

## Multicomponent Materials

After his deanship, Prof. Faupel took a sabbatical in the winter semester 2010/2011, and the Multicomponent Materials group (formerly Chair for Multicomponent Materials) commenced various new projects supported mainly by external sources. Currently, the group participates actively in three Collaborative Research Centers (SFBs) and has third party funds of about 3 million euro from the German Research Foundation (DFG), the BMBF (Ministry for Education and Research), the AIF (Working Group Industrial Research) and others. As a consequence, the group size increased considerably and comprises 15 PhD students, for instance. Concerning the scientific output, more than 20 publications were accepted in international peer reviewed journals during the last year. Here, only a few aspects of the present research can be discussed. For more details we refer to our website <http://www.tf.uni-kiel.de/matwis/matv/> and the papers listed below.

A special highlight of the last year was the strong feedback on our investigation of glass formation in so called metallic glasses. The report was published in the renowned journal "Physical Review Letters" and has been referred to in several newstickers and even newspapers. Another hot topic of great technological potential was transparent metallic coatings. This work, which involves the activities of the group on metal-polymer nanocomposites, was initiated by the former group member Prof. Elbahri and will be described in his Almanac chapter. A joint paper was just accepted in the top journal "Advanced Materials".

Working in three Collaborative Research Centers, the group strongly benefited from the joint interdisciplinary work with partners ranging from fundamental physics and organic chemistry to electrical engineering and medicine. The activities within the Collaborative Research Center SFB 677 - Function by Switching - were particularly successful last year as reflected in several new publications. Following the very positive evaluations of our joint project "Plasma Processes for the Deposition of Nanostructured Composite Materials" within the Collaborative Research Center SFB TR 24 on complex plasmas a strong and fruitful cooperation has been established with the group of Prof. Kersten from the physics department of the CAU. First results are also already available in our new project within the Collaborative Research Center SFB 855 on magneto-electric nanocomposites for medical applications. Our research performed with partners within the DFG priority program "Polymer-solid contacts: Interfaces and Interphases" which was co-initiated by Prof. Faupel, also led to several publications enlarging our understanding of the formation and structure of interfaces between polymers and solid materials, which are important in many technical applications. The group also performed investigations at large scale facilities particularly at the Electron storage ring BESSY in Berlin and at the positron beam facility of the Research Reactor Garching.

In addition, various projects were carried out with industry. Besides direct cooperation with companies, joint work with industry was performed within projects of the BMBF and the AIF.

From July 2008 to June 2010 Prof. Faupel was Dean of the Faculty of engineering and still serves as Vice Dean. His main concern was to strengthen the cooperation within the Faculty of Engineering and to promote further interdisciplinary research with partners from other Faculties of the Christian-Albrechts University.

Irrespective of Prof. Faupel's sabbatical during the winter semester 2010/2011, the group was strongly involved in teaching and took great effort to inspire pupils for materials science and engineering in various ways including visits to schools in Schleswig-Holstein.

### Results

#### a) Mechanism of glass formation in undercooled metallic melts

Metallic glasses are mixtures of metals and non-metals which can be employed in a vast range of applications from ultra-thin electronic housings to biodegradable implants. Although the appearance of metallic glasses resembles that of ordinary metals, their atomic structure differs completely. While the atoms in a conventional metal arrange in a periodic

lattice, there is no such order in metallic glasses. This disordered state, which is similar to a frozen liquid, can be created by rapid quenching of a melt. However, only for certain mixtures of elements the glassy state will be accessible with technically reasonable cooling rates. A strategy to reduce the necessary cooling rate is called the "confusion of atoms". The mixture is chosen to crystallize in a complex lattice, thus hindering the atoms to move into place. In this scheme the individual mobility of the constituents, which is called diffusivity, is decisive whether the cooling melt crystallizes or not.

So far it was not known, which of the constituents determines viscosity. In the equilibrium melt all constituent diffusivities are equal and inversely related to the viscosity. However, up to now no experiment has investigated, how the diffusivities of the individual components behave upon cooling and how structure and dynamics are correlated during glass formation. We measured the diffusivities of all constituents of the representative glass forming alloy Pd-Cu-Ni-P in the temperature range from the glass transition up to the melting temperature. Our findings reveal that in the low temperature range the diffusivities of the individual species decouple and differ by up to four orders of magnitude. At higher temperatures the diffusivities of the constituents were found to be equal, indicating a homogeneous dynamic behavior. However, the majority constituent Pd, the atoms of which are the largest in the alloy, follows the temperature behavior of the viscosity over 14 orders of magnitude. We deduce from these data that the Pd-atoms form a network of low mobility within the alloy at decreasing temperature which hinders the crystallization of the melt. Thus our results, which aroused much international attention and were published in the prestigious journal "Physical Review Letters" provide a universal mechanism for the formation of metallic glasses.

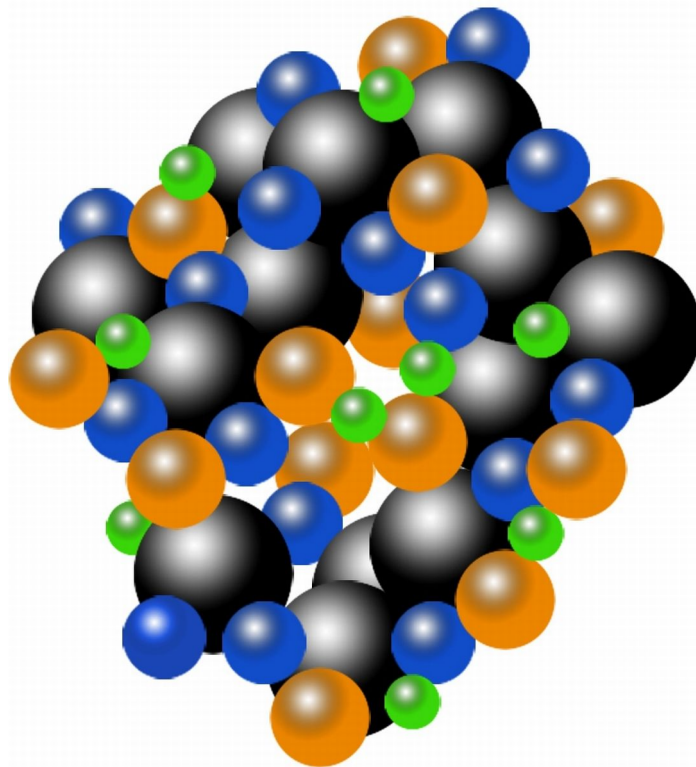


Fig. 1: In a mixture of Palladium, Copper, Nickel and Phosphorous the relatively large Palladium atoms form an immobile framework before the melt solidifies. Thus the other atoms are restricted to cages within the framework.

#### b) Polymer-solid contacts

Within the DFG priority program "Polymer-solid contacts: Interfaces and Interphases" which was co-initiated by Prof. Faupel, we studied the structure and formation of interfaces between plastics and solid materials like metals and ceramics. Such interfaces are important in many technical applications including polymer nanocomposites in which solid nanoparticles

are embedded in a polymer matrix.

In particular, we probed the distribution of the unoccupied space across the polymer-solid interface. This so-called free volume, strongly affects many physical properties like viscosity, diffusivity and brittleness. With the technique of positron annihilation lifetime spectroscopy, the average hole size in a material can be directly determined at the atomic scale. A moderated beam of positrons with well defined implantation energy, available at the Research Reactor Garching, can even probe thin films and interphases, which are extended interfacial regions with properties different from the bulk polymer. We systematically examined the interphase of planar Teflon AF/Si samples, for instance. As expected, for thermally evaporated films we found no significant interphase. However, for spin coated samples the free volume was reduced within the polymer-substrate interphase. This finding enabled us to determine the width of the interphase to be of some ten nm. This phenomenon has to be taken into account especially in polymer-nanocomposites, in which the properties of the polymeric matrix are significantly affected by the contribution of the interphase around the solid nanoparticles.

A separate project revealed that the influence of a functionalized layer on the surface of nanoparticles, which is generally used in commercial nanocomposites to obtain a uniform dispersion of the nanoparticles, can be seemingly similar to that of an interphase. Our results evidence that these two effects need to be strictly separated, which has not been done in literature, yet.

#### **c) Structural investigation of super sticky barnacle glue**

Positron annihilation lifetime spectroscopy with a moderated beam was also applied to the adhesive layer of barnacles. The latter stick on every material, even on Teflon-coated ship hulls. Understanding the mechanisms of this extraordinary adhesion might help to develop new glues. Our investigations showed that the structure of the barnacle adhesive is highly porous up to the sub-nm scale. We suppose that the flexibility and the fracture behavior of the adhesive originate in this pronounced porosity.

#### **d) Nanocomposites for functional applications**

The nanocomposites investigated in our group consists of metallic nanoparticles embedded in an insulating matrix, either polymeric or ceramic in nature. The size of the nanoparticles is in between that of atoms and macroscopic materials and thus gives rise to new properties not observed in conventional materials. These new properties are explored for a broad range of applications ranging from high frequency magnetic materials to antimicrobial coatings. The nanocomposites are mostly deposited as thin films by vapor phase deposition methods, in particular evaporation and sputtering from solid targets. During the last year, plasma polymerization and physically enhanced chemical vapor deposition (PECVD) have also been employed in a joint project of the above mentioned Collaborative Research Center SFB TR 24 with Prof. Kersten's group from the physics department. The central idea is to combine the complimentary know-how of the Kersten group on advanced plasma diagnostics and the expertise of the Faupel group on nanostructured materials to develop new tailored nanomaterials by understanding of the correlation between plasma parameters and resulting nanostructure. In this context, we also developed two new cluster sources for the deposition of nanoparticles. In a cluster source, the nanoparticles form in the gas phase and not on the surface of the growing composites. This, among other advantages, allows chemical reactions between the metallic component and the matrix to be widely eliminated. Moreover, the source also allows to deposit highly porous films made up of aggregated nanoparticles, which are presently investigated. One of the sources is shown in Fig. 2.

A cluster source was also employed for the deposition of magnetic particles which will be used in our project within the new Collaborative Research Center SFB 855 on magneto-electric nanocomposites for medical applications. The main idea of the project is to embed magnetostrictive nanoparticles, which change their shape in a magnetic field, in a piezoelectric matrix. The change in shape of the particles can be measured as a voltage change via elastic coupling to the piezoelectric material.

Nanocomposites also play a key role in one of our projects within the Collaborative Research Center SFB 677 "Function by Switching". Here, the nanocomposites are combined with photoswitchable molecules. These so-called chromophores change

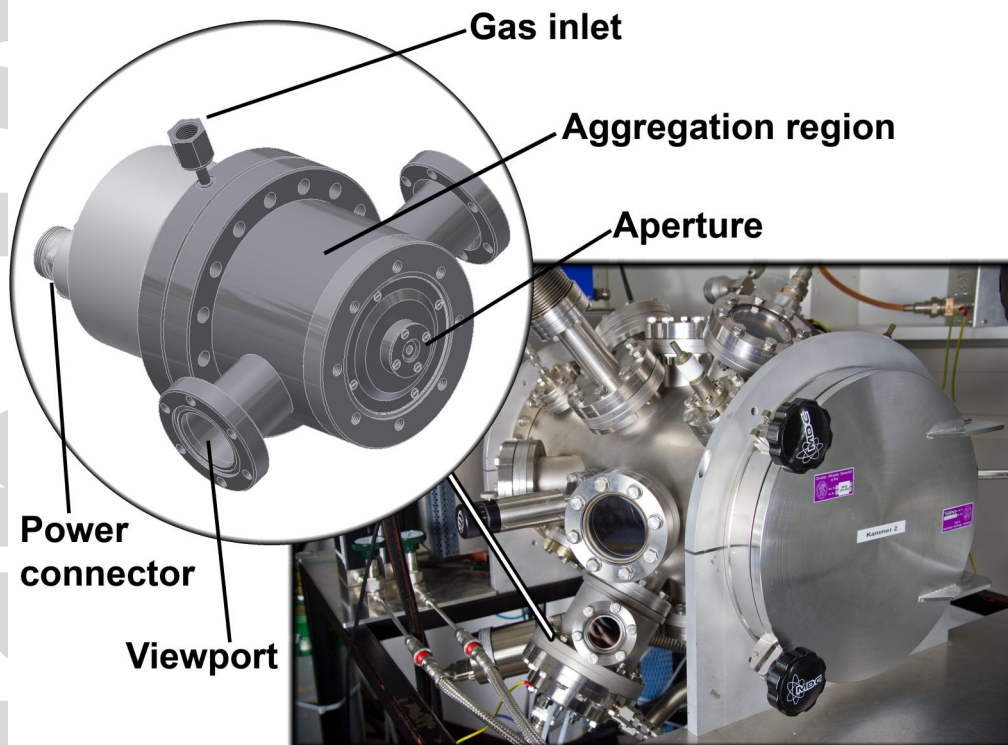


Fig. 2: One of the newly developed cluster sources for the deposition of nanoparticles from the gas phase.

their properties reversibly upon irradiation with light of two different wavelengths. Very interesting new electro-optical properties arise through interactions between chromophores and the so-called surface plasmon resonance of the metallic nanoparticles. As described in the Almanac 2006 these resonances are collective oscillations of the conduction electrons in the electrical field vector of electromagnetic radiation. Our recent major progress in this field is reported in many listed publications.

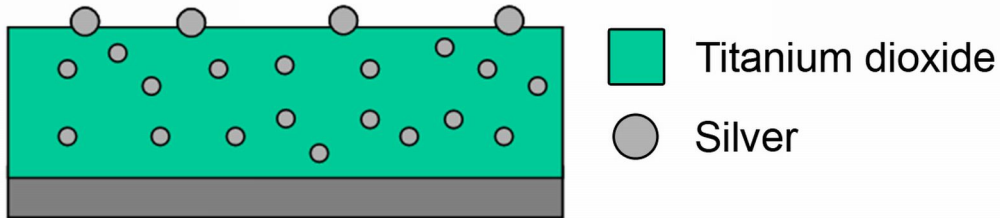
In a second joined project in the SFB 855 together with the group of Prof. Quandt we developed a new type of magnetic field sensor by combining a magnetostrictive material with a nanocomposite near the percolation threshold. Here, the dimensional change in the magnetostrictive material causes a change in the separation between the nanoparticles and thus changes the tunneling current between the particles.

In several projects we explore the large specific surface area of the finely dispersed nanoparticles and the strong influence of the surface or interfacial energy on the material's properties. This is particularly the case in antibacterial coatings with nanoparticles of silver and other noble metals where a high metal ion release rate is strived for since the antimicrobial activity originates from the released metal ions. This research has been supported by the World Gold Council and is carried out in cooperation with Prof. Podschun from the Institute of Infection Medicine of the University Hospital Schleswig-Holstein/Campus Kiel. Toxicity of nanoparticles is studied in cooperation with PD Röhl from the Institute of Toxicity of the CAU. In addition, among other partners, we cooperate with Prof. Grundmeier from the Chemistry Department of the University at Paderborn in a joint DFG project.

Recently, emphasis is put on noble metal-titania composites. A key point is the control of the ion release behavior via tailored nanoparticle filling factor profiles and diffusion barriers which ensure long-term release. In this connection, we discovered segregation of silver on the titania surface as an important issue which also affects the release behavior. Much effort has been invested in order to understand the segregation mechanism. Here high resolution transmission electron microscopy in conjunction with advanced tomography turned out to be very helpful. This work was performed in the group

of Prof. Kienle (see his Almanac chapter). Fig.3 shows an example.

### Surface segregation



### TEM-tomography

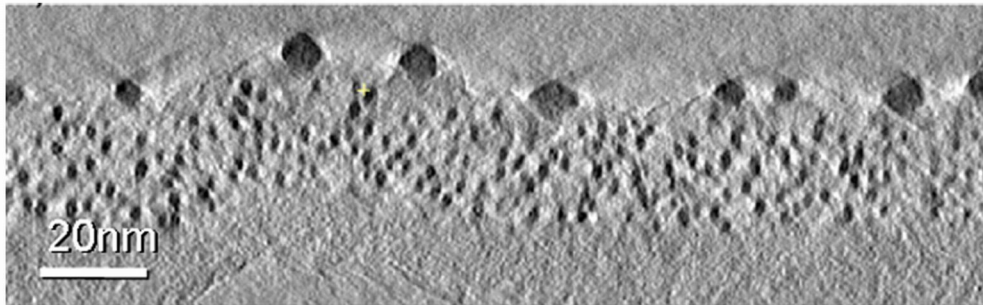


Fig. 3: Sketch of silver segregation on a titania surface and corresponding electron microscopy micrograph obtained in the group of Prof. Kienle by the advanced tomography technique.

The group also investigates various other functional properties of nanocomposites with metallic nanoparticles and an organic or ceramic matrix. Interested readers are referred to the attached list of publications and earlier Almanac editions. Concerning optical and plasmonic properties and so-called metamaterials, we refer to the Almanac chapter of Prof. Elbahri who initiated some exiting new applications pursued together with our group.

## Personnel

Head of the group: Prof. Dr. F. Faupel; Secretary: N. Gühlke (50%), Dipl.-Chem. S. Kastaun (50%), Dipl.-Geol. B. Minten (50%)

Technical Staff: Dipl.-Ing. (FH) R. Kloth, C. Ochmann, Dipl.-Ing. (FH) S. Rehders

Scientific Staff:

M.Sc. M. Ahadi	25.11.-31.12.2010	Fellowship Iran
Functional nanocomposites		
M.Sc. N. Alissawi	01.03.-31.12.2010	DFG
Ag-ion transfer		
Dipl.-Phys. B. Gojdka	01.01.-31.12.2010	SFB 855, CAU
Magneto-electric nanocomposites		
Dipl.-Ing. C. Hanisch	01.01.-14.03.2010	Tutech, World Gold Council
Functional nanocomposites		

Dipl.-Phys. S. Harms Polymer-solid interfaces	01.01.-31.12.2010	DFG SSP 1369
M.Sc. B. Henkel Functional nanocomposites	01.10.-31.12.2010	BMBF
Dipl.-Phys. T. Hrkac Functional materials	01.01.-31.12.2010	BMWI
Dr. S. Jebril PolyMet	01.02.-31.12.2010	BMWI
M. Sc. M. Keshavarz Hedayati Optical nanocomposites	01.08.-31.12.2010	CAU with Prof. Elbahri
M.Sc. T. Koschine Positron beam, polymers	01.10.-31.12.2010	BMBF
M.Sc. A. Kulkarni High-frequency magnetic nanocomposites	01.01.-31.12.2010	DFG SFB 677
M.Sc. Q. Ma Magnetoelectric nanocomposites	01.04.-31.12.2010	Stipendium China, SFB 855
Dipl.-Ing. K. Meurisch Magneto-electric nanocomposites	01.01.-31.12.2010	CAU, SFB 855
Dipl.-Chem. C. Pakula Functional nanocomposites	01.01.-31.12.2010	DFG SFB 677
Dipl.-Phys. T. Peter Nanoparticles from plasmas	01.01.-31.12.2010	SFB TR24
Prof. Dr. K. Rätzke Supercooled melts, positron annihilation	01.01.-31.12.2010	CAU
M.Sc. M.Q. Shaikh Free volume in epoxies	01.01.-31.12.2010	BMBF, CAU
Dr. T. Strunskus Functional nanocomposites	01.01.-31.12.2010	SFB 855
M.Sc. J. Xiong Functional nanocomposites	15.01.-31.12.2010	Fellowship China
Dr. V. Zaporozhchenko Functional nanocomposites	01.01.-31.12.2010	CAU

### Lectures, Seminars, and Laboratory Course Offers

*Winter 2009/2010*

Werkstoffe ( Metalle ), 2 (+ 1) hrs Lecture (+ Exercises)/Week,  
F. Faupel

Thin Films II, 2 (+ 1) hrs Lecture (+ Exercises)/Week,



Einführung in die Vakuumtechnik, 2 hrs Lecture/Week,  
V. Zaporojtchenko

Advanced Organic Materials, 2 hrs Seminar/Week,  
T. Strunskus

Übungen zur Physik I, 2 hrs Seminar/Week,  
K. Rätzke

Advanced Materials A - Metals, 2 (+ 1) hrs Lecture (+ Exercises)/Week,  
K. Rätzke (+ N. Alissawi)

Advanced Materials A - Polymers, 2 (+ 1) hrs Lecture (+ Exercises)/Week,  
T. Strunskus (+ D. Gedamu)

Thin Films II, 2 (+ 1) hrs Lecture (+ Exercises)/Week,  
K. Rätzke (+ T. Peters)

Einführung in die Materialwissenschaft 1, 2 hrs Lecture/Week,  
K. Rätzke (+ O. Riemenschneider)

## Third-Party Funds

DFG, DST, *Formation of metallic nanostructures in organic matrix by vapour and plasma phase deposition and its modification by swift heavy Iron Irradiation*, 01.03.2006-12.01.2010 (77.130 Euro)

DFG, *Diffusion in glasbildenden Metallschmelzen vom Gleichgewichtszustand bis zum kalorischen Glasübergang*, 15.09.2006-30.03.2010 (130.295 Euro)

DFG SFB 677, *Funktion durch Schalten: Kombination von schaltbaren Polymeren und Nanokompositen nahe der Perkolationschwelle*, 01.07.2007-30.06.2011 (237.600 Euro)

DFG SFB 677, *Funktion durch Schalten: Komposite aus Polymermatrix und ferromagnetischen Formgedächtnis-Nanopartikeln als magnetische Schalter*, 01.07.2007-30.06.2011 (211.640 Euro)

DFG, *Einfluss der Verhinderung der Kollagen-Degradation durch MMPs auf den Dentin-Klebeverbund*, 04.10.2007-31.01.2011 (25.944 Euro)

DFG, SFB TR24, *Verteilung des Freien Volumens an Polymer-Festkörper-Grenzflächen*, 04.04.2008-04.04.2011 (245.970 Euro)

DFG, *Magnetic nanocomposites for rf applications in mobile communication*, 15.09.2008-30.09.2010 (129.566 Euro)

DFG, *Grundlagen komplexer Plasmen: Plasmaprozesse zur Abscheidung von nanostrukturierten Kompositmaterialien*, 01.07.2009-30.06.2013 (287.640 Euro)

China Scholarship Council, *Stipendium für Qian Ma, PhD-Student für 1 Jahr*, 01.09.2009-31.08.2010 (12.000 Euro)

AIF, *PolyMet-Polymer-Metalloxid-Compositschichten für flexible optische Schichtsysteme, PolyMet-Kiel: Polymer-Metalloxid-Schichtabscheidung und Charakterisierung*, 01.11.2009-31.10.2011 (175.000 Euro)

DFG SFB855, *Magnetoelektrische Verbundwerkstoffe-biomagnetische Schnittstellen der Zukunft: Gasphasenabscheidung von magnetoelektrischen 0-3 Nanokompositen*, 01.01.2010-31.12.2013 (635.280 Euro)

DFG, *Ion transfer reactions at Ag-nanoparticle/polymer interfaces*, 17.02.2010-17.02.2012 (190.424 Euro)

Fraunhofer-Institut für Siliziumtechnologie ISIT, *Untersuchungen mittels Photoelektronenspektroskopie von Elektrodenoberflächen*, 09.-09.03.2010 (780 Euro)

BMBF, *Nano-Purification - Entwicklung fortschrittlicher Materialien und Verfahren zur Wasser- und Abwasserbehandlung mittels funktioneller Nanokomposite*, 01.05.2010-30.04.2013 (202.489 Euro)

DAAD, *Forschungsstipendium im Rahmen des Programms GERSS (German Egyptian Research Short-term Scholarships) für Frau Dr. Rania Mohammed Ahmed Khalil*, 21.05.-21.11.2010 (11.565 Euro)

AvH, *Stipendium für Prof. Dr. Amita Chandra für 1 Monat*, 29.05.-27.06.2010 (2.300 Euro)

BMBF, *Verbundprojekt POSIMETHOD: Teilprojekt 5: "Charakterisierung nanoskopischer Leerstellen in dünnen Polymerfilmen mittels Positronenlebensdauerspektroskopie"*, 01.07.2010-30.06.2013 (213.300 Euro)

Dräger Safety AG und Co. KGA, *Untersuchung von 4 Proben mit Hilfe der Photonelektronenspektroskopie*, 05.-19.07.2010 (357 Euro)

China Scholarship Council, *Stipendium für Jian Xiong für 4 Jahre*, 15.11.2010-15.11.2014 (48.000 Euro)

KHS Plasmax GmbH, *XPS-Messungen: Komposition-Tiefenprofil von einer Beschichtung auf PET Proben mit Hilfe der Photonelektronenspektroskopie*, 17.-17.11.2010 (1.100 Euro)

Iran Government, *Stipendium für Amir Mohammad Ahadi für 3 Jahre*, 25.11.2010-25.03.2014 (45.000 Euro)

## Further Cooperation, Consulting, and Technology Transfer

### *University:*

Prof. M. Bauer, F. Tuzcek, O. Magnussen, Prof. W. Herges: Kombination von schaltbaren Molekülen und Nanokompositen nahe der Perkolationschwelle (SFB „Funktion durch Schalten“ )

Prof. W. Bensch, Institut für Anorganische Chemie: Komposite aus Polymermatrix und ferromagnetischen Formgedächtnis-Nanopartikeln als magnetische Schalter (SFB „Funktion durch Schalten“ )

Dr. Peter Budd, Manchester School of Chemistry, The University of Manchester, Manchester UK, Polymermembranen

Prof. Dr. S. Deki, Kobe, Japan, Optische Nanokomposite

Dr. G. Dlubek, ITA Institute for Innovative Technologies, Universität Halle, Positronenvernichtung in nichtmolekularen Substanzen

Prof. Dr. G. Dollinger, Dr. W. Egger, Universität der Bundeswehr, München, PLEPS am FRM II

Prof. Dr. M. Es-Souni, FH Kiel, Ferroelektrische Schichten und Grenzflächen zu Metallen

Dr. Chr. Hugenschmidt, TU München und FRM II, NEPOMUC

Prof. Dr. M. Kern, Zahnmedizin, Universität Kiel, AFM, XPS und Kontaktwinkelmessungen an Zähnen

Prof. R. Knöchel, Inst. f. Elektrotechnik und Informationstechnik, magnetische HF-Materialien ( DFG-projekt )

Prof. Dr. R. Podschun, Institut für Infektionsmedizin, Universität Kiel, antibakterielle Beschickung

Prof. Dr. W. Possart, Universität Saarbrücken, BMBF-Projekt, Nanomodule

Prof. Dr. E. Quandt, Anorganische Funktionsmaterialien, CAU, Komposite aus Polymermatrix und ferromagnetischen Formgedächtnis-Nanopartikeln als magnetische Schalter (SFB „Funktion durch Schalten“ )

Dr. C. Röhl, Prof. Dr. J. Sievers, Anatomisches Institut, Toxikologische Auswirkung von metallischen Nanopartikeln auf menschliche Zellen

Prof. Dr. V. Shantarovich, N.Semenov Institute of Chemical Physics, Russian Academy of Sciences, Moskau, Positronenvernichtung und Membranpolymere

Prof. Dr. C. Staudt, Düsseldorf, Blockcopymere

Prof. Dr. F. Tuzcek, Institut für Anorganische Chemie, CAU Kiel, Self-assembled monolayers

Prof. Dr. Y. Yampolskii, A.V. Topchiev Institute of Petrochemical Synthesis, Laboratory of Membrane Gas Separation, Russian Academy of Sciences, Moskau, Positronenvernichtung und Membranpolymere

*Research Institutes:*

Dr. D. K. Avasthi, Materials Science Group, Nuclear Science Centre New Delhi, India, High energy ion beam effects in polymer-metal nanocomposites

Prof. Dr. Dietmar Fink, Hahn-Meitner-Institut, Berlin, High energy ion beam effects in polymer-metal nanocomposites

Dr. D. Fritsch und Prof. Dr. V. Abetz, Institut für Polymerforschung, GKSS-Forschungszentrum Geesthacht, Freies Volumen in Polymeren mit intrinsischer Mikroporosität

Prof. Dr. G. Grundmeier, Max-Planck Institut, Düsseldorf, Antibakterielle Beschichtungen

Prof. Dr. A. Meyer, Dr. A. Griesche, DLR, Köln, Diffusion in Pd-Cu-Ni-P Legierungen

Dr. M. Noeske, Fraunhofer-Institut für Fertigungstechnik und Angewandte Materialforschung, IFAM Bremen, BMBF-Projekt, Nanomodule und PALS an Polymer-Kompositen

Prof. Dr. K.V. Peinemann, GKSS, Geesthacht, Freies Volumen und Permeabilität in Spezialpolymeren

Prof. Schwarz, Dr. Drusch, Lebensmitteltechnologie, Kiel, Verkapselung von Lebensmitteln

Dr. Thomas Neubert, Fraunhofer Institut für Schicht- und Oberflächentechnik (IST), Braunschweig, Polymer-Metalloxid-Kompositschichten für flexible optische Schichtsysteme

*Industry:*

o.m.t. Lübeck, Photoaktive Schichten

Sennheiser Electronic KG Wedemark, Elektrete

Wöhlk, Schönkirchen, Oberflächenmodifikationen von Kontaktlinsen

World Gold Council, G.R.O.W., Improvement of antibacterial coatings by incorporation of gold nanoparticles

*Partner in AIF-Projekt Polymet:*

Wohlrab Aufdampftechnik GmbH, Langenzenn

Rolf Schäfer Beschichtungskomponenten, Münchweiler

plastic-design GmbH, Bad Salzuffen

*Partner in BMBF-Projekt Umsicht:*

Fraunhofer Institut für Umwelt-, Sicherheits- und Energietechnik, Oberhausen

Hans-Huber AG, Berching

Kryschi Wasserhygiene, Kaarst

Evers-Wassertechnik, Hopsten

Gelsenwasser AG, Gelsenkirchen

**Diploma, Bachelor and Master Theses**

A. Al Zayed, *Electro-optica properties of gold/platinum polymer nanocomposite films doped with azobenzene ethers*, 18.05.2010

S. Dollinger, *Freies Volumen mit PALS in leitfähigen Polymernanokompositen*, 31.05.2010

- B. Henkel, *Combined Quasi-Magneto-resistive Magnetic Field Sensor - utilizing Magnetostriction and Quantum Tunneling*, 01.10.2010
- S.W. Basuki, *Photo-induced capacitance modulation in chromophore/PMMA blends and DC conductance modulation in MWCNT based resistors*, 01.10.2010
- H. Jebriil Mahammad, *Study of electrical and optical properties of polymer/spiropyrane blends with embedded noble metal nanoparticles*, 22.12.2010
- M. Wegner, *Investigation of the preparation of nanocomposites by plasmapolymerization and high pressure magnetron sputtering*, 13.09.2010
- C. Wang, *Photocatalysis Studies on Silver-modified Titania Nanocomposites and Sandwiched Cells prepared by Magnetron Co-sputtering*, 26.08.2010
- H. Aboufadel, *Investigation of the Portevin-Le Chatelier effect by Atom Probe Tomography*, 09.12.2010
- D. Haffner, *Charakterisierung und Optimierung des Feedstock beim MIM von Ti6Al4V*, 19.10.2010
- P.H. Mösel, *Eutectic cells in cast iron and their influence on thermomechanical properties*, 22.09.2010
- V. Rübisch, *Auswahl und Charakterisierung von wasserlöslichen Bindern für die Herstellung von Anoden in Lithium-Ionen-Batterien*, 08.10.2010
- N. Alemayehu Zerihun, *Optimization of the morphology of Volatile Organic Compound (VOC) Sensors based on Polymer-metal Nanocomposites*, 08.02.2010
- S. Mohammadzadeh Polami, *Stress Analysis during Welding of LTT Alloys under Defined Restraint Intensity*, 22.02.2010
- A. Tavassolizadeh, *Investigation of Piezoelectricity of Corona Poled Vacuum-Deposited Nylon 11 Films*, 29.09.2010
- M.S. Mohajerani, *Deposition and patterning of superconductor yttrium-barium-copper oxide thin films*, 05.11.2010

## ▀ Dissertations / Postdoctoral Lecture Qualifications

- M.Q. Shaikh, *Free Volume and Storage Stability of one component Epoxy Nanocomposites*, 11.11.2010

## ▀ Publications

Published in 2010

- K. Rätzke, M.Q. Shaikh, F. Faupel, P.-L.M. Noeske, *Shelf stability of reactive adhesive formulations: A case study for dicyandiamide-cured epoxy systems*, *International Journal of Adhesion and Adhesives*, **30**, 105 - 110 (2010)
- G. Dlubek, Q. Shaikh, K. Rätzke, M. Paluch, F. Faupel, *Free volume from positron lifetime and pressure-volume-temperature experiments in relation to structural relaxation of van der Waals molecular glass-forming liquids*, *Journal of Physics*, **22**, 235104 - 235114 (2010)
- M. Quitzow, M. Wolter, V. Zaporozhchenko, H. Kersten, F. Faupel, *Modification of polyethylene powder with an organic precursor in a spiral conveyor by hollow cathode glow discharge*, *Eur. Phys. J. D*, **58**, 305 - 310 (2010)
- V. Zaporozhchenko, V.S.K. Chakravadhanula, F. Faupel, S. Tamulevicius, M. Adrusevicius, A. Tamulevicius, L. Angulis, *Residual stress in polytetrafluoroethylene-metal nanocomposite films prepared by magnetron sputtering*, *Thin Solid Films*, **518**, 5944 - 5949 (2010)
- G. Dlubek, M.Q. Shaikh, K. Rätzke, J. Pionteck, M. Paluch, F. Faupel, *Subnanometre size free volumes in amorphous Verapamil hydrochloride: A positron lifetime and PVT study through Tg in comparison with dielectric relaxation spectroscopy*, *European Journal of Pharmaceutical Science*, **41**, 388 - 398 (2010)
- H. Takele, V.S.K. Chakravadhanula, C. Hanisch, M. Elbahri, T. Strunskus, V. Zaporozhchenko, L. Kienle, F. Faupel, *Preparation and plasmonic properties of polymer based composites containing Ag-Au alloy nanoparticles produced by vapor phase co-deposition*, *Journal of Material Science*, **45**, 5865 - 5865 (2010)
- F. Faupel, K. Rätzke, B. Gojdka, *Metallische Gläser - hart im Nehmen und extrem vielseitig*, *Welt der Physik*, [www.weltderphysik.de/de/8475.php](http://www.weltderphysik.de/de/8475.php), 25.10.2010, (2010)
- Y.K. Mishra, S. Mohapatra, V.S.K. Chakravadhanula, N.P. Lalla, V. Zaporozhchenko, D.K. Avasthi, F. Faupel, *Synthesis and*

- characterization of Ag-polymer nanocomposites, *Journal of Nanoscience and Nanotechnology*, **10**, 2833 - 2837 (2010)
- A. Bartsch, K. Rätzke, A. Meyer, F. Faupel, *Dynamic Arrest in Multicomponent Glass-Forming Alloys*, *Physical Review Letters*, **104**, 195901 - 195901 (2010)
- S. Harms, K. Rätzke, W. Egger, L. Ravello, A. Laschewsky, W. Wang, P. Müller-Buschbaum, *Free volume and swelling in thin films of poly(N-isopropylacrylamide) end-capped with n-butyltrithiocarbonate*, *Macromolecular rapid communications*, **31/15**, 1364 - 1367 (2010)
- B. Wunderle, E. Dermitzaki, O. Hölck, J. Bauer, H. Walter, M.Q. Shaikh, K. Rätzke, F. Faupel, B. Michel, H. Reichl, *Molecular dynamics approach to structure-property correlation in epoxy resins for thermo-mechanical lifetime modeling*, *Microelectronics Reliability*, **50/7**, 900 - 909 (2010)
- T. Emmler, K. Heinrich, D. Fritsch, P.M. Budd, N. Chaukura, D. Ehlers, K. Rätzke, F. Faupel, *Free Volume Investigation of Polymers of Intrinsic Microporosity (PIMs): PIM-1 and PIM1 Copolymers Incorporating Ethanoanthracene Units*, *Macromolecules*, **43(14)**, 6075 - 6084 (2010)
- C. Pakula, V. Zaporojtchenko, T. Strunskus, D. Zargarani, R. Herges, F. Faupel, *Reversible light-controlled conductance switching of azobenzene-based metal/polymer nanocomposites*, *Nanotechnology*, **21(46)**, 465201 - 465201 (2010)
- M. Marschall, J. Reichert, K. Seufert, W. Auwärter, F. Klappenberger, A. Weber-Bargioni, S. Klyatskaya, G. Zoppellaro, A. Nefedov, T. Strunskus, C. Woll, M. Ruben, J.V. Barth, *Supramolecular Organization and Chiral Resolution of p-Terphenyl-m-Dicarbonitrile on the Ag(111) Surface*, *Chemphyschem*, **11(7)**, 1446 - 1451 (2010)
- K. Rajalingam, L. Hallmann, T. Strunskus, A. Bashir, C. Woll, F. Tuzcek, *Self-assembled monolayers of benzylmercaptan and para-cyanobenzylmercaptan on gold: surface infrared spectroscopic characterization*, *Physical Chemistry Chemical Physics*, **12(17)**, 4390 - 4399 (2010)
- S. Harms, K. Rätzke, F. Faupel, G.J. Schneider, L. Willner, D. Richter, *Free volume of interfaces in model nanocomposites studied by positron lifetime spectroscopy*, *Macromolecules*, **43**, 10505 - 10511 (2010)
- S. Harms, K. Rätzke, V. Zaporojtchenko, F. Faupel, W. Egger, L. Ravelli, *Free Volume distribution at the teflon af/silicon interfaces probed by a slow positron beam*, *Polymer*, **52(2)**, 505 - 509 (2010)
- K. Rätzke, M. Wiegemann, M.Q. Shaikh, S. Harms, R. Adelung, W. Egger, P. Sperr, *Open volume in bioadhesive detected by positron annihilation lifetime spectroscopy*, *Acta Biomaterialia*, **6**, 2690 - 2694 (2010)
- F. Faupel, V. Zaporojtchenko, T. Strunskus, M. Elbahri, *Metal-Polymer nanocomposites for functional applications*, *Advanced Engineering Materials*, **12(12)**, 1177 - 1190 (2010)
- C. Hanisch, N. Ni, A. Kulkarni, V. Zaporojtchenko, T. Strunskus, F. Faupel, *Fast electrical response to volatile organic compounds of 2D Au nanoparticle layers embedded into polymers*, *Journal of Material Science*, **46(2)**, 438 - 445 (2010)
- B. Gojdka, *Einzigartig dank Unordnung. Aussichtsreiche Zukunft für metallische Gläser*, *Spektrumdirekt*, <http://www.wissenschaft-online.de/artikel/1053339>, (2010)
- S.V. Merzlikin, N.N. Tolkachev, L.E. Briand, T. Strunskus, C. Wöll, I.E. Wachs, W. Grünert, *Anomalous Surface Compositions of Stoichiometric Mixed Oxide Compounds*, *Angewandte Chemie*, **49(43)**, 8037 - 8041 (2010)
- S. Stepanow, R. Ohmann, F. Leroy, N. Lin, T. Strunskus, C. Wöll, K. Kern, *Rational Design of Two-Dimensional Nanoscale Networks by Electrostatic Interactions at Surfaces*, *ACS Nano*, **4(4)**, 1813 - 1820 (2010)
- S. Harms, K. Rätzke, C. Pakula, V. Zaporojtchenko, T. Strunskus, F. Faupel, W. Egger, P. Sperr, *Free Volume Changes on Optical Switching in Azobenzene-Polymethylmethacrylate Blends Studied by a Pulsed Low-Energy Positron Beam*, *Journal of Polymer Science, part B Polymer Physics*, **49(6)**, 404 - 404 (2010)



## Patent Applications

- M. Elbahri, R. Adelung, F. Faupel, K. Hirmas, *Verfahren zur Nanostrukturierung mittels spinodaler Entnetzung*, *Deutsches Patentamt*, 26.08.2010, EP2206153

- F. Faupel, *Metal-Polymer nanocomposites for functional applications (Invited talk)*, INM (Leibnitz-Institut für neue Materialien), Saarbrücken, Germany, 13.-13.01.2010
- K. Rätzke, *Materialwissenschaften in Kiel (Talk)*, Berufsinformationstag Helene Lange Gymnasium, Rendsburg, Germany, 16.-16.02.2010
- K. Rätzke, *Free volume and structure in polymeric membranes. PALS and XRD (Invited talk)*, AG Prof. Staudt, Düsseldorf, Germany, 01.-02.03.2010
- S. Harms, *Free Volume in Polymers Position Annihilation Lifetime Spectroscopy (Talk)*, Interphases and faces: Programm spring school Fulda, DFG project SPP 1369, Fulda, 08.-11.03.2010
- F. Faupel, A. Bartsch, K. Rätzke, A. Meyer, *Dynamic Arrest in Multicomponent Glass Forming Alloys (Invited talk)*, DPG-Frühjahrstagung 2010, Regensburg, Germany, 21.-26.03.2010
- B. Gojdka, V. Zaporojtchenko, T. Strunskus, F. Faupel, *Vapour Phase Deposition of Ceramic-based Granular Nanocomposites for Magnetolectric Applications (Poster)*, DPG-Frühjahrstagung 2010, Regensburg, Germany, 21.-26.03.2010
- S. Harms, K. Rätzke, F. Faupel, W. Egger, L. Ravelli, A. Laschewsky, W. Wang, P. Müller-Buschbaum, *Free Volume and Swelling in Thin Films of Poly(N-Isopropylacrylamide) End-capped with n-Butyltrithiocarbonate (Talk)*, DPG-Frühjahrstagung 2010, Regensburg, Germany, 21.-26.03.2010
- C. Pakula, C. Hanisch, T. Strunskus, D. Zargarani, V. Zaporojtchenko, R. Herges, F. Faupel, *Photo-switchable sensors based on azomolecule containing nanocomposites (Talk)*, DPG-Frühjahrstagung 2010, Regensburg, Germany, 21.-26.03.2010
- T. Peter, S. Bornholdt, M. Wolter, T. Strunskus, V. Zaporojtchenko, H. Kersten, F. Faupel, *Nanocompsite thin films prepared by co-sputtering and via deposition from a cluster source (Poster)*, DPG-Frühjahrstagung 2010, Regensburg, Germany, 21.-26.03.2010
- A. Kulkarni, V. Zaporojtchenko, T. Strunskus, F. Faupel, E. Quandt, V.S.K. Chakravadhanula, L. Kienle, *Magnetic and structural properties of TiO<sub>2</sub>-FeCo nanocomposite (Talk)*, DPG-Frühjahrstagung 2010, Regensburg, Germany, 21.-26.03.2010
- T. Hrkac, V.S.K. Chakravadhanula, N. Wohner, V. Zaporojtchenko, T. Strunskus, D. Garbe-Schönberg, F. Faupel, *Ag-TiO<sub>2</sub> nanocomposites for antibacterial and photocatalytic applications (Poster)*, DPG-Frühjahrstagung 2010, Regensburg, Germany, 21.-26.03.2010
- K. Meurisch, V. Zaporojtchenko, T. Strunskus, F. Faupel, *Polymer-Based Magnetolectric Composites (Poster)*, DPG-Frühjahrstagung 2010, Regensburg, Germany, 21.-26.03.2010
- V.S.K. Chakravadhanula, A. Lotnyk, T. Hrkac, A. Kulkarni, H.T. Beyene, T. Strunskus, V. Zaporojtchenko, C. Kuebel, R. Podschun, F. Faupel, L. Kienle, *Synthesis and characterization of functional metal-polymer and metal-oxide nanocomposite thin films (Invited talk)*, ICN 2010 (International Conference on Nanomaterials: Synthesis, Characterization and Applications), Kottayam, Kerela, India, 27.-29.04.2010
- F. Faupel, *Metal-Polymer nanocomposites for functional applications (Invited talk)*, Kolloquium TU Chemnitz, Institut für Physik, Chemnitz, Germany, 28.-29.04.2010
- V. Zaporojtchenko, C. Pakula, T. Strunskus, R. Herges, F. Faupel, *Reversible electro-optical switchable effects in azomolecule containing nanocomposites (Talk)*, The international Workshop "Electronic, transport and optical properties of low-dimension systems" (WS10-ETOLDS), Valencia, Spain, 31.05.-02.06.2010
- K. Rätzke, F. Faupel, A. Bartsch, A. Meyer, *Dynamic Arrest in Multicomponent Glass Forming Alloys (Invited talk)*, International Workshop DSS-2010 "Grain Boundary Diffusion, Stresses and Segregation", Moskau, Russia, 01.-04.06.2010
- K. Meurisch, V. Zaporojtchenko, T. Strunskus, F. Faupel, *Polymer-Based Magnetolectric Composite Films (Talk)*, E-MRS Spring Meeting 2010, Straßburg, France, 07.-11.06.2010
- T. Peter, C. Bornholdt, V.S.K. Chakravadhanula, A. Kulkarni, T. Hrkac, C. Hanisch, M. Wolter, T. Strunskus, V.

- Zaporojtchenko, H. Kersten, F. Faupel, *Nanocompositedeposition by plasmas (Invited talk)*, 24th Symposium on Plasma Physics and Technology, Prag, Czech Republic, 14.-17.06.2010
- F. Faupel, A. Bartsch, K. Rätzke, A. Meyer, *Dynamic Arrest in Multicomponent Glass Forming Alloys (Invited talk)*, Konferenz "Emerging Concepts in Glass Physics", Santa Barbara, USA, 21.-24.06.2010
- F. Faupel, *Dynamic Arrest in Multicomponent Glass Forming Alloys (Invited talk)*, 17th International Symposium on Metastable, Amorphous and Nanostructured Materials (ISMANAM 2010), Zürich, Switzerland, 05.-07.07.2010
- V. Zaporojtchenko, T. Strunskus, A. Kulkarni, T. Hrkac, V.S.K. Chakravadhanula, E. Quandt, R. Podschun, F. Faupel, *Nanocomposites for Functional Applications by Physical Vapor Deposition Processes (Talk)*, Nanofair 2010 (8th International Nanotechnology Symposium - New Ideas for Industry), Dresden, Germany, 06.-07.07.2010
- K. Rätzke, S. Harms, F. Faupel, *Free volume distribution at polymer-solid interfaces (Talk)*, 2. Jahrestreffen SPP 1369 (Polymer-Festkörperkontakte), Dechema, Frankfurt, Germany, 09.-09.07.2010
- V. Zaporojtchenko, *Surface modification of polymers by low energy ions and plasmas (Talk)*, 2nd Graduate Summer Institute, Greifswald, Germany, 11.-13.08.2010
- V. Zaporojtchenko, T. Hrkac, T. Strunskus, V.S.K. Chakravadhanula, N. Alissawi, R. Podschun, C. Röhl, D. Garbe-Schönberg, F. Faupel, *Tuning of the Silver Ion Release from Antibacterial Nanocomposite Coatings (Talk)*, International NanoBio Conference 2010, Zürich, Switzerland, 24.-27.08.2010
- T. Strunskus, T. Hrkac, V.S.K. Chakravadhanula, N. Wohner, V. Zaporojtchenko, R. Podschun, D. Garbe-Schönberg, F. Faupel, *Nanocomposite Films with Embedded Silver Nanoparticles for Antimicrobial Applications (Poster)*, Materials Science and Engineering, Darmstadt, Germany, 24.-26.08.2010
- A. Kulkarni, V. Zaporojtchenko, T. Strunskus, F. Faupel, E. Quandt, F. Hettstedt, R. Knöchel, V.S.K. Chakravadhanula, L. Kienle, *Magnetic nanocomposite preparation, characterization and applications (Poster)*, Materials Science and Engineering, Darmstadt, Germany, 24.-26.08.2010
- F. Faupel, *Metal-Polymer nanocomposites for functional applications (Plenary talk)*, Materials Science and Engineering, Darmstadt, Germany, 24.-26.08.2010
- K. Meurisch, V. Zaporojtchenko, T. Strunskus, F. Faupel, *Piezoelectricity in Thermally Evaporated Thin Films of Nylon 11 (Poster)*, Materials Science and Engineering, Darmstadt, Germany, 24.-26.08.2010
- K. Rätzke, F. Faupel, *Free Volume in high free volume polymeric membranes investigated by positron annihilation lifetime spectroscopy (Talk)*, 14th International Conference "Polymeric Materials", Halle (Saale), Germany, 15.-17.09.2010
- B. Gojdka, *Towards 0-3 dimensional ceramic based magnetoelectric composites (Talk)*, SFB 855 Herbstworkshop und Sommerschule des integrierten Graduiertenkollegs, Salza, Germany, 29.09.-01.10.2010
- F. Faupel, H. Kersten, R. Peter, V. Zaporojtchenko, T. Strunskus, C. Bornholdt, M. Fröhlich, *Deposition of nanostructured composite materials (Talk)*, SFB-Kolloquium des TR24, Wismar, Germany, 30.09.-01.10.2010
- V. Zaporojtchenko, T. Hrkac, T. Strunskus, V.S.K. Chakravadhanula, T. Peter, R. Podschun, C. Röhl, D. Garbe-Schönberg, F. Faupel, *Tunable Antibacterial Nanocomposites Coatings (Poster)*, Nanosmat: 5th international Conference on Surfaces, Coatings and Nanostructured Materials, Reims, France, 19.-21.10.2010
- F. Faupel, *Metal-Polymer nanocomposites for functional applications (Invited talk)*, Physikalisches Kolloquium Uni Göttingen, Göttingen, Germany, 01.-01.11.2010
- F. Faupel, *Metal-Polymer nanocomposites for functional applications (Invited talk)*, 2nd ZUM-HASYLAB Colloquium "The metal-polymer interface", DESY, Hamburg, Germany, 02.-02.11.2010
- M. Keshavarz Hedayati, V.S.K. Chakravadhanula, V. Zaporojtchenko, M. Elbahri, F. Faupel, *Transparent conductors based on metal-polymer nanocomposites (Talk)*, Materials Science and Engineering, Darmstadt, Germany, 24.-26.08.2010
- F. Faupel, *Neue Materialien durch Nano-Technologie (Invited talk)*, Gothaer Allgemeine Versicherung AG, Köln, Germany, 03.-04.11.2010
- F. Faupel, *Metal-Polymer nanocomposites for functional applications (Invited talk)*, Metal Kokkola 2010, Kokkola, Finland, 16.-17.11.2010
- K. Rätzke, F. Faupel, *Free Volume and Positron Annihilation in Polymers and Polymer Electrolytes (Invited talk)*,

ICEP2010 (4th International Conference on Electroactive Polymers: Materials and Devices), Dehli, India, 22.-27.11.2010

## Further Activities and Events

### Selected Honorary Activities of Prof. Faupel:

Dean of the Faculty of Engineering from July 2008 until July 2010 (Technische Fakultät der CAU),

Coordinator of the *North German Initiative Nanomaterials (NINA)*,

Principle Editor of the *Journal of Materials Research, edited by the Materials Research Society (MRS)*,

Editor of the *encyclopedia RÖMPP online, Thieme Chemistry*,

Member of the Advisory Board of *Diffusion and Defect Data*,

Member of the DGM Scientific Advisory Board, *German Material Research Society*,

Member of the Program Committee of the DFG Priority Program "*Polymer-Solid Interfaces, Thin Films, and Interphases - from Molecular View to Continuum*",

Vice Speaker of the SFB 677 "*Function by switching*",

Member of the managing committee of the SFB855 "*Magnetoelectric composites - biomagnetic interfaces of the future*",

Member of the *Societas Christiana Albertina*,

Member of the HWT (Hochschule-Wirtschaft-Transfer)-Jury of the ISH (Innovation Foundation Schleswig-Holstein),

Member of the Steering Committee of the Focal Point of Support "*Nano and surface science*",

Member of the Steering Committee Quality Management of the CAU,

Member of KARE, (*Kiel Alliance of Research and Education*),

In addition to the activities listed above, Prof. Faupel was involved in many evaluations for the German Science Foundation (DFG), scientific journals, and other Institutions in Germany and abroad.