Algorithm Engineering and the technology transfer program HWT (Hochschule-Wirtschaft-Transfer) with a joint project with the MINT GmbH, Kiel.

Prof. Srivastav gave invited lectures, e.g. at the Humboldt University, Berlin, and Dayalbagh Educational Institute, Agra, India.

A main focus of the group has been new approximation algorithms for optimization problems in hypergraphs, where papers were presented at major international conferences, namely the European Symposium on Algorithms (ESA 2009) in Copenhagen and the Symposium on Experimental Algorithms (SEA 2009).

Personnel

Head of the group: Prof. Dr. A. Srivastav; Secretary: G. Thiel (50%)

Scientific Staff:

Dipl.-Math. M. El Ouali 01.01.-31.12.2009 (50%) CAU / DFG
Matching in Hypergraphs

Dr. M. Gnewuch 01.01.-31.08.2009 DFG
Hochdimensionale numerische Integration

Dr. G. Jäger 01.08.-31.12.2009 DFG
Exzellenzcluster Future Ocean

Dipl.-Math. L. Kliemann 01.01.-30.11.2009 CAU
Algorithmische Spieltheorie: Multicast Routing in Netzwerken

Dr. B. Langfeld 01.03.-31.12.2009 CAU
Graphtheory and Discrete Tomography

Dipl.-Math. V. Sauerland 01.01.-31.12.2009 CAU / HWT
Evolutionary Algorithms in Marine Science
Lectures, Seminars, and Laboratory Course Offers

**Winter 2008/2009**

Kombinatorische Optimierung - Polynomialität und Optimalität, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
A. Srivastav

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

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

Diplomandenseminar, 2 hrs Seminar/Week,
A. Srivastav

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

**Summer 2009**

Mathematik für Informatiker IV - Diskrete Strukturen und Wahrscheinlichkeitstheorie, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
A. Srivastav

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

Forschungsseminar Diskrete Optimierung, 2 hrs Seminar/Week,
A. Srivastav

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

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

**Winter 2009/2010**

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

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

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

Mathematik für Informatiker A - Grundlagen und Diskrete Strukturen, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
A. Srivastav

Probabilistische Kombinatorik, 2 hrs Lecture/Week,
A. Srivastav (+ L. Kliemann)

Masterabschlussseminar, 2 hrs Seminar/Week,
A. Srivastav (+ B. Langfeld)
Third-Party Funds

DFG SPP 1126, Spieltheoretische Gleichgewichte in Unicast- und Multicast-Netzwerken, 01.09.2005-31.03.2009 (154200 Euro)
DFG SPP 1307, Engineering randomisierter Algorithmen für Optimierungsprobleme in Hypergraphen, 01.10.2007-31.10.2010 (134600 Euro)
DFG SPP 1307, Engineering randomisierter Algorithmen für Optimierungsprobleme in Hypergraphen, 01.10.2009-30.09.2011 (136000 Euro)
DFG, Exzellenzcluster 'The Future Ocean' - Numerische Simulation, 01.01.2009-30.09.2011 (47300 Euro)
DFG, Hochdimensionale numerische Integration, 01.04.2009-31.03.2011 (117000 Euro)
ISH, Entwurf effizienter Algorithmen für die Lehrprogrammsplanung bei Fluggesellschaften, 01.11.2009-28.02.2011 (71988 Euro)

Further Cooperation, Consulting, and Technology Transfer

Cooperation with:
- Peter Gritzmann, Technische Universität München. Project: Diskrete Tomographie.
- Frank-André Siebert, Universitätsklinikum Kiel. Project: Touroptimierung in der Strahlentherapie.
- J. Dick, School of Mathematics, University of New South Wales, Sydney, Australien. Project: Fractional discrepancy and numerical integration.

Diploma, Bachelor and Master Theses

Anna Heinle, Automatische Wolkenklassifikation von Bildern der Vollhimmelskamera, 13.08.2009
Sebastian Eggert, Matchingalgorithmen im Semi-Streaming Modell, 11.06.2009

Dissertations / Postdoctoral Lecture Qualifications


Publications

Published in 2009
A. Baltz, A. Srivastav, Multicast routing and design of sparse connectors, J. Lerner, D. Wagner, K.A. Zweig (Eds.), Algorithmics of Large and Complex Networks, Springer Lecture Notes in Computer Science, 5515, 247 - 265 (2009)
B. Doerr, M. Gnewuch, M. Wahlström, 

M. Gnewuch, A. Srivastav, C. Winzen, 
Finding optimal volume subintervals with k points and calculating the star discrepancy are NP-hard problems, Journal of Complexity, 25, 115 - 127 (2009)

M. Gnewuch, 

M. Gnewuch, 

M. Gnewuch, H. Wozniakowski, 

M. Gnewuch, A.V. Rosca, 
On G-discrepancy and mixed Monte Carlo and quasi-Monte Carlo sequences, Acta Universitatis Apulensis, 18, 97 - 110 (2009)

M. Gnewuch, 

M. Gnewuch, 

G. Ökten, M. Gnewuch, 

G. Jäger, S. Climer, W. Zhang, 

L. Kliemann, A. Srivastav, 
Models of non-atomic congestion games — from unicast to multicast routing, J. Lerner, D. Wagner, K. Zweig (Eds.) Algorithmics of Large and Complex Networks, Lecture Notes in Computer Science, 5515, 292 - 318 (2009)

L. Kliemann, A. Srivastav, 

B. Langfeld, H. Gluesing-Luerssen, W. Schmale, 

V. Sauerland, L. Kliemann, A. Srivastav, C. Patvardhan, 

V. Sauerland, A. Srivastav, C. Patvardhan, 

S. Eggert, L. Kliemann, A. Srivastav, 

Presentations

M. Gnewuch, 
Algorithmic Construction of Low-Discrepancy Point Sets via Dependent Randomized Rounding, 3rd Workshop on High-Dimensional Approximation, Sydney, Australia, 19.02.2009

M. Gnewuch, 

M. Gnewuch, 
Inefficiency of equilibria in non-atomic congestion games, Columbia University, Seminar on Information-Based Complexity, New York, USA, 09.09.2009

G. Jäger, 
Complete Parsimony Haplotype Inference Problem and Algorithms, 17th Annual European Symposium on
Algorithms (ESA), Copenhagen, Denmark, 07.-09.09.2009  
L. Kliemann, Hypergraph b-Matching: Complexity and (LP-based) Heuristics, DFG SPP-Workshop Algorithm Engineering for Integer Programming, Kiel, 07.-08.05.2009  
L. Kliemann, Experimental study of non-oblivious greedy and randomized rounding algorithms for hypergraph b-matching, 8th International Symposium on Experimental and Efficient Algorithms (SEA 2009), Dortmund, 03.-06.06.2009  
G. Kliemann, Bipartite graph matchings in the semi-streaming model, MADALGO Workshop on Massive Data Algorithms, Aarhus, Denmark, 11.06.2009  
L. Kliemann, Bipartite graph matchings in the semi-streaming model, 17th European Symposium on Algorithms (ESA 2009), Copenhagen, Denmark, 07.-09.09.2009  
V. Sauerland, Lower Bounds for non-linear Regression Problems, Future Ocean Cluster Retreat, Salzau, 31.03.2009  
A. Srivastav, Algorithm Engineering, Dayalbagh Educational Institute, Deemed University, Agra, India, 18.03.2009  
A. Srivastav, Bipartite Graph Matchings in the Semi-Streaming Model, Annual colloquium of the DFG priority program, Dortmund, 03.06.2009  
A. Srivastav, Multicast routing in networks, Chalmers University Göteborg, Göteborg, Sweden, 16.10.2009  
A. Srivastav, Bipartite matchings in the semi-streaming model, Seminar, Humboldt University Berlin, Berlin, 02.11.2009  

Further Activities and Events

M. Gnewuch: Research stay at the School of Mathematics, University of New South Wales, Sydney, Australia, with Prof. Ian H. Sloan, February 16 - March 27, 2009.

M. Gnewuch: Program Committee Member of the Genetic and Evolutionary Computation Conference (GECCO), Montreal, Canada, July 2009.

M. Gnewuch: Research Fellow at the Department of Computer Science, Columbia University, New York, USA, September 2009 - August 2010.


A. Srivastav: Organization of the DFG-Workshop on Algorithm Engineering for Integer Programming, May 7-8, 2009, University of Kiel.
Real Time Systems / Embedded Systems

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

The number of embedded real-time systems today exceeds by far the number of "classical" computers. However, this area is still a comparatively new field within computer science. In the past, application experts without a specific computer science background have primarily developed such systems. However, because of the ever-increasing complexity of today's applications, this becomes less and less practical.

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,
- Reactive processors, and
- 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 (KIOLER) 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. In 2009, KIOLER was developed to the point that it largely replaced its predecessor KIEL, and included novel capabilities such as the automatic layout of data-flow diagrams and an interface to UC Berkeley's Ptolemy system as a simulation backbone.

Reactive Processors aim to implement reactive behaviour with deterministic behaviour and minimal resource usage. The Kiel Esterel Processor (KEP) is a reactive processor that supports concurrency through multithreading and offers highly predictable timing at minimal power consumption. In 2009, developments focused on the Kiel Lustre Processor, a reactive processor for the synchronous data-flow language Lustre.

The major result in the area deterministic concurrency and synchronous languages is the development of Synchronous C (SC) and Synchronous Java (SJ), which are lightweight 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. Hence SC and SJ require neither special hardware nor a special compiler. However, SC is able to take advantage of machine instructions (through gcc embeddings) that are not directly accessible in C.

Personnel

Head of the group: Prof. Dr. R. von Hanxleden; Secretary: S. Lersmacher (50%), G. Walsdorf (50%)
Technical Staff: T. Grebien (50%)
Fig. 1: Example of SyncChart and corresponding tick function for Synchronous C program.

Scientific Staff:

Dipl.-Inf. H. Fuhrmann 01.01.-31.12.2009 Landesmittel
Dipl.-Inf. M. Spönemann 01.04.-31.12.2009 Landesmittel
Dipl.-Inf. C. Traulsen 01.01.-31.12.2009 Landesmittel

Lectures, Seminars, and Laboratory Course Offers

Winter 2008/2009

MS1103: Entwurf eingebetteter Echtzeitsysteme, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
R. von Hanxleden (+ H. Fuhrmann)
A5.3.3: Fortgeschrittenenpraktikum - Synchrone Sprachen, 4 hrs Exercise/Week,
R. von Hanxleden (+ C. Traulsen)
BA6.1: Projektmodul - Echtzeitsysteme/Eingebettete Systeme (Synchrone Sprachen), 6 hrs Exercise/Week,
R. von Hanxleden (+ C. Traulsen)
MSS1101: Seminar -Echtzeitsysteme/Eingebettete Systeme (Eclipse Technologien), 2 hrs Seminar/Week,
R. von Hanxleden (+ H. Fuhrmann)
Oberseminar Echtzeitsysteme/Eingebettete Systeme, 2 hrs Seminar/Week,
R. von Hanxleden

Summer 2009

A5.3.3: Fortgeschrittenenpraktikum - Echtzeitsysteme/Eingebettete Systeme, 4 hrs Exercise/Week,
Fig. 2: Excursion to Daimler Center for Automotive IT Innovations, Berlin (09.10.).

R. von Hanxleden (+ H. Fuhrmann, M. Spönemann)

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

G2.1: Informatik II - Algorithmen und Datenstrukturen, 4 (+2) hrs Lecture (+ Exercices)/Week,
R. von Hanxleden (+ H. Schnoor)

MS1101: Modellbasiertter Entwurf und Verteilte Echtzeitsysteme, 4 (+2) hrs Lecture (+ Exercices)/Week,
R. von Hanxleden (+ H. Fuhrmann)

MS1101: Seminar - Echtzeitsysteme/Eingebettete Systeme (Seminar Synthese Graphischer Systemmodelle), 2 hrs Seminar/Week,
R. von Hanxleden (+ M. Spönemann)

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

Winter 2009/2010

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

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

MS1102: Synchronize Sprachen, 4 (+2) hrs Exercise ( + Exercices)/Week,
R. von Hanxleden (+ C. Troulsen)

MSS1101: Seminar -Echtzeitsysteme/Eingebettete Systeme (Modellierung und Ausführung Nebenläufiger Systeme), 2 hrs Seminar/Week,
Third-Party Funds

KoSSE, Modellbasierte Entwurfsmethoden für eine neue Generation elektronischer Stellwerke (MENGES), 01.08.2009-31.07.2012 (171,584 Euro)
Alexander von Humboldt-Stiftung, Forschungsstipendium für erfahrene Wissenschaftler, 01.01.-01.06.2009 (14,700 Euro)

Further Cooperation, Consulting, and Technology Transfer

Cooperation with Edward A. Lee, University of California, Berkeley, on the automatic layout of Ptolemy II diagrams and simulation of SyncCharts.

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

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

Cooperation with Partha Roop and Sidharta Andalam, University of Auckland, New Zealand, on reactive processors. Partha Roop visited our group on a Humboldt Fellowship 01.01.- 30.06.09.

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

Cooperation with CEA List (Saclay, Paris), on pragmatics of UML2 modeling.

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

Cooperation with ETAS/Bosch, on visual model exploration.

Diploma, Bachelor and Master Theses

F. Starke, Executing Safe State Machines with the Kiel Esterel Processor, 09.01.2009
M. Schmeling, ThinkCharts - The Thin KIELER SyncCharts Editor, 02.09.2009
O. Bayramoglu, KIELER Infrastructure for Textual Modeling, 03.12.2009

Publications

Published in 2009


H. Fuhrmann, R. von Hanxleden, Enhancing Graphical Model-Based System Design - An Avionics Case Study, Conjoint workshop of the European Research Consortium for Informatics and Mathematics (ERCIM) and Dependable Embedded Components and Systems (DEECOS) at SAFECOMP’09, Hamburg, Germany, September 2009, (2009)


Presentations

C. Traulsen, Reactive Processors, Informatik-Symposium Schleswig-Holstein, Neumünster, 23.03.2009


A. Schipper, H. Fuhrmann, R. von Hanxleden, Visual Comparison of Graphical Models, In Proceedings of the Fourth IEEE International Workshop UML and AADL, held in conjunction with the 14th International International Conference on Engineering of Complex Computer Systems (ICECCS’09), Potsdam, Germany, 02.06.2009
C. Traulsen, Synchronous Languages and Reactive Processing, Colloquium of the School of Physics, State University Irkutsk, Irkutsk, Russia, 10.09.2010

H. Fuhrmann, R. von Hanxleden, Enhancing Graphical Model-Based System Design— An Avionics Case Study, In Conjoint workshop of the European Research Consortium for Informatics and Mathematics (ERCIM) and Dependable Embedded Components and Systems (DECOS) at SAFECOMP’09, Hamburg, Germany, 15.09.2009


R. von Hanxleden, SyncCharts in C, Excursion Daimler Center for Automotive IT Innovations, Berlin, 08.10.2010

H. Fuhrmann, Enhancing Graphical Model-Based System Design - KIELER, Excursion Daimler Center for Automotive IT Innovations, Berlin, 08.10.2010


Further Activities and Events

Excursion to Rexxon GmbH, Kiel (25.02.).

Excursion to Daimler Center for Automotive IT Innovations, Berlin (09.10.).

R. von Hanxleden:

Member of the IEEE Esterel v7 Standardization Working Group.

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

C. Motika, C. Schneider:

Demonstration of the Model-Railway, Girls’ Day 2009 (23.04.)

R. von Hanxleden, C. Traulsen:

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

Besides the research activities the working group provides courses for the various computer science programs (bachelor, master and diploma). Moreover, the implementation of the new bachelor program in business information systems is the main focus of 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.

**Personnel**

Head of the group: Prof. Dr. Andreas Speck; Secretary: Sylvia Lassen (50%)

Technical Staff: B.Sc. Timo Hebebrand

Scientific Staff:

- Dipl.-Wirt.-Inf. Sven Feja 01.01.-31.12.2009
- MBA Andreas Rusnjak 01.01.-31.12.2009

**Lectures, Seminars, and Laboratory Course Offers**

**Summer 2009**

- WG2.2:-Grundlagen Wirtschaftsinformatik II, 3 (+ 1) hrs Lecture (+ Exercises)/Week, Andreas Speck (+ Sven Feja)
- WA4.3:-Proseminar/ Projekt, 3 hrs Seminar/Week, Andreas Speck
- eCommerce Systeme, 4 (+ 2) hrs Lecture (+ Exercises)/Week, Andreas Speck (+ Sven Feja)
- Marktorientierte und betriebliche Anwendungssysteme, 2 hrs Lecture/Week, Andreas Speck (+ Sven Feja, Andreas Rusnjak)

**Winter 2009/2010**

- WInf-WInf1:-Grundlagen Wirtschaftsinformatik I, 2 (+ 2) hrs Lecture (+ Exercises)/Week, Andreas Speck (+ Sven Feja, Andreas Rusnjak)
- MS0703:-Qualitätssicherungsmanagement, 4 (+ 2) hrs Lecture (+ Exercises)/Week, Andreas Speck (+ Sven Feja)
S5.1.- Seminar - Architekturen betrieblicher Systeme, 2 hrs Seminar/Week,
Andreas Speck

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

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

Third-Party Funds

Kampuni- im Projekt L@INC, Individuen-Netzwerk-Campus, 01.10.2009-30.09.2011 (10000 EUR)

Diploma, Bachelor and Master Theses

Mario Sponholz, Netzeffekte - ein Erfolgsfaktor im Mobile-Commerce-Markt?, 17.08.2009
Hristomir Hristov, Lean Controlling im e/mCommerce, 26.10.2009
Marcel Humann, Integration von externen Systemen in ein ERP-System, 01.01.2009

Dissertations / Postdoctoral Lecture Qualifications


Publications

Published in 2009

Sven Feja, Jens Drewehr, Anwendung von grafischen Validierungsregeln bei der Entwicklung von IT-Integrationsprozessen, Workshop Modellgetriebene Softwarearchitektur — Evolution, Integration und Migration (MSEIM), (2009)
Andreas Rusnjak, Modelling Critical Success Factors in mCommerce-Programs, Business Process, Services Computing and Intelligent Service Management, LNI 147, 238 - 240 (2009)

Presentations

Algorithmic Optimal Control - CO2 Uptake of the Ocean

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 in 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 and computer science are used. Main challenges are the huge computational effort to spin-up 3-D models to steady seasonal cycles in order to optimize them, and the sparsity of the data. Among other different optimization techniques, the algorithmic generation of sensitivities, and Newton-like methods for the computation of 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 traps part of the radiation reflected from the earth’s surface in the atmosphere. Thus, on the one hand, CO\(_2\) is responsible for the comfortable warm climate on earth allowing us to survive at all. On the other hand, the increase of CO\(_2\) emissions in the last 200 years has caused a temperature rise with 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

Water circulation determines the amount and distribution of CO\(_2\) in the ocean by biochemical processes, namely the assimilation of CO\(_2\) by phytoplankton (algae), 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. One example is the NPZD model with the four tracers dissolved being inorganic nitrogen, phytoplankton, zooplankton, and detritus. The coupling relations between the tracers in these models are more or less empirical, i.e. it is not very clear how the coupling terms appear 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.

Parameter optimization

The resulting problems belong to the mathematical disciplines of Optimization, Optimal Control, and Inverse Problems: The aim is to minimize a least-squares type cost function, measuring the model misfit with respect to the data. The optimization variables are the unknown parameters in the nonlinear coupling terms in the system of tracer transport equations. They can be spatially and temporally constant or - in more sophisticated models - distributed functions. It is well known that these kind of problems are hard to tackle, even more since the models are high-dimensional, and the available data are not very dense with regard to space and time, and are subject to uncertainty.

Fast solution algorithms

The mathematical algorithms used for parameter optimization work iteratively and require several model runs with different parameter values. Because it is necessary to run the models into a periodic state (corresponding to the annual cycle), the efficient computation of this so-called spin-up is crucial for a successful optimization. The often used technique to integrate the model in time until the periodic state is reached, is replaced in this project by direct computation using a preconditioned Newton-Krylov method, a variant of the classical Newton method adapted to the huge amount of unknowns in global 3-D
models.

SAND: Simultaneous Analysis and Design

Another approach to deal with the huge computational effort when iterating the process cycle “model spin-up -> parameter update” was successfully applied to the Rahmstorf box model of the thermohaline circulation: The two iterations (simulation and optimization) are combined in the sense that a parameter (or model design) update is performed in every model iteration, and not only when the spin-up is complete.

Further methods and outlook

Linear-quadratic Control Theory is used to incorporate timely variant parameters. Linearizations of the full nonlinear models are obtained algorithmically by the method of Automatic Differentiation (AD), which has been applied to several biogeochemical models. This use of exact derivatives can be important since approximated gradients may destroy the convergence of the methods in some cases. In this research field many models are in use, and some of them can be ordered hierarchically. Here the technique of Space Mapping or Surrogate Optimization is investigated. It aims at obtaining an optimal solution in an efficient way by optimizing with a cheap and simple model, while performing only some model runs with a more sophisticated and expensive one. The main goal for the next period in the project is to extend some of the methods above to fully realistic 3-D biogeochemical models and to improve the used optimization methods.

Results

We studied different optimization methods for a 1-D so-called NPZD model and found that the model itself can be optimized efficiently by gradient-based methods using randomly distributed initial parameter guesses. We also showed that the uncertainties of the provided measurement data result in a spread in the optimized parameters, i.e. with these data errors no unique “optimal” parameters can be found. We developed test cases for model validation, for example with respect to initial values, spin-up periods etc., and started to build a flexible software framework to perform this validation for arbitrary models and user-chosen optimization methods.

Personnel

Head of the group: Prof. Dr. T. Slawig; Secretary: I. Niehaus (50%)

Scientific Staff:

Cluster Future Ocean A3

Cluster Future Ocean A3

SPP 1253/Cluster Future Ocean A3

Dr. H. Mütze 01.09.2009-31.10.2011 (50%) DFG
Cluster Future Ocean A3

Cluster Future Ocean A3

Dipl.-Phys. M. Prieß 01.10.-31.12.2008 DFG
Cluster Future Ocean A3
Lectures, Seminars, and Laboratory Course Offers

Winter 2008/2009

MS1604: Nichtlineare Gleichungssysteme und Optimierungsaufgaben, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
T. Slawig (+ Mustapha El Jarbi)

Seminar Numerische Mathematik und Optimierung, 2 hrs Seminar/Week,
T. Slawig

Oberseminar: Numerische Mathematik, 2 hrs Seminar/Week,
T. Slawig

ISOS Short Course Parameter Optimisation for the Future Ocean, 2 hrs ISOS Course/Week,
T. Slawig

Oberseminar: Numerische Mathematik, 2 hrs Seminar/Week,
T. Slawig

Summer 2009

MS1603: Klimamodelle und Klimasimulationen, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
T. Slawig (+ M. Prieß)

Programmierpraktikum 2 Java, 3 hrs Lab/Week,
T. Slawig (+ J. Schönborn, A. Jordt)

Seminar Numerische Mathematik und Optimierung, 2 hrs Seminar/Week,
T. Slawig

Oberseminar Numerische Mathematik, 2 hrs Seminar/Week,
T. Slawig

Winter 2009/2010

Einführung in die Optimierung, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
T. Slawig

Seminar Numerische Mathematik und Optimierung, 2 hrs Seminar/Week,
T. Slawig

MSP1601: Algorithmische Optimale Steuerung/Klimasimulation, 2 hrs Projektmodul/Week,
T. Slawig

Third-Party Funds

DFG, Personal/Sachmittel, 01.01.-31.12.2009 (20000 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 Institut für Mathematik, Humboldt Universität zu Berlin Prof. Dr. Nicolas Gauger, DLR Braunschweig and Institut für Mathematik, Humboldt Universität zu Berlin Ira Neitzel, DFG SPP 1253, Institut
Publications


Presentations


M. Prieß, Space Mapping Optimization, Nordostsee-Doktorandenkonferenz, Salzau, 22.-24.01.2009

M. Prieß, Space Mapping Optimization in Ecosystem Models, Seminar AG Kunisch, FB Mathematik, Karl-Franzens-Universität Graz, Graz, 12.-12.03.2009

Further Activities and Events

Dipl.-Math. Claudia Kratzenstein joined in as a tutor during “Girls’ Day” in April 2009 (“Ein Blick in die Zukunft - Wie entwickelt sich das Klima?”)
Cognitive Systems

The Cognitive Systems research group of Christian-Albrechts-University was established sixteen years ago. The main focus of its research profiles is the tight coupling of (visual) perception and action in technical systems. One of the central problems is the learning of competences. We are considering especially the neural network paradigm. For some years we have been extending that approach by the topic of the evolutionary learning of neural network topologies. The embedding of the perception-action cycle into the framework of Clifford Algebras has been studied here for more than ten years. We are mainly concentrating on two central problems. These are parameter estimation from uncertain data in computer vision and feature extraction from multidimensional data. The goal of the last topic is to establish a novel approach to image analysis.

Results

N. Siebel has worked on the methodology of evolutionary learning of neural structures. His main activities have been in consolidation and in diverse applications.

The most general signal representation for phase based image analysis was developed by L. Wietzke in the project LEV-MON. The signal multivector is based on the use of Hilbert transforms up to third order. It results from the isomorphism of a Clifford valued analogue to the Hesse matrix in a multivector representation of homogenous conformal algebra. It delivers local spectral representations and the complete geometry of superimposed 1D signals each with arbitrary amplitude and phase.

In the project GENHIL, O. Fleischmann developed a Hilbert transform on the two-sphere by spherical harmonic expansion. This result is applicable not only in image processing but also in geodesy.

Fig. 1: From left to right: Amplitude, orientation and phase output of the filters with a filter mask size of 9 pixels and a scale of $r = 0.99$.

Personnel

Head of the group: Prof. Dr.-Ing. G. Sommer; Secretary: A. Wichmann (50%)
Technical Staff: Dipl.-Ing. (FH) G. Diesner, Dipl.-Ing. (FH) H. Schmidt (50%)
Scientific Staff:
Dr.-Ing. Sven Buchholz 01.01.-30.04.2009 CAU
GA - PAC
Dipl.Inf. Oliver Fleischmann 01.01.-31.12.2009 CAU
GENHIL
Dr. Nils Siebel 01.01.-31.10.2009 CAU
ROBVIS
Lectures, Seminars, and Laboratory Course Offers

Winter 2008/2009

MSP1201: Fortgeschrittenenpraktikum - Visuelle Robotik, 4 hrs Lab/Week,
N. Siebel

MS1204 - Geometrische Modellierung in Robot Vision, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
S. Buchholz (+ S. Buchholz)

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

MSS1201 - Seminar - Robot Vision, 2 hrs Seminar/Week,
G. Sommer

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

Diplomandenseminar ‘Kognitive Systeme’, 2 hrs Seminar/Week,
N. Siebel

Summer 2009

Informatik II für Ingenieure, 3 (+ 1) hrs Lecture (+ Exercises)/Week,
G. Sommer, N. Siebel (+ G. Sommer, O. Fleischmann)

Praktische Übungen zu: Informatik II für Ingenieure, 2 hrs Exercise/Week,
G. Sommer (+ O. Fleischmann, N. Siebel)

MS1202 - Stochastische, topologische und geom. Grundlagen von Computer Vision, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
G. Sommer (+ G. Sommer, O. Fleischmann)

Diplomandenseminar ‘Kognitive Systeme’, 2 hrs Seminar/Week,
N. Siebel

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

Winter 2009/2010

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

MSP1201 - Fortgeschrittenenpraktikum - Computer Vision I, 4 hrs Lab/Week,
O. Fleischmann

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

Diplomandenseminar - Kognitive Systeme, 2 hrs Seminar/Week,
O. Fleischmann
Third-Party Funds

DFG, Verknüpfung von 3D-Formenwissen und Lageschätzung mit Bildsegmentierung, L. Wietzke, 01.01.-31.10.2009 (45.383,68 EUR)

Further Cooperation, Consulting, and Technology Transfer

Within the actual DFG project (LEV-MON) cooperation with the University of Saarland was successful. While the Saarbrücken group mainly studied the occlusion problem in motion capture, we concentrated on local feature extraction to support the correspondence finding in that context.

S. Buchholz continued his fruitful cooperation with his Japanese colleagues; E. Hitzer, Mechanical Engineering Dept., Fukui University, K. Tachibana, Graduate School of Engineering, Nagaya University, and T. Nitta, AIST, Tsukuba.

N. Siebel continued his cooperation with J. Pauli, University Duisburg-Essen. They organized two International Workshops in the USA.

Diploma, Bachelor and Master Theses


Dissertations / Postdoctoral Lecture Qualifications

F. Chavarria, Monocular Pose Estimation based on Global and Local Feature, 05.06.2009


Publications

Published in 2009


Presentations

N. Siebel, Developing Robot Controllers by Neuro-Evolution using EANT, Machine Learning and Robotics Group, TU Berlin, Berlin, Germany, 20.03.2009

N. Siebel, Learning Solutions to Computer Vision Problems by Neuro-Evolution, Computer Vision Group, University of Leeds, Leeds, UK, 16.03.2009

G. Sommer, L. Wietzke, O. Fleischmann, Generalized monogenic signal in conformal geometric algebra, Int. Workshop on Applications of Clifford Algebra in Signal Processing, University of La Rochelle, La Rochelle, France, 02.-04.07.2009


O. Fleischmann, G. Sommer, A Hilbert transform on S2 with applications in omnidirectional vision, University of La Rochelle, La Rochelle, France, 02.-04.07.2009


N. Siebel, J. Baetel, G. Sommer, Efficient neural network pruning during neuro-evolution, International Joint Conference on Neural Networks (IJCNN 2009), Atlanta, USA, 14.-19.06.2009


L. Wietzke, G. Sommer, O. Fleischmann, The geometry of 2D image signals, CVPR 2009, Miami, USA, 20.-25.06.2009


O. Fleischmann, A monogenic signal on the two-sphere with applications in omnidirectional vision, GraVisMa 2009, University of West Bohemia, Plzen, Czech Republic, 02.-05.09.2009

Further Activities and Events

N. Siebel represented our research group at the Institute’s Girls’ Day. He organized two workshops with J. Pauli, Duisburg-Essen.; 2nd Int. Workshop on Evolutionary and Reinforcement Learning for Autonomous Robot Systems, St. Louis, MO, USA (October 15, 2009) and 1st International Workshop on Hybrid Control of Autonomous Systems Integrating
Learning, Deliberation and Reactive Control, Sadena, CA, USA (July 13, 2009).

N. Siebel, J. Boetel, and G. Sommer won the Best Poster Award of 2009 International Joint Conference on Neural Networks in Atlanta, GA, USA for their paper ‘Efficient neural-network pruning during neuro-evolution’.

In November N. Siebel took up a professorship for Building Automation at the University of Applied Sciences, Berlin. We wish him good success.

L. Wietzke and our former staff member C. Perwass established a company called Raytrix GmbH. They are selling a novel type of light-field camera. We wish them success in the commercial world.

The habilitation thesis of C. Perwass has been published with Springer-Verlag in the series Geometry and Computing.

G. Sommer was the President of the German Pattern Recognition Society (DAGM) until September 2009. He is a member of the MINERVA supervising committee of the Ollendorf Centre, Haifa. He is also a member of the Coordination Committee of CAIROS (Clifford Algebras International Research Open Studies) at University Paul Sabatier, Toulouse. G. Sommer is a member of the Steering Committee of the International Conference on Computer Analysis of Images and Patterns (CAIP) and of the Advisory Board of the International Conference on Clifford Algebras and their Applications (ICCA). He is a member of the Editorial Boards of Journal of Visual Communication and Image Representation, and Machine Graphics & Vision.
Communication Systems

The Research Group for Communication Systems (AG ComSys) was established in the Dept. of Computer Science of the CAU Kiel in Oct. 2000, and since then has been directed by Prof. Dr.-Ing. Norbert Luttenberger. The AG ComSys performs research work in four different application-orientated areas. These areas will be introduced below.

Results


The SWARMS project is funded by the Deutsche Forschungsgemeinschaft in the context of its SPP 1140 „Base Software for Self-organizing Infrastructures for Networked Mobile Systems“. It is conducted in cooperation with Prof. Dr. Stefan Fischer, University of Lübeck. In 2009, the research efforts of AG ComSys were focussed on the development of a sensor network simulation strategy that helps the network engineer to find valid values for a number of different network parameters: these values can be used in both simulation experiments and in sensor networks deployments. In the proposed methodology, valid parameter values are determined by comparing simulation output to reference data collected earlier during field tests of small-scale mobile sensor networks. It could be shown that evolutionary algorithms support this tuning step very well. A number of different fitness functions were defined and analyzed.

2. XML language technology for marine and biological research

In the context of the Cluster of Excellence „Future Ocean“, AG ComSys closely cooperated with oceanographers and biologists from CAU and IfM Geomar. The project goal is to combine formal descriptions of scientific workflows with GML/XML schemas that describe the format of measurement data and related meta-data. In 2009, a graphical workflow editor was designed and implemented that enables researchers to describe their scientific workflow in great detail. Each workstep in a workflow is attributed with grammar elements that are used to validate obtained measurement data and meta-data.

3. Verification of Railway Infrastructures

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

4. Parallel Processing on Graphics Cards

This new project was set up to find out about enhanced parallel processing methods for XML-coded documents on commercially available and cheap parallel processors, namely high-performance graphics cards. We focussed on NVIDIA’s GTX series of cards, because these cards come with a programming environment (called CUDA) that enables the programmer to develop general-purpose programs that can run on a graphics card. A recurrent step in all document-processing algorithms is sorting. This is why the first efforts were centred around sorting algorithms that are well adapted to the hardware structure of graphics cards. In a research paper we were able to show that our implementation of bitonic sort is among the best implementations in the world for sorting algorithms.

Personnel

Head of the group: Prof. Dr.-Ing. Norbert Luttenberger; Secretary: Maren Lutz
Technical Staff: Matthias Westphal
Scientific Staff:

MSc. Michael Lodemann 01.01.-31.12.2009 ISH-HWT
Railway infrastructure verification

Dipl.-Inf. Hagen Peters 01.01.-31.12.2009 Land SH
Massive parallel processing

Dipl.-Inf. Jesper Zedlitz 01.01.-31.12.2009 ExC Future Ocean
Workflow definition for oceanographic research

Lectures, Seminars, and Laboratory Course Offers

Winter 2008/2009

Systemorientierte Informatik 3 Betriebssysteme, 3 (+2) hrs Lecture (+ Exercises)/Week,
Norbert Luttenberger (+ Hagen Peters)

Internet Communications, 4 (+2) hrs Lecture (+ Exercises)/Week,
Norbert Luttenberger (+ Hagen Peters)

Summer 2009

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

Computer Networks and Internetworking, 2 (+1) hrs Lecture (+ Exercises)/Week,
Norbert Luttenberger (+ Hagen Peters)

Academic Writing, 2 (+1) hrs Lecture (+ Exercises)/Week,
Norbert Luttenberger

Bachelor-Abschlussprojekt Kommunikationssysteme, 6 hrs Seminar/Week,
Norbert Luttenberger (+ Hagen Peters)

Winter 2009/2010

Systemorientierte Informatik 3 Betriebssysteme, 3 (+2) hrs Lecture (+ Exercises)/Week,
Norbert Luttenberger (+ Hagen Peters)

Internet Communications, 4 (+2) hrs Lecture (+ Exercises)/Week,
Norbert Luttenberger (+ Hagen Peters)

Master-Praktikum Kommunikationssysteme, 6 hrs Seminar/Week,
Norbert Luttenberger (+ Hagen Peters)

Third-Party Funds

DFG, SWARMS, 01.01.-31.05.2009 (25000 EUR)
ISH-HWT, RTVE, 01.01.-31.12.2009 (60000 EUR)
ExC Future Ocean, XDataCollection, 01.01.-31.12.2008 (60000 EUR)

Further Cooperation, Consulting, and Technology Transfer

The main cooperation partners of the Research Group for Communication Systems were the following:
Institut für Telematik, Universität Lübeck, Prof. Dr. Stefan Fischer, in the context of the DFG-funded project SWARMS.

IFM-GEOMAR (Physikalische Ozeanographie), Prof. Dr. Martin Visbeck; Institut für Polarökologie der CAU Kiel, Prof. Dr. Dieter Piepenburg; IFM-GEOMAR (Marine Biogeochemie), Prof. Dr. Ulf Riebesell in the context of the XDataCollection project (EXC Future Ocean).

Fa. Funkwerk IT GmbH in the context of the RTVE project.

MARUM (Universität Bremen), Dr. Chr. Waldmann, in the context of the XDataCollection project.

**Diploma, Bachelor and Master Theses**


Ben Willers, *Entwurf und Realisierung einer autonom und kooperationsfähigen Quadrocopter-Plattform*, 10.05.2009

**Publications**

Published in 2009


**Presentations**


**Further Activities and Events**


N. Luttenberger organized the Technical Faculty’s Winterfest, 05.12.2009.
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 2009, 12 scientific researchers were involved in 10 research projects. Project funding was supported by DFG, EU, BMWi, Land Schleswig-Holstein, and Industry (Daimler, Raytheon, SevenCs, IBAK, RealEyes, Vision-n).

Results

Several projects in the field of 3D data processing are currently under investigation. The EU-funded project 3D4YOU aims at developing the complete production chain for future 3D Television, namely the content generation, data compression, and 3D visualisation. The partners Philips, France Telecom, Thompson, Fraunhofer HHI, KuK Film productions, and CAU MIP jointly develop structures and algorithms to fulfil this goal. MIP has taken on the challenge to develop a 3D multi-camera prototype for real-time 3D-TV recording, by integrating HDTV colour cameras with range cameras, and to develop a suitable 3D data format, the Layered depth video data, to handle 3D data with occlusion information and to convert the video and range data streams into this format. Figure 1 shows an image of the multi-camera rig, composed of 5 colour cameras and 2 range cameras.

Fig. 1: Top left: multi-camera rig with a central HDTV camera, 4 satellite colour cameras, and 2 range cameras to support depth and occlusion data. Right: Layered depth image with colour (top) and depth (bottom). Bottom left: object segmentation of person from background, based on depth.

A second project for visualising high quality 3D data is a BMWi project with the company RealEyes and some partners from Industry and Fraunhofer Research. The goal of the project is to produce highly realistic large-scale 3D posters with up to 50,000 separate views, to achieve unprecedented realism by the use of micro-lens arrays. One of the obstacles of such a 3D poster is the huge amount of data, since typically for each square-meter of poster, 250,000 images with different view points are to be rendered and processed, resulting in about 200 GB of image data and a processing time of several months per poster. The achievement of MIP in this project is the development of a highly compressed data structure that allows the exploitation of the redundancy of the images and to reduce image data by a factor of 150 to 1.3 GB. Additionally, the rendering time of an A0-size poster could be reduced by a factor of 500 from 8 month to 13 hrs on a standard computer.
As part of a bundle of DFG projects to exploit the time-of-flight (tof) range camera technology, MIP has developed several new techniques for the handling of combined depth and video data. This new data type can be exploited in a variety of ways, and as one possible prototype solution, MIP has developed a Mixed Reality system for Virtual Studios, MixIn3D. The depth data is exploited to build a 3D environment model of the studio room, and the range data from the tof camera is used to segment the actors and to mix real live data with virtual content. The novel feature is that both, real and virtual content may occlude each other mutually and even cast shadows to increase realism. Figure 2 shows the 3D acquisition system on a pan-tilt head and some results of the studio images with and without mixing of real and virtual content.

The 3D reconstruction of real scenes from image and video data is a central research topic of the MIP group, and several projects investigate applications of this approach. One application is the 3D environment reconstruction of deep-sea structures, like black smokers on the ocean floor. In this project, funded by DFG and the Future Ocean Excellence initiative, video data from the remotely operated vehicle Kiel6000 are utilised to reconstruct geological structures. From the image data alone it is possible to reconstruct geometry and surface colour of such underwater structures. Special care is taken to correct the colour attenuation under water, and to reconstruct the 3D surface of the structures. Figure 3 shows some reconstruction results.
Fig. 3: Top left: ROV Kiel 6000 with cameras. Bottom: Underwater Images (from different view points). Top right: reconstructed surface model of black smoker Irina II.

**Personnel**

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

Technical Staff: T. Storm

Scientific Staff:

- **B. Bartczak**
  - 3D4You/Land
  - 01.01.-31.12.2009
  - EU/CAU

- **S. Esquivel**
  - Land
  - 01.01.-31.12.2009
  - CAU

- **A. Frick**
  - 3D4You
  - 01.01.-31.12.2009
  - EU

- **K. Hoase**
  - AR-Fernglas
  - 01.01.-31.12.2009
  - ISH

- **A. Jordt**
  - 3D4You
  - 01.08.-31.12.2009
  - EU

- **D. Jung**
  - InnoNet
  - 01.01.-31.12.2009
  - BMWi

- **F. Kellner**
  - InnoNet
  - 01.01.-31.12.2009
  - BMWi

- **K. Koeser**
  - Land
  - 01.01.-31.03.2009
  - CAU

- **A. Petersen**
  - Land
  - 01.01.-31.12.2009
  - CAU
Lectures, Seminars, and Laboratory Course Offers

Winter 2008/2009

Computer Graphik, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
R. Koch (+ S. Esquivel, D. Jung)

3D-Szenenrekonstruktion aus Bildfolgen, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
R. Koch (+ S. Esquivel, A. Sedlazeck)

Visuelle Modellierung, 2 hrs Seminar/Week,
R. Koch (+ K. Köser)

Multimediale Informationsverarbeitung, 2 hrs Advanced Seminar/Week,
R. Koch (+ K. Köser)

Multimedia Communications, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
R. Koch (+ K. Köser, A. Petersen)

Summer 2009

Vertiefende Übung Computer Graphik/Computer Vision, 6 hrs Advanced Seminar/Week,
R. Koch (+ A. Petersen, F. Kellner)

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

Multimediale Informationsverarbeitung, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
R. Koch (+ S. Esquivel, A. Petersen)

Systemorientierte Informatik II - Organisation und Architektur von Rechnern, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
R. Koch (+ C. Traulsen)

Oberseminar Multimediale Informationsverarbeitung, 2 hrs Seminar/Week,
R. Koch (+ S. Esquivel, A. Petersen)

Winter 2009/2010

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

Vertiefende Übung Visuelle Modellierung, 4 hrs Advanced Seminar/Week,
R. Koch (+ A. Petersen, F. Kellner, A. Frick)

Multimedia Communications, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
R. Koch (+ S. Esquivel, A. Petersen)

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

Bachelor and Master Thesis Seminar, 4 hrs Advanced Seminar/Week,
R. Koch (+ S. Esquivel, D. Jung, A. Frick, F. Kellner)

**Third-Party Funds**

BMWi + Partner, Entwicklung und Aufbau einer Herstellungskette für hochwertige 3D-Bilder TV: Aufbau eines Renderers für 3D Bilder, 01.06.2008-31.05.2010 (238.520 EUR)
EU, 3D4YOU, 01.02.2008-30.07.2010 (418.100 EUR)
DFG, Dynamisches 3D Sehen, 11.02.2008-31.01.2010 (150.000 EUR)
Deimler AG, Collision Avoidance, 01.04.2008-28.02.2010 (145.000 EUR)
DFG Exzellenzcluster, Future Ocean, 01.04.2008-31.08.2009 (100.000 EUR)
DFG, Seafloor modeling, 01.04.2009-31.03.2011 (150.000 EUR)
EU, InterReg, 01.09.2009-31.07.2012 (273.000 EUR)
EU, KoSSe, 01.08.2009-31.07.2012 (330.000 EUR)

**Further Cooperation, Consulting, and Technology Transfer**

Dr. Hunger, Fa. IBAK, Kiel
Dr. Didier Stricker, IGD - FHG, Darmstadt
Prof. Dr.-Ing. Michael Felsberg, Linköping University, Linköping, Schweden
Fabian Doil, VW, Wolfsburg
Friedhelm Moggert-Kägeler, Seven Cs, Hamburg
Prof. Joachim Weickert, Uni Saarland, Saarbrücken
Prof. Hans-Peter Seidel, MPI für Informatik, Saarbrücken
Dr. Bodo Rosenhahn, MPI für Informatik, Saarbrücken
Jürgen Streufert, Raytheon Anschütz GmbH, Kiel
Yoav Schechner, Israel Institute of Technology Haifa, Israel
Shahriar Negadaripour, University of Miami Miami, USA

**Diploma, Bachelor and Master Theses**

M. Jackwerth, Evaluation des AR-Frameworks FARA für die weitere Verwendung in der Lehre, 07.10.2009
R. Wolff, 3D-Rekonstruktion archäologischer Schritte in Einzelbildsequenzen, 16.07.2009

**Dissertations / Postdoctoral Lecture Qualifications**

K. Köser, Geometric Estimation with Local Affine Frames and Free-form Surfaces, 20.03.2009
Published in 2009


L. Papp, M. Zuhayra, R. Koch, Triple-modality Normalized Mutual Information based Medical Image Registration of Cardiac PET/CT and SPECT Images, Informatik Aktuell, 446, 386 - 389 (2009)

Presentations

B. Bartczak, Dense Depth Maps from Low Resolution Time-of-Flight Depth and High Resolution Color Views, ISVC 09, Las Vegas, USA, 02.12.2009

F. Kellner, MixIn3D: 3D Mixed Reality with ToF-Camera, DAGM Dyn3D Workshop, Jena, Deutschland, 14.05.2009

I. Schiller, Datastructures for Capturing Dynamic Scenes with a Time-of-Flight Camera, DAGM Dyn3D Workshop, Jena, Deutschland, 08.09.2009

S. Esquivel, Reconstruction of Sewer Shaft Profiles from Fisheye Lens Camera Images, DAGM, Jena, Deutschland, 09.09.2009

A. Frick, Generation of 3D-TV LDV-content with Time of Flight Camera, 3DTV-CON 2009, Potsdam, Deutschland, 05.05.2009


R. Wulff, *3D Reconstruction of Archaeological Trenches from Photographs*, SCCH 2009, Heidelberg, Deutschland, 17.11.2010

A. Sedlazeck, *3D Reconstruction Based on Underwater video from ROV Kiel 6000 Considering Underwater Imaging Conditions*, IEEE Oceans 2009, Bremen, Deutschland, 14.05.2010


**Further Activities and Events**

*Young Talent Award 2009 DAGM*, Falko Kellner, für *Environment Modelling and Object Segmentation using an actively steered Time-of-Flight Camera*

*Schüleruni und Lehrertagungen* boten 2009 wieder eine Plattform für zahlreiche Vorträge zum Thema Multimedia, Filmtechnik und MP3

*Workshop Bildverarbeitung* am 03.12.09 wurde ein Workshop im Rahmen des Arbeitskreises Bildverarbeitung Schleswig-Holstein ausgerichtet.

*Workshop Dynamic 3D Imaging (Dyn3D)* zusammen mit der DAGM 2009 in Jena wurde im September ein Workshop organisiert.

*Kunsthalle zu Kiel* *Fundort Priene: Alltag und Fest in einer griechischen Stadt* Für die Ausstellung vom April 2009 bis April 2010 drehte Robert Wulff ein Video *3D Szenenrekonstruktion in der Ärcheologie*.

*Intuniversitäre Gremien*

- Vorsitzender des Prüfungsausschusses „Ingenieurinformatik“

*Reviews*

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

- 3DTV-Con
- 3DPVT 2009
- CVMP 2009
- CVPR 2009
- DAGM 2009
- ICCV 2009
- ICIP 2009
- ICME 2009
- PSIVI 2009
- ISMAR 2009
- VMV 2009
- 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

Reviewer for the following journals:
- IEEE-IE Transactions IE, Special Issue on Optomechatronics
- International Journal of Image and Graphics
- IEEE T-IP: Transactions for Image Processing
- IEEE T-PAMI Transactions of Pattern Analysis and Machine Intelligence
- Journal on CVIU Computer Vision and Image Understanding
- Journal PFG (Photogrammetrie, Fernerkundung, Geoinformation)
- Journal Mathematical Imaging and Vision
- EURASIP
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 has been supported by the DFG (German Research Foundation) and the DAAD (German Academic Exchange Service).

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 programs. This also enables opportunities for improving the execution of programs. Instead of a stepwise execution oriented towards the sequential program text, a compiler may select a much more efficient demand-driven strategy oriented towards the data flow of the program. This separation of logic and control supports more efficient program development. However, in the case of programming errors, traditional debugging methods, like stepwise tracing of the program’s execution, are not appropriate. Therefore, we extended our previous work on new debugging techniques, like debugging by observing the evaluation of distinguished expressions or functions, or declarative debugging. The latter is implemented by a two-phase execution: the first phase executes the program and collects information about program execution. This information is used as an “oracle” for the second phase which presents the program’s execution in a different order that is more comprehensible for the programmer. In order to ease the implementation of tools related to the second phase, we developed a rather generic framework to control oracle-based interpreters in a monadic manner.

In the area of the design and semantics of declarative languages, we collaborated with the Portland State University (Oregon, USA) and developed a new method to encapsulate nondeterministic computations in functional logic programs. This method is based on associating to each function a set-valued function encapsulating the nondeterminism caused by the function’s execution. It is the first referentially transparent approach to encapsulate nondeterministic computations and, thus, solves a long-standing problem in this area. Further work in this area was the development of a new semantic foundation for declarative languages covering various degrees of nondeterministic behaviour. This research was done in cooperation with the research group “Computer-Aided Program Development”.

We also investigated several issues related to the implementation of functional programming languages. We extended the implementation of KiCS (Kiel Curry System) that is based on a couple of new theoretical insights arising from the research of our group in previous years. We also explored a new alternative implementation of nondeterminism in a purely functional language that is based on monads. This monadic approach allows the selection of the concrete search strategy by different monad instances so that various search strategies can be selected and combined at run-time. This also provides a new basis to exploit parallelism since one can implement nondeterministic computations by concurrent threads that run on multicores. We experimented with various parallel search strategies in order to lay the foundations for future parallel implementations of declarative languages.

Related to the application of declarative languages, we developed a new framework to specify graphical and web-based user interfaces in a uniform manner so that one can generate graphical user interfaces for desktop applications as well as web-based user interfaces for web applications from the same interface specification. This approach decreases the implementation efforts for application systems. Furthermore, we designed and implemented a new framework, called Spicy, to generate complete web applications from a specification of the underlying data as an entity-relationship model. Since the generated implementation is a high-level declarative program, it is easy to adapt this program to various
customer requirements. In contrast to other web frameworks, our framework exploits high-level declarative programming techniques so that it yields reliable implementations that avoid data inconsistencies at various levels.

Our research group was also engaged in public relations activities. For instance, we gave an introduction to elementary programming at the Girls’ Day of the institute. The visiting students learnt basic programming techniques with the little ladybird Kara. This introduction has also been used for a one-week course on programming where the participating students developed a distributed chat program in the concurrent functional language Erlang. This course was organized by Frank Huch (in collaboration with Thomas Wilke).

### Personnel

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

Scientific Staff:

<table>
<thead>
<tr>
<th>Name</th>
<th>Title/Duration</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr.phil. Bernd Bößel</td>
<td>01.04.-30.09.2009</td>
<td>DFG</td>
</tr>
<tr>
<td>Dipl.-Inf. Sebastian Fischer</td>
<td>01.01.-31.12.2009</td>
<td>CAU</td>
</tr>
<tr>
<td>Priv.-Doz. Dr. Frank Huch</td>
<td>01.01.-31.12.2009</td>
<td>CAU</td>
</tr>
<tr>
<td>Dipl.-Inf. Fabian Reck</td>
<td>01.01.-31.12.2009</td>
<td>CAU</td>
</tr>
<tr>
<td>Dr. Friedemann Simon</td>
<td>01.01.-31.12.2009</td>
<td>CAU</td>
</tr>
</tbody>
</table>
Lectures, Seminars, and Laboratory Course Offers

Winter 2008/2009

Diplomandenseminar, 2 hrs Seminar/Week,
Michael Hanus

G1.1 Informatik I - Programmierung, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Michael Hanus (+ Fabian Reck, Christina Otte)

BA6.5: Projektmodul - Werkzeuge zur Fehlersuche, 6 hrs Exercise/Week,
Michael Hanus (+ Bernd Braßel)

Informatik für Nebenfächer, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Frank Huch (+ Sebastian Fischer)

MS0301: Prinzipien von Programmiersprachen, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Michael Hanus

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

MS0309: Softwareschnittstelle zum Zertifizieren von Systemen, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Wolfgang Goerigk

MSP0302: Masterprojekt - Werkzeuge zur Fehlersuche, 4 hrs Exercise/Week,
Michael Hanus (+ Bernd Braßel)

Objektorientierte Programmierung für Nebenfächer, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
Friedemann Simon
W108: - Objektorientierte Programmierung, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
Friedemann Simon

Summer 2009

Systematisches Programmieren, 2 (+ 4) hrs Lecture (+ Exercises)/Week,
Friedemann Simon

Diplomandenseminar, 2 hrs Seminar/Week,
Michael Hanus

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

MS0303: - Deklative Programmiersprachen, 4 (+ 2) hrs Seminar (+ Exercises)/Week,
Michael Hanus (+ Fabian Reck)

MS0306: - Nebenläufige und verteilte Programmierung, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Frank Huch

MS0302: Seminar - Programmiersprachen und Programmiersysteme, 2 hrs Exercise/Week,
Michael Hanus

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

W109: - Fortgeschrittene Programmierung, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
Michael Hanus (+ Frank Huch, Sebastian Fischer)

Winter 2009/2010

Diplomandenseminar, 2 hrs Seminar/Week,
Michael Hanus

Inf-Prog: - Programmierung, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Michael Hanus (+ Fabian Reck, Christina Otte, Bernd Braßel, Sebastian Eggert)

MS0302: Übersetzerbau, 4 (+ 2) hrs Exercise (+ Exercises)/Week,
Michael Hanus (+ Sebastian Fischer)

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

W116: Programmiertechniken für die Künstliche Intelligenz, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
Friedemann Simon

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

MSS0302: Seminar - Programmiersprachen und Programmiersysteme, 2 hrs Seminar/Week,
Michael Hanus

MSS0303: Masterabschlusseminar Programmiersprachen, 2 hrs Seminar/Week,
Michael Hanus

NF-Inf-1: Informatik für Nebenfächler, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
Frank Huch (+ Sebastian Fischer, Hauke Furhmann)

Vertiefende Übung zu: Informatik für Nebenfächler, 2 hrs Exercise/Week,
Frank Huch (+ Sebastian Fischer)
Third-Party Funds

DFG, Systematische Fehlersuche in deklarativen Programmen, 01.01.-26.10.2009 (31.139,41 EUR)
DAAD, Implementation of Instrumented Semantics for Declarative Multi-Paradigm Languages, 01.01.-31.12.2008 (7.402,00 EUR)

Further Cooperation, Consulting, and Technology Transfer

The research group cooperates with:
Portland State University (Sergio Antoy)
Technical University of Valencia (Josep Silva, German Vidal)
University of Münster (Herbert Kuchen)

Diploma, Bachelor and Master Theses

Andreas Müller, Von der Finanzplanung zum unternehmensweiten Finanzberichtswesen - ein Berichtssystem für den BusinessPlanner .NET der Bank Austria, 23.03.2009
Christoph Wulf, Code-Erzeugung zur Unterstützung der Fehlersuche, 15.04.2009
Jan-Philip Rathje, Entwicklung eines Java-nach-C++-Übersetzers zur Transferierung von Java-API's, 05.05.2009
Gunnar Biederbeck, Ein verteiltes Objektsystem zur Programmierung und synchronen Steuerung von Geräten in hochgradig multimedialen Rechnernetzen, 17.08.2009

Dissertations / Postdoctoral Lecture Qualifications

P. Sadeghi, Run-Time Debugging for Functional Logic Languages, 27.01.2009

Publications

Published in 2009

D. Seipel, Michael Hanus, A. Wolf, Applications of Declarative Programming and Knowledge Management, Springer Lecture Notes in Artificial Intelligence, 5437, (2009)


**Patent Applications**


**Presentations**

*Michael Hanus, Declarative Programming of User Interfaces*, International Symposium on Practical Aspects of Declarative Languages (PADL 2009), Savannah, Georgia, USA, 19.01.2009

*Fabian Reck, A Graphical Debugger for Haskell’s Software Transactional Memory*, 26. Workshop der GI-Fachgruppe Programmiersprachen und Rechenkonzepte, Bad Honnef, Germany, 05.05.2009

*Bernd Braßel, Proposing Order-Sorted Algebra as Foundation for Declarative Programming*, 26. Workshop der GI-Fachgruppe Programmiersprachen und Rechenkonzepte, Bad Honnef, Germany, 06.05.2009

*Sebastian Fischer, Purely functional lazy non-deterministic programming*, 26. Workshop der GI-Fachgruppe Programmiersprachen und Rechenkonzepte, Bad Honnef, Germany, 06.05.2009

*Sebastian Fischer, Purely functional lazy non-deterministic programming*, 14th International Conference on Functional Programming (ICFP’09), Edinburgh, Scotland, 31.08.2009

*Bernd Braßel, Functional (logic) programs as equations over order-sorted algebras*, 19th International Symposium on Logic-Based Program Synthesis and Transformation (LOPSTR’09), Coimbra, Portugal, 11.09.2009


*Sebastian Fischer, Reinventing Haskell Backtracking*, Fourth Working Conference on Programming Languages, Lübeck, Germany, 01.10.2009

*Fabian Reck, Towards a Parallel Search for Solutions of Non-deterministic Computations*, Fourth Working Conference on Programming Languages, Lübeck, Germany, 01.10.2009

*Michael Hanus, Set Functions for Functional Logic Programming*, 15th Colloquium on Programming Languages and Foundations of Programming, Maria Tafelr, Austria, 12.10.2009

*Sebastian Fischer, Reinventing Haskell Backtracking*, 15th Colloquium on Programming Languages and Foundations of
Further Activities and Events

S. Fischer: Research stay related to “Graph-based Evaluation of Functional Logic Programs” at Portland State University (Oregon, USA) with Prof. Sergio Antoy, September 12-26, 2009

M. Hanus: Organization of the 26th Workshop of the GI-Fachgruppe Programmiersprachen und Rechenkonzepte, Bad Honnef (Germany), May 2009

M. Hanus: Program committee member of TFP 2009 (Tenth Symposium on Trends in Functional Programming), Komarno (Slovakia), June 2009

M. Hanus: Program committee member of WFLP 2009 (18th Workshop on Functional and (Constraint) Logic Programming), Brasilia (Brazil), June 2009

M. Hanus: Program committee member of WST 2009 10th International Workshop on Termination), Leipzig, June 2009

M. Hanus: Program committee member of ICLP 2009 (25th International Conference on Logic Programming), Pasadena (California, USA), July 2009

M. Hanus: Program committee member of CICLOPS 2009 (9th International Colloquium on Implementation of Constraint and Logic Programming Systems), Pasadena (California, USA), July 2009

M. Hanus: Program committee member of PPDP 2009 (11th International Symposium on Principles and Practice of Declarative Programming), Coimbra (Portugal), September 2009

M. Hanus: Program committee member of LOPSTR 2009 (19th International Symposium on Logic-based Program Synthesis and Transformation), Coimbra (Portugal), September 2009

M. Hanus: Program committee member of WLP 2009 (23rd Workshop on (Constraint) Logic Programming), Potsdam, October 2009

M. Hanus: Organization and program committee co-chair of the Fourth Working Conference on Programming Languages (ATPS’09), Lübeck, 2009 (part of the 39th annual conference of the German Gesellschaft für Informatik)

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

M. Hanus: Chair of the executive committee of the Fachgruppe “Programmiersprachen und Rechenkonzepte” of the Gesellschaft für Informatik e.V.

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

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

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

M. Hanus: Member of the selection committee of the DAAD (German Academic Exchange Service) for the project-related support to scientific cooperation with Spain and Portugal
M. Hanus: Member of the advisory board of the „Berufsakademie an der Wirtschaftsakademie Schleswig-Holstein“

M. Hanus: Referee of the habilitation of Janis Voigtländer (title: “Types for Programming and Reasoning”), University of Dresden, 2009

M. Hanus: Chair of the managing directorate of the Institute of Computer Science, University of Kiel

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

M. Hanus: Member of the convent of the Faculty of Engineering, University of Kiel

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

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

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

F. Huch: Vice-Chair of the executive committee of the Fachgruppe „Programmiersprachen und Rechenkonzepte“ of the Gesellschaft für Informatik e.V.

F. Huch: Programming course with the little ladybird Kara, Girls’ Day, April 23, 2009

F. Huch: Organisation (together with Thomas Wilke) of the “Schnupperstudium Informatik für Schülerinnen und Schüler”, April 6 - 9, 2009, Kiel, 70 participants. Course on introduction to programming: navigation of a pirates ship by means of the programming language Erlang, final project: development and implementation of a distributed chat.


F. Reck: Research stay related to „Graph-based Evaluation of Functional Logic Programs“ at Portland State University (Oregon, USA) with Prof. Sergio Antoy, September 12-26, 2009

F. Simon: Lectures related to the advanced training of teachers (IQSH)

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

F. Simon: “Computer Museum” representative of the Faculty of Engineering in the board of control
Computer-Aided Program Development

The main topics of the group are the fundamentals of programming languages and formal methods for problem specification and program development, axiomatic relation algebra and related calculi and their use in computer science, and applications of relation-based structures like graphs in computer science. The investigations always have been done with a view to supporting computer systems and led during the last years to the following three tools developed by the group: Kiel, a tool for the visual execution of functional programs written in a subset of Standard ML, Java-Rap, a tool for the prototyping of modular algebraic specifications based on the native Passau Rap system, and RelView, a tool for the manipulation and visualization of relations and for relational prototyping and programming. For certain purposes, the group also always uses further tools, like the automatic theorem prover Prover9 for the verification of proof obligations during program developments and the tool Marce4 for constructing counter-examples.

Results

The first research topic of the group is the investigation of programming languages, their semantic fundamentals, and the application of formal and computer-aided methods for problem specification and program development. A second topic is axiomatic relation algebra and the use of relation-algebraic techniques in computer science and related disciplines. For example, relations are used to solve problems on graphs, Petri nets, games and orders. Thirdly, the group explores the use of binary decision diagrams, on the one hand for the efficient implementation of relations in the relation-algebraic tool RelView and on the other hand for the efficient representation of simple games and the solution of problems of social choice theory.

In the area of programming language semantics we have investigated type-based reasoning in functional logic programming languages. Type-based reasoning is popular in functional programming. In particular, parametric polymorphism, a feature of modern functional programming languages constrains functions in such a way that statements about their behaviour can be derived without consulting function definitions. We have investigated whether the same is true in a strongly, and polymorphically, typed functional logic language. To prove our example driven observations we started developing a functional style denotational semantics for functional logic programming languages.

Furthermore the group has worked on the semantic foundations of minimally strict sequential functions in functional programming languages. In a call-by-name functional programming language functions can differ with means of strictness. We have developed an approach that can identify whether a sequential function exists that is less strict than a given one. The existing approach did not consider sequentiality.

Regarding the fundamentals of programming languages the group has investigated the possibility to model functional logic programming languages as equations within a special form of algebra.

In the area of simple games and its classes of weighted and vector-weighted voting games we have investigated mechanisms for coalitions formation and the calculation of power for the players in a simple game by so called power indices, which are hard to compute. Many of these problems are of highly practical relevance, for instance to analyze the distribution of power in the EU Council of Ministers, the International Monetary Fund and in some organizations of the World Bank. Our investigations have covered the application of relation algebra and the RelView tool, as well as direct application of binary decision diagrams which can seamlessly be integrated into the RelView approach. Beside that, we are developing a standalone application which has ease of use in mind and will be released soon.

Personnel

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

Dipl.-Inf. Stefan Bolus 01.06.-31.12.2009 DFG
SOCIAL SOFTWARE for elections, the allocation of tenders and coalition/alliance formation (SSEAC)

Dr. phil. Bernd Braßel 01.01.-31.03.2009
Semantics of functional-logic programs and methods for debugging

Dr. phil. Bernd Braßel 01.10.-31.12.2009 CAU
Semantics of functional-logic programs and methods for debugging

Dipl.-Inf. Jan Christiansen 01.01.-31.12.2009
Investigations concerning strictness and non-strictness in functional languages

Dr. Martin Halfpap 01.01.-31.12.2009 CAU
Technical didactics of computer science

Lectures, Seminars, and Laboratory Course Offers

Winter 2008/2009

Fachunterricht - Konzeption und Gestaltung im Fach Informatik, 2 (+ 2) hrs Seminar (+ Exercises)/Week,
Martin Halfpap

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

G1.3: - Programmierpraktikum P1, 3 hrs Exercise/Week,
Rudolf Berghammer (+ Jan Christiansen, Lars Prädel)

MS0402: - Ordnungen und Verbände, 4 (+2) hrs Lecture (+ Exercises)/Week,
Rudolf Berghammer (+ Bernd Braßel)

G1.3L: - Programmierpraktikum P1, 3 hrs Exercise/Week,
Rudolf Berghammer (+ Jan Christiansen, Lars Prädel)

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

Summer 2009

Fachdidaktik der Informatik, 2 (+ 2) hrs Seminar (+ Exercises)/Week,
Martin Halfpap

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

TEF-inf-FD1: Grundlagen der Fachdidaktik Informatik, 2 (+ 2) hrs Seminar (+ Exercises)/Week,
Martin Halfpap

MS0401: - Semantik von Programmiersprachen, 4 (+2) hrs Lecture (+ Exercises)/Week,
Rudolf Berghammer (+ Jan Christiansen)

MS0403: - Relationale Methoden in der Informatik, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Rudolf Berghammer

Oberseminar, 2 hrs Seminar/Week,
Rudolf Berghammer
Informatikanwendungen von Ordnungen und Verbände, 2 hrs Seminar/Week,
Rudolf Berghammer

Winter 2009/2010

TEF-inf-FD2: Planung, Durchführung und Analyse von Informatikunterricht (im Praxismodul 2) (TEF-inf-FD2), 2 (+ 2) hrs Seminar (+ Exercises)/Week,
Martin Halfpap

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

MS0402: Ordnungen und Verbände, 4 (+ 2) hrs Exercise (+ Exercises)/Week,
Rudolf Berghammer (+ Bernd Braßel)

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

Übung zu: Mathematik für Informatiker A - Grundlagen und Diskrete Strukturen, 2 hrs Exercise/Week,
Rudolf Berghammer

Vertiefende Übung zu: Planung, Durchführung und Analyse von Informatikunterricht (im Praxismodul 2), 2 hrs Exercise/Week,
Martin Halfpap

Third-Party Funds

DFG, LogiCCC: SOCIAL SOFTWARE for elections, the allocation of tenders and coalition/alliance formation (SSEAC),
10.02.-31.12.2009 (30.788,52 EUR)

Further Cooperation, Consulting, and Technology Transfer

Applications of relational methods in computer Science, with A. Fronk (Dortmund), 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 (Lyon, France) and H. de Swart (Tilburg, The Netherlands)

Evolutionary and approximation algorithms, binary decision diagrams, with F. Neumann (Saarbrücken)

Proofing techniques and semantics for functional logic programming languages with D. Seidel, J. Voigtländer (Bonn, former Dresden).

Guests in the year 2008: V. Gerdt (Dubna, Russia) in March 2009 and F. Neumann (Saarbrücken)

Diploma, Bachelor and Master Theses

Maik Barz, Algorithmen für die Analyse und systematische Bewertung von Express-Zertifikaten, 30.04.2009
Christian Lange, Algorithmen zur systematischen Schätzung von erwarteten Dividendenzahlungen, 27.05.2009
Tim Chr. Reshöft, Relationen algebraische Lösungen von Aussagenlogischen Problemen, 01.06.2009

Publications

Published in 2009


**Presentations**

Rudolf Berghammer, *Combining relation algebra and RelView in formal program development*, Workshop on Social Software and Computational Social Choice, Lyon, Frankreich, 01.-02.04.2009

A. Rusinowska, Rudolf Berghammer, H. de Swart, *Applying relation algebra and RelView to measures in a social network*, 23rd European Conference on Operational Research, Bonn, Deutschland, 05.-08.07.2009


H. de Swart, A. Rusinowska, Rudolf Berghammer, *Computational social choice using relation algebra and RelView*, 11th International Conference on Relational Methods in Computer Science and 6th International Workshop on Applications of Kleene Algebra, Doha, Qatar, 01.-06.11.2009

Rudolf Berghammer, G. Schmidt, *Contact relations with applications*, 11th International Conference on Relational Methods in Computer Science and 6th International Workshop on Applications of Kleene Algebra, Doha, Qatar, 01.-06.11.2009

Rudolf Berghammer, A. Fronk, *A relation-algebraic approach to liveness of place/transition nets*, 11th International Conference on Relational Methods in Computer Science and 6th International Workshop on Applications of Kleene Algebra, Doha, Qatar, 01.11.1009-06.11.2009
Further Activities and Events

R. Berghammer, B. Braßel, J. Christiansen and S. Bolus 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 Methods in Computer Science and Applications of Kleene Algebra” (RelMiCS/AKA) and one of the editors of the electronic journal “Journal on Relational Methods in Computer Science”. Together with A. Jaoua and B. Möller he organized the RelMiCS/AKA 2009 meeting in Doha (Qatar) in November 2009.


R. Berghammer is a member of the German initiative “Softwarevisualisierung”. For details, see URL http://www.softwarevisualisierung.de.

In his spare time J. Christiansen has designed the logo for the ACM symposium on principles of programming languages. The logo will be used for the conferences in 2009, 2010, and 2011.
Scientific Computing

Since November 2008, Prof. Dr. Steffen Börm has been head of the „Scientific Computing“ Group.

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),

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., by preparing them for parallelization or vectorization).

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

Personnel

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

Scientific Staff:

Dipl.-Math. J. Gördes 01.-31.12.2009 (50%) CAU

Lectures, Seminars, and Laboratory Course Offers

Winter 2008/2009

Elementare numerische Methoden 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 (+ M. Gnewuch)

Numerische Behandlung von Eigenwertaufgaben (Mathematisches Praktikum), 2 (+4) hrs Lecture (+ Exercises)/Week,
S. Börm (+ J. Burmeister)

Numerische Mathematik für Ingenieure, 2 (+1) hrs Lecture (+ Exercises)/Week,
S. Börm (+ M. Gnewuch)

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

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

Summer 2009
Elementare numerische Methoden und ihre Implementierung II, 2 hrs Lecture/Week,
S. Börm (+ J. Burmeister)

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

Grundlagen der Numerik, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
S. Börm (+ J. Burmeister)

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

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

Winter 2009/2010
Elementare numerische Methoden 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)

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

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

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

Third-Party Funds
Land Schleswig-Holstein, Innovationsfonds, 01.10.2005-31.03.2009 (160000 EUR)

Further Cooperation, Consulting, and Technology Transfer
Max-Planck-Institut Leipzig Dr. Lars Grasedyck und Prof. Dr. h.c. Wolfgang Hackbusch (hierarchische Matrizen)
Dr. Lars Grasedyck (schnelle Integrationsverfahren auf Grundlage von Tensorzerlegungen)

Diploma, Bachelor and Master Theses
A. Staacken, Die numerische Behandlung von stochastischen partiellen Differentialgleichungen, 25.02.2009
J. Gördes, Eigenwertprobleme von hierarchischen Matrizen mit lokalem Rang 1, 29.10.2009

Publications
Published in 2009
Presentations


S. Börm, *Numerische Verfahren für nicht-lokale Phänomene*, Antrittsvorlesung in der Technischen Fakultät, Kiel, Deutschland, 04.05.2009


Further Activities and Events

01.01.2009 Prof. Dr. Steffen Börm appointed Associate Editor of *SIAM Journal for Scientific Computing*

Visit to “Academica XIII” at our Estonian partner university at Tartu.

Software Engineering

Research of the Software Engineering Group focuses on Software Engineering for parallel and distributed systems. Traditionally, software engineering addresses the process of constructing and evolving software systems. The operation of systems that are expected 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 and operating continuously operating software systems.

Since October 2008, Prof. Dr. Wilhelm Hasselbring has been head of the Software Engineering Group. Before that, he was head of the Software Engineering Group at the University of Oldenburg. Prof. Hasselbring is still associated with the DFG Graduate School TrustSoft (http://trustsoft.uni-oldenburg.de) and the OFFIS institute (http://www.offis.de). Currently, he intends to establish the new KoSSE network together with other colleagues of the Computer Science Institutes in Kiel and Lübeck (http://www.kosse-sh.de).

Results

BIS-Grid

The BIS-Grid project, as part of the German D-Grid initiative, investigates service orchestration using Grid service technologies to show how such technologies can be employed for information systems integration, especially when crossing enterprise boundaries. Small and medium enterprises will be enabled to integrate heterogeneous business information systems and to use external resources and services with affordable effort. BIS-Grid supports the new orchestration as a Service (OaaS) paradigm. The BIS-Grid workflow engine orchestrates both plain Web services and stateful, WSRF-based Grid services. For more information, refer to http://bisgrid.d-grid.de.

![Fig. 1: The BIS-Grid workflow engine.](image-url)
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. A requirement for its robust operation is the 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 framework components to be replaced or added, 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-orientated 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, refer to http://kieker.sourceforge.net.

**Fig. 2: Kieker Monitoring Framework Architecture**

**Personnel**

Head of the group: Prof. Dr. W. Hasselbring; Secretary: M. Lutz (50%)

Technical Staff: M.Sc. M. Westphal (50%)

Staff:

Prof. Dr. W.-P. de Roever 01.01.-31.12.2009 retired

Scientific Staff:

Dipl.-Wirt.-Inf. J. Ehlers 01.01.-31.12.2009 CAU
M.Sc. S. Frey 01.01.-31.12.2009 CAU
Dipl.-Inform. I. Grabe 01.11.-31.12.2009 EU
Dipl.-Inform. S. Gudenkauf 01.01.-31.12.2009 OFFIS, BMBF
M.Sc. I. Gul 01.07.-31.12.2009 DFG
Lectures, Seminars, and Laboratory Course Offers

Winter 2008/2009

Informatik III - Softwaretechnologie, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
W. Hasselbring (+ S. Frey, J. Waller, N.T. Siebel)

Oberseminar - Software Engineering, 2 hrs Seminar/Week,
W. Hasselbring

Summer 2009

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

Software Architectures for Adaptive and Self-managed Systems, 2 hrs Seminar/Week,
W. Hasselbring

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

Oberseminar - Software Engineering, 2 hrs Seminar/Week,
W. Hasselbring

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

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

Fortgeschrittenenpraktikum - Software Engineering, 4 hrs Exercise/Week,
W. Hasselbring (+ S. Frey, J. Ehlers, J. Waller)

Winter 2009/2010

Oberseminar - Software Engineering, 2 hrs Seminar/Week,
W. Hasselbring

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

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

Informatik III - Softwaretechnologie, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
W. Hasselbring (+ S. Frey, J. Waller, S. Esquivel)
Third-Party Funds

BMWF, BIS-Grid: Betriebliche Informationssysteme: Grid-basierte Integration und Orchestrierung, 01.05.2007-30.04.2010 (379.426 EUR)
Zukunftsprogramm Wirtschaft (ZPW), MENGES (Modellbasierte Entwurfsmethoden für eine neue Generation elektronischer Stellwerke), 01.08.2009-31.07.2012 (435.120 EUR)

Further Cooperation, Consulting, and Technology Transfer

In BIS-Grid, we cooperate via the OFFIS-Institute with CADsys Vertriebs- und Entwicklungsgesellschaft mbH, with CeWe Color AG & Co. OHG, with Forschungszentrum Jülich, with KIESELSTEIN GmbH, with Siemens IT Solutions and Services, with TU Berlin, and with the Paderborn Centre for Parallel Computing (PC2).

In TrustSoft, we cooperate within the context of the Kieker project with EWE TEL GmbH and with CeWe Color AG & Co. OHG.

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

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

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 and with several regional companies.

Dissertations / Postdoctoral Lecture Qualifications

S. Bärisch, Model-Driven Test Case Construction by Domain Experts in the Context of Software System Families, 28.02.2009
H. Niemann, Regelbasierte Replikationsstrategie für heterogene, autonome Informationssysteme, 31.07.2009
J. Matevska, Modellbasierte erreichbarkeitsoptimierte Rekonfiguration komponentenbasierter Softwaresysteme zur Laufzeit, 31.07.2009

Publications

Published in 2009


**Presentations**


W. de Roever, *Main highlights of my Archive, donated as first contribution to the Historical Collection of the Dept. of Computer Science, University of Swansea*, Lecture, Swansea, Wales, 21.04.2009


W. Hasselbring, *Automatic Failure Diagnosis Support in Distributed Large-Scale Software Systems based on Timing Behavior Anomaly Correlation*, Dagstuhl-Seminar, Schloß Dagstuhl, 11.05.2009

Further Activities and Events

W. Hasselbring:

- Board of GI-Fachgruppe Softwaretechnik
- Board of GI-Fachgruppe Software-Architektur
- Board of GI-Querschnittsfaachausschuss Modellierung
- Vice Chair of D-Grid-Beirat
- Jury of Microsoft Imagine Cup

- Editorial Board of the following journals:
  - Advances in Software Engineering
  - International Review on Modelling and Simulations
  - Enterprise Modelling and Information Systems Architectures - An International Journal
  - International Journal of Software Architecture

- Reviewer for
  - Deutsche Forschungsgemeinschaft
  - Arbeitsgruppe Innovative Projekte (AGIP) beim niedersächsischen Ministerium für Wissenschaft und Kultur
  - IEEE Transactions of Software Engineering
  - Journal of Systems and Software
  - Software and Systems Modeling
• Organization of
  – Software-Architektur 2009
  – Grid Workflow Workshop 2009
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 2008 can be subsumed under three headings: First, the ongoing development of the massively parallel architecture COPACOBANA, second, the development and implementation of new parallel algorithms for specific, computationally demanding problems in bioinformatics, and third, the deployment of COPACOBANA for problems in crypto analysis.

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 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 application specific integrated circuits, ASICs.

The research group technical computer science 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 has been developed in a collaboration with the university of Bochum between 2005 and 2007. Due to the fact that many algorithms in crypto analysis make heavy use of floating-point operations and COPACOBANA is not strong in floating-point performance, a new research project was launched in 2008. Its goal was to develop a floating-point optimized version of COPACOBANA for crypto analytic algorithms. In collaboration with the federal department for security of information technologies (BSI) this floating-point optimized massively parallel architecture, called COPACOBANA V4SX35, combines the benefits of FPGAs with the floating-point performance of common CPUs. This development finished in 2009.

In order to meet the requirements of modern Bioinformatics, a number of additional features for COPACOBANA are desired. In a HWT2-project funded by the ISH (Innovation Society Schleswig-Holstein), the architecture COPACOBANA 5000 has been designed for this purpose. It uses new versions of the XilinX-Spartan series, the Spartan3-5000. The first prototype of the new machine is planned to operate in March 2010.

Algorithms in Bioinformatics

In the area of bioinformatics several projects have been completed, others are in progress. These projects span a variety of different algorithms in bioinformatics, primarily Motif finding, sequence alignment, and short read assembly/error correction.

In cooperation with the Institute for Infectious Diseases at the University of Kiel and the Institute for Virology at Freie Universitaet in Berlin different diagnostic tools using sequence alignment have been or are developed. These tools help in treatment by, for example, diagnosing patients’ DNA samples and identifying underlying diseases or resistances. The tools are used on a daily basis in the diagnostic department of the university clinic in Kiel as well as on a web basis for the international community.

A second cooperation with these two institutes came to life in the area of motif finding. Motif finding deals with the problem of finding regulatory sequences in genomes without knowing their length or structure just by analyzing representation of sequences in the genome. This problem is very demanding in its computational effort, so we utilize our special purpose hardware architecture COPACOBANA to speed up this process. The results showed significantly faster speeds compared to standard PC architectures and allowed extensive analysis of viral genomes. The results are analysed by the biologists.
participating in this project and the promising candidates for newly discovered motifs are further processed in experiments in the laboratory.

The third topic, sequence assembly and error correction, was developed in cooperation with National ICT Australia and RMIT in Melbourne. DNA sequencing is spoken of as one of the most significant techniques of the century. Its relevance to progress in medical and biological research is profound. Sequencing means the process of translating or reading molecular DNA into a digital representation consisting of letters. New technologies to increase speed are being developed and the costs for sequencing DNA is dropping accordingly. The new technologies however demand new computer techniques to process the raw output from the sequencing machines and since the amount of data produced every day is increasing all the time the requirement for computing resources does so as well. So far the cooperation dealt with correcting errors in the output data of sequencing machines allowing easier processing of the data. Recently a new project partner, the Institute for Molecular Biology in Kiel, joined this project and the goal is to implement assembly algorithms on massively parallel hardware architectures to speed up the assembly process hence allowing bigger genomes to be sequenced faster.

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 there has been a funding of seven projects in this context. One of these projects is managed by the research group Technical Computer Science. 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 co-ordination. 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 for three years.

Personnel

Head of the group: Prof. Dr. rer. nat. M. Schimmler; Secretary: B. Scheidemann (50%)

Scientific Staff:

A. Abbas 01.01.-31.12.2009 University Aleppo
M.Sc. Y.Ch. Ching 01.01.-31.03.2009 E.On, EnBW, RWE
M.Sc. S. Koschnicke 01.09.-31.12.2009 HWT
Dipl.-Ing. G. Pfeiffer 01.01.-14.09.2009 Land SH
Dipl.-Inf. Ch. Starke 01.01.-31.12.2009 Land SH

Lectures, Seminars, and Laboratory Course Offers

Winter 2008/2009

Systemorientierte Informatik I (Digitale Systeme), 3 (+ 2) hrs Lecture (+ Exercises)/Week,
M. Schimmler (+ G. Pfeiffer, J. Schröder)

Hardware-Praktikum, 3 hrs Practical/Week,
M. Schimmler (+ J. Nass, G. Pfeiffer, J. Schröder)

FPGA’s-Praktikum, 4 hrs Practical/Week,
M. Schimmler (+ G. Pfeiffer)
Algorithmen der Bioinformatik, 2 hrs Seminar/Week,
M. Schimmler (+ J. Schröder)

Oberseminar Technische Informatik, 2 hrs Seminar/Week,
M. Schimmler

Summer 2009

Hardwarepraktikum, 3 hrs Practical/Week,
L. Wienbrandt

Winter 2009/2010

Digitale Systeme, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
M. Schimmler (+ Ch. Starke, L. Wienbrandt)

Hardwarepraktikum, 3 hrs Practical/Week,
M. Schimmler (+ Ch. Starke, L. Wienbrandt)

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

Oberseminar, 2 hrs Seminar/Week,
M. Schimmler

Third-Party Funds

University of Aleppo, Stipendium Ayman Abbas, 01.01.-31.12.2009 (11.094,00 EUR)
Innovationsfonds des Landes S-H, Bio-Engine, 01.01.2009-31.03.2010 (100.00,00 EUR)
SCI Engines GmbH, Bio-Engine, 01.01.2009-31.03.2010 (25.000,00 EUR)
Prof. Dr. Werner Petersen-Stiftung, Stipendien Software-Challenge, 03.03.2009 (18.000,00 EUR)
BLK-Modellversuch, Software-Challenge, 01.08.2009-30.06.2010 (35.000,00 EUR)
Frauenbeauftragte, Stipendien, 10.06.2009 (3.600,00 EUR)
datapore, Software-Challenge, 26.05.2009 (3.600,00 EUR)
b+m Informatik AG, Software-Challenge, 20.01.2009 (10.000,00 EUR)
Ministerium für Wissenschaft, Wirtschaft und Verkehr, Universeller Aufgabenclient zur Unterstützung des technischen Betriebsmanagements bei verteilter Datenhaltung, 01.10.2009-31.08.2012 (176.233,00 EUR)
ESN, Universeller Aufgabenclient zur Unterstützung des technischen Betriebsmanagements bei verteilter Datenhaltung, 01.10.2009-31.08.2012 (20.264,36 EUR)
GISWORK, Universeller Aufgabenclient zur Unterstützung des technischen Betriebsmanagements bei verteilter Datenhaltung, 01.10.2009-31.08.2012 (2.251,60 EUR)

Diploma, Bachelor and Master Theses

Ch. Läubrich, Soft Core Controlled Multi-Cryptographic-CoProcessor FPGA System, 06.03.2009

Publications

Published in 2009


Tim Güneysu, Gerd Pfeiffer, Christof Paar, Manfred Schimmler, 3 Years of Evolution: Cryptanalysis with COPACOBANA, Special-purpose Hardware for Attacking Cryptographic Systems, SHARCS 2009, (2009)

Further Activities and Events

M. Schimmler: Vicedean of the Faculty of Engineering from 01.01.-31.12.2009

Software Challenge 2008

Many first-year students in computer science and electrical engineering come with a wrong idea about the subjects they have to learn. Therefore, during the first semesters we observe a strong diminution in the number of students in almost all programmes of the faculty. In order to help school-leavers to find the best decision for or against a study program in the Faculty of Engineering we organize the so called Software Challenge once a year. The Software Challenge is a programming competition between the secondary schools of Schleswig-Holstein. Professors, teaching assistants, and tutors of the department of computer science are sent into the secondary schools in order to support the teachers in computer science classes. This year, the pupils had to write a program for a player of the board game ‘Hase und Igel’. In the time interval between March and May the programs of the different schools played a complete tournament and the leading eight schools met again in the quarter finals at the Sophienhof, Kiel. The best schools were assigned money prizes and the best pupils received grants for a study programme at the Faculty of Engineering of the CAU. The project has been funded by the b+m Informatik AG, Dataport, DiWISH, the Prof.-Dr.-Werner-Petersen Stiftung, and the Ministry of Science, Economy and Traffic of Schleswig-Holstein.
Information Systems Engineering

Research and teaching in the chair 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 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,
* Performance assessment, forecasting, and tuning for large database applications.

Results

Integrated development of information systems based on co-design: The co-design methodology has been assessed by the SPICE committee and has been evaluated to be one of the first methodologies at the 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. Co-evolution and co-existence use the concept of model suites.

Content management systems: The department is currently developing a novel technology of content management systems based on a separation into content, concepts, and topics. Content is supported by media types. A theoretical foundation of concepts has been developed. The approach has been tested and applied to the development of semantic wikis.

Technology of application modelling and of component systems: Component systems are becoming the main approach for efficient and effective development of large systems. Based on the approaches that have been developed to application modelling here 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.

Theory of database and information systems: Research has been mainly orientated on semantic foundations of database and knowledge base systems. The theory of model suites generalizes approaches to co-existence and co-evolution of models and to model ensembles. A new approach has been developed to approximate database operations for stochastic databases. XML technology has been grounded on the ASM theory. The BPMN standard has been entirely analysed and re-specified. The theoretical foundation of BPMN based on ASM has been developed in this department. Transaction processing has been re-specified and based on the ASM theory. The theory of integrity constraints can be supported by graphical reasoning beyond classical logical reasoning. It has been proved that graphical reasoning subsumes logical reasoning for the main classes of database constraints.

Languages for modelling and development of web information systems: The department has been developing a number of languages for the specification and implementation of web information systems. The concept of life cases and of application cases has been integrated into this theory and technology. The power of the approach has been demonstrated for edutainment (e-learning) systems. A theory of context of web information systems has been developed in this department. Two tutorials have been given at international conferences.

Support of information systems applications: Information systems applications are becoming more heterogeneous and larger. Several approaches have been developed here for performance assessment, forecasting and tuning of applications.
A novel approach to support privacy of users has been developed.

**Graph-based analysis and synthesis of polyhedral networks in crystal structures:** In the field of polyhedra graphs we investigate properties of the realization space of these graphs. Furthermore, we consider methods for determining similarities of crystal structures using their representation by polyhedra graphs. A method has been developed and implemented which allows the classification of topologically equivalent substructures with respect to their geometric conformity. It can be used to rank results of queries asking for similar clusters of polyhedra in large crystallographic databases. Further investigations are directed towards enumeration methods for models of crystal structures.

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**Personnel**

Head of the group: Prof. Dr. B. Thalheim; Secretary: A. Wichmann (50%)
Technical Staff: M.Sc. S. Goede

**Scientific Staff:**
- Dipl.-Inf. K. Jannasch 01.01.-31.12.2009 CAU
- apl.-Prof. Dr. H.-J. Klein 01.01.-31.12.2009 CAU
- Dipl.-Ing. G. Millahn 01.01.-10.06.2009 Vattenfall Europe
- M.Sc. R. Noack 01.01.-31.12.2009 DFG
- Dipl.-Inf. O. Sörensen 01.01.-31.12.2009 CAU
- Dipl.-Inf. M. Tropmann 01.01.-31.05.2009 Vattenfall Europe
- Dipl.-Inf. M. Tropmann 01.06.-31.07.2009 CAU
- Dipl.-Inf. M. Tropmann 01.09.-16.10.2009 (50%) Vattenfall Europe
- Dipl.-Inf. M. Tropmann 17.-31.10.2009 CAU
- Dipl.-Inf. M. Tropmann 01.11.-31.12.2009 CAU

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**Lectures, Seminars, and Laboratory Course Offers**

*Winter 2008/2009*

**MS0508:** - Fuzzy-Methoden, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
A. Salski (+ A. Salski)

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

**MSS0503 - Seminar Datenbanksysteme,** 2 hrs Seminar/Week,
H.-J. Klein, B. Thalheim
Fortgeschrittenenpraktikum - Vertiefende Übung 'Datenbankprogrammierung II', 4 hrs Lab/Week, B. Thalheim

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

W102: Wahlpflichtmodul Informatik - Datenbanktechnologie, 4 (+2) hrs Lecture (+ Exercises)/Week, H.-J. Klein (+ K. Jannaschk)

Data Mining, Data Application and Statistics, 2 hrs Lecture/Week, B. Thalheim

Summer 2009

A4.2: Systemorientierte Informatik IV - Datenbanksysteme, 4 (+2) hrs Lecture (+ Exercises)/Week, H.-J. Klein (+ H.-J. Klein, C. Starke, K. Jannaschk)

Intensivkurs - Grundlagen der Informatik für Wirtschaftsinformatiker, 6 hrs Lecture/Week, O. Sörensen

MS0501: - Modellierung großer Informationssysteme, 4 (+2) hrs Lecture (+ Exercises)/Week, B. Thalheim (+ B. Thalheim, O. Sörensen)

MS0507: - Künstliche Intelligenz, 2 (+1) hrs Lecture (+ Exercises)/Week, A. Salski (+ A. Salski)

Praktische Übung zu Künstliche Intelligenz, 1 hrs Exercise/Week, A. Salski

MS0503: Seminar - Datenbanksysteme, 2 hrs Seminar/Week, H.-J. Klein, B. Thalheim

MS0504: Oberseminar - Technologie der Informationssysteme, 2 hrs Seminar/Week, H.-J. Klein, B. Thalheim

W110: - Anwendung von Informationssystemen, 2 (+1) hrs Lecture (+ Exercises)/Week, B. Thalheim (+ B. Thalheim)

Winter 2009/2010

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

MS0508: - Fuzzy Methoden, 2 (+1) hrs Lecture (+ Exercises)/Week, A. Salski (+ A. Salski)

Praktische Übung zu: Fuzzy-Methoden, 1 hrs Exercise/Week, A. Salski

MS0503 - Seminar Datenbanksysteme, 2 hrs Seminar/Week, H.-J. Klein, B. Thalheim

MS0504: Oberseminar - Technologie der Informationssysteme, 2 hrs Seminar/Week, B. Klein, H.-J., B. Thalheim

Data Mining, Data Application and Statistics, 2 hrs Lecture/Week, B. Thalheim

MS0509: - Pattern-based information systems development, 4 (+2) hrs Lecture (+ Exercises)/Week, B. Thalheim (+ B. Thalheim, K. Jannaschk)
Third-Party Funds

DFG, Adaptables content- und benutzungsgesteuertes generisches Layout von Web-Anwendungen,
01.01.-31.03.2009 (13.910,40 EUR)
DAAD, Projektbezogener Personenaustausch mit Finnland - PPP Finnland, 01.01.-31.12.2009 (2.500,00 EUR)
Vattenfall Europe, Intelligenter Performance Monitor, 01.01.-13.08.2009 (74.970,00 EUR)
DAAD, Projektbezogener Personenaustausch mit Japan : Knowledge Technology for Next Generation Web,
01.01.-31.12.2009 (12.444,00 EUR)
DFG, Adaptables content- und benutzungsgesteuertes generisches Layout von Webanwendungen,
01.04.-31.12.2009 (45.340,00 EUR)

Further Cooperation, Consulting, and Technology Transfer

University of Antwerp (Jan Paredaens), Free University Berlin (Heinz Schweppe, Hans-Joachim Lenz), Technical University Berlin (Herbert Weber), Humboldt University Berlin (Johann Christoph Freytag, Oliver Günther), Alfred Renyi Institute Budapest (Gyula Katona, Dezso Miklos), MTA SZTAKI Budapest (Janos Demetrovics), University Concepcion (Marcela Varaos), Cottbus University of Technology (Heinrich-Theodor Vierhaus), University of Dortmund (Gabriele Kern-Ibsen, Joachim Biskup), Freiburg University (Dietmar Janetzko), Technical University Hamburg-Harburg (Joachim W. Schmidt), Klagenfurt University (Heinrich Mayr), Louisiana State University (Peter P. Chen), Kazakhstan Institute of Management, Economics and Strategic Research KIMEP, Almaty (Roland Kaschek), Information Science Research Centre Palmerton North (Klaus-Dieter Schewe), Lomonossov University Moscow (Elyar Gasonov, Valerij B. Kudriavcev), Charles University Prague (Jaroslav Pokorny), Microsoft Research Redmond (Yuri Gurevich), Saarbrücken University (Klaus-Peter Jantke), Brigham Young University Salt Lake City (David Embley), Silicon Valley Lab IBM (Laura Haas, Holger Kache), Tampere University of Technology (Hannu Joakko), Tampere University (Hannu Kangassalo), Umea University (Oleg Seleznev), Versailles University (Elisabeth Metois), Portland State University (James Bailey), University of Melbourne (X. Sean Wang), Victoria University, Wellington (Hui Ma)

Diploma, Bachelor and Master Theses

A. Seifert, Methoden und Verfahren für Performance Forecasting in datenintensiven Anwendungen, 30.07.2009
A. Aksac, Knowledge Engineering and Semantics for the Quality Based Next Generation Knowledge Web, 05.05.2009
O. Sörensen, Semantics of Joins in Cyclic BPMN Workflows, 01.03.2009
B. Jensen, Graphalgorithmen zum Erkennen von Hohlraumen in hypothetischen Kristallstrukturen, 01.07.2009

Publications

Published in 2009

H.-J. Klein, A general enumeration method for models of crystal structures, Proc. 3rd Int. Conf. on Advanced Engineering Comp. and Appl. in Sciences, Sielma, Malta, 29 - 34 (2009)
H. Ma, K.-D. Schewe, B. Thalheim, Modelling and Maintenance of Very Large Database Schemata, UNISCON, Vol. 20, 17 - 28 (2009)
H. Ma, K.-D. Schewe, B. Thalheim, A Theory of Data-Intensive Software Services, Service Oriented Computing and Applications,ISSN 1863-2386 (Print) 1863-2394 (Online), Vol. 3, No. 4, 263 - 283 (2009)
A. Salski, B. Holstein, Fuzzy knowledge- and data-based models of damage to reeds by Greylag Geese, Ecological Informatics, 4/3, 156 - 162 (2009)
A. Salski, A fuzzy set approach to ecological knowledge discovery, Proc. of the IFSA-World Congress, Lisbon, 725 - 730 (2009)
P. Schmidt, S. Kowski, M. Behrens, Applying Concept-Driven Engineering for Business Process Specifications, Proc.of the
P. Schmidt, B. Thalheim, Management of UML Clusters, Böger Festschrift, LNCS 5115, 111 - 129 (2009)
B. Thalheim, K.-D. Schewe, H. Ma, Conceptual Application Domain Modelling, APCCM, Vol. 96, 49 - 57 (2009)

Presentations

K. Jannasch, Towards Guided Intelligent Data Analysis and Mining, Romanian-German Symposium on Mathematics and Its Applications, Sibiu, Romania, 14.05.2009
K. Jannasch, Towards Guided Intelligent Data Analysis and Mining, KEIO University, Invited Talk, Tokyo, Japan, 29.09.2009
H.-J. Klein, A general Enumeration method for models of crystal structures, ADVCOMP 2009, Valencia, Italy, 12.10.2009
A. Salski, A fuzzy approach to ecological knowledge discovery, IFSA-World Congress, Lisbon, Portugal, 20.07.2009
B. Thalheim, Algebraische Grundlagen der Datenbanktheorie, Mathematisches Seminar, CAU Kiel, Kiel, Germany, 09.01.2009
B. Thalheim, Handling for Information and Software Systems, Kolloquium, UPC, Barcelona, Spain, 04.03.2009
B. Thalheim, The Background for Guided Intelligent Data Analysis and Mining for Concepts, RoGerS 2009, Sibiu, Romania, 14.05.2009
B. Thalheim, A fixed-point query languages for XML, EJC 2009, Maribor, Slovenia, 03.06.2009
B. Thalheim, Instead Web 4.0: Knowledge Web, EJC 2009, Maribor, Slovenia, 04.06.2009
B. Thalheim, Web Information Systems Design and Web 2.0, Uni Linz, Fakultät für Wirtschaftswissenschaften, Fakultätskolloquium, Linz, Austria, 17.06.2009
B. Thalheim, Semantics in Databases, KEIO University, Workshop Novel Computing, Tokyo, Japan, 29.09.2009
B. Thalheim, The Path to Knowledge Web through Advanced Knowledge Management, KEIO University, 2nd Cluster
System Seminar, Tokio, Japan, 29.09.2009
B. Thalheim, Towards a Theory of Conceptual Modelling, ETHeCoM 2009, Gramado, Brazil, 09.11.2009
B. Thalheim, Mathematics of structural and functional integration, Kolmogorow lecture, Lomonossow State University Moscow, Mat-Nat Faculty, Moscow, Russia, 21.12.2009
B. Thalheim, Model suites, Kolmogorow lecture, Lomonossow State University Moscow, Mat-Nat Faculty, Moscow, Russia, 22.12.2009
B. Thalheim, Knowledge, information and data discovery, Kolmogorow lecture, Lomonossow State University Moscow, Mat-Nat Faculty, Moscow, Russia, 23.12.2009
B. Thalheim, Evolution of information systems, Kolmogorow lecture, Lomonossow State University Moscow, Mat-Nat Faculty, Moscow, Russia, 29.12.2009
M. Tropmann, Performance Forecasting, 21. GI Grundlagenworkshop von Datenbanken, Rostock-Warnemünde, Germany, 02.06.2009
M. Tropmann, Performance Forecasting, Abschlussvortrag bei Vattenfall, Berlin, Germany, 23.07.2009

Further Activities and Events

H.-J. Klein:
Member of Program Committee:
FoIKS 2010 (Int. Symp. on Foundations of Information and Knowledge Systems), Sofia, Bulgaria, 2010
ADVCOMP 2009 (Third Int. Conf. on Advanced Engineering Computing and Applications in Sciences), Sliema, Malta, 2009
DTA 2009 (Int. Conf. on Database Theory and Application), Jeju Island, Korea, 2009

R. Noack:
Member of Programme Committee: WISE ’09 Web Information Systems Engineering, Poznan, Oktober 2009

A. Salski:
Reviewer for: Ecological Informatics (Elsevier)
Ecological Complexity (Elsevier)

B. Thalheim:
Kolmogorow-Professor, Lomonossow-University, Moscow, since 2005
ER 2009: Fellow
Member of Program Committee:
APCCM’08, Asia-Pacific Conference on Conceptual Modelling, Wellington, New Zealand, January 2009
FINCO’09, York, UK, March 2009
MBSDI’09, Model-Based Software & Data Integration, Sydney Australia, April 2009
eComo’09, Adelaide, Australia, April 2009
EJC’09, European-Japanese Symposium on Conceptual Modelling, Maribor, Slovenia, June 2009
NGITS 2009, Haifa, Israel, June 2009
Member of Steering Committees of International Conferences:
SDKB, ER, ADBIS, ABZ, EJC, NLDB, Baltic DB, ISTA
Vice-Chair of the Steering Committee of the FOIKS Conferences
Logic-Based Modelling, ER’09 Workshop, Gramado, Brazil, November 2009
PhD Workshop, ER ’09 Workshop, Gramado, Brazil, November 2009
ACM-L Workshop ER ’09, Gramado, Brazil, November 2009
APSCC 2009, Singapore, December 2009
WITS 2009, Phoenix, December 2009
SITIS ’09, Marrakech, Morocco, November 2009

Tutorials at International Conferences:
Web Information Systems Co-Design u. Web 2.0, ER 2009, Gramado, Brazil, November 2009
Web Information Systems Design in the Era of Web 2.0 and Beyond, iiWAS 2009, December 2009, Malaysia

Workshops:
CoMoL 2009, Gramado, Brazil, 09.11.2009
QoIS 2009, Gramado, Brazil, 09.11.2009

Participation in Industrial Committees:
Member of the advisory board of Dataport
Theoretical Computer Science

The theory group of the Department of Computer Science is specialized in automata theory, verification, logic in computer science, foundations of IT-security, computational complexity theory, and didactics of computer science.

Results

UML. The Unified Modelling Language (UML) is by now a widespread modelling language in software engineering; the theory group studies its formal foundation. From a formal methods point of view, a major problem with UML is that it is ambiguous and admits many different semantics. In 2009, one of the achievements in this respect was a rigorous semantics for UML state machines with interlevel transitions. This result was complemented by an appropriate notion of refinement, which supports hierarchical system design, and transformations that preserve the semantics of UML. Further research went into the study of sub-state machine behaviour, in particular, readiness.

Manipulating Elections. In social choice theory, a collective decision is viewed as the aggregate of individual interests. One direction of research in this area is to develop appropriate election systems. The theory group is interested in the complexity of such systems. In 2009, the theory group focused on the Copeland election system, where a group of voters each ranks the possible alternatives (candidates) as a total order. The winner(s) of the election are computed by granting each candidate 1 point for every candidate that he „beats” in the majority of voters, and a variable (alpha) amount of points for each candidate that he ties with. We resolved the complexity of the manipulation problem for the practically relevant cases.

Logics for Probabilistic Strategic Games. Strategic games play an important role in the modelling and analysis of various kinds of systems. The theory group is interested in alternating-time temporal logic (ATL), which is used to reason about strategic abilities of agents. Aiming at strategies that can realistically be implemented in software, many variants of ATL study a setting where strategies may only take available information into account. Another generalization of ATL is Probabilistic ATL, where strategies achieve their goal with a certain probability. We introduced a semantics of ATL that takes into account both of these aspects. We prove that our semantics allows simulation relations similar in spirit to usual bisimulations, and has a decidable model checking problem in the case of memoryless strategies: A key property of our logic is that it allows the modelling of prior agreement as relevant for jointly developed software agents.

Security of Contract-Signing Protocols. As in recent year, the theory group has worked on modelling, analyzing, and designing contract-signing protocols. In 2009, we developed a probabilistic contract signing protocol that achieves the crucial security notion of balance even in the presence of an adversary that may delay messages sent over secure channels. To show that this property holds in a computational setting, we first proposed a probabilistic framework for protocol analysis, then proved that in a symbolic setting the protocol satisfies a probabilistic alternating-time temporal formula expressing balance, and finally established a general result stating that the validity of formulas such as our balance formula is preserved when passing from the symbolic to a computational setting. The key idea of the protocol is to take a „gradual commitment” approach.

Authenticated Message Exchange. The last topic the theory group has worked on in 2009 is simulation-based security of cryptographic protocols. The main objective is to give rigorous proofs of the security of practically relevant protocols. Simulation-based security notions for cryptographic protocols are regarded as highly desirable, primarily because they admit strong composability and, consequently, a modular design. We developed a simulation-based security definition for two-round authenticated message exchange and showed that a concrete, natural protocol, 2AMEX-1, satisfies our security property, that is, we provided an ideal functionality for two-round authenticated message exchange and show that 2AMEX-1 realizes it securely.
Personnel

Head of the group: Prof. Dr. Th. Wilke; Secretary: F. Lorenz (50%)
Technical Staff: Th. Hess (50%)

Scientific Staff:
M.Sc. I. Khan 01.01.-31.12.2009 DAAD

Trust Management in Public Key Infrastructure
Dr. H. Schnoor 01.01.-31.12.2009 CAU
StR S. Schulmeister 01.08.-31.12.2009 (50%) CAU
Dipl.-Inf. J. Schönborn 01.04.-31.12.2009 (50%) CAU
Dipl.-Inf. M. Tropmann 01.06.-31.07.2009 CAU

Lectures, Seminars, and Laboratory Course Offers

Winter 2008/2009

Automaten, Logiken, Spiele, 4 (+2) hrs Lecture (+ Exercises)/Week, Th. Wilke
Kryptographie: Verfahren und Angriffe, 2 (+1) hrs Lecture (+ Exercises)/Week, H. Schnoor

Mathematik für Informatiker III - Logik für Informatiker, 4 (+2) hrs Lecture (+ Exercises)/Week, Th. Wilke (+ R. Thöle)
Theoretische Informatik, 2 hrs Seminar/Week, Th. Wilke
Anleitung zum wissenschaftlichen Arbeiten, 1 hrs Lecture/Week, Th. Wilke

Summer 2009

G2.3: Programmierpraktikum II (ProgPrak) (080064), 3 hrs Exercise/Week, T. Slawig (+ J. Schönborn, A. Jordt)
Übungen zur G2.1: Informatik II - Algorithmen und Datenstrukturen, 2 hrs Exercise/Week, H. Schnoor (+ L. Prödel, B. Kinscher, N. Prühs, H. Schade)

Winter 2009/2010

2-Fächer-AG, 2 hrs Seminar/Week, Th. Wilke

Inf-EinfPP: Einführendes Programmierpraktikum, 3 hrs Lecture/Week, Th. Wilke (+ S. Schulmeister)
MS010: Kryptographie, 4 (+2) hrs Lecture (+ Exercises)/Week, Th. Wilke und H. Schnoor (+ H. Schnoor)
Third-Party Funds

DFG, Automatische Analyse kryptographischer Protokolle mit komplexen Nachrichtenformaten, 01.01.2009-30.08.2010 (119500 EUR)
DAAD, Stipendiat Imran Khan, 01.01.-31.12.2009 (11274 EUR)

Further Cooperation, Consulting, and Technology Transfer
The theory group cooperates with groups in Berlin (Prof. Dr. Marcel Kyas), Hannover (Prof. Dr. Heribert Vollmer), Rochester (Prof. Dr. Edith Hemaspaandra), Trier (Prof. Dr. Ralf Küsters), and Warsaw (R. Mikolaj Bojanczyk).

Publications
Published in 2009
J. Schönborn, M. Kyas, Refinement Patterns for Hierarchical UML State Machines, LNCS, 5961, 371 - 386 (2009)

Presentations
J. Schönborn, Ready Semantics for UML State Machines, 21st Nordic Workshop on Programming Theory, Kopenhagen, Dänemark, 14.-17.10.2009
Further Activities and Events

Th. Wilke was associate editor of *Formal Methods in System Design* and member of the editorial board of *Fundamenta Informaticae* and *Lecture Notes in Logic*.

Th. Wilke was PC member for the conferences AutoMatha, CSL, FSTTCS, LATA, STACS and a workshop of Informatik 2009.

Th. Wilke was member of the executive committee of the GI technical committee Theoretische Informatik and the Council of the European Association for Theoretical Computer Science.

The theory group took part in the following P.R. campaigns of the department: Girls’ Day, two one-week programs for high-school students (one with more than 60 participants, and another with about 20 participants).
Theory of Parallelism

Our workgroup performs research in the field of optimization problems. On 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 workgroup’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:**

- F. Diedrich 01.01.-30.04.2009 EU
  AEOLUS

- C. Otte 01.01.-31.12.2009 (50%) DFG
  C. Otte 01.01.-31.12.2009 (50%) CAU
  Hochschulpakt 20/20

- L. Prädel 01.01.-31.12.2009 (50%) DFG
  L. Prädel 01.01.-31.12.2009 (50%) CAU
  Hochschulpakt 20/20

- U. Schwarz 01.01.-31.12.2009 CAU

**Lectures, Seminars, and Laboratory Course Offers**

**Winter 2008/2009**

- Fortgeschrittenen Praktikum - Effiziente Algorithmen, 4 hrs Lab/Week, K. Jansen (+ F. Diedrich, U. Schwarz)
- Diplomandenseminar, 2 hrs Seminar/Week, K. Jansen
- Masterpraktikum - Vertiefende Übung, 4 hrs Praktikum/Week, K. Jansen (+ F. Diedrich, U. Schwarz)
- Oberseminar - Algorithmen, Kombinatorik und Komplexität, 2 hrs Seminar/Week, K. Jansen (+ A. Srivastav)

**Summer 2009**
Winter 2009/2010

Third-Party Funds


Further Cooperation, Consulting, and Technology Transfer

Our workgroup cooperates closely with the Max-Planck-Institut für Informatik in Saarbrücken mainly with the researchers Rob van Stee and Rolf Harren. Through a visit in January 2009 the cooperation with M. Srividenko from IBM T.J. Watson Research Center near New York was strengthened and enhanced.

Publications

Published in 2009
K. Jansen, R. Solis-Oba, Rectangle packing with one-dimensional resource augmentation, Discrete Optimization, 6, 310 - 323 (2009)
E. Bampis, K. Jansen, Approximation and Online Algorithms (WAOA 2009), LNCS, 5893, (2009)

Presentations

C. Otte, Approximative Algorithmen für Packungsprobleme, Nordostsee-Doktorandenkonferenz, Salzau, Germany, 22.-24.01.2009
K. Jansen, C. Otte, Approximation Algorithms for Multiple Strip Packing, ASTEC 2009 (Workshop/Summer school on Algorithms and Techniques for Scheduling on Clusters and Grids), Les Plantiers, France, 02.-05.06.2009
K. Jansen, L. Prädel, U. Schwarz, A 2-approximation for 2D bin packing, Theorietag der GI, Köln, Germany, 03.06.2009
K. Jansen, L. Prädel, U. Schwarz, A 2-approximation for 2D bin packing, Workshop on Algorithms and Data Structures (WADS), Banff, Canada, 21.08.2009
U. Schwarz, Scheduling with nested assignment restrictions, Theorietag der GI, Lübeck, Germany, 01.10.2009
N. Bansal, A. Caprara, K. Jansen, L. Prädel, M. Sviridenko, How to maximize the total area of rectangles packed into a rectangle?, Theorietag der GI, Köln, Germany, 03.06.2009
K. Jansen, L. Prädel, U. Schwarz, A 2-approximation for 2D bin packing, 17. ÖMG-Kongress - Jahrestagung der DMV,
Graz, Austria, 20.-25.09.2009
N. Bansal, A. Caprara, K. Jansen, L. Prädel, M. Sviridenko, How to maximize the total area of rectangles packed into a rectangle?, 17. ÖMG-Kongress --- Jahrestagung der DMV, Graz, Austria, 20.-25.09.2009
K. Jansen, L. Prädel, An Approximation Algorithm for Two-Dimensional Strip-Packing with Absolute Performance Bound 7/4+epsilon, Theoretag der GI, Lübeck, Germany, 01.10.2009
N. Bansal, A. Caprara, K. Jansen, L. Prädel, M. Sviridenko, A Structural Lemma in 2-Dimensional Packing, and its Implications on Approximability, Seminar am Max Planck Institut Informatik Saarbrücken, Saarbrücken, Germany, 27.11.2009
K. Jansen, R. Thiele, Approximation algorithms for scheduling parallel jobs: Breaking the approximation ratio of 2, IBM T. J. Watson Research Center, Yorktown Heights, USA, 08.01.2009
K. Jansen, Parameterized approximation scheme for the multiple knapsack problem, ACM -SIAM Symposium on Discrete Algorithms (SODA 2009), New York, USA, 03.-06.01.2009
K. Jansen, Parameterized approximation scheme for the multiple knapsack problem, Dimacs Workshop in Memory of Leonid Khachiyan, Rutgers University, Piscataway, USA, 09.-10.03.2009
K. Jansen, Parameterized approximation scheme for the multiple knapsack problem, Department of Computer Science, Evry, France, 08.04.2009
K. Jansen, Parameterized approximation scheme for the multiple knapsack problem, DFG SPP Workshop Algorithm Engineering for Integer Programming, Kiel, Germany, 07.05.2009
K. Jansen, Approximation algorithms for knapsack and scheduling problems, ARRIVAL/ AEOLUS Workshop and School on Large-Scale Optimization, Patras, Greece, 13.-15.05.2009
K. Jansen, n EPTAS for scheduling jobs on uniform processors: using an MILP relaxation and a rounding method, DMV Tagung, Graz, Austria, 22.-25.09.2009
K. Jansen, A fast approximation scheme for the multiple knapsack problem, GI Workshop über Algorithmen und Komplexität, Lübeck, Germany, 01.10.2009
K. Jansen, A fast approximation scheme for the multiple knapsack problem, Max-Planck-Institut für Informatik, Saarbrücken, Germany, 25.11.2009

Further Activities and Events

Prof. Jansen was a member of the program committee of the design and analysis track of the conference ESA 2009 (European Symposium on Automata) which was held in Copenhagen. He was a program co-chair of WAOA 2009 (Workshop on Approximation and Online Algorithms) that was taking place in Copenhagen at the same time. Two additional workshop co-chairs in Berkeley are relevant; Workshop on Approximation Algorithms for Combinatorial Optimization Problems (APPROX 2009), and Workshop on Randomization and Approximation Techniques in Computer Science (RANDOM 2009).
Institute of Electrical and Information Engineering

The Institute of Electrical and Information Engineering (Institute of ET&IT) of Christian-Albrechts-University was founded in 2006 and is engaged in a great variety of cooperative and interdisciplinary research projects. The faculty of Engineering has a close collaboration with the Institute for Computer Science (Informatik) with a common research focus of “Information Engineering”. We also have another collaboration with the Institute for Materials Science and the Physics department covering the topic “Nanosystems”. Towards the end of 2009, the grant committee of the DFG (“German Research Foundation”) recognised the Collaborative Research Centre SFB 855, initiated by Prof. Dr.-Ing. Eckhard Quandt. Funding will be provided for research into “Magneto-Electric Composites - Biomagnetic Interfaces of the Future”. The Institute of ET&IT is very proud to take part in this Collaborative Research Centre with its many research groups. In addition, the Institute is engaged in the Cluster of Excellence “The Future Ocean” of the CAU, the “Computational Sciences Centre” as well as in the research network “CEwind Centre of Competence in Wind Energy”.

There are currently 11 professorships including the position of the Managing Director of the Institut für Siliziumtechnologie (ISIT) in Itzehoe, Prof. Dr.-Ing. Wolfgang Benecke, who holds an external professorship at the Institute. One of these professorships was newly appointed in 2009, and a further chair was reassigned: Prof. Dr.-Ing. Dirk Manteuffel accepted the appointment as the W2-professorship of “Funkkommunikation” (“Wireless Communications”). He has been with the Institute since February 2009. In April 2009, Prof. Dr. Hermann Kohlstedt took over the professorship “Nanoelektronik” (“Nano-electronics”) as the successor of Prof. Dr.-Ing. Peter Seegebrecht. Prof. Dr.-Ing. Ulrich Heute retired at the end of the summer term (semester). The search procedure for his successor was successfully finished in autumn 2009: Dr.-Ing. Gerhard Schmidt accepted the appointment as W3-professor of “Digital Signals and Systems” and will take office in March 2010.

In the winter term (semester) 2009/2010 a total of 196 new students enrolled in course programmes offered by the Institute of ET&IT. In the Bachelors programme “Electrical Engineering and Information Technology” (7 terms) 63 students started their studies, and 111 enrolled in the Bachelors program “Industrial Engineering” with a focus on “Electrical Engineering and Information Technology” (7 terms). The Masters programme “Digital Communications” saw 22 new students enrolling, with all courses offered in English (4 terms). Enrollment in the diploma programmes “Electrical Engineering and Information Technology”, “Industrial Engineering”, as well as the upgrade programme in “Electrical Engineering and Information Technology for FH-graduates” is only offered to students in higher classes. In the summer term 2011 the Institute will offer for the first time 3-term Masters programmes in “Electrical Engineering and Information Technology” and “Industrial Engineering” with a focus on “Electrical Engineering and Information Technology”.

In spring 2009 the Institute of ET&IT, together with the Institute for Materials Science, founded the “Centre for Study Services” in order to effectively manage all matters of interest for both of the institutes in the areas of study, course programme, internships and examinations.

In 2009 the Institute was very active in the promotion of young talent. The Institute took part in the events “Girls Day”, “Schul-AG Technik” (Study group engineering for pupils), and organized a project week “Mobile Communications” for a school in Schleswig-Holstein as well as a guided tour for 40 pupils to the Hannover fair within the program Techtoyou. In February 2009, the Institute hosted the participants of the workshop “lütting” on the University Campus.
Fig. 1: Professors of the Institute of Electrical and Information Engineering
Automation and Control Engineering

The year 2008 marked major changes in the staff of our institute. Michael Kräling, the principal researcher in the joint research project with the food industry “Process control prediction and estimation in the dairy industry”, left the institute to take a position in the solar industry in France. Eduard Peter had to take over and he did his very best to keep to the schedule and to familiarize himself with the project. Towards the end of the year, the institute had to bear further big losses: Dorothee Barth and Joachim Hörrmann left the institute after having finished their theses. Dorothee took a position as a postdoc in Finland and Joachim is now working with the power industry in southern Germany.

In 2009 members of the institute attended renowned international conferences in Japan, Hawaii and Lisbon to present their research on estimation, prediction and control of biotechnological processes as well as advances in coriolis mass flow metering.

Major achievements could be achieved in phasor control of the Coriolis Mass Flow Meter. For the first time the compensation approach was presented to measure the inverse linear characteristics of the meter with respect to mass flow, i.e. the impact of the 2nd mode oscillation to that in 1st mode. Although this impact is rather weak, it can nevertheless be used for self-calibration purposes. The phasor control scheme used in the Coriolis Meter proved to be very powerful and seems also to be useful in other areas of application. At the moment there are discussions to apply the control scheme to micromechanical systems (MEMs).

Our activities in the control of under-actuated mechanical systems were forced to slow down, as Eduard Peter had to take over the bio-project. At the moment 10 out of 12 state transitions of the double inverted pendulum (DIP) are possible by tracking control and can be demonstrated in a lab-scale experiment, i.e. transitions from an unstable equilibrium to another unstable equilibrium. The swing-up of the triple inverted pendulum (TIP) is under investigation. So far the control scheme only works in simulation. Further work is necessary to construct robust trajectories.

Results

Process control prediction and estimation in the dairy industry (Michael Kräling, Joachim Hörrmann, Dorothee Barth, Eduard Peter)

The bacterium Streptococcus thermophilus is an important agent in the dairy industry and is used for the production of various dairy products, e.g. yoghurt or cheese. Its production is still mainly carried out using traditional methods relying on experience and experimental knowledge.

Based on theoretical and practical results obtained in the research projects;

- Process control of the fermentation of the Bacterium Streptococcus thermophilus (Joachim Hörrmann, Dorothee Barth),

the fermentation of Streptococcus thermophilus as a starter culture for the production of yoghurt in an industrial process has to be optimized with respect to quality and yield. Within this context, a combination of methods of artificial intelligence and mathematical modelling based on formal kinetics and balance equations seems to be an adequate means for prediction, estimation and control. The fermentation process has yet been tested in a lab-scale experiment and will be applied to a production process in the food industry. The expected improvement in product quality and yield will mark a big step in the direction of product quality control.

Coriolis Mass Flow Meter (Felix Koschmieder)

Phasor control of the Coriolis Mass Flow Meter was further investigated and extended to simultaneously control the 1st and 2nd eigenmode of the meter. The complete control scheme now allows for realizing different measuring principles
such as compensation and deflection. When using the compensation principle, both of the meter characteristics could be investigated. The 1st characteristic i.e. the characteristic exploited by all of the meters available on the market is the 2nd mode oscillation induced by stimulating the 1st mode, where the amplitude of the 2nd mode is proportional to mass flow.

The 2nd characteristic or inverse characteristic i.e. the oscillation of the 1st mode stimulated by the 2nd mode, has been measured for the first time and proved also to be linearly dependant on mass flow. As the interaction between 1st and 2nd mode according to the inverse characteristic is rather weak, it can nevertheless be used for diagnosis and self-calibration. An interesting idea is to exploit both of the characteristics simultaneously in order to detect zero and sensitivity without the need for a cyclic operation of the meter.

Nonlinear Control of Underactuated Mechanical Systems (Eduard Peter)

The new method for designing transition trajectories between different equilibria of an under-actuated system - the two-degrees-of-freedom approach proposed by Graichen et al. (2005) - was further examined and applied to the double inverted pendulum on a cart (DIP). As the double-pendulum-system has one stable and three unstable equilibria, there exist 12 different transitions. Up to now, trajectories for 10 transitions could be constructed by solving 10 different 2-point boundary value problems. The transition up/down to up/up and vice versa is still unsolved. In simulation the swing up of the triple inverted pendulum on a cart (TIP) from the down/down/down to the up/up/up position could also be successfully tested. Implementation in a lab-scale experiment has yet to be achieved.

Trajectory Control of Blood Glucose Levels in Insulin-Dependant Diabetes Patients (Ekatarina Papazova)

The objective of the project was to develop a system allowing for continuous control of insulin-dependent type 1 and type 2 diabetes patients. The thesis was completed in 2009. The next step on the agenda is to test the control system in a pilot study. This study will be carried out by our former project partner tecura.
Lectures, Seminars, and Laboratory Course Offers

Winter 2008/2009

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

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

Digitale Regelungstechnik, 2 (+1) hrs Lecture (+ Exercises)/Week,
H. Röck (+ D. Barth)

Praktikum Regelungstechnik I, 4 hrs Lab/Week,
H. Röck (+ D. Barth, J. Hörrmann, F. Koschmieder, E. Peter)

Ausgewählte Kapitel der Regelungstechnik, 2 hrs Seminar/Week,
H. Röck

Anleitung zum wissenschaftlichen Arbeiten, 1 hrs Lecture/Week,
H. Röck (+ E. Peter, F. Koschmieder, J. Hörrmann, D. Barth)

Summer 2009

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

Robuste Regelung, 2 (+1) hrs Lecture (+ Exercises)/Week,
H. Röck

Anleitung zum wissenschaftlichen Arbeiten, 1 hrs Lecture/Week,
H. Röck (+ E. Peter, F. Kochem, J. Hörrmann, D. Barth)

Winter 2009/2010

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

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

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

Regelungstechnik I, 3 (+2) hrs Lecture (+ Exercises)/Week,
H. Röck (+ F. Koschmieder)

Ausgewählte Kapitel der Regelungstechnik, 2 hrs Seminar/Week,
H. Röck (+ J. Hörrmann, E. Peter, F. Koschmieder)

Anleitung zum wissenschaftlichen Arbeiten, 1 hrs Lecture/Week,
H. Röck (+ E. Peter, F. Koschmieder, J. Hörrmann)

Third-Party Funds

Danisco Niebüll, Control of biotechnological systems, 01.09.-31.12.2009 (28.700 EUR)
Innovationsstiftung Schleswig-Holstein, Control of biotechnological systems, 01.01.-31.12.2009 (31.000 EUR)
Further Cooperation, Consulting, and Technology Transfer

Fa. Danisco, Niebüll: Fermentation of Streptococcus thermophilus
Fa. tecura, Kiel: Control of blood glucose levels

Publications

Published in 2009

M. Kräling, J. Hörmann, E. Peter, H. Röck, Prediction and estimation of the optimal time for harvesting Streptococcus thermophilus in a fermentation process, ICROS-SICE International Joint Conference in Fukuoka, Japan, (2009)
J. Hörmann, M. Kräling, D. Barth, H. Röck, Trajectory Tracking Control for the Fermentation of Biotechnological Processes, IASTED International Conference on Identification, Control and Applications Hawaii, USA, (2009)

Presentations

M. Kräling, Prozessoptimierung mit Neuronalen Netzen, Vortrag bei Danisco, Niebüll, Deutschland, 24.04.2009

Further Activities and Events

Honary positions of Prof. Röck

Executive director of the Institute of Electrical and Information Engineering Member of the GMA Workshop Theoretic Methods in Control Engineering (GMA Arbeitskreis Theoretische Verfahren der Regelungstechnik) Member of the Academic Teachers’ Workshop for Measurement Technology (Arbeitskreis der Hochschullehrer für Messtechnik) Head of Engineering Branch Library (Fachbibliothek Ingenieurwissenschaften) Member of Examination Committee Industrial Engineering (with emphasis on Electrical and Information Engineering) Examination Chairman for the Lectureship’s Department „German as a Foreign Language“ Reviewer and Associate Chairman for IEEE CCA 2010
Technology of Silicon-Based Micro- and Nano-Systems

Prof. Dr. Wolfgang Benecke is since October 2008 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 - to 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 millimeter 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 applicationspecific 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, analyze the quality and reliability of electronic components, and develop advanced power-supply components for electronic systems.

The institute employs a staff of around 150 people

Further information about Fraunhofer ISIT is available in 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
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 regarded 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. The research is presently focused on non-contacting determination of the properties of dielectric objects. 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.

The work on power amplifier (PA) principles is mainly concerned with so-called sequential amplifiers and outphasing amplifiers. Sequential amplifiers were investigated with respect to efficiency and linearity. Some work has been devoted to a novel approach of linearization by predistortion. Outphasing amplifiers have also been investigated for many years in this laboratory. Present work concentrates on special power combiners and PA linearization.

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 millimeter wave doppler radar sensors for the characterization of, for example aerosols, on other radar sensors and on sensors for medical applications. Significant effort has been devoted to investigations concerning the characterisation of magnetoelectric sensors 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 on spectroscopy itself, but also on the development of new spectrometers in the millimeter and sub-millimeter wave region.

Results

Non-contacting characterisation of the dielectric properties of objects of irregular shape

The DFG-project ISOPerm (irregular shaped objects’ permittivity) aims at the development of an UWB method for the measurement of the dielectric properties of irregularly shaped bodies by using a non-contacting approach. Industrial processes often require the determination of the water content of bulk materials and other process parameters. There is a strong correlation between many of those quantities and the dielectric properties. Therefore, dielectric measurements are well suited for material characterisation. Existing methods for such measurements require that the samples are regular in shape and that the material under test fills the entire cross section of the applied electromagnetic field. The method investigated and developed avoids these restrictions. Unlike existing methods, and as a novel approach, an attempt was made to use multivariate analysis to separate those effects caused by the geometry of the object from those caused by its dielectric properties. It was successfully proved with simulations and measurements of dielectric objects and the use of multivariate analysis methods that the determination of the dielectric properties within a certain accuracy is possible independent of shape, size and orientation. An UWB measurement system consisting of one transmitting antenna and an array of receiving antennas was built. This array receives scattered pulses of the illuminated object under test in two orthogonal polarizations. Further investigations will focus on the development of a stand-alone sensor system capable of
working in real time. This will reveal the system performance and accuracy under practical conditions. The system will be tested with unknown objects of irregular shape. Another aspect that will be investigated is whether it is possible in practice to classify objects according to shape, size or other variables. Specialized systems may be devised with greatly reduced hardware effort but increased accuracy.

Radar-sensor

As a continuation of the remote sensing study of aerosols with small particle sizes (dust, rain, fog, etc.), a two-frequency millimetre wave Doppler radar system was constructed on the basis of the previously developed radars with operating frequencies of 35 GHz and 94 GHz. One of the problems of aerosol sensing by Doppler radar using only one operation frequency is the impossibility to determine characteristics for existing aerosols without any calibration procedure. Due to high complexity under real conditions these calibration procedures cannot be carried out frequently. Therefore, an attempt to develop a data processing method that can avoid calibration was made. The method is based on the combination of spectral analysis and Mie theory (the analytical solution of the dielectric sphere diffraction problem), since the aerosol particle size is essentially smaller than the operating wavelength and since it can be assumed that the shape of the particles is spherical. Therefore, radar cross-section dependencies on particle size are different for each wavelength. This permits the estimation of the physical characteristics (such as parameters of particle size distribution, mass loading and particle concentration) of polydisperse media with different particle size distribution laws. The method was tested with calibrated experimental powder with a log-normal particle size distribution law and satisfactory results were obtained: the calculated and measured data discrepancy is less than 10% for mass loading determination, and about 25% for particle concentration determination.

Radar Antennas & Systems

A high performance radar antenna array (X-band) prototype with low side lobe levels was designed and built. The strong coupling of adjacent radiating elements was taken into account. Full wave simulations verified the overall design. The antenna was measured and characterized by indoor near-field and outdoor far-field measurements showing excellent...
performance and an over-fulfilling of the electrical performance requirements in terms of gain, beamwidth, side lobes, VSWR and bandwidth. The antenna industry has consulted with us on design and improvement of radar systems and components.

**Magnetoelectric sensors**

New magnetoelectric (ME) sensors will be developed in collaboration with the Multicomponent Materials Chair of CAU Kiel in order to measure weak biomagnetic fields in the region of 1 pT and below. A new electronic readout matched to the sensor will be created. In a first step equivalent circuits of different ME sensors were modelled. Measurements have shown that these equivalent circuits are capable of describing the ME sensor in resonance. In order to perform ME sensor measurements, it was necessary to establish a measurement setup. The core of this setup are two pairs of Helmholtz coils, which generate a DC magnetic field to investigate the optimal working point and an AC magnetic field to investigate linearity and resonance of different ME sensors. Furthermore the noise behaviour of the whole detection unit consisting of the ME sensor and the following low noise preamplifier is under investigation. From a model of the equivalent circuit, we are able to calculate the broadband noise behaviour of the ME sensor. In order to improve the signal-to-noise ratio of the detection unit, low noise preamplifiers have been investigated which are suitable for this new kind of magnetic field sensor. Noise measurements are performed, to evaluate the noise calculations for sensor and preamplifier.

**Wireless flow rate measurement in vascular implants**

For some congenital heart abnormalities surgical corrections are possible to enable survival of the patient. For example the hypoplastic left heart syndrome can be treated by several sequential operations. Between these operations the use of vascular implants is necessary for some months. The vascular implants are made from plastic and not from body tissue so there is a relatively high risk for a stenosis by fibrin.

In order to prevent this life-threatening complication a periodic monitoring of the flow rate in the vascular implant is obligatory. The use of imaging methods based on X-rays has the disadvantage that the patients will accumulate high radiation dosages: this is especially critical for infants. Since the vascular implant is only within the body for a relative short time theoretically it is possible to include a flow rate sensor within it. A small battery can power the electronics and the sensor can transmit the information about the flow rate to the reading device outside the body using electromagnetic fields. Hence the important information is immediately available whenever it is needed without physical or mental stress for the patient.

Beside the RF-electronics there is a need for the actual flow rate sensor. The method used should work without direct contact to the blood because foreign substances provoke stenosises. In this project capacitive designs and methods based on the Lorentz-force have been investigated together with the pediatric cardiology clinical centre of the Christian-Albrechts University. The work was started in 2009 and the first encouraging results have been obtained.

**Magnetic Nanocomposites for RF-Applications**
In cooperation with the Multicomponent Materials and the Inorganic Functional Materials chair novel magnetic materials are being developed, and novel devices using these materials are under investigation. Analytical expressions for the properties of these materials have been found and the materials characterized by measurements. In addition the measured permeability spectrum has been used to calculate the unknown parameters of materials using nonlinear regression algorithms.

Furthermore a new approach to magnetic core toroidal microinductors was introduced. The core consists of a segmented metal-polymer composite. The investigations aim to meet the requirements in modern mobile communication electronics of small size, high inductance, high operation frequency, and adequate quality factor. A toroidal inductor was designed using HFSS and realized in thin-film technology with various core designs to avoid eddy currents and minimize parasitic capacitances. The magnetic core is formed by a segmented multilayer of soft magnetic FeCoBSi sputter deposited in such a way as to realize a crossed anisotropy.

**Sequential Power Amplifiers**

Ordinary power amplifiers achieve maximum efficiency only at maximum output power levels. If the output power is reduced efficiency decreases dramatically. Due to the properties of the modulated signals (peak to average ratios of 5-10 dB), average efficiencies of only 10% and lower are achieved under linear amplification. Therefore efficiency enhancement is strongly required.

The Sequential Power Amplifiers (SPA) concept is investigated as a new method to enhance the efficiency of ordinary amplifiers driven with digitally modulated signals. In its simplest form a SPA consists of two ordinary amplifiers combined in parallel with a conventional directional coupler. For low power only one amplifier is operating while the second amplifier is switched off and energy is saved. At high power levels both amplifiers contribute rf power to the output. Therefore the average efficiency of the whole system compared to an equivalent single amplifier is significantly improved due to the turned off periphery in the lower power region. SPAs achieve about 50% of average efficiency for a WDCMA signal, where the ordinary amplifier achieves only 37%.

In 2009 investigations were focused on the bandwidth requirements for the required signal pre-distortion. The signal construction for the individual amplifiers causes a bandwidth widening and therefore a bandwidth restriction is necessary. The reduced bandwidth also influences the system efficiency, which results in a bandwidth dependence of the SPA efficiency.

**Efficiency and Linearity enhancement of outphasing power amplifiers**

Further research is ongoing in the field of efficient and linearly operating outphasing power amplifiers. A novel compact outphasing combiner was proposed and developed incorporating various design trade-offs. Its operation and design application was mathematically described. and practical validation was performed by simulation and measurements. Further research interest is the analytical analysis of the impact of the transistor’s load line modulation on the obtainable linearity.

**Digital dynamic predistortion linearization of high power short wave (1.5-30MHz) power amplifiers**

The strong static and dynamic (memory effects) distortions of a broadband short wave frequency high power (150W) amplifier were investigated by practical measurements. Two tone and QPSK test signals were applied. Potential electrical and temporal sources of memory distortions, especially those occurring with signals with increased bandwidth, were applied. Recommendations to improve the electrical PA design were carried out. A digital predistortion algorithm capable of compensating dynamical memory effects was developed and applied to the PA. The intermodulation distortions of a broadband two-tone signal could be improved by more than 20dB. This demonstrates the superior performance of the applied dynamical predistortion algorithm. Furthermore a practical TX/RX system based on a FPGA-core utilizing a polynomial memory architecture was proposed and investigated.

**Molecular Spectroscopy**
Molecular spectroscopy in the range of millimeter- and submillimeter 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 millimeter- and submillimeter wave spectrometer to allow very precise measurements of transition frequencies between rotational energy states. Astronomical observations in millimeter- and submillimeter wavelengths have led to the discovery of many different molecules in the interstellar clouds. Laboratory spectra of such molecules in the millimeter- and submillimeter range measured with a precision $\leq 1$ kHz are therefore needed for modern astrophysical investigations. To this purpose this laboratory’s spectrometer has been supplemented with devices that have allowed the observation of absorption lines with lamb-dip (a result of a saturated absorption process) accuracy. This method allows the measurement of the absorption lines with a precision $\leq 1$ kHz. A corresponding paper was published in 2007 in Astrophysics Letters. Within the scope of the DFG-cooperation project (official ending end of 2010) with the Institute of Applied Physics of the Russian Academy of Science (Nizhnii Novgorod) spectra of the HCCCN (propine cyanide), NH3 (ammonia) and various isotopologues of water have been investigated with the goal of obtaining precise transition frequencies in the millimeter- and submillimeter range with accuracies $\leq 1$ kHz for investigation of the dynamics of interstellar clouds.

Fig. 3: Visit to RFS, Hannover

Personnel

Head of the group: Prof. Dr.-Ing. R. Knöchel; Secretary: M. Bork
Technical Staff: Dipl.-Ing. (FH) W. Taute

Scientific Staff:

M.Sc. C.-C. Chao 01.01.-31.12.2009 fremd
UWB-Innenraumradar

Dr.-Ing. F. Daschner 01.01.-31.12.2009 CAU
Resonante Stents / Mikrowellensensoren für dielektrische Eigenschaften / Miniaturisierter Netzwerkanschluss
Lectures, Seminars, and Laboratory Course Offers

**Winter 2008/2009**

Leitungstheorie, 2 (+1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ F. Daschner)

Radar, 2 (+1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ F. Hettstedt)

Hochfrequenzschaltungen in Mobil- und Satellitenfunk, 2 (+1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ H. Mextorf)

Praktikum Hochfrequenztechnik, 4 hrs Lab/Week,
R. Knöchel (+ F. Daschner, F. Hettstedt, T. Lehmann, H. Mextorf)

Seminar Hochfrequenztechnik, 2 hrs Seminar/Week,
R. Knöchel

**Summer 2009**

Nichtlineare Schaltungen, 2 (+1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ F. Hettstedt)

Hochfrequenzschaltungen für Mobil- und Satellitenfunk, 2 (+1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ H. Mextorf)

Radar, 2 (+1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ F. Hettstedt)

Praktikum Hochfrequenztechnik, 4 hrs Lab/Week,
R. Knöchel (+ F. Daschner, F. Hettstedt, T. Lehmann)
Seminar Hochfrequenztechnik, 1 hrs Seminar/Week,
R. Knöchel

Winter 2009/2010

Leitungstheorie, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
R. Knöchel (+ F. Daschner)

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,
R. Knöchel (+ T. Lehmann)

Praktikum Hochfrequenztechnik, 4 hrs Lab/Week,
R. Knöchel (+ F. Daschner, F. Hettstedt, T. Lehmann, H. Mextorf)

Seminar Hochfrequenztechnik, 2 hrs Seminar/Week,
R. Knöchel

Third-Party Funds


Deutsche Forschungsgemeinschaft, Magnetic nanocomposites for rf applications in mobile communication (Folgeprojekt), 01.10.2008-31.03.2010 (91400 EUR)

Deutsche Forschungsgemeinschaft, Kontaktlose Bestimmung der dielektrischen Eigenschaften unregelmäßig geformter Objekte (ISOPerm), 01.10.2008-30.09.2010 (122300 EUR)

Deutsche Forschungsgemeinschaft, Aufbau und Optimierung von Spektrometern für den Submillimeterwellen-Bereich sowie Fortsetzung der rotationsspektroskopischen Messungen an interstellaren Spezies, 01.10.2008-30.09.2010 (53995 EUR)

Further Cooperation, Consulting, and Technology Transfer

There is close cooperation concerning „magnetic nano composites“ for rf applications with the chairs 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 „magnetoelastic 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 and the “Institute of Radiophysics (IRE)”, Prof. Shichegoleva and Prof. Khlopav respectively, 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. Schünenmann, Technische Universität Hamburg Harburg and Prof. G. Khlopav, Institute of Radiophysics, Kharkov, Ukraine we cooperate in the area of industrial radar sensors.
Concerning sub-millimeter 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,

NXP Semiconductors, Nijmegen, Holland, regarding microwave power amplifiers,

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 pediatric cardiology clinical center of the Christian-Albrechts-University (PD Dr. Rickers).

Diploma, Bachelor and Master Theses

T. Huang, Ultra-Breitband Antennensystem bei 24 GHz, 12.01.2009
R. Martens, Entwicklung und Aufbau dual polarisierter UWB-Antennen, 05.06.2009
M. Weinrich, Aufbau und Untersuchung eines Doherty-Verstärkers, 11.06.2009
S. Hoffmann, Entwicklung eines resonanten Stents zur drahtlosen, nicht invasiven Messung von Stenosen, 16.06.2009
R. Jahns, Magnetoelektrische Sensoren für medizinische Anwendungen, 06.11.2009
Q. Zhong, Entwicklung und Untersuchung eines Mikrowellensensors zur Permittivitätsmessung, 16.11.2009

Publications

Presentations

H. Mextorf, R. Knöchel, Kontaktlose Bestimmung der dielektrischen Eigenschaften unregelmäßig geformter Objekte, UKoLoS Berichtskolloquium, Erlangen, Germany, 26.-27.02.2009

F. Hettstedt, U. Schürmann, R. Knöchel, E. Quandt, Double Coil Permeameter for the Characterization of Magnetic Material, German Microwave Conference, München, Germany, 16.-18.03.2009

T. Lehmann, R. Knöchel, Power Amplifier Efficiency Enhancement using Adaptive Load Transformation, German Microwave Conference, München, Germany, 16.-18.03.2009

W. Gerhard, R. Knöchel, Improved Design of Outphasing Power Amplifier Combiners, German Microwave Conference, München, Germany, 16.-18.03.2009


T. Lehmann, R. Knöchel, Sequential Power Amplifier with Adaptable Combiners, International Microwave Symposium, Boston, USA, 07.-12.06.2009

H. Mextorf, T. Lehmann, R. Knöchel, Systematic Design of Reconfigurable Quadrature Directional Couplers, International Microwave Symposium, Boston, USA, 07.-12.06.2009

A. Teplyuk, R. Knöchel, G. Khlopov, Aerosol Particle Sensor Based on Millimeter-Wave Coherent Radar with High Spatial Resolution, International Microwave Symposium, Boston, USA, 07.-12.06.2009

A. Teplyuk, R. Knöchel, G. Khlopov, 94-GHz Industrial Radar Sensor for the Quantitative Monitoring of Dust Particles and Aerosol, New Component Technologies for Vehicular and Industrial Radar Applications Workshop, International Microwave Symposium, Boston, USA, 07.-12.06.2009


H. Mextorf, F. Daschner, R. Knöchel, Drahtlose Erkennung dielektrischer Objekte unregelmäßiger Form mittels UWB-Pulsen, Kleinheubacher Tagung, Miltenberg, Germany, 28.09.-01.10.2009


Further Activities and Events

Prof. Knöchel served as Vice-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, since 2007, a member of the selection committee for the “IEEE MTT Distinguished Microwave Lecturers” and Vice-Chairman of the technical committee MTT-16, “Microwave Systems”. In the “Technical Coordination Committee (TCC)” of the MTT society he was responsible for “European Liaison”. 
He also represents the MTT in the executive committee of the “International Conference on Ultra-Wideband, ICUWB”. He is member of the “editorial board” of “Frequenz” and 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) and other journals. He is also member of VDE Expert Group 7.3, “Mikrowellentechnik”. Prof. Knöchel was also a member of the selection committee “MENA” of the German Academic Exchange Service for students from North Africa and Near East. He also has been a member of the prize committee of the “Schmidt-Römhild-Technologiepreis” of Schleswig-Holstein for many years. Apart from his membership of the IEEE he is also a member of the “European Microwave Association, EuMA” and of URSI, commission A.

The microwave group has participated in the project-week mobile communications and in the “Schüler Technik AG“, where FM Radio receivers were built up. Work was done by Dipl.-Ing. T. Lehmann.

Two student excursions have been made: The first in February 2009 visited Raytheon Anschütz in Kiel. Twenty students and rf staff participated. The second took place in June. RFS (Radio Frequency Systems) was visited with fifteen students and rf staff. Dipl.-Ing. Thomas Lehmann has devoted much work to these excursions.

Prof. A. Guarnieri, is working in the microwave laboratory and leading the “molecular spectroscopy”.

Awards: Dipl.-wirts.-Ing. Steffen Hoffmann received the 2009 Petersen-Award of the Petersen-Foundation for the best Diploma-thesis entitled “Entwicklung eines resonanten Stents zur drahtlosen nicht invasiven Messung von Stenosen”. 
Integrated Systems and Photonics

In 2009 the group for Integrated Systems and Photonics (ISP) grew continuously and now includes 5 postdocs, 8 Ph.D. students, and several student researchers. The group’s research activities 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.

Particularly important for us was the installation in the NanoLab Kiel in 2009 of a high vacuum thermal evaporation system as well as a glove box for fabrication in a nitrogen atmosphere. These systems allow us to fabricate our own integrated optoelectronic devices.

In the winter term 2009/2010 we offered for the first time a laboratory course for M.Sc. students in the NanoLab Kiel. During this course 7 students in 3 groups fabricated and characterized organic light emitting diodes (OLEDs) and organic photo detectors (OPDs). In the winter term 2009/2010 we also offered a new class on „Photonic Components“, in which advanced students study and discuss current research literature.

Results

Lab-On-A-Chip

Miniaturization of medical and biological measurement systems promises fast and cost efficient analysis of small substance volumes. In 2009 we demonstrated that label-free optical measurements are possible with enhanced signal-to-noise ratio if a periodically nanostructured substrate is employed. Optical modes coupling into such a photonic crystal structure result in a resonantly enhanced measurement of the photonic crystal surface properties. At the same time the use of crossed polarization filters suppresses background light.

We realized a simple prototype system using an LED as the light source and a phototransistor as the detector. Using a nanostructured substrate functionalized with biotin a label-free detection of 2.5 nMol streptavidin was demonstrated. A patent application on this method was filed and a publication is in preparation. The next step will be to integrate the light source and the photodetector onto the same substrate.

Organic Optoelectronics

Organic light emitting diodes (OLEDs) and organic photodetectors (OPDs), i.e., optoelectronic components fabricated using compounds whose molecules contain carbon, are particularly well suited for integration in compact optical measurement systems as well as for cost-effective transceiver modules for medium speed communications. In 2009 we installed a glovebox (Fig. 1(a)) for the fabrication of organic optoelectronic devices in a nitrogen atmosphere. By preventing oxygen contact during fabrication degradation of organic materials is reduced significantly. Furthermore, we installed a high vacuum thermal evaporation system in the NanoLab Kiel. The two-chamber system shown in Fig. 1(b) has four metal sources in the first chamber and four organic sources in the second chamber.

Using the glovebox and the thermal evaporation system we are now fabricating polymer based OLEDs and OPDs. For the fabrication of OLEDs as a first step indium tin oxide coated glass substrates are structured with photolithography to provide the anode electrical contact. Subsequently, a layer of ~20 nm of poly(3,4-ethylenedioxythiophene):poly(styrene sulfonate) (PEDOT:PSS) and a layer of ~50 nm of phenylene substituted poly(para-phenylenevinylene) (Ph-PPV; better known as Super Yellow from Merck OLED Materials GmbH) are spin-coated in the glove box. Finally, a cathode consisting of magnesium and silver is thermally evaporated. Bulk heterojunction OPDs are fabricated following the same procedure except that as the active layer a polymer blend system consisting of poly(3-hexylthiophene-2,5-diyil) (P3HT) and the fullerene derivative (6,6)-phenyl C_{61}-butyric acid methyl ester (PCBM) is spin-coated. All devices are characterized in our own optical laboratories.
Integrated Optics

In 2009 we continued our work on tunable microoptical components based on an elastomer layer integrated into a spatially dispersive multilayer thin film structure. As shown schematically in Fig. 2 (a) a 9 µm layer of the dielectric elastomer polydimethylsiloxane (PDMS) is sandwiched between two partially transparent silver electrode layers on a glass substrate. Both silver layers were structured in 1 mm wide and 10 mm long stripe patterns with the top layer contacted at the ends for thermal actuation via Joule heating. Actuation states of 17 mA and 24 mA current were investigated corresponding to heating powers in the ratio of 1:2. The device was placed in a convergent Gaussian beam as shown schematically in Fig. 2 (b). Through-focus images of the beam were taken at different distances behind the sample and the focus position was determined from Gaussian beam fitting for different incidence angles and different thermo-optic actuation states.

Optical Measurement

Optical measurement techniques allow for a fast, non-contact, continuous property evaluation. We work on projects related to the process integrated measurement of optical properties of highly scattering substances, such as milk, cream, or pharmaceutical tablets. In particular, we considered the influence of the fat content of milk on an optical transmission signal. The fat droplets in milk render it highly scattering. The scattering coefficient increases with the fat content. In contrast to the light propagation properties in highly absorbing media, highly scattering media divert the light path. Therefore,
the shape and the composition of the measurement environment influences the result of transmission measurements. We simulated the transmission signal for four different cuvettes with two different widths and made of black plastic and glass, respectively. As shown in Fig. 3, black cuvettes show a larger signal change with fat content allowing for a more precise fat content determination.

![Fig. 3: (left) Schematic of cuvette from side and top. (right) Simulated transmission for black and glass cuvettes of two different widths filled with milk-water-mixtures as a function of fat content.](image)

**Modelling and Design**

For device and system design as well as for interpretation of experimental results a detailed modelling is necessary. We performed both analytical calculations as well as numerical simulations. One focus was the design of highly dispersive thin-film stacks with integrated active layers, which was performed using a transfer matrix algorithm implemented in MATLAB. A second focus was the modelling of OLEDs with nanostructured materials using FDTD (MIT Meep, Lumerical FDTD Solutions, Remcom XFdtd). For optical system design and characterization we used ray tracing software (ZEMAX) as well as Monte Carlo simulations. For system analysis with the finite element method we employed COMSOL Multiphysics.

**Personnel**

Head of the group: Prof. Dr. M. Gerken; Secretary: S. Thielbörger (50%)
Technical Staff: Dipl.-Ing. J. Buschmann (50%), T. Feldmann

Scientific Staff:

- **Dr.-Ing. J. Adam** 01.01.-31.12.2009 BMBF
  Design and modelling

- **Dipl.-Ing. Christian Kluge** 01.06.-31.12.2009 CAU
  Design and modelling of nanostructured devices

- **Dr. Matthias Krantz** 01.10.-31.12.2009 BMBF
  Experimental characterization of thin-film devices

- **Dipl.-Ing. P. Metz** 01.01.-31.12.2009 CAU
  Design and characterization of microoptical systems
Dr. J. Mikat 01.01.-31.12.2009 DFG
Experimental characterization of devices and systems

M.Sc. Y. Nozirizadeh 01.01.-31.12.2009 BMBF
Optical characterization of nanostructured devices

Dipl.-Ing. M. Nordhausen 01.01.-31.12.2009 CAU
HSP 2020

M.Sc. Arfat Pradana 01.06.-31.12.2009 CAU
Fabrication of organic optoelectronics

Dr. Michael Räder 01.07.-31.12.2009 BMBF
Fabrication of organic optoelectronics

Fabrication of organic optoelectronics

Lectures, Seminars, and Laboratory Course Offers

Winter 2008/2009
Grundgebiete der Elektrotechnik I, 3 (+2) hrs Lecture (+ Exercises)/Week,
M. Gerken (+ staff and student tutors)
Seminar Integrierte Systeme und Photonik, 3 hrs Seminar/Week,
M. Gerken

Summer 2009
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, 3 hrs Seminar/Week,
M. Gerken

Winter 2009/2010
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)
Praktikum Optoelektronik, 4 hrs Exercise/Week,
M. Gerken (+ scientific staff)
Seminar Integrierte Systeme und Photonik, 3 hrs Seminar/Week,
M. Gerken

Third-Party Funds

BMBF, Nanostrukturierte optoelektronische Bauelemente, 01.03.2007-31.12.2011 (1600000 EUR)
DFG, Entwurf, Herstellung und experimentelle Charakterisierung von aktiven hochdispersiven Dünnichtfiltern für die Brennweitendurchstimung, 01.10.2008-30.09.2011 (213000 EUR)
COST, Towards Functional Sub-Wavelength Photonic Structures, 17.12.2007-20.01.2012 (Reisekosten)

Diploma, Bachelor and Master Theses

Daniela Threm, Herstellung und Charakterisierung organischer optoelektronischer Bauelementprototypen für Chiplabore, 14.10.2009
Christian Kluge, Entwurf und Realisierung aktiver Mikrooptiken auf Basis dielektrischer Elastomere, 03.06.2009

Publications

Published in 2009

Patent Applications

Boris Riedel, Martina Gerken, Julian Hauß, Uli Lemmer, LADUNGSTRÄGER-TRANSPORTSCHICHT, VERFAHREN ZU IHRER HERSTELLUNG UND ELEKTROOPTISCHES BAUELEMENT, Europäische Patentanmeldung, 22.08.2009, 09010783.0-1235
Y. Nazirizadeh, M. Gerken, Uli Lemmer, OPTISCHES ELEMENT, VERFAHREN ZU NACHWEIS DES VORHANDENSEINS VON SUBSTANZEN UND VERWENDUNG ..., Europäische Patentanmeldung, 29.04.2009, 09005905.6
Information and Coding Theory

The research activities of the Information and Coding Theory Laboratory (ICT) of the University of Kiel are in the general area of wireless digital communications. Simply speaking, ICT is designing new digital transmission schemes and developing corresponding software algorithms. The proposed transmission schemes are motivated by insights from applied information theory. They help to serve more users in future cellular radio systems and/or save transmission power.

The main expertise is in the area of channel coding (Turbo codes, LDPC codes, decoding with reliability information, space-time codes), applied information theory, digital modulation schemes (adaptive modulation and channel coding, IDMA, OFDM, DS-CDMA, IDMA), 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 acoustic communications, satellite radio, and terrestrial broadcasting systems.

The Information and Coding Theory Lab is member of the Wireless World Research Forums (WWRF), the Australian Communications Research Network (ACoRN) and the Excellence Cluster “The Future Ocean”.

Concerning teaching, we offer lectures and exercises on channel coding, information theory, wireless communications (DSP) and advanced wireless communications (DSP), partly in English, within the international master program on “Digital Communications”. A lecture on system identification (with focus on underwater communications) is offered in the form of a teaching assignment. A second teaching assignment in the area of time series analysis (with focus on medical applications) is in preparation. Furthermore, several seminars and labs are provided for our students.

Results

Joint Communication and Navigation (Rebecca Block, Kathrin Schmeink) Recently, 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 and one major application is the automated localization of emergency calls. 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. For optimization, different algorithms like the Levenberg-Marquardt method or particle swarm optimization have been applied. Simulation results obtained by Monte-Carlo simulations have been compared to the Cramer-Rao lower bound. It has been shown that the proposed estimator is asymptotically optimal and efficient.

Channel Estimation for MIMO-OFDM (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 in multiple antenna environments is a challenging task. ICT developed a graph-based iterative receiver, 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 traditional approaches like Wiener filtering.

Superposition Mapping (Dapeng Hao, Meelis Noem, Tianbin Wo) Superposition mapping (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.

Power and phase allocation is an important issue for superposition mapping. 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, 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 were investigated to further improve the system performance.

Graph-based Channel Estimation and Data Detection (Tianbin Wo, Zhenyu Shi) Additional effort has been spent on graph-based soft channel estimation (GSCE) and data detection, as reported in the Almanach 2008. The algorithm is now able to support higher-order modulation formats, such as PSK/QAM. Furthermore, it is found that the most suitable code structure for GSCE is to use a parity-check code as the outer code and a repetition code as the inner code.

Further work includes an extension of the graph-based estimator to MIMO-OFDM systems via multi-dimensional estimation, its performance improvement for higher-order modulation schemes in conjunction with channel coding, and its implementation in a cellular environment. 3GPP LTE-A is treated as a special application.

Time Series Analysis (A. 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.

Underwater Communications (Ivor Nissen, Christian Schroeder) In contrast to wireless RF communications, underwater communications (UWC) typically do not use electromagnetic waves as a carrier. This is because of the strong absorption of EM-waves in water. Only for very low frequencies (below 20 kHz) or at optical frequencies may these waves propagate over small distances. Therefore, acoustic waves are used, which are less subject to absorption and can travel further (hundreds of kilometers in the deep sound channel). This leaves only three frequency regions for wireless data transmission (as depicted in the figure).

![Fig. 1: Absorption of EM and acoustic waves in water.](image)
However, using acoustic waves comes with several drawbacks. One is the lower propagation speed (around 1500 m/s), which varies with temperature, depth and salinity. This causes large latencies and also makes the signals more vulnerable to Doppler influence than in RF transmission, which is determined by the relation of user speed to wave propagation speed. The Doppler is induced by the almost inevitable drift of the communication nodes in the water and also by the random movement of the reflecting sea surface. Due to the channel geometry there are many reflections from the surface and the seabed resulting in an increasing number of multi-path components at the receiver causing long delay spreads and, hence, inter-symbol interference. The long propagation delay does not allow the assumption of a constant channel during one transmission frame. Moreover, due to the non-constant sound velocity profile in the water column, the propagation is not direct but is affected by refraction. The usable acoustic bandwidth for UWC is rather limited to some tens of kHz (strongly depending on the desired range, which increases with lowering the frequency) and does not allow data rates known from current RF networks.

Since Kiel is a centre for marine research and technology, research in the fields of underwater communications is more than obvious. Hence, there is intensive cooperation with other institutes and companies working on this topic, especially with the Research Department for Underwater Acoustics and Marine Geophysics (FWG) of the Bundeswehr Technical Centre 71. In conjunction with this a special lecture on UWC is offered in the international study course on Digital Communications.

Currently, two system approaches are under investigation for underwater acoustic communication, designed for different kinds of application. The first uses a multi-carrier system with non-orthogonal pulse shaping for high data rates (i.e., in the range of some kbps). The second system is designed for small data packets used for example for command & control links to underwater vessels. This uses very short bursts over almost the whole available bandwidth. The benefit is the mitigation of inter-symbol interference due to the short duration and small payload. This might later be used to deploy an underwater network between several mobile nodes or sensors.

The need for underwater mobile communications arises in several fields, from military applications (e.g. communication with submarines) through industrial use (e.g. exploration of natural resources and deep sea-mining) to marine research (geology, oceanography etc.).

Personnel

Head of the group: Prof. Dr.-Ing. P. A. Höher; Secretary: S. Schuchardt (50%)
Technical Staff: Dipl.-Ing. T. Rabsch (50%)

Scientific Staff:
- Dipl.-Ing. R. Block 01.04.-31.12.2009 DFG
  Joint Navigation and Communication
- Dr. rer. nat. A. Galka 01.06.-31.12.2009 Lecturer
  Time Series Analysis
- Dipl.-Ing. M. Gregory 01.06.-31.12.2009 External PhD student
  Hybrid FSO/RF Communication
  Interleave-Division Multiplexing (IDM)
- Dipl.-Ing. Ch. Knievel 15.-31.03.2009 CAU
  3GPP LTE-A
- Dipl.-Ing. R. Kreimeyer 01.04.-31.07.2009 Industry
  Software Development for an Underwater Modem
Lectures, Seminars, and Laboratory Course Offers

Winter 2008/2009

System Identification, 2 (+ 1) hrs Vorlesung (+ Exercises)/Week,
I. Nissen

Communications Lab, 4 hrs Praktikum/Week,
P.A. Höher (+ U. Heute, W. Rosenkranz, und Mitarbeiter)

Advanced Topics Lab, 4 hrs Praktikum/Week,
P.A. Höher (+ U. Heute, W. Rosenkranz, und Mitarbeiter)

Informationstechnik und Codierung, 1 hrs Seminar/Week,
P.A. Höher

Summer 2009

Information Theory and Coding I, 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 I, 2 (+ 1) hrs Vorlesung (+ Exercises)/Week,
P.A. Höher (+ und Mitarbeiter)

Digital Communications, 4 hrs Seminar/Week,
P.A. Höher (+ U. Heute, W. Rosenkranz, und Mitarbeiter)

Informationstechnik und Codierung, 1 hrs Seminar/Week,
P.A. Höher

Winter 2009/2010
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)

Wireless Communications II, 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 Praktikum/Week,
P.A. Höher (+ U. Heute, W. Rosenkranz, und Mitarbeiter)

Advanced Topics Lab, 4 hrs Praktikum/Week,
P.A. Höher (+ U. Heute, W. Rosenkranz, und Mitarbeiter)

Informationstechnik und Codierung, 1 hrs Seminar/Week,
P.A. Höher

### Third-Party Funds

**DFG, Multi-Antenna Multi-Layer Interleave-Division Multiple Access (HO 2226/10-1), 01.07.2007-30.06.2010**
(185468 EUR)

**DFG, Joint Navigation and Communication based on Interleave-Division Multiple Access (HO 2226/11-1),
15.03.2009-14.03.2012**
(180590 EUR)

**DFG, Multi-Layer Interleave-Division Multiple Access (HO 2226/9-2), 01.02.2009-30.07.2010**
(95704 EUR)

**FWG (WTD-71), Acoustical Underwater Communications, 01.07.2008-30.06.2011**
(270835 EUR)

**Industry, Pilot Design for Multi-User MIMO OFDM Operating in Cellular Networks, 01.10.2008-30.09.2010**
(160000 EUR)

**Industry, Interleave-Division Multiplexing, 01.11.2009-31.01.2011**
(87500 EUR)

### 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:

- German Aerospace Research Establishment (DLR), Oberpfaffenhofen
- DoCoMo Euro Labs, Munich
- L-3 Communications ELAC Nautik GmbH, Kiel
- Ericsson GmbH, Backnang
- Research Institute of the Armed Forces on Underwater Sound and Geophysics (FWG), Kiel
- Fraunhofer Institute for Integrated Circuits (IIS), Erlangen
- Huawei Technologies, Shanghai
- Nokia Siemens Networks (NSN), Munich
- Toshiba Telecommunications Research Laboratory (TRL), Bristol.
Diploma, Bachelor and Master Theses

Y. Zheng, *Comparison of methods for frame synchronization in wireless communication systems*, 01.01.2009
J. Xu, *Low Complexity Detection for Superposition Modulation*, 01.06.2009
Y. Su, *Graph-based Channel Estimation for 3GPP Long Term Evolution*, 01.11.2009

Dissertations / Postdoctoral Lecture Qualifications


Publications

Published in 2009


Patent Applications


Further Activities and Events

Prof. Dr. Peter Adam Hoeher had a sabbatical during the winter term 2008/09, during which he spent some time in Hong Kong. Till 2009, two papers co-authored by Peter Adam Hoeher have been cited more than 1000 times.
Dipl.-Ing. Kathrin Schmeink has been a member of the Convention of the Faculty of Engineering since July 2009. She is a member of the study board on doctorate regulations.

M.Sc. Meelis Noemm is a member of the examination board on Digital Communications.
Power Electronics and Electrical Drives

In 2009 the institute was able to work again in satisfactory circumstances. The financial situation with respect to university funding is regular: the number of university financed research assistants remained unchanged at three. We also have good third party fund, obtained in 2007 and 2008 to support nine research assistants as well as financing materials and investment. Due to our lack of space an extra room has been built to accommodate the student laboratory. The Institute of Electrical and Information Engineering is now defining its position: “Regenerative Energies” has been defined as one of the directions.

Fields of research that we are still working on are as follows (although the addition of two new research members in 2009 created some minor adjustments);
- novel converter topologies and power semiconductors with control, including EMC, mains disturbance, power losses,
- power converters and drives for renewable energies, especially wind energy, fuel cells, photovoltaic, including grid performance,
- modern control methods for power converters and electrical drives,
- condition monitoring and fault tolerance for power converters and drives.

Very good results in research and teaching have been obtained from the work of our strong team. We have published 27 papers at conferences and in journals and participated in three major conferences. Almost all of our research projects have industrial partners with whom we have had regular meetings. Moreover we are involved intensively in two research and development centres of excellence: The KLSH Centre of Excellence Power Electronics Schleswig-Holstein, with universities and industrial companies and CEwind e.G. Centre of Excellence for research in wind energy of universities in Schleswig-Holstein. In order to fix its structure a cooperative for the latter has been founded, of which Prof. Fuchs is chairman of the supervisory board.

During this summer we welcomed Prof. Dr.-Ing. Marco Lisere from University of Bari, Italy, as DFG-Mercator visiting professor. He is an outstanding specialist in control of grid side converters. He did research and gave a lecture series entitled “Control of PWM converters for renewable energy systems”. His wife, Natalia Orlando, was also here at the same time as a visiting researcher.

We continued to have regular meetings with other power electronics institutes in the north of Germany (“Leistungselektronik-Kolloquium Nord”) with technical presentations and a laboratory visit, this year in Hannover.

The teaching has been carried out as usual. Again the high number of students in our field writing theses, assisting in research work or passing through the power electronics laboratory is pleasing.

Concerning infrastructure, we must mention our new equipment for calorimetric power loss and two grid emulators, which can emulate almost arbitrarily grid voltages for analyzing wind turbine pwm converters.

The number of scientific team members is still 11. Mr. Jensen and Mr. Rothenhagen have left; we wish them all the best in industry, Mr. Hoffmann and Mr. Böttcher are new members.

Results

Condition Monitoring of Electrical Components mainly in Wind Energy

Wind turbines are increasingly being installed in areas that are difficult to access, especially due to the rising number of offshore applications. Thus maintenance is much more difficult to accomplish and defects can cause breakdowns for a long time, if they are not repaired quickly. This would entail heavy financial losses.
Condition Monitoring of the Sensors (Rothenhagen)

One remedial action that can be taken is the use of condition monitoring, which facilitates a more efficient maintenance strategy. It is possible by early detection of failures to detect and identify existing defects in their formation phase. For mechanical components condition monitoring is state of the art whereas it is in the early stage of development regarding electrical components. In the past there have been two projects on condition monitoring topics at the institute with promising results. The first one, concluded in 2008, was focused on defects in sensors of voltage, current and speed measurement. Fault-tolerant operation, based on observers, could be implemented successfully (two publications in IEEE Transactions on Industrial Electronics).

Condition Monitoring of the Generator (Dinkhauser)

The second project, which was finished in 2009, was targeted on condition monitoring of the generator based on electrical currents. The main focus has been placed on detection of rotor turn-to-turn faults and partially of defects in the slip-ring system. Positive results have been achieved by using an observer, based on a newly developed hybrid state space model.

Condition Monitoring of the Converter (Böttcher)

The objective of the current project, which started in September 2009, is the development and investigation of a broad, practice-oriented and independent monitoring system, which takes the most important components of the frequency inverter into consideration. These are especially the power semiconductors, the capacitors and the control including the sensors. The monitoring system should only use the signals that are accessible. These signals are the input as well as the output currents and voltages of the inverter, the rotor speed of the generator and internal component signals if they are available. The goal is finally to classify the operating behaviour of the frequency inverter into categories of faultless and faulty with an early detection of failures and precautionary measures. If possible the condition monitoring of the converter should lead to a fault-tolerant operation.

Power Converters, Power Semiconductors and EMC of Converters

Solar Inverter and new Power Semiconductors (Franke)

For feeding the grid with solar energy a highly efficient inverter is necessary. To achieve an outstanding efficiency the losses in all components of the inverter like power semiconductors, capacitors and inductors have to be optimized as well as the total system. During the last years, new semiconductor devices using silicon carbide (SiC) instead of silicon (Si) as the substrate have been developed. These devices promise to have very low switching losses, enabling higher switching frequencies and thus reducing the effort for the passive filter elements in the converter. The goal of the institute’s work is an optimized solar inverter equipped with SiC devices. Driver and protective circuits known from their silicon counterparts are not compatible with the new devices and have to be adapted. Therefore different SiC power devices have been investigated in respect to their switching and conducting behaviour and adapted drivers have been developed. In addition six different topologies for solar inverters have been investigated and three of them have been built and operated in the lab. The upcoming requirements for system services for solar application have been analyzed.

High Efficiency low volume 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 realized. This converter has to be distinguished by a small volume, a high efficiency and a simple method of power multiplication. For the goals it is important to optimize the power losses. A project team of the „Competence Center for Power Electronics“ with up to six, partly external members is executing the research work. 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 and modules combined with an optimized power module layout and short switching times are the measures developed in this project to improve converter efficiency. A detailed calculation of converter efficiency for different layout variants was performed.
Additionally, different capacitor types with different protection circuits were analyzed. In the actual second part the main focus is on the control of the semiconductor power devices. Besides the development of a suitable driver circuit further additional driver circuits are being analyzed to achieve an optimal switching behavior. Finally the converter will be put into operation and a small series of prototypes will be built and tested in the laboratory.

**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 Center for Power Electronics”. A low inductive inverter layout is one of basic requirements 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 to determine one setup with the best tradeoff 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. In the end of the test phase long term studies will be carried out to confirm functionality and to examine reliability.

**Fast Switching Converter for Grid Impedance Measurement (Knop)**

For a three phase high frequency grid analysis a fast switching converter with a fast and robust control is very important. A FPGA-based tolerance band or hysteresis control conform this requirements. In this project a three-phase converter with high output frequencies for measuring the grid impedance is develop. The research work is the complete development of this converter with the power stack, the driver for the semiconductors and the FPGA-based control structure with the hardware. The converter has an output of 15 kVA and a measurement current in a frequency range from 50 Hz to 10 kHz.

**Modern control methods in power electronics and electrical drives**

The goal of this research field is to investigate modern control and observer methods in three different engineering applications of practical interest. The main research areas are voltage and current control of grid-connected PWM converters with LCL filter and small DC link capacitance, grid-adaptive control of grid-connected PWM converters with additional active-filter functionality in wind energy applications, and motor control for elastically coupled load and backlash.

**Modern Control for Active Rectifiers with LCL Filter and Low DC Link Capacitor (Dannehl)**

Grid-connected PWM converters with DC link capacitors are typically used in regenerative energy systems and industrial drives. Optimization of the converter system for these applications is still in progress. For instance, replacing the electrolytic DC link capacitors by film capacitors improves the system life time and use of LCL filters instead of conventional L filters offers cost reduction as smaller filter elements can used. These improvements come along with new challenges the control has to cope with. Research emphasizes the application of modern nonlinear control methods for handling the problems related to the LCL filter, the small DC link capacitor, and rejection of line voltage distortions. The DFG-financed project has been continued this year. Moreover, collaborations with industrial partners and international researchers also have been continued. Control systems based on sliding mode control theory as well as passivity-based concepts for converters with LCL-grid filters have been developed and analyzed. Furthermore, investigations of control of converters with small DC link capacitances based on conventional and modern approaches have been carried out. It could have been shown that new control approaches provide considerable advantages over the conventional ones. Results have been published also in IEEE Transactions on Industrial Electronics.

**Modern Control of Induction Machines with Torsional Load and Gearbox (Thomsen)**

Conventional electrical drive systems consist of an inverter-fed ac motor and a load. The load is connected to the motor via transmission elements which have a non ideal transmission behaviour like a finite torsional stiffness. This finite stiffness can lead to unwanted torsional oscillations. Backlash effects can occur if gearboxes or clutches are located in the drive system and yield to high torque impulses. Torsional oscillations and torque impulses can stress both the mechanical and
electrical components and thus can reduce lifetime of the system significantly. The aim of this research work is a high
dynamic speed control with active damping of torsional vibrations, limiting the influence of backlash and the adoption
of unknown parameters. The DFG-financed project was continued in 2009. The construction of an electro-mechanical
laboratory test bench for the analysis of torsional oscillations was completed. A conventional PI-control, a PI-based state
space control and a model based predictive control method has been designed, implemented and analyzed. Compared to
the PI-control, the speed control performance could be improved significantly by the PI-based state space control and the
model based predictive control. Furthermore, a system analysis of a fork lift truck and the design and implementation of
an improved speed control with vibration damping has been done as part of a six-month industrial project.

Grid-adaptive Control and Active-Filter Functionality of grid-connected PWM-inverters in Wind Energy
Applications (Hoffmann)

Power electronic generator systems in distributed regenerative power generation applications are used to inject electrical
power to the mains conforming to the international standards. Such a power electronic generator system consists typically
of a grid-tied inverter and a frequency converter. The frequency converter itself is composed of a grid-connected
PWM-converter and a generator-connected PWM-converter to be able to realize a bidirectional power flow between the
generator and the mains. With using a grid-connected PWM converter in addition to a proper designed current and
voltage control it is possible to affect the mains power quality concerning to low-frequency current harmonics, voltage and
current unbalances and reactive power. The aim of this research project of Cewind Competence Centre of Research in Wind
energy in Schleswig-Holstein is to investigate different grid-adaptive and modern control strategies for grid-connected
PWM-inverters in wind energy applications. The grid-adaptive inverter control should lead to an 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. Furthermore the grid-adaptive inverter control should be designed to reduce the
injection of higher-frequency harmonic current components by the used grid-connected PWM-inverter. The design and
construction of a laboratory test bench has been started in December 2009 and will be finished in summer 2010.

Power Electronic Generator Systems in Wind Energy Applications

Wind energy is one of the fastest-growing ways of electricity generation from renewable energy in the world with a
promising future. Nevertheless, wind power stations still have to be optimized and equipped with new functions. We work
in research and development for performance optimization of power electronic generator systems for wind turbines for
land-based and offshore installations.

Control Methods for Full Scaled Wind Power plants (Lohde)

One research topic covers control methods for full scaled wind power plants. The line side converter which transfers the
power to the grid has to comply with the grid codes. The behavior of the line side converter controlled by means of direct
power control (DPC) and standard voltage oriented control (VOC) were analyzed and the control structure and behavior
were optimized for operation during dynamic grid faults like voltage dips and unbalanced grid voltage. By means of this
improved control methods it is possible to ride through low voltages in compliance with the grid codes and with high
dynamics. A grid emulator as a part of the laboratory test bench was designed and constructed in 2009. It is able to
generate different types of disturbed grid voltages up to a rated power of 30 kVA, including frequency and phase variation
as well as harmonics to test grid connected converters and generators. Operating the wind power plant at maximum power
point leads to strain of gearbox and other parts of the drive train. Likewise, the fluctuating power in case of fluctuating
wind speed pollutes the grid and leads to impermissible flicker values that have to be avoided. In 2009 different control
methods including PI-speed control and the PI-state space control for control of generator and generator side converter of
wind turbines were analyzed and optimized to increase the power gain to reduce dynamic loads of the drive train and to
reduce flicker caused by fluctuating wind speed.
Optimized Performance of Windturbines Using Flexible AC Transmission Systems (Wessels)

A further research topic covers the optimization of the grid side performance of wind turbines using Flexible AC Transmission systems (FACTs). Ambitious grid code requirements to maintain a stable and safe operation of the energy network have to be fulfilled by wind farms. Grid codes will prescribe that wind turbines have to support the grid by generating reactive power during a network fault to support and restore quickly the grid voltage. In case of wind turbine technologies using doubly fed induction generators (DFIG) the reaction to grid voltage disturbances is sensible and requires additional protection for the power electronic converter. Protection methods are investigated to ride through grid faults safely and fulfill the grid codes. There are several approaches limiting the rotor currents during transient grid voltage dip by changing the rotor side converters control without using external protection devices. If an external power electronic device is used to separate the wind turbine system from the faulty grid, the wind turbine system can remain unchanged and continue nominal operation and standard control. Such an external device is called Dynamic Voltage Restorer (DVR), which is a voltage source converter connected by a coupling transformer in series to the grid to correct deteriorated line voltages. A laboratory type dynamic voltage restorer was built in 2009 and the mitigation of grid faults generated by a transformer based voltage sag generator were investigated.

Fig. 1: Low Voltage Ride Through of a doubly-fed induction generator with crowbar. Stator voltage (upper), DC link voltage (middle), stator current (lower, blue), rotor current (lower, green), crowbar current (lower, red)

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 01.09.-31.12.2009 Zukunftsprogramm SH/WTSH
CEwind - Kompetenzzentrum Windenergie S-H Phase II: Condition Monitoring für Frequenzumrichter und Regelung an Generatoren in Windenergieanlagen
Dipl.-Ing. J. Dannehl 01.01.-31.12.2009 DFG/Industry
Modern control of power electronics and electrical drives/ Multivariable control of LCL-filter-based grid-connected PWM converter in wind power applications

Dipl.-Ing. V. Dinkhauser 01.01.-31.12.2009 ESF/Land SH
CEwind Phase I: Condition monitoring for power electronics generators in wind turbines

Dipl.-Ing. T. Franke 01.01.-31.12.2009 CAU/Stipendium
Investigation of modern Silicon-Carbide semiconductors for high efficient converters for solar applications

CEwind - Kompetenzzentrum Windenergie S-H Phase II: Netzadaptive Führung der Betriebsverhaltens und der Aktiv-Filter Funktionalität von Netzpulsstromrichtern in Windenergieanlagen

Dipl.-Ing. (FH) S. Jensen 01.01.-31.03.2009 Industrie
Interactions between power electronics generator systems of a wind park and a high voltage direct current (HVDC) transmission system with voltage source inverter

Dipl.-Ing. A. Knop 01.01.-31.12.2009 Innovationsfonds
Converter for grid impedance measurement

Dipl.-Ing. R. Lohde 01.01.-31.12.2009 ESF/Land SH
CEwind Phase I: Power electronics generator systems in wind turbines and its grid behaviour

Dipl.-Physiker O. Mühlfeld 01.01.-31.12.2009 Frauenhofer ISIT/Land SH
Electromagnetic compatibility of future battery-fed low-voltage converters

Dipl.-Ing. S. Thomsen 01.01.-31.12.2009 DFG
Modern control of electrical drives with oscillatory mechanical loads

Dipl.-Ing. Ch. Wessels 01.01.-31.12.2009 ESF/Land SH
Power electronics generator systems in wind turbines and its grid behaviour

Dipl.-Ing. B. Wittig 01.01.-31.12.2009 Frauenhofer ISIT/Land SH
Electrical design and development of future battery-fed low-voltage converters
Lectures, Seminars, and Laboratory Course Offers

Winter 2008/2009

Power Electronics I - Basics, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
F.W. Fuchs (+ B. Wittig)

Power Electronics III - Electrical drives, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
F.W. Fuchs (+ V. Dinkhauser)

Control of Electrical Drives, 2, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
F.W. Fuchs (+ R. Lohde)

Seminar on Power Electronics, 2 hrs Seminar/Week,
F.W. Fuchs

Power Electronics - laboratory course, 4 hrs Lab/Week,
F. W. Fuchs (+ J. Donnehl, R. Lohde, O. Mühlfeld, A. Knop, S. Thomsen, T. Franke, C. Wessels, V. Dinkhauser, B. Wittig)

Power Electronics - excursion, Danfoss Drives, Graasten, DK, 1 hrs Excursion/Week,
F.W. Fuchs

Power Electronic Generator Systems for Wind Turbines, 3 (+ 1) hrs Master Studycourse Wind Engineering in CEwind (+ Exercises)/Week,
F.W. Fuchs (+ V. Dinkhauser, S. Thomsen, C. Wessels)
Summer 2009

Basics of energy systems and power engineering, 3 (+ 1) hrs Lecture (+ Exercises)/Week,
F.W. Fuchs (+ S. Thomsen, C. Wessels, V. Dinkhauser, K. Rothenhagen, S. Jensen)

Power Electronics II - Advanced, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
F.W. Fuchs (+ T. Franke)

Electrical energy conversion of renewable energy sources, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
F.W. Fuchs (+ R. Lohde)

Semiconductor applications, 1 hrs Lecture/Week,
F.W. Fuchs (+ T. Franke, A. Knop, V. Dinkhauser)

Microprocessors for real-time control, 1 (+ 1) hrs Lecture (+ Exercises)/Week,
T. Leifert (+ A. Knop)

Control of PWM converters for renewable energy systems, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
M. Prof. Liserre

Power Electronics - laboratory course, 4 hrs Lab/Week,
F.W. Fuchs (+ T. Franke, S. Thomsen, A. Knop, C. Wessels, K. Rothenhagen, J. Dannehl, S. Jensen, S. Thomsen, V. Dinkhauser)

Seminar on Power Electronics, 2 hrs Seminar/Week,
F.W. Fuchs

Power Electronics - excursion, 1 hrs excursion/Week,
F.W. Fuchs

Winter 2009/2010

Power Electronics I- Basics, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
F.W. Fuchs (+ O. Mühlfeld)

Power Electronics III- Electrical drives, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
F.W. Fuchs (+ N. Hoffmann)

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 (+ B. Wittig, S. Thomsen, T. Franke, M. Böttcher, C. Wessels, R. Lohde, J. Dannehl, O. Mühlfeld)

Seminar on Power Electronics, 2 hrs Seminar/Week,
F.W. Fuchs

Power Electronics - excursion, 1 hrs excursion/Week,
F.W. Fuchs (+ M. Böttcher, N. Hoffmann)

Power Electronic Generator Systems for Wind Turbines, 3 (+ 1) hrs Master Studycourse Wind Engineering in CEwind (+ Exercises)/Week,
F.W. Fuchs (+ S. Thomsen, T. Franke, C. Wessels, J. Dannehl)

Third-Party Funds

Industry, control of active rectifiers including modern control, 01.01.2007-31.12.2009 (12.000 EUR + MWSt)
Further Cooperation, Consulting, and Technology Transfer

The Competence Centre for Wind Energy (Schleswig-Holstein CE wind) has founded a cooperative CEwind e. G. to concentrate its research efforts in wind energy. The new research program for connected universities (CE wind2), started in October 2008, and financed by the European Union and Schleswig-Holstein, is proceeding well.

With the name KLSH a Competence Centre for Power Electronics Schleswig Holstein started in 2008 and is financing a research project for a future battery fed converter. The partners are Fraunhofer Institute for Silicon Technology (ISIT, Itzehoe), several industrial companies in Schleswig-Holstein as well as three universities (Christian-Albrechts-Universität, Kiel; Fachhochschule Kiel; Fachhochschule Westküste, Heide). The main development tasks have been carried out in 2009.

The working group is member of the category „research“ in the European Centre for Power Electronics Promotion of research, education and technology transfer of power electronics; founded by industrial companies.

Prof. Marco Liserre, Politecnico di Bari, has been a guest lecture on Control of PWM converters for renewable energy systems.

To strengthen cooperation with industry the existing contacts have been deepened and active cooperation with a company for converters for renewable energy has been achieved.

Technology transfer in the field of control of active rectifiers with LCL-filters has been carried out with some companies in the fields of wind power, converters and control.

We continued the cooperation with the Fachhochschule Kiel (Prof. Hinrichs) for grid impedance measurement.
There is a periodic joint colloquium of the power electronic institutes of the universities Bremen, Hamburg, Hannover, Magdeburg, Kiel (Leistungselektronik Nord).

The Erasmus Contact to University of Nottingham (Prof. Asher) continues.

We have been carrying out small and medium scale industrial projects.

Diploma, Bachelor and Master Theses

Alexander Weber, Vergleichende Untersuchung zu direkten und prädiktiven Regelungsverfahren für doppelt gespeiste Asynchrongeneratoren in Windenergieanlagen bei verzerrter Netzspannung und Netzspannungsfehlern, 12.03.2009

Nicky Flügger, Regelung einer permanentenregten Synchronmaschine, 01.03.2009

Matthias Böttcher, Untersuchung verschiedener Methoden zur Stromregelung eines Netzpulsstromrichter mit LCL-Filter im Zustandsraum, 09.04.2009

Felix Fuchs, Sliding Mode-Regelung eines Netzpulsstromrichters mit LCL-Filter, 15.07.2009

Philipp Teipelke, Regelung eines dreiphasigen Frequenzumrichters mit Folenkondensatoren im Zwischenkreis zur Speisung einer Asynchronmaschine, 09.04.2009

Nils Hoffmann, Prädiktive Regelung eines Antriebsystems mit schwingungsfähiger Last, 03.08.2009


Stefan Cvenarski, Entwurf, Aufbau und Inbetriebnahme eines batteriegespeisten Umrichters für Automobin-Anwendungen, 05.09.2009


Arne Bredemeier, Realisierung eines Antriebsumrichters für ein windenergiegespeistes Fahrzeug, 28.10.2009

Torge Wehrend, Inbetriebnahme, Erweiterung und Untersuchung eines Laborteststandes für Windenergieanlagen mit doppelgespeistem Asynchrongenerator, 18.11.2009

Mirco Scholz, Aufbau eines Z-Source-Wechselrichters und Simulation, Implementierung und Untersuchung einer Regelung zur Einspeisung von Solarenergie ins Netz, 06.11.2009

Jens Schröder, Systemoptimierung der Stützung der Batteriespannung durch streomrichterangkoppelte Doppelschichtkondensatoren bei Drehstromantrieben in Flurförderfahrzeugen, 09.12.2009


Publications


J. Dannehl, C. Wessels, F.W. Fuchs, Limitations of Voltage-Oriented PI Current Control of Grid-Connected PWM Rectifiers


W. T. Franke, B. Carstens, F.W. Fuchs, E. Eggert, A Detailed Analysis of a Power Converter to Buffer the Battery Voltage in Lift Trucks, IECN09, (2009)


**Presentations**


J. Dannehl, *Control of Line-Side Converters with L- and LCL-Filter and small DC-link capacitance*, Industrie, 11.09.2009


V. Dinkhauser, *Condition Monitoring und fehlertoleranter Betrieb von elektrischen Antriebsystemen*, CE wind, 20.03.2009


W. T. Franke, *Temperature depending losses of SiC BJT*, Industrie, 22.01.2009


R. Lohde, Leistungselektronik-Generatorsysteme für Windenergieanlagen, CE wind, 20.03.2009
R. Lohde, Regelung der PMSM am Versuchsstand, Industrie, 18.06.2009
R. Lohde, Forschungsarbeiten zum Thema Windenergie am Lehrstuhl, Industrie, 09.09.2009
O. Mühfeld, Optimierung der Streuinduktivitäten in drei phasigen MOSFET Leistungsmodulen, LE Nord, 06.07.2009
S. Thomsen, Regelung des Antriebsstranges eines Elektrofahrzeuges - Teil 1, Industrie, 13.07.2009
S. Thomsen, Regelung des Antriebsstranges eines Elektrofahrzeuges - Teil 2, Industrie, 12.10.2009
S. Thomsen, Regelung des Antriebsstranges eines Elektrofahrzeuges - Teil 3, Industrie, 27.11.2009
C. Wessels, High Voltage Ride Through with FACTS for DFIG Based Wind Turbines, EPE-2009, Barcelona, Spain, 09.09.2009
C. Wessels, Leistungselektronik Generatorsysteme in Windenergieanlagen und ihr Betriebsverhalten, ETG Kongress, 06.10.2009
B. Wittig, Treibervarianten für Low Voltage Umrichter, LE Nord, 06.07.2009

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 study course „electrical and information engineering and business information”
Reviewer, session chairman, topic co-chairman (PESC-, EPE-, IECON-conferences, IEEE Transactions on Power Electronics; - on Industrial Electronics)
Referee (DFG)

Infrastructure
- Grid anulator in laboratory type (30 KVA) for generating grid fault to test wind turbine or solar converters
- Back to back converter for feeding permanent magnet synchronous machine for research on control
- construction of one extra room for students laboratory
- New software: Comsol Multiphysics (finite element software for electrothermal simulation)

Contribution to external representation of the Faculty of Engineering
Tech to you (Industry Fair Hannover, tour for pupils, guide by research assistants, April 2009)
Presentation on two job information events (each for 4 gymnasiums, January, February 2009)
Several times presentation „Energy Change“ given for the Universitätsgesellschaft in Schleswig-Holstein.

Presentation of the Engineer in Electrical and Information Engineering and Business Administration at the Kiel University Study Information Days (March 2009)

Carried out parts of the Technique working group for pupils (Winter 2007/2008/2009)

Special

Mr. Thomsen has worked 6 months in an industrial project.

Mr. Böttcher and Mr. Hoffmann are new research assistens since Autumn 2009.

Guests from other Universities

Prof. Liserre, Politecnico di Bari, Mercator guest professorship, February to August 2009.

Dipl.-Ing. Orlando, Politecnico di Bari, Guest Scientist, February to August 2009.
Nanoelectronics

In April 2009, Prof. Dr. Hermann Kohlstedt joined the Faculty Engineering of CAU Kiel and took over the professorship „AG Nanoelektronik (Nanoelectronics)” as successor to Prof. Dr.-Ing. Peter Seegebrecht.

Research Activities:

Exciting new opportunities for future information technology arise from unconventional and novel electronic materials, nanoscale phenomena, and advanced processing technologies, which have to be controlled at 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 and/or spin transport will rely on the fundamental laws of quantum mechanics rather than on classical electrodynamics. In this context, new materials and material combinations are urgently required in order to develop tunnel junctions and novel transistors with enhanced functionalities and performance. The chair 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 mainstream development of the nanoelectronics industry. Three main pillars define the research area of the AG Nanoelectronic, i.e. (1) new device concepts based on quantum phenomena, (2) interfacial studies, and (3) novel fabrication routes. For example, we will explore multiferroic tunnel junctions based on complex oxide materials, superconducting junction for quantum bits and lateral tunnel junctions (Nanogaps). A considerable technological and metrological infrastructure is an essential precondition to being competitive in science and technology on an international level. Part of the equipment required is available via the recently installed Kieler Nanolabor electron-beam-writer, focused ion beam system and Pulsed Laser Deposition system. Various current-voltage acquisition systems, magneto-resistance apparatus and ferroelectric thin film analyzers are available in our laboratory. All of which can operate at temperatures ranging from 4.2 K to 300 K. 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

In 2009 our research has focused on the theoretical descriptions of magnetoelectric coupling phenomena for new devices in the areas of non-volatile memories and novel magnetic field sensors. The results have been published in two renowned journals, Appl. Phys. Lett. and Phys. Rev. B.

1) Magnetic tunnel junction on a ferroelectric substrate

Here we describe theoretically the concept of magnetic tunnel junctions fabricated on ferroelectric substrates. The main advantage of such a multiferroic hybrid is the electric control of the junction resistance without the use of the magnetic field necessary in the case of conventional MTJs. As will be shown below, the application of a moderate electric field to a ferroelectric substrate with a high piezoelectric response makes it possible to rotate the magnetization in one of the ferromagnetic electrodes thus changing the junction resistance. Both a gradual reversible rotation and an abrupt irreversible change of magnetization direction in the free ferromagnetic layer can be achieved by this technique. The former may be employed in the sensor applications of MTJs, whereas the latter allows the development of an electric-write nonvolatile memory based on magnetic tunnel junctions. Consider a MTJ with two dissimilar ferromagnetic electrodes, which is mechanically coupled to a thick substrate possessing piezoelectric properties (see Fig. 1). Single crystals of relaxor ferroelectrics, having ultrahigh piezoelectric coefficients, represent the most suitable substrate. The electrodes should be first homogeneously magnetized by a sufficiently strong external magnetic field H, which is removed afterwards. For definiteness, we assume that the initial magnetizations of two electrodes are oriented in the same direction parallel to the junction plane. For our purposes, two opposite faces of the substrate, which are orthogonal to the junction plane, must be covered by continuous electrodes (see Fig. 1). This configuration makes it possible to create a horizontal electric
field $E$ in the substrate, which induces macroscopic deformations of piezoelectric origin here. Owing to the mechanical coupling between the constituents of the material system, the field-induced substrate deformations change the in-plane lattice strains in the metal-insulator-metal trilayer, which form the MTJ. This can result in magnetization reorientations in ferromagnetic electrodes. To maximize the change in the MTJ resistance, the top electrode should have a magnetization that is not switchable by substrate-induced strains. On the contrary, a strain-sensitive highly magnetostrictive ferromagnetic material must be chosen for the bottom electrode, for example, Ni or CoFe2O4. We see that MTJ can be switched from a low-resistance state to a high-resistance one by an external electric field. Therefore, a suitable MTJ fabricated on a ferroelectric substrate represents an electric-write nonvolatile magnetoresistive memory. The measurement of tunnel current flowing across the junction allows a non-destructive electric readout. It should be emphasized that no magnetic field is required for the operation of this device. The switching of the MTJ back to the initial low-resistance state may be realized via the application of an opposite electric field to the substrate. Owing to the correlated interface roughness leading to a ferromagnetic coupling between the top and bottom electrodes, this switching will always lead to the parallel orientation of electrode magnetizations, which is energetically more favourable than the anti-parallel orientation of $M_s$. Thus, the encoding of the memory cell into two definite states appears to be possible, which demonstrates that the memory is electrically rewritable.

![Fig. 1: Schematic drawing of a magnetic tunnel junction fabricated on a ferroelectric substrate sandwiched between two electrodes orthogonal to the junction plane. The magnetizations of the top and bottom ferromagnetic electrodes, which are initially parallel (a), become almost orthogonal to each other after the application of an electric field $E > E_c$ to the substrate with the spontaneous polarization $P_s$ (b).](image)

2) Strong enhancement of direct magnetoelectric effect in strained ferroelectric-ferromagnetic thin-film heterostructures

The direct magnetoelectric (ME) effect is potentially useful for magnetic field sensing, novel magnetic recording read heads, current measurement probes for high-power electric transmission systems, and for energy harvesting. Since the ME response of single-phase magnetoelectric material is too small for device applications, intensive experimental and theoretical studies were focused on multiferroic composites combining ferroelectric and ferromagnetic materials. The theoretical studies of ME effects in multiferroic composites and heterostructures were predominantly based on linear constitutive equations. The linear theory predicted, in particular, that the ME voltage coefficient of PZT-Terfenol-D multilayers with ideal interfacial coupling may be as large as 5 V cm$^{-1}$ Oe$^{-1}$. The influence of imperfect interfacial bonding on the ME responses of multiferroic laminates was later modelled phenomenologically. Using a linear theory, Nan et al. also evaluated the direct ME effect in the thin-film ferroelectric-ferromagnetic heterostructures fabricated on thick passive substrates. These authors did not study, however, the expected dependence of the magnetic-field-induced polarization on the lattice strains created in the ferroelectric phase by a dissimilar substrate. Moreover, the mechanical boundary conditions employed in their calculations correspond to the 3D clamping of heterostructure (all components of the strain tensor are fixed), whereas
the substrate actually produces 2D clamping only (three strains and three stresses remain constant). Accordingly, a finite ME response was incorrectly predicted for a ferromagnetic-ferroelectric bilayer clamped by a thick substrate. Consider a single-crystalline ferroelectric film sandwiched between two continuous electrodes. The film is assumed to be epitaxially grown on a bottom electrode ensuring the (001) crystallographic orientation of the film lattice, as happens in many ferroelectric heterostructures. The electrode-ferroelectric-electrode trilayer should be fabricated on a thick ferromagnetic substrate, which may require the deposition of an additional buffer layer (Fig. 2). The initial strain state of an epitaxial film is defined by the lattice matching to the bottom electrode, which may be strained itself due to the mechanical interaction with the substrate.

Fig. 2: Schematic representation of a hybrid material system involving a thin ferroelectric film deposited on a thick ferromagnetic substrate. The film is sandwiched between two continuous electrodes enabling the measurements of magneto-electric coefficients. The film average polarization equals $P$ in the initial state (left) and changes to $P + \Delta P$ under a magnetic field $H$ applied to the substrate (right).

The ME voltage coefficient defines the magnetically induced output voltage under open-circuit conditions. For epitaxial PZT films, the dielectric response was calculated as a function of the misfit strain. Our calculations predict a drastic increase of the magnetic field sensitivity in terms of the ME voltage coefficient, near to structural phase transitions of ferroelectric films (see Fig. 3). This result may lead to novel magneto-electric sensors using epitaxial heterostructures and is especially of interest for sensitive magnetic field sensors within the SFB 855, electric composites and heterostructures for medical sensor applications.

**Personnel**

Head of the group: Prof. Dr. H. Kohlstedt; Secretary: S. Benecke

Technical Staff: Dipl.Ing.(FH) N. Röschmann

Scientific Staff:

<table>
<thead>
<tr>
<th>Name</th>
<th>Date</th>
<th>Institute</th>
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<tr>
<td>M. Hambe</td>
<td>04.10.-07.12.2009</td>
<td>DAAD</td>
</tr>
<tr>
<td>Dr. A. Petraru</td>
<td>01.08.-31.12.2009</td>
<td>CAU</td>
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<tr>
<td>Dr. O. Vavra</td>
<td>01.10.-31.12.2009</td>
<td>CAU</td>
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**Lectures, Seminars, and Laboratory Course Offers**

*Summer 2009*

Electronics, 4 (+2) hrs Lecture (+ Exercises)/Week,  
H. Kohlstedt
Fig. 3: Magnetoelectric voltage coefficient calculated for a hybrid heterostructure involving the Terfenol-D substrate and the single-domain epitaxial PZT 20/80 film subjected to the isotropic biaxial in-plane strain. The predicted ME voltage coefficient could be as large as 100 V cm\(^{-1}\) Oe\(^{-1}\) close to the c- to r-phase phase transition of the PZT film.

Winter 2009/2010

Nanoelectronics, 3 hrs Seminar/Week,
H. Kohlstedt (+ A. Petru, O. Vavra)

Fabrication of Electronic Devices, 2 (+1) hrs Lecture (+ Exercises)/Week,
H. Kohlstedt

Third-Party Funds


DAAD, Interfaces in complex oxide ferroelectric/ferromagnetic heterostructures, 01.01.2008-31.12.2009 (11870 EUR)

Further Cooperation, Consulting, and Technology Transfer

University of Tuebingen, Germany, Experimentalphysik II and Center for Collective Quantum Phenomena: Josephson Junctions for Quantum Bits

University of New South Wales (UNSW), Australia, Department of Material Science: Multiferroic Tunnel Junctions

University of Lincoln, Nebraska, USA, Department of Physics and Astronomy: Ferroelectric polymers for field effect transistors and tunnel junctions

A.F. Ioffe Physico-Technical Institute, St. Petersburg, Russia: Landau-Theory on strain effect in magnetoelectric heterostructures

University of California, Berkeley, USA, Materials Science Devison: Multiferroic BiFeO\(_3\)

Fa. Oerlikon, Leybold, Germany, Cologne: Development of thin film processes
RWTH Aachen, Germany, Inst. für Werkstoffe der Elektrotechnik II, Multiferroic BiFeO₃

Publications

Published in 2009


Presentations

M. Disch, H. Kohlstedt, *Electrical characterization of ferroelectric tunnel junctions with ferromagnetic electrodes*, Deutsche Physikalische Gemeinschaft (DPG), Frühjahrstagung, Dresden, D, 22.-27.03.2009


H. Kohlstedt, *Complex Oxide Tunnel Junctions*, European Materials Science Society (EMRS), Strasbourg, F, 08.-12.06.2009
Communications

Research Activities:

- 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)
- Synchronization in communication systems (clock and carrier synchronization, PLL-applications)

Results

Laboratory for Optical Communications

The capabilities of the well-equipped laboratory for optical communications were extended in 2009 by two pairs of very useful instruments. Firstly, a two-channel arbitrary waveform generator (AWG) has been funded by DFG, which allows the generation of two arbitrary signals in parallel up to a bandwidth of 6 GHz and beyond. It can be considered as a high-speed digital-to-analog converter with a sampling rate of 20 Gsamples/s (i.e. 20 billion samples per second). Using this device, many different modulation formats for high-speed data transmission may be generated (e.g. multilevel amplitude shift keying (M-ASK) or orthogonal wavelength-division multiplexing (OFDM)) without having to buy new hardware components. This is enabled by generating those signals in software using the in-house simulation tool followed by transfer of the data to the AWG. Correspondingly in the receiver, the newly purchased real-time oscilloscope (BMBF funding) samples the data with a speed of up to 50 Gsamples/s. The data is transferred back to the software tool for signal evaluation (e.g. measurement of the bit error ratio).

Secondly, a bit pattern generator and a corresponding error analyzer, both funded by CAU and the state of Schleswig-Holstein, allow the investigation into data transmission of up to 56 Gsymbols/s. Using strategies like higher-order modulation formats (e.g. 4-ASK, QASK) or polarization shift keying that enable coding of at least two bits into one symbol, currently the aim is to realize data transmission of 112 Gb/s.
Now having acquired these four devices the laboratory is state of the art in terms of the enormous improvement in electronics speed. They enable worldwide competitive experiments to be carried out. Several contributions on OFDM incorporating experimental results obtained with the help of the new devices have already been published. Also, Master and Diploma theses with an experimental part have been carried out using the new equipment.

**Multi-level modulation formats in combination with coherent receivers**

Due to the increasing demand on transmission capacity it is necessary to use bandwidth efficient modulation formats for optical communication systems. One possibility is to use multi-level modulation formats. With these formats it is possible to transmit within the same bandwidth a multiplicity of data compared to binary modulation formats. The combination of multi-level modulation formats with coherent reception has the advantage that arbitrary multi-level modulation formats can be demodulated. Thus, for example for all multi-level phase shift keying and quadrature amplitude modulated formats (M-PSK and M-QAM) only the phase estimation in the digital signal processing in the coherent reception has to be adapted. Another advantage is that the polarization can be used as an additional degree of freedom. Thus it is possible for example to transmit 100 Gbit/s with 25 GBaud QPSK (quadrature phase shift keying) on two polarizations. Due to the use of a coherent receiver it is not necessary to separate both polarizations exactly at the receiver side. The decoupling of both signals can be equalized afterwards with the use of digital signal processing. One research topic is the investigation of clock- and carrier recovery for such a polarization-multiplexed system in the presence of signal distortions like chromatic dispersion and polarization mode dispersion.

**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**  15.03.-31.12.2009  Industry
- **M.Sc. Abdulamir Ali**  01.01.-31.12.2009  DFG
  - Orthogonale Frequenzmultiplextechnik (OFDM)
- **Dipl.-Ing. Annika Dochhan**  01.01.-31.12.2009  CAU
  - Modulationsverfahren
- **Dr.-Ing. Majed Dwairi**  15.06.-14.09.2009  visiting research fellow
- **Dipl.-Ing. Christina Hebebrand**  01.01.-31.12.2009  Industry
  - Kohärente Empfänger
- **M.Sc. Shahidul Islam**  01.01.-31.03.2009  Industry
  - Entzerrung des optischen Übertragungskanals
- **M.Sc. Apostolos Karadimitrakis**  01.08.-31.12.2009  Scholarship
Lectures, Seminars, and Laboratory Course Offers

Winter 2008/2009

Nachrichtenübertragung II, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
W. Rosenkranz (+ A. Dochhan)

Optische Kommunikationstechnik II (Hochgeschwindigkeitssysteme und Netze), 2 (+ 1) hrs Lecture (+ Exercises)/Week,
W. Rosenkranz (+ J. Leibrich)

Anleitung zum wissenschaftlichen Arbeiten für Studierende der Elektrotechnik und Informationstechnik, 2 hrs Seminar/Week,
W. Rosenkranz

Seminar über ausgewählte Kapitel der Nachrichtentechnik, 3 hrs Seminar/Week,
W. Rosenkranz und Mitarbeiter/innen

Seminar über Studien- und Diplomarbeiten der Nachrichtentechnik, 2 hrs Seminar/Week,
W. Rosenkranz und Mitarbeiter/innen

Communications Lab, 4 hrs Lab/Week,
W. Rosenkranz (+ C. Hebebrand)

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)

Summer 2009

Anleitung zum wissenschaftlichen Arbeiten für Studierende der Elektrotechnik und Informationstechnik, 2 hrs Seminar/Week,
W. Rosenkranz

Nachrichtenübertragung I, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
W. Rosenkranz (+ A. Dochhan)

Optical Communications, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
W. Rosenkranz (+ J. Leibrich, M. Silva-Lopez)

Optische Kommunikationstechnik I (Grundlagen und Komponenten, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
W. Rosenkranz (+ J. Leibrich, M. Silva-Lopez)

Praktikum Nachrichten- und Informationstechnik, 4 hrs Lab/Week,
W. Rosenkranz und Mitarbeiter/innen

Seminar über ausgewählte Kapitel der Nachrichtentechnik, 3 hrs Seminar/Week,
W. Rosenkranz und Mitarbeiter/innen

Seminar über Studien- und Diplomarbeiten der Nachrichtentechnik, 2 hrs Seminar/Week,
W. Rosenkranz und Mitarbeiter/innen
Winter 2009/2010

Nachrichtenübertragung II, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
W. Rosenkranz (+ A. Dochhan)

Optische Kommunikationstechnik II (Hochgeschwindigkeitssysteme und Netze), 2 (+ 1) hrs Lecture (+ Exercises)/Week,
W. Rosenkranz (+ J. Leibrich)

Anleitung zum wissenschaftlichen Arbeiten für Studierende der Elektrotechnik und Informationstechnik, 2 hrs Seminar/Week,
W. Rosenkranz

Seminar über ausgewählte Kapitel der Nachrichtentechnik, 3 hrs Seminar/Week,
W. Rosenkranz und Mitarbeiter/innen

Seminar über Studien- und Diplomarbeiten der Nachrichtentechnik, 2 hrs Seminar/Week,
W. Rosenkranz und Mitarbeiter/innen

Communications Lab, 4 hrs Lab/Week,
W. Rosenkranz (+ J. Zhao)

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)

Third-Party Funds

Deutsche Forschungsgemeinschaft (DFG), Orthogonale Frequenzmultiplextechnik (OFDM) in der leitungsgebundenen
optischen Hochgeschwindigkeitsübertragung, 01.01.-31.12.2009 (76.000 EUR)

Deutsche Forschungsgemeinschaft (DFG), Forschungsaufenthalt Dwairi, 15.06.-14.09.2009 (6.900 EUR)

Industrie, Chirp Managed Laser, 01.01.-31.12.2009 (9.900 EUR)

Fa. ADVA, Industrie, Untersuchungen zur Identifikation der optimalen Takt- und Trägerrückgewinnung eines kohärenten Epfängers
mit Polarisationsmultiplex, 01.01.-31.12.2009 (95.000 EUR)

BMBF, Übertragungskonzepte mit Parallelisierung für 100Gbit/s Ethernet Metronetze, 01.01.-31.12.2009 (98.600 EUR)

Further Cooperation, Consulting, and Technology Transfer

The chair is a partner in the project CELTIC OPTRONET (optimized transponders for durable optical networks) with the
following partners: Siemens S.A. (Portugal), CIVCOM Inc.,

(CoreOptics GmbH (Nürnberg), Instituto de Telecommunicacoes Aveio (Portugal).

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

Mr. Prof. Dr. Nguyen LeBinh from the Centre for Telecommunications and Information, Department of Electrical and
Computer Systems, Monash University, Melbourne, Australia, stayed as a visiting professor for a year.
Mr. Dr. Majed Dwairi from the Electrical Engineering Department, Faculty of Engineering Technology, Al-Balqa Applied University, Amman, Jordanien, stayed as a research fellow for three months.

**Diploma, Bachelor and Master Theses**


Nadim Serhal, *Simulative and Experimental Investigation of Multi-level Modulation Formats for Optical Communications*, 02.12.2009


**Dissertations / Postdoctoral Lecture Qualifications**


**Publications**

Published in 2009


S. Adhikari, S.L. Jansen, V.A.I.M. Sleiffer, W. Rosenkranz, *On the nonlinear tolerance of 42.8-Gb/s DPSQ with co-propagating OFDM neighbors*, IEEE LEOS Annual Meeting, Antalya, Turkey, 04.-08.10.2009, ME1, 2009


Intensity Modulation with Direct Detection, 10. ITG-Fachtagung Photonische Netze, 04.-05.05.2009, Leipzig, Germany, 197 - 201 (2009)

Patent Applications
C. Hebebrand, A. Bianciotto, B. Spinnler, A. Napoli, Polarization effects tolerant clock recovery for polarization multiplex coherent receivers, PVA SH, 05.06.2009, —

Presentations
J. Leibrich, A. Dochhan, Optimierte Amplitudenstufen und Wandlerkennlinien für Modulationsformate in Metronetzen, Workshop der ITG Fachgruppe 5.3.1, Berlin, Germany, 12.-13.11.2009
W. Rosenkranz, Research at CAU University of Kiel: Multi-level Modulation Formats and OFDM for High-speed Optical Links, Seminar at Bell Labs, Holmdel, USA, 31.-31.03.2009
S.L. Jansen, D. van den Borne, S. Adhikari, Past, Present and Future of Optical OFDM, Asia Communications and Photonics Conference, APC 2009, Shanghai, China, 02.06.-06.11.2009
W. Rosenkranz, A. Ali, J. Leibrich, Orthogonal Frequency Division Multiplexing (OFDM) in Optical Communications with Direct Detection for Metro Networks, ICTON 2009, Ponta Delgada, Azores, Portugal, 28.06.-02.07.2009
A. Ali, J. Leibrich, H. Paul, W. Rosenkranz, K.D. Kammeyer, Experimental Analysis of 10Gb/s Optical OFDM Based on Intensity Modulation with Direct Detection, 10. ITG-Fachtagung Photonische Netze, Leipzig, Germany, 04.-05.05.2009
A. Dochhan, S. Smolorz, H Rohde, W. Rosenkranz, Electronic Equalization of FBG Phase Ripple Distortions in 43 Gb/s WDM Systems, 10. ITG-Fachtagung Photonische Netze, Leipzig, Germany, 04.-05.05.2009
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)”
* “SPIE Asia-Pacific Conference on Optical and Wireless Communications (APOC)”
* “International Conference on Computers, Communications and Power (ICCCP)”

LNT-Mitarbeiter wirken mit im „Arbeitskreis Übertragungstechnik“ im Rahmen des BMBF Verbundprojektes „EIBONE“.

Der Lehrstuhl wirkte mit an:

* Projektwoche „Mobilfunk“ des Gymnasiums Bad Oldesloe

Awards

Herr Dr. Murat Serbay (ehemaliger Mitarbeiter) wurde mit dem Fakultätspreis (12.07.2009) ausgezeichnet.
Circuit and System Theory

The chair, abbreviated LNS for „Lehrstuhl für Netzwerk- und System-Theorie“, has been in existence since October 1993. At the beginning of 2009, there were five scientific co-workers, three paid by the state, and two on a project-funding basis, plus the Head of the group with a secretary and a technician (both also working for the group for Information & Coding Theory (ICT) of Prof. Dr.-Ing. P. Höher). Furthermore, several students helped us, on a short-term job basis, with the everyday work in teaching, research, and administration.

Two of the scientists finalized their dissertations at the end of the year; a third will do the same in January 2010, and another in summer 2010 after returning from her maternity break.

One new scientist joined us in September, paid by third-party funds. As one of the projects within the new „Sonder-Forschungsbereich” (SFB 855), granted by DFG in autumn this year, will be carried out within our group, and since a single DFG project was accepted also, the LNS team will consist of 4 co-workers, next year.

Our cooperation with the Federal-Navy Research Institute for Under-Water Acoustics and Geophysics (based on two BMV-funded projects meanwhile), and with the Neurology Department of the University Clinics Kiel continued with very good success. The latter work on neurological signal processing led to one of the aforementioned doctoral theses.

As the decreasing total number of doctoral candidates as well as the thesis work mentioned above indicate, deep cuts are at hand: After this 16th year of its existence, the chair as such will end its work. Prof. Heute retired officially on October 1st, 2009, after his 65th birthday, but has continued to govern the group until his successor takes over. This will happen on March 1st, 2010: Prof. Dr.-Ing. Gerhard Schmidt will then lead the newly defined „Group for Digital Signal Processing and System Theory“. The remaining and new LNS scientists, including Prof. Heute, will thereafter be members of the new chair.

Results

In 2009, our work has led to numerous publications.

Prof. Heute himself was a co-author of a chapter on source- and channel-coding aspects for speech transmission, in a Springer book covering all kinds of signal-processing topics in acoustics. The chapter’s topic used to be a central chair item of the years 1998 - 2007, and the co-author was Norbert Görtz, the first LNS scientist to work in this field. He is now a full professor of TU Vienna. Furthermore, Prof. Heute gave an invited speech on the transition „from telephone-band to wide-band speech“ on the occasion of a Head Acoustics’ event at Aachen. At DAGA’09, which was combined with the Netherlands’ Acoustical-Society conference at Rotterdam, he presented an overview on our still continuing work on attribute-based speech quality measures.

In the various LNS fields, of course, the co-workers also presented their results:

**Speaker Characterization and Transformation:** Jan Schwarz continued to work on this topic intensively, publishing results at DAGA’09, in Rotterdam, and his Interspeech’09 contribution to the Fujisaki prosody model was presented at Brighton by one of his two co-authors, namely, Dr. H. Pfitzinger, of the phonetics department of CAU Kiel. At Berlin, he gave a colloquium presentation, invited by the TU Usability Laboratories. Above all, however, he „wrote everything up“, finalizing his thesis at the end of the year.

**Speech Quality:** As mentioned, this is still a central item of LNS research. Lu Huo was a co-author of the above-mentioned overview paper at Rotterdam, before she began a maternity break in April: in summer 2009, she became a mother of a little boy. Meanwhile, she is summarizing and supplementing her work and writing her thesis.

The work on speech quality relies on a continuous and extremely fruitful cooperation with „T-Labs“ at TU Berlin, especially the group of Prof. Dr.-Ing. Sebastian Müller. Two paths of common interests have been identified during previous work,
one of them leading to a DFG project proposal, which was granted very recently, to be started in 2010.

**Medical-Signal Processing:** Our work with bio-medical signals has been traditional since the Bochum times of Prof. Heute; the present status is as follows:

- ECGs are analyzed with the aim of sleep-stage identification, which is normally done from EEG analysis with much higher measurement effort. Halil Özer looked both into common parameters, like - Fourier and Wavelet-based - spectra of heart-rate variability, and into not so well investigated morphological details of the ECG itself, based on pattern-matching and filter-bank/ wavelet approaches. While the absolute recognition accuracies are still not completely satisfying, it must be stated that they are comparable to, or even considerably better than, those of earlier work from other groups. His proposal to adapt the comparison process to the progress of the varying sleep behaviour during night time is a promising, new basis for further work. Parts of his results were published at the World Congress on Medical Physics and Biomedical Engineering 2009, at München. He had several students helping him with their theses, and further, his cooperation with Prof. A. N. Hossen from SQU Oman, Muscat, was continued also towards a submitted paper. At the end of 2009, his doctoral thesis on this subject was almost finished.

- EEGs are analyzed by Muthuraman Muthuraman, cooperating closely with (and co-financed by) the Neurology group at Kiel’s University Clinics. The aim is to find new hints to the sources of Parkinson’s disease. The methods include coherence analysis between muscle activities (EMG), electrical potentials on the head surface (EEG), and internal brain observations (fMRI). The results led again to various publications; three at international conferences, and one in an international journal on Clinical Neurophysiology. Above all, once more, the finalization of a doctoral thesis can be reported as a successful conclusion of the cross-disciplinary work with Prof. Deuschl and Dr. Raethjen. Due to a newly granted project within a DFG-financed „Sonderforschungsbereich“ (SFB 855), this cooperation will, however, be strengthened and continued for the next four years.

**Sonar-Signal Processing:** Kathrin Seget has been working for 2.5 years for an FWG-BMV project on active-sonar DSP, with a focus on tracking by means of variants of Kalman filters. The cooperation includes, apart from the FWG team at Kiel, the strong tracking-expert group of FGAN at Wachtberg and practical experiments on research vessels of the Federal Navy. Results were presented at a workshop in Lübeck.

**Marine-Mammal Classification:** In autumn 2009, a new project was initialized by FWG, positioned within a large NATO investigation: whales and dolphins are to be classified from their acoustic sounds, i. e., „chirps”, „thumps”, and „whistles”, or even „songs”, with the aim to avoid any strong disturbance of these magnificent creatures by (extremely loud) sonar signals. Roman Kreimeyer analyzes the signals available on a large (but still too small) data base, and tries to find features and methods for good automatic detection and classification. Meanwhile a short presentation of his first ideas has already found strong interest at an ITG workshop in Erlangen.
Personnel

Head of the group: Prof. Dr.-Ing. U. Heute; Secretary: S. Schuchardt (50%)
Technical Staff: Dipl.-Ing. T. Rabsch (50%)

Scientific Staff:

M.Sc. L. Huo 01.01.-30.06.2009 CAU
Speech-Quality Measurement

Marine-Mammal Classification

M.Sc. M. Muthuraman 01.01.-31.12.2009 LNS / Neurology
EEG- and EMG Analysis of Tremor Patients

Dipl.-Ing. J. Schwarz 01.01.-31.12.2009 CAU
Speaker Charact. and Transformation

Dipl.-Ing. K. Segel 01.01.-31.12.2009 BMWV
Sonar-Signal Processing

Dipl.-Ing. H. Özer 01.01.-31.12.2009 CAU
Bio-Medical / ECG Signal Processing

Lectures, Seminars, and Laboratory Course Offers

Winter 2008/2009

Systemtheorie, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
U. Heute (+ H. Özer)

Advanced Signals and Systems, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
U. Heute (+ K. Segel)

Applied DSP II: Speech-Signal Processing, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
U. Heute (+ L. Huo)

Advanced Digital Signal Processing, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
U. Heute (+ J. Schwarz)
Ausgewählte Kapitel der Systemtheorie, 2 hrs Seminar/Week,
U. Heute

Communications Lab I, 4 hrs Lab/Week,
U. Heute (+ M. Muthuraman)

Advanced Topics Lab’, 4 hrs Lab/Week,
U. Heute (+ M. Muthuraman, J. Schwarz, H. Özer)

**Summer 2009**

Signale und Systeme I, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
U. Heute (+ H. Özer)

Digitale Signalverarbeitung I, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
U. Heute (+ J. Schwarz)

**Applied DSP II**: Speech-Signal Processing, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
U. Heute (+ U. Heute)

Ausgewählte Kapitel der Systemtheorie, 2 hrs Seminar/Week,
U. Heute

Systemtheorie, 4 hrs Lab/Week,
U. Heute (+ M. Muthuraman, K. Segert)

Seminar Digital Communications, 2 hrs Seminar/Week,
U. Heute (+ H. Özer, J. Schwarz, M. Muthuraman, K. Segert)

**Winter 2009/10**

Signale und Systeme II, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
U. Heute (+ H. Özer)

Advanced Signals and Systems, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
U. Heute (+ K. Segert)

Advanced Digital Signal Processing, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
U. Heute (+ J. Schwarz)

Ausgewählte Kapitel der Systemtheorie, 2 hrs Seminar/Week,
U. Heute

Communications Lab I, 4 hrs Lab/Week,
U. Heute (+ M. Muthuraman)

Advanced Topics Lab’, 4 hrs Lab/Week,
U. Heute (+ R. Kreimeyer)

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**Third-Party Funds**


Spende, Wiss. Arbeit, 01.-31.12.2009 (4000 EURO)
Further Cooperation, Consulting, and Technology Transfer

The close cooperation with the Federal-Navy Research Institute for Water Acoustics and Geophysics (FWG) was continued, and strengthened in terms of teachers from FWG in elective courses and especially in two funded research projects. The recent inclusion of FWG into a larger unit, namely, WTD-71 (“Wehrtechnische Dienststelle”) at Eckernförde, did not at all hinder the exchange of ideas and results.

Our good relations with „T-Labs“, a German Telekom institute at TU Berlin, especially Prof. S. Möller’s „usability“ group, led to a new DFG project concerning an extension of earlier speech-quality investigations.

Our contacts with the phonetics group at CAU, within the Faculty of Philosophy, and Dr. H. Pfitzinger (acting as interim caretaker of the corresponding professorship) was continued intensively. He also acted as a referee (and will be an examiner) for J. Schwarz.

The cooperation with the Neurology group around Prof. Deuschl and Dr. Raethjen has become a fundamental part of our work meanwhile. In particular, the „larger project being planned with involvement of neurologists, LNS researchers, and numerous other scientists“ , mentioned a year ago in the almanach, has been approved now by DFG. Within this „Sonderforschungsbereich“ on new magneto-electric sensors, our group will investigate possible algorithmic signal enhancements in terms of both noise and artefacts. This work will also intensify the cooperation within electrical and information engineering, since the chair for radio-frequency engineering is our „neighbour“ with regard to signal acquisition, and the group for numerical field simulation acts as the „customer“, to apply our hopefully enhanced signals, prior to medical evaluation.

Diploma, Bachelor and Master Theses


Publications

Published in 2009


Presentations


Further Activities and Events

Memberships and functions of Prof. Heute:

− Co-editor of the half-year CAU journal „Christiana Albertina“

− Head of the Kiel Section of „Schleswig-Holsteinische Universitätsgeellschaft“ (SHUG, Schleswig-Holstein University Association)

− Jury member for ISH / Schmidt-Römhild Technology Award

− Member, Advisory Committee of the European Association for Signal Processing (EURASIP)

− Member, Editorial Board of the Journal for Signal Processing (Elsevier)

− Member, Editorial Board of the Journal for Advances in Signal Processing (Hindawi)

− Programme-committee member, European Signal-Processing Conference (EUSIPCO’09), Edinburgh, UK

− Programme-committee member, Annual Conf. of the International Speech-Communication Association (INTER-SPEECH’09), Brighton, UK

− Member, ITG / VDE „Fachaußschuss Sprachakustik“ (expert committee speech acoustics)

− Member, ITG / VDE „Fachgruppe Algorithmen der Signalverarbeitung“ (expert group for DSP algorihms)

− Reviewer for various IEEE and IEE journals

− Member, Award Committee for the journal Speech Communication (Elsevier)

− Organizer of „Projektwoche Mobifunk“ (project week mobile communication) with a school at Bad Oldesloe

Reviewer activities of

− Lu Huo for Int. Conf. INTERSPEECH’09, Brighton, UK

− Halil Özer for the EURASIP journals Adv. Signal Processing (Hindawi) and Signal Processing (Elsevier)
— Jan Schwarz for Int. Conf. INTERSPEECH’09, Brighton, UK, EURASIP Conf. EUSIPCO’09, Edinburgh, UK, and for the EURASIP journal Signal Processing (Elsevier)
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 such as 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, and fields and waves in biological systems.

Results

a) Efficient near-field far-field transformation for the FDTD-method

Multipole analysis is a classical technique to analytically describe electromagnetic and other fields using series expansions. In the electromagnetic case it is an orthogonal decomposition 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 (the classical Mie solution) and diffraction at a perfectly conducting cone.

This DFG-supported project exploits the extraordinary features of multipole analysis to evaluate and post-process far-fields from numerically obtained near-fields. Within the Finite-Difference Time-Domain (FDTD) method, that near-field far-field transformation utilizes the spherical-multipole interface: the sources of the field are replaced by electric and magnetic dipoles on a closed surface surrounding all actual sources. In contrast to the conventional method where for each far-field point of interest a numerical integration over the whole surface is required, for the new method that integration has to be performed only once, as has been shown for the frequency-domain as well as for the time-domain.

In addition, the analytical multipole expansion of the far-field obtained allows for an enhancement of the numerically obtained results using a spatial frequency low-pass filter.

Fig. 1: Three-dimensional radiation pattern of a Vivaldi antenna computed by means of the new multipole-based near-field to far-field technique.

In this research project a novel technique has been developed, which is perfectly adjusted to the problem. It allows for a very efficient calculation of the Legendre polynomials needed here. As an application of this technique the calculation of
the far-fields of UWB antennas for an entire frequency range by just one single FDTD-run has been shown. The promising multipole interface for computational electromagnetics is still being developed and further extended.

b) Numerical and analytical examination of shielding and shielding effectiveness: An example for statistical EMC

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 disturbances or pulsed (transient) disturbances. This research project concentrates on the evaluation of 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) 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 dominating the field outside the very narrow 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.

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.

d) Multipole antennas

Antennas are renowned as key elements in wireless digital communications. In multipath propagation scenarios, like 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.

e) A new theorem concerning uniqueness of the electromagnetic field

It has been shown that the electromagnetic field in any homogeneous region is unambiguously and accurately determined, if it is known in one single point in space and its immediate neighbourhood. The proof is performed by consecutively conducted multipole expansions and includes a method to reconstruct such a field. An application of this finding could be the development of novel sensors, which aside from measuring the dipole-part of the field also detect higher moments (e.g. quadrupole). These could be used to characterize a field not only at the measuring position, but also in the surroundings.

Personnel

Head of the group: Prof. Dr.-Ing. L. Klinkenbusch; Secretary: S. Thielbörger (50%)
Technical Staff: Dipl.-Ing. J. Buschmann (50%)
Scientific Staff:

Dipl.-Ing. Michael Kijowski 01.04.-31.12.2009 DFG
Semiinfinite Strukturen

Dipl.-Phys. Kai Körber 01.01.-31.12.2009 CAU
Statistical EMC

Dipl.-Ing. Christian Möller 01.01.-31.12.2009 CAU
HS2020

Lectures, Seminars, and Laboratory Course Offers

Winter 2008/2009

Theoretische Elektrotechnik I, 3 (+ 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)

Summer 2009

Elektromagnetische Verträglichkeit, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
L. Klinkenbusch (+ K. Körber)

Theoretische Elektrotechnik II, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
L. Klinkenbusch (+ K. Körber)

Intensivübung Theoretische Elektrotechnik (Blockveranstaltung), 1 hrs Exercise/Week,
L. Klinkenbusch (+ C. Möller, K. Körber)

Seminar Feldtheorie, 1 hrs Seminar/Week,
L. Klinkenbusch

Winter 2009/2010

Elektromagnetische Felder 1, 3 (+ 1) hrs Lecture (+ Exercises)/Week,
L. Klinkenbusch (+ C. Möller)

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. Möller, K. Körber, M. Kijowski)

Third-Party Funds

DFG, Semiinfinite Strukturen, 01.04.2009 (1/1 E13 + 1 WiMi + Sachmittel)

DFG, ISTET’09 - International Symposium on Theoretical Electrical Engineering, Lübeck, 22.-24.06.2009 (21000 EUR)

DFG, SFB 855 TP D7, 01.01.2010 (2 E13 + Sachmittel)

DFG, SFB 855 TP D4, 01.01.2010 (1 E13 + Sachmittel)
Further Cooperation, Consulting, and Technology Transfer

1. Prof. Dr. H. Chaloupka, Bergische Universität Wuppertal, Subject: Multimode Antennas
2. Prof. Dr. M. Popovic, McGill University, Montreal (Canada), Subject: Bioelectromagnetic fields
3. Prof. Dr. R. Sikora, Westpommeranian University Szczecin (Poland), Subject: Non-destruction evaluation
4. Prof. Dr. E. Cardelli, University Perugia (Italy), ERASMUS partnership
5. Prof. Dr. Paul Urbach, TU Delft und Philips Eindhoven (Netherlands), Subject: Scattering theory, FDTD-Simulationen
6. Physikalisch-Technische Bundesanstalt, Braunschweig, Dr. Schrader Subject: Shielding effectiveness
7. Prof. L. Pichon, University Paris-Sud (XV) (France) Subject: EMC of complex systems, ERASMUS partnership
8. Prof. G. Manara, University of Pisa (Italy), ERASMUS partnership

Diploma, Bachelor and Master Theses

Rüdiger Pedersen, Konzeption und feldtheoretische Analyse einer Induktions-Ladestation für Elektrofahrzeuge, 30.09.2009

Dissertations / Postdoctoral Lecture Qualifications

J. Adam, Analyse und Verarbeitung numerisch berechneter elektromagnetischer Felder mittels Multipolentwicklungen, 08.12.2009

Publications

Published in 2009

L. Klinkenbusch, Application of a new uniqueness theorem to two-dimensional electromagnetic problems (invited), Frenquenz, 63, 157 - 159 (2009)

Patent Applications

L. Klinkenbusch, Verfahren und Anordnung zum Rekonstruieren der Quelle eines elektromagnetischen Feldes, Deutsches Patentamt München, 16.07.2009, DE102009033421.1
Presentations

L. Klinkenbusch, Plane-Wave Scattering by an Elliptic Cone, Progress in Electromagnetics Research Symposium (PIERS), Peking, China, 26.03.2009
L. Klinkenbusch, On Consequences of a Recent New Theorem in Electromagnetics For Inverse-Scattering Problems, IEEE International Symposium on Antennas and Propagation, Charleston, USA, 02.06.2009

Christian Möller, L. Klinkenbusch, Near-field shielding effectiveness for a Huygens source, International Symposium in Theoretical Electrical Engineering (ISTET09), Lübeck, 24.06.2009

Further Activities and Events

Prof. Klinkenbusch is a member of the steering committee of the International Symposium on Theoretical Electrical Engineering (ISTET). He organized and chaired the ISTET’09 successfully held in Lübeck, Germany in June 2009. Moreover he is Chairman of the Local Organizing Committee of the URSI International Symposium on Electromagnetic Theory (EMT-S) to be held in Berlin, Germany in August 2010. Since 2009 he has been a Committee member of the German Academic Exchange Service (DAAD) for the region Near-East/ North Africa.

Prof. Klinkenbusch is Chairman of the examining board and academic adviser for the departmental programs in electrical and information engineering (Diploma and Bachelor). He is representative of the Faculty of Engineering in the Schleswig-Holsteinische Universitätsgesellschaft.

Prof. Klinkenbusch is a member of VDE and of IEEE and serves in the IEEE Antennas and Propagation Education Committee. Effective January 1 2009, he has been elected Fellow of IEEE for Contributions to spherical-multipole analysis of electromagnetic fields.
Wireless Communications

The Wireless Communications group CWC has been funded since 1st of February 2009. The chair, Prof. Manteuffel, was formerly with the IMST, a leading German R&D company in the area of mobile and satellite communication.

The research of 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. In antenna design it is often seen as an art to apply basic electromagnetic principles to build up real structures with the required properties. Nowadays applications offer limited space for the integration of the wireless modules and therefore antenna performance especially is dominated by the integration problems. 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-body wireless channels become an interesting research topic.

Results

Reconfigurable Multistandard Antennas for Mobile Terminals

Within cooperation with IMST GmbH the wireless communications research group designed a novel concept for a reconfigurable multi standard antenna for small mobile terminals, such as mobile phones. The concept uses a standard coupling element, which enables the chassis of the mobile terminal itself to act as an antenna. A reconfigurable tuning circuit realizes optimized tuning of the coupling element in multiple frequency bands. The multi circuit component is manufactured in LTCC (Low Temperature Co-fired Ceramic) technology in IMST’s LTCC fab. Prototypes have been manufactured for up 6 bands and show very promising results. This research was part of the project MxMobile funded by the BMBF.

Fig. 1: Reconfigurable multi standard antenna tuning component manufactured in LTCC technology by IMST GmbH
UWB Communication and Localization

UWB (Ultra WideBand) technology enables the development of low power, high data rate short-range wireless applications. Furthermore, pulse-based systems allow accurate localization of mobile stations. The combination of both, communication and localization, offers possibilities for new applications and services. 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. Several two-antenna systems are integrated into the cabin ceiling while a miniature mobile device contains a single antenna that is specifically designed to work in close proximity to the human body.

MIMO Antenna Integration into Small Terminals

MIMO (Multiple Input Multiple Output) is a technique to utilize multi-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. Robert Martens investigated the coupling between multiple antenna elements on small terminal platforms and its influence on the element correlation as part of his PhD thesis. 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 have the potential for deriving design rules for the integration of multiple antennas into small terminals. As a short term prospective, such rules will be valuable, for example, for the design of LTE (Long Term Evolution) mobile terminals and WLAN IEEE802.11.n devices.

Implanted Antennas and RF propagation within the human body

A Body Area Network (BAN) is a combination of several electronic applications that are worn on or in the body having preferably a wireless interconnection with each other or with external peripherals. The applications can range from consumer electronic devices and security equipment to 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 recently was considered 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, respectively.

Fig. 2: RF propagation excited by an implanted antenna inside the body
Head of the group: Prof. Dr.-Ing. D. Manteuffel; Secretary: M. Bork
Technical Staff: Dipl.-Ing. W. Taute

Scientific Staff:
Dipl.-Wirtsch.-Ing. R. Martens 01.07.-31.12.2009 CAU

Lectures, Seminars, and Laboratory Course Offers

Summer 2009

Antenna Design, 2 (+1) hrs Lecture (+ Exercises)/Week,
D. Manteuffel (+ D. Manteuffel)

Communication Devices II: RF Communication, 2 (+1) hrs Lecture (+ Exercises)/Week,
D. Manteuffel (+ D. Manteuffel)

Hochfrequenztechnik, 2 (+1) hrs Lecture (+ Exercises)/Week,
D. Manteuffel (+ D. Manteuffel)

Winter 2009/2010

Grundgebiete der Elektrotechnik III, 3 (+2) hrs Lecture (+ Exercises)/Week,
D. Manteuffel (+ D. Manteuffel, R. Martens, Ch. Möller, M. Nordhausen)

Entwurf von Antennen, 4 hrs Lab/Week,
D. Manteuffel (+ R. Martens)

Third-Party Funds

Industry cooperation, UWB Antennas and Propagations for a combined communication and localization systems inside an aircraft cabin, 01.02.2009-30.06.2010 (EUR non-disclosed)

Industry cooperation, Preparation of the ESoA course “Industrial Antenna Design”, 01.01.-31.12.2009 (EUR non-disclosed)

UPC (Polytechnical University of Catalunya), ESoA course “Compact Antennas”, 01.01.-31.12.2009 (Travel funds)

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. In the framework of cooperation with Loughborough University Yiannis Makris worked towards his PhD on the design of UWB antenna integration in consumer products. The research is jointly supervised by Prof. Vardaxuglu and Prof. Manteuffel. Industrial cooperations have been conducted with I2R Singapore, IMST GmbH, Airbus and Draeger.

Publications

Published in 2009

Presentations

D. Manteuffel, Concepts for Future Multistandard and Ultra Wideband Mobile Terminal Antennas using Multilayer LTCC Technology, IWAT 2009, Santa Monica, USA, 02.-04.03.2009

D. Manteuffel, Considerations on configurable multi-standard antennas for mobile terminals realized in LTCC technology, EuCAP 2009, Berlin, Germany, 23.-27.03.2009

D. Manteuffel, Industrial Antenna Design, ESoA Course, Düsseldorf, Germany, 04.-08.05.2009

D. Manteuffel, EM Modelling, ESoA Course, Barcelona, Spain, 07.07.2009


Further Activities and Events

VDE ITG Fachauschuss 7.1 “Antennen”: Prof. Manteuffel was invited to join this national committee of experts in February. His appointment is for 7 years.

Standardization: Prof. Manteuffel is a member of the ICES working group TC34.

Prof. Manteuffel is an editor of the IET Proceedings on Microwave, Antennas and Propagation.

ESoA - European School of Antennas: Prof. Manteuffel is a member of the board of the European School of Antennas which is a geographically distributed post-graduate school offering courses in selected topics on antennas. Prof. Manteuffel organized the “Industrial Antenna Design” course in May 2009 in cooperation with IMST. In March 2009 Prof. Manteuffel was nominated to be in charge of disseminating actions of the ESoA.


Institute for Materials Science

General Development of the Institute

The Institute for Materials Science enjoyed a successful year. The outstanding event in 2009 was certainly the approval of the “Sonderforschungsbereich” (Collaborative Research Centre), SFB 855 – ‘Magnetoelectric composites - future biomagnetic interfaces’, with only nominal budget cuts. Work will start in January 2010.

Two new professors should be welcomed. Prof Dr. Mady Elbahri joined the professorial staff of the Institute early in 2009, as “Junior Professor”. He heads a “Helmholtz Nachwuchsgruppe” (Helmholtz University Young Investigators Group) funded by the “Helmholtz Gemeinschaft” (Helmholtz Association) and the GKSS. While he is based in Geesthacht at the GKSS, he will also spend time in Kiel. Prof. Dr. Bernhard Wagner from the ISIT, after some procedural difficulties, finally could be officially welcomed as a member of the professorial staff of the Institute.

This is a remarkable development. Materials Science in Kiel was organised for many years around 4 professors based in Kiel and 1 professor based at the GKSS in Geesthacht. By the end of 2009, the Institute already had 6 professors based in Kiel (Including 2 Heisenberg professors), 3 professors based at the GKSS in Geesthacht, and 1 professor based at the ISIT in Itzehoe. The Institute has applied for yet another Heisenberg professorship: the decision will be made in 2010.

Prof. Dr. E. Quandt was named as a member of the Materials Science and Engineering Expert Committee (MatSEEC) of the European Science Foundation (ESF), member of the Executive Board and spokesperson of the Advisory Board of the Deutsche Gesellschaft für Materialkunde (DGM). He is, moreover, the spokesperson of the Christian-Albrechts-University of Kiel research focus “Nano and Surface Science”.

The interaction with Electrical Engineering could be substantially strengthened. 5 professors from Electrical Engineering participate with their groups in the SFB, and interaction on the base of the “Kieler Nanolabor” is evolving quite successfully.

While the study courses are running comparatively successfully and smoothly, the bureaucratic monster “Reakkreditierung” (reaccreditation) reared its ugly head. Much work was done to adjust the Master study course to the new challenges. In particular, a growing number of German students in this course with a Bachelor in Materials Science necessitates certain changes, and much paperwork was done to produce the necessary documentation by early 2010.

Dr. Kai Dolgner, the person behind the professional organization and much more of our study courses, was elected to the state parliament in May 2009. What Schleswig-Holstein gained is our loss: Dr. Dolgner has done much for the Institute and our students and we use this opportunity to express our sincere gratitude for his tireless work far above the call of duty. He has continued to teach in the autumn term 09/10, and our students thus had the rare privilege to learn about Materials Science from a Member of Parliament. We are confident that Dr. Dolgner will use the knowledge gained while working for the Institute to the profit of his electorate and that this will also be profitable to us.

In the autumn of 2009 the last proposal (key word “Kompetenzzentrum”) within the context of the Kieler Nanolabor was sent to the Ministry of Science and Commerce. It mainly concerns the necessary personnel to sustain the many successful activities already begun, and we are confident that in early 2010 the proposal will be approved.

In recent years the Institute for Materials Science has acquired a good reputation within the CAU. This was demonstrated when the president charged Prof. Quandt with the preparation of a major proposal for an “Exzellenzcluster”, a much coveted and hard-to-obtain status, that if granted will not only bring in substantial funding but high prestige.
General Materials Science

New applied projects have been started together with partners concerning Si nano structures and for thermoelectric energy harvesting and solar cell technology based on porous silicon. A yet internal project concerning the production of Si nanowire arrays for high-capacity Li ion batteries in cooperation with the ISIT has enjoyed some popularity and yielded two patent applications: it will be continued. The topic of optical properties of porous semiconductors was finished for the time being with a Springer monograph that appeared in 2009. Dedicated research in the model system n-type InP yielded deeper insights into pore formation mechanisms that could be already used for the projects mentioned above. R&D in solar energy focused on getting CELLO and CELLOplus ready for marketing and on a better understanding of the requirements and possibilities of CELLOplus. Moreover, work has started (together with Basler AG) to develop an innovative luminescence technique dubbed „SHALUM“ (for „SHAded LUMinescence“).

Results

AMAT has been working continuously within the BMBF project „Solarfocus“ since 1995. Outside this project contacts exist to companies like Bosch, for which the first organic solar cells have been characterized with the CELLO and CELLOplus diagnostic tools in Kiel. Major progress had been made with the CELLO and CELLOplus hardware. For years, unpredictable disturbances of the amplitude and phase of the signals compromised precision measurements: even so these disturbances were extremely small. A complete and very time-consuming analysis of all critical components, together with a redesign of some hardware, removed this problem.

For the new „shaded luminescence“ (SHALUM) technology (financed by the „Innovationsstiftung Schleswig-Holstein“ (ISH) and pursued together with Basler AG (Schleswig-Holstein), novel hardware has been designed and built: as is usual, initial tests encountered unexpected problems but are quite promising.

The projects with the ISIT concerning MEMS micro-scanner and three-dimensional integration via through-Si contacts concluded their current stage by successful PhD examinations.

The new cooperation with the ISIT battery department with the goal to explore the potential of Si nanowires for the Li ion battery resulted in spectacular results, which are described later in the research part of this report. New projects concerning „Macroporous Si for ultra-thin single crystalline wafer based photo-voltaics“ (together with the „Institute for Solar Energy Research GmbH“, Hamelin/Emmerthal (ISFH), funded by the BMU) and „Porous Si as a thermoelectric material“ (together with the MPI „Microstructure Physics“ in Halle, funded by the BMBF) were started later in the year. Legal contract issues took a long time to clear; the „photovoltaic“ project, for example, while officially started, has not seen any cash flow in 2009.

While all these projects in the first instance concern technology transfer, they also have a strong research component.

Research

The highlight in 2009 was the production of Si nanowire array batteries that proved to be ideally suited for anodes in Li ion batteries. The „electrical“ car of the (near) future needs Li ion batteries with substantially improved (by at least a factor of 5) specific properties like stored energy per kg and cost, and in particular safety (no „accidental“ explosions). Since Si can intercalate 10 times more Li per kg anode mass than the present day standard graphite anode, while offering far better intrinsic safety (less mass, does not burn), it would make an ideal electrode for the anode. However, the volume expansion upon incorporating Li will invariably fracture solid Si electrodes into a pile of dust after the first charge / discharge cycle. This is not so for Si nanowires arrays, as shown by a Stanford group (including R. A. Huggins, honorary professor at the TF).

The problems encountered with the first nanowire arrays in 2008 have been completely solved. Using a sequence of electrochemical macropore etching, chemical etching, „nano“-galvanics of Cu, and Li isolation by Au sputtering on the
electrode rim, nearly perfect anodes could be produced that showed excellent properties in standard tests done with the help of the ISIT (Dr. Neumann).

![Fig. 1: Si nanowire electrode. a) nanowire array; b) after use in battery.](image)

Fig. 1a) shows an optimized dense nanowire array obtained via pore etching. The next (and rather difficult step) is to deposit galvanically about 10 $\mu$m Cu at the bottom of the nanowires. This layer is necessary not only for electrical contact, but also prevents Li incorporation into the bulk Si substrate. Fig.1b) shows an electrode after several cycles in a test battery.

![Fig. 2: Finished electrode and test results.](image)

Fig. 2a) shows a finished electrode with the (black) nanowire array in the centre and Au coated rim. Fig. 2b) gives a small part of the current-voltage characteristics obtained at the end of 100 cycles of a charging / recharging cycling test (taking about 2 months). No fading was apparent; the test battery matched all parameters of a corresponding reference battery with graphite electrode, except that it had a much higher capacity (essentially limited by the cathode) and an inherently higher safety. At the end of 2009 the production process of the nanowire electrode could be substantially improved. Fine-tuning of the pore etching allows the provision of stabilizing layers between the nanowires (cf. Fig. 3a) and a very reduced connection to the substrate (Fig. 3b). This permits easy separation of the nanowire layer from the substrate and keeps the surface in a condition where it can be processed (avoidance of „stiction“).
While the direct technical importance of the Kiel Si nanowire electrode for use in an advanced Li ion battery is obvious, the topic requires rather involved fundamental research, since hardly anything is known about the process of Li intercalation. Intensive cooperation with the TEM group and others is therefore scheduled for 2010.

Major progress has also been made in the fundamental issue of understanding pore etching. The focus is on InP, not only because it appears to be best suited as the paradigmatic model material for semiconductor pore etching but also because the self-organized pore crystals with lattice constant in the (100 - 500) nm region obtainable with n-type InP may have direct bearing on the SFB 855 (“Magnetoelectric compounds”) since it is expected to be a piezoelectric “metamaterial”. A project in this regard will start in 2010.

A combination of dedicated experiments with tightly controlled parameters, impedance spectroscopy, and mathematical analysis of the data obtained allowed pore growth in InP to be modelled in great detail and the results transferred to pore etching in Si, where they are directly used for the thermoelectric project mentioned above. This work also received international recognition; the principal investigator (M. Leisner, PhD student), for example, has been invited to an international conference on interacting nanostructures (CCIN 2010).

Research in the solar cell characterization area produced deeper insights into the two dimensional resistance of a solar cell containing mainly the emitter, contact, and grid finger resistance. First approaches to separate the resistance contribution were made by combining CELLO maps with different sizes of the LASER focus and by correlating these maps to integral values extracted from impedance measurements. A second LASER with a different optical wavelength has been implemented into the CELLO system to test the possibilities of the so called two colour impedance analysis.

**Teaching**

Hyperscripts: The hyperscripts are still very popular and for 2009 the following statistics were obtained (the numbers for 2008 are in brackets): 18.5 Mio (19 Mio) Hits and 2,24 (1.7 TByte) Downloads from 1 010 000 (936 000) Hosts.

**Personnel**

Head of the group: Prof. Dr. Helmut Föll; Secretary: Katrin Brandenburg (50%)
Technical Staff: Dipl.-Ing. (FH) Jörg Bahr
Scientific Staff:

Dr. Jürgen Carstensen 01.01.-31.12.2009 CAU
Theory, software development, supervision of teaching

Dr. Ala Cojocaru 01.01.-31.12.2009 1) DFG, 2) BMBF
1) 01.01. - 30.09.2009 CELLOplus, 2) 01.10. - 31.12.2009 Poröses Silizium als Thermoelektrisches Material (PoSiTeM)

Dipl.-Ing. Dirk Kaden 01.01.-31.12.2009 FhG-ISiT
PZT layers in MEMS technology

Dr. Sergiu Langa 01.-30.11.2009 CAU

Dipl.-Ing. Malte Leisner 01.01.-31.12.2009 CAU


Anselm Pape 01.04.-31.12.2009 (50%) ISH
Quantitative Photolumineszenzanalyse von Siliziumsolarzellen

Dr. habil. Georgi Popkirov 01.01.-31.12.2009 (50%) 1) DFG, 2) ISH / Firma Basler
1) 01.01.2009 - 14.05.2009 CELLOplus, 2) 01.10.2009 - 31.12.2009 Quantitative Photolumineszenzanalyse von Siliziumsolarzellen

Dr. Oliver Riemenschneider 01.01.-14.10.2009 CAU
Light induced nano etching, project management

Dipl.-Ing. Andreas Schütt 01.01.-28.02.2009 Third-Party Funds

Lectures, Seminars, and Laboratory Course Offers

Winter 2008/2009

Electronic Materials, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Helmut Föll (+ Malte Leisner)

Quantenmechanische Aspekte in der Materialwissenschaft, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Jürgen Carstensen

Aktuelle Fragen der Forschung, 2 hrs Seminar/Week,
Helmut Föll (+ Oliver Riemenschneider, Jürgen Carstensen)

Materialwissenschaft I, 3 (+ 1) hrs Lecture (+ Exercises)/Week,
Helmut Föll (+ Andreas Schütt)

Laboratory Course: Scientific Methods, 4 hrs Lab/Week,
Kai Dolgner (+ Andreas Schütt, Dirk Meyners, Vladimir Zaporojtchenko, Mohammed Qasim Shaik, Seid Jebril, Ala Cojocaru, Dietrich Häußler, Ulrich Roß)

Einführung in die Physik, 4 (+ 1) hrs Lecture (+ Exercises)/Week,
Wilhelm Stamm (+ Oliver Riemenschneider)
Mathematics for Material Scientists, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Jürgen Carstensen

Basic Laboratory Course for Master Students, 4 hrs Lab/Week,
Kai Dolgner (+ Rodrigo Lima de Miranda, Oliver Riemenschneider, Mohammed Qasim Shaikh, Amit Kulkarni, Dirk Meyners, Ulrich Schürmann, Emmanuel Ossei-Wusu)

Einführung in die Halbleitertechnologie, 2 hrs Lecture/Week,
Helmut Föll

Praktikum: Analytische Methoden, 4 hrs Lab/Week,
Kai Dolgner (+ Marlies Schwitzke, Klaus Rätzke, Dirk Meyners, Mady Elbahri, Malte Leisner, Dietrich Häußler, Ulrich Roß)

Materialwissenschaftliches Seminar, 1 hrs Seminar/Week,
Helmut Föll (+ Eckhard Quandt)

Grundlagen der Materialwissenschaft, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
Helmut Föll (+ Malte Leisner)

Summer 2009

Materialwissenschaft II, 3 (+ 1) hrs Lecture (+ Exercises)/Week,
Helmut Föll (+ Malte Leisner)

Statistical Mechanics, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Jürgen Carstensen

Aktuelle Fragen der Forschung, 2 hrs Seminar/Week,
Helmut Föll (+ Oliver Riemenschneider, Jürgen Carstensen)

Laboratory Course: Functional Materials, 4 hrs Lab/Week,
Kai Dolgner (+ Mohammed Qasim Shaikh, Amit Kulkarni, Malte Leisner, Andriy Lotnyk, Dietrich Häußler)

Semiconductors, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Helmut Föll

Übungen zur Physik II, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
Wilhelm Stamm (+ Oliver Riemenschneider)

Computergestützte Mathematik, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Jürgen Carstensen

Übungen zur Physikalischen Chemie 1 für Materialwissenschaftler, 3 (+ 1) hrs Lecture (+ Exercises)/Week,
Friedrich Temps (+ Oliver Riemenschneider)

Winter 2009/2010

Electronic Materials, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Helmut Föll (+ Malte Leisner)

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 (+ Andreas Schütt)
Laboratory Course: Scientific Methods, 4 hrs/Week,
Kai Dolgner (+ Vladimir Zaporojtchenko, Mohammed Qasim Shaik, Seid Jebril, Ala Cagocaru, Dietrich Häufler, Malte Leisner, Emmanuel Ossei-Wusu)

Mathematics for Material Scientists, 2 (+1) hrs Lecture (+ Exercises)/Week,
Jürgen Carstensen

Basic Laboratory Course for Master Students, 4 hrs/Week,
Kai Dolgner (+ Marlies Schwitzke, Mohammed Qasim Shaik, Amrit Kulkarni, Sönke Kaps, Emmanuel Ossei-Wusu, Christina Pakula)

Halbleitertechnik und Nanoelektronik, 2 (+1) hrs Lecture (+ Exercises)/Week,
Helmut Föll (+ Rainer Adelung)

Praktikum: Analytische Methoden, 4 hrs/Week,
Kai Dolgner (+ Marlies Schwitzke, Klaus Rätzke, Dirk Meyners, Mady Elbahri, Malte Leisner, Dietrich Häufler)

Grundlagen der Materialwissenschaft, 3 (+2) hrs Lecture (+ Exercises)/Week,
Helmut Föll (+ Anselm Pape)

Third-Party Funds

Industrie, Solarpunkt, 01.02.2006-31.01.2009 (270070 EUR)

BMWi (BEO Jülich), SolarFocus, TP5: Charakterisierung der Wechselwirkung zwischen Defekten und ihres Einflusses auf die elektrischen Eigenschaften unter besonderer Berücksichtigung der Synchrotron-Mikroskopie, 01.03.2007-28.02.2010 (87000 EUR)

Fraunhofer Institut für Siliziumtechnologie (FhG ISiT), Itzehoe, Erstellung einer Studie zum Thema: Untersuchungen zur Herstellung von piezoelektrischen Bauelementen mit Dünnfilm-PZT-Schichten, 15.11.2007-14.11.2010 (228757 EUR)

DFG, Schnelle quantitative und ortsaufgelöste Komplettcharakterisierung von Solarzellen durch Kombination von “CELLO” auf FFT Impedanzspektroskopie, 01.06.2008-31.05.2010 (172000 EUR)

DFG, Programmuspensche zu Schnelle quantitative und ortsaufgelöste Komplettcharakterisierung von Solarzellen durch Kombination von “CELLO” auf FFT Impedanzspektroskopie, 01.06.2008-31.05.2010 (34400 EUR)


DAAD, Reisekostenzuschuss für Herrn Prof. Dr. H. Föll zur Teilnahme am 215th ECS Meeting in San Francisco, U. S. A., 24.-29.05.2009 (1371 EUR)

DAAD, Reisekostenzuschuss für Herrn Dipl.-Ing. M. Leisner zur Teilnahme am 215th ECS Meeting in San Francisco, U. S. A., 24.-29.05.2009 (978 EUR)

BMBF, Poröses Silizium als Thermoelektrisches Material (PoSiTeM), 01.07.2009-30.06.2011 (160763 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 and in the “Netzwerk Diagnostik”.

Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany; Scientific cooperation with Dr. Schmid on “Porous Si for thermoelectric applications”.

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ISFH, Hameln/Emmerthal, Germany; Cooperation within the framework of the SolarFocus project and application of electrochemical pore formation for solar cell production and with respect to a common project.

Fraunhofer-Institut für Solare Energiesysteme, Freiburg, Gelsenkirchen, Germany; Scientific cooperation with Dr. Warta and Prof. Dr. Schindler within the framework of the SolarFocus project and the “Netzwerk Diagnostik”; CELLO-measurements in connection with the shared supervision of a Ph.D. student.

Fraunhofer-Institut für Siliziumtechnologie, Itzehoe, Germany; Shared supervision of Ph.D. students and Bachelor-Thesis. Scientific cooperation with respect to Li-Ion Batteries.

Luna Innovations, U. S. A.; Consultancy.

Semitool, U. S. A.; Consultancy and discussion of future cooperations.

BetaBatt, Inc., U. S. A.; Consultancy and etching of porous structures.


Infineon Technologies AG, München, Germany; Scientific cooperation; Preliminary tests for possible electrochemically etched structures.

RWE Schott Solar GmbH, Alzenau, Germany, Deutsche Solar GmbH, Freiberg, Germany, Deutsche Cell GmbH, Freiberg, Germany, Shell-Solar GmbH, München, Germany, ERODL, Erfurt, Germany, Sunways, Konstanz; Cooperation with companies within the framework of the SolarFocus project for solar cell characterization and single measurements.

Hahn-Meitner-Institut Berlin, Germany; Shared supervision of a Ph.D. student.

e.m.t. GmbH, Lübeck, Germany; Shared solar project.

Wiking-Solar GmbH, Schwarzenbek, Germany; Consultancy.

Fraunhofer IST, Braunschweig, Germany; Scientific Cooperation.

Bosch AG, Stuttgart; Shared supervision of Bachelor- and Master-Thesis; preliminary measurements for possible cooperation in characterization of solar cells.

Atlas Elektronik, Wedel, Bremen; Discussion about possible cooperation for production of Li-Ion Batteries.

Varta; Discussion about possible cooperation for production of Li-Ion Batteries.

**Diploma, Bachelor and Master Theses**


Alireza Abdollahinia, *Improved modelling of the distributed solar cell serial resistance by fitting of IV-curves and resistance maps using CELLO*, 20.05.2009

Sushobhan Joshi, *Determination of SiPM (Silicon Photomultiplier) properties using a photon source based on asymmetric down conversion*, 08.07.2009


Daniel Dorow-Gerspach, *FFT-Impedanz-Spektroskopie des kristallographischen Porenwachstums in n-GaAs*, 02.10.2009

Christine Kirchhof, *CELLO-Analyse an organischen Solarzellen*, 02.10.2009

Hauke Hartz, *Production and Usage of Si-Nanowires for anodes in Li-Ion Batteries*, 12.10.2009


Dissertations / Postdoctoral Lecture Qualifications


Publications

Published in 2009


Presentations

J. Carstensen, A. Schütt, H. Föll, Ortsaufgelöste Untersuchungen des BSF auf Standard- und schnellgezogenen
EFG-Solarzellen mit CELLO, SolarFocus Projekttreffen, Apolda, Germany, 17.-19.03.2009
J. Carstensen, A. Schütt, H. Föll, CELLO • Untersuchungen an Solarzellen aus IS20-Si mit unterschiedlicher
Ge-Konzentration, SolarFocus Projekttreffen, Apolda, Germany, 17.-19.03.2009
H. Föll, Materialwissenschaft, Universität und Land (Studieninformationstage), Kiel, Germany, 01.-01.04.2009
Ehren von Herrn Prof. Dr. Ulrich Gösele am Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany, 15.05.2009
H. Föll, M. Leisner, J. Carstensen, P. Schauer, Growth mode transition of crypto and curvo pores in III-V semiconductors,
215th ECS Meeting (invited), San Francisco, U. S. A., 24.-29.05.2009
M.-D. Gerngroß, H. Föll, A. Cojocaru, M. Leisner, J. Carstensen, Production of high aspect ratio single holes in
J. Carstensen, A. Cojocaru, M. Leisner, H. Föll, Dynamics of macropore growth in n-type silicon investigated by FFT in-situ
M. Leisner, J. Carstensen, H. Föll, Simulating crystallographic pore growth on III-V semiconductors, 215th ECS Meeting,
San Francisco, U. S. A., 24.-29.05.2009
J. Carstensen, A. Schütt, G. Popkirov, H. Föll, CELLO investigation for local characterization and optimization of solar
cells, Vortrag an der Universität Stuttgart (IPE), Stuttgart, Germany, 06.07.2009
J. Carstensen, A. Schütt, G. Popkirov, H. Föll, CELLO investigation for local characterization and optimization of solar
cells, Vortrag Firma Bosch AG, Stuttgart, Germany, 07.07.2009
J. Carstensen, A. Schütt, H. Föll, CELLO FFT impedance analysis as a routine tool for identifying various defect types on
crystalline silicon solar cells, 24th European Photovoltaic Solar Energy Conference and Exhibition, Hamburg, Germany,
21.-25.09.2009
J. Carstensen, A. Abdollahinia, A. Schütt, A. Pape, H. Föll, Characterization of the grid design by fitting of the distributed
serial grid resistance to CELLO resistance maps and global IV curves, 24th European Photovoltaic Solar Energy
Conference and Exhibition, Hamburg, Germany, 21.-25.09.2009
J. Carstensen, H. Föll, New modes of Fast Fourier Impedance spectroscopy applied to semiconductor pore etching and
solar materials characterization, 216th ECS Meeting (invited), Wien, Austria, 04.-09.10.2009
J. Carstensen, A. Schütt, H. Föll, CELLO • Untersuchungen an Serie von EFG-Solarzellen aus Material von Rohr 13, Säule
7, SolarFocus Projekttreffen, Ochsenfurt, Germany, 06.-08.10.2009
J. Carstensen, Using high CH$_3$COOH concentration for fast pore growth, MACPSI Projekttreffen, Hameln, Germany,
09.12.2009

Further Activities and Events

Guests in 2009

08.06.2009 Dr. Gerold Neumann, Fraunhofer-Institut für Siliziumtechnologie, Itzehoe, Colloquium of the Faculty of
Engineering „Lithium-Akkumulatoren: Stand der Technik und Forschung“

14.12.2009 Prof. Dr. H. J. Lewerenz, Helmholtz Zentrum, Berlin, Colloquium of the Faculty of Engineering „Nanostructuring
of Interfaces for Photoelectrochemical Solar Energy Conversion“
Inorganic Functional Materials

The department for „Inorganic Functional Materials“ concentrates on the development of smart materials in the form of thin films, as well as the micro- resp. nanotechnological applications of these films. As an inherent property these smart materials directly transduce electrical, magnetic and thermal energy into mechanical energy and vice versa. Therefore they are most suitable for the realization of miniaturized actuators and sensors. The particular energy transduction processes are based on the physical phenomena of magnetostriction, the piezo effect and the shape memory effect.

Furthermore, the research is focused on multiferroic materials, either on natural multiferroics like magnetic shape memory materials or artificial multiferroics like magnetoelectric composites. The latter combine magnetostrictive and piezoelectric components and are the basis for the magnetic field sensor development within the new Collaborative Research Centre SFB 855.

Thin film fabrication processes turned out to be a promising approach to produce smart and/or multiferroic materials as this manufacturing technology offers cost-effective and easy down-scaling into the micro- resp. nanometer range. Furthermore it is compatible to micro-, nanoelectronics fabrication and allows for the realization of novel materials such as multilayer systems, which show superior behaviour compared to their traditional bulk counterparts.

These small and easy-to-integrate, „intelligent“ micro-actuators and -sensors are essential for a high number of application areas in automotive, information, biochemical, and medical technology. Selected examples are discussed in more detail in the following chapters.

Results

Kieler Nanolabor

Grants of the EFRE (Europäischer Fond für Regionale Entwicklung) programme and the Ministry of Science, Economic Affairs and Transport of the State of Schleswig-Holstein made possible the construction and equipment of a clean-room facility at the University of Kiel.

Since its official start in July 2008, the Kieler Nanolabor has offered an outstanding technology platform for advanced university research in nanoscience, for collaborations with industry, and for up-to-date education. In 2009 the clean-room facility within the Kieler Nanolabor increased its capabilities continuously. A number of devices were successfully installed and also further processes were implemented. Both the Multicomponent Materials Group (Prof. Faupel) and the Integrated Systems and Photonics group (Prof. Gerken) have installed their own devices in the clean-room. The planned Pulsed Laser Deposition (PLD) device was also successfully installed and is already being used by two different research teams.

Concerning the on-site characterization of probes in terms of their functionality and structure, both a doubled beam laser interferometer for investigating piezoelectric properties and an ellipsometer were launched last year.

The variety of thin film technology devices available, for example magnetron sputtering, photolithography, ion beam and reactive ion etching, were intensively used in 2009, not only by the Inorganic Functional Materials Group but also by a number of research teams from other groups at the faculty.

Thin films Stents

Stents are devices used to scaffold or brace the inside of tubular passages or lumens, e.g. oesophagus, biliary duct, and most importantly, a series of blood vessels, e.g. coronary, carotid, iliac, aorta, femoral arteries, etc. The success of stents and other medical implants, which conventionally consist of thin walled, laser structured tubes based on superelastic TiNi on the one hand, and the limitations regarding the miniaturization of these medical devices on the other, motivate the application of thin film technology as an attractive alternative approach for some applications, e.g. devices for small vessels. In 2009, the process to fabricate thin film stents (magnetron sputtering, UV lithography and wet etching) was...
optimized and stents with 1.5 mm diameter and thickness of 10-15 µm were produced and mechanically tested. Figure 1 shows a 1.5 mm diameter thin film stent during crimping simulation.

![Crimp Simulations](image)

**Fig. 1**: Optical micrographs from the crimping simulation realized on a 1.5 mm diameter TiNi thin film stent device. (a) TiNi thin film stent was introduced in a 0.6 mm final diameter glass filler, (b) and (c) device was moved into place using a pincer, (d) device returns to its original shape after passing through the filler aperture.

The crimping simulation test, together with stress-strain and hoop force tests confirmed the exceptional mechanical properties of TiNi thin film stents. Radiopacity tests using an ultrasound device were also realized in cooperation with UKSH (Prof. Heller).

This project received the first award on the „Ideenwettbewerb Gesundheitswirtschaft Schleswig-Holstein“ (Nov. 2009).

**ME Sensors**

In 2009 the German Science Foundation (DFG) evaluated and approved the Collaborative Research Centre SFB 855 „Magnetoelectric Composite Materials - Biomagnetic Interfaces of the Future“. Prof. Quandt is the spokesperson of the SFB, which has been approved for a first funding period of four years. The general aim of this centre is the development of novel magnetic field sensors for medical applications like magnetocardiography (MCG) or magnetoencephalography (MEG). The sensor concept is based on the magnetoelectric (ME) effect of composite materials, which in this case is the product property of a magnetostrictive and a piezoelectric phase.

The group for Inorganic Functional Materials is involved in several projects of the SFB. Project A1 deals with the development of 2-2 composites of magnetostrictive and piezoelectric phases. These are either prepared by magnetron sputtering or by sol-gel techniques, where the later involves spinodal decomposition to achieve a perpendicular 2-2 structure.

Such magnetoelectric composites will also be used in the project C2, a cooperative project involving the group of Inorganic Functional Materials and the group for Microsystems Technology of Prof. Wagner at the Fraunhofer Institute of Silicon Technology in Itzehoe. Here, such thin film composites will be integrated in micro-/nanoelectromechanical systems (MEMS/NEMS) based sensors and sensor-arrays. The main goals are to realize a vector field sensor that allows 3-dimensional detection of magnetic fields, as well as providing sensor elements for application in other projects of the SFB.

Project Z1 is a joint project with Prof. Kienle’s group „Synthesis and Real Structures“ . It will provide structural and functional characterization of ME composite materials and sensor elements.

Figure 1 a) shows an example for a Si cantilever with a ME composite sandwich. The ME signal can be enhanced by about
2 orders of magnitude when it is driven in its mechanical resonance. Figure 1b) shows preliminary results for a sensitivity measurement of a sample consisting of a magnetostrictive layer of 4.8 µm FeCoBSi that was sputtered onto a 0.6 mm thick bimorph PZT bending element. The sample has its first resonance at about 3200 Hz. At this frequency a sensitivity of approximately 1 nT is achieved: here urban noise is the limiting effect due to lack of electromagnetic shielding.

Fig. 2: ME Sensors

Magnetic Sensors

The priority program „HAUT“ (SPP 1299) funded by the Deutsche Forschungsgemeinschaft (DFG) is concentrated on development and investigation of adapting surfaces for high temperature applications. Our contribution focuses on developing a new sensor concept based on frequency mixing as a suitable non-contacting technique to investigate magnetic thin coatings. Thickness, temperature and induced strain are indirectly determined by measuring magnetic properties of the coating.

I. Nano-structured magnetic thin layer-composites for application in high temperature sensor systems

In this project new nano-structured magnetic thin film composites are developed for application in high temperature sensors. 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 which are used as sensor components. A high temperature activation process in which the films form special multiphase microstructures realizes the functionality. For these multifunctional systems a non-contacting measurement technology is established for temperature and stress, which is based on the inverse magnetostrictive effect.

II. Depletion sensor for protective high temperature coatings for in-situ detection of the degradation state

Magnetic phases are integrated into high temperature protective coatings in order to measure their degradation, as well as partial or complete loss of the coatings. Here, the frequency mixing method is employed to measure the magnitude of magnetic moments and implicitly the thickness of these coatings. Special attention for the sensor design was paid to eliminating cross-sensitivities due to the distance variations between coil and sample present in all noncontact magnetic sensor applications.

Nanosecure

NanoSecure is an EU funded large scale integrating project focusing on the development and combination of nanotechnologies to detect, identify and neutralize toxic/harmful airborne chemical and biological agents and narcotics with the aim to produce advanced sensor and detoxification systems. In the NanoSecure consortium, the CAU Kiel is concentrating its efforts on Surface Acoustic Wave (SAW) devices for cocaine detection.

SAW-based detection of cocaine
The principle is based on the use of a piezoelectric substrate (Quartz or Lithium Tantalate) provided with interdigital structures (IDTs) to create acoustic waves by applying an alternating field on these structures. A guiding layer deposited on the substrate surface having an acoustic velocity lower than those of the substrate, leads to the formation of Love waves confined in the guiding layer with most of the energy of the wave concentrated at the surface. This way sensor sensitivity at the surface is enhanced.

Cocaine polyhapteners (polyhapteners are analogues of hapten molecules like cocaine bound to carrier polymers for better coating of surfaces) are attached to the active sensor surface consisting of silicon dioxide. In the competitive assay used in this work, these analogues are competing with free analyte molecules (i.e., cocaine molecules present in the sample to be analysed) for the specific binding of labelled cocaine antibodies. If no specific analyte molecules are present in the sample the antibodies will bind to the polyhapten on the sensor surface causing an increase of the signal response, but if specific analyte (cocaine) is present their molecules link to the labelled antibodies. Such antibodies are then not available for further binding with cocaine polyhapten attached to the sensor surface. As a result, reduced or wiped out signal occurs. These changes are detected by the IDTs and converted again to an electrical signal, indicating presence of cocaine in the medium flowing over the SAW chip.

Fig. 3: Schematic of a sensor chip with sensitive area and measurement principle of SAW-based sensing of molecular interaction. Fig. 2 Series of competition curves of cocaine antibody (5 µg/ml) premixed with indicated amounts of cocaine (From the top: variation of 30 nM to 10 µM and two runs without cocaine) prior to reaction with the capture pad (400 µg/ml cocaine polyhapten).

The research work focuses on the development of SAW chips with enhanced sensitivity as well as on lowering the detection limit of cocaine by optimizing the concentration and distribution of polyhapteners on the chip surface. Competition tests based on premixing of antibody with cocaine have been successfully performed (see figure above), showing that this approach works. Cocaine concentrations of 30 nM (corresponding to a cocaine level of 10 ppb) gave a reduction of signal by more than 50%. Further improvements may enable a detection limit around 1 ppb, which would exceed the project target.

Personnel

Head of the group: Prof. Dr.-Ing. Eckhard Quandt; Secretary: Gislinde Schroeder
Technical Staff: Janine Dahmke, Dipl.-Ing. (FH) Thomas Metzing

Scientific Staff:
Dipl.-Ing. Christoph Bechtold 01.01.-31.12.2009 DF6

SPP 1239
Lectures, Seminars, and Laboratory Course Offers

Winter 2008/2009

Ceramic Materials, 2 (+1) hrs Lecture (+ Exercises)/Week, E. Quandt

Einführung in die keramischen Werkstoffe, 2 hrs Lecture/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: Scientific Methods, 4 hrs Lab/Week,
D. Meyners

**Summer 2009**

- Sensors, 2 (+1) hrs Lecture (+ Exercises)/Week, E. Quandt
- Anorganische Funktionsmaterialien, 2 hrs Seminar/Week, E. Quandt
- Laboratory Course: Functional Materials, 4 hrs Lab/Week, D. Meyners

- Smart Materials, 2 (+1) hrs Lecture (+ Exercises)/Week, E. Quandt

**Winter 2009/2010**

- 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: Analytische Methoden - Praktikum, 4 hrs Lab/Week, D. Meyners (+ M. Schwitzke, K. Rätzke, M. Elbahri)

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**Third-Party Funds**

- DFG, SPP 1299 HAUT, Nanostrukturierte magnetische Dünnenschicht-Komposite für Anwendungen in der Hochtemperatur-Sensorik, 01.09.2007-31.08.2010 (160.000 EUR)
- DFG, SPP 1299 HAUT, Sensorfunktion für Hochtemperatur-Schutzschichten zur in situ Erfassung des Degradationszustands, 01.11.2007-31.10.2010 (203.800 EUR)
- DFG, Magnetic Nanocomposites for rf Applications in Mobile Communication, 01.07.2009-31.12.2010 (100.000 EUR)
- DFG, SPP 1239, Änderung von Mikrostruktur und Form fester Werkstoffe durch äußere Magnetfelder, Teilprojekt: Exploitation and Transfer of Results of the SPP 1239, 01.07.2008-30.06.2010 (65,000 EUR)
- DFG, PAK 1: Fe-Pd-X Thin Film-Polymer Composites for Sensor Applications, 01.01.2009-31.12.2010 (144.020,00 EUR)
- DFG, Herstellung von bioresorbierbaren Dünnenschicht-Gefäßstützen (Stents) aus Magnesium-Legierungen durch Magnetron-Sputter-Technologie, 01.09.2009-01.08.2012 (236.783,00 EUR)
- DFG, SFB 677, Funktion durch Schalten, Teilprojekt C07: Komposite aus Polymermatrix und ferromagnetischen Formgedächtnis-Nanopartikeln als magnetische Schalter, 01.06.2007-31.12.2011 (192.400 EUR)
- BMBF, Verbundprojekt: TMR-Sensoren als Technologieplattform für Anwendungen im Automobilbereich - Teilvorhaben: Drucksensor (13N9083), 01.10.2007-30.06.2009 (366.300 EUR)


EFRE/Landesmittel, Kielner Nanolabor - Geräteteilansatz des Reinraums, 01.10.2007-30.06.2010 (4.046.000 EUR)

BMWi, PRO INNO II, Kooperationsprojekt: Entwicklung eines neuerartigen Stentsystems zur endoluminalen Therapie instabiler Plaques (Softplaques), Teilprojekt: Umhüllung eines Stents mittels Magnetronsputterns, 01.06.2008-31.03.2010 (125.000 EUR)

Office of Naval Research (ONR,USA), NICOP, FeGa-based Nanoelectronic Strain Sensor, 01.07.2008-03.06.2011 (165.232 EUR)

Industrie, Industrieprojekte (Magnetismus, Formgedächtnistechnik), 01.09.2008-31.08.2011 (255.000 EUR)

Further Cooperation, Consulting, and Technology Transfer

Prof. Dr. M. Wuttig, University of Maryland, USA

Further cooperations within the third party funding projects

Diploma, Bachelor and Master Theses

Enno Lage, Fabrication and Characterization of Biodegradable Magnesium Thin Films, 23.03.2009
Jan-Hendri Pöhls, Messung des piezoelektrischen Effekts an Dünnschichtproben, 02.06.2009
Eric Woltermann, Herstellung und Charakterisierung von magnetoelektrischen Dünnschichtkompositen, 03.08.2009
Kristina Schütte, Korrosionsuntersuchungen von Dünnschicht-Magnesiumlegierungen, 30.09.2009
Jannatin Ardhuha, Influence of Heat Treatment on the Microstructure of Sputtered Shape Memory Alloy Composites (FePd/NiTi), 11.11.2009

Enno Lage, Electrochemical Investigation of Alloys for Pacemaker Components, 30.11.2009

Dissertations / Postdoctoral Lecture Qualifications

Rodrigo Lima de Miranda, Fabrication of TiNi thin film stents, 06.11.2009

Publications

Published in 2009


D. Meyners, T. von Hofe, A. Malavé, E. Quandt, Magnetostriective TMR Sensors for Mechanical Measurements, ECS. Trans, 16 (45), 297 (2009)
Presentations


C. Thede, S. Chemnitz, E. Quandt, *Non-contact Temperature Sensor Based on Inverse Magnetostriction*, DPG Spring Meeting, Dresden, 23.-27.03.2009

C. Thede, S. Chemnitz, E. Quandt, *Non-contact Temperature Sensor Based on Inverse Magnetostriction*, Internat, Sacramento, USA, 04.-08.05.2009


E. Quandt, *Funktionale Dünnenschichten - neue Anwendungsfelder durch Kieler Nanolabor*, IHK Kiel Innovationstour, Kiel, 27.01.2009

E. Quandt, *Magnetostriktive TMR-Drucksensoren*, ISIT Kolloquiumsreihe, Itzehoe, 04.03.2009


E. Quandt, *Fabrication of Toroidal Microinductors for RF Applications*, Internat 2009, Sacramento, USA, 06.05.2009


E. Quandt, *Formgedächtnislegierungen für medizinische Implantate*, DGM Workshop, Aachen, 15.10.2009


E. Quandt, *Non-contact Strain Measurements based on Magnetic Shape Memory and Magnetostrictive Thin Films*, MRS Fall Meeting, Boston, USA, 30.11.-04.12.2009

Further Activities and Events

Spokesperson of the DFG Collaborative Research Centre (SFB 855) „Magnetoelectric Composites - Biomagnetic Interfaces of the Future”

Member of the Materials Science and Engineering Expert Committee (MatSEEC) of the European Science Foundation (ESF)
Spokesperson of the Research Focus „Nano and Surface Science“ of the Christian-Albrechts-Universität zu Kiel

Member of the Executive Board and spokesperson of the Advisory Board of the Deutsche Gesellschaft für Materialkunde (DGM)

Member of the Scientific Advisory Board of the Acandis GmbH and Co. KG, Pfinztal

Chair of the Technical Committee „Thin Films“ of the Deutsche Gesellschaft für Materialkunde (DGM)

Chair of the Working Group „Thin Films for MEMS“ of the Deutschen Gesellschaft für Materialkunde (DGM)

Other events in 2009:

1st prize of the „Ideenwettbewerb Gesundheitswirtschaft Schleswig-Holstein“ (Dr. Rodrigo Lima de Miranda und Prof. Dr. Eckhard Quandt)

Evaluation of the DFG Collaborative Research Centre (SFB 855) „Magnetolectric Composites - Biomagnetic Interfaces of the Future“
Materials and Processes for Nanosystem Technologies

Prof. Dr. Bernhard Wagner is the Deputy 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 - to 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 millimeter 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 applicationspecific 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, analyze the quality and reliability of electronic components, and develop advanced power-supply components for electronic systems.

The institute employs a staff of around 150 people

Further information about Fraunhofer ISIT is available in 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
Synthesis and Real Structures

Within the last year, the group „Synthesis and Real Structure“ established itself as a competence centre for all inorganic material based issues of transmission electron microscopy (TEM). This is emphasized by our interdisciplinary research projects inside and outside CAU. Two permanent members of the group serve as the backbone of the scientific activities, Dr. Andriy Lotnyk (TEM coordinator) and Christin Szillus (TEM preparation). Moreover, one postdoc and three PhD students with their fully funded projects enabled the opening of new research areas for TEM. Recent projects cover a broad field of materials and underline the development potential of our research:

- Multilayer materials and composites for applications in thermoelectric devices (SPP 1386)
- Materials for biomagnetic sensing (SFB 855)
- High performance materials Ti-Al and chemical derivates (PAK 19)
- Ferromagnetic shape memory alloys (preliminary work for SPP 1239)
- Core-shell particles for medical applications (preliminary work for SPP 1237)
- Nanoparticles for magnetic paint (AiF)

Results

Focus on materials

a) In-situ TEM on Phase Change Materials (with Prof. Bensch and MPI for Solid State Research)

The function of Ge-Sb-Te Phase Change Materials (PCM) is based on a reversible switching between amorphous and crystalline states, resulting in their application for optical information storage. For gaining a deeper understanding of the intermediate structures occurring during information transfer, in-situ crystallization experiments were performed on thin films of Ge$_2$Sb$_2$Te$_5$, GeSb$_2$Te$_4$, Ge$_2$Sb$_2$Te$_4$ and Ge-rich bulk samples.

![Fig. 1: Top: comparison of the real structure of GST528 before and after applying transformation mode, bottom: antiphase lamellae of a high temperature phase of GST528. All zone axis [100].](image)

The PCM films were deposited by dc magnetron sputtering from stoichiometric compound targets. Bulk samples were prepared by high-temperature synthesis and quenching. In all cases the deposited films were fully amorphous and chemically homogeneous.
For all PCM, the initial irradiation in the electron beam produces seeds with NaCl-type structure characterized by a disorder of vacancies, Ge- and Sb atoms. Subsequently, GST124 and GST225 display a broadening of the seeds and an aggregation of vacancies, which forces a reduction of the average symmetry from cubic to trigonal. The distances of adjacent VL could vary, but generally coincide with those of annealed and stoichiometric bulk crystals.

Like GST225 and GST124, crystalline Ge-rich bulk materials contain VL which are components of a complicated real structure dominated by misfit and disorder. In accordance with the composition of the samples (e.g. for the new compound Ge₅Sb₂Te₈) and the corresponding changes in vacancy concentration the distances of the VL increase with respect to GST124 and GST225. All Ge-rich VL compounds exhibit continuous structural changes in transformation mode. The distances of the VL increase and thick antiphase lamellae of a cubic high-temperature phase are formed. Two counteracting forces could rationalize this observation; the formation of VL and the tendency for their random distribution at high temperatures.

b) Characterization of ferromagnetic shape memory alloys (preliminary work within the frame of SPP 1239)

Ferromagnetic shape memory alloys (FSMAs) have already attracted some attention due to the possibility of controlling their dimensional changes with an external applied magnetic field. A combined approach of TEM methods was selected including state of the art techniques of electron diffraction, high resolution imaging and electron spectroscopy for unravelling unknown features of the real structure of these alloys with particular focus on thin film materials. For this purpose, electron microscopy analysis was first performed on the Fe₇₀Pd₃₀ compounds, where the Bain transformation path from FCC austenite to BCT martensite can be influenced by deposition on different buffer layers. A broad range of heterostructure models were studied and after optimizing deposition parameters and selecting the accurate buffer layer (5 nm Cr and 50 nm Au on MgO substrate), HRTEM images and FFT patterns revealed the entire heterostructure to be epitaxial and that 1.2 µm Fe₇₀Pd₃₀ film crystallizes directly in the BCT type. For identification of the magnetic structure Lorentz microscopy studies were carried out and it is concluded that, after illuminating the objective lens rapidly, the magnetic domain walls in polycrystalline FePd were mobile. Further examinations were concentrated on changes of microstructure and composition at the nano-scale, where samples heated in-situ, EDX elemental maps and STEM images confirmed that Fe diffuses out during the heating procedure.

c) Tomography of nanocomposite thin films (Prof. Dr. Faupel, Dr. Kübel)

Morphology of nanocomposites (NCs) plays a pivotal role in determining the functional properties of NC thin films. Nanoparticles are promising candidates for NC thin film applications like optical and antibacterial coatings. In this work, the nanocomposites have been prepared in the group of Prof. Faupel by using vapour phase co-deposition methods. However, the use of NC coatings requires further study of possible size effects on their functional properties. Understanding the morphology related properties of the NCs requires the knowledge of both two-dimensional (2D) and three-dimensional (3D) information about the NCs. Although transmission electron microscopy (TEM) has been applied to characterize the morphology of the NCs, there is clearly a limit of observation and characterization because the electron transparent NC specimen can be either analyzed by top view (conventional TEM) or by cross-sectional analysis methods. Despite the meticulous sample preparation, there is always a high probability of cutting the nanoparticles with the cut-surface having variable diameter. Hence, the state-of-the-art technique „non-destructive 3D electron tomography” offers the solution.

Electron tomography allows the alignment, reconstruction and visualization of the 3D structure of the NC thin film from a tilt series. Here, the effects of morphology of the NC thin films have been investigated experimentally using 3D electron tomography in the TEM. Furthermore, in Ag-TiO₂ NCs, we stress that the functional properties are sensitive to the morphology of the NCs, because the surface layers predominantly are sufficient to induce a considerable change in the properties of the entire NC. This work emphasizes the necessity of taking into account the 3D morphology of nanoparticles in the NCs to understand and control their functionality.
Fig. 2: (a) to (c) show clearly different sections of the Ag-TiO$_2$ nanocomposite thin film as one travels from the top surface (a) through the sample (b) to visualizing the full film as can be seen from the top view (c); (d) and (e) show different orientations of the nanocomposite film, clearly showing the larger nanoparticles on the top surface and the smaller clusters deeper inside the matrix of the nanocomposite film, which generally are difficult to observe by the conventional TEM methods.

Focus on fundamental research

a) State-of-the-art crystallography on complex chalcogenides

A group of solids with the general composition $A_2In_{12}Q_{19}$ ($A = K$, Tl, NH$_4$; $Q = Se$, Te) was characterized by combined X-ray and HRTEM examinations. Similar nanosize domains with variable sizes and complex internal structures are common to all three compounds. Although a partial ordering of domains for the bulk of $K_2In_{12}Se_{19}$ is dominating, the observed ordering patterns range from total random orientation to a pattern with a nine fold superstructure. In spite of testing various synthesis conditions it was not possible to avoid these complex structural features for $K_2In_{12}Se_{19}$, which are apparently intrinsic. However, slight chemical modifications, e.g. in terms of compositions $K_2In_{12}Se_{19-x}Te_x$ and $K_{2-y}Tl_yIn_{12}Se_{19}$ produce significantly larger domains and result in a twofold superstructure that can be observed with X-ray diffraction also on a macroscopic scale. The recently synthesized $(NH_4)_2In_{12}Se_{19}$ is a special case where a metastable ordering is observed which has apparent similarities to that of $K_2In_{12}Se_{19}$. The ordering of the pristine material disappears rapidly by electron beam irradiation and is replaced by a twofold superstructure similar to $K_2In_{12}Se_{19-x}Te_x$ and $K_{2-y}Tl_yIn_{12}Se_{19}$. Precession electron diffraction (PED) and HRTEM was applied for the quantitative characterization of the new and in-situ formed phase (see Fig. 3). The reason for the structural change was identified as a combined process of domain broadening and NH$_3$ evaporation. It must be noted that the present case is unique regarding the formation of a new phase with ordered structure from a disordered precursor material inside the TEM.

b) Structural transformations in CdSe-Cr$_2$Se$_3$ composites by electron beam impact

The synthesis of multinary nanomaterials is generally complicated due to separation phenomena, e.g. by the formation of
mixtures containing binary compounds instead of ternary nanoparticles. Such limitation particularly applies when using soft chemical approaches for the syntheses, since the low diffusion coefficients at low temperatures favour metastable and inhomogeneous products. A well-defined phase separation was observed during attempts to prepare ternary nanoparticles of CdCr$_2$Se$_4$ using a soft chemistry approach. X-ray diffraction analysis shows the presence of CdSe nanoparticles with the wurzite type structure. However, no information about the Cr containing constituent could be derived. Via HRTEM, the nanodispersive nature of the samples becomes evident. TEM-EDX analyses give an average composition close to the intended one of CdCr$_2$Se$_4$ and again no clear information about the Cr containing constituent. Such a finding could be rationalized by assuming a composite of CdSe nanoparticles homogeneously distributed inside a matrix of amorphous Cr$_2$Se$_3$ with a ratio of CdSe:Cr$_2$Se$_3=1$. This assumption was confirmed by applying a high dose radiation in TEM on the sample by adjusting the emission parameters and removing the condenser aperture. The increase of the current density of such a transformation mode vs. the average TEM setting is estimated to be 40-fold. After long-term exposure in TEM very faint and diffuse intensity on concentric rings with the characteristic d-values calculated for Cr$_2$Se$_3$ were observed in SAED patterns. Moreover a partially crystalline Cr$_2$Se$_3$ component was identified. Comparisons of HRTEM micrographs recorded before and after the transformation are evidence for the removal of CdSe nanoparticles while both Cr$_2$Se$_3$ species remain unaffected by the electron irradiation.

**Fig. 3:** a) PED patterns of (NH$_4$)$_2$In$_{12}$Se$_{19}$ recorded within an exposure series (time slice of 30 seconds), b) HRTEM micrographs of long-term irradiated (NH$_4$)$_2$In$_{12}$Se$_{19}$ with inserted simulation.

**Personnel**

Head of the group: Prof. Dr. Lorenz Kienle; Secretary: Katrin Brandenburg
Technical Staff: Christin Szillus
Scientific Staff:

M.Sc. V.S. Kiran Chakravadhanula 01.03.-31.12.2009 DFG
Elektronenmikroskopische Untersuchung der Mikrostruktur und der lokalen chemischen Zusammensetzung im Rahmen des Paketantrags

Dr. Andriy Lotnyk 01.01.-31.12.2009 CAU

Dr. Ulrich Schürmann 01.05.-31.12.2009 1) CAU, 2) DFG
1) 01.05.2009 - 31.05.2009, 2) 01.06.2009 - 31.12.2009 Comprehensive clarification of the physical background of the breakthrough of ZT-2.4/1.7 for p/n-V2V13-Superlattices

Lectures, Seminars, and Laboratory Course Offers

Winter 2008/2009

Thermodynamics and Kinetics I, 2 (+1) hrs Lecture (+ Exercises)/Week,
Lorenz Kienle (+ Tim Behrens)

Practical TEM, 2 (+1) hrs Lecture (+ Exercises)/Week,
Lorenz Kienle

Analytics I, 2 (+1) hrs Lecture (+ Exercises)/Week,
Lorenz Kienle

Seminar Synthese und Realstruktur, 2 hrs Seminar/Week,
Lorenz Kienle

Grundlagen der HRTEM, 3 hrs Lecture/Week,
Lorenz Kienle (+ Andriy Lotnyk)

Summer 2009

Fundamentals of Solids, 3 hrs Lecture/Week,
Lorenz Kienle

Thermodynamics and Kinetics, 2 (+1) hrs Lecture (+ Exercises)/Week,
Lorenz Kienle

Hochauflussende Transmissionselektronenmikroskopie: Prinzipien und Anwendungen, 2 hrs Lecture/Week,
Lorenz Kienle

Practical TEM, 2 (+1) hrs Lecture (+ Exercises)/Week,
Lorenz Kienle (+ Andriy Lotnyk)

Seminar Synthese und Realstruktur, 2 hrs Seminar/Week,
Lorenz Kienle

Winter 2009/2010

Thermodynamics and Kinetics I, 2 (+1) hrs Lecture (+ Exercises)/Week,
Lorenz Kienle

Practical TEM, 2 (+1) hrs Lecture (+ Exercises)/Week,
Lorenz Kienle (+ Andriy Lotnyk)

Solid State Chemistry, 2 (+1) hrs Lecture (+ Exercises)/Week,
Lorenz Kienle
Application of TEM for the Characterization of Inorganic Materials, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Lorenz Kienle

Seminar Synthese und Realstruktur, 2 hrs Seminar/Week,
Lorenz Kienle

Biomaterials, 2 hrs Lecture/Week,
Lorenz Kienle (+ Rainer Adelung)

Third-Party Funds

DFG, Elektronenmikroskopische Untersuchung der Mikrostruktur und der lokalen chemischen Zusammensetzung,
01.04.2008-31.03.2011 (117800 EUR)

DFG, Heisenbergprofessur zum Thema: Synthese und Analytik von Festkörpern mit ungewöhnlichen Realstrukturen,
01.06.2008-31.01.2009 (102000 EUR)

DFG, Fortführung der Heisenbergprofessur zum Thema: Synthese und Analytik von Festkörpern mit ungewöhnlichen Realstrukturen,
01.02.2009-31.01.2011 (163200 EUR)


DFG (SPP 1386), Comprehensive clarification of the physical background of the breakthrough of ZT-2.4/1.7 for p/n-V2V13-Superlattices, 01.06.2009-31.05.2012 (138225 EUR)

DFG, Programmpauschale zu: Comprehensive clarification of the physical background of the breakthrough of ZT-2.4/1.7 for p/n-V2V13-Superlattices, 01.06.2009-31.05.2012 (28900 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. Dr. E. Quandt, CAU Kiel
- Inorganic Chemistry - Prof. Dr. W. Bensch, CAU Kiel
- Inorganic Chemistry - Prof. Dr. N. Stock, 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, Institut für Physik, Martin-Luther-Universität Halle-Wittenberg
- Institute of Polymers and Composites - Prof. Dr. K. Schulte, Technische Universität Hamburg-Harburg
- Institut für Anorganische Chemie - Prof. Dr. A. Pfitzner, University of Regensburg
- 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 Center, India
Published in 2009


E. Q. Gonzalez, L. Kienle, W. Bensch, Nanocrystalline hexagonal phases in the Cu-In-S system synthesized under solvothermal conditions, Z. Kristallogr. (Suppl. 2009), 69, (2009)


M. C. Schaloske, L. Kienle, V. Duppel, H. Mattausch, A. Simon, Isolated and underoccupied Y_{19-x}C_{2}I_{34}, Z. Kristallogr. (Suppl. 2009), 36, (2009)


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A. Lotnyk, L. Kienle, Z. Huang, W. Bensch, S. Fuentes, J. Bocarando, G. Alonso, C. Ornelas, A TEM study of...


L. Kienle, V. Duppel, V. Smetona, A. Simon, Electron microscopy investigations on highly beam and moisture sensitive samples - the system Li-Ba-Ca, Z. Anorg. Allg. Chem. (early view), (2009)


Presentations

Z. Huang, W. Bensch, L. Kienle, S. Fuentes, G. Alonso, C. Ornelas, SBA-15 as Support for Hydrogen Desulfurization Catalysts: Development of an All Sulphide Route, Deutsche Zeolith-Tagung, Kiel, Germany, 06.03.2009

L. Kienle, Discoveries by Transmission Electron Microscopy, Physikalisch Chemisches Seminar, University Regensburg, Regensburg, Germany, 05.05.2009

O. Breitenstein, J. Bauer, J.-M. Wagner, H. Blumtritt, A. Lotnyk, M. Kasemann, W. Kwapił, W. Warta, Physical
J. Bauer, J.-M. Wagner, A. Lotnyk, H. Blumtritt, O. Breitenstein, Untersuchungen an Vordurchbrüchen in multikristallinen Silizium-Solarzellen, R and D Meeting Ersol, Erfurt, Germany, 11.06.2009
J. Tomforde, W. Bensch, J.D. König, W. Warta, H. Böttner, L. Kienle, A study of thermoelectric properties and microstructure of phase change materials as potential thermoelectric generators, 28th International / 7th European Conference on Thermoelectrics, Freiburg, Germany, 29.07.2009
A. Lotnyk, H. Blumtritt, J. Bauer, O. Breitenstein, FIB preparation and TEM characterization of Si3N4 precipitates grown in multicrystalline Si solar cell application, Microscopy Conference MC 2009, Graz, Austria, 30.08.-04.09.2009
L. Kienle, Kristallographische Materialforschung in Kiel, Norddeutsche Initiative Nanomaterialien, Itzehoe, Germany, 02.10.2009

Further Activities and Events

19.01.2009 Inaugural lecture of Prof. Dr. Lorenz Kienle „Discoveries by Transmission Electron Microscopy”

Guests in 2009

18.05.2009 PD Dr. Tom Nilges, Universität Münster, Colloquium of the Faculty of Engineering „Coinage metal polychalcogenide halides, materials with reversible and switch-able Semiconductor properties: RedOx reactions in the crystalline phase”

23.06.2009 Dr. Bojja Sreedhar, Indian Institute of Chemical Technology (IICT), Tarnaka, Hyderabad, India, Special colloquium of the Faculty of Engineering „Synthesis, Characterization and Applications of Silica CoreShell Nanoparticles for Various Organic Transformations”

16.09.2009 Dr. Tilo Söhnel, Department of Chemistry, The University of Auckland, New Zealand, Special colloquium of the Faculty of Engineering „Structure and Characterization of a new Group of Tin-rich Clusters”

30.11.2009 Matthias Kellermann, Universität Regensburg, Colloquium of the Faculty of Engineering „Co-precipitation of
calcium carbonate and silica

17.12.2009 Dr. H. Böttner, J. König, Fraunhofer IPM, Freiburg, Special colloquium of the Faculty of Engineering „Nanotechnological concepts for new thermoelectric materials“ (J. König), „Thermoelectrics for high temperatures - A survey about state of the art“ (H. Böttner)
Materials Mechanics

Prof. Dr.-Ing. Wolfgang Brocks retired in 2007 but he still publishes results of his former research activities at the „Forschungszentrum GKSS Geesthacht“. These publications are listed below to demonstrate his successful work.

Publications

Published in 2009

R. Falkenberg, W. Brocks, W. Dietzel, I. Scheider, Simulation of Stress-Corrosion Cracking by the Cohesive Model, 8th International Conference on Fracture and Damage Mechanics, FDM 2009, St. Julians (M), (2009)
Multicomponent Materials

The main research activities of the Multicomponent Materials group (formerly Chair of Multicomponent Materials) are functional nanocomposites, metal-polymer interfaces, polymer surface modifications by low energy ions, glass transition and diffusion in metallic and organic glass formers including thin films and confined systems, as well as investigation of nanostructural properties by means of positron annihilation. Here, only a few aspects can be discussed. For more details we refer to our homepage at http://www.tf.uni-kiel.de/matwis/matv/ and the more than 220 publications listed there.

Special highlights last year were the very positive evaluations of the Collaborative Research Centre SFB TR 24 on complex plasmas and of the Collaborative Research Centre SFB 855 on magneto-electric nanocomposites for medical applications. In the SFB TR 24, which also involves the plasma activities in Greifswald, the group now works in a joint project with Prof. Kersten from the Physics Department on deposition of nanocomposites from plasmas. In the SFB 855, the aim is to develop nanocomposites combining a piezoelectric organic or ceramic matrix with a magnetostrictive metallic alloy component as sensors for extremely low magnetic fields. The group also participates in the Collaborative Research Centre SFB 677 - Function by Switching - with 2 projects.

Working in three Collaborative Research Centres, the group strongly benefits from the joint interdisciplinary work with partners ranging from fundamental physics and organic chemistry to electrical engineering and medicine.

As in the years before, the group also cooperated with industry. In addition to direct cooperation with companies, joint work with industry was carried out within projects of the BMBF (Ministry for Education and Research) and the AIF (Working Group Industrial Research). Details will not be reported here.

In addition to research, the group was strongly involved in teaching and made a great effort to inspire pupils for materials science and engineering.

Since July 2008 Prof. Faupel has been Dean of the Faculty of engineering. In this position, his main concern is to strengthen the cooperation within the Faculty of Engineering and to further promote interdisciplinary research with partners from other Faculties of the Christian-Albrechts University.

Results

a) Functional nanocomposites

Nanocomposites for different applications are investigated in several projects. They consist of metallic nanoparticles, embedded in an insulating matrix, either polymeric or ceramic in nature. The majority of the nanocomposites are polymer based. The nanocomposites are deposited as thin films by physical vapour phase deposition methods, in particular evaporation and sputtering from solid targets. Now, within the framework of the above mentioned Collaborative Research Centre SFB TR 24, plasma polymerization and physically enhanced chemical vapour deposition (PECVD) are also employed, and the metallic component can also be deposited by a newly developed cluster source. In the cluster source, the nanoparticles form in the gas phase and not on the surface of the growing composites. This, among other advantages, allows chemical reactions between the metallic component and the matrix to be widely eliminated.

Due to the small size of the metallic nanoparticles in the range of a few nanometers the composites exhibit interesting optical, electrical and magnetic properties. The large specific surface area of the finely dispersed particles and the strong contribution of the surface or interfacial energy to the Gibbs free energy can be also very advantageous, e.g., in applications such as antibacterial coatings where a high metal ion release rate is sought.

As described in the Almanac 2008, we explore nanocomposite coatings based on a vapour phase co-deposition of noble metals and polymers or ceramics to protect a surface against growth of bacteria. This research is 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. Recent activities are devoted to obtaining a well controlled release profile for application in dental implants and have contributed to the submission of a proposal to the German Science Foundation (DFG) for a Research Unit “Periimplantitis, Development, progression and prevention” with partners from dental medicine, pharmacy, and materials science. Another aspect of current research concerns the various factors governing ion release on the nanoscale. The DFG just granted a joint project with Prof. Grundmeier from the Chemistry Department of the University at Paderborn.

Nanocomposites with noble metals show interesting optical properties caused by the plasmon resonance of the metallic nanoparticles. As described in the Almanac 2006 these are collective oscillations of the conduction electrons in the electrical field vector of electromagnetic radiation. The physical vapour deposition methods allow the preparation of metallic alloy nanoparticles in polymeric matrices, where the composition can be varied over the whole range. This makes possible tuning of the resonance frequency. Fig. 1 shows an example for an Ag$_x$Cu$_{1-x}$ alloy. In contrast to the Ag$_x$Au$_{1-x}$ alloys described in the last almanac, which exhibit complete miscibility, the Ag-Cu system shows phase separation in the bulk. In nanoparticles, however, the aforementioned contribution of the surface energy can increase the Gibbs free energy to such an extent that miscibility is observed under conditions where the bulk phase diagram predicts phase separation. A nice example is shown in Fig. 1.

Plasmon resonances in nanocomposites have a host of applications (see earlier reports). Together with our colleague and former group member Prof. Elbahri, for instance, we presently develop transparent conductive coatings which are based on his idea of coupling surface plasmons of ultrathin films with particle plasmons. Details will be reported in the Almanac 2010.

Fig. 1: Typical UV-Vis spectra showing the plasmon resonance in Ag$_x$Cu$_{1-x}$ nanoparticles in a vapour deposited Teflon AF polymer matrix. For small nanoparticles (filling factor of 0.17) a single plasmon resonance indicates complete miscibility (a) while for larger particles (filling factor of 0.54) the appearance of a second peak shows the occurrence of phase separation. The composition x, which can be varied continuously in our vapour phase co-deposition approach, is displayed in the figures by different colours.

In a cooperation with Dr. Avasthi from the Nuclear Science Centre in New Delhi, Dr. Fink, formerly Hahn-Meitner-Institute in Berlin, and Prof. Kienle from the Institute for Materials Science (see his almanac chapter) the group studies the tailoring of nanomaterials by swift heavy ion irradiation. When materials are exposed to high energetic particles, such as during ion beam processing, many defects are created in the displacement cascade. The cascade occurs over very short time and spatial scales (~ ps and nm), initiating a complex microstructural evolution that can alter many functional properties. Irradiation can be used as a tool to create new materials and structures and can drive materials into novel thermodynamic states. Swift heavy ions (SHI) can be used for controlled tailoring of the nanocomposites and their properties.
As an example, Fig. 2 shows the formation of single crystalline TiO particles upon irradiation of sputter deposited nanocomposites made up of Ag nanoparticle in an amorphous titania matrix (Fig. 2a) with a 100 MeV Ag\(^{8+}\) ion beam. The TiO particles form at a particular fluence of 3 x 10\(^{12}\) ions/cm\(^2\) (Fig. 2b). The formed TiO crystals are of the order of ~400 nm in size. Selected area electron diffraction studies together with the high resolution transmission electron microscopy (HRTEM) and energy dispersive X-ray analysis (EDX) studies confirm the formation of TiO.

![Transmission electron micrographs (left) and diffraction patterns (right) showing the formation of single crystalline TiO particles in the amorphous titania matrix of a Ag/titania nanocomposite (a) after irradiation with a swift heavy ion beam of 100 MeV Ag\(^{8+}\) ions at a fluence of 3 x 10\(^{12}\) ions/cm\(^2\) (b).](image)

Ongoing projects also deal with the incorporation of magnetic particles into insulating matrices by self-organization during physical vapour deposition, like the preparation of high frequency core materials reported in the Almanac 2007. The challenge is to obtain a high dispersion of the metal particles in the matrix while suppressing chemical reactions at the interface of the reactive metals, which would lead to a degradation of the magnetic properties. This work is also a very good basis for the new SFB 855 mentioned above, where the group develops composites of magnetostrictive alloys with piezoelectric matrices for applications as very sensitive magnetic sensors for medical applications.

b) Glass transition and diffusion in metallic and organic glass formers Alloys

Recently, the glass transition has again strongly attracted materials scientists as well as physicists. In particular metallic glasses are currently among the most actively studied metallic materials. Apart from their many novel applicable properties metallic glasses have also been in the focus of research advancing our understanding of liquids and of glasses in general. The most interesting alloys are from the family of the bulk metallic glass formers. Unlike conventional metallic glasses, bulk metallic glasses exhibit exceptional stability in the undercooled liquid state with respect to crystallization. They have thus enabled studies of atomic diffusion, viscous flow, and the glass transition previously not possible in metallic systems. Recent investigations in Kiel were devoted to structural arrest in metallic multicomponent glass formers that precedes the caloric glass transition. Details were given in the last almanac.
Much interest has arisen recently in the glass transition in confined systems and at the surface. As described in previous almanac editions (2003, 2008) the group developed a new approach to measure the surface glass transition temperatures by embedding inert metal clusters into polymer films upon softening of the surface. Embedding is monitored in situ by X-ray photoelectron spectroscopy with a sub 0.1 nm resolution. An unexpected strong depression of the glass transition temperature of about 20 °C was demonstrated for polycarbonate. Meanwhile, the mechanism of the embedding of nanoparticles below the polymer surface was further explored. It was shown (Fig. 3a) that embedding requires a mobility of at least 2 polymer segment lengths (4 polymer persistence lengths). This also explains the so far unexplained increase in the measured surface glass transition temperatures for polystyrene and the absence of a corresponding increase in polycarbonate (Fig. 3b).

Fig. 3: (a) Sketch of the embedding model for a spherical nanoparticle showing that the mobility of 2 Kuhn segment lengths (4 polymer persistence lengths) is required for wetting (b) Surface glass transition temperatures measured with the cluster embedding technique for polystyrene and polycarbonate as function of 1/4 of the cluster perimeter (red line in Fig. 3a).

c) Positron annihilation spectroscopy

Positron annihilation is a very powerful method employed by the group to determine relative concentration and size of free volume holes on the atomic scale from the lifetime of positrons, the anti-particles of electrons. In polymers, the free volume, i.e. the unoccupied space between the polymer chains, is a key property determining other properties like viscoelasticity or permeability and selectivity, for example, in membrane applications. During the last years the group extended its research in this area, which is financially supported by DFG and BMBF. The more basic research with national and international partners is partly performed within the DFG priority program “Polymer-solid interface”, which was co-initiated by Prof. Faupel, and aims at understanding the formation and structure of interfaces between polymers and solid materials. Within the BMBF project „Nanomodule“ the group cooperates with several industrial partners. A key result within the last year regarding membranes was the discovery of an unusual temperature dependence of the free volume in TEFNON AF, a high free volume membrane material. It was explained in terms of increased mobility of side-groups. Further work on block-copolymer membranes was performed together with the group of Prof. Abetz at the GKSS Research Center Geesthacht on PEBAX, a block-copolymer, where adding a low molecular weight polyethylene glycol increased permeability and selectivity without affecting the free volume significantly. Within a large BMBF project with various industrial partners, positron annihilation lifetime spectroscopy was established as a very sensitive method to follow curing of epoxies. Additionally, the Johnson-Mehl-Avrami-Kolmogorov kinetic equation was applied to extrapolate accelerated tests of shelf storage stability to lower temperatures. The latter is important for the development of new, nanocomposite based epoxies.
### Personnel

**Head of the group:** Prof. Dr. F. Faupel; **Secretary:** Dipl.-Chem. S. Kastaun (50%), Dipl.-Geol. B. Minten (50%), C. Otte-Hüls (50%)

**Technical Staff:** Dipl.-Ing. (FH) R. Kloth, Dipl.-Ing. (FH) S. Rehders

**Scientific Staff:**

<table>
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<tr>
<th>Name</th>
<th>Start Date</th>
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<tr>
<td>Dipl.-Ing. A. Bartsch</td>
<td>01.01.-31.08.2009</td>
<td></td>
<td>Glass-forming melts</td>
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<td>M. Sc. V.S.K. Chakravadhanula</td>
<td>01.01.-28.02.2009</td>
<td></td>
<td>Optical nanocomposites</td>
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<tr>
<td>Dipl.-Ing. C. Hanisch</td>
<td>01.01.-31.12.2009</td>
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<td>Functional nanocomposites</td>
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<td>Dipl.-Phys. S. Harms</td>
<td>01.07.-31.12.2009</td>
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<td>Dipl.-Phys. T. Hrkac</td>
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<td>Dr. S. Jebril</td>
<td>01.02.-31.12.2009</td>
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<td>Polymer</td>
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<td>M. Sc. M. Keshavarz Hedayati</td>
<td>01.08.-31.12.2009</td>
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<td>M.Sc. A. Kulkarni</td>
<td>01.01.-31.12.2009</td>
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<td>Dipl.-Chem. C. Pakula</td>
<td>01.07.-31.12.2009</td>
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<td>Priv. Doz. K. Rätzke</td>
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<td>Supercooled melts, positron annihilation</td>
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<td>Dr.-Ing. M. Scharnberg</td>
<td>01.01.-31.01.2009</td>
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<td>Metallization of organic semiconductors</td>
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<td>M.Sc. M.Q. Shaikh</td>
<td>01.01.-31.12.2009</td>
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<td>Free volume in epoxies</td>
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<td>Dr. T. Strunskus</td>
<td>01.01.-31.12.2009</td>
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<td>Functional nanocomposites</td>
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<tr>
<td>Dr. V. Zaporotchenko</td>
<td>01.01.-31.12.2009</td>
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<td>Functional nanocomposites</td>
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Lectures, Seminars, and Laboratory Course Offers

Winter 2008/2009

Einführung in die metallischen Werkstoffe, 2 hrs Lecture/Week,
F. Faupel
Einführung in die Vakuumtechnik, 2 hrs Lecture/Week,
V. Zaporojtchenko
Metals I, 2 (+1) hrs Lecture (+ Exercises)/Week,
F. Faupel (+ V.S.K. Chakravadhanula)
Polymers II, 2 hrs Lecture/Week,
M. Scharnberg
Polymers II, 1 hrs Seminar/Week,
M. Scharnberg
Seminar for Members of the Chair for Multicomponent Materials and interested guests, 2 hrs Seminar/Week,
F. Faupel
Thin Films II, 2 (+1) hrs Lecture (+ Exercises)/Week,
K. Rätzke (+ T. Hrkac)
Einführung in die Materialwissenschaft I, 2 hrs Lecture/Week,
K. Rätzke (+ K. Dolgner)

Summer 2009

Solid State Physics II, 1 hrs Exercise/Week,
S. Jebril
Thin Films I, 2 (+1) hrs Lecture (+ Exercises)/Week,
K. Rätzke (+ T. Hrkac)
Einführung in die Materialwissenschaft II, 2 hrs Lecture/Week,
K. Rätzke (+ D. Dolgner)
Vacuum Technology and Materials, 2 hrs Lecture/Week,
V. Zaporojtchenko
Advanced Metallic Materials, 2 hrs Seminar/Week,
F. Faupel
Functional Nanocomposites, 2 hrs Seminar/Week,
V. Zaporojtchenko
Polymers I, 2 hrs Lecture/Week,
F. Faupel (+ D. Gedamu)
Seminar for Members of the Chair for Multicomponent Materials and interested guests, 2 hrs Seminar/Week,
F. Faupel
Special Problems of Soft Matter Physics, 2 hrs Lecture/Week,
K. Rätzke

Winter 2009/2010

...
Werkstoffe (Metalle), 2 (+1) hrs Lecture (+ Exercises)/Week,
F. Faupel
Thin Films II, 2 (+1) hrs Lecture (+ Exercises)/Week,
K. Rätzke (+ T. Hrkac)
Seminar for Members of the Chair for Multicomponent Materials and interested guests, 2 hrs Seminar/Week,
F. Faupel
Metals, 2 (+1) hrs Lecture (+ Exercises)/Week,
F. Faupel (+ M. Keshavarz Hedayati)
mawi-409: Einführung in die Vakuumtechnik, 2 hrs Lecture/Week,
V. Zaporojtchenko
Advanced Organic Materials, 2 hrs Seminar/Week,
T. Strunskus
mawi-101: Übungen zur Physik I, 2 hrs Seminar/Week,
K. Rätzke
Solid State Physics I, 1 hrs Exercise/Week,
S. Jebril
Einführung in die Materialwissenschaft I, 2 hrs Lecture/Week,
K. Rätzke (+ K. Dolgner)

Third-Party Funds

o.m.t., Solarprojekt, 01.02.2006-31.01.2009 (256,567 EUR)
DFG DST, Formation of metallic nanostructures in organic matrix by vapour and plasma phase deposition and its
modification by swift heavy Iron Irradiation, 01.03.2006-31.07.2009 (77,130 EUR)
DFG, Diffusion in glasbildenden Metallschmelzen vom Gleichgewichtszustand bis zum kalorischen Glasübergang,
15.09.2006-30.10.2009 (130,295 EUR)
BMBF, Entwicklung vernetzungssteuernder Nanomodule mit controlled Release-Funktion für Polymerharz-Systeme mit
erhöhter Lagerstabilität und reduzierter Här tungstemperatur, 01.11.2006-31.10.2009 (100,227 EUR)
DFG, SFB, Funktion durch Schalten: Kombination von schaltbaren Polymeren und Nanokompositen nahe der
Perkolationsschwelle, 01.07.2007-30.06.2011 (237,600 EUR)
DFG, SFB, Funktion durch Schalten: Komposite aus Polymermatrix und ferromagnetischen
Formgedächtnis-Nanopartikeln als magnetische Schalter, 01.07.2007-30.06.2011 (211,640 EUR)
DFG, Magnetic nanocomposites for rf applications in mobile communication, 01.06.2006-31.07.2009 (161,405 EUR)
DFG, Einfluß der Verhinderung der Kollagen-Degradation durch MMPs auf den Dentin-Klebebund,
04.10.2007-31.03.2010 (25,944 EUR)
World Gold Council, Improvement of antibacterial coatings by incorporation of gold nanoparticles,
15.12.2007-31.03.2009 (44,874 EUR)
DFG, Magnetic nanocomposites for rf applications in mobile communication, 15.09.2008-15.03.2010 (129,566 EUR)
Stryker Trauma GmbH, Changes with nanostructure coating, 09.04.-30.06.2009 (9,200 EUR)
KHS Plasmax GmbH, Untersuchung von 4 PET-beschichtungen mittels Röntgen-Photoelektron-Spektroskopie (ESCA),
22.04.2009 (600 EUR)
DFG, Programmmpauschale für Projektleiter Prof. Dr. Faupel, 08.05.2009 (24,300 EUR)
DFG, Programmmpauschale für Projektleiter Prof. Dr. Rätzke, 09.05.2009 (41,800 EUR)
AvH, Stipendium Chandra, 25.05.-23.06.2009 (2,300 EUR)
Further Cooperation, Consulting, and Technology Transfer

University:

Prof. M. Bauer, F. Tuczek, O. Magnussen, Prof. W. Herges: Kombination von schaltbaren Molekülen und Nanokompositen nahe der Perkolationsschwelle (SFB „Funktion durch Schalten“)

Prof. W. Bensch, Institut für Anorganische Chemie: Komposite aus Polymermatrix und ferromagnetischen Formgedächtnis-Nanopartikeln als magnetische Schalter (SFB „Funktion durch Schalten“)

Dr. Peter Budd, Manchester School of Chemistry, The University of Manchester, Manchester UK, Polymermembranen

Prof. Dr. S. Deki, Kobe, Japan, Optische Nanokomposite

Dr. G. Dlubek, ITA Institute for Innovative Technologies, Universität Halle, Positronenvernichtung in nichtmolekularen Substanzen

Prof. Dr. G. Dollinger, Dr. W. Egger, Universität der Bundeswehr, München, PLEPS am FRM II

Prof. Dr. M. Es-Souni, FH Kiel, Ferroelektrische Schichten und Grenzflächen zu Metallen, Magnetische Nanodrähte

Prof. U. Hillerkingmann, Universität Paderborn, Elektretsichten für organische Feldeffekt-Transistoren

Dr. Chr. Hugenschmidt, TU München und FRM II, NEPOMUC

Prof. Dr. M. Kern und Prof. Dr. K. Ludwig, Zahnmedizin, Universität Kiel, AFM, XPS und Kontaktkontaktmessungen an Zähnen

Prof. Dr. L. Kipp, Experimentelle und Angewandte Physik der Universität Kiel, Eigenschaften von Schichtkristallen und organische Materialien, Photoemission an Organischen Moleküllkristallen

Prof. R. Knöchel, Inst. für Elektrotechnik und Informationstechnik, magnetische HF-Materialien (DFG-Projekt)

Dr. G. V. Kornich, Zaporozhye National Technical University, Ukraine, Computersimulation zum Sputtern von Clustern

Prof. Dr. W. Lang, IMSAS, Universität Bremen, Silizium-Elektret-Mikrophone

Prof. Dr. O. Magnussen, Institut für Experimentelle und Angewandte Physik, Elektrodosposition auf Schichtkristallen

Dr. J. Pflaum, Universität Stuttgart, Organische kristalline Halbleiter

Prof. Dr. R. Podschun, Institut für Infektionsmedizin, Universität Kiel, antibakterielle Beschickung

Prof. Dr. W. Possart, Universität Saarbrücken, BMBF-Projekt, Nanomodule

Prof. Dr. E. Quandt, Anorganische Funktionsmaterialien, CAU, Komposite aus Polymermatrix und ferromagnetischen Formgedächtnis-Nanopartikeln als magnetische Schalter (SFB „Funktion durch Schalten“)
Dr. C. Röhl, Prof. Dr. J. Sievers, Anatomisches Institut, Toxikologische Auswirkung von metallischen Nanopartikeln auf menschliche Zellen

Prof. Dr. V. Shantarovich, N. Semenov Institute of Chemical Physics, Russian Academy of Sciences, Moskau, Positronenvernichtung und Membranpolymere

Prof. Dr. C. Staudt, Düsseldorf, Blockcopoymere

Prof. S. Tougard, Physics Institut, University of Southern Denmark, Embedding of nanocluster in polymers

Prof. Dr. F. Tuczek, Institut für Anorganische Chemie, CAU Kiel, Self-assembled monolayers

Prof. Dr. Y. Vampolskii, A.V. Topchiev Institute of Petrochemical Synthesis, Laboratory of Membrane Gas Separation, Russian Academy of Sciences, Moskau, Positronenvernichtung und Membranpolymere

Research Institutes:

Dr. D. K. Avasthi, Materials Science Group, Nuclear Science Centre New Delhi, India, High energy ion beam effects in polymer-metal nanocomposites

Prof. Dr. Dietmar Fink, Hahn-Meitner-Institut, Berlin, High energy ion beam effects in polymer-metal nanocomposites

Dr. D. Fritsch und Prof. Dr. V. Abetz, Institut für Polymerforschung, GKSS-Forschungszentrum Geesthacht, Freies Volumen in Polymeren mit intrinsischer Mikroporosität

Prof. Dr. G. Grundmeier, Max-Planck Institut, Düsseldorf, Antibakterielle Beschichtungen

Prof. Dr. A. Meyer, Dr. A. Griesche, DLR, Köln, Diffusion in Pd-Cu-Ni-P Legierungen

Dr. M. Noeske, Fraunhofer-Institut für Fertigungstechnik und Angewandte Materialforschung, IFAM Bremen, BMBF-Projekt, Nanomodule und PALS an Polymer-Kompositen

Prof. Dr. K.V. Peinemann, GKSS, Geesthacht, Freies Volumen und Permeabilität in Spezialpolymeren

Prof. Schwarz, Dr. Drusch, Lebensmitteltechnologie, Kiel, Verkapselung von Lebensmitteln

Dr. Thomas Neubert, Fraunhofer Institut für Schicht- und Oberflächentechnik (IST), Braunschweig, Polymer-Metallocid-Kompositschichten für flexible optische Schichtsysteme

Industry:

Degussa AG, BMBF-Projekt, Nanomodule

Infineon, Regensburg, externe Promotion

ISH, Förderprogramm Organische Nanometalle

Kämmerling Chemische Fabrik GmbH, BMBF-Projekt, Nanomodule

a.m.t. Lübeck, Photoaktive Schichten

Ormecon, Ammersbek, Organische Nanometalle

Sennheiser Electronic KG Wedemark, Elektrete

Siemens AG, BMBF-Projekt, Nanomodule, Projekt Organische Leuchtdioden

Sika Tivoli GmbH, BMBF-Projekt, Nanomodule

Wöhlk, Schönkirchen, Oberflächenmodifikationen von Kontaktlinsen
Diploma, Bachelor and Master Theses

M. Jeppel, *Poren und Benetzung an ausgewählten Beispielen*, 06.07.2009

Dissertations / Postdoctoral Lecture Qualifications

A. Bartsch, *Diffusion und Viskosität in der Gleichgewichtsschmelze und im unterkühlten Zustand glasbildender Metalllegierungen*, 12.05.2009

Publications

Published in 2009

B. Wunderle, E. Dermitzaki, O. Holck, J. Bauer, H. Walter, Q. Shaik, K. Rätzke, F. Faupel, B. Michel, *Molecular Dynamics Simulation and Mechanical Characterisation for the Establishment of Structure-Property Correlations for Epoxy*


Presentations

K. Rätzke, Isotope effect, Diffusion and Viscosity in undercooled metallic melts (invited talk), Institut für Materialwissenschaft im Weltraum, Köln, Germany, 03.-03.02.2009

K. Rätzke, M. Scharnberg, Materialwissenschaften in Kiel (talk), Helene Lange Gymnasium, Rendsburg, Germany, 11.-11.02.2009

F. Faupel, Deposition of nanostructured composite materials, TransRegio24 (TRR24) Begutachtung, Greifswald, Germany, 24.-25.02.2009

A. Bartsch, V. Zöllmer, K. Rätzke, A. Meyer, F. Faupel, Diffusion and viscous flow in bulk glass forming alloys (invited talk), DMGT (2nd Discussion Meeting on Glass Transition), Sendai, Japan, 27.02.-01.03.2009


K. Rätzke, Temperature dependence of positron annihilation in high permeability polymers: Teflons AF (Poster), DPG-Frühjahrstagung 2009, Dresden, Germany, 22.-27.03.2009

S. Harms, K. Rätzke, V. Zaporozhchenko, F. Faupel, W. Egger, P. Sper, Free volume distribution at a polymer-solid interface investigated by a slow positron beam (talk), DPG-Frühjahrstagung 2009, Dresden, Germany, 22.-27.03.2009

C. Pakula, C. Hanisch, V. Zaporozhchenko, T. Strunskus, F. Faupel, R. Herges, Switchable electro-optical properties of polymer/metal nanocomposites containing chromohores (talk), DPG-Frühjahrstagung 2009, Dresden, Germany, 22.-27.03.2009

M. Q. Shaikh, K. Rätzke, F. Faupel, P.-L. M. Noeske, Shelf Life of one-component epoxy resin system studied by Positron Annihilation Lifetime Spectroscopy (talk), DPG-Frühjahrstagung 2009, Dresden, Germany, 22.-27.03.2009

I. Strunskus, Investigation of Silver Release from 2d and 3d Metal/Polymer Nanocomposites (talk), DPG-Frühjahrstagung 2009, Dresden, Germany, 22.-27.03.2009


F. Faupel, Abscheidung von Metall-Polymer-Nanokompositen (invited talk), AK Plasma Frühjahrssitzung 2009, Kiel, Germany, 25.-26.05.2009

A. Piorra, V. Zaporozhchenko, E. Quandt, F. Faupel, Polymer / ferromagnetic shape memory magnetic nanoparticles
composites as a switch: Composites exhibiting TMR (Poster), SFB-Konferenz, Salzau, Germany, 27.-29.05.2009
F. Faupel, Sensors and switches based on polymer-metal nanocomposites near the percolation threshold (invited talk), SFB-Konferenz, Salzau, Germany, 27.-29.05.2009
C. Pakula, C. Hanisch, T. Strunskus, V. Zaporotchenko, F. Faupel, R. Herget, C. Bornholdt, D. Zargarani, Switchable electro-optical properties of 2D chromophore/polymer/metal nanocomposites near the percolation threshold (Poster), SFB-Konferenz, Salzau, Germany, 27.-29.05.2009
S. Harms, K. Rätzke, V. Zaporotchenko, F. Faupel, W. Egger, P. Spener, Depth profiling of free volume at polymer-solid interfaces (Poster), Jahrestreffen DFB Schwerpunkt 1369, Frankfurt, Germany, 26.-26.06.2009
K. Rätzke, F. Faupel, Free volume and positron annihilation in polymeric membranes and epoxides: selected applications (invited talk), Neutronenseminar TU München, München, Germany, 29.-29.06.2009
C. Pakula, Azobenzene containing nanocomposites for functional applications (talk), SFB-677 Kolloquium, Sehlendorf, Germany, 17.-18.08.2009
S. Harms, K. Rätzke, V. Zaporotchenko, F. Faupel, Depth profiling of free volume at polymer-solid interfaces (talk), international Bunsen Discussion Meeting, Darmstadt, Germany, 30.08.-01.09.2009
A. Bartsch, K. Rätzke, A. Meyer, F. Faupel, Dynamic Arrest in Multicomponent Glass Forming Alloys (invited talk), 6th International Discussion Meeting on Relaxations in Complex Systems (IDMRCS), Rom, Italy, 30.08.-05.09.2009
F. Faupel, Abspcheidung von Nanokompositen in Plasmen (invited talk), Workshop, Dresden, Germany, 29.-29.09.2009
T. Strunskus, Use of thin organic layers as chemical platforms (invited talk), BESSY-Nutzertreffen, Berlin, Germany, 12.-13.11.2009
F. Faupel, Neue Werkstoffe durch Nanotechnologie (invited talk), Schleswig-Holsteinische Universitäts-Gesellschaft,
Further Activities and Events

Selected Honorary Activities of Prof. Faupel:

Dean of the Faculty of Engineering (Technische Fakultät der CAU),
Coordinator of the North German Initiative Nanomaterials (NINA),
Principle Editor of the *Journal of Materials Research*, edited by the Materials Research Society (MRS),
Member of the Editorial Advisory Board of the *Journal of Adhesion Science and Technology*,
Member of the des Advisory Board of *Diffusion and Defect Data*,
Vice Chair of the Technical Consulting Board of the *GKSS-Forschungszentrum Geesthacht*,
Member of the Program Committee of the DFG Priority Program “Polymer-Solid Interfaces, Thin Films, and Interphases - from Molecular View to Continuum”,
Vice Speaker of the SFB 677 “Function by switching”,
Member of the managing committee of the SFB855 “Magnetolectric composites - biomagnetic interfaces of the future”
Member of the *Societas Christiana Albertina*,
Member of the Steering Committee Quality Management of the CAU,
Member of the HWT (Hochschule-Wirtschaft-Transfer)-Jury of the ISH (Innovation Foundation Schleswig-Holstein),
Member of the Steering Committee of the Focal Point of Support “Nano and surface science”.

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.
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-orientated 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
- Nanoanalysis with electrons in materials and surface science

The Centre of Materials Analysis (CMA) and the „Kieler Nanolabor“ of the CAU (see TF almanach 2008) provide access to a number of 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, 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 central TEM laboratory - coordinated by Dr. Andriy Lotnyk - is a FEI Tecnai F30 analytical transmission electron microscope, equipped with a GATAN GIF/TRIDIEM B63 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. Furthermore, a conventional Philips CM30 transmission electron microscope CTEM, a FEI XL 30 scanning electron microscope, and laboratories for conventional TEM specimen preparation - coordinated by Ms. C. Szillus - are available.

Course Teaching and Research Thesis Projects: Study courses for Bachelor and Master 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 and Master students, and for Dissertation projects.


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 as follows:

- Quantitative TEM of Multilayers for Commercial Synchrotron Optics (methodological development oriented towards technology support)
- TEM of Nanoparticle Materials (applied nanoanalytical studies):
  - Metallic Core-Shell Nanoparticles
  - Nanocrystalline Diamond
- Functional Doped Oxide Semiconductor Nanostructures (fundamental research)
- TEM for Improved High-Efficiency Solar Cells (fundamental studies)
A. QUANTITATIVE TEM OF MULTILAYERS FOR COMMERCIAL SYNCHROTRON OPTICS


As part of our continued collaboration with the INCOATEC GmbH Geesthacht and the GKSS Helmholtz-Centre Geesthacht, Institute for Materials Research, we explored quantitative characterisations by scanning transmission electron microscopy (STEM) in order to enable the assessment of the layer growth, the coating control, and the reflectivity properties of multilayer systems for X-ray optics. More recent investigations focussed on characterisations for developing state-of-the-art thin film X-ray optical multilayer coatings for advanced X-ray analytical equipment and for conventional synchrotron beam lines and FEL sources. The development and fabrication of multilayer coatings for X-ray optics are an excellent example of nanotechnology with a large interdisciplinary scope addressing new products for advanced applications in materials science, semiconductor industries, as well as in life science (please see www.incoatec.de for examples of products and applications).

Fig. 1: QUANTITATIVE STEM OF APERIODIC MULTILAYER MIRRORS FOR SYNCHROTRON OPTICS. Example of HAADF-STEM cross-section micrograph displaying the section of a tungsten (W) - carbon (C) multilayer system on a silicon (Si) substrate. STEM image taken along the <110> silicon projection in a FEI TECNAI F 30 operated at 300 kV. Insert: Colour coded bi-layer thickness distribution obtained from the analyses of the STEM image.

Periodic multilayer systems consisting of ultrathin bilayers on the nanometre scale constitute the basis for monochromators of small spectral bandwidth. Aperiodic multilayer systems are used as advanced X-ray optical components for large spectral bandwidth synchrotron applications. The development of these novel multilayer systems requires precise monitoring of the multilayer parameters, such as layer thickness, layer periodicity and uniformity, and interface quality. High-angle annular dark-field scanning TEM (HAADF-STEM) was applied to cross-section imaging of periodic and aperiodic W/C multilayer systems and their interfaces (Fig. 1) and was combined with analyses of image intensity profiles. It is shown that the local layer thickness can be determined with sub-nanometre precision. Both methods lead to good agreement with nominal data, except for layer systems containing near-substrate growth-induced thickness fluctuations. Analyses of the position and the width of the interface contrast were employed for the quantitative determination of the interface roughness. This
procedure yields separate values for the lateral interface roughness and for interface broadening. For periodic multilayer systems the results show also excellent agreement with data obtained from X-ray reflectivity measurements.

B. TEM OF NANOPARTICLE MATERIALS - Metallic Core-Shell Nanoparticles

Cooperations: Dr. B. Schaffer, Dr. F. Hofer, Institute for Electron Microscopy, Graz University of Technology, Graz, Austria, and SuperSTEM Facility Daresbury, UK. Dr. D. Häussler CAU. M.Sc. Fu Liu, Prof. X. Zhang, Dept. Materials Science and Engineering, Zhejiang University, Hangzhou, China.

Fig. 2: STEM SPECTRUM IMAGING (SI) ANALYSES OF PALLADIUM-TIN NANOPARTICLES WITH CORE-SHELL STRUCTURE. STEM-HAADF image (left), STEM EDX SI taken with tin (Sn) signal (centre) and STEM EDX SI taken with palladium (Pd) signal (right). For the region marked by crosses the EDS spectrum is displayed below. The analysis shows a high fraction of Pd in the core region and a high fraction of Sn in the shell region, thus confirming earlier studies with an FEG-TEM that is equipped with an HR-imaging filter [TF Almanach 2007]. In addition the effects of possible contaminations during particle processing by other than nominal elements are detected.

Metallic core-shell nanoparticles for applications in catalysis and as data storage materials offer the possibility to tailor macroscopic properties generally not obtained by the single-component particles. Pd-Sn core-shell nanoparticles were fabricated by a solution-impregnation method on multi-wall carbon nanotubes and characterised by a combination of various spectroscopic and imaging high resolution transmission electron microscope (TEM) methods as well as by electron nano-diffraction. Our methodological approach demonstrates the feasibility to precisely analyse and map structure, morphology, and chemical composition of such particles (Fig. 2). It turns out that for the palladium-tin system composition analyses by electron-energy loss spectroscopy (EELS) are aggravated by overlapping ionization edges and suffer from limited detection sensitivity whereas energy-dispersive X-ray microanalyses (EDX) with high spatial resolution reveal small spectral signal-to-noise ratios. The scanning TEM high-angle-annular dark-field (HAADF) image contrast allows Sn to be distinguished from Pd and other lighter elements due to the strong atomic number (Z) dependence of electron scattering to high angles and imaging of atom columns. Electron nano-diffraction patterns provide additional information about the particle structure. Our analyses of a number of Sn-Pd particles with diameters as small as 20 nm reveal that both polycrystalline particles with Pd-rich cores and oxidized shells that mainly contain Sn as well as polycrystalline alloy particles are formed.
C. TEM OF NANOPARTICLE MATERIALS - Nanocrystalline Diamond

Cooperation: Dr. O. Williams, Dr. A. Kriele, Prof. Ch. Nebel, Fraunhofer Institute for Applied Solid State Physics FhG-IAF. Dipl.-Ing. Ch. Dieker CAU.

Diamond foam from Nano-Crystalline Diamond (NCD) films is promising for demanding applications such as fuel cells, water purification systems, and molecular traps where chemical stability, biocompatibility and longevity are required. Nano-crystalline diamond prepared by chemical vapour deposition (CVD) consists of diamond crystals (sp3 bonding of carbon) surrounded by non-diamond carbon (sp2 bonding). The ratio of sp2/sp3 is controlled by variation of the ratio $\text{CH}_4/\text{H}_2$ during the CVD growth. Thermal annealing in air is applied to remove graphite and amorphous carbon and to generate a porous foam structure with sub-nanometer voids in the film. The microstructure of NCD and the effects of thermal annealing are characterized by high-resolution TEM, by selected area electron diffraction (SAED) and by electron energy loss spectroscopy (EELS), and the propagation of ions through voids is investigated.

D. OXIDE SEMICONDUCTOR NANOMATERIALS

Cooperation: Prof. Dr. J. Piqueras, Prof. Y. Ortega Villafuerte, Dr. D. Maestre Varea, Physics Department, Universidad Complutense de Madrid, Spain. Dipl.-Ing. Ch. Dieker, Dr. D. Häussler CAU.

Fig. 3: FUNCTIONAL DOPED ZINC OXIDE (ZnO) NANOSTRUCTURES. (left) Bright-field TEM micrograph of single Sn-doped ZnO nanorod showing hollow core regions, regions consisting of Sn-rich material, and surface nanocrystals. (right) Spatially-resolved EDX spectrum displaying the presence of Sn and of traces of S in the core region.

Advanced imaging and spectroscopic techniques of electron microscopy play a crucial role in characterising the microstructure and the structure-property relationships of nanostructured functional materials and interfaces. Oxide semiconductor nanostructured materials, such as ZnO, In$_2$O$_3$, or SnO$_2$ nanostructures, were grown by catalyst-free vapour solid growth from different precursors. The morphology and the cathodoluminescence (CL) were investigated in a SEM equipped with a cathodoluminescence (CL) spectrometer. The structure and the interface phenomena were investigated for a variety of rod-like nanostructures by bright-field, dark-field, and high-resolution TEM imaging and combined with composition analyses by energy-dispersive x-ray microanalysis (EDX). ZnO as a functional material is of interest for transparent windows in solar cells, in ultra-violet (UV) lasers and light emitting diodes, or as field emitters in flat-panel displays. For doped ZnO, the CL investigations reveal locally varying emission intensities with a maximum intensity from the core region of the nanostructures. A broad emission band visible in the CL spectra suggests the presence of defects. The TEM investigations reveal that, for the case of Sn- and Al-doping, the rod-like nanostructures are characterised by distinct core and shell regions, with the core regions frequently containing either voids or other defects. Void formation appears to be absent for rod-like Eu-doped ZnO nanostructures. As an example, Fig. 3 shows a single nanorod structure with a hollow core next to a core region enriched in Sn. In addition, the surfaces are decorated by nanocrystals. The spatially resolved EDX measurement clearly indicates the presence of Sn in this region (as opposed to the adjacent hollow
region). Small amounts of S are also detected (the Cu signal results from the TEM support grid). High-resolution lattice images taken from a near-tip region of the rod-like ZnO nanostructures are consistent with the ZnO wurtzite structure. For Sn-doped ZnO nanostructures, the comparison between TEM and CL investigations suggests that the spatial and spectral distribution of CL intensity can be correlated with the presence of defects in a core-shell arrangement in different regions of the nanostructures.

E. TEM FOR IMPROVED HIGH-EFFICIENCY SOLAR CELLS

Cooperation: Dr. F. Dimroth, Dr. A. Bett, Fraunhofer Institute for Solar Energy Systems FhG-ISE Freiburg. Dipl.-Ing. Ch. Dieker CAU.

Our investigations aiming at the development of new concepts for defect engineering and at the control of strain in heteroepitaxial crystal layer growth for high-efficiency solar cells were continued. Highest efficiencies for solar energy conversion are currently achieved for so-called metamorphic solar cell structures, which consist of crystalline layer stacks based on III-V compound semiconductor materials on germanium and on silicon substrates. A prerequisite for achieving the highest efficiencies are active regions of the solar cell that remain relatively free of defects. Concentrating the sunlight onto the small area of such solar cells by an appropriate lens system leads to even higher efficiencies. This technique is applied in photovoltaic concentrator systems and is of interest for solar energy power stations in countries with high solar radiation and for power generation in satellites. By using a GaInP/GaInAs layer structure on a Ge substrate and by concentrating the sunlight by a factor of 454 onto a small 5 mm$^2$ multi-junction solar cell made from this system, the researchers at the Fraunhofer Institute for Solar Energy Systems ISE have achieved an efficiency of 41.1% for the conversion of sunlight into electricity. This represented a world record in efficiency (as of Jan14, 2009) reached for multi-junction solar cells. Present microstructure research focuses on GaInNAs layer systems with different N contents and GaInP buffer layer systems.

Personnel

Head of the group: Prof. Dr. Wolfgang Jäger, Secretary: Katrin Brandenburg (50%)

Scientific Staff:

Dipl.-Ing. Christel Dieker 01.03.-31.12.2009 CAU
TEM of layer systems and nanomaterials and preparation for TEM

Dr. Dietrich Häußler 01.01.-31.12.2009 ISH until 31.08.2010, CAU
Analytical TEM of layer systems and nanomaterials

M.Sc. Fu Liu 06.04.-30.09.2009 CAU International Center
Guest Scientist, Zhejiang University, Hangzhou, V. R. China

Dr. David Maestre Varea 05.05.-31.12.2009 Ministerio de Ciencia e innov.
Guest scientist, Facultad de Ciencias Fisicas, UCM - Universidad Complutense Madrid, Spain

Dr. Yanicet Ortega Villafuerte 10.02.-31.07.2009 Ministerio de Ciencia e innov.
Guest scientist, Facultad de Ciencias Fisicas, UCM - Universidad Complutense Madrid, Spain

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 Metallforschung, Stuttgart, Dr. P. Van Aken)

M.Sc. V. Burak Özdoł 01.01.-31.12.2009
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 Metallforschung, Stuttgart, Dr. P. Van Aken)
Lectures, Seminars, and Laboratory Course Offers

Winter 2008/2009

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

Laboratory Course: Scientific Methods, 4 hrs Lab/Week,
Kai Dolgner (+ Andreas Schütt, Dirk Meyners, Vladimir Zaporozchenko, Mohammad Qasim Shaikh, Seid Jebril, Ala Cojocaru, Dietrich Häußler, Ulrich Roß)

Praktikum: Analytische Methoden, 4 hrs Lab/Week,
Kai Dolgner (+ Marlies Schwitzke, Klaus Rätzke, Dirk Meyners, Mady Elbahri, Malte Leisner, Dietrich Häußler, Ulrich Roß)

Summer 2009

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

Laboratory Course: Functional Materials, 4 hrs Lab/Week,
Kai Dolgner (+ Mohammed Qasim Shaikh, Amit Kulkarni, Malte Leisner, Andriy Lotnyk, Dietrich Häußler)

Winter 2009/2010

Analytics I, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Wolfgang Jäger

Transmission Electron Microscopy I, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
Wolfgang Jäger

Analytical Methods in Materials Research, 2 hrs Seminar/Week,
Wolfgang Jäger

Materialwissenschaft III, 3 (+ 1) hrs Lecture (+ Exercises)/Week,
Wolfgang Jäger

Laboratory Course: Scientific Methods, 4 hrs Lab/Week,
Kai Dolgner (+ Vladimir Zaporozchenko, Mohammed Qasim Shaikh, Seid Jebril, Ala Cojocaru, Dietrich Häußler, Malte Leisner)

Praktikum: Analytische Methoden, 4 hrs Lab/Week,
Kai Dolgner (+ Marlies Schwitzke, Klaus Rätzke, Dirk Meyners, Mady Elbahri, Malte Leisner, Dietrich Häußler)
Third-Party Funds

DFG, Mikroskopische Charakterisierung von inkommensurablen Grenzflächen in modulierten Fehlpassungsschichtstrukturen mittels ultrahochauflösender Durchstrahlungselektronenmikroskopie, 07.12.2007-31.01.2010 (150000 EUR)
HWT II ISH, TEM - Nanoanalytik zur Entwicklung von Incoatec Synchrotronoptiken, 01.07.2007-31.08.2009 (96000 EUR)
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 (29158 EUR)
DAAD, Reisekostenzuschuss zur Teilnahme von Herrn Prof. Dr. Wolfgang Jäger an der 11th International Conference on Advanced Materials ICAM 2009, Rio de Janeiro, Brasilien, 20.-25.09.2009 (1710 EUR)
DGE Deutsche Gesellschaft für Elektronenmikroskopie, Reisestipendium zur Teilnahme von Ulrich Roß an der Microscopy Conference MC 2009, Graz, Austria, 30.09.-04.10.2009 (500 EUR)
Ministerio de Ciencia e Innovacion, Madrid, Spain, Gastwissenschaftlicher Aufenthalt, Dr. Yanicet Ortega Villafuerte, 10.02.-31.07.2009 (x EUR)
Ministerio de Ciencia e Innovacion, Madrid, Spain, Gastwissenschaftlicher Aufenthalt, Dr. David Maestre Varea, 05.05.2009-30.04.2010 (x EUR)
CAU International Center, Exchange of scientists with the Zhejiang University, Hanzhou, V. R. China, M.S. Fu Liu, 06.04.-30.09.2009 (x EUR)

Further Cooperation, Consulting, and Technology Transfer

Technology-oriented collaborations with industry and external research institutes

Continued collaboration (consulting, application of high-resolution TEM methods) in the development of nanomaterials for high-capacity hydrogen storage (Dr. M. Dornheim, Dr. U. Bösenberg, GKSS Helmholtz Center Geesthacht, Dept. Nanotechnology).

Continued collaboration (consulting, application of high-resolution TEM methods) in the development of commercial X-ray optical components with Incoatec GmbH Geesthacht (funding support by the ISH HWT program) and with the GKSS Helmholtz Center Geesthacht, Institute of Materials Research (Dr. M. Stöhrer).

Collaboration with 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 (Dipl.-Ing. Ch. Dieker).

Collaboration with Fraunhofer Institute for Applied Solid State Physics IAF, Dr. O. Williams, Dr. A. Kriele, Prof. Ch. Nebel) on the development of diamond layers and nanodiamond (Dipl.-Ing. Ch. Dieker).

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 the 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

Continued research collaboration (CAU funding support) with Materials Science and Engineering and State Key Laboratory for Silicon Materials, Zhejiang University, Hangzhou, China, Prof. Dr. X. Zhang, M.Sc. Fu Liu: TEM characterisation for processing of nanoparticle composites.
Co-supervision (Prof. W. Jäger) of PhD theses research work at the Max-Planck-Institute for Metal Research, Stuttgart, Germany (Stuttgart Center for Electron Microscopy Dr. P. van Aken, Dr. F. Philipp, Dr. W. Sigle) on TEM characterisations of semiconductor heterostructures and of metal nanoparticles.

Analytical support (Dipl.-Ing. Ch. Dieker, with contributions by Dr. Ch. Zamponi from the Anorganic Functional Materials Group) by materials analyses of an archaeological find (“Beil von Ahneby”) for a research project of the Archäologisches Landesmuseum (Dr. M. Freudenberg, Director Prof. Dr. C. v. Carnap-Bornheim).

DFG Graduate School Human Development in Landscapes at the CAU (Coordination Prof. J. Müller CAU) - lecture offers on methods of electron microscopy and materials analysis. Member of the board of directors (Prof. W. Jäger).

Dissertations / Postdoctoral Lecture Qualifications

Magnus Garbrecht, Aberration-corrected high-resolution transmission electron microscopy of the misfit layered compound (PbS)$_{1.14}$NbS$_2$, 17.04.2009

Jan Schöne, Kontrolle von Spannungsrelaxation und Defektbildung in metamorphen III-V Halbleiterheterostrukturen für hocheffiziente Solarzellen (Bestbewertung opus eximium), 21.07.2009

Publications

Published in 2009


M. Garbrecht, Aberration-corrected high-resolution transmission electron microscopy of the misfit layered compound (PbS)$_{1.14}$NbS$_2$, Dissertation CAU Kiel, (2009)


Presentations


Further Activities and Events


Selection of Activities Prof. W. Jäger

Member of evaluation committee for a National Research Program of the Swiss National Science Foundation (SNSF), Berne, Switzerland.

Expert consultant for research funding agencies in Germany (DFG and others) and abroad.

Member of the Editorial Board of Springer Journal of Materials Science.

Reviewer for several international scientific journals.

Member of board of directors DFG CAU Graduate School „Human Development in Landscapes“.


Guests in 2009

Prof. Dr. W. Mader, Anorganic Chemistry, University of Bonn, Germany, on Oxide Semiconductors, 17. - 18.04.2009

Prof. Dr. U. Dahmen, LBL National Center for Electron Microscopy, Berkeley, USA, on Usage of TEAM Facility, 29. - 30.04.2009

Prof. Dr. Dietrich Hesse, Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany, Colloquium of the Faculty of Engineering, „Laterally and vertically nanostructured ferroelectric, magnetic and multiferroic epitaxial complex oxide heterostructures“, 29.06.2009

Prof. Dr. Javier Piqueras, Dept. Materials Physics, University Complutense of Madrid, Madrid, Spain, on Semiconductor Oxide Nanostructures, 13. 07.2009

Dr. Christian Kübel, Forschungszentrum Karlsruhe, Institute for Nanotechnology, Karlsruhe, Germany, Colloquium of the Faculty of Engineering „Electron Tomography in Materials Science“, 02.11.2009, and project collaboration discussion, 21.12.2009

Offers for the general public and for schools

Functional Nanomaterials

Novel methods in nanoscale technology were the focus of the 2009 research; this includes pharmaceutical and macroscopically expanded 3D inorganic nanostructures. Furthermore, important progress was made by the ‘on chip’ integrated nanowire electronics and a breakthrough in the understanding of the underlying theory of water jet reflection. New members have joined the group. Dr. Yogendra Kumar Mishra won a prestigious Humboldt fellowship for two years, starting from February 2009, Eman Abdalla joined in April. The latter is financed for her PhD in Germany by a very rare grant from the Government of Egypt for the total duration of 4 years. Her aim is to perform nanotechnology in medicine and pharmacy. Furthermore, Xin Jin joined in December to work for a PhD. On the other hand, two PhD students finished their theses; Dr. Sebastian Wille and Dr. Saïd Jebril. While Dr. Jebril joined the group of Prof. Franz Faupel, Dr. Wille continues as a postdoctoral research fellow on a BMBF project that was positively evaluated in Summer 2009 and starts in 2010. A further DFG project was positively evaluated: it is proposed in the framework of the newly started SFB 855 “Biomagnetic Sensing”, with Prof. Eckhard Quandt as spokesperson. In this SFB Rainer Adelung contributed also as a Co-investigator for the integrated graduate college.

Another remarkable event was an interdisciplinary German-Danish workshop, which was organized by the group and held at the TF. This workshop with more than 20 participants from different scientific fields resulted in 8 short proposals, each with a partner from Germany and Denmark. The international relations of the group were further strengthened by two visiting scientists. Dr. Qui from Zhejiang stayed from first of April till the 30th September and performed research on ZnO, and Dr. Avasthi from the International University Accelerator centre in New Delhi stayed from 15th May till the 15th June. The work of the group was acknowledged by several invitations to international conferences, more than it would have been reasonable to accept. Finally three were attended, Thermec 2009 located in Berlin, Thermodynamics and Transport Kinetics of Nanomaterials (TTk) in Nordkirchen castle close to Münster, and the International Conference on Advanced Nanomaterials and Nanotechnology 2009 in Guwahati, Assam, in India. Two students in the group (Arnim Schuchard and Maria Claus) that completed their bachelor degree were honoured by the ‘best bachelor’ awards at the “Sommerfest” and “Winterfest”.

As already indicated above, the group shifted its focus further towards medical research and its applications. This was carried out in continued collaboration with the dental clinic and a project on the nanostructuring of pharmaceutical substances together with the group of Prof. Steckel in the pharmacy department. In the framework of the ‘inflammation on interfaces’ cluster of excellence, experiments were carried out together with the Group of Prof. Bosch in biology. Antibacterial tests of nanostructures were examined as well as their potential for drug delivery. For further details, see the results chapter. Two new joint lectures were established, one is covering also medical topics: Biomaterials was presented and established in the 3rd master semester together with Prof. Kienle. The other lecture was called micro- and nanoelectronics and was established together with Prof. Föll in the 5th bachelor semester. Both lectures were completely new material.. Further information about them can be found in the lists continuing this text. Apart from the basic research and lectures, applied projects were carried out directly together with companies, examples being the Wöhlk-Contactlinsen GmbH, nanoproofed, in Glesendorf, a big multinational company, the latter carried out via TuTech GMBH in a collaboration with the IUHH. In the framework of this project, a completely new in- situ technique was developed.

Results

3D-ZnO nanostructures:

In order to utilize and demonstrate the novel features of nanostructures, it is typically necessary to produce them in such high quantities that they can fill macroscopic areas and thus can be linked to the macroscopic world. This was one major aim of the research work carried out in 2009. As a prime example for nanostructure formation, ZnO is an excellent choice as it has the tendency to form nanostructures due to its highly polar character. Thus it was also chosen to build macroscopically expanded structures consisting of nanoscopic structural elements. In the Almanach 2008, the so-called core spike particles
formed in a gas transport furnace under vacuum had been reported. This approach was further developed and brought out of the vacuum. For the formation of samples of the fully nanostructured structures shown in Figure 1, the vacuum furnace is no longer needed. For this novel approach, only a substrate, a regular muffle type furnace, a mixture of Zn-micro powder with a sacrificial polymer and a solvent are necessary. The approach is using the ability of the ZnO to form nanostructures while the polymer in the mixture is decomposing. This is a simple trick to guarantee free volume that is necessary to connect these nanostructured building blocks. Now it is possible to form very lightweight and even flexible ZnO structures. This was made possible in a serial development during work for 3 Bachelor theses: in the work of Thomas Preusse a conventional setup with a tube furnace was chosen and different conditions for the growth of core spike like nanostructures were examined. In the work of Maria Claus she made the breakthrough approach to form nanostructures even without a vacuum pump just by using a slurry in a regular furnace under ambient conditions. This was further developed by Charline Wolpert in order to characterize systematically the important parameters. Another substantial breakthrough was finally carried out by Yogendra Kumar Mishra, identifying the right parameters to form foam like ceramic structures that show the already mentioned elasticity. A further direct application of the ceramic foams is in their ultrahydrophilic nature. As those structures allow easy spreading on large surface areas, joint projects have been started with Prof. Graf from the University of Applied Sciences in Kiel to coat parts of sailing boats.

Fig. 1: Microscopic images of ZnO structures formed via a new synthesis directly under ambient conditions. a) Scanning electron microscopy (SEM) image, part of a silicon substrate coated with millions of nanonails with a hexagonal top. b) Foam like semiconducting agglomerates with a true three dimensional structure, the sample dimensions continue in a macroscopically expanded network c) Optical micrograph of an ultrahydrophilic surface structure formed by the same approach d) This magnification in SEM of c shows the underlaying hierarchical structure, which is responsible for the ultrahydrophilic surface character SEM

Nanowire structures:
A long lasting focus of the group is on the electronic properties of nanowires. Dawit Gedamu, who is continuing the work of Dr. Seid Jebril, is integrating nanowires in microscopic contacts on silicon chips. This is now finally possible with the lithographic techniques in the clean room in the Kieler Nanolab. The great help obtained from Prof. Quandt’s group is acknowledged. While in preliminary experiments an influence of a gate voltage on nanowires was already observed in single measurements, he could mainly demonstrate the influence of the gate voltage on a technologically relevant scale. By forming core shell nanowires with a conductive core and an insulating shell, a factor of 500 in the on/off ratio could be shown with the help of gate voltages below 1 Volt. To understand these phenomena, this research is being carried out in collaboration with Prof. Kohlstedt in electrical engineering. Further tests to utilize these wires as gas sensors are very promising. Semiconducting zinc oxide wires especially could be fabricated in a reproducible manner by sputter deposition and a subsequent annealing step. The fracture based nanowire fabrication approach has also been used in collaboration with Prof. L. S. Shvindlerman from the Russian Academy of Sciences. In this project, the main focus is on the grain boundaries in the formed nanowires. Sören Kaps made another breakthrough in the understanding of water jet reflection. Vertical nanowires are coated with a thin layer of Teflon in collaboration with the group of Prof. Faupel. This forms an extreme ultra-hydrophobic surface. The phenomenon of water jet reflection on the ultra-hydrophobic surfaces is different from all other reflection phenomena. A water jet impinges on an ultra-hydrophobic surface, flows for a distance of several beam diameters and then takes off. The newly developed theory that can simulate this behaviour opens the door to understanding the reduced friction of the water sliding over the surface. Figure 2 shows the water jet from the side and from the top together with a viewgraph from the calculation, showing exactly the same shape. As the underlying theory is based on first principles, a comparison between experiment and theory allows the influence of the different contributions to be understood.
Medical projects:

In the project of Eman Abdalla carried out with the pharmaceutical department and with Prof Steckel and Prof. Größner Schreiber from the dental clinic, it turned out to be possible to fabricate solvent free thin films, multi layers or mixed layers of pharmaceutical molecules. More than 90% of all newly discovered drugs result in molecules of poor solubility, which causes low bioavailability or gives rise to large fluctuations in the fraction absorbed in humans. By depositing multilayers of insoluble molecules mixed with soluble molecules a better solubility might occur. The ability to nanostructure molecules could have also other advantages, for example for coating nanostructures that can be utilized for drug delivery. The accessibility of this approach includes a large variety of pharmaceutical substances for many diseases like antibiotics, antimicrobial, antifungal, non steroidal anti-inflammatory drugs, antirheumatic, local anaesthetics, antiplatelet, non-selective muscarinic receptor agonist and beta blockers as well as carrier or biocompatible materials, inactive substances for drug encapsulation and controlled release like cholesterol or PLGA. Furthermore, the high surface to volume ratio of nanostructures itself is responsible for a better solubility. Figure 2 shows examples of the nanostructures that can be formed by the approach. The absence of a solvent is a further advantage as often some traces of solvent remain in the pharmaceutical substance, resulting in toxic effects. For several of these substances already preliminary tests have shown pharmaceutical activity. A further example of the structuring of surfaces for medical applications is the installation of photon sieves on polymeric contact lenses by conventional and e-beam lithography. This project, carried out by Xin Yin in her master thesis and Frank Spors in his PhD thesis, is a collaboration with the physics group of Lutz Kipp. The basic idea for this project is to give contact lenses a second optical active element, a diffraction optics. The photon sieve pattern with its soft transition to boundaries was chosen due to the limited aperture radius of the eye, the pupil. The difficulties in microstructuring on a curved polymer surface could be overcome. Very promising experiments were carried out by Yogendra Kumar Mishra in collaboration with the group of Prof. Bosch in the Biology department. Here, different nanostructures were tested for their antibacterial activity. It turned out that the shape of the nanomaterials has a strong influence on the antibacterial activity.

Fig. 3: The SEM image shows different magnifications of samples that are coated with nanostructured pharmaceutically active molecules. In the magnification b) the nanorod like structures can be clearly seen. Eman Abdalla thanks her husband for assistance with the images.

Personnel

Head of the group: Prof. Dr. R. Adelung; Secretary: Dipl.-Chem. S. Kastaun, DFG overhead (50%), Dipl.-Geol. B. Minten (50%), C. Otte-Huls (50%) 
Technical Staff: Dipl.-Ing. R. Kloth, Dipl.-Ing. S. Rehders
Scientific Staff:

Dr. M. Elbahri 01.01.-30.06.2009 CAU
Nanochemistry and nanoengineering

M.Sc. D.M. Gedamu 01.01.-31.12.2009 DFG
Nanowire electronics

Dr. S. Jebril 01.01.-31.12.2009 CAU, DFG
Nanowires on silicon

M. Sc. X. Jin 01.-31.12.2009 Grant CAU
Optics of contact lenses

Dipl.-Ing. S. Kaps 01.11.-31.12.2009 DFG
Wetability

Dr. Y.K. Mishra 01.01.-31.12.2009 AvH Grand
ZnO-Nanostructures

Dr. S. Wille 01.01.-31.12.2009 DFG
Nanochannels

M. Sc. E.S.E.S.A. Zarie 07.03.-31.12.2009 Grant Goverment Egypt
Drug evaporation

Lectures, Seminars, and Laboratory Course Offers

Winter 2008/2009

Mathematik für Materialwissenschaftler I, 4 (+2) hrs Lecture (+ Exercises)/Week, R. Adelung (+ S. Wille, T. Strunskus)

Nanochemistry for Nanoengineering, 2 hrs Lecture/Week, M. Elbahri

Solid State Physics I, 2 (+1) hrs Lecture (+ Exercises)/Week, R. Adelung (+ S. Jebril)

Summer 2009

Mathematik für Materialwissenschaftler II, 4 (+2) hrs Lecture (+ Exercises)/Week, R. Adelung (+ S. Wille)

Solid State Physics II, 2 (+1) hrs Lecture (+ Exercises)/Week, R. Adelung (+ S. Jebril)

Voraussetzungen und Auswirkungen Nanotechnologie, 2 hrs Lecture/Week, R. Adelung

Winter 2009/2010

Biomaterials, 2 hrs Lecture/Week, R. Adelung
Third-Party Funds

DFG, Schwerpunktprogramm: Nanodrähte und Nanoröhren: von kontrollierter Synthese zur Funktion - Thin film fracture based fabrication of nanowires and tubes in device geometry, 01.08.2006-31.01.2009 (130,760 EUR)

DFG, Heisenberg-Professur: Interdisziplinäre anwendungsnahe Forschung mit nanostrukturierten Materialien, 01.06.2007-01.06.2010 (244,800 EUR)

DFG, Einfluss der Verhinderung der Kollagen-Degradation durch MMPs auf den Dentin-Klebeverbund, 04.07.2001-04.01.2009 (25,944 EUR)


Dritte, 07.07.2009 (1800EUR)

DFG, Anschubfinanzierung für Projekt, 01.01.2009-30.06.2011 (14,080 EUR)

DAAD, Stipendium für ein Fachpraktikum für Harikesh Arunachalam, 01.02.2009-31.01.2011 (73,200 EUR)

Uni Kiel, Wissenschaftlicher Austausch mit der VR China, Zusammenarbeit mit der Universität Zhejiang, Hanzhou, 04.01.-30.09.2009 (5,400 EUR)

Uni Kiel, Reisekostenzuschuß für einen Doktoranden/Postdoc an Symposien, Tagungen oder Fachkongressen; Kostenübernahme für Publikationen; Bonus für Veröffentlichungen, 23.-23.01.2009 (1,200 EUR)

Botschaft der Arabischen Republik Ägypten, Ägyptisches Regierungsstipendiat in Long Term Mission System für Zarie für 4 Jahre, 07.03.2009-06.03.2013 (66,000 EUR)

Uni Kiel, Untersuchungen von Bakterien mittels Rasterkraftmikroskopie, 09.-09.12.2009 (420 EUR)

Wölk-Contact-Linsen GmbH, Untersuchung von Linsen mit Rasterkraftmikroskopie, 09.-09.12.2009 (1,050 EUR)

Further Cooperation, Consulting, and Technology Transfer

University:

Dr. D. K. Avasthi, Materials Science Group, Nuclear Science Centre New Delhi, India, Temperaturabhängige Leitfähigkeit von Nanodrähten

Prof. Dr. T. Bosch, Zoologisches Institut und Museum (Sektion Biologie), Allgemeine Zoologie, CAU Kiel

PD Dr. V. Cimalla, TU-Illmenau, Nanodrahtbrücken

Prof. F. Faupel, Universität Kiel, Lehrstuhl für Materialverbunde, Mehrere gemeinsame Projekte zu organischen Materialien und Ultrahydrophobität

Dr. Größner-Schreiber, Modifikation von Titanoberflächen

Dr. A.W. Hassel, Max-Planck Institut, Düsseldorf, Nanostrukturierte Eutektika
Prof. Dr. M. Kern, Prof. Dr. K. Ludwig, Zahnmedizin, Universität Kiel, AFM, XPS und Kontaktwinkelmeßungen an Dentalmaterialien

Prof. Dr. L. Kipp, Experimentelle und angewandte Physik der Universität Kiel, Diffaaktive Optiken für Kontaktlinsen

PD Dr. C. Ronning, Universität Jena, Nanosegel aus Zinkoxid

Dr. B. Schmitt, FZ Rossendorf, Mikrostrukturierung zur Integration von Nanoröhren in die Halbleitertechnik

Prof. Dr. K. Schulte, TU Hamburg, Kontaktierte CNT-Brücken

PD Dr. Maja Wiegemann, Alfred-Wegner Institut Bremen, Zweigstelle Helgoland, Untersuchungen zum Seepockenklebstoff

Research Institutes:

Dr. A.W. Hassel, Max-Planck Institut, Düsseldorf, Nanostrukturierte Eutektika

Industry:

Nanoproofed, Süsel, Vorarbeiten maritimes Spitzencluster

Wöhlk, Schönkirchen, Untersuchungen an Kontaktlinsen

TuTech, in situ Experimente zu mechanischen Eigenschaften

**Diploma, Bachelor and Master Theses**

C. Ohrt, Charakterisierung ultrahydropher Oberflächen mittels Wasserstrahlreflexion, 01.07.2009


T. Preußé, Growth of ZnO nanostructures by VLS approach, 01.07.2009

M. Claus, Massentaugliche Synthese von Zinkoxid-Mikrokern-Nanostachel-Partikeln, 20.08.2009

C. Wolpert, Synthese und Benetzungseigenschaften von großflächigen ZnO-Kern-Nanostachel-Systemen, 01.10.2009

H. Kuhlmann, Rheometrie an Polyurethan, 27.10.2009

**Dissertations / Postdoctoral Lecture Qualifications**

S. Wille, Mikrostrukturierungsfreie Herstellungsmethoden für anwendungsnahe Nanokomposite mit ein- und zweidimensionalen Füllstoffen, 14.05.2009


**Publications**

Published in 2009


Presentations


R. Adelung, *Integration of self organized nanostructures into devices* (invited talk), Institutseminar im Institut für Festkörperphysik in Jena, Jena, Germany, 12.-12.06.2009


Nanochemistry and Nanoengineering

Nanochemistry and Nanoengineering is a newly established Helmholtz-University Young Investigators Group (HUG) chosen through an international call of the Helmholtz Association. The research group is based in the Material Science Institute of the engineering faculty of the Christian Albrechts University of Kiel as well as the Institute of Polymer Research at GKSS/Geesthacht, a division of the Helmholtz Association. Our research interests include the design, synthesis, patterning and self-assembly of nanoscale materials for applications in optics, electronics, photonics, sensing, separation, biology and medicine. Using wet chemistry, electrospinning and physical deposition methods and combinations thereof, we aim to create new inorganic and organic-inorganic hybrid materials with diverse properties and multifunctional abilities to not only improve existing technologies, but also to create novel smart materials which can respond to small changes in environmental conditions.

Results

Current research activities are concentrated on controlled fabrication and spatial distribution of nanoscale materials, which are the foundational principles of multifunctional and smart nanoengineered technologies. The group began its work in July 2009 and the following results will be published soon. The fabrication methods used for these results are patented technologies, which are wholly unique in the field of nanoengineering and allow us to develop new materials rapidly. Further methods have also recently been developed by us and are presently undergoing submission. Because of this we show the results only in coloured form and without details.

As an example, several of our recent advances are based on the Leidenfrost phenomena - commonly observed when water is spilled on a hot stove. Water under the Leidenfrost condition possesses two interfaces, a top interface (air/water, called “cold interface”) and a bottom one (water/vapor, called “hot interface”). The hot interface formed under Leidenfrost conditions permits a novel interface chemistry under the water that enables a ‘green’ synthesis of nanocomponents in either
a beaker using a water film ("Lab-in-Beaker" patent) or directly onto a substrate using a single water drop ("Lab-in-Drop" patent). This is a rapid, simple and environmentally friendly manner using only aqueous solutions of the common salts and a minimum of supporting reagents. Using this method nanocrystals of different materials, e.g. semiconductors, metals and ceramics, with various morphologies, are successfully produced within minutes without the need for hazardous chemical components or expensive equipment. Some of the nanostructures for ZnO with various morphologies formed by this method under different experimental conditions are illustrated in Fig. 2.

![Fig. 2: SEM images of surfaces covered with various morphologies of ZnO deposited from a drop (Lab in Drop) as well as floating thin film (Lab in Beaker).](image1)

Another example of our patented techniques is a novel design method used for 1D nanostructuring. The "DDD" (Drop De-wetting around a Defect) method combines the spinodal de-wetting aspect of an evaporating drop with another old aspect, specifically the deformation of a liquid contact line around a wettable defect. A gradient of wires covering an area of several millimeters and down to nanometer scale has been achieved. Primary results were shown in the Almanach last year. The progress of this work shows the applicability of our methods with several materials that range from nanoparticles to polymeric materials. Fig. 3 shows particulate nanowires of ZnO nanoparticles formed by "Lab in Beaker" (Fig. 2).

![Fig. 3: A) Aligned ZnO nanoparticles fabricated via the DDD method. B) Spun polymer nanofibres exhibiting anisotropic wetting behaviour. X = contact angle across the nanofibers, Y = contact angle along the nanofibres.](image2)
Unlike lotus leaf type hydrotropic surfaces, some plant leaves have special surfaces with anisotropic wetting properties. For example, water droplets on a bamboo leaf are not spherical but elliptical. Indeed, for the lotus effect, periodicity does not play a role and randomly oriented fibres with a rough surface exhibit an isotropic hydrophobic effect. For the bamboo leaf effect however we need periodicity in surface roughness. Aligned fibres were prepared on a glass plate and the orientation of fibres was checked via SEM. The fibres were found to be highly aligned and contact angle measurements of these aligned fibres showed a very pronounced anisotropic wetting effect with $\Delta \Theta$ as high as 37$^\circ$. Recently we have fabricated coloured bamboo leaf like materials with tunable anisotropic wettability through a combination of electrospinning and sputtering. This technique will be patented and further results will be shown in detail.

**Personnel**

Head of the group: Prof. Dr. -Ing. M. Elbahri; Secretary: Dipl.-Chem. S. Kastaun, Dipl.-Geo. B. Minten (50%), C. Otte-Hüls (50%)

Technical Staff: Dipl. -Ing. (FH) R. Kloth, Dipl.-Ing. (FH) J. Koll (GKSS), Dipl.-Ing. (FH) S. Rehders

Scientific Staff:

- **M. Sc. R. Abdelaziz 01.07.-31.12.2009** Grant
  Nanocrystal Synthesis

- **M.Sc. T. Dai 01.07.-31.12.2009** bei GKSS, DAAD
  Nanofibers

- **M. Sc. K. Hirmas 01.07.-31.12.2009** bei GKSS, HUG
  Nanowires

- **M. Sc. S. Homaeigohar 01.07.-31.12.2009** bei GKSS, DAAD
  Nanofibres

- **M. Sc. M. Keshavarz Hedayati 01.07.-31.12.2009 (50%)** CAU, DFG
  Advanced nonocomposites

- **A. Usman Zillohu 01.07.-31.12.2009** bei GKSS, HUG
  Nanofibers

**Lectures, Seminars, and Laboratory Course Offers**

**Winter 2009/2010**

Nanochemistry for Nanoengineering, 2 hrs Lecture/Week, M. Elbahri

Nanochemistry for Nanoengineering - Seminar, 1 hrs Seminar/Week, M. Elbahri

**Third-Party Funds**

GKSS, Helmholtz / University research foundation, 01.03.2009-28.02.2015 (2.100.000 EUR)

DFG, Nanosynthesis and Nanopatterning based on “Drop-on-a-hot-plate”, 27.03.2009-27.09.2011 (280.370 EUR)

Uni Kiel, Ph.D scholarship for Ramzy Abdelaziz, 01.08.2009-31.07.2010 (10.800 EUR)
Further Cooperation, Consulting, and Technology Transfer

Prof. Dr. F. Faupel, Institute for Material Science, several topics with hybrid organic/inorganic materials with a joint Ph.D student (M. Sc. Mehdi Keshavarz)

Prof. Dr. R. Adelung, Institute for Material Science, several topics nanostructures, biomaterials i.e. submitted DFG joint project for conductive polymer nanowires.

Prof. Dr. L. Kienle, Institute for Material Science, transmission electron microscopy.

Prof. Dr. V. Abetz, GKSS Geesthacht, blockcopolymers

Dr. A. Boschetti-de-Fierro, GKSS Geesthacht, transparent conductors based on CNT/polymer

Prof. Dr. Eich, TU Hamburg, photonic crystal.

Diploma, Bachelor and Master Theses

N. Alissawi, Metallo-Polymer Based Smart Materials, 01.10.2009
S.M. Enayat, Novel Method for Fabrication of Nanowires and Nanochannels Using Drop on a Hot Plate, 29.09.2009
A.U. Zillohu, Smart and Multifunctional Nanofiber, 01.12.2009
J. Worley, Synthesis and Characterization of ZnO Nanocrystal, 01.12.2009

Publications


Presentations

M. Elbahri, Green nanosynthesis and nanopatterning using a drop on a hot plate (talk), Nanotech Europe 2009, Berlin, Germany, 28.09.2009

M. Elbahri, Nanochemistry and Nanoengineering (invited talk), German-Denmark (CAU and SDU) workshop, Kiel, Germany, 15.12.2009

Further Activities and Events

Member of Gesellschaft Deutscher Chemiker e. V.

Member of Deutschen Gesellschaft für Materialkunde e.V.
Computational Mechanics

Prof. Dr.-Ing. habil. Jörn Mosler, Head of Department Simulation of Solids and Structures, GKSS-Forschungszentrum Geesthacht GmbH in Geesthacht.

Prof. Mosler became professor of the Faculty of Engineering in 2008. Information about his scientific work is available on the Website of GKSS-Forschungszentrum Geesthacht GmbH in Geesthacht: http://www.gkss.de/.
Polymerbased Multicomponents Materials

Prof. Dr. Volker Abetz, Head of the Institute of Polymer Research GKSS-Forschungszentrum Geesthacht GmbH in Geesthacht.

Results

The Institute of Polymer Research of the GKSS-Forschungszentrum Geesthacht GmbH is structured into several departments, which cover a broad range of activities from synthesis of new polymers via characterisation to processing and application as membranes or structural materials.

Fig. 1: Block copolymer membrane, which was produced by so-called “phase inversion”. The top layer shows the typical pattern of a cylindrical morphology, while the layer underneath is a sponge-like less ordered structure of the same material as the top layer. Pictures taken with scanning electron microscopy, top left a section from the top layer as observed by tapping mode scanning force microscopy, and bottom left shows a cross sectional cut investigated by transmission electron microscopy.

Polymer-based membrane materials are developed for a number of applications, like gas separation, pervaporation, or organic solvent nanofiltration. Depending on the application, membranes are prepared as flat membranes or hollow fibre membranes. Besides the materials design, also the separation processes are developed, where computer simulation plays an essential role. A new area of research in the Institute is the development of polymer-based nanocomposites. Here functionalised nanoparticles, such as carbon nanomaterials, or silica nanoparticles are decorated with polymers in order to incorporate these particles into polymer matrices. This is done by using controlled polymerisation techniques, such as controlled radical polymerisation. Also new high performance polymer matrix materials are developed, which show high potentials for light weight applications.
CMA Center for Materialanalytics

Executive board: Prof. Dr. F. Faupel, Prof. Dr. H. Föll, Prof. Dr. A. Heuberger, 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:

- materials characterization
- 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
- support of scientific cooperation, service and consulting for industry and research institutes
- coordination and supervision of the recently founded TEM centre
- 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

The CMA offers access to latest, high tech devices, not only during practical courses, but also for research work, e.g. within their respective theses:

- advertisement for the different study courses
- collecting and evaluating applications for the study courses
- mentoring and supervising students, not only in topics related to study courses, but also for foreign students with respect to daily life in Germany
- planning and development of new study courses
- accreditation and reaccreditation of study courses
- examination office materials science
- design and shipping of brochures for information about study courses and the cma
Personnel

Head of the group: Dr. K. Dolgner; Secretary: M. Wallisch (75 percent)
Technical Staff: Dipl.-Ing. K. Rath (85 percent), Christin Szillus

Scientific Staff:

Dr. A. Lotnyk 01.01.-31.10.2009 Third-Party Funded
TEM-Laboratory
Dipl.-Min. M. Schwitzke 01.01.-31.12.2009 (50%)

Lectures, Seminars, and Laboratory Course Offers

Winter 2008/2009

Tutorium for Junior Students, 1 hrs Seminar/Week,
K. Dolgner
Tutorium for Senior Students, 1 hrs Seminar/Week,
K. Dolgner
Basic Lab Course, 4 hrs Lab/Week,
Einführung in die Materialwissenschaft I, 2 hrs Lecture/Week,
K. Dolgner (+ K. Rätzke)
Lab Course Scientific Methods, 4 hrs Lab/Week,
Tutorium für Bachelorstudierende, 1 hrs Seminar/Week,
K. Dolgner
Grundpraktikum für Ingenieure I, Montagskurs, 4 hrs Lab/Week,
K. Dolgner (+ J. Nass, K. Scholz, T. Hrkac)
Grundpraktikum für Ingenieure I, Dienstagskurs, 4 hrs Lab/Week,
K. Dolgner (+ J. Nass, T. Hrkac, K. Scholz)

Summer 2009

Grundpraktikum für Ingenieure II, Dienstagskurs, 4 hrs Lab/Week,
K. Dolgner (+ M. Schwitzke, K. Scholz, C. Pakula, J. Reverey)
Einführung in die Materialwissenschaft II, 2 hrs Lecture/Week,
K. Rätzke (+ K. Dolgner)
Lab Course: Functional Materials, 4 hrs Lab/Week,
K. Dolgner (+ scientific staff of the Inst. f. Materials Science)
Tutorium for Junior Students, 1 hrs Seminar/Week,
K. Dolgner
Tutorium for Senior Students, 1 hrs Seminar/Week,
K. Dolgner
Grundpraktikum für Ingenieure II, Mittwochskurs, 4 hrs Lab/Week,
K. Dolgner (+ M. Schwitzke, C. Pakula, J. Reverey, T. Peters)

Tutorium für Bachelorstudierende, 1 hrs Seminar/Week,
K. Dolgner

Winter 2009/2010

Tutorium für Junior Students, 1 hrs Seminar/Week,
K. Dolgner

Tutorium für Senior Students, 1 hrs Seminar/Week,
K. Dolgner

Basic Lab Course, 4 hrs Lab/Week,

Einführung in die Materialwissenschaft I, 2 hrs Lecture/Week,
K. Dolgner (+ K. Rätzke)

Lab Course Scientific Methods, 4 hrs Lab/Week,

Tutorium für Bachelorstudierende, 1 hrs Seminar/Week,
K. Dolgner

Grundpraktikum für Ingenieure I, Dienstagskurs, 4 hrs Lab/Week,

Grundpraktikum für Ingenieure I, Mittwochskurs, 4 hrs Lab/Week,
K. Dolgner (+ K. Meurisch, I. Paulowicz)

Third-Party Funds

contract work, maintenance and expansion of equipment, 01.01.-31.12.2009 (5.583,60 EUR)

Further Cooperation, Consulting, and Technology Transfer

Cooperation with Industry

1. Tijet Medizintechnik GmbH, Kiel
2. Deutsches Zentrum für Luft- und Raumfahrt e. V., Köln
3. Sagem Orga GmbH, Flintbek
4. Institut für Schadenverhütung und -forschung, Kiel
5. HDW, Kiel

Industrial 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 micro and macro scale
Service Center

The Service Centre was launched at the Faculty of Engineering 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 in the organizational structure of the Faculty of Engineering. The Service Centre is managed by the assistants of 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 programs of both institutes. In case of vacation or illness the employees can replace each other so that service continuity is guaranteed. The following tasks belong to the above-named fields:

Studies

- Accreditation and re-accreditation of all study courses
- Design and development of study and examination regulations
- Capacity calculation
- Public relations, e.g. information days and hosted programs at schools

Teaching and laboratory courses

- Coordination of schedules for all study courses of the two institutes
- Coordination of the rooms for all lectures of the two institutes
- Support of UnivIS entries
- Organization and administration of the joint basic laboratory courses

Examinations

- 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 August, we were happy to welcome our colleagues for an inauguration party. Already half a year after establishing the Service Centre the first change in staff has occurred: Dr. Dolgner, one of the directors of the centre, was elected to the state parliament. This vacancy will be filled in 2010.
Results

Personnel

Head of the group: Dr. Kai Dolgner, Dr.-Ing. Kirstin Scholz; Secretary: Maren Wallisch (75 percent)

Staff:

Vera Nilsson 01.01.-31.12.2009 (50%)
Christiane Otte-Hüls 01.06.-31.12.2009 (50%)
Deanship

Results

The Deans office is the central administration of the Faculty of Engineering and therefore responsible for managing the complete budget including running expenses, investments, and the finances for the staff. Concerning the part of the Faculty located in Kiel-Gaarden, the Dean’s office is also in charge of the computer operating services, the building services and the mechanical workshop. The Dean’s office is managed by Dr. Frank Paul the head of the administration of the Faculty.

To fulfill all these tasks there are about 17 persons in the Dean’s office. Furthermore Prof. Dr. Franz Faupel has been Dean of the faculty since 2008 as well as Prof. Dr. Manfred Schimm ler and Prof. Dr.-Ing. Reinhard Knöchel the Vice Deans.

Worth mentioning are the successful negotiations with several newly appointed professors. In 2009 became Dr. Hermann Kahlstedt, Dr. Dirk Manteuffel and Dr. Bernhard Wagner (“Fraunhofer Institut für Silizium Technologie” in Itzehoe) professors of the faculty. In addition the first “Junioprofessor” of the Faculty of Engineering was welcomed: Dr. Mady Elbahri. His position as well as his group and its funding is financed by the GKSS Research Centre Geesthacht as a member of the “Helmholtz Association” totally.

Besides the impressive scientific work of the different groups which is reflected in this Almanach, the raising of a respectable amount of third party funds has to be mentioned.

Finally it should be noted that the Dean’s office successfully organised the contest “Jugend forscht - Schüler experimentieren” in Schleswig-Holstein. After participation in the regional contest about 50 young participants were guests of the Faculty of Engineering in spring 2009. Later, in Osnabrück two groups were successfully placed on fourth position on the ranking of the federal contest of “Jugend forscht” in Chemistry as well as Mathematics. However, the main aim of supporting “Jugend forscht” is to recruit well educated young scientists for the Faculty of Engineering and the Christian-Albrechts University in general.

Personnel

Dr. F. Paul (Managing Director)

Staff:

S. Anders 01.01.-31.12.2009 (50%)
Head Administrator for Staff and Budget Department

U. Bruse 01.01.-31.12.2009
Division Manager of Building Services

M. Burmeister 01.01.-31.12.2009
Division Manager of the Mechanical Workshop

R. Doose 01.01.-31.12.2009
Caretaker

M. Firnau 01.01.-31.12.2009
Division Manager of Computer Service Department

S. Fischer 01.01.-31.12.2009
Trainee
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<th>Name</th>
<th>Position</th>
<th>Start Date</th>
<th>End Date</th>
</tr>
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<tr>
<td>M. Hacker</td>
<td>Secretary of Budget Department</td>
<td>01.01.2009</td>
<td>31.12.2009</td>
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<td>C. Hinrichsen</td>
<td>Administrator Deans Office</td>
<td>01.01.2008</td>
<td>31.12.2008 (50%)</td>
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<td>S. Johnsen</td>
<td>Employee of the Mechanical Workshop</td>
<td>01.01.2009</td>
<td>31.12.2009</td>
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<tr>
<td>M. Kulling</td>
<td>Employee of the Mechanical Workshop</td>
<td>01.01.2009</td>
<td>31.12.2009</td>
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<tr>
<td>J. Marienfeld</td>
<td>Trainee</td>
<td>01.08.2009</td>
<td>31.12.2009</td>
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<tr>
<td>S. Moeller</td>
<td>Secretary of Staff Department</td>
<td>01.01.2009</td>
<td>31.12.2009</td>
</tr>
<tr>
<td>B. Neumann</td>
<td>Vice Division Manager of the Mechanical Workshop</td>
<td>01.01.2009</td>
<td>31.12.2009</td>
</tr>
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Friends of the Faculty of Engineering

Einleitung

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. Manfred Schimmner (Assessor)
Prof. Dr. Ulrich Heute (Assessor)
Dr. Ulrich Stier (Assessor)
Herbert Jacobs (Assessor)

Auditors: Prof. Dr. Michael Hanus, Prof. Dr.-Ing. Eckard Quandt

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."

"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, 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 2009 the Friends of the Faculty were active concerning these basic ideas. Many different projects were supported and prizes awarded; for the best Diploma, bachelor thesis, master graduation and Ph.D. theses. The 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.

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. It should be noted furthermore, that the president became a member of the “Deutsche Bundestag” in September. Thus the Friends of the Faculty now have an important representative in the economic and political community.