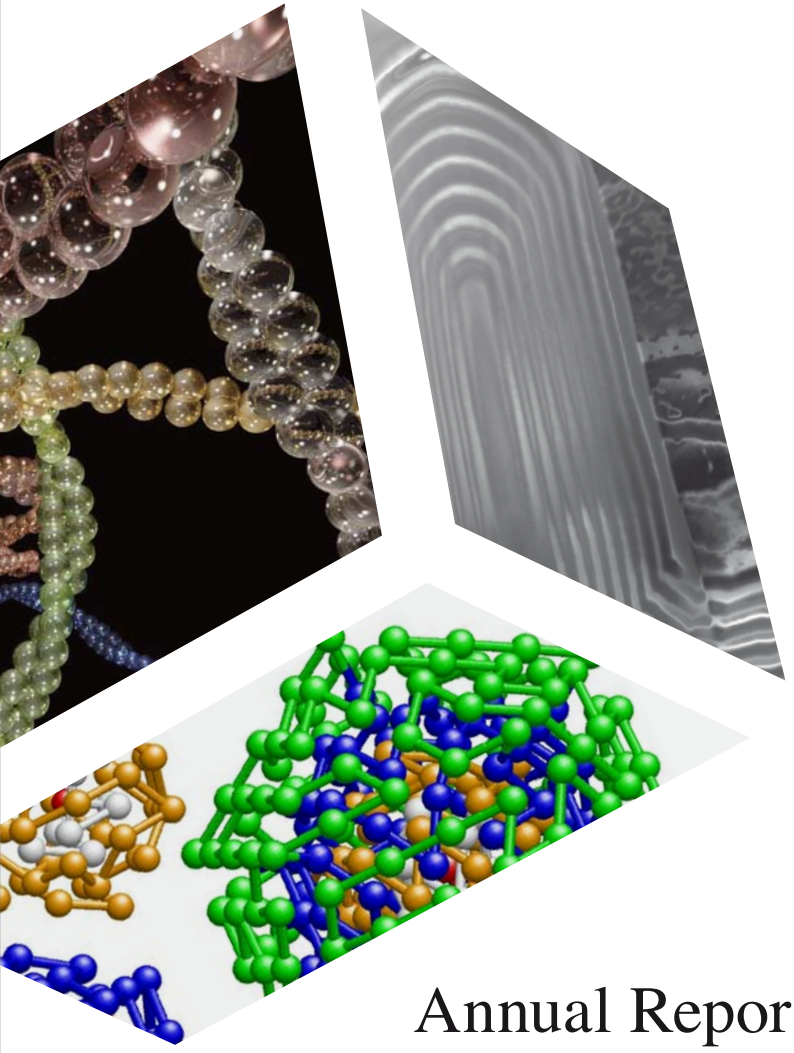
UNIVERSITÄT LEIPZIG

BuildMoNa

Graduate School
Building with Molecules and Nano-objects



Annual Report 2008

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Funded by the DFG within the Excellence Initiative

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Leipzig school of natural sciences – the first year of building with molecules and nano-objects

Preface Prof. Dr. Evamarie Hey-Hawkins

The Graduate School *Leipzig School of Natural Sciences – Building with Molecules and Nano-objects* (BuildMoNa) focuses on interdisciplinary education of young scientists based on excellent research. The latter follows the "bottom-up" strategy for the development of new materials: From suitable building blocks, such as nano-objects, adaptable molecules, polymer grids, peptides and proteins, new materials are designed, preferably by processes like self-organisation. These materials are intelligent, adaptable, environmentally friendly, cost-efficient and resemble living matter. This paradigm shift from homogeneous to multifunctional materials based on an intelligent combination of the above-mentioned building blocks will determine the transfer of knowledge between fundamental and applied research.

Building with molecules and nano-objects is a scientific strategy which is not only reflected in the research projects, but equally in the development and application of new methods and in the training programme.

After the successful application of BuildMoNa *within the Excellence Initiative* proclaimed by the German Federal and State Governments in 2007, the main focus for 2008 was the recruiting of appropriate doctoral candidates as well as the build-up and implementation of the training programme.

Four announcements led to selection of 76 of the proposed 100 doctoral candidates by 31 December 2008. 38 of them are funded by third parties and 23 were offered a BuildMoNa scholarship from the budget of the Graduate School. 20 *ESF-Landesinnovationspromotionen* could be obtained from the European Social Fund (ESF) as a contribution of the Saxon Ministry of Science and Fine Arts (15 started in 2008).

Based on the general concept of BuildMoNa a training programme was constructed according to the curriculum framework of the *Research Academy Leipzig* (RAL). The training programme consists of Scientific and Methods Modules which reflect BuildMoNa's interdisciplinary research focus. Each module has to be completed with an exam graded with credit points referring to the European Credit Transfer System. The Doctoral Degree Regulations of the participating faculties allow the candidates to replace their rigorosum by 10 graded credit points.

In addition to the modules Transferable Skills Workshops were organised, which offer the doctoral candidates a profound development of their soft skills. Scientific events include the BuildMoNa *Symposium* and the BuildMoNa *Workshop for Doctoral Candidates*. Each doctoral candidate can choose appropriate modules and workshops individually in agreement with his/her supervisors. The individual training activities are recorded in a Personal Development Plan.

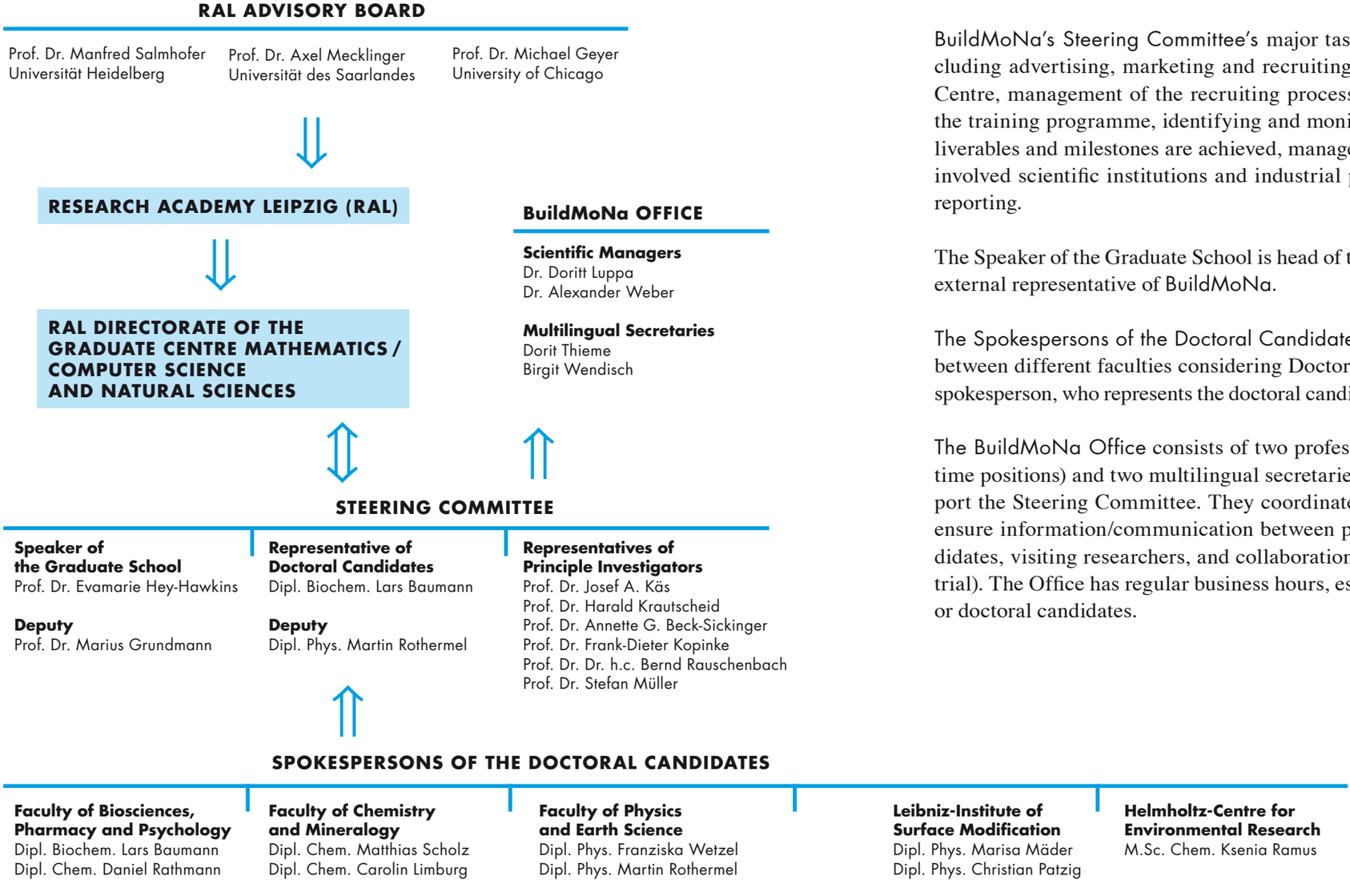
On 10 December 2008 we celebrated BuildMoNa's first anniversary. Amongst other highlights an important one was the presentation of BuildMoNa *Awards* to three doctoral candidates for their scientific publications resulting from their doctoral research. The high quality and number of their scientific publications reflects the large number of excellent young researchers in our Graduate School.

During the next year, 2009, which will see the 600th anniversary of the foundation of our university, we expect to fill the final slots for doctoral candidates as well as to graduate the first third-party funded doctoral candidates. We will further develop the already well established national and international network of BuildMoNa with universities, research institutes and industry, in which most of our graduates will find their future positions.

Excellency in research and training will form a sound basis for further applications as well as for the continuation of the Graduate School in 2012.

Prof. Dr. Evamarie Hey-Hawkins

Organisation and management



The Graduate School BuildMoNa is a class of the *Research Academy Leipzig* (RAL) within the Graduate Centre for Mathematics, Computer Science and Natural Sciences, its director being Prof. Dr. S. Luckhaus. BuildMoNa is represented within the RAL by Prof. Dr. E. Hey-Hawkins as RAL Board member and by Lars Baumann as representative of the doctoral candidates.

The RAL Advisory Board evaluates the scientific activities of the Graduate School by accepting the annual report and providing recommendations for further development.

BuildMoNa's Steering Committee's major tasks are: coordination of activities including advertising, marketing and recruiting in collaboration with the Graduate Centre, management of the recruiting process, establishment and organisation of the training programme, identifying and monitoring whether the programme's deliverables and milestones are achieved, management of the collaboration with other involved scientific institutions and industrial partners, management of funds, and reporting.

The Speaker of the Graduate School is head of the Steering Committee as well as the external representative of BuildMoNa.

The Spokespersons of the Doctoral Candidates are responsible for communication between different faculties considering Doctoral Candidate's issues. They elect one spokesperson, who represents the doctoral candidates within the Steering Committee.

The BuildMoNa Office consists of two professional scientific managers (two half-time positions) and two multilingual secretaries (two half-time positions), who support the Steering Committee. They coordinate the doctoral training activities and ensure information/communication between participating scientists, doctoral candidates, visiting researchers, and collaboration partners (non-university and industrial). The Office has regular business hours, especially for requests from applicants or doctoral candidates.

Doctoral candidates

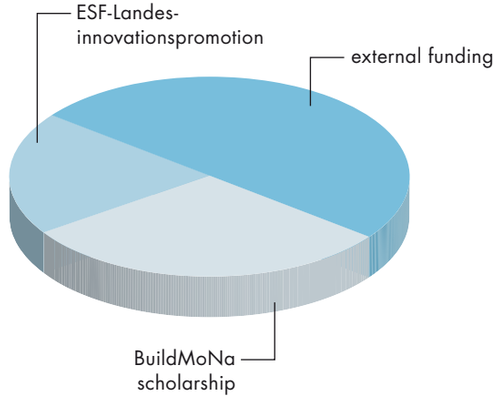
Title and Name	First / Second Supervisor	Working title of doctoral thesis
M.Sc. Chem. Dalia Angeles-Wedler	Prof. Dr. F.-D. Kopinke	*Environmental application of palladium catalyst for hydrodechlorination reactions*
Dipl. Chem. Sebastian Bauer	Prof. Dr. E. Hey-Hawkins / Prof. Dr. B. Kersting	*Synthesis of carbaboranylphosphonites as ligands for late transition metal complexes*
Dipl. Biochem. Lars Baumann	Prof. Dr. A.G. Beck-Sickinger / Prof. Dr. A. Robitzki	*Structure-activtiy relation of chemokines*
Dipl. Chem. Kathrin Bellmann-Sickert	Prof. Dr. A.G. Beck-Sickinger / Prof. Dr. A. Robitzki	*Improvement of the bioavailability of neuropeptides and chemokines*
Dipl. Chem. Ralf Biedermann	Prof. Dr. H. Krautscheid / Prof. Dr. T. Butz	*Synthesis and characterisation of molecular single source precursors for copper-indium-dichalcogenides*
M.Eng. Material Marina Ines Cornejo	Prof. Dr. B. Rauschenbach / Prof. Dr. M. Grundmann	*Pattern formation on Si- and Ge-surfaces by low-energy ion-beam erosion*
Dipl. Phys. Christian Czekalla	Prof. Dr. M. Grundmann / Prof. Dr. J. Haase	*Microoptical investigation of ZnO resonators*
B.Sc. Chem. Jorge Luis Cholula Díaz	Prof. Dr. Krautscheid / Prof. Dr. M. Grundmann	*Properties of novel precursor based materials*
M.Sc. Chem. Marina Loredana Drob	Prof. Dr. M.R. Buchmeiser / Prof. Dr. B. Rauschenbach	*Biopolymeric materials for regenerative medicine*
M.Sc. Phys. Srujana Dusari	Prof. Dr. P. Esquinazi / Prof. Dr. H. Morgner	*Measurements of the mean free path and spin diffusion length in multigraphene*
M.Sc. Phys. Susanne Ebert	Prof. Dr. J. Käs / Prof. Dr. A. Robitzki	*The development of a novel technique to measure the proteomic content of biological cells by combining microfluidics, laser-based nano-manipulation and optical high-resolution tomography*
Dipl. Phys. Roxana-Giorgiana Ene	Prof. Dr. F. Kremer / Prof. Dr. M.R. Buchmeiser	*Structural levels of organisation in spider silk as studied by time-resolved polarised Rheo-FTIR spectroscopy*
M.Sc. Chem. René Frank	Prof. Dr. E. Hey-Hawkins / Prof. Dr. A.G. Beck-Sickinger	*Carbaboranyl amino acids for application in BNCT*
Dipl. Phys. Heiko Frenzel	Prof. Dr. M. Grundmann / Prof. Dr. H. Morgner	*Transport investigations on ZnO based field-effect structures*
M.Sc. Chem. Dirk Friedrich	Prof. Dr. H. Krautscheid / Prof. Dr. M. Grundmann	*Synthesis, characterisation and deposition of CIGS precursors*
Dipl. Phys. Anatol Fritsch	Prof. Dr. J. Käs / Prof. Dr. K. Kroy	*Growth of soft breast tumor cells in micro- and nano-structured hard environments*
Dipl. Biochem. Marco Glaß	Prof. Dr. A. Robitzki / Prof. Dr. A.G. Beck-Sickinger	*HP-Bioforce: An integrated and automated screening plattform for functional force measurement at cell and tissue layers for pharmaceutical research*
Dipl. Phys. Jens Glaser	Prof. Dr. K. Kroy / Prof. Dr. S. Müller	*Theory of semiflexible polymers*
M.Sc. Phys. Markus Gyger	Prof. Dr. J. Käs / Prof. Dr. A. Robitzki	*Active and passive biomechanical measurements for characterisation and stimulation of biological cells*
Dipl. Biochem. Sina Haas	Prof. Dr. A. Robitzki / Prof. Dr. J. Käs	*Development of a bioforce microarray sensor for measuring cellular biomechanical forces of ischemic cell layers*
M.Sc. Chem. Tobias Hammer	Prof. Dr. H. Morgner / Prof. Dr. A.G. Beck-Sickinger	*Investigation of aqueous solutions with Ion-Scattering-Spectroscopy*
Dipl. Biochem. Rayk Hassert	Prof. Dr. A.G. Beck-Sickinger / Prof. Dr. M. Grundmann	*Peptides for specific adhesion to hard matters*
Dipl. Phys. Helena Hilmer	Prof. Dr. M. Grundmann/ Prof. Dr. F. Cichos	*Growth and characterisation of UV-microcavities*
Dipl. Phys. Florian Huber	Prof. Dr. J. Käs / Prof. Dr. M. Grundmann	*Artificial cell motility*
M.Sc. Phys. Ciprian-Ghiorghita Iacob	Prof. Dr. F. Kremer / Prof. Dr. J. Kärger	*Molecular dynamics of organic materials confined in nano-pores*
M.Sc. Chem. Nicole Jahr	Prof. Dr. S. Berger / Prof. Dr. A.G. Beck-Sickinger	*NMR-investigations at modified ubiquitines*
M.Eng. Material Xiaosong Jiang	Prof. Dr. P. Esquinazi / Prof. Dr. J. Haase	*Magnetoresistance characteristics and hydrogen NMR of single magnetic grains*
M.Sc. Chem. Cathleen Juhl	Prof. Dr. A.G. Beck-Sickinger / Prof. Dr. A. Robitzki	*Investigation of the function of adiponektin receptors by peptide segmentation*

Title and Name	First / Second Supervisor	Working title of doctoral thesis
M.Sc. Phys. Chinmay Khare	Prof. Dr. B. Rauschenbach / Prof. Dr. M. Grundmann	*Glancing angle deposition*
Dipl. Phys. Tobias Kießling	Prof. Dr. J. Käs / Prof. Dr. A. Robitzki	*Molecular marker free isolation of pluripotent haematopoetic stem cells and metastatic cancer cells from blood*
M.Sc. Chem. Aslihan Kircali	Prof. Dr. E. Hey-Hawkins / Prof. Dr. H. Krautscheid	*Phosphorus-rich complexes as precursors for binary or ternary metal phosphides M_xP_y or $M_xM'_yP_z$*
Dipl. Math. Melanie Knorr	Prof. Dr. J. Käs	*Role of stochasticity in a moving thin polymer film*
Dipl. Phys. Markus Kraus	Prof. Dr. F.-D. Kopinke	*Application of coupled temperature- and concentration pulses for the efficient adsorptive catalytic elimination of pollutants from contaminated exhaust air*
Dipl. Biochem. Dana Krinke	Prof. Dr. A. Robitzki / Prof. Dr. A.G. Beck-Sickinger	*Development of an impedance-based HTS screening on novel neuronal 2D and 3D cell culture models for testing drugs against neurodegenerative diseases*
Dipl. Chem. Jochen Lach	Prof. Dr. B. Kersting / Prof. Dr. P. Esquinazi	*Thin films of redox-active high-spin molecules*
Dipl. Phys. Alexander Lajn	Prof. Dr. M. Grundmann / Prof. Dr. J. Käs	*Fabrication and characterisation of transparent field-effect-transistors*
Dipl. Phys. Martin Lange	Prof. Dr. M. Grundmann/ Prof. Dr. F. Cichos	*Growth and characterisation of quantum wire heterostructures*
M.Sc. Chem. Ulrike Lehmann	Prof. Dr. B. Kersting / Prof. Dr. E. Hey-Hawkins	*Hydrogenation of CO_2 by supported container molecules*
Dipl. Chem. Carolin Limburg	Prof. Dr. E. Hey-Hawkins / Prof. Dr. H. Krautscheid	*Ferrocenylphosphanides and phosphanediides as building blocks for heterometallic complexes*
Dipl. Phys. Johanna Lutz	Prof. Dr. B. Rauschenbach	*Phase formation and diffusion behaviour for ion implanted austenitic metal alloys*
M.Sc. Chem. Martyna Madalska	Prof. Dr. E. Hey-Hawkins / Prof. Dr. R. Gläser	*Immobilised switchable phosphine-based catalysts*
Dipl. Phys. Marisa Mäder	Prof. Dr. B. Rauschenbach	*Substrate-bound nano-structures by diffraction mask projection laser ablation*

Title and Name	First / Second Supervisor	Working title of doctoral thesis
Dipl. Phys. Monika Möddel	Prof. Dr. W. Janke / Prof. Dr. M. Grundmann	*Modelling and computer simulations of adsorption specifity of synthetic peptides*
Dipl. Phys. Karla Müller	Prof. Dr. J. Käs / Prof. Dr. A. Robitzki	*The use of scanning probe techniques and laser nano-manipulation to isolate and mechanostimulate highly potent mesenchymal stem cells*
Dipl. Phys. Alexander Müller	Prof. Dr. M. Grundmann / Prof. Dr. W. Janke	*Investigation of carrier dynamics in ZnO films and microcavities*
Dipl. Phys. Nils Neubauer	Prof. Dr. F. Cichos / Prof. Dr. K. Kroy	*Photothermal fluctuation spectroscopy on gold nano-particle dimers*
Dipl. Phys. Lena Neumann	Prof. Dr. B. Rauschenbach / Prof. Dr. M. Grundmann	*Hyperthermal ion assisted atomic assembly*
M.Sc. Phys. David K. Nnetu	Prof. Dr. J. Käs / Prof. Dr. A. Robitzki	*The use of biomechanics to reduce metastatic aggressiveness*
Dipl. Phys. Christian Patzig	Prof. Dr. B. Rauschenbach	*Glancing angle deposition of Si nano-structures*
M.Sc. Chem. Santhosh-Kumar Podiyanacharim	Prof. Dr. M.R. Buchmeiser / Prof. Dr. B. Rauschenbach	*Cyclopolymerisation of 1,6-heptadiynes*
Dipl. Chem. Christian Raeck	Prof. Dr. S. Berger / Prof. Dr. E. Hey-Hawkins	*Investigation of phosphorylation and dephosphorylation with NMR*
M.Sc. Chem. / M.Sc. Environmental protection Ksenia Jolanta Ramus	Prof. Dr. F.-D. Kopinke / Prof. Dr. R. Gläser	*Thermodynamic activity versus total concentration of Xenobiotics as predictors of bioavailability*
Dipl. Chem. Daniel Rathmann	Prof. Dr. A.G. Beck-Sickinger / Prof. Dr. A. Robitzki	*Structure activity relationships of RF-amide peptide receptors with chemical modified peptides*
Dipl. Phys. Martin Rothermel	Prof. Dr. T. Butz / Prof. Dr. M. Grundmann	*Spatially resolved characterisation of the composition, structural disorders and electronic properties of inorganic nano-structures*
Dipl. Phys. Stefan Schnabel	Prof. Dr. W. Janke	*Adsorption and aggregation properties of short substrate binding peptides*
Dipl. Phys. Jens Schneider	Prof. Dr. F.-D. Kopinke / Prof. Dr. M. Grundmann	*Studies of dissociation processes of water exposed to high-frequency electromagnetic fields*
Dipl. Phys. Sebastian Schöbl	Prof. Dr. W. Janke / Prof. Dr. M. Grundmann	*Modelling and computer simulations of molecular pattern recognition*

Title and Name	First / Second Supervisor	Working title of doctoral thesis
Dipl. Chem. Matthias Scholz	Prof. Dr. E. Hey-Hawkins / Prof. Dr. A.G. Beck-Sickinger	*Imitation and modification of bioactive lead structures via integration of clusters*
M.Sc. Phys. Ilya Semenov	Prof. Dr. F. Kremer / Prof. Dr. K. Kroy	*Dynamics of DNA under tension and in confinement*
M.Sc. Molec. Biotechnology Lorenz Steinbock	Prof. Dr. U. Keyser / Prof. Dr. F. Kremer	*Detection und sequencing of biopolymers by electrophoretic translocation through pores*
Dipl. Biochem. Max Steinhagen	Prof. Dr. A.G. Beck-Sickinger	*Enzyme analytics*
Dipl. Biochem. Anja Steude	Prof. Dr. A. Robitzki / Prof. Dr. A.G. Beck-Sickinger	*Development and fabrication of novel peptide based biosensors for neuronal diagnostic tools*
Dipl. Phys. Dan Strehle	Prof. Dr. J. Käs / Prof. Dr. K. Kroy	*Mechanical and dynamic properties of actin bundles*
Dipl. Phys. Sebastian Sturm	Prof. Dr. K. Kroy / Prof. Dr. F. Kremer	*Nonequilibrium dynamics of forced and confined semiflexible polymers*
Dipl. Phys. Chris Sturm	Prof. Dr. M. Grundmann / Prof. Dr. W. Janke	*Investigation of the cw optical properties of ZnO cavities*
M.Sc. Chem. Mavila Sudheendran	Prof. Dr. M. Buchmeiser/ Prof. Dr. H. Krautscheid	*Functional monolithic media*
Dipl. Chem. Ronny Syre	Prof. Dr. B. Kersting / Prof. Dr. M. Buchmeiser	*Photo-induced electron tranfer in multimeric capsule complexes*
Dipl. Phys. Carolin Wagner	Prof. Dr. F. Kremer	*Investigation of the interaction of receptors and ligands by optical tweezers*
Dipl. Chem. Franziska Weichelt	Prof. Dr. M. Buchmeiser / Prof. Dr. B. Kersting	*Synthesis und characterisation of new composite and hybrid materials based on functionalised nano- and microparticles of metal oxides and salts*
M.Sc. Phys. Sandro Wenzel	Prof. Dr. W. Janke	*Quantum Monte Carlo Simulations of low-dimensional quantum spin systems*
Dipl. Phys. Franziska Wetzel	Prof. Dr. J. Käs / Prof. Dr. K. Kroy	*Direct staging of primary mammacarcinomas by determining their cellular composition including metastatically competent cells, dormant cancer cells and cancer stem cells*
Dipl. Phys. Micha Wiedenmann	Prof. Dr. W. Janke / Prof. Dr. B. Kremer	*Cluster aggregation and condensation of nano-objects*
Dipl. Phys. Lars Wolff	Prof. Dr. K. Kroy / Prof. Dr. J. Käs	*Plasticity and active remodelling of cells*
Dipl. Phys. Hendrik Zachmann	Prof. Dr. B. Rauschenbach	*Electrical defects in ion beam assisted deposition of $Cu(In,Ga)Se_2$ thin film solar cells*
Dipl. Phys. Jan Zippel	Prof. Dr. M. Grundmann / Prof. Dr. B. Kersting	*Magnetic tunnel junctions*
Dipl. Chem. Denise Zwanziger	Prof. Dr. A.G. Beck-Sickinger / Prof. Dr. E. Hey-Hawkins	*The labelling of peptide hormones with metal complexes for radiopharmaceutical applications in the field of tumor diagnosis and therapy*

FUNDING OF THE DOCTORAL CANDIDATES' SCHOLARSHIPS:



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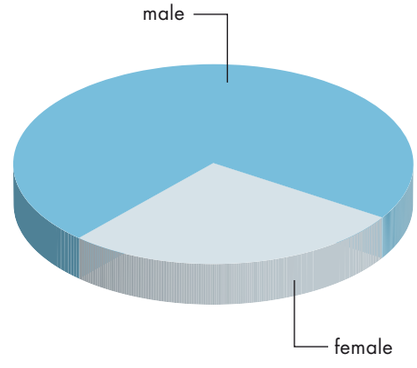

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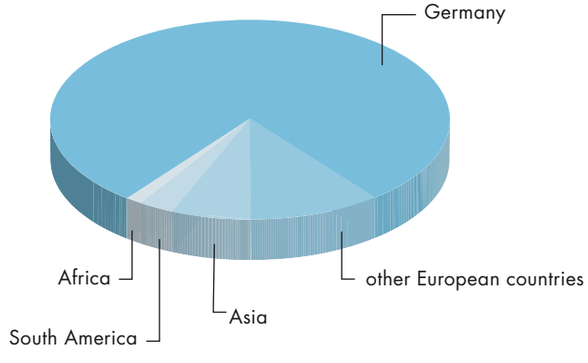


Chemical modification of peptides and proteins

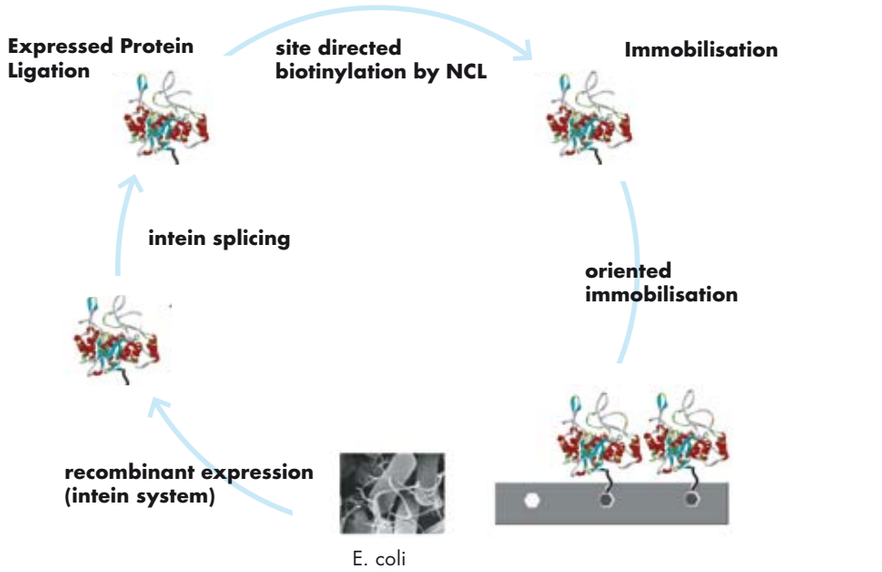
Prof. Dr. Annette G. Beck-Sickinger
Dipl. Biochem. Lars Baumann, Dipl. Chem. Kathrin Bellmann-Sickert,
Dipl. Biochem. Rayk Hassert, Dipl. Chem. Cathleen Juhl, Dipl. Chem. Daniel Rathmann,
Dipl. Biochem. Max Steinhagen, Dipl. Chem. Denise Zwanziger

Aim of the project is the synthesis and testing of chemically modified peptides and proteins for different, mainly nanobiomaterial application. Peptides are synthesised by solid phase peptide synthesis. Proteins are expressed recombinantly and fused to the peptides by native chemical ligation or click chemistry.

Denise Zwanziger and Daniel Rathmann synthesise chemically modified peptide hormones, like neuropeptide Y or neuropeptide FF analogues for diagnostic application. Chelators are introduced into the hormones by means of selective side chain protection strategies and metals like Ga, Gd, Cu or Re are conjugated. Metal-containing peptide hormones are used to follow their uptake into cells and to localise their distribution on a subcellular level. By using ^{99m}Tc the peptides can be used for radiodiagnostics.

Kathrin Bellmann-Sickert, Cathleen Juhl and Lars Baumann work on chemically modified proteins. Interleukin 8 (IL-8) and SDF-1, two chemokines, and adiponectin, a adipocytokine, are chemically modified by polyethyleneglycol, fluorescent dyes, non proteinogenic amino acids or photoactivable protecting groups to induce, follow or modulate activity. Modification with polymers and the generation of these hybrid molecules significantly improves half life under physiological conditions.

Rayk Hassert and Max Steinhagen work on chemically modified peptides and proteins to improve the properties of biomaterials. Rayk develops peptides that bind to surfaces, e. g. Ti, ZnO or Au, whereas Max engineers peptides and enzymes to modulate tailor made properties for immobilisation of biomolecules to surfaces.



⇑ Scheme of specific protein immobilisation

⇒ *Novel Chemically Modified Analogues of Neuropeptide Y (NPY) for Tumor Labelling and Biodistribution*
D. Zwanziger, I. U. Khan, I. Neundorf, S. Sieger, L. Lehmann, M. Friebe, L. Dinkelborg, A. G. Beck-Sickinger / Bioconjugate Chemistry (2008) **19** 1430

⇒ *Radiometal Targeted Tumor Diagnosis and Therapy with Peptide Hormones*
D. Zwanziger, A. G. Beck-Sickinger / Current Pharmaceutical Design (2008) **14** 2385

⇒ *Artificial Chemokines – Combining Chemistry and Molecular Biology for the Elucidation of Interleukin-8 Functionality*
R. David, R. Günther, L. Baumann, T. Lühmann, H.-J. Hofmann, D. Seebach, A. G. Beck-Sickinger / Journal of the American Chemical Society (2008) **130** 15311

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Biomolecular problems studied by NMR

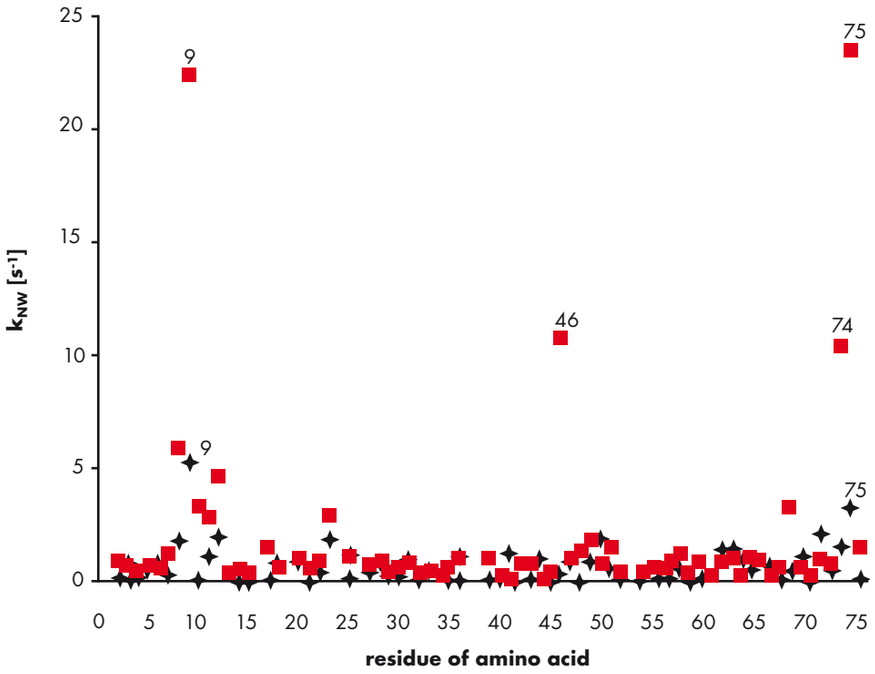
Prof. Dr. Stefan Berger
Dipl. Chem. Nicole Jahr, Dipl. Chem. Christian Raeck

Nicole Jahr investigates the NH-exchange rates of proteins by NMR methods and tries to find a common principle to explain these exchange rates from a structural point of view. The investigated proteins are derived from human ubiquitin by replacing specific amino acids using the point mutant approach. The modified proteins are constructed using known biomolecular procedures, expression and purification techniques.

A new NMR method to measure exchange rates has been developed and is compared methodologically with known procedures such as the MEXICO sequence. A typical diagram of the scientific outcome for the protein ubiquitin F45W, produced

and measured in 2008, is given in the Figure. The theoretical calculations for the interpretation of these results are in progress.

Christian Raeck is studying NMR methods to detect phosphorylation of biological molecules. Although NMR will be always less sensitive than any other spectroscopic method it has the distinct advantage of site specifity, if one applies phosphorylation to a larger peptide or a protein. Christian Raeck could develop and publish (2007) a new pulse sequence which is capable to monitor the kinetics of phosphorylation and dephosphorylation of peptides site specifically. The extension of these techniques for larger proteins is planned.



⇑ Comparison of the NH exchange rates of NT Ubiquitin (red) with the mutant F45W (black)

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Nano-particle modified polymer layers and monolithic separation media for the analysis of biologically relevant compounds

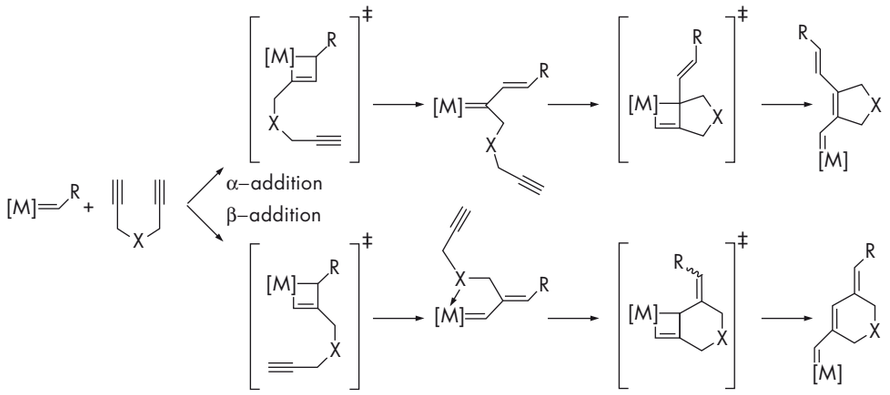
Prof. Dr. Michael R. Buchmeiser
M.Sc. Marina L. Drob, M.Sc. Chem. Mavila Sudheendran,
M.Sc. Santosh K. Podiyanacharim, Dipl. Chem. Franziska Weichelt

Franziska Weichelt synthesises and characterises functional nano-particles for use in coatings. The corresponding nano-composites are designed in a way that they exhibit improved scratch- and abrasion-resistance, improved mechanical properties such as high notch impact strength, but also high UV-resistance, e.g. for wood coatings for outdoor applications.

Santosh K. Podiyanacharim entails the tailor made synthesis of conjugated polymers with high effective conjugation lengths. These are designed in a way that they are soluble in organic solvents and can thus be easily dispersed in coating formulations. The focus here is on antistatic coatings. Additional applications aim on printable electronics. The polymers are prepared via cyclopolymerisation applying both well-defined Schrock and Buchmeiser-Grubbs-Hoveyda initiators.

Marina L. Drob deals with the application-oriented synthesis of micro-, meso- and nanoporous monolithic materials for tissue engineering. The corresponding polymers are designed in a way that they are biocompatible and biodegradable. Synthesis is accomplished both via ring-opening metathesis polymerisation (ROMP) and electron beam-triggered free radical polymerisation. The pore sizes are tailor made and designed in a way that sufficient cell adhesion is guaranteed. Cell proliferation and ingrowth is enabled by providing a substantial amount of large interpenetrating pores in the 200 μm range.

Recently, selective end-capping techniques for ROMP are under investigation that allow not only for the synthesis of telechelic and ditelechelic polymers, but also for functional monolithic materials applying a simple, but highly selective end-capping approach.



⇑ Cyclopolymerisation-derived conjugated polymers

⇒ *Cyclopolymerisation of N,N-Dipropargylamines and N,N-Dipropargyl Ammonium Salts*
Y. S. Vygodskii, A. S. Shaplov, E. I. Lozinskaya, P. S. Vlasov, I. A. Malyshkina, N. D. Gavrilova, P. S. Kumar, M. R. Buchmeiser / Macromolecules (2008) **41** 1919

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Ion beam analysis and material modification at LIPSION

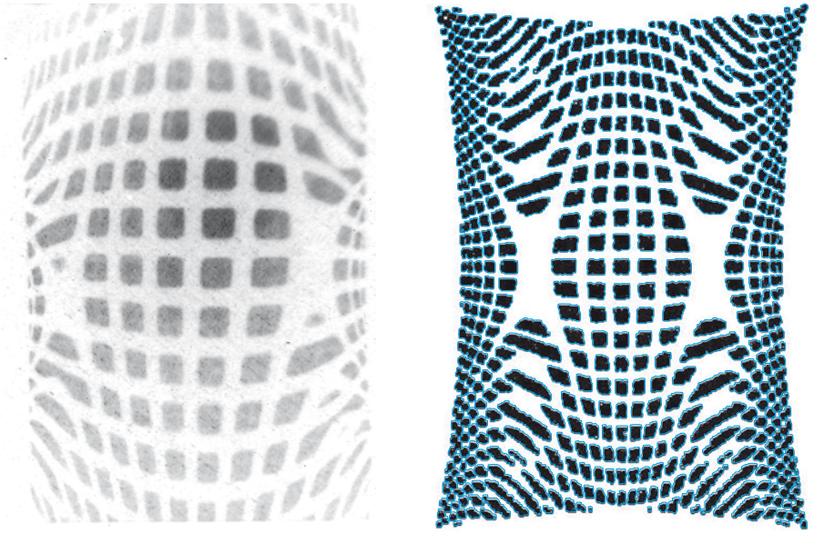
Prof. Dr. Tilman Butz
Dipl. Phys. Martin Rothermel

The contribution by the nuclear solid state division to BuildMoNa's research is manifold. Martin Rothermel investigates the various applications of our high energy nano-probe LIPSION, in material research as well as life sciences.

Since the theoretical limit in resolution is not yet reached, there is still a lot of research on enhancing the resolution in ion beam techniques. That is search for aberrations in the ion optical system, quantitative determination of the aberration coefficients, simulation of the real system and insertion of correcting ion optical elements. Furthermore, the influence of extrinsic disturbances like noisy scan amplifiers is investigated and reduced.

Using the high-performance beam, we were the first to run experiments on PIXE-tomography (Particle Induced X-ray Emission) with sub-micron resolution. However, reconstruction of these data needs a sophisticated iterative algorithm and is still subject to improvement.

The fruitful collaborations with the superconductivity and magnetism division and the semiconductor physics group have been continued. Subjects of this research are “ion beam induced magnetism in highly ordered pyrolytic graphite” and “elemental distribution in nano-structures grown by Pulsed Laser Deposition”.



⇑ Comparison of an experimental (left) and a simulated (right) grid shadow pattern allows to determine the aberrations of the ion optical system

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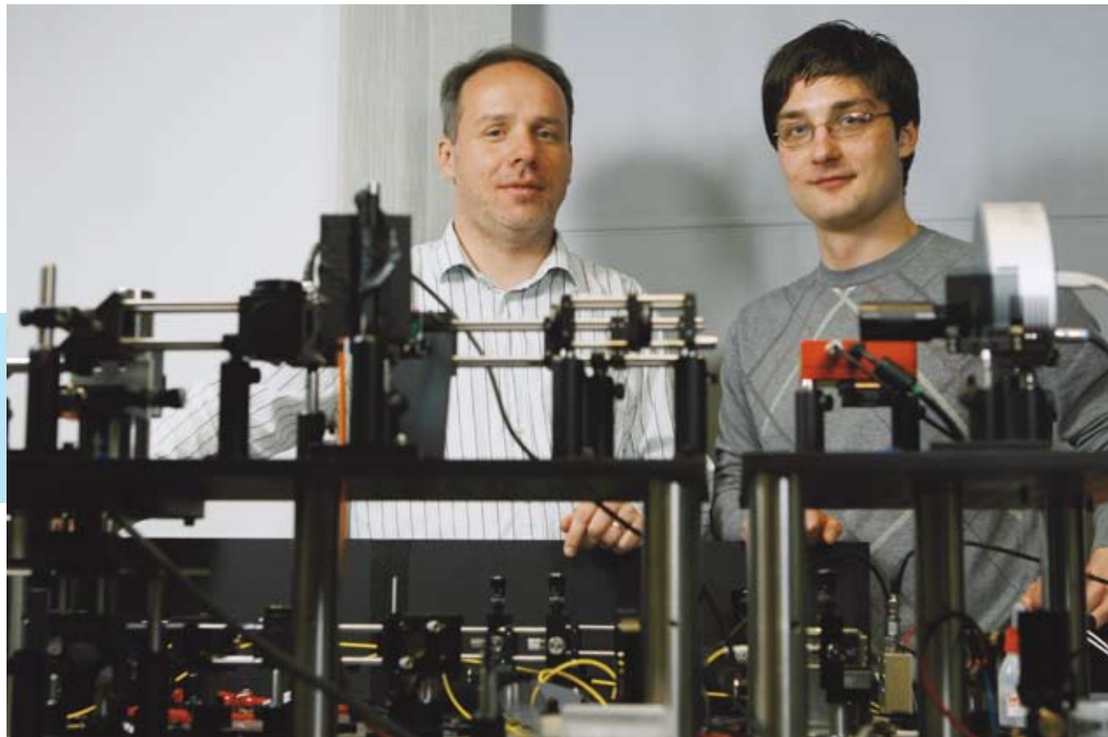
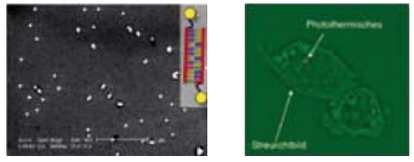
Photothermal detection for biophysical applications

Prof. Dr. Frank Cichos
Dipl. Phys. Nils Neubauer

Measurements of tiny distances on the nanometer scale are usually based on the coupling of two organic chromophores by a strong distance dependent energy transfer (Fluorescence Resonance Energy Transfer). Such organic chromophores, however, suffer from photochemical limitations, which strongly limit their observability. The research group therefore follows new routes to couple extremely photostable gold nano-particles by their plasmon resonance and to develop new detection techniques for distance measurements. For this purpose, gold nano-particles are fixed at a well defined distance with the help of complementary DNA strands. To allow for a detection of even nanometer sized gold nano-particles, the group employs photothermal microscopy that is based on a modulated optical heating of the gold nano-





⇑ Left: 40nm gold nano-particle dimers, which are linked by complementary DNA single strands. Right: gold nano-particles in a fibroplast

particles. The resulting temperature gradient around the particles causes a local refractive index gradient, that is monitored by a highly sensitive heterodyne detection technique. Combined with a newly developed correlation method, these studies are envisaged to provide new insight into the melting of single DNA double strands.

Photothermal detection is further applied to manipulate gold nano-particles in living cells. Gold nano-particles are incorporated into living fibroblasts in collaboration with the group of Prof. Käs. The nano-particles are used to trigger biochemical reactions by the released heat locally, and in a highly controlled way. This heat is supplied by individual gold particles in the cells. The reaction of the cell on the thermal stimuli is monitored with the help of fluorescence and stray light imaging in real time.

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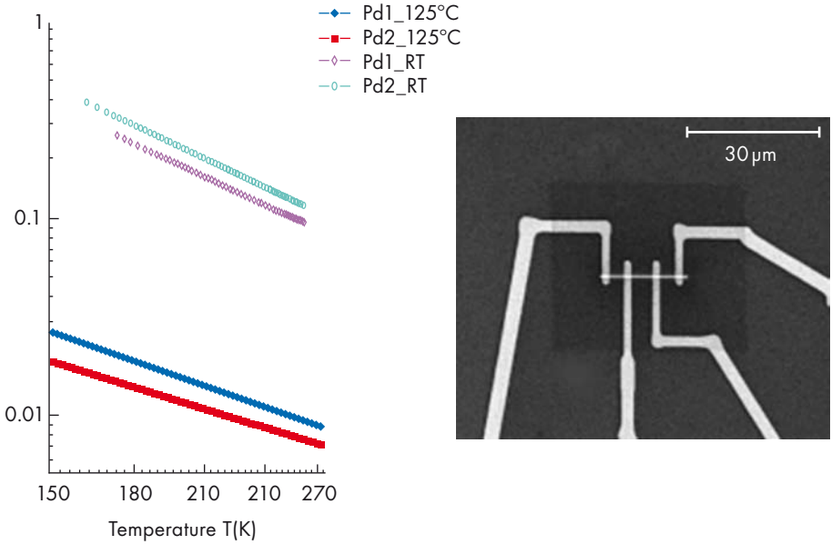
Magnetoresistance characteristics and hydrogen-NMR of single magnetic grains

Prof. Dr. Pablo D. Esquinazi
M. Eng. Xiaosong Jiang, M.Sc. Phys. Srujana Dusari

We want to study the transport properties of single magnetic grains in the micrometer region. There are two main difficulties that one should solve first: (a) the selection and cutting of the grain and (b) the preparation of the electrical contacts without influencing the material itself. Xiaosong Jiang started working on this project in August 2008. By means of a dual beam microscope he is learning how to solve these



⇑ Resistivity vs. temperature of two pairs of Pd-nano-wires (thickness × width × length ~ 150 × 500 × 4000 nm³) prepared at room temperature (upper curves) and at 125°C (lower curves)

⇑ SEM picture of a four point contacts geometry and a nano-wire in between (bar scale: 30 μm)

difficulties. Using graphite as the testing material we prepare thin lamellas (~200 nm thick and an area of several square micrometers). To contact the samples it is not advisable to use Ga^+ ions to deposit the electrodes because these affect the sample itself. Therefore, Electron Beam Induced Deposition (EBID) has to be used. The main problem with this last method is that the deposited electrodes are usually insulating. To increase their conductivity, nano-wires of W, Pd and Pt were deposited by EBID at higher temperatures (above 100°C) and measured. As an example, the results for the PdC nano-wires are shown in the figure. The obtained decrease in resistivity is promising and indicates that the EBID method could be used in the future for contacting the samples.

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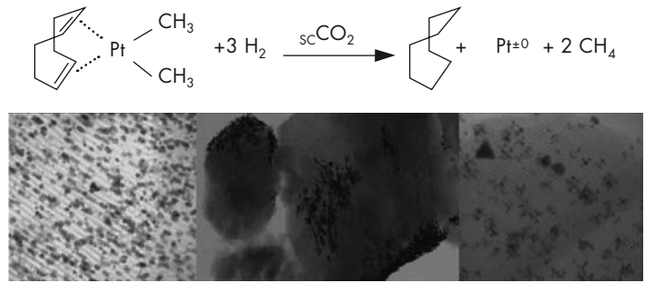
Nanoporous solids as hosts for metal nano-particles and hydrogen storage

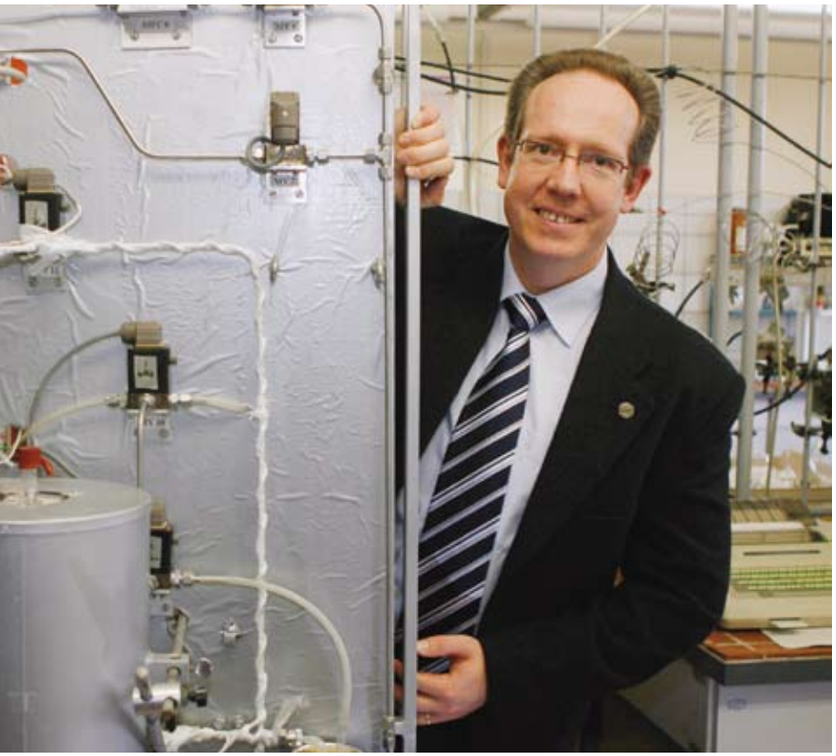
Prof. Dr. Roger Gläser

The research is focused on nanoporous materials with defined porositiy on the micro-, meso- and macroscale. The chemistry of guests under nano-confinement within the pores of these materials is the basis for innovative applications of these materials in sorption and heterogeneous catalysis. For instance, active components of metals and metal oxides are introduced as nano-particles into the pore structures of these materials. These activities form part of the BuildMoNa topical area "complex nanostructures" with contributions to the sub-fields of inorganic nano-structures and surfaces.

Two major lines of research are the following: (i) nanoporous materials are studied as hosts for the storage of hydrogen as a fuel and energy carrier for the future economy. As materials with high potential in this area carbon nano-tubes and nano-fibres, zeolites and metal-organic frameworks are included into this study. (ii) Metal nanoparticles are prepared within the pores of ordered mesoporous materials via reductive



⇑ Reactive deposition of platinum on ordered mesoporous materials with pore diameters of 2–7 nm via reduction of a Pt-complex dissolved in supercritical CO_2



deposition of precursor complexes from supercritical solutions. Previous tasks of our group have now been extended to include multimetallic systems by designing the appropriate precursor complexes and characterising the resulting multimetallic composite materials. Application of these materials as catalysts for the cleaning of off-gas and waste water streams is envisaged.

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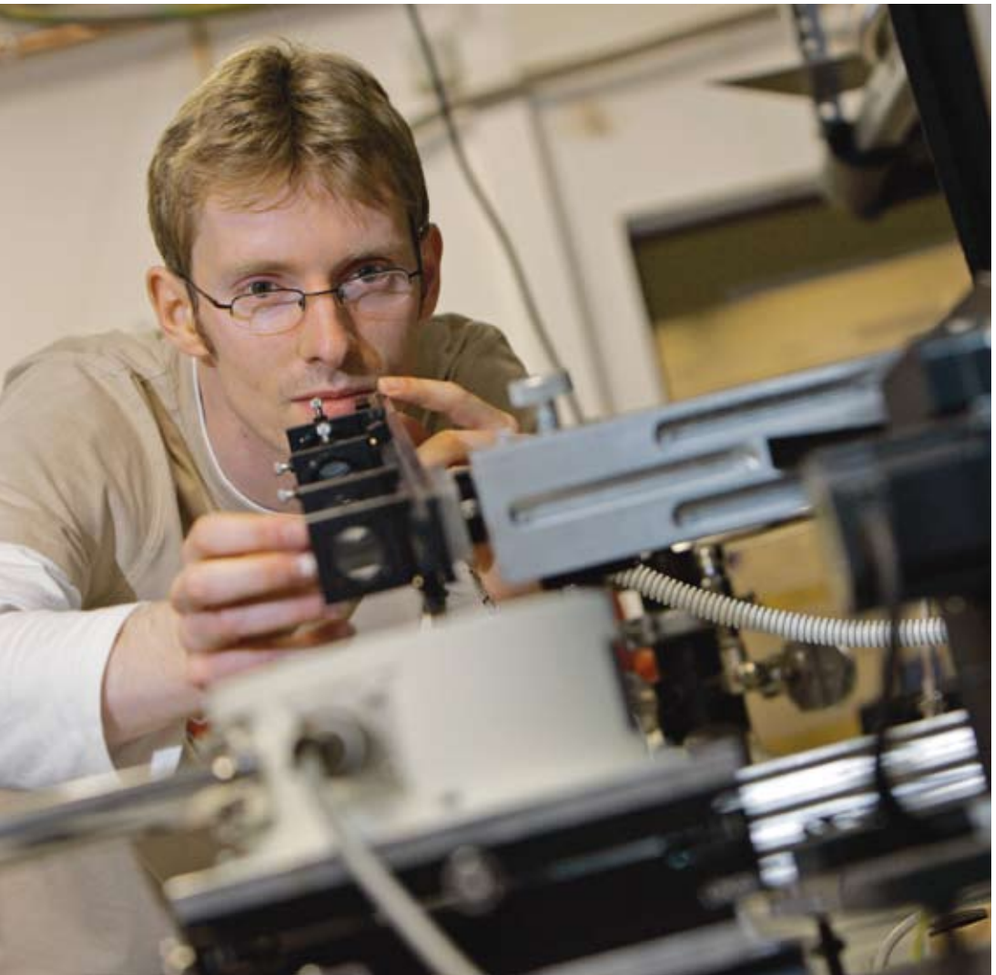
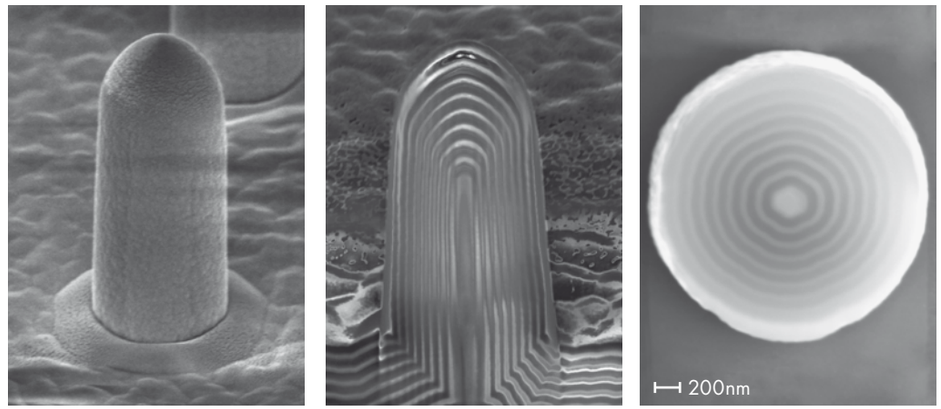
ZnO-nano-wires for miniaturised light sources

Prof. Dr. Marius Grundmann
Dipl. Phys. Christian Czekalla, Dipl. Phys. Heiko Frenzel, Dipl. Phys. Helena Hilmer, Dipl. Phys. Alexander Lajn, Dipl. Phys. Martin Lange, Dipl. Phys. Alexander Müller, Dipl. Phys. Chris Sturm, Dipl. Phys. Jan Zippel

We investigate light confinement in semiconductor nano-wires based on ZnO. Those nano-structures are building blocks for miniaturised light sources. They are grown with pulsed laser deposition (PLD) at pressures in the range of 10^4 Pa. Pure ZnO micro-wires exhibit lasing when optically pumped. The lasing spectra consist of a series of peaks due to whispering gallery type modes. Mode energies and broadening were systematically investigated by Christian Czekalla and found to agree with a plane-wave model. The intensity of each lasing peak exhibits a strong non-linear characteristic vs. pump power with a low threshold of about 150 kW/cm^2.

The growth of MgZnO/ZnO heterostructures on top of ZnO nano-wires leads to the formation of ZnO quantum dots which have been detected through their sharp, individual luminescence lines. The growth of MgZnO/ZnO heterostructures around ZnO nano- and micro-wires leads to cylindrical quantum wells. In order to reduced lateral leakage of light, the nano-wires have been 'wrapped' with a cylindrical Bragg mirror consisting of alternating layers of two dielectrics with different refraction indices as seen in the figure. Such layers had been optimised on planar substrates first and found by Chris Sturm to lead to strong exciton-photon coupling in planar ZnO based resonators. Further work of Helena Hilmer will be directed towards three-dimensional light confinement and exciton-polariton condensation. Equally based on ZnO, transparent MESFETs (Schottky gate field effect transistors) were fabricated by Heiko Frenzel and Alexander Lajn. The devices show superior performance compared to reports in the literature.





⇑ Scanning electron images of a PLD grown ZnO nano-wire wrapped with a 8.5 pair Bragg reflector and two cross sections thereof

⇒ *Whispering Gallery Mode Lasing in Zinc Oxide Microwires*
C. Czekalla, C. Sturm, R. Schmidt-Grund, B. Q. Cao, M. Lorenz, M. Grundmann / Applied Physical Letters (2008) **92** 241102

⇒ *Spatial Fluctuations of Optical Emission from Single ZnO/MgZnO Nanowire Quantumn Wells*
C. Czekalla, J. Guinard, C. Hanisch, B. Q. Cao, E. M. Kaidashev, N. Boukos, A. Travlos, J. Renard, B. Gayrel, D. Le Si Dang, M. Lorenz, M. Grundmann / Nanotechnology (2008) **19** 115202

⇒ *Structural and Optical Properties of ZrO_2 and Al_2O_3 Thin Films and Bragg Reflectors Grown by Pulsed Laser Deposition*
J. Sellmann, C. Sturm, R. Schmidt-Grund, C. Czekalla, J. Lenzner, H. Hochmuth, B. Rheinländer, M. Lorenz, M. Grundmann / Physica status solidi (2008) **5** 1240

⇒ *ZnO Metal-Semiconductor Field-Effect Transistors with Ag-Schottky Gates*
H. Frenzel, A. Lajn, M. Brand, H. von Wenckstern, H. Hochmuth, M. Lorenz, M. Grundmann / Applied Physical Letters (2008) **92** 192108

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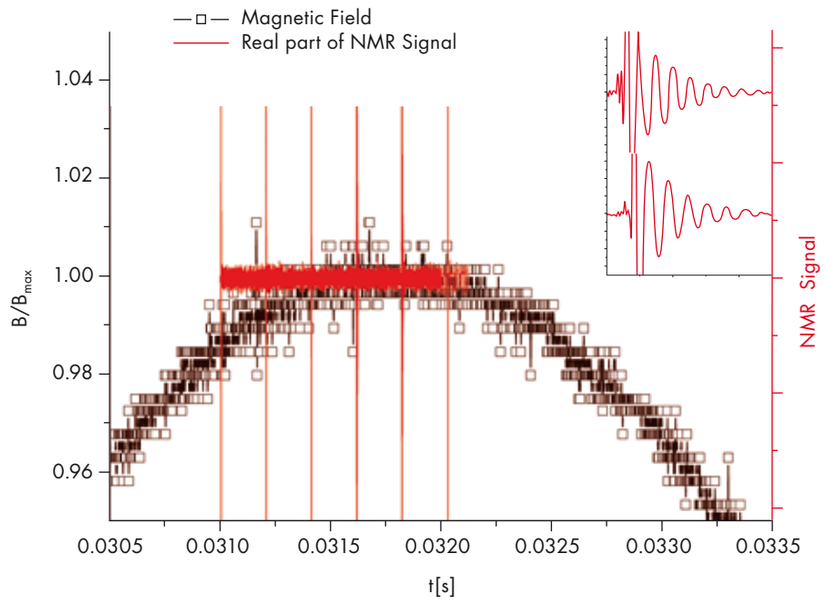
Development of NMR in pulsed magnetic fields and solid state NMR and EPR studies of high-temperature superconductors and metal-organic frameworks

Prof. Dr. Jürgen Haase

Our research deals with the structural characterisation of materials with solid-state nuclear magnetic resonance (NMR) and electronparamagnetic resonance (EPR). These techniques are bulk methods with atomic-scale resolution and element-selective information can be obtained. Within BuildMoNa we focus on three areas of research: development of magnetic resonance in pulsed magnetic fields (up to 80 T), high-temperature superconductors and modern porous coordination polymers, such as metal-organic frameworks (MOF).



⇑ First high-field measurement in pulsed magnets. Variation of magnetic field is shown in black and time domain NMR signal in red and magnified for two signals in the insets

The highest achievable magnetic fields can be generated with pulsed magnets, where the magnetic field is only stable for several milliseconds. The detection of an NMR signal is therefore technically challenging. This work is done in cooperation with the Forschungszentrum Dresden-Rossendorf.

The origin of superconductivity in high-temperature superconductors based on cuprates is not fully understood. NMR at variable temperatures down to liquid helium temperature is a very efficient tool for studying the structure of this type of superconductors.

Metal-organic frameworks combine organic linking groups with metal centres that have a porous structure. Due to their flexible synthesis they are envisioned as special materials for catalysis and chemical separation. Our aim is the spectroscopic characterisation of host-guest interactions with NMR and EPR techniques.

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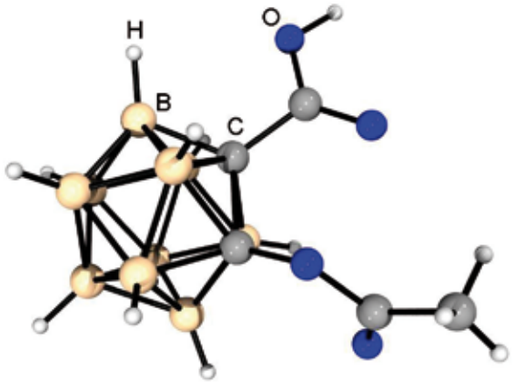
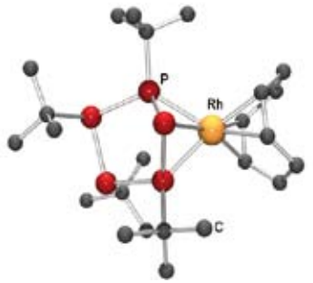
Smart carbaborane- or phosphorus-containing molecules as building blocks in medicinal chemistry, materials science, and catalysis

Prof. Dr. Evamarie Hey-Hawkins
Dipl. Chem. Sebastian Bauer, M.Sc. Chem. René Frank, M.Sc. Chem. Aslihan Kircali, Dipl. Chem. Carolin Limburg, Dipl. Chem. Matthias Scholz, M.Sc. Chem. Martyna Madalska

Besides three-dimensional aromaticity, carbaboranes exhibit extremely high hydrophobicity. They can be easily integrated into organic and biochemical structures due to their organic reaction behaviour, and can therefore replace phenyl groups as pharmacophoric moieties in biologically active structures, e.g., aspirin (Matthias Scholz). Another approach is the integration of carbaborane-containing amino acids into carrier peptides (René Frank).



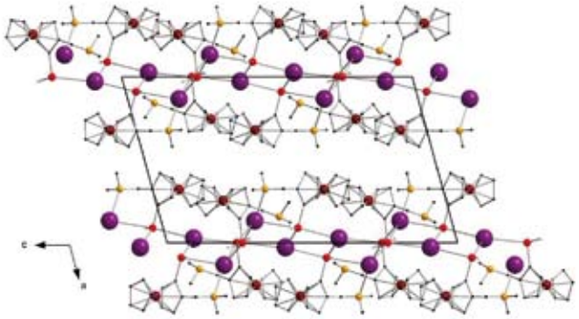
⇑ Asborin – the carbaborane-analogue of aspirin



⇐ Organometallic rhodium-phosphorus precursor molecule

We are developing novel synthetic approaches to binary metal phosphides MP_x, which often exhibit interesting optical, electronic and/or magnetic properties, starting from volatile phosphorus-rich transition metal complexes as molecular precursors (Aslihan Kircali). Other targets are metal phosphanides $M(PR_2)_x$ and phosphanediides $M(PR)_y$ (R = alkyl, aryl, etc.), which can exhibit unusual structures in solution and in the solid state, as well as unusual electronic, magnetic and optical properties (Carolin Limburg).

Chiral bis-phosphines play an important role as ligands in catalytically active complexes. Carbaboranyl bis-phosphines combine the properties of the electron-poor cluster with those of a bis-phosphine and can, furthermore, be selectively functionalised in the 9-position to allow immobilisation and thus combine the advantages of homogeneous and heterogeneous catalysis (Sebastian Bauer). Similarly, chiral ferrocenyl phosphines will be immobilised on electrode surfaces (graphite, gold, etc.), and their applications as switchable catalysts (redox-active ferrocenyl unit) will be explored (Martyna Madalska).



⇑ [{K-1-PH-2-$CH_2N(CH_3)_2C_2H_3$}$Fe(C_5H_5)$]$_n$ forms sheets in the solid state
(hybrid material: inorganic K,P layers covered by organometallic ferrocenyl units)

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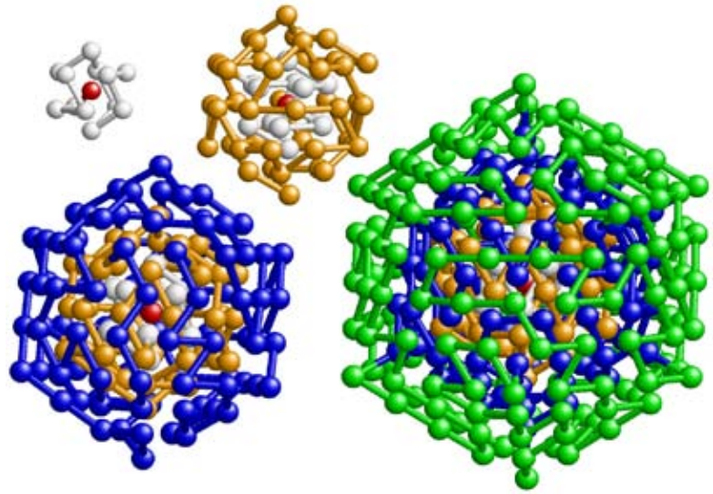
Monte Carlo and molecular dynamics simulations of structure formation processes

Prof. Dr. Wolfhard Janke
Dipl. Phys. Monika Möddel, Dipl. Phys. Stefan Schnabel, Dipl. Phys. Sebastian Schöbl, M.Sc. Phys. Sandro Wenzel, Dipl. Phys. Micha Wiedenmann

The BuildMoNa related research activities of the computationally oriented theoretical physics group currently concentrate on three subprojects: Monika Möddel and Stefan Schnabel study structure formation processes of polymers and proteins employing a variety of coarse-grained mesoscopic models up to all-atom formulations, Sebastian Schöbl and Micha Wiedenmann investigate condensation and aggregation phenomena in simplified lattice models, and Sandro Wenzel focuses on the physics

of quantum phase transitions and other quantum effects for patterned spin systems. The methodology mainly relies on sophisticated Monte Carlo and thermostated Molecular Dynamics computer simulations. They are adapted by us to the problems at hand and are constantly further improved in order to cope with the complexity of the considered problems. More concretely we have analysed hydrophobic collapse, crystallisation, as well as compact hydrophobic-core formation with mesoscopic models for the folding of flexible homo-polymers and hydrophobic-polar hetero-polymers, the aggregation of polymers and peptides, and in particular also their adsorption propensity to attractive solid substrates. The latter research is conducted in close cooperation with the experimental semiconductor and biochemistry groups. For a better understanding of the aggregation mechanism we have developed a micro-canonical formulation which will be helpful for relating this problem to our theoretical investigations of the evaporation/condensation transition in liquid/gas or solid/gas mixtures in the second subproject. The focus of the third subproject is currently on quantum compass models, which may yield important insights into quantum computing, and various dimerised quantum Heisenberg models, for which we have recently, in a special case, identified a quite unconventional quantum phase transition.



⇑ Perfectly icosahedral “magic” ground-state conformations of elastic flexible Lennard-Jones polymers in the crystallisation process

⇒ *Monte Carlo Simulations of the Directional-Ordering Transition in the Two-Dimensional Classical and Quantum Compass Model*
S. Wenzel, W. Janke / Physical Review B (2008) **78** 064402-1–8, Publisher’s Note:
Physical Review B (2008) **78** 099902(E), Fig. 1 selected for Physical Review B “Kaleidoscope” August 2008

⇒ *Evidence for an Unconventional Universality Class from a Two-Dimensional Dimerized Quantum Heisenberg Model*
S. Wenzel, L. Bogacz, W. Janke / Physical Review Letters (2008) **101** 127202-1–4

⇒ *Thermodynamics of Protein Folding from Coarse-Grained Models’ Perspectives*
M. Bachmann and W. Janke / in:
Rugged Free Energy Landscapes: Common Computational Approaches to Spin Glasses, Structural Glasses and Biological Macromolecules
edited by W. Janke, Lecture Notes in Physics (2008) **736** 203

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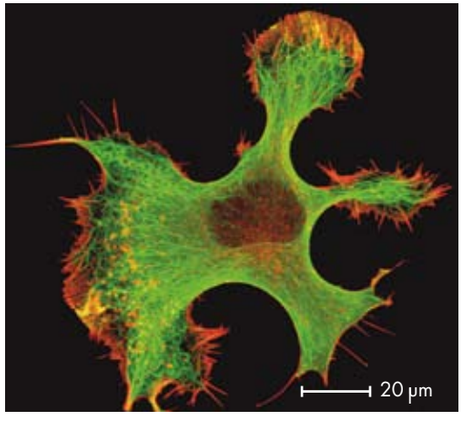
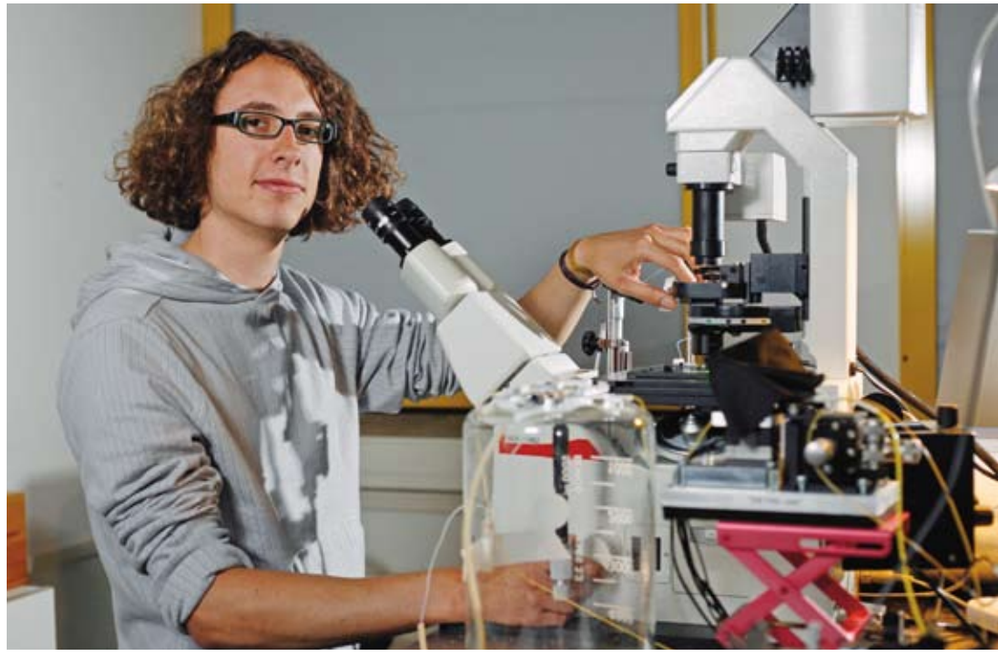
The cytoskeleton – from living nano-structures to cancer diagnosis and stem cell therapy

Prof. Dr. Josef Alfons Käs
M.Sc. Phys. Susanne Ebert, Dipl. Phys. Anatol Fritsch, M.Sc. Phys. Markus Gyger, Dipl. Phys. Florian Huber, Dipl. Phys. Tobias Kießling, Dipl. Math. Melanie Knorr, Dipl. Phys. Karla Müller, M.Sc. Phys. David Nnetu, Dipl. Phys. Dan Strehle, Dipl. Phys. Franziska Wetzel

Nature has been building with molecules and nano-objects for a fairly long time and has thereby developed reliable designs and concepts fitting to that unfamiliar scale of the microcosm. The biophysical research performed in our laboratories aims to investigate these concepts on a cellular level and understand the underlying mechanical mechanisms as well as the occurrence of malfunctions like cancer. Our focus is set on the so-called cytoskeleton, a dynamic network that maintains cell shape, enables cell motility, and plays important roles in both intracellular transport and cellular division. For an integral view on these fascinating features of the cell's cytoskeleton, building blocks such as actin filaments all the way up to whole-cell mechanical properties are subject to studies from our BuildMoNa students.



⇐ Cells, nature's smallest functional units, are able to build up functional structures on the nano-scale with intriguing capabilities such as to generate forces and thus mechanically scan their environment for preferable conditions. Actin (red), Microtubules (green)



We developed a stochastic 2D computer simulation to investigate the formation of growing actin networks in migrating cells. On the same scale we use a bottom up approach to characterise the forces of contractile bundles of actin filaments and motors, enabling cells to probe their surrounding and exert extremely small forces.

The global mechanical response of the cytoskeletal network to defined optical forces allows for the characterising of different stages of a cell, which as we measured, is connected to cell motility and proliferation. Here we study primary and cell line breast cancer cells as well as mesenchymal stem cells.

In order to connect the underlying changes in the architecture of the cytoskeleton of our global mechanical measurements to the nano-world of polymers, a new method was developed for optical high-resolution single cell tomography.

⇒ *Growing Actin Networks Form Lamellipodium and Lamellum by Self-assembly*
F. Huber, J. A. Käs, B. Stuhrmann / Biophysical Journal (2008) **95** 5508

⇒ *The Optical Cell Rotator*
M. K. Kreysing, T. Kießling, A. Fritsch, C. Dietrich, J. R. Guck, J. A. Käs / Optics Express (2008) **16** 16984

⇒ *Errors in Two Particle Tracking at Close Distances*
M. Gyger, F. Rückerl, J. A. Käs, J. Ruiz-García / Journal of Colloid and Interface Science (2008) **326** 382

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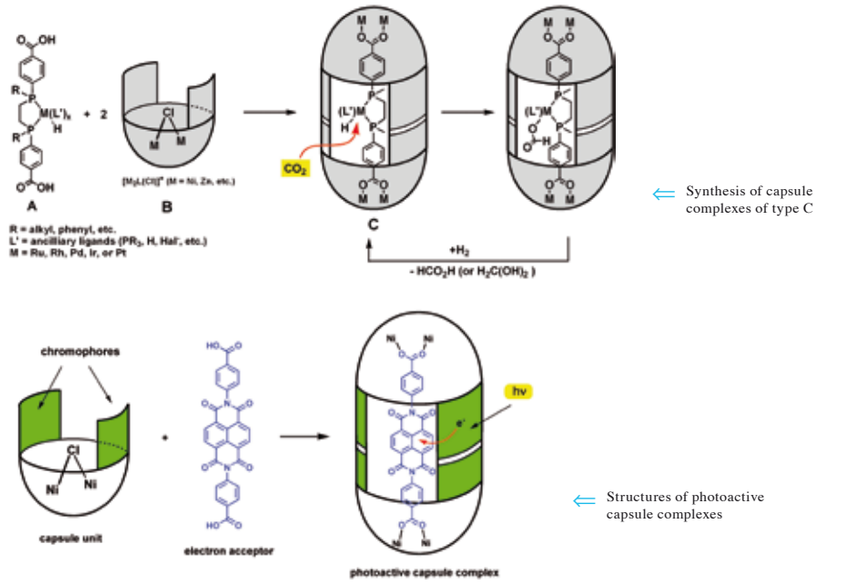
Chemistry of supported container molecules and photo-induced electron transfer in multimeric capsule complexes

Prof. Dr. Berthold Kersting
Dipl. Chem. Jochen Lach, Dipl. Chem. Ulrike Lehmann, Dipl. Chem. Ronny Syre

The host-guest chemistry of capsule-like macromolecules has been extensively investigated and more sophisticated examples with other forms and larger cavities have been reported. An attractive feature is the use of such complexes as molecular reaction chambers for promoting reactions within their interiors. In most cases, non-covalent capsule complexes were designed to study Lewis-acid/base reactions between organic species in solution. What has barely been addressed is the chemistry of supported container molecules and little is known about their



reactivity. The project of Ulrike Lehmann aims at the development and use of type C catalysts which unite novel aspects of supramolecular chemistry and heterogeneous catalysis (see Scheme) for the activation and transformation of small molecules.

Ronny Syre develops novel container molecules containing redox-active and photoactive components to address aspects of photosynthetic mimicry, photocatalysis, and the conversion of light into chemical energy. Particular emphasis of the project will be put on (I) the targeted assembly of spherical multimeric chromophore/electron donor (or acceptor) complexes by using a modular approach, (II) the investigation of their photochemical properties (i.e. photo-induced electron-transfer from chromophores to encapsulated donor or acceptor molecules), and (III) attempts to use these assemblies as homogeneous catalysts for light driven multi-electron transfer reactions (e.g. reduction or oxidation of small molecules such as N_2, CO_2 and H_2O to usable products such as NH_3, H_2, and CH_3OH).

⇒ *Dinuclear Complexes with dithiolate-bridged Square-pyramidal and Octahedral Nickel(II) ions: Syntheses, Characterization and Crystal Structures*
V. Lozan, R. Syre, B. Kersting /
Zeitschrift für anorganische
und allgemeine Chemie (2008) **634** 2330

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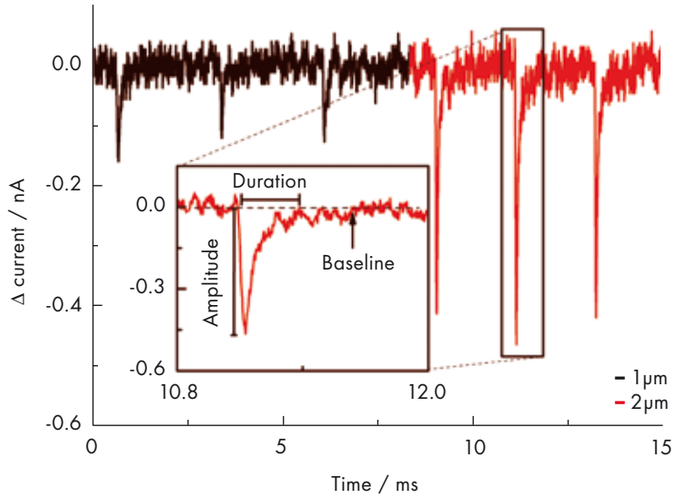
Characterising single molecules and colloids in aqueous solutions

Dr. Ulrich Felix Keyser
since 01.09.2008 Cavendish Laboratory, University of Cambridge
M.Sc. Mol. Biotech. Lorenz Steinbock

The main topic of Lorenz Steinbock's doctoral research is the transport of molecules through cellular membranes. This process is of fundamental importance for any living organism. We are investigating the properties of solid-state micro- and nanopores in aqueous solutions as model systems. Special emphasis lies on the physics of molecules and colloids in these confined geometries. We developed a novel setup combining the well-known resistive-pulse technique with optical tweezers. Our novel single molecule technique provides the means to gain novel insights into the hydrodynamic and electrostatic interactions in salt solutions. Of special interest



⇑ Typical translocation events for 1 and 2 micron colloids in a micro capillary based Coulter counter

is the force on a single DNA molecule or single colloids in liquids. The complex interplay between counter ions and the surrounding water was experimentally investigated and qualitatively modelled by a numerical computer model. We designed and built a new microcapillary-based Coulter counter and detected the surface coating of colloids with diameters down to 200 nm. Further miniaturisation will allow for the detection of single molecules and even proteins by simply measuring the ionic current. In addition a dynamical model was introduced to describe the full translocation process of DNA and molecules in arbitrary geometries.

⇒ *Sensing DNA-coatings of Microparticles Using Micropipettes*
L. J. Steinbock, G. Stober, U. F. Keyser / Biosensors and Bioelectronics,
DOI 10.1016 / j.bios.2008.12.026 (2008)

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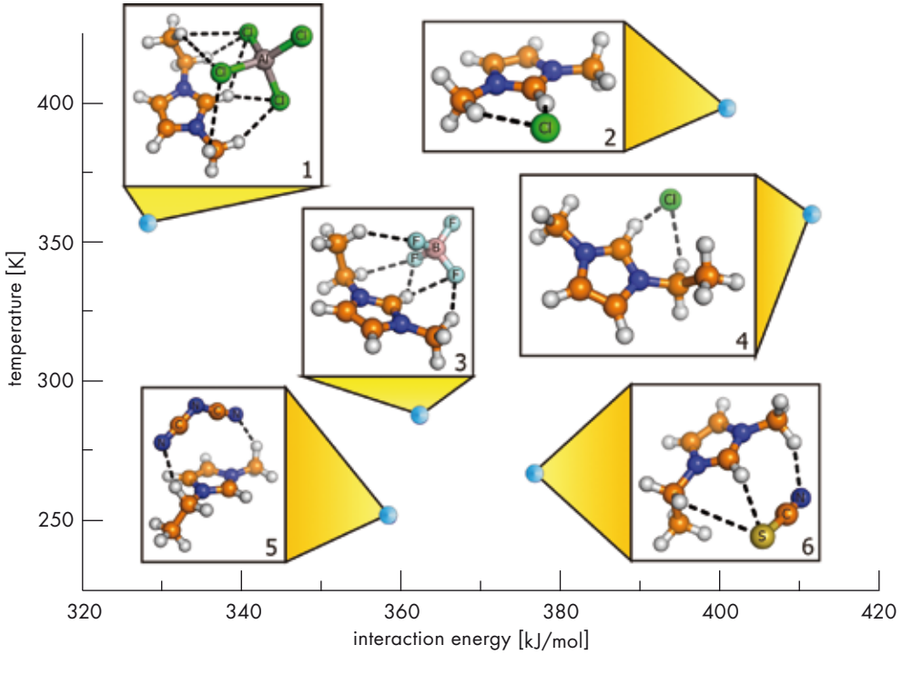
Smart molecules from theoretical calculations

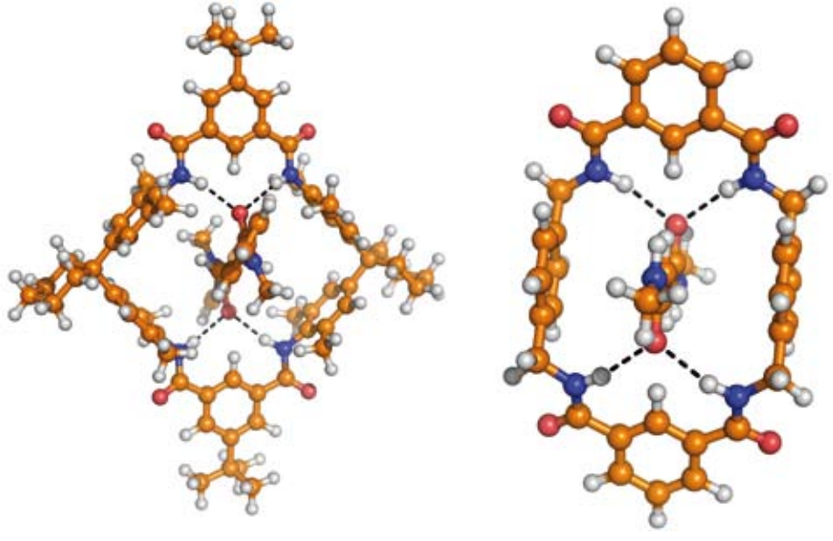
Prof. Dr. Barbara Kirchner

The newly developed relativistic all-electron molecular dynamics simulations method using Douglas–Kroll–Hess theory will be applied to several systems of smart molecules. It will yield more accurate results for spectroscopic properties which are probed at the nuclei. Furthermore, the core electrons will gain enough flexibility to adjust to any situation occurring in order to account for unforeseen events.

The intermediate interaction of ion pairs changing from a typical solid to ionic liquids will be compared by electronic structure calculations. Previously we found the surprising result that the IL minimum geometry is not exclusively determined by largest attractive interaction energy, namely the electrostatics. This implies that the ions interact in the repulsive region considering the electrostatic forces making the overall interaction weaker. Now we want to understand the degree of hydrogen bonding in these smart systems.



⇑ Several ionic liquid ion pairs



⇑ Different types of smart rotaxane molecules

Theoretical calculations of rotaxanes containing different hydrogen bonds will be carried out. Data for different axle-substituted pseudorotaxanes with several hydrogen bonds will be obtained. A descriptor for individual trends of the different hydrogen bonds will be developed.

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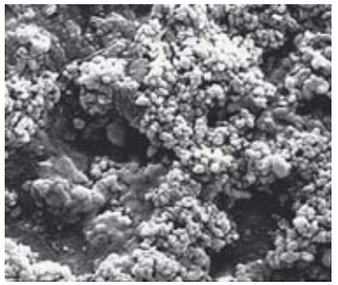
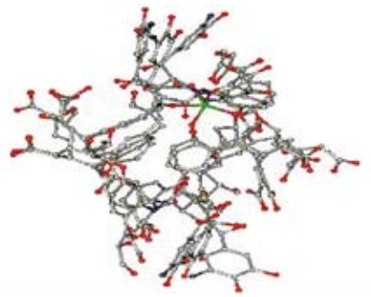
Wastewater and -air treatment with colloids and nano-catalysts

Prof. Dr. Frank-Dieter Kopinke
M.Sc. Chem. Dalia Angeles-Wedler, Dipl. Phys. Markus Kraus,
M.Sc. Chem./Environ. Prot. Ksenia J. Ramus, Dipl. Phys. Jens Schneider

Dalia Angeles-Wedler is going to complete her work on nano-catalysts for water cleaning. She found an efficient procedure based on permanganate to regenerate fouled Pd catalysts, which are highly active in the hydrodechlorination of chlorinated compounds in contaminated wastewaters.
Markus Kraus is looking for an efficient adsorptive-catalytic elimination of pollutants from contaminated exhaust air by a new radio-wave supported technique. The concept is based on a combination of micro-porous adsorbers, nano-scaled metal clusters and their selective dielectric heating.

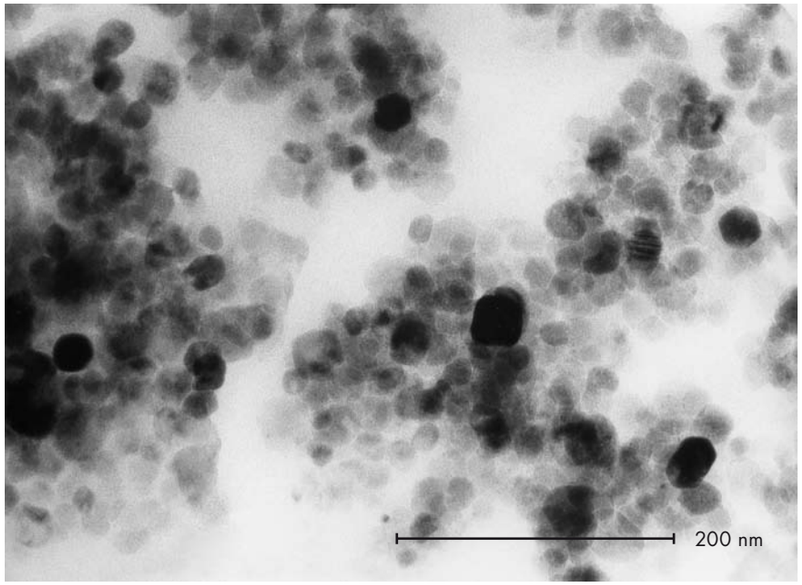


⇑ SEM image (approx. 2000 times enlarged) of solid humic acid (www.hagroup.neu.edu)



⇑ Proposed humic acid building block with a hollow for water retention (Davies et al. 1997)

Ksenia Ramus deals with the influence of natural colloids such as humic acids on the transport and bioavailability of organic pollutants in contaminated groundwater. In contrast to the prevailing view that humic acids enhance the transport of hydrophobic compounds in water by a shuttle-like mechanism, she found that humic acids can significantly hamper the mass transfer of volatile compounds through the



⇑ 20–30 nm magnetite particles coated with 0.15 wt% Pd

water-air interface. This finding may have importance for modelling the fate of such compounds in the unsaturated soil zone.

Jens Schneider will elucidate the phenomenon of water dissociation under the action of high-frequent electromagnetic fields. For thermodynamic reasons there is no hope to find an efficient source of hydrogen gas, but the chemistry behind these phenomena can possibly be exploited for oxidation and reduction reactions in the aqueous phase. These might be controlled by the addition of appropriate nano-catalysts.

⇒ *Influence of Salt Impregnation on the Initiation of Thermo-chromatographic Pulses by Dielectric Heating*
U. Roland, M. Kraus, U. Trommler and F.-D. Kopinke /
Journal of Microwave Power and Electromagnetic Energy (2008) **42** 45

⇒ *Oxidative Water Pre-treatment as a Preventive Strategy against Sulphide Poisoning of Pd Catalyst*
D. Angeles-Wedler, K. Mackenzie, F.-D. Kopinke / Environmental Science Technology (2008) **42** 5734

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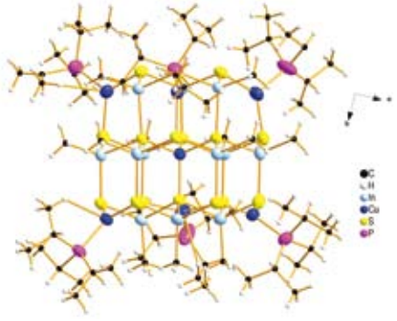
Molecular precursors for copper indium and copper gallium chalcogenides

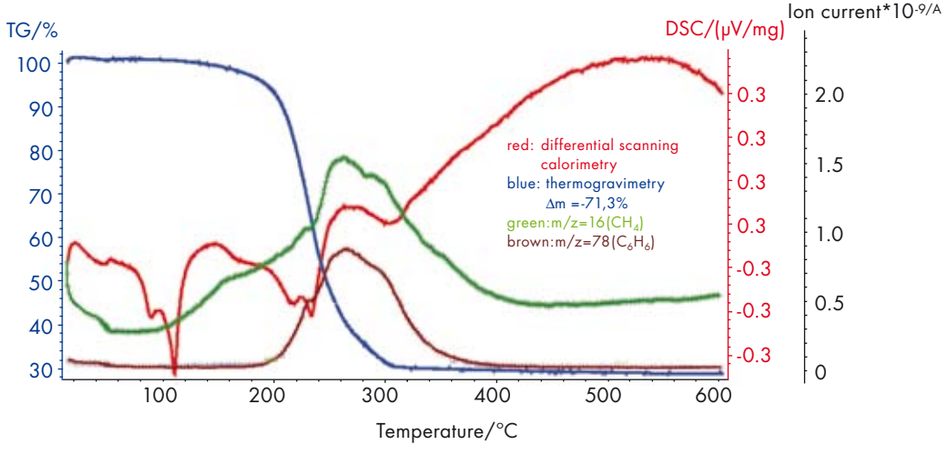
Prof. Dr. Harald Krautscheid
Dipl. Chem. Ralf Biedermann, BSc. Chem. Jorge Luis Cholula Díaz,
M.Sc. Chem. Dirk Friedrich

Research projects related to the Graduate School BuildMoNa focus on molecular compounds that can be used as precursors for the preparation of CuIn and CuGa chalcogenides as thin films. These ternary semiconductors are efficient materials for application in photovoltaics, since they have high absorption coefficients as well as suitable band gaps for the transformation of sunlight into electrical energy.



⇐ Structure of the anion in $[(^{i}Pr_3P)_2Cu(MeCN)][(^{i}Pr_3PCu)_6Cu(InMe)_{12}S_{16}]$, 50% ellipsoids (Cu, In, S, P)

⇓ Thermogravimetric/ DSC analysis of $[(^{t}Bu_3PCu)_2(PhSe)_3(InMe_2)]$



Several molecular clusters containing Cu, In or Ga and Se or S atoms in different ratios have been synthesised, crystallised and characterised by X-ray diffraction and thermal analysis (TG, DSC) methods. Examples range from $[(^{i}Pr_3P)_2CuSSiMe_3(InMe_3)]$ and $[(^{t}Bu_3PCu)_2(PhS)_3(InMe_2)]$ to clusters like $[(^{t}Bu_3PCu)_3(InMe)_4(\mu_2\text{-}PhS)_3(\mu_3\text{-}S_4)]$ or $[(^{i}Pr_3P)_2(MeCN)Cu][(^{i}Pr_3PCu)_6Cu(InMe)_{12}S_{16}]$. All these clusters are stabilised by tertiary phosphine ligands and hydrocarbon substituents; Ga and In atoms are always tetrahedrally coordinated, S and Se atoms act as bridging ligands. They are soluble in organic solvents and decompose at temperatures of 150 to 400 °C yielding the ternary semiconductors. X-ray powder diffraction studies show that the phase purity of thermolysis products varies with the composition of the precursors. For instance, thermolysis of $[(^{i}Pr_3PCu)_4(InMe)_4Se_6]$ yields pure crystalline $CuInSe_2$. Investigations of the thermolysis process and the preparation of thin CuIn and CuGa chalcogenide films are in progress.

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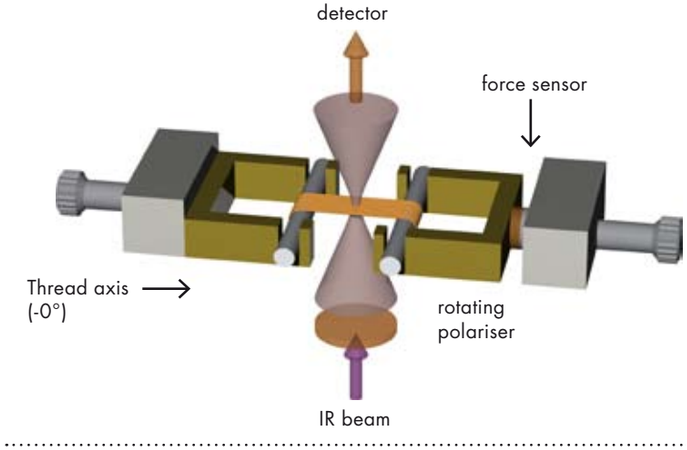
Structure-property relationship in minor ampullate spider silk as unraveled by combined mechanical and time-resolved polarised FTIR studies

Prof. Dr. Friedrich Kremer
Dipl. Phys. Roxana-G. Ene, M.Sc. Phys. Ciprian G. Iacob, M.Sc. Phys. Ilya Semenow, Dipl. Phys. Carolin Wagner

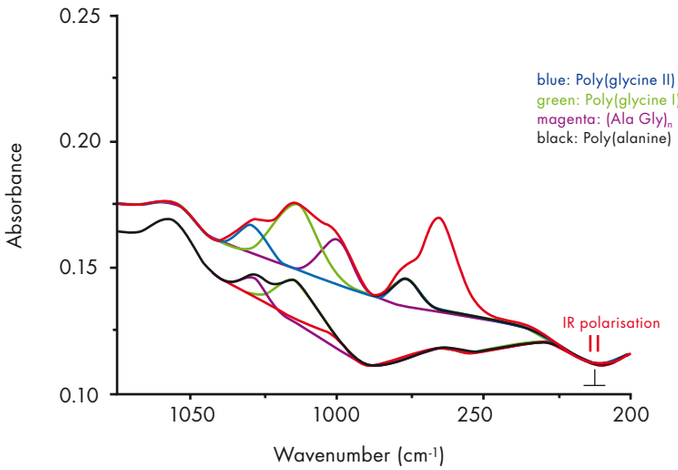
Simultaneous FTIR and mechanical measurements are employed in order to explore the relation between macroscopic and microscopic properties, in spider silk. Minor ampullates have been studied because although their chemical structure is similar to major ampullates, which are composed of a single protein, minor ampullate spidroin (MiSp) is rich in alanine and glycine with the repeating $(AlaGly)_n$ sequence as the dominant pattern, their mechanical properties differ considerably.

The infrared absorption spectrum reveals that the chemical structure of the (MiSp) protein is composed of $(Ala)_n$, $(AlaGly)_n$, PGly I and PGly II. The first two make β-sheets in crystals, PGly I makes low-persistence length β-sheets and PGly

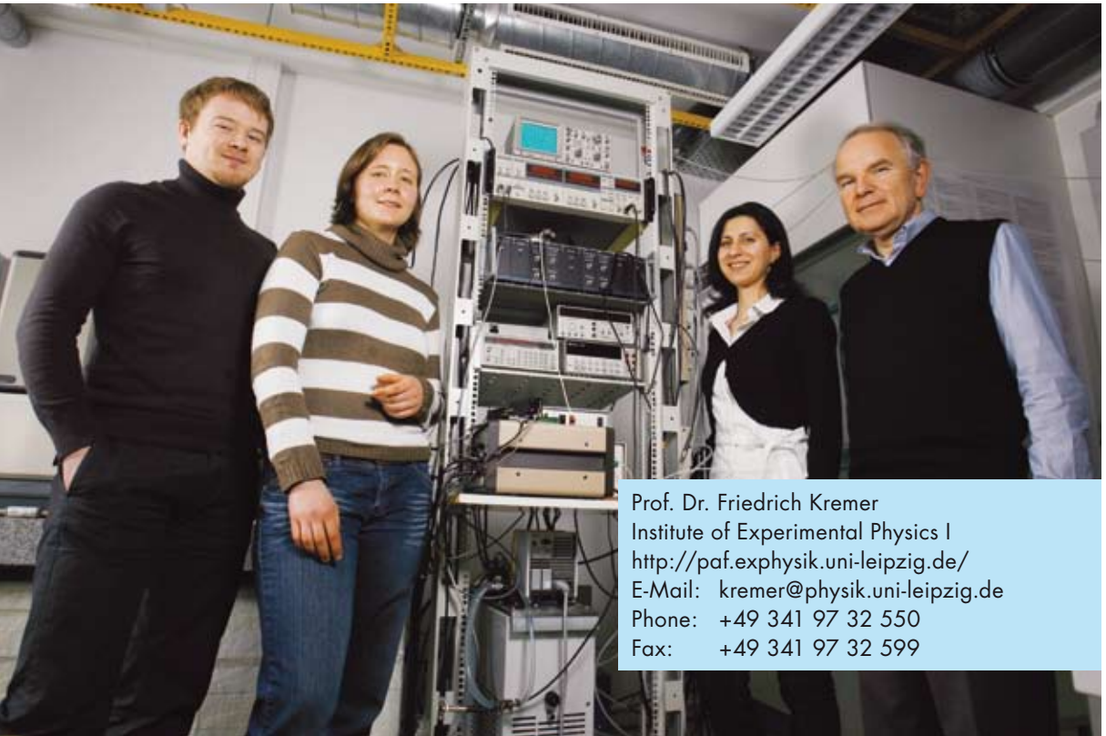


⇐ Experimental setup to measure the polarisation dependency of the infrared absorption spectrum

II makes helices or coils. The $(AlaGly)_n$ and $(Ala)_n$ moieties are already almost perfectly oriented along the fibre. This fact, in combination with the assignment to the β-sheet structure, is the first evidence that these proteins are composed of β-sheeted crystals. On the other hand, the glycine-rich structures have a lower order parameter (S^{mol}) value.



⇐ Infrared absorbance of minor ampullate spider silk with an IR beam polarised parallel (red curve) and perpendicular (black curve) to the fibre axis



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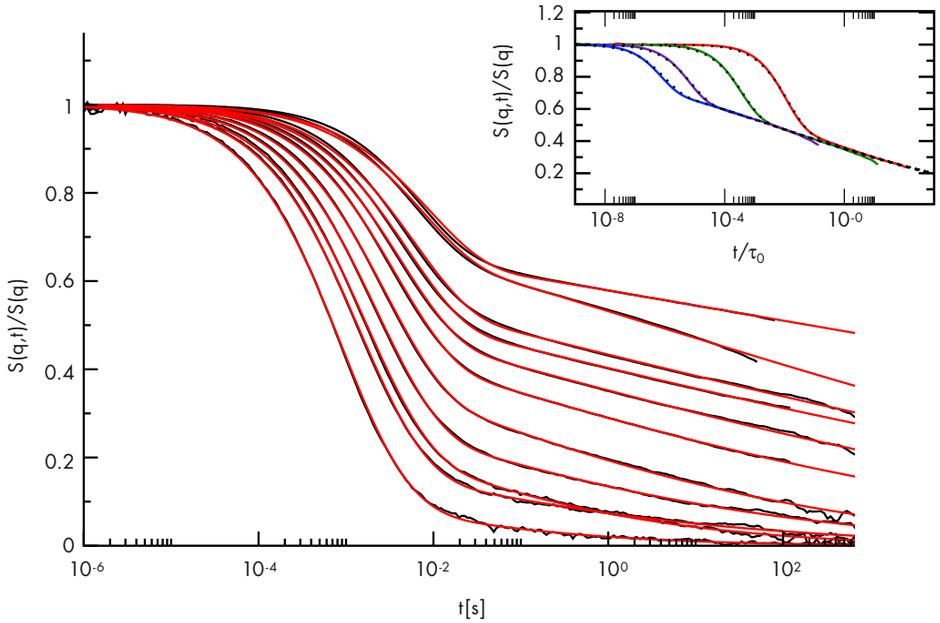
From single molecule dynamics to slow glassy relaxation of networks and living cells

Prof. Dr. Klaus Kroy
Dipl. Phys. Jens Glaser, Dipl. Phys. Sebastian Sturm, Dipl. Phys. Lars Wolff

Multifunctional scaffolds are the essential building blocks of living cells as well as of a broad class of modern synthetic materials. Examples range from the soft cytoskeleton of the animal cell to stiff carbon nanotube networks. These materials share universal properties and a physical description of their mechanical behaviour is indispensable to understand, for example, the effect of stretch on airway cells, which is a major factor in asthma. A successful strategy towards understanding the universal properties of the cytoskeleton as a fibrous, polymeric scaffold has proven



⇑ C. Semmrich, T. Storz, J. Glaser, R. Merkel, A. R. Bausch, K. Kroy, Proc. Natl. Acad. Sci. USA (2007) **104** 20199

to be the ‘bottom-up’ approach, where the complex problem of cell mechanics is investigated in terms of the less complex mechanics of the sub-systems (e.g., in-vitro F-actin networks). In this spirit, we study the nontrivial nonlinear properties of the well established wormlike chain model, which describes single semi-flexible polymers such as actin and DNA. Furthermore, we are working on an extension of the wormlike chain model, the glassy wormlike chain, which accounts for the properties of networks of stiff polymers by taking into account the stickiness and steric interactions of the polymers. From this theory, we were already able to derive quantitative results, which were applied in cooperation with experimental biophysics groups ([1], [2]). The achieved results constitute a significant step towards a quantitative understanding of cell mechanics.

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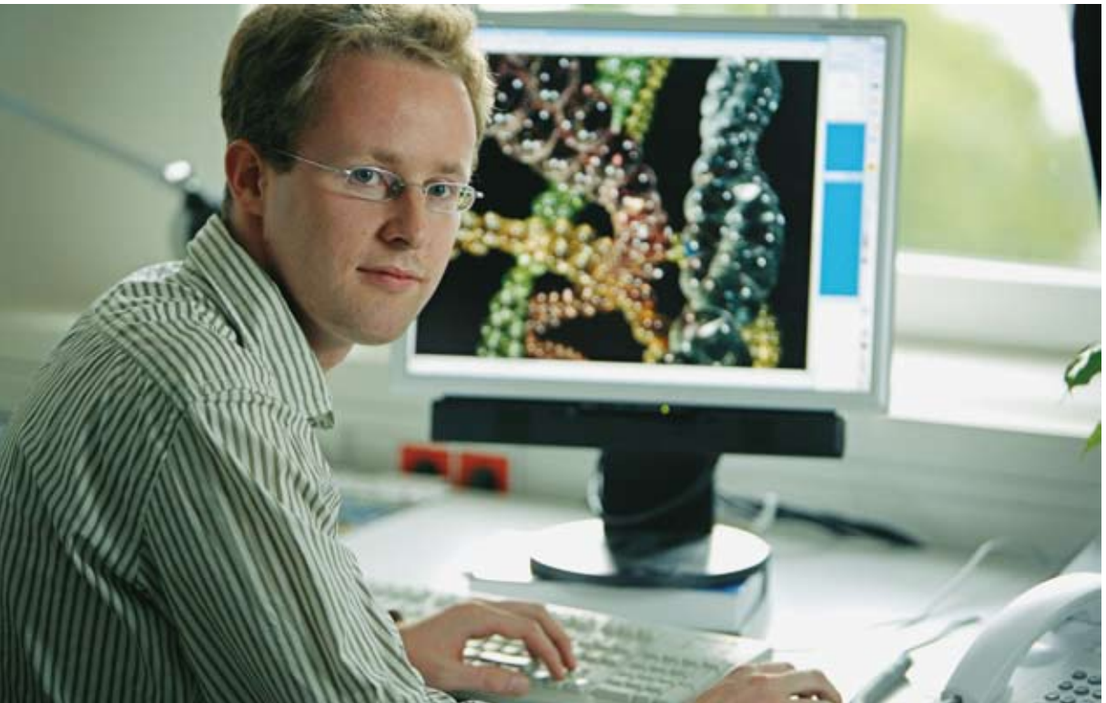
⇒ *[1] Glass Transition and Rheological Redundancy in F-actin Solutions*
C. Semmrich, T. Storz, J. Glaser, R. Merkel, A. R. Bausch, K. Kroy / Proc. Natl. Acad. Sci. USA (2007) **104** 20199

⇒ *[2] Dynamic Structure Factor of a Stiff Polymer in a Glassy Solution*
J. Glaser, O. Hallatschek, K. Kroy / Eur. Phys. J. E. (2008) **26** 123

⇒ *Dynamics of Sticky Polymer Solutions*
J. Glaser, C. Hubert, K. Kroy / Path Integrals – News Trends and Perspectives; W. Janke, A. Pelser (eds.) World Scientific (2008)

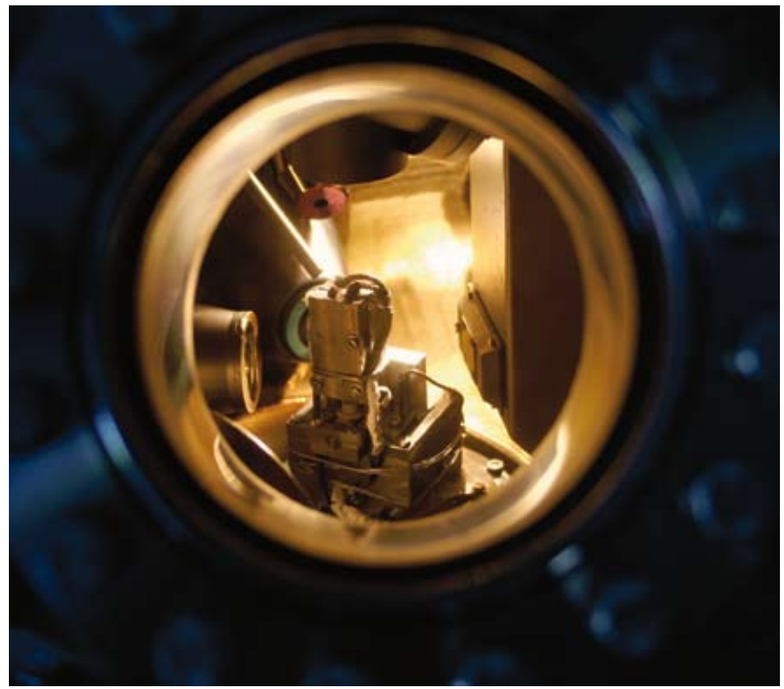
⇒ *Dynamics of wormlike and glassy wormlike chains*
K. Kroy / Soft Matter (2008) **4** 2323



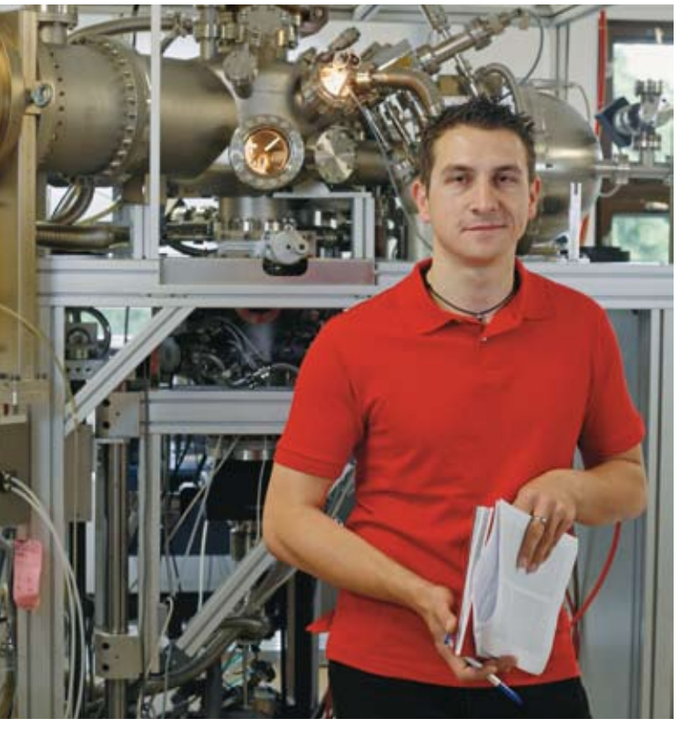
Neutral impact collision ion scattering spectroscopy for the investigation of liquid surfaces

Prof. Dr. Harald Morgner
M.Sc. Chem. Tobias Hammer

Neutral Impact Collision Ion Scattering Spectroscopy (NICISS) is used to study the molecular surface structure of ionic liquids. Ionic liquids are investigated with the emphasis on how the aliphatic chain length of the cation is accomodated at the surface. The standard technique of NICISS is able to yield the concentration depth profiles



⇑ A glimpse into one of our vacuum systems for surface analysis



of all elements present in the sample. The angular resolved version of the technique which we have developed can even characterise the three dimensional structure of the surface.

The technique NICISS is developed further to allow access to volatile liquids, in particular to water at ambient temperature. The construction of the improved apparatus is underway. Preliminary experiments with water exist, but are restricted to aqueous solutions with high salt concentrations and low temperatures. This project aims at the application of the technique to systems of biological relevance and to atmospheric chemistry.

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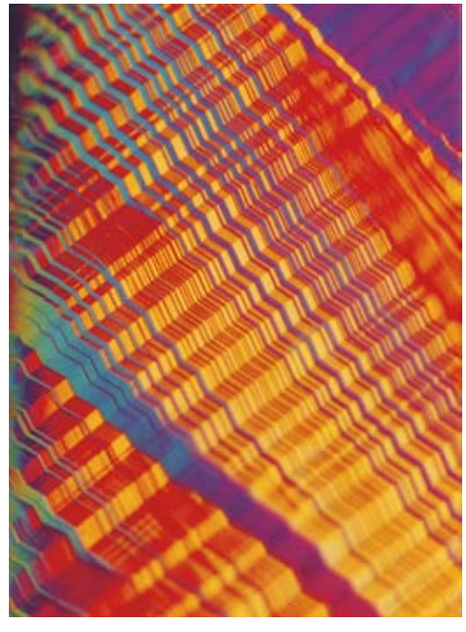
Understanding of formation processes and macroscopic effects of microstructure

Prof. Dr. Stefan Müller
since 01.12.2008 Hausdorff Chair at the Hausdorff Center for Mathematics,
Universität Bonn

Our goal is to develop mathematical methods to describe and understand multi-scale problems and the formation, evolution and macroscopic effects of microstructure, in particular in advanced materials. We have always been fascinated by the subtle interplay of geometry, analysis and physics in nonlinear elasticity, both for conventional and for phase-transforming materials. Results include the first rigorous un-



⇐ Microstructure in a shape-memory material

derstanding of dimension reduction in nonlinear elasticity and rigorous scaling laws for branching near austenite/martensite interfaces. Another important area is micromagnetics, where a simple, yet subtle, energy functional describes a huge variety of magnetisation patterns on very different scales.
Currently we are trying to learn about ideas from probability and statistical mechanics. An ambitious and very long term goal would be to contribute to a rigorous statistical mechanics of solids, which would have to include both a treatment of the breaking of the lattice symmetry at various scales (defects, dislocations, grain and phase boundaries, etc.) and a suitable treatment of metastability (e.g. by the imposition of additional constraints). For the moment we are looking at a much more modest problem. We are studying the strict convexity properties of free energy in scalar lattice gradient models with non-convex interactions by closely following the renormalisation approach of Brydges et al.

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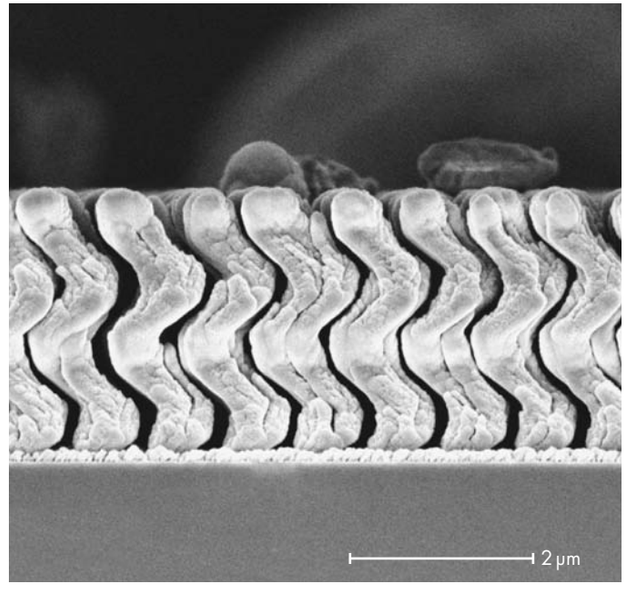
Nano-structures by ion beam techniques

Prof. Dr. Dr. h.c. Bernd Rauschenbach
M. Eng. Mat. Marina I. Cornejo, M.Sc. Phys. Chinmay Khare, Dipl. Phys. Johanna Lutz, Dipl. Phys. Marisa Mäder, Dipl. Phys. Lena Neumann, Dipl. Phys. Christian Patzig, Dipl. Phys. Hendrik Zachmann

In the BuildMoNa projects, the basic investigations focus on the fundamental processes at hyperthermal deposition and at nano-structure growth by laser and low-energy ion beam technologies. The influence of the ion irradiation on the nucleation density, the formation of nano-structures, as well as on the structural properties of the growing ultrathin film as a consequence of the near surface energy and momentum input and ballistic adatom rearrangement by atomic collisions are to be studied. Also the ultrashort laser pulse irradiation of thin metal films is used to form sub-



⇐ Silicon spirals deposited on pre-patterned Si-templates by ion beam sputter glancing angle deposition

wavelength nano-structures in a very controllable way. Silicon nano-structures are grown with the so-called glancing angle deposition technique, a sophisticated vacuum deposition process with precise control of the angle between target and substrate as well as substrate rotation. This technology allows the formation of a manifold of differently shaped nano-structures for example spirals, screws or vertical posts.

⇒ *Large Area Metal Dot Matrices Made by Diffraction Mask Projection Laser Ablation*
M. Mäder, T. Höche, J.W. Gerlach, R. Böhme, K. Zimmer, B. Rauschenbach /
Phys. Stat. Sol. –RLL (2008) **34** 2

⇒ *Growth of Si Nanorods in Honeycomb and hcp Arrays Using Glancing Angle Deposition*
C. Patzig, B. Rauschenbach, B. Fuhrmann, H. S. Leipner /
J. Appl. Phys. (2008) **103** 28844027

⇒ *Nano-pattering by Diffraction Mask-projection Laser Ablation*
M. Mäder, K. Zimmer, R. Böhme, T. Höche, J.W. Gerlach, B. Rauschenbach /
J. Laser Micro/Nano-engineering (2008) **3** 9

⇒ *Periodic Nanoscale Si Structures by Ion Beam Induced Glancing Angle Deposition*
B. Rauschenbach, C. Patzig /
Proceed. 2nd IEEE International Nanoelectroniocs Conference, Shanghai, 1084 – 1088

⇒ *ZnO Nanowall Networks Grown on DiMPLA Pre-patterned Thin Gold Films*
M. Mäder, J. W. Gerlach, T. Höche, C. Czekalla, M. Lorenz, M. Grundmann, B. Rauschenbach /
Phys. Stat. Sol. – RRL, (2008) **2** No.5 200 – 202 / DOI 10.1002 / pssr.200802174

⇒ *Temperature Effect on the Glancing Angle Deposition of Si Sculptured Thin Films*
C. Patzig, B. Rauschenbach /
J. Vac. Sci. Technol. A (2008) **26** 881

⇒ *Comparative Study of Enhanced Fluorescence from Nano Sculptured Thin Films*
I. Abdulhalim, C. Patzig, A. Karabchevsky, B. Rauschenbach /
SPIE Proceed. (2008) **7041** 70410G

⇒ *Glancing Angle Sputter Deposited Nanostructures on Rotating Substrates: Experiments and Simulations*
C. Patzig, T. Karabacak, B. Fuhrmann, B. Rauschenbach /
J. Appl. Phys. (2008) **104** 094318

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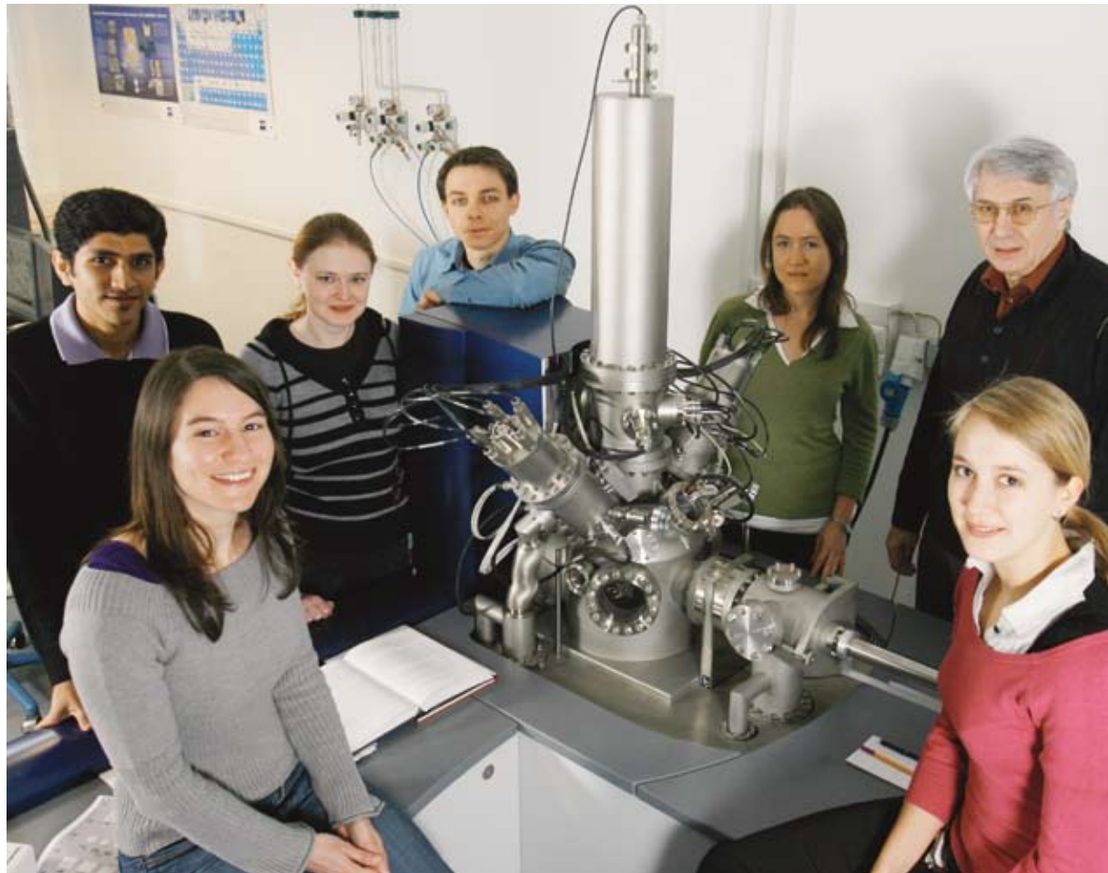
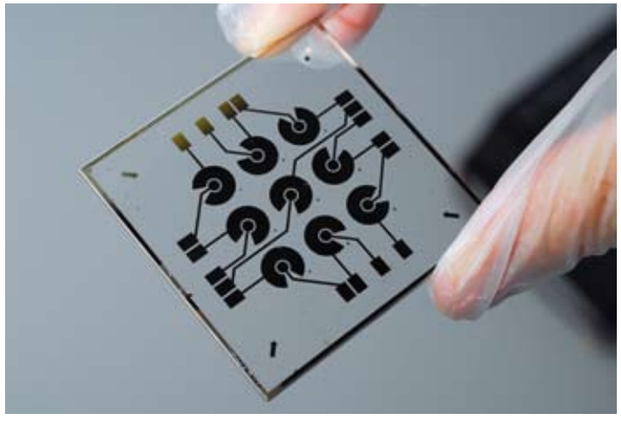


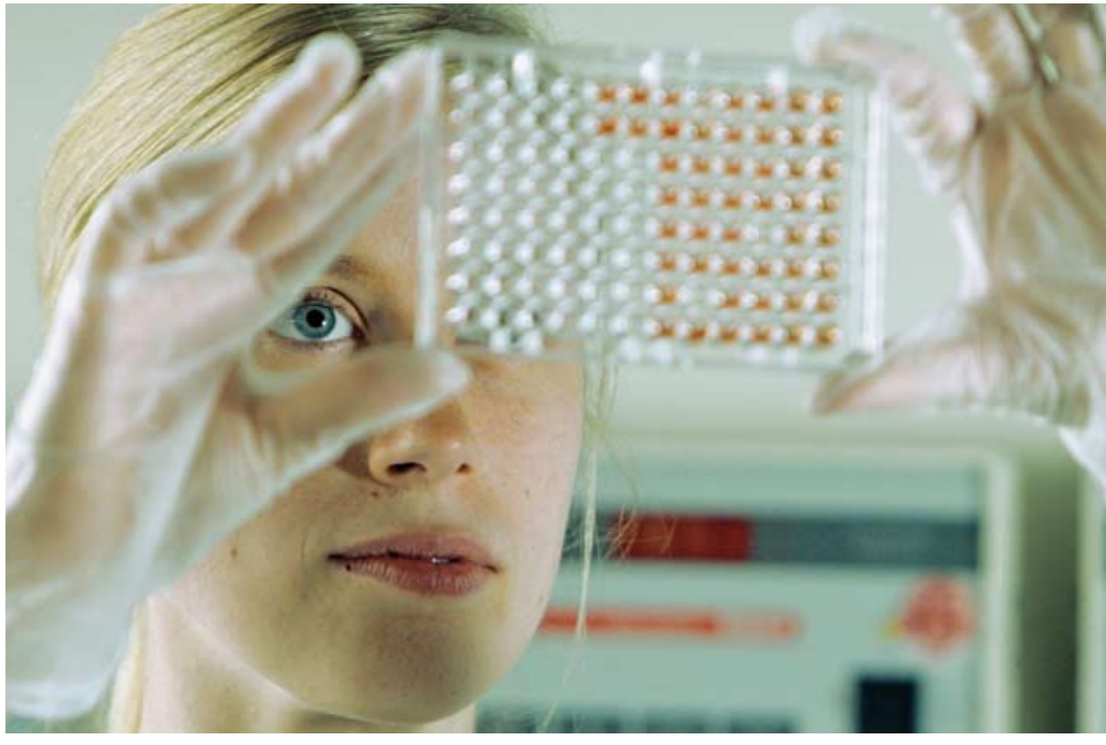
NanoBioengineering – novel nano- and micro-technological aspects of multi-electrode arrays in Life Sciences

Prof. Dr. Andrea A. Robitzki
Dipl. Biochem. Marco Glaß, Dipl. Biochem. Sina Haas,
Dipl. Biochem. Anja Steude, Dipl. Biochem. Dana Krinke

Anja Steude deals with the development, fabrication and validation of 2D and 3D micro (cavity) arrays as novel peptide based biosensors for diagnostic tools in neurodegenerative diseases: Electrochemical biosensors, using multi-electrode arrays with immobilised proteins as the recognition layer, constitute a promising tool for neuronal diagnostics. The first prototype was designed consisting of nine gold working electrodes and nine platinum auxiliary electrodes on a 96-well scale. For its fabrication methods of photolithography, alternating current sputtering, and etching techniques were applied. Nine separate measurement chambers were implemented as well as Ag/AgCl reference electrodes for each well. The validation of the multi-electrode array was carried out using cyclic voltammetry and impedance spectroscopy.



⇐ Novel microelectrode array for ultra-sensitive real time impedimetric and electrophysiological monitoring



Sina Haas is developing a bioforce mirco-array sensor for measuring cellular biomechanical forces of ischemic cell layers: Cardiac ischemia with a following reperfusion injury is a serious problem, resulting from the clinical setting of coronary revascularisation in acute myocardial infarction, cardiopulmonary bypass surgery and heart transplantation. Understanding the cellular and molecular mechanisms of ischemia and reperfusion injury is of great importance for heart attack and stroke therapy. To identify proteins involved in these processes we used fluorescence two-dimensional difference gel electrophoresis (DIGE) and MALDI-TOF/TOF-MS. The induction of ischemia was carried out on viable cardiomyocytes and monitored on multi-electrode arrays according to electrophysiological activity.

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Experiences

BuildMoNa's first year – a PI's view

Prof. Dr. Berthold Kersting

BuildMoNa offers doctoral candidates a well-structured interdisciplinary training program based on the scientific capacities of the participating research groups. It consists of training modules, the training of complementary skills, colloquia, a workshop and a symposium. Guest scientists from all over the world complemented these events in a stimulating and useful way.

Nine training modules were offered in BuildMoNa's first year focusing on its central research theme – building with molecules and nano-objects. The modules were established to provide a common basis of knowledge to all doctoral candidates, encompassing very diverse scientific areas, such as "from molecules to materials", "nano-manipulations", and "complex nano-structures" to name but a few. To ensure a high quality of the scientific discourse between those diverse areas participation in the modules was compulsory and complemented by a written or an oral examination at the end of each module. The exams' results covered the whole range of possible marks which in my opinion may be traced to the different native languages spoken by different scientists rather than to a low quality of our doctoral candidates.

A series of high-ranked colloquia provided the doctoral candidates with a broader overview on BuildMoNa's scientific areas in addition to their specialised field of research. The colloquia were organised in part by the students, which, in my opinion, is excellent: it gives them the opportunity to discuss their own results and raises even more interest in the guest scientist's work.

A large number of our doctoral candidates presented their scientific results to the BuildMoNa community at the first BuildMoNa workshop, with the intention of evaluating the progress of his/her project, to critically discuss scientific results with a broad audience and to practice presentation skills. These events also heavily promoted communication between all members of the Graduate School. In my opinion these workshops represent a new and useful extension of training for prospective scientists.

The particular resources of the Graduate School allowed us to invite internationally renowned guest lecturers for our two-day scientific BuildMoNa Symposium. It allowed doctoral candidates to intensify their scientific exchange and to extend their networking activities.

Even though I draw a positive balance of BuildMoNa's first year, there is room for improvement: We should increase our promotion activities to make surrounding scientists aware of high-level scientific events in Leipzig. Interest of the PIs in the workshop for doctoral candidates has to be increased and I would like to see more initiative from the doctoral candidates in organising BuildMoNa events. Let us fill BuildMoNa with even more life the next year. I am looking forward to it!

Prof. Dr. Berthold Kersting

BuildMoNa's first year – a DC's view

Dipl. Biochem. Lars Baumann

BuildMoNa arose out of the concept of interdisciplinarity. Its main objective has been, and still is the integration of various scientific areas towards new, innovative research beyond classic fields such as material, environmental, biomedical or natural sciences.

At the beginning, like most doctoral candidates, I was slightly doubtful concerning the Graduate School. I felt uncertain whether this newly installed institution would cost more effort than bring advantage for me. But during the project period I personally met the people behind this institution at various events. For me, it gave the BuildMoNa project a real face, which I highly appreciate: the "straightforward thinking" of most participants. The Graduate School presents itself as a partner rather than a superior. The interaction between the steering committee and doctoral candidates has been constructive at all times, even in controversial discussions. All decisions were made having the interest of the basis in mind - the doctoral candidates.

By and by the advantages for us doctoral candidates became clearer. For example, the possibility of an education in a multidisciplinary environment, the opportunity of refining soft and social skills during diverse workshops or having the chance of replacing the "Rigorosum" by attending scientific modules. BuildMoNa opens the eyes for new expertises and allows for setting up a first internal scientific network.

From my point of view, the Graduate School started up with a group of experienced and highly motivated university personnel without great trouble. Nevertheless, in the future there is room for improvement. I would wish for more participation on the part of the doctoral candidates. Use your possibilities to direct the Graduate School towards a dynamic institution, which works in your sense! Moreover, I wish for more collaboration among the different research groups. Exchange of competences might be strengthened in order to develop innovative ideas and concepts.

I think BuildMoNa should be understood as a pilot project for Leipzig as a location of excellent doctoral education. Self-renewal should be the slogan in order to master coming years!

L. Baumann

Dipl. Biochem. Lars Baumann

Training

The research training program consists of the research work and a well-structured training program in accordance with the RAL guidelines. The training program has a modular structure (see table), from which doctoral candidates may choose, based on their individual skills and time management, within three years of their graduate studies, provided that 20 credit points (10 graded, 10 non-graded) have been acquired.

Nine Scientific and Methods Modules as well as five Transferable Skills Workshops were offered during BuildMona's first year, which are described on the following pages.

TRAINING CONCEPT

Training activity	Type	Min. CP	Month (March to February)											
			M	A	M	J	J	A	S	O	N	D	J	F
			summer term							**winter term**				
Research work	R	–												
Scientific and methods modules	R/E	10	M	M	M	M	M			M	M	M	M	M
Workshop for doctoral candidates	R	5							W					
Scientific symposium	R/E		SY											
Literature seminars	R/E			S		S		S		S		S		S
Guest lectures/ colloquia	E		L	L	L	L	L	L	L	L	L	L	L	L
Tutoring	R/E			T	T	T	T			T	T	T	T	
Research stays abroad	E		flexible during the whole year (1 week up to a few months)											
Summer/winter schools	E													
Industrial training	E													
Active participation in conferences/workshops	R/E		flexible during the whole year (1 up to a few days)											
Transferable (generic) skills	R/E	5		S	S	S	S			S	S	S	S	
					M		M				M		M	

BuildMoNa Training Program: M, W, SY, M: two-day blocks,
S: 1–2 hours, L, T: 2 hours per week
R = required
E = elective
R/E = required-elective

Scientific and methods modules

Nano-manipulations (2008 – M01)

13 / 14 March 2008,
written exam, 2 credit points, yearly recurrence with modification, 17 participants

The module introduced the building tools for the controlled manipulation of nano-objects, macromolecules, proteins, and cells. Particular attention was paid to basic working principles of the covered nano-manipulation techniques.

Responsible Scientists:
Prof. Dr. J. Käs, Prof. Dr. F. Kremer, Prof. Dr. A. A. Robitzki

Guest Lecturer:
Dr. C. Dittrich, Carl Zeiss MicroImaging GmbH, Jena, Germany

Contents:
⇒ Electromagnetic forces: electric fields and dielectric materials, electrophoresis for molecules, proteins, and cells, magnetic forces
⇒ Optical forces: gradient, scattering, and optical surface forces, Maxwell surface tensor, momentum transfer, transferring angular momentum, holographic tweezers, Mie- vs. Raleigh-regime
⇒ Scanning force approaches: Van der Waals forces, inter- and intra-molecular interactions, detection with quadrant diodes
⇒ Soft lithography

Methods:
⇒ Optical traps: optical tweezers, optical stretcher, optical cell guidance, optical spanners and rotators, optical sorting and deposition, laser dissection
⇒ Magnetic tweezers
⇒ Scanning force microscopy and spectroscopy
⇒ Dielectrophoretic field cages
⇒ Lab-on-a-chip

From molecules to materials (2008 – M02)

27 / 28 March 2008,
written exam, 2 credit points, yearly recurrence with modification, 20 participants

This module linked molecular sciences with materials science. It explained how materials with optimised catalytic activity and adjustable magnetic, electronic, or optical properties are obtained from molecules. It provided a basis for understanding properties and applications of these materials.

Responsible Scientists:
Prof. Dr. M. R. Buchmeiser, Prof. Dr. B. Kersting, Prof. Dr. H. Krautscheid

Guest Lecturers:
Prof. Dr. G. Kickelbick, Technische Universität Wien, Austria

Contents:
⇒ "Hard" (synthetic molecules and crystalline nano-structures) and/or "soft" (polymers) building blocks
⇒ Novel materials: polymers, hybrid materials, supra-molecular arrangements
⇒ Modifications to improve material quality
⇒ Metal-organic frameworks (MOFs)
⇒ Thin films
⇒ Nano-structures
⇒ Properties of these materials: mass transfer, porosity, pore size distribution, specific surface areas, functionality, thermal properties, thermodynamics
⇒ Application of these materials: catalysis, gas separation or gas storage, sensors, electronics

Methods:
⇒ Templated synthesis
⇒ Immobilisation techniques
⇒ Polymer synthesis
⇒ Generation of porosity by micro- and macro-phase separation
⇒ Heterogeneous molecular catalysis

Theory (2008 – M03)

30 March / 04 April 2008, oral exam, 2 credit points, yearly recurrence with modification, 10 participants

This module provided a computer simulation tool box to investigate complex disordered structures exhibiting rugged free-energy landscapes. It combined a multitude of analytical (quantum field theory, series expansions) with computer modelling approaches in generalised ensembles. The module introduced applications, which range from diluted ferromagnets, spin glasses and glasses over polymeric scaffolds and proteins to random lattices, graphs and networks.

Responsible Scientists:
Prof. Dr. W. Janke, Prof. Dr. K. Kroy, Prof. Dr. S. Müller

Guest Lecturers:
Prof. Dr. B. Berche, Laboratoire de Physique des Materiaux, Nancy, France
Prof. Dr. H. G. Katzgraber, ETH Zürich, Switzerland
Prof. Dr. D. P. Landau, University of Georgia, Athens, USA
Dr. F. Liers, Universität Köln, Germany
Prof. Dr. V. Martin-Mayor, Universidad Complutense de Madrid, Spain
Prof. Dr. A. Pelissetto, University of Rome, Italy
Martin Weigel, Johannes-Gutenberg Universität Mainz, Germany

Contents:
⇒ Markov chain Monte Carlo simulation techniques: from basics to advanced
⇒ Generalised ensemble methods for problems with rugged free-energy landscapes
⇒ Quenched, disordered ferromagnets
⇒ Random lattices/graphs and complex networks
⇒ Spin glass models

Methods:
⇒ Monte Carlo simulation techniques
⇒ Generalised ensemble methods: multi-canonical, Wang-Landau and parallel tempering method
⇒ Modelling of disordered systems
⇒ Combinatorial optimisation

From biomolecules to cells (2008 – M04)

(together with the Centre for Biotechnology and Biomedicine (BBZ) and the Association for Electrical, Electronic & Information Technologies (DGBMT/VDE))
27 / 28 March 2008, written exam, 2 credit points, yearly recurrence with modification, 21 participants

The module helped to understand the biophysics of cells to manipulate them and use them as bioreactors. This includes the combination of cells with bioelectronics and nano-biotechnological applications and understanding how the cellular machinery changes when intracellular proteins are changed.

Responsible Scientist:
Prof. Dr. A. A. Robitzki

Guest Lecturers:
Prof. Dr. V. Mironov, Medical University of South Carolina, Charleston, USA
Prof. Dr. P. Vadgama, University of London, Great Britain
Prof. Dr. E. Günther, Natural and Medical Science Institute,
Eberhard-Karls-Universität Tübingen, Germany
Dr. C. Ehnert, Cytocentrics AG, Rostock, Germany

Contents:
⇒ Cell compartments with their different functions: cytoskeleton, cell membrane compartments, selected cell types (cardiac and neural cells/tissues, stem cells)
⇒ Biophysical techniques to characterise cells, manipulation of cell growth and orientation with physical and chemical tools, application of cell manipulation in biosensor technology
⇒ Modelling and simulation of the interface between chip and neuron
⇒ Electrical multifocal stimulation of electrogenic tissue (neuronal, muscular)
⇒ Electrical characterisation of stimulation and recording electrodes
⇒ Electrophysiology with microelectrode arrays (MEAs)
⇒ Electrical stimulation and recording from single cells and networks
⇒ Substance characterisation in single cell cultures and acute or organotypic slice cultures
⇒ Eukaryotic expression of proteins in cell culture, 2D and 3D tissue culture, comparison of primary versus altered cells

Methods:
⇒ Techniques to characterise cells: microscopic techniques, staining and bio-electronical recording vs. optical analysis
⇒ Transfection studies to create artificial cells with different activities
⇒ Impedance spectrometry to characterise modified cells

Smart molecules (2008 – M05)

23 / 24 June 2008,
written exam, 2 credit points, yearly recurrence with modification, 20 participants

This module aimed at linking molecular sciences, homogeneous, heterogeneous and bio-catalysis.

Responsible Scientists:
Prof. Dr. A. Beck-Sickinger, Prof. Dr. E. Hey-Hawkins

Guest Lecturers:
Prof. Dr. Moris S. Eisen, Technion, Haifa, Israel
Prof. Dr. Paul Kamer, University of St. Andrews, Great Britain
Dr. Katharina Welser, University of Nottingham, Great Britain
Prof. Dr. Roger Gläser, Universität Leipzig, Germany

Contents:
⇒ Specific synthesis, modification and understanding of the changes in the (electronic) structure of molecules that are precursors for materials with optimised catalytic activity
⇒ Small molecules: organometallic and transition metal complexes, homogeneous catalysis (principles, examples, applications), immobilisation of catalysts (on solid or in liquid supports), building blocks for metal-organic frameworks (MOFs)
⇒ Design and application of nanoporous catalysts for sustainable chemical processes, catalysis on zeolites and related materials (fundamentals and applications), introduction of catalytic functionalities into nanoporous materials, green synthesis of smart molecules (fine chemicals)
⇒ Designing and synthesising smart molecules that contain biological and chemical segments, strategies to introduce metals into biomolecules by selectively introduced chelators, monitoring structural changes

Magnetic resonance (2008 – M06)

02 / 03 September 2008,
written exam, 2 credit points, yearly recurrence with modification, 15 participants

Magnetic resonance, in particular NMR, is one of the very few local probes of bulk matter with applications in almost all natural sciences. This module provides a special knowledge of its methods, techniques, and hardware. Basic courses in magnetic resonance lay the foundation for its application. Due to the exceptional breadth of applications, advanced courses focus on current research needs.

Responsible Scientists:
Prof. Dr. S. Berger, Prof. Dr. J. Haase

Contents:
⇒ Basic principles of NMR and EPR
⇒ NMR of liquids and of solids as a basic analytical tool
⇒ Advanced methods: in biological systems, quantum solids, surfaces
⇒ Hardware development for special applications: thin films, high fields and frequencies

Methods:
⇒ High-resolution methods for liquids
⇒ Nuclear double-, triple-resonance
⇒ Higher dimensional NMR methods
⇒ Pulsed fields
⇒ EPR
⇒ ENDOR

Complex nano-structures (2008 – M07)

01 / 07 October 2008,
oral exam, 2 credit points, yearly recurrence with modification, 16 participants

The module focused on the understanding of the physical properties of nano-structures. The relation of properties to shape and geometry, energy transfer mechanisms as well as properties of coupled nano-systems were discussed.

Responsible Scientists:
Prof. Dr. P. D. Esquinazi, Prof. Dr. M. Grundmann

Guest Lecturers:
Prof. Dr. N. Garcia, Consejo Superior de Investigaciones Científicas, Madrid, Spain
Dr. A. Rosenthal, FEI Company Tools for Nanotec, Eindhoven, Netherlands
Prof. Dr. D. Chakarov, Tekniska Högskola Göteborg University, Sweden
Prof. Dr. R. Cuerno, Universidad Carlos III de Madrid, Spain
Dr. Francesco Buatier de Mongeot, Università di Genova, Italy
Prof. Dr. E. Chason, Brown University, Providence, USA

Contents:
⇒ Functional nano-structures for advanced and novel applications
⇒ Fundamentals of charge carrier confinement
⇒ Tunnelling
⇒ Electronic coupling of nano-structures
⇒ Coulomb blockade
⇒ Introduction to spin related phenomena and magnetism
⇒ Electronic transport in ferromagnetic nano-structures
⇒ Formation of self-assembled nano-structures
⇒ Optical and electronic properties

Methods:
⇒ Formation of contacts
⇒ Dual beam microscope
⇒ Magneto transport
⇒ Self-assembly during epitaxy (pulsed laser deposition)
⇒ Cathodoluminescence

Synthesis (2008 – M08)

09 / 10 October 2008,
oral exam, 2 credit points, yearly recurrence with modification, 16 participants

The module helped to understand epitaxial growth, growth of two-, one- and zero-dimensional films and hetero structures, synthesis of new materials via molecular precursors, ion beam methods, alloy formation, understanding and application of the different methods to prepare complex systems.

Responsible Scientists:
Prof. Dr. M. Grundmann, Prof. Dr. B. Rauschenbach

Guest Lecturers:
Prof. T. Karabaczak, Arkansas University, USA
Prof. Z. Shen, Stockholm University, Sweden
Dr. Christoph Giesen, Aixtron AG, Aachen, Germany

Contents:
⇒ Physical and chemical aspects of epitaxial processes for layered and nano-structured materials
⇒ Examples from industrial processes
⇒ Device-relevant layered structures

Methods:
⇒ Chemical deposition techniques (MOCVD)
⇒ Physical deposition techniques (MBE, PLD, IBAD)
⇒ Preparation and characterisation of thin films

Multifunctional scaffolds (2008 – M10)

23 / 24 September 2008,
written exam, 2 credit points, yearly recurrence with modification, 13 participants

The module aimed at providing the scientific background required to study and manipulate biopolymers, biopolymer networks, proteins and protein networks, including the highly dynamic polymer scaffolds in living tissues as an organising matrix for smart nano-elements, molecular motors, mechano-sensing, force-generation, motile polymeric machines, etc.

Responsible Scientists:
Prof. Dr. J. Käs, Prof. Dr. K. Kroy, Prof. Dr. F. Kremer

Guest Lecturers:
Prof. Dr. X. Trepat, Harvard School of Public Health, Boston, USA
Prof. Dr. P. Fernandez, Technische Universität München, Germany
Prof. Dr. T. Hugel, Technische Universität München, Germany
Dr. P. Marcq, Institut Marie Curie, Paris, France
Prof. Dr. T. Friedrich, Albert-Ludwigs Universität Freiburg, Germany
Prof. Dr. S. Engelhaaf, Heinrich-Heine Universität Düsseldorf, Germany
Dr. M. Salomo, Universität Leipzig, Germany
Prof. Dr. W. Richtering, RWTH Aachen, Germany
Prof. Dr. W. A. Goedel, Technische Universität Chemnitz, Germany
Dr. R. Vicent, Massey University, New Zealand

Contents:
⇒ Physical, chemical and biological perspectives onto various multifunctional scaffolds
⇒ Soft matter background
⇒ Statistical physics and Monte Carlo simulation approaches
⇒ Protein folding assembly and aggregation
⇒ Complex interactions in aqueous media
⇒ Biopolymers and biopolymer networks
⇒ Molecular motors
⇒ Artificial nano-motors
⇒ Structure and mechanics of the cytoskeleton
⇒ Cell-cell interactions via artificial extracellular scaffolds

Methods:
⇒ Single molecule imaging
⇒ Optical tweezers
⇒ Microscopy: scanning atomic force microscopy, digital polarisation microscopy, confocal/multiphoton microscopy
⇒ Dielectric spectroscopy
⇒ Single particle tracking
⇒ Soft lithography and micro-fluidics
⇒ Recombinant DNA
⇒ Theoretical methods: statistical mechanics, thermodynamics, Monte Carlo simulations

Transferable skills workshops

Fundraising for young scientists: How to open doors and avoid pitfalls in research funding

Dr.-Ing. Claudia Eggert, Dr. Simon Golin, Golin Wissenschaftsmanagement,
4 July 2008, 13 participants

Good projects need money in order to be put into practice. In the light of limited public funding, the securing of sources of financial support is an important task – whether classic science funding organisations, foundations or companies – especially in the academic and non-profit sectors. Even though there is no guaranteed path to reach the target, successful fundraising is not a coincidence. A prerequisite is an attractive project concept. In addition, professional skills and abilities are necessary in order to locate suitable funding sources and approach them with the right strategy. If a convincingly formulated application is then submitted, the chances of securing funding are good.

Team work & leadership competencies in academia and beyond: Youngster – team player – key player

Dr. Simon Golin, Golin Wissenschaftsmanagement,
12 September 2008, 15 participants

When doctoral candidates make the transition into the labour market they are often expected to take on leadership responsibilities. Not only careers outside the higher education sector but also such in academia involve leadership roles – e.g., in the supervision of students or junior colleagues or the 'lateral guidance' of colleagues. A better understanding of leadership mechanisms is also useful in situations where one is being led, for example as a doctoral candidate by a supervisor. 'Bottom up' leadership techniques can contribute to the success of cooperation in this context.
With sound knowledge of leadership, team dynamics can be optimised and situations of conflict better managed. New recruits can therefore grow with their leadership role and constructively work with their colleagues.
In this workshop participants were introduced to the most important leadership styles and techniques and acquired knowledge of the methodical approach to leadership tasks. Topics like leadership styles and techniques, conflict management and team work were dealt with.

Advanced presentation skills

Prof. Dr. Roger Gläser,
14 / 17 October 2008, 11 participants

How to give successful oral presentations in natural and related sciences? The workshop aimed at an improvement of the presentation skills of doctoral candidates. A short review of the basic principles of successful oral presentations was given. In addition the workshop covered advanced methods and techniques for preparing and performing oral presentations with special focus on the particular setting at international scientific conferences. As a major element of the workshop, the attendees jointly prepared and practiced their yearly progress report presentation in front of their colleagues and advisors. The presentation at the 1st BuildMoNa Workshop was monitored by video and thoroughly analysed in group and plenary discussions with the colleagues on the second workshop day.

Career planning for PhD students: Application standards – personal strategies

Dr. Simon Golin, Golin Wissenschaftsmanagement,
7 November 2008, 20 participants

An occupation in research and teaching, a career in the economic or service sector or in a non-profit organisation – after the doctorate there are numerous open career paths. Because of this, strategic career planning is necessary. A series of important questions has to be answered: What are my goals and interests, what are my strengths and weaknesses? Where can I apply? Do I know what is expected of me and how to deal with that?
On the basis of these questions the current application standards were conveyed and individual application strategies were worked out. With the help of selected examples from practice, the participants developed the competencies needed for a successful approach to the application process.

Training for intercultural competence

Viola Stoehr, s.cope,
26 November 2008, 13 participants

A person who is interculturally competent captures and understands, in interaction with people from foreign cultures, their specific concepts in perception, thinking, feeling and acting. Earlier experiences are considered, free from prejudices; there is an interest and motivation to continue learning. Basic needs are sensitivity and self-consciousness: the understanding of other behaviors and ways of thinking. The ability to express one's own point of view in a transparent way with the aim to be understood and respected by staying flexible where this is possible, and being clear where this is necessary. A theory-based introduction was followed by interactive training sessions concerning experience of alienation, non-verbal communication and homesickness.

Colloquia

Invited Speaker	*Institution*	Title	Date	*Place*
Prof. Dr. Cees Dekker	*Delft University of Technology, Kavli Institute of NanoScience*	Nano-technology tools for biology, the power of single molecule biophysics	4 December 2007	*Faculty of Physics and Earth Science*
Prof. Dr. Ernst-Ludwig Florin	*Center for Nonlinear Dynamics and Department of Physics, University of Texas Austin, USA*	From molecular interactions to cellular functions: Novel approaches to explore the complexity of cells	20 May 2008	*Faculty of Physics and Earth Science*
Prof. Dr. Glen B. Deacon	*Monash University, Melbourne, Australia*	Rare earths – A source of continuing excitement	21 May 2008	*Faculty of Chemistry and Mineralogy*
Prof. Dr. Günter Reiter	*Institut de Chimie des Surfaces et Interfaces, ICSI-UHA-CNRS, Mulhouse, France*	Cloning polymer single crystals via self-seeding	10 June 2008	*Faculty of Physics and Earth Science*
Prof. Dr. Michel Orrit	*Molecular Nano-Optics and Spins, Institute of Physics, Universiteit Leiden, Netherlands*	The power of single molecule optics	24 June 2008	*Faculty of Physics and Earth Science*
Prof. Dr. Greg van Patten	*Department of Chemistry and Biochemistry, Ohio University, USA*	Synthesis of colloidal nano-particles	1 July 2008	*Faculty of Chemistry and Mineralogy*
		Interactions among nano-particles	8 July 2008	*Faculty of Chemistry and Mineralogy*
		Applications for nano-particle assemblies and assembly of nano-particles (Part I)	15 July 2008	*Faculty of Chemistry and Mineralogy*
		Applications for nano-particle assemblies and assembly of nano-particles (Part II)	18 July 2008	*Faculty of Chemistry and Mineralogy*

Invited Speaker	*Institution*	Title	Date	*Place*
Prof. Dr. Neil Burford	*Department of Chemistry, Dalhousie University, Halifax, Nova Scotia, Canada*	*catena*-Phosphorus chemistry	09 July 2008	*Faculty of Chemistry and Mineralogy*
Prof. Dr. Hans Frauenfelder	*Los Alamos National Laboratory, Theory division, USA*	A unified model of protein dynamics	14 October 2008	*Faculty of Physics and Earth Science*
Prof. Dr. Keith Morris Sanders	*Chemical Laboratory of Cambridge University, Cambridge, Great Britain*	Discovering synthesis receptors through design, selection and serendipity	6 November 2008	*Faculty of Chemistry and Mineralogy*
Prof. Dr. Jeffrey J. Fredberg	*Harvard School of Public Health, Department of Environmental Health, Boston*	A hard day in the life of a soft cell	11 November 2008	*Faculty of Physics and Earth Science*
Prof. Dr. J.-L. Fillaut	*Université Rennes 1, France*	Ruthenium acetylide complexes: from sensors to molecular materials	12 November 2008	*Faculty of Chemistry and Mineralogy*
Prof. Dr. Marina A. Petrukhina	*Department of Chemistry, University at Albany, State University of New York, USA*	Fullerene fragments: synthesis, molecular geometry, solid state packing and reactivity	12 November 2008	*Faculty of Chemistry and Mineralogy*
Dr. Thomas Fischbacher	*School of Engineering Sciences, University of Southampton, Great Britain*	Die Fehler der letzten 10 000 Jahre	18 November 2008	*Faculty of Physics and Earth Science*
Prof. Dr. Jörg P. Kotthaus	*Ludwig-Maximilians-Universität München, Center for Nano Science*	Photonische Fallen und Förderbänder – Manipulation Licht-induzierter Ladungen auf einem Chip	25 November 2008	*Faculty of Physics and Earth Science*
Prof. Dr. Tobias Hertel	*Institut für Physikalische Chemie, Universität Würzburg, Germany*	Photochemie von Kohlenstoff Nanoröhren: Im Grenzgebiet zwischen Makro-Molekül und Nano-Festkörper	4 December 2008	*Faculty of Biosciences, Pharmacy and Psychology*
Prof. Dr. Lauń Niinströ	*Technical University of Helsinki*	Atomic Layer Deposition (ALD) a key technology in the processing of nanomaterials for advanced applications	9 December 2008	*Faculty of Chemistry and Mineralogy*

Events

Opening ceremony

In conjunction with the first anniversary of the Research Academy Leipzig the “Leipzig School of Natural Sciences – Building with Molecules and Nano-objects (BuildMoNa)” was opened in a grand ceremony in the lecture hall of the Center for Biotechnology and Biomedicine (BBZ) on 17 December 2007. The Vice President of the Association of Universities and other Higher Education Institutions in Germany, Prof. Dr. Klaus Dicke, presented his point of view concerning the effects of the Excellence Initiative on German universities; Prof. Dr. Evamarie Hey-Hawkins (Speaker of BuildMoNa) presented the newly installed Graduate School as an example of the projects financed by this initiative. The scientific idea behind BuildMoNa was explained to the broad audience by Prof. Dr. Josef A. Käs from the Institute of Experimental Physics I: “From nano-muscles and polymerisation-driven molecular machines to cancer diagnosis and nerve regeneration”.

⇑ The first Doctoral Candidates of BuildMoNa

1st Scientific symposium

The first Scientific Symposium, held on 7 and 8 February 2008, marked the start of the structured doctoral training program of BuildMoNa. Seven external speakers held lectures concerning up-to-date topics in the Arthur Hantzsch Lecture Hall of the Faculty of Chemistry and Mineralogy. 70 participants followed the thoughts of:

⇒ Prof. Madan Rao (Raman Research Institute, Bangalore, India) about cell membranes and the role of the actin cytoskeleton.
⇒ Prof. Kay Severin (Ecole Polytechnique Fédérale de Lausanne, Switzerland) about the formation of functional nano-structures and their applications as sensors for biologically active compounds.
⇒ Prof. Régis Réau (Université Rennes, France) about the design of nano-scale materials with the help of concepts from coordination chemistry.
⇒ Dr. Gerd Lippold (City Solar AG, Bitterfeld-Wolfen, Germany) about progress on the way to low-price solar cells based on novel molecular precursors.
⇒ Prof. Julia Yeomans (R. Peierls Centre for Theoretical Physics, Oxford, Great Britain) about the modelling of motion in micrometer scale drops on chemically modified surfaces.
⇒ Prof. Hermann E. Gaub (Ludwig-Maximilians-Universität, München, Germany) about scanning force microscopy techniques for the monitoring of folding processes of membrane proteins.
⇒ Prof. Dieter Bimberg (Technische Universität, Berlin, Germany) about the application of semi-conductor quantum dots for opto-electronics and novel flash memory materials.

⇐ Scientific discussions between the lectures

⇑ Participants of the 1st Scientific Symposium

⇐ In a poster session the freshly selected doctoral candidates had the possibility to present their research projects and to discuss them with each other and with guests of the symposium

1st Workshop for doctoral candidates

30 doctoral candidates presented their first scientific results with short talks on the 1st BuildMoNa Workshop on 16 and 17 October 2008. About 70 BuildMoNa participants followed the lectures in the Leipziger Kubus, the conference venue of the Helmholtz-Institute for Environmental Research. Presentations covered the whole research profile of the Graduate School: Development of novel materials from appropriate building blocks, such as nano-objects, tailor-made molecules and polymers as well as peptides and proteins. Mechanisms of material formation from building blocks, e. g. self-organisation, were also included.

For the 11 participants of the Transferable Skills Workshop "Advanced Presentation Techniques" by Prof. Dr. Roger Gläser this was the opportunity to directly apply their newly acquired knowledge in that area. Their talks were filmed and critically discussed afterwards. Two internationally renowned guests complemented the scientific program: Professor Katharina Landfester from the Max-Planck-Institute of Polymer Research in Mainz presented the institute's competences for the formation and stabilisation of complex nano-capsules. Professor Fernando Briones from the Institute of Materials Science (CSIC) in Madrid showed the possibilities for using "Quantum Nano-structures for Solar Energy Harvesting". At the end of the workshop a jury selected three presentations given by the doctoral candidates: The first prize (300€) was awarded to Marisa Mäder, the second (200€) to Christian Czekalla and the third prize was shared between Dalia Angeles-Wedler and Matthias Scholz (100€ each).

⇐ Prof. Dr. Fernando Briones explaines the application of quantum nano-structures for solar energy harvesting

Annual reception

BuildMoNa's 1st anniversary was celebrated on 10 December 2008 with a reception for 70 invited guests from the industry and the university. It was held in the Faculty of Physics and Earth Science building. The plenary lecture was given by Professor Stefan Spange from the Technical University Chemnitz. He presented "twin-polymerisation" as a novel concept in macromolecular chemistry.

Following a retrospective look at BuildMoNa's first year Professor Evamarie Hey-Hawkins awarded the three BuildMoNa Awards. The recipients were selected by a committee (uninvolved PIs) in order to honour their scientific work. The first prize (2500€) was awarded to Christian Patzig for the extraordinary quality and number of publications and oral presentations concerning his research topic "Glancing Angle Deposition of Silicon Nano-structures". P. Santosh Kumar received the second prize (1500€) for his paper "Factors Relevant for the Regioselective Cyclopolymerization of 1,6-Heptadiynes, *N,N*-Dipropargylamines, *N,N*-Dipropargyl Ammonium Salts, and Dipropargyl Ethers by Ru^{IV}-Alkylidene-Based Metathesis Initiators" which was recently accepted for publication in the Journal of the American Chemical Society and for his Best-Poster-Award at the NATO ASI Meeting 2008 in Antalya. The third

prize (1000€) went to Florian Huber for his paper “Growing Actin Networks Form Lamellipodium and Lamellum by Self-Assembly” in the Biophysical Journal.

⇑ The first recipients of the BuildMoNa Award with the Speakers of the Graduate School; from left to right: Prof. Dr. Marius Grundmann, Florian Huber, P. Santosh Kumar, Christian Patzig, Prof. Dr. Evamarie Hey-Hawkins

⇐ Prof. Dr. Stefan Spange answers questions concerning twin-polymerisation

Promotion activities

The aim of several public relations activities was to advertise the possibilities offered by BuildMoNa in order to attract excellent young researchers from all over the world to the University of Leipzig.

One highlight was the participation of BuildMoNa within the German Cluster at the MIT European Career Fair in Boston from 1 to 4 February 2008. The integration of BuildMoNa into the concept of the Research Academy Leipzig and the research environment in the Leipzig area was presented.

Furthermore BuildMoNa was represented at the DAAD Promotion Tour ”German Higher Education Fair“ in India from 09 to 21 February 2008. Members of the Leipzig delegation were Prof. Evamarie Hey-Hawkins (Speaker of the Graduate School BuildMoNa), Jane Moros (Academic Exchange Service), Dr. Doritt Luppa (Scientific Manager of BuildMoNa and Coordinator of RAL) und Arun Voruganti (doctoral candidate, RAL). They participated in several job fairs and visited potential cooperation partners such as the Indian Institute of Technology Delhi, the Department of Chemistry of the Pune University, the University of Hyderabad and the Indian Institute of Technology (IIT) Madras.

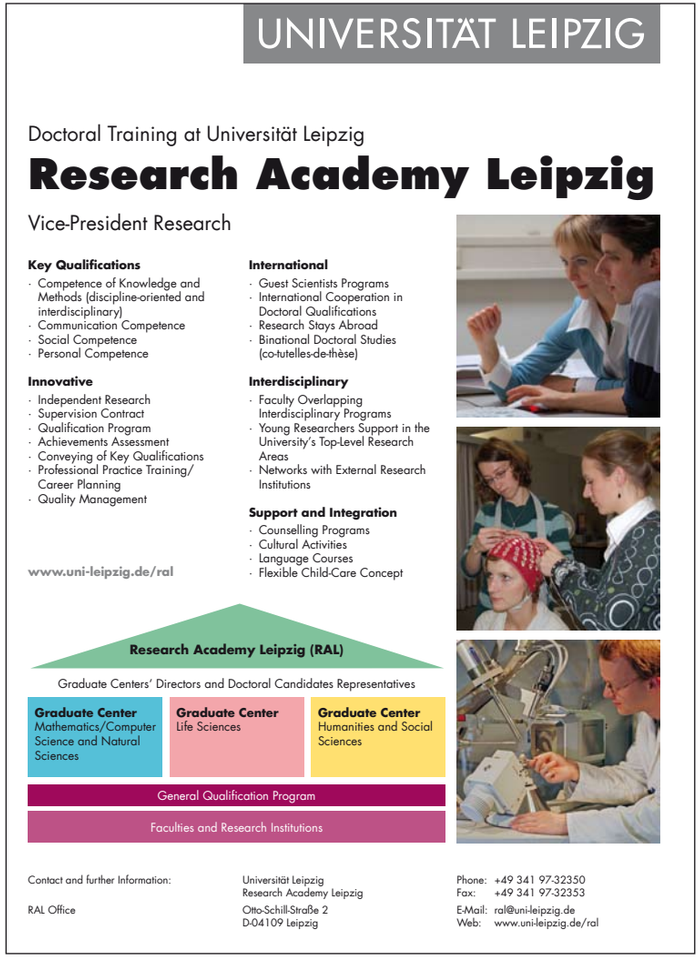
Nine German scientists, amongst them Prof. Dr. E. Hey-Hawkins, represented German universities during a promotion tour to the United States of America within

⇑ Visit of the Madras university during the “A Passage to India Tour”

⇑ Interested students at the BuildMoNa information desk

the “Research in Germany – Land of Ideas” initiative. The initiative was funded by the Excellence Initiative and organised by DFG, DAAD and AvH. The scientists had the possibility to visit the Washington, San Francisco and Los Angeles scientific centres in order to inform of the changes and new opportunities at German universities and to arrange new cooperation partners.

Other promotional activities included publications of job advertisements in “Die Zeit”, “Nature”, “Nachrichten aus der Chemie” as well as the usage of the online employment market and internet promotions.



⇐ Presentation of the Research Academy Leipzig at the MIT European Career Fair in Boston

⇒ www.buildmona.de

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