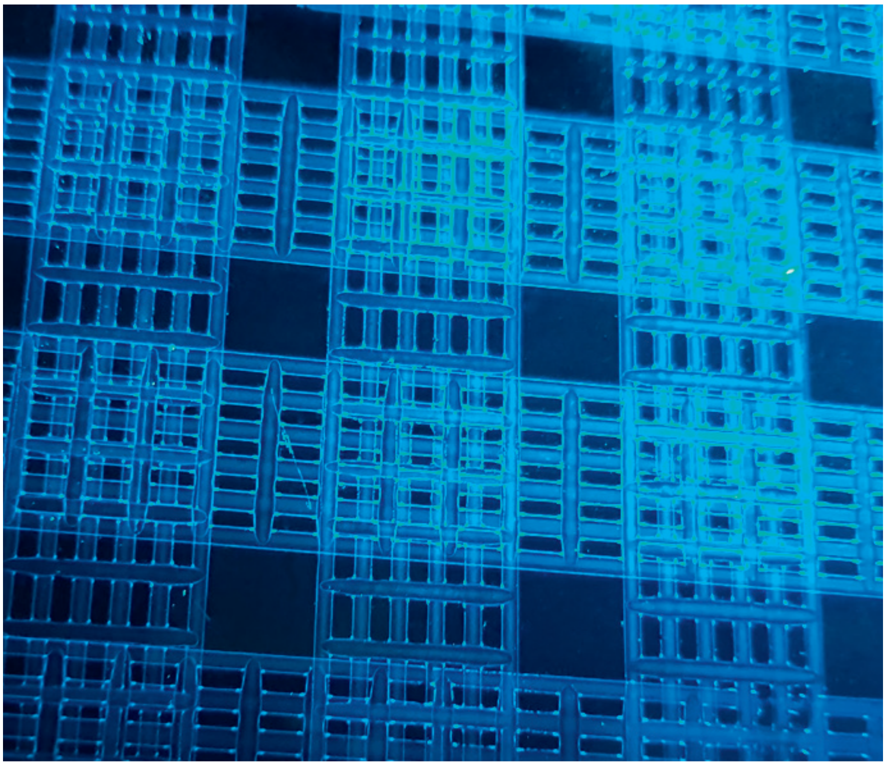
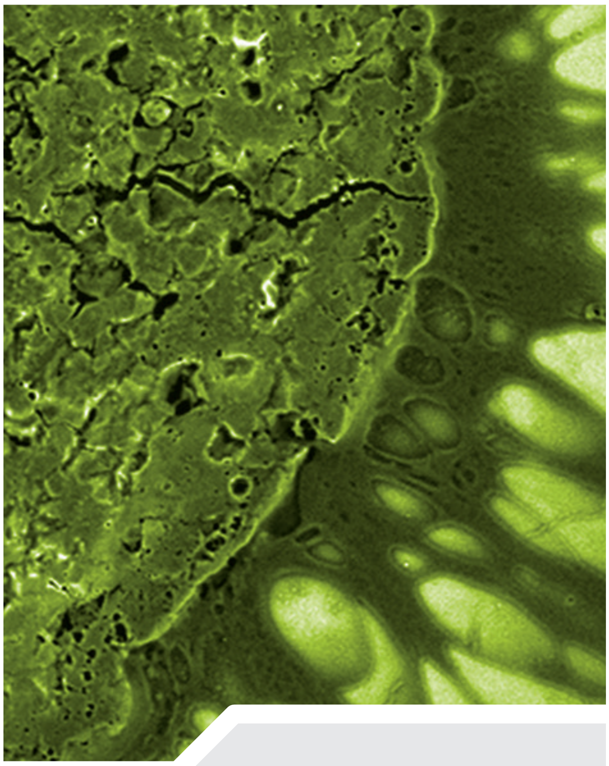
Neues Denken. Neue Materialien.





JAHRESBERICHT 2018
ANNUAL REPORT 2018

Leibniz Gemeinschaft

INM Leibniz-Institut für Neue Materialien

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Business Director

Prof. Dr. Aránzazu del Campo

Wissenschaftliche Geschäftsführerin/
Scientific Director

Prof. Dr. Eduard Arzt

Wissenschaftlicher Geschäftsführer und
Vorsitzender der Geschäftsführung/
Scientific Director and CEO

LIEBE FREUNDINNEN UND FREUNDE DES INM,

es ist geschafft: Mit der Stellungnahme des Senats der Leibniz-Gemeinschaft und der Zustimmung der GWK zur weiteren Förderung des INM konnten wir 2018 das Evaluierungsverfahren unseres Instituts abschließen. Wir freuen uns über das hervorragende Ergebnis und haben bereits begonnen, die Empfehlungen der Evaluierung umzusetzen.

Das vergangene Jahr wurde wieder durch sehr schöne Erfolge geprägt: So gelang es dem Institut erstmals, einen ERC – Proof of Concept einzuwerben. Etwas Besonderes war die Auszeichnung von Aleeza Farrukh mit dem Leibniz-Promotionspreis. Dazu hat unser Kooperationspartner, Professor Robert McMeeking von der UC Santa Barbara, einen Humboldt-Alumni-Preis zum Aufbau eines innovativen Modellierungsnetzwerks am INM erhalten.

Inhaltlich nutzen wir die Zeit nach der Evaluierung, um neue Themen zu initiieren. Hierzu intensivieren wir unsere Zusammenarbeit auf dem Campus der Universität des Saarlandes: Dies gilt insbesondere für die Gebiete der biomedizinischen Materialien und der Materialien in der digitalen Umgebung. Für diese beiden Zukunftsbereiche des INM planen wir eine räumliche Erweiterung; mit den Baumaßnahmen soll 2020 begonnen werden.

Wir danken Ihnen für Ihre Unterstützung des INM im vergangenen Jahr und freuen uns, wenn Sie uns auch 2019 wieder begleiten werden.

DEAR FRIENDS OF INM,

It's done: With the statement of the Leibniz Senate and the approval of the GWK to continue public funding of INM, the evaluation of our institute was successfully completed. We are pleased with the outstanding result and have already begun to implement the recommendations.

The past year was again marked by major success stories. For example, the institute succeeded for the first time in obtaining an ERC Proof-of-Concept grant. Especially noteworthy is Aleeza Farrukh´s Leibniz Award for the best PhD thesis. Additionally, our cooperation partner, Professor Robert McMeeking from UC Santa Barbara, was awarded a Humboldt Alumni Prize for developing an innovative modeling network at INM.

In terms of content, we are using the time after the evaluation to initiate new thematic areas. To this end, we intensify our cooperation with the campus of Saarland University with the aim to accelerate our research in the areas of biomedical materials and of materials in the digital environment. For these two future research themes of the INM, we plan a spatial expansion of the institute. The necessary construction work is supposed to start in 2020.

We thank you for your support of the INM in the past year and look forward to your continued support in 2019.

GRUPPENBERICHTE / GROUP REPORTS

Niels de Jonge
Head *Innovative Electron Microscopy*

Roland Bennewitz
Head *Nanotribology*

Eduard Arzt
Head *Functional Microstructures*

Volker Presser
Head *Energy Materials*

"OUR RESEARCH FIELD FOCUSSES ON PHYSICAL AND PHYSICO-CHEMICAL PROCESSES AT INTERFACES. WE DESIGN, SYNTHESIZE AND CHARACTERIZE MATERIALS AND STRUCTURES WITH HIGH DENSITIES OF SURFACES AND INTERFACES. RECENT DEVELOPMENTS INCLUDE A PROGRESSIVE SHIFT FROM SCIENTIFIC CONCEPTS TO APPLICATION."

GRENZFLÄCHENMATERIALIEN / *INTERFACE MATERIALS*

ENERGIE-MATERIALIEN / ENERGY MATERIALS

PROF. DR. VOLKER PRESSER

ZUSAMMENFASSUNG

Der Programmbereich *Energie-Materialien* erforscht elektroaktive Grenzflächen und entwickelt funktionale Nanomaterialien für elektrochemische Anwendungen zur Energiespeicherung und Wasseraufbereitung. Hochporöse Kohlenstoffmaterialien können mittels chemischer Prozesse auf der Nanoskala mit Metalloxiden und Metallsulfiden hybridisiert werden. Besonders interessant sind dabei Kohlenstoffnanozwiebeln und Verfahren wie die Atomlagenabscheidung. Wir untersuchen zudem Faraday'sche Materialien wie zweidimensionale Karbide (MXene) und Chalkogenide. Neben Superkondensatoren sowie Lithium- und Natrium-Ionen-Batterien erforschen wir redoxaktive Elektrolyte zur Entwicklung schneller Energiespeicher mit hoher Speicherkapazität. Besondere Bedeutung hat die Charakterisierung elektrochemischer Prozesse, die mit In-situ-Methoden untersucht werden. Damit reichen unsere Aktivitäten von Materialsynthese und Grundlagenforschung bis hin zu Methodenentwicklung, Zelldesign und Industriekollaborationen zur angewandten Energieforschung.

MISSION

Research in the Program Division *Energy Materials* is focused on the synthesis, characterization, and application of electroactive interfaces and functional nanomaterials. Our activities focus on electrochemical energy storage (supercapacitors, redox electrolytes, lithium-ion and sodium-ion batteries) and water treatment (capacitive deionization, electrochemical desalination). Carbon materials and nanohybrids are the most important electrode materials, and we utilize non-porous carbon nanoparticles (carbon onions, carbon black) and nanoporous carbon materials (activated carbons, carbide-derived carbon, polymer-derived carbon, carbon nanofibers) to obtain electrodes for electrochemical applications. Hybridization of carbon is accomplished by implementation of nanoscale metal oxides or metal sulfides. We also investigate Faradaic materials, such as two-dimensional transition metal dichalcogenides or carbides (MXene). Redox electrolytes capitalize on the rapid charge transfer when in nanoconfined space; utilized as nanoreactors, nanoporous carbons combined with redox electrolytes enable the unique combination of battery-like energy storage while maintaining supercapacitor-like charge/discharge rates. We focus on a comprehensive array of materials characterization techniques and in situ methods to gain novel insights into electrochemical processes. Our contributions range from basic research, materials synthesis, and the refinement of testing procedures to industrial collaboration and technology development.

CURRENT RESEARCH

Core / shell design of metal oxide / carbon hybrid materials

High performance electrochemical materials require both: electrical conductivity and high ion storage capacity. Our work employs metal carbides as the precursor and a chloroxidation process based on the thermal decomposition of metal chloride hydrates. Together with partners at the Technical University Darmstadt, we explore one-step synthesis concepts that yield nanohybrids of metal oxides with carbon materials. The resulting materials are highly attractive for use as electrodes in lithium- or sodium-ion batteries.

Redox-active electrolytes

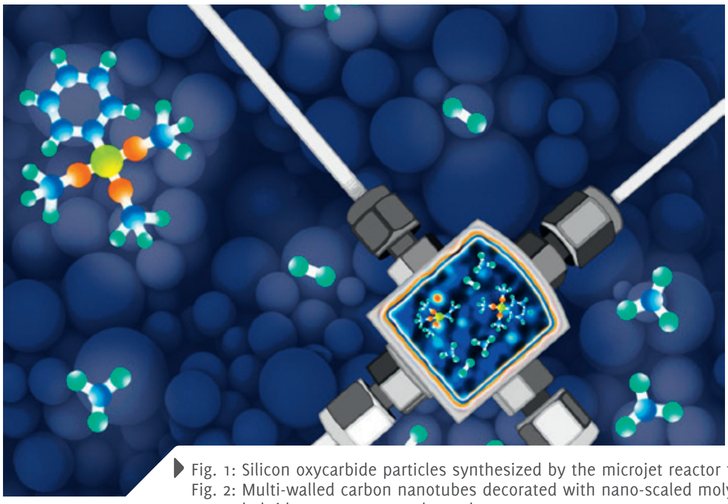
Unshackled from solid-state diffusion, redox-active electrolytes allow the access to the combined high power / high energy regime for electrochemical energy storage. The confinement of redox-active ions in carbon nanopores enables high charge transfer rates and, for some ions, results in weak chemisorption that makes the use of ion exchange membranes between the electrode pair obsolete. Aqueous redox systems capitalize further on the non-flammability for enhanced operation safety compared to energy storage modules based on organic electrolytes. Our team has also demonstrated that redox-active electrolytes can be used for water desalination with enhanced performance by translating the enhanced charge storage capacity to an increased ion removal ability.

Faradaic materials for water treatment

Capacitive deionization is an emerging technology for energy efficient water desalination, usually employing nanoporous carbon electrodes. We have demonstrated the high suitability of pseudocapacitive and battery-like electrode materials, such as MXene, transition metal dichalcogenides and metal oxide / carbon nanohybrids. Our work has shown that unlike capacitive deionization, Faradaic deionization allows the ion-selective desalination at high molar strength, enabling applications such as sea water treatment or mining water remediation. By this way, our research also involves electrode materials equally suited for sodium-ion batteries.

OUTLOOK

Our team will continue to broaden the utilization of interfacial electrochemistry and hybrid carbon nanomaterials. We will continue to enhance our collaboration with industry for the development of high capacity energy storage devices, with strong focus on carbon/metal oxide nanohybrid materials. We will also further explore electroactive interfaces and Faradaic materials for advanced electrochemical desalination. The low energy consumption and excellent performance for the desalination of high salinity media overcomes the present-day issues of capacitive deionization and will lead to a new technology field of desalination batteries. The latter critically requires thorough understanding of the structural changes during charging/discharging and selectivity of Faradaic materials towards ionic species.



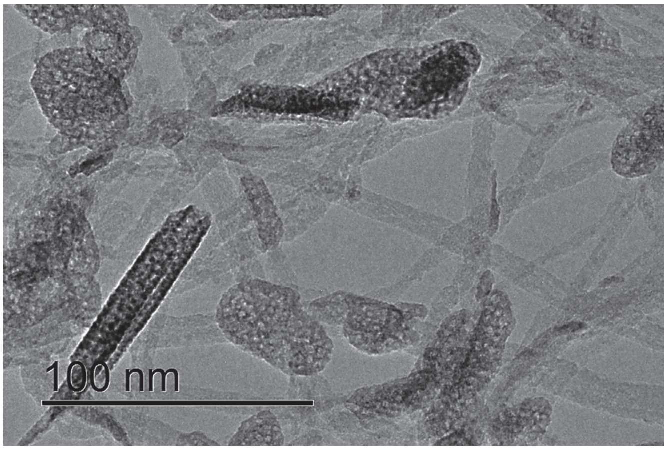


Fig. 1: Silicon oxycarbide particles synthesized by the microjet reactor technique can be used as anodes for lithium ion batteries.
Fig. 2: Multi-walled carbon nanotubes decorated with nano-scaled molybdenum oxide obtained from atomic layer deposition for hybrid energy storage electrodes.

FUNKTIONELLE MIKROSTRUKTUREN / FUNCTIONAL MICROSTRUCTURES

PROF. DR. EDUARD ARZT, DR. RENÉ HENSEL

ZUSAMMENFASSUNG

Mikrostrukturierte Oberflächen versprechen neue mechanische, optische, thermische und haptische Funktionalitäten. Der Programmbereich befasst sich mit der experimentellen und theoretischen Untersuchung solcher Oberflächen, deren Konzepte von Vorbildern in der belebten Natur inspiriert sind. Der Fokus der laufenden Arbeiten liegt auf fibrillären, bioinspirierten Haftsystemen für die temporäre Adhäsion (Abb. 1). Schwerpunkte sind die Optimierung der Kontaktflächen sowie das Zusammenspiel der Kontaktelemente einer Haftstruktur anhand numerischer Modellierung und experimenteller Validierung. In Kooperation mit Industriepartnern werden technische Gecomer-Greifsysteme für spezifische Anwendungen entwickelt. Eine neue erfolgversprechende Richtung ist das Design von Wundpflastern in Kooperation mit der Universitätsklinik in Homburg. Unsere Arbeiten werden von der EU (ERC Advanced Grant, zwei ERC Proof-of-Concept Grants, sowie einem ITN Trainee Network), einem Projekt der Leibniz-Gemeinschaft und durch Industriekooperationen gefördert.

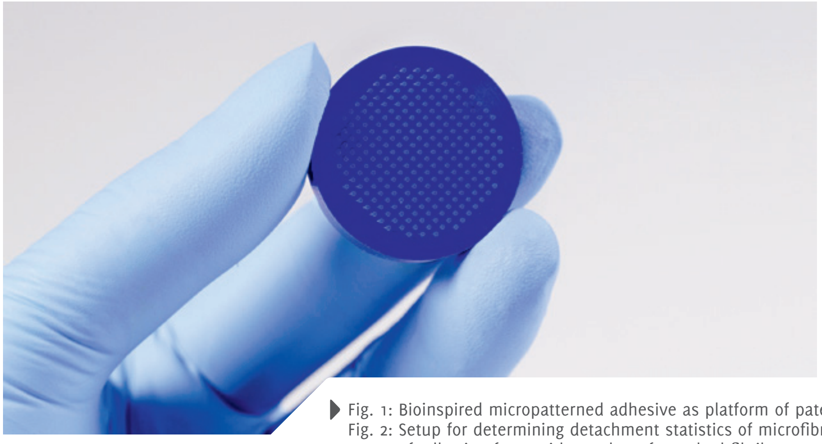
MISSION

Micropatterned surfaces promise new mechanical, optical, thermal, and haptic functionalities. The Program Division *Functional Microstructures* conducts experimental and theoretical research on the design, fabrication and characterization of such surfaces by combining suitable morphologies and materials. Inspired by the adhesive performance of natural systems, the group mimics such mechanisms to control the adhesion of synthetic surfaces (figure 1). To optimize adhesion, the stress distribution in the contact interface is modelled numerically and the statistics and interplay of individual adhesive contacts are investigated. In cooperation with industrial partners and clinicians, we currently transfer our Gecomer Technology into industrial applications. A promising new direction is the design of wound adhesives for clinical application. Our research is funded by an ERC Advanced Grant, two ERC Proof-of-Concept Grants, an EU ITN Trainee Network, a Leibniz transfer project, and industrial contracts.

CURRENT RESEARCH

Interplay of individual pillars within a micropatterned adhesive array

While the adhesion of single polymeric pillars is reasonably well understood, the collective statistics of detachment has not received research attention so far. To gain microscopic insight into the detachment mechanisms of micropatterned arrays, a novel approach is taken. Individual contacts are imaged by frustrated total internal reflection, allowing *in-situ*



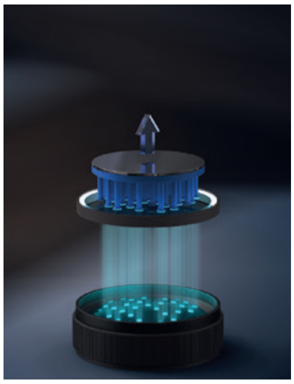


Fig. 1: Bioinspired micropatterned adhesive as platform of patented Gecomer-Technology.
Fig. 2: Setup for determining detachment statistics of microfibril arrays based on correlation of adhesion force with number of attached fibrils.

observation of contact formation and separation during adhesion tests (Fig. 2). Imperfections in the contact of individual pillars lead to a distribution of individual contact quality as a function of surface roughness. This distribution dominates the detachment process and the resulting adhesion strength, in air and under reduced pressure. In collaboration with J. Booth and Prof. R. M. McMeeking (UC Santa Barbara), further parameters such as system compliance, misalignment, and array size are numerically modelled to rationally optimize array designs for high performance. (Adv. Funct. Mater., 2019)

Skin adhesives

Novel skin adhesives could potentially revolutionize wound healing strategies and open new avenues for human-computer interaction. Skin is, however, a challenging substrate for achieving reliable adhesion as it is rough and compliant. In addition, the adherent has to be biocompatible to avoid irritations. New silicone-based films for the treatment of ear drum perforations were developed and successfully tested *in vivo* in mice (cooperation with Prof. B. Schick and OÄ Dr. G. Wenzel, SUH Homburg). In a new ERC Proof-of-Concept grant (STICK2HEAL – *Innovative adhesives for ear drum healing*), the clinical potential of these materials is currently evaluated. In a collaboration with the Saarland Informatics Campus (Prof. J. Steimle, Saarland University), new films for wearable electronics applications were developed. We analyzed their effect on human tactile perception in psychophysical experiments. (J. Mech. Behav. Biomed. Mater., 2018)

Technology transfer

INM's Gecomer Technology has now been validated for numerous pick & place scenarios, even in challenging environments. The patent base was extended to include additional effects expected to be of practical use for specific applications. A roll-to-roll micropatterning process was successfully implemented in collaboration with the *InnovationCenter INM*, thanks to funding by the Leibniz-Association. In a Proof-of-Concept project funded by ERC, we currently take our Technology to the first steps of commercialization. (Materials, 2019)

OUTLOOK

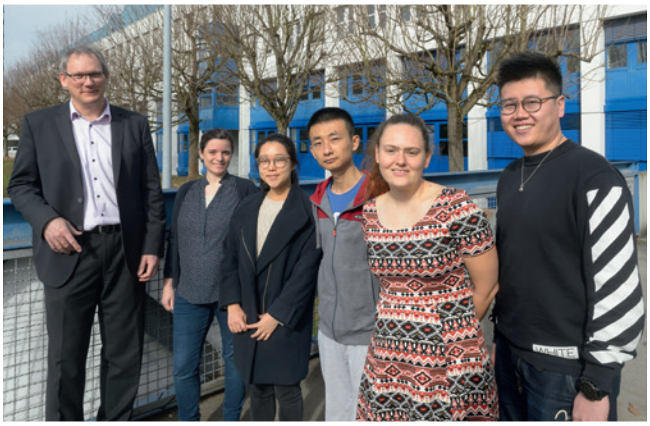
Scientifically, micropatterned surfaces will continue to play a central role in INM's research portfolio. Among the fundamental aspects to be explored are, e. g., the contact mechanics in the presence of edge and misalignment effects and the mechanics of interaction with ultra-soft substrates. Additional functionalities will be introduced to improve the reliability of adhesive devices in critical applications. In cooperation with Saarland University Hospital, biomedical prototypes will very likely enter the stage of testing on humans. New functions of micropatterned surfaces such as electrical interfacing and haptic properties will be explored in future collaborations (e. g. with *Nanotribology*). Micromechanical modeling of adhesion performance will remain an important baseline to rationally optimize adhesion, e. g. for intelligent gripping devices with adjustable touch. The potential applications range from medical devices to space robotics.

NANOTRIBOLOGIE / NANOTRIBOLOGY

PROF. DR. ROLAND BENNEWITZ

ZUSAMMENFASSUNG

Der Programmbereich *Nanotribologie* forscht an der Entwicklung neuer Materialien mit besonderen adhäsiven und tribologischen Eigenschaften. Im Zentrum stehen dabei die Strukturierung und Funktionalisierung von Oberflächen und das Verständnis physikalisch-chemischer Mechanismen, die mechanische Eigenschaften wie Reibung, Verschleiß, Schmierung, Verformung und Adhäsion bestimmen. Vermehrt widmet sich der Programmbereich auch nanomechanischen Problemen der Biophysik. Die experimentellen Projekte basieren auf unserer Expertise in der hochauflösenden Rasterkraftmikroskopie. Auch auf größeren Längenskalen werden grundlegende Experimente zu Reibung und Verschleiß durchgeführt, wobei vor allem die Rolle der Reibung mit Haut in der haptischen Wahrnehmung von Materialien untersucht wird. Zu den wichtigsten Ergebnissen des Jahres 2018 gehören die Charakterisierung der Struktur von Schmierstoff in nanoskaligen Spalten, die Aufklärung tribochemischer Prozesse bei der Reibung zwischen Silizium und Gold, sowie eine skalenübergreifende Untersuchung der Transferfilmbildung bei der Reibung zwischen Stahl und PEEK.



MISSION

The Program Division *Nanotribology* explores new materials with specific adhesion and friction properties. We focus on surface functionalization and on understanding the physical chemistry of friction, wear, lubrication, deformation, and adhesion. Our work extends to nanomechanical problems in biophysics. The experimental projects rely on our expertise in the field of high-resolution force microscopy. Fundamental tribology experiments also address larger length scales, in particular in skin friction and its role in the haptic perception of materials. New projects have been initiated in the field of single-molecule force spectroscopy in soft matter for biophysical applications.

CURRENT RESEARCH

The following examples describe research results which led to publications in international research journals:

Molecular layering in nanometer-confined lubricants

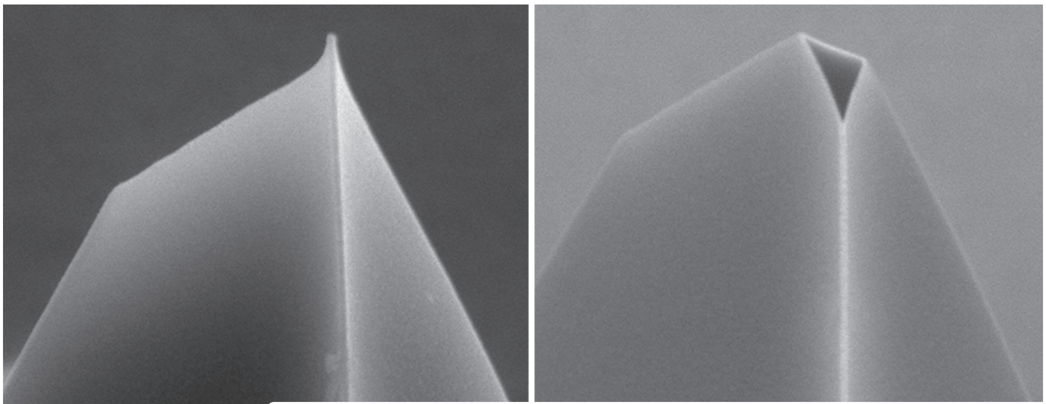
Liquid lubricants reduce friction and wear by separating roughness asperities of sliding surfaces in contact. Their load-bearing capacity and their shear properties depend critically on the molecular structure in contacts under high pressure. In collaboration with an industrial partner, we have demonstrated that even large branched lubricants such as poly-alpha-olefins evolve a layered structure of higher order in nanometer confinement.

Tribochemistry in sliding friction of silicon and gold

Friction and wear depend on chemical interactions between the surfaces in sliding contacts, but pressure, shear, and temperature can also initiate chemical reactions. A famous example is contact ageing of silica-silica interfaces, where the increase in the number of chemical bonds during a period of static contact leads to an increase in the static friction coefficient. By implementing contact ageing experiments in ultra-high vacuum, we could demonstrate that clean silica surfaces do not show contact ageing in the absence of water. Similarly, no contact ageing was found for clean gold surfaces. Only after the removal of passivating oxide layers, silicon exhibited strong tribochemical effects, which include the formation of a nanometer-scale amorphous surface layer at the interface.

Multiscale tribology of the PEEK – steel contact

In collaboration with the Chair of Composite Engineering at the Technische Universität Kaiserslautern (Prof. A. Schlarb) and supported by the German Research Association, we have studied the mechanisms of friction and wear in sliding contacts between PEEK and steel. Experiments at different length scales revealed the mechanisms of transfer film formation, which eventually led to a stable low-friction interface. Roughness asperities at the steel surface play a key role by plowing in the softer polymer matrix. While plowing leads to increased friction, it also starts the formation of a low-friction transfer film which nucleates around the asperities. We could demonstrate that single-asperity scratching experiments and high-resolution pin-on-disk experiments provide the same friction coefficients as standardized macroscopic tribological tests, if they are repeated often enough to allow for the initiation of transfer film formation.



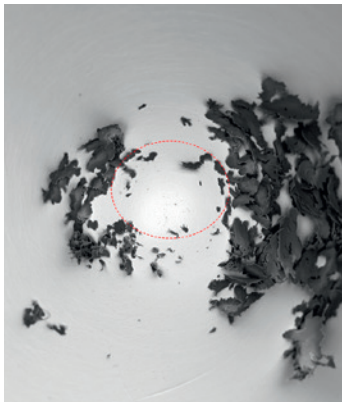


Fig. 1: The tip of an atomic force microscope before and after friction experiments on a reactive silicon surface. Tribochemical processes led to a perfectly smooth removal of the contacting apex.
Fig. 2: Development of wear debris as source for a compacted transfer film at the apex of a steel tip used for scratching in PEEK. Contact area indicated by red ellipse.

OUTLOOK

We will continue to investigate the mechanisms which link the structure and the dynamics of surfaces to friction and wear in new materials. Our current projects include nanomechanical studies of hydrogels in collaboration with the Program Division *Dynamic Biomaterials* and the development of novel molecular materials with force sensing functions for biophysical applications. We investigate electrochemical processes at the surface of metallic glasses at the nanometer scale. We will continue our activities in tribochemistry, investigating the interplay of mechanical and chemical processes in the formation of tribofilms. Our research on haptic perception of materials will be further developed in collaboration with the Program Division *Functional Microstructures*, and the Departments of Materials Science, of Psychology, and of Computer Science at Saarland University, with the goal to reveal fundamental pathways of tactile perception through psychophysical experiments on microstructured materials.

INNOVATIVE ELEKTRONENMIKROSKOPIE / INNOVATIVE ELECTRON MICROSCOPY

PROF. DR. DR. H. C. NIELS DE JONGE

ZUSAMMENFASSUNG

Eine nanometergenaue Materialcharakterisierung ist unabdingbar für die Weiterentwicklung der modernen Nanotechnologie und der Biologie. Der Programmbereich *Innovative Elektronenmikroskopie* betreibt interdisziplinäre Forschung an der Schnittstelle der Physik der Elektronenmikroskopie (EM), Biophysik, Materialwissenschaft, Zellbiologie und Bildverarbeitung. Wir entwickeln modernste Techniken im Bereich der *in situ* Transmissions-EM (TEM) und Raster-TEM (STEM) für die Forschung an funktionellen Materialien und biologischen Systemen unter realen Bedingungen. Außerdem untersuchen wir neue Wege für die dreidimensionale Datenaufnahme. Wir verfügen über langjährige Erfahrung mit Bildverarbeitung sowie mit der Entwicklung von Protokollen für die spezifische Proteinmarkierung mit Nanopartikeln. Dem Programmbereich steht ein hochmodernes Elektronenmikroskop (JEOL ARM200) zur Verfügung. Wir haben vielfältige Forschungskooperationen mit verschiedenen Universitäten und der Industrie.

MISSION

Nanoscale characterization is essential for the development of modern nanotechnology, energy science, biology, and biomedical sciences. The Program Division *Innovative Electron Microscopy* conducts interdisciplinary research at the interface of physics of electron microscopy, biophysics, materials science, cell biology, and image processing being world leading in the area of liquid-phase electron microscopy (LP-EM). We develop forefront *in situ* transmission electron microscopy (TEM) and scanning TEM (STEM) methods for the study of functional materials and biological systems at realistic conditions, mostly using a liquid flow system. Also we are exploring new routes for three-dimensional (3D) data acquisition using intelligent STEM – and image reconstruction strategies. In addition, we have extensive experience with image processing and with developing protocols for specific labeling of proteins with nanoparticles. The group houses a state-of-the-art electron microscope (ARM200, JEOL). Various research collaborations exist both with academia and industry.

CURRENT RESEARCH

Growth factor receptors in cancer cells

We study the growth factor receptor HER2 at the single-molecule level within whole breast cancer cells in liquid, thereby analyzing differences in protein function between individual cancer cells (cancer cell heterogeneity). This research is done in cooperation with Prof. S. Wiemann of the German Cancer Research Center, Heidelberg, and Prof. E.-F. Solomayer of the Saarland University Hospital, Homburg. The project is funded by the Else Kröner-Fresenius-Stiftung.

Stoichiometry of calcium channels

LP-EM is being used to study the stoichiometry of Ca^{2+} channels formed by ORAI proteins in mammalian cells. The relative ratio of the different ORAI channels is highly relevant for cell function. This project is conducted together with Prof. B. Niemeyer, Biophysics, Saarland University, Homburg, and is part of the SFB Collaborative Research Center 1027.

MULTIMAT

We are partner in the MARIE SKLODOWSKA-CURIE ACTIONS Innovative Training Network (ITN) project "A multiscale approach towards mesostructured porous material design, MULTIMAT", headed by Prof. N. Sommerdijk of the Technical University of Eindhoven, the Netherlands. Our role is to expand the application area of LP-EM to image self-assembly of soft matter.

3D STEM

We are currently innovating in 3D STEM for obtaining nanometer resolution in micrometers-thick specimens. The project is a collaboration with Dr. T. Dahmen, German Center for Artificial Intelligence, Saarbrücken and is funded by the DFG.

Studying the behavior of protein and nanomaterials in liquid

A graphene liquid enclosure has been developed, capable of imaging proteins in liquid (Nano Lett. 2018). Dynamic processes at the solid-liquid interface were studied with STEM at the nanoscale. We have active research interactions with the program division *Structure Formation*.

Resolution of LP-EM

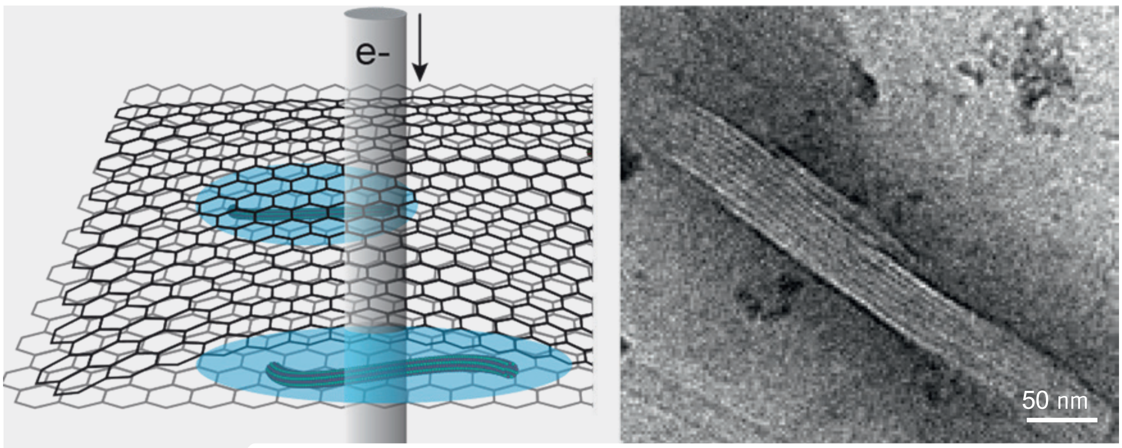
The spatial resolution of LP-EM has been studied as a function of the electron dose aiming at achieving nanometer resolution on soft matter, which is highly challenging due to the occurrence of radiation damage (Nat. Rev. Mat. online, 2018).

INM-focus project

We have one INM internal focus project in which we study the spatial correlation between cytoskeleton and signaling active HER2 homodimers (CYHER) in a joint project with the Junior Research Group *Cytoskeletal Fibers*.

OUTLOOK

The group is well prepared to conduct research at the international forefront of electron microscopy both in the areas of biology/biophysics, and materials science. A future aim is to study processes of protein complexes by developing a Liquid STEM as a standard characterization method for membrane proteins in cells. Furthermore, we would like to study HER2 in gastric cancer, improve the time-resolution of *in situ* STEM via adaptive sampling techniques, and develop Liquid 3D STEM.

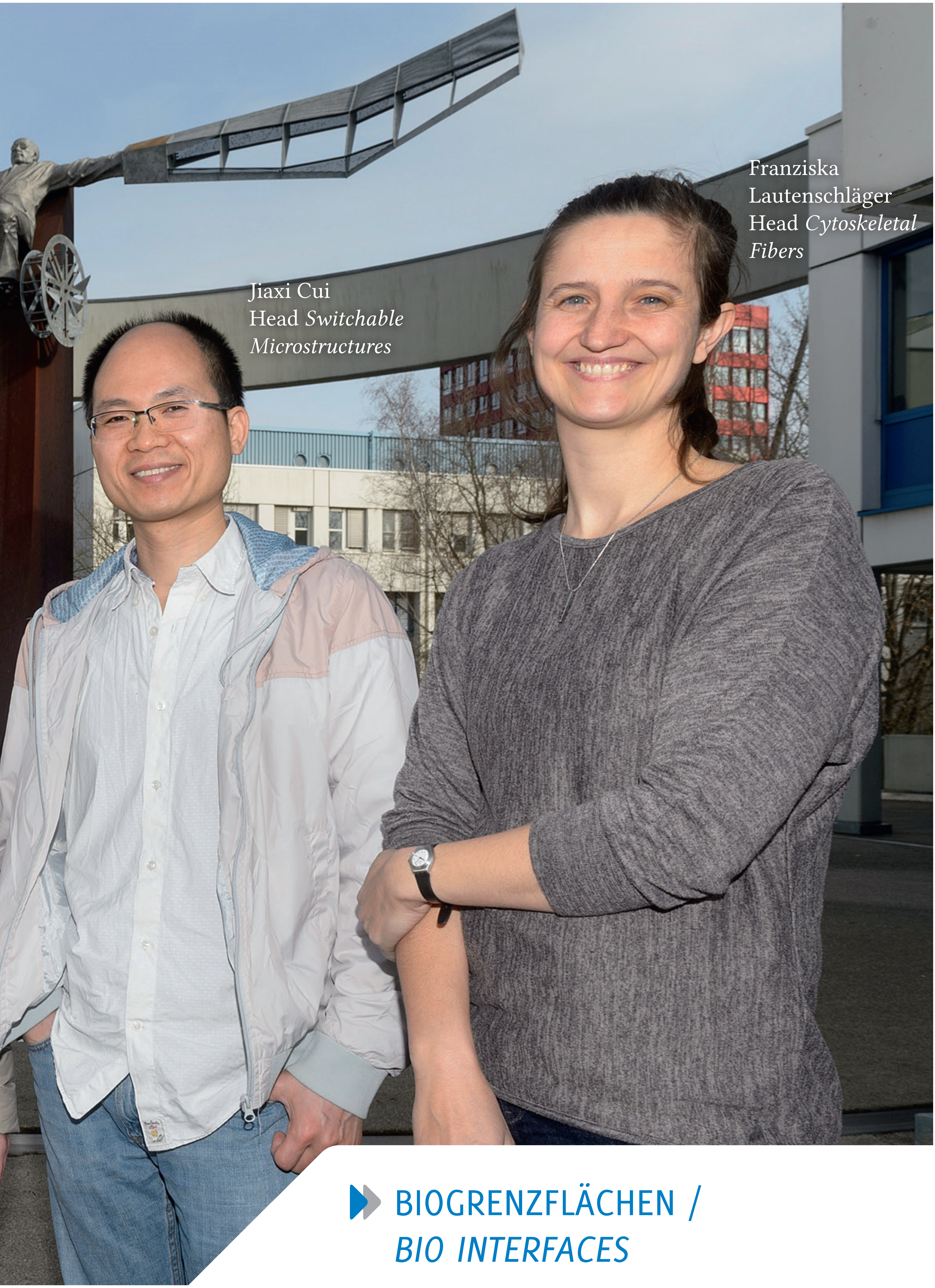


TEM of graphene-encapsulated microtubule proteins.
Fig. 1: Schematic representation of hydrated microtubules in liquid droplets encapsulated by graphene layers.
Fig. 2: TEM of a microtubule. Interior lines with 5 nm spacing corresponding to 2D projection of protofilaments clearly visible.

"OUR RESEARCH FIELD DEVELOPS POLYMERS AND CELLULAR MICRO-ENVIRONMENTS MIMICKING THE DYNAMIC PROPERTIES OF NATURAL TISSUES. WE USE THEM TO RECREATE CELL SCENARIOS OF BIOMEDICAL RELEVANCE. OUR RESULTS WILL CONTRIBUTE TO NEW BIOMEDICAL APPLICATIONS."

Aránzazu del Campo
Head *Dynamic Biomaterials*

Annette Kraegeloh
Head *Nano Cell Interactions*



Jiaxi Cui
Head *Switchable Microstructures*

Franziska Lautenschläger
Head *Cytoskeletal Fibers*

BIOGRENZFLÄCHEN / *BIO INTERFACES*

DYNAMISCHE BIOMATERIALIEN / DYNAMIC BIOMATERIALS

PROF. DR. ARÁNZAZU DEL CAMPO

ZUSAMMENFASSUNG

Der Programmbereich *Dynamische Biomaterialien* entwickelt zellinstruktive Materialien, die in der Lage sind, das Zellwachstum zu unterstützen und das Schicksal der Zellen zu lenken. Dazu nutzen wir synthetische Phototrigger und photoresponsive biologische Prozesse, um Materialien mit latenten Funktionsstufen zu entwerfen, die mittels Lichteinwirkung angeschaltet werden können (4D-Biomaterialien). Eigenschaftsänderungen können bei Bedarf mit genauer räumlicher und zeitlicher Kontrolle eingeleitet, verstärkt oder beendet werden. Diese Veränderungen ahmen den adaptiven Charakter der zellulären Mikroumgebung in lebenden Organismen nach. Wir verwenden unsere Biomaterialien, um solche Änderungen in *In-vitro*-Kulturen und *In-vivo*-Modellen nachzubilden. Dynamische Biomaterialien sind als Gerüste für die Entwicklung prädiktiver Krankheitsmodelle, als instruktive Matrizes für fortschrittliches Tissue Engineering und als Träger für die Verbesserung von Medikamenten und zellbasierten Therapeutika gedacht.

MISSION

The Program Division *Dynamic Biomaterials* develops cell-instructive materials able to support cell growth and guide cellular's fate. We exploit synthetic phototriggers and photoresponsive biological processes to design materials with latent functional levels that can be unlocked upon light exposure (4D biomaterials). Property changes can be initiated, reinforced, or terminated on demand with precise spatiotemporal control. These changes mimic the adaptive character of the cellular microenvironment in a living organism. We apply our biomaterials to recreate such changes in *in vitro* cultures and *in vivo* models. Dynamic biomaterials are envisioned as scaffolds for the development of predictive disease models, as instructive matrices for advanced tissue engineering, and carriers for improving drug- and cell-based therapeutics.

CURRENT RESEARCH

A few highlights of the research work in *Dynamic Biomaterials* during 2018 follow:

Cellular microenvironments with reconstructed cell-matrix and cell-cell interfaces

We have developed in-situ forming hydrogels decorated with photoactivatable matrix adhesive ligands (EU funded project, *FET Mechanocontrol*) and growth factors to regulate the function of embedded cells. 3D bioprinting allows us to fabricate customized scaffolds for reconstructing tissues and disease models *in vitro* (BMBF funded project, *In vitro Challenge*). Moreover, we have developed hydrogels that mimic neighboring cells and accelerate microtissue formation. Muscle cells cultured on these substrates were able to form mature myofibers within a few days. Adaptation of the hydrogel design to culture other cell types (cardiomyocytes, neuronal stem cells, skin basal keratinocytes) is in progress. We will

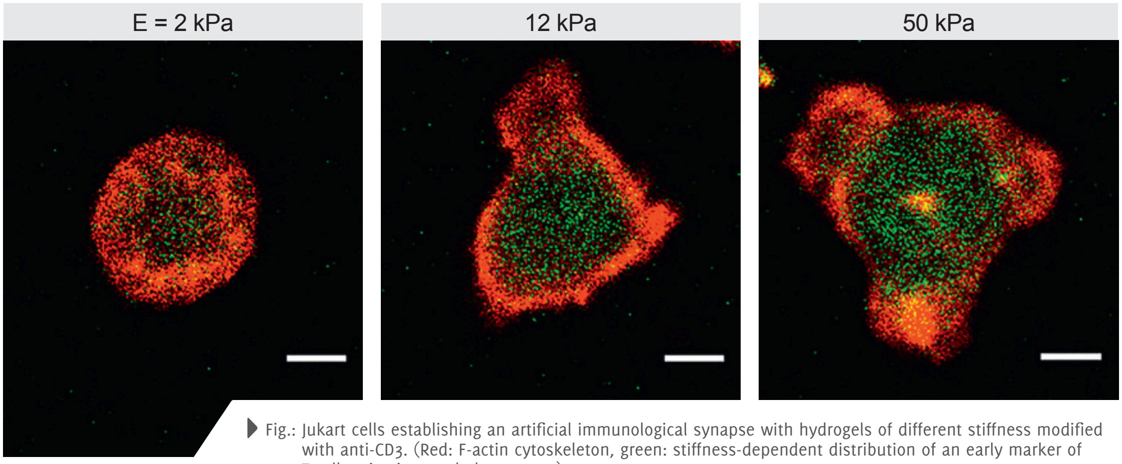


Fig.: Jukart cells establishing an artificial immunological synapse with hydrogels of different stiffness modified with anti-CD3. (Red: F-actin cytoskeleton, green: stiffness-dependent distribution of an early marker of T cell activation, scale bar: 10 µm)

investigate the potential of these hydrogels to accelerate culture of delicate cells to form cardiac tissue, nerves or stratified epithelium for regeneration purposes (DFG funded project within the SPP 1782, cooperation with Dermatology, University Clinic Cologne and Biology Department, University Leipzig).

Hydrogels that support bacterial drug production: new devices for long-term therapeutics.

In cooperation with C. Wittmann (Systems Biotechnology, Saarland Univ.), we have demonstrated the possibility of incorporating bacteria into hydrogels to produce a shrunk biopharmaceutical factory which allows external regulation of drug production and release using optogenetic tools. These bacterial hydrogels allow spatially confined protein expression and dosed release over several weeks. (Adv Sci 2018, Small 2019, Adv Biosys 2019) These living materials hold immense potential and versatility as innovative drug delivery systems for future therapeutics. We continue work in this topic in cooperation with the Pharmacy Department of Saarland University and the Helmholtz Center for Pharmaceutical Research.

Immunointeractive materials

The group cooperated with Biophysics at UKS within the SFB 1027 to study how materials design can be used to regulate immune cells. In cooperation with B. Qu (INM Fellow from UKS), we have identified hydrogel designs that can trigger T cells activation depending on the mechanical properties and biochemical functionalization. In cooperation with R. Bennewitz (*Nanotribology*) we study how hydrogel architecture affects the mechanical exchange between materials and cells. In cooperation with J. Rettig (Biophysics, UKS) we investigate light-based methods to regulate the T-cell/hydrogel interaction on-demand. On a long-term perspective, we aim to apply our materials and knowledge to the field of immunotherapeutics.

OUTLOOK

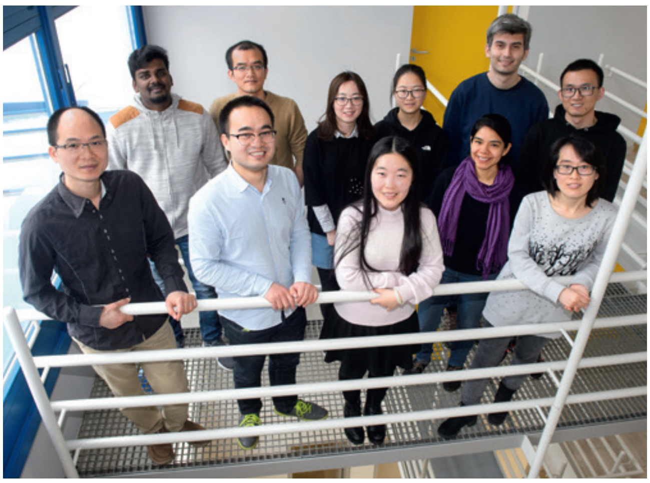
The development of cellular microenvironments to support and control cell growth and function remains a major topic in the group. The synthetic toolbox is moving from pure organic synthesis to biochemical approaches, and from phototriggers to natural optical switches (optogenetics). Progress on the biomaterial side involves implementation of 3D printable bioinks and development of co-cultures. The focus of the group is currently set to the development of biomaterials supporting tissue regeneration. However, we envision applying tissue engineering concepts to recreate biological materials *in vitro*, breaking the classical border between synthetic and bioengineering approaches in biomaterials science.

SCHALTBARE MIKROFLUIDIK / SWITCHABLE MICROFLUIDICS

DR. JIAXI CUI

ZUSAMMENFASSUNG

Die Juniorforschungsgruppe *Schaltbare Mikrofluidik* zielt darauf ab, dynamische Polymermaterialien zu entwickeln, die in der Lage sind, ihre Vernetzungsstruktur, ihre physikalischen und chemischen Eigenschaften und ihre makroskopische Geometrie zu verändern, um schaltbare Oberflächen und Biomaterialien herzustellen, die den neuen Anforderungen in Biosynthese, Biomedizin und anderen Bereichen gerecht werden. Zu diesem Zweck entwerfen wir molekulare Strukturen, synthetisieren organische Bausteine und setzen fortschrittliche Polymerisationstechnologien ein, um definierte Materialien herzustellen und ihre Struktur-Eigenschafts-Beziehungen sowie ihre Reaktionsfähigkeit auf Stimuli zu untersuchen. An diesen dynamischen Polymersystemen wenden wir biologisch inspirierte Strategien an, um intelligente Oberflächen für die Flüssigkeitsübertragung zu schaffen, die Haftung und Reibung der Oberfläche zu steuern und heterogene Strukturen und Metamaterialien aufzubauen. Wir untersuchen auch die grundlegenden Mechanismen des Transports und der Umwandlung von Molekülen in dynamischen Polymernetzwerken.



MISSION

The Junior Research Group *Switchable Microfluidics* aims to develop dynamic polymer materials able to change their crosslinking structure, their physical and chemical properties, and their macroscopic geometry to produce switchable surfaces and biomaterials for meeting emerging needs in biosynthesis, biomedicine, and other areas. For this purpose, we design molecular structures, synthesize organic building blocks, and apply advanced polymerization techniques to prepare well-defined materials, and to investigate their structure-property relationship and stimuli-response. At these dynamic polymer systems, we apply bio-inspired strategies for creating smart surfaces to transfer liquids, and for controlling adhesion and friction to build heterogeneous structures and metamaterials. We also investigate fundamental mechanisms of molecule transport and conversion in dynamic polymer networks.

CURRENT WORK

Enzyme-based switchable reactor

We design a class of thermo-responsive magnet nanoparticle carriers to switch the solubility of enzyme catalysts in aqueous solution for mediating biosynthesis and enzyme recycling. Enzymes are efficient but expensive catalysts and thus need to be recycled. Currently, the immobilization of enzymes on magnet nanoparticles represents one of the most convenient methods to separate the enzyme catalysts from the reaction solution. For efficient catalysis, the enzyme-anchored magnet nanoparticles should be well dispersed in aqueous solution. However, the good dispersibility would significantly reduce the recycling ratio and rate. We built a switching mechanism into the enzyme-anchored magnet nanoparticles to alter their dispersibility in aqueous solutions

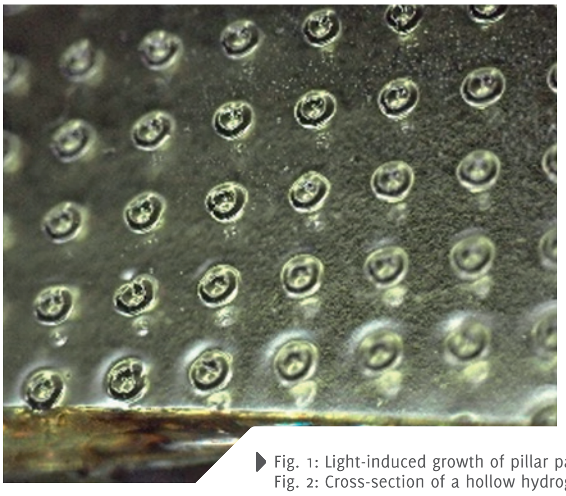


Fig. 1: Light-induced growth of pillar pattern.
Fig. 2: Cross-section of a hollow hydrogel fiber in a 3D printed scaffold.

on demand. Our idea is based on the thermo-induced phase transition of the polymers with lower critical solution temperatures (LCST) in aqueous solution. Thermo-responsive polymer brushes were prepared by surface-initiated living/controlled polymerization on magnet nanoparticle surfaces, followed by converting the free terminal end of the tethered polymer chains to highly active groups for binding enzymes. We demonstrated thermo-switchable dispersibility of the enzyme-anchored reactor to be well-dispersed at temperatures below the LCST but to accumulate at higher temperatures for easy collection. The concept was fully established, and we are on our way to test the activity of the enzyme.

Photo-guided growth of polymer materials

Living organisms distinguish from artificial objects by their unique ability to grow. Inspired by this hallmark, we develop a class of synthetic polymer systems able to absorb nutrient to grow up with controllable changes in size, shape, and composition. In 2018, the group focused on the photo-guided growth of this kind of materials. By utilizing the change of Zeta potential in a photo-induced reaction, we can control the transport of nutrient, a mixture of monomer and crosslinker, in the polymer matrix and converse them into the bulk constituent. As the result of the increase in composition, polymer patterns grow out of the substrate, without any template (Fig. 1).

Self-reshaping hydrogels

Hydrogels made from dynamic polymer networks can continue to change their geometry and properties. Based on the observation of a self-hollowing process in a class of dynamic hydrogels consisting of two non-covalent crosslinking interactions, i. e., hydrophobic association and ion-coordination, we continued to study the evolving process. We discovered the molecular transfer process in the self-hollowing process and developed a primary model to describe it. The fundamental understanding allows us to design various hollow structures combined with 3D printing technology. Thus, a hollow 3D hydrogel scaffold can be printed (Fig. 2). The scaffold's cavities could be interconnected or isolated. More important, the scaffold is biocompatible and allows for cell cultures. We closely collaborate with the Program Division *Dynamic Biomaterials* on this topic.

OUTLOOK

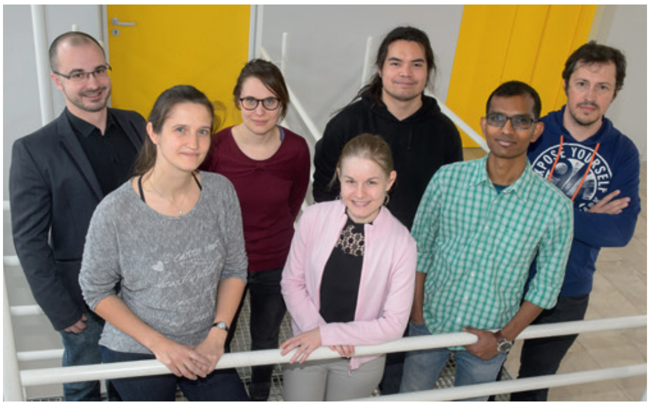
We will continue to develop enzyme-based reactors with specific attention to improve the recovery rate of anchored enzymes, study the underlying mechanisms of mass transport and interconversion in polymer matrices, and develop printable hydrogel materials with post-tunable geometry and properties. The group will focus on dynamic polymer gels in which reversible chemistry not only occurs between polymer chains but also between the polymer and small molecules or among small molecules. These results will lead us to design self-regulated coatings that can automatically alter their properties to prevent fouling, increase adhesion, restore damage, bear loading, or reflect light etc.

ZELLSKELETALE FASERN / CYTOSKELETAL FIBERS

JUN.-PROF. DR. FRANZISKA LAUTENSCHLÄGER

ZUSAMMENFASSUNG

Die Juniorforschungsgruppe *Zellskeletale Fasern* arbeitet seit Januar 2017 an natürlichen Polymeren, welche in Zellen vorkommen und deren Funktionen beeinflussen. Längst sind nicht alle dieser Funktionen aufgeklärt. Zu den bisher erforschten Aufgaben zählen die Adhäsion von Zellen an Oberflächen oder die Generierung von Kräften, welche wiederum in vielen Prozessen beteiligt sind, wie z. B. der Fortbewegung, der Zellteilung oder der Kommunikation von Zellen mit ihrer Umgebung. Bei dieser Umgebung kann es sich sowohl in der Form als auch in der Zusammensetzung um in der Natur vorkommende oder um komplett neu gestaltete Materialien handeln. Diese zellskeletalen Fasern, ihre spezifischen Rollen in zellulären Systemen und ihre Reaktion auf die sie umgebenden Matrices bilden die Grundlage für die Kooperationen der Juniorforschungsgruppe mit mehreren Programmbereichen, wie *Dynamische Biomaterialien*, *Nano Zell Interaktionen* und *Innovative Elektronenmikroskopie*.



MISSION

The Junior Research Group *Cytoskeletal Fibers* investigates natural supramolecular polymeric structures at the INM since January 2017. These are built inside the cells and strongly influence their function. Major tasks are the adhesion of cells on surfaces and the generation of forces, which are involved in many processes: cellular movement, cell division or the communication of cells with their close environment. This environment can be the one occurring naturally, or a designed material. Cytoskeletal fibers, their specific roles in cellular systems and their reaction to the surrounding matrix form the basis of the collaborations of the Junior Research Group with several Program Divisions, such as *Dynamic Biomaterials*, *Nano Cell Interactions* and *Innovative Electron Microscopy*.

CURRENT RESEARCH

The group is working on a number of projects, continuing the close collaboration with the Saarland University. Examples of these projects are:

Actin waves in migrating immune cells

In this project, which is part of the SFB 1027, the group correlated the migration trajectories of immune cells in confined spaces with the dynamics of their actin cytoskeleton. They found that actin polymerization waves are involved in two types of movement: a diffuse and a directed motion.

The spatial correlation between actin and active Her2 homodimers

Closely collaborating with the Program Division *Innovative Electron Microscopy*, the group is investigating the position of active Her2 homodimers – a membrane protein which has been related to aggressive breast cancer – related to actin fibers.

Extracellular vimentin on the proliferation of cells

Under specific circumstances such as inflammation, particular immune cells secrete a part of their cytoskeleton into the extracellular environment. The group is investigating which effect the presence of this polymer in the extracellular matrix has on specific cellular functions such as their proliferation rate.

Quantitative analysis of the actin cortex

Using the manifold electron microscopy facilities present at INM, the group is imaging the actin cortex of cells in adherent or suspended states. This imaging is carried out in close collaboration with the Service Group *Physical Analytics*. By quantitative image analysis it is possible to detect smallest alterations in cellular cortices which can explain functional differences of cells in both states, for example in cellular mechanics.

Search optimization of immune cells in well-defined environments

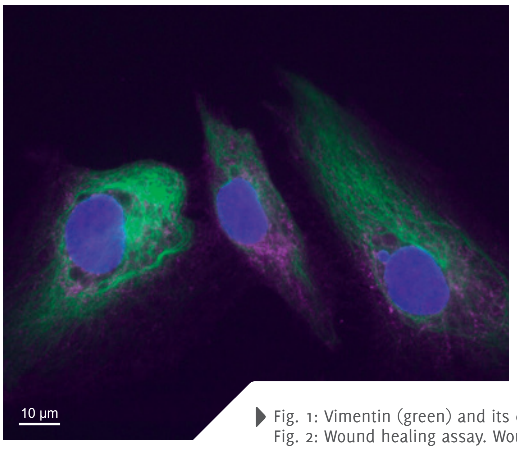
In order to test if immune cells have an optimized search strategy when exploring their environment for pathogens and if this search depends on the physical conditions of the surroundings, the group is generating a range of microenvironments with various properties and tests them for immune cell migration. This project is carried out in collaboration with Saarland University in the framework of SFB 1027.

Interactions of cytoskeletal proteins

One type of cytoskeletal filaments, actin, is well known to be the key player for the generation of cellular forces. However, all three types of cytoskeletal polymers are connected to each other, either directly or via crosslinkers. In this project, the group is investigating the effect of a vimentin and its linkage to actin on the generation of cellular forces.

OUTLOOK

The Junior Research Group *Cytoskeletal Fibers* performs research on the cellular cytoskeleton and its changes under external factors such as chemical adhesion or physical forces. By now, the group has incorporated new methodologies to their scientific portfolio, for example high resolution microscopy for the analysis of cytoskeletal fibers. Furthermore, the group is exploring the role of a rather unknown fiber type called vimentin and its relation to actin on cellular functions, such as cellular migration, mechanics, and proliferation. Interestingly, vimentin seems to have an effect of cells when being present either inside or outside of the cell. In the future the group will explore if this polymer type could be used in order to voluntarily stimulate cellular functions, for example to speed up wound healing.



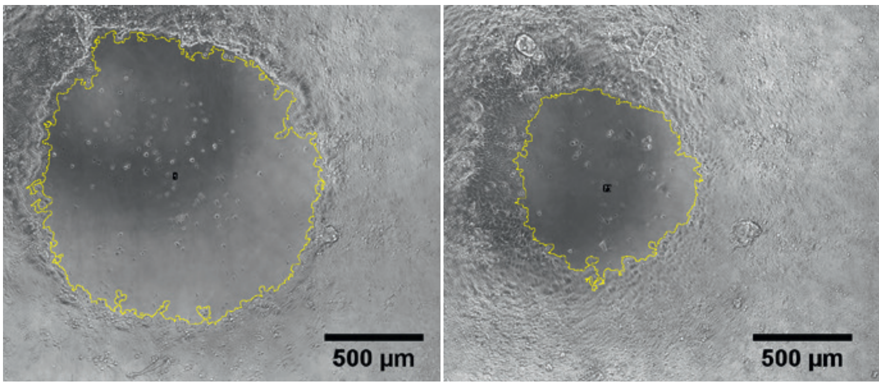


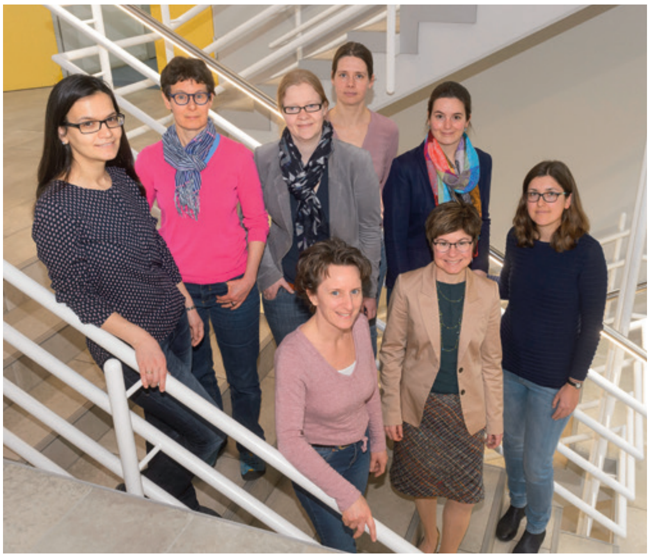
Fig. 1: Vimentin (green) and its crosslinker to actin (plectin, in purple) in HFF cells. Nucleus in blue.
Fig. 2: Wound healing assay. Wound after 0h (left) and 24h (right).

NANO ZELL INTERAKTIONEN / NANO CELL INTERACTIONS

DR. ANNETTE KRAEGELOH

ZUSAMMENFASSUNG

Der Programmbereich *Nano Zell Interaktionen* beschäftigt sich mit den Auswirkungen technisch hergestellter Nanoobjekte auf menschliche Zellen, um zu einer sicheren Anwendung von Nanomaterialien in technischen und biomedizinischen Bereichen beizutragen. Ziel ist es, zu verstehen, wie bestimmte Partikeleigenschaften Struktur und Biochemie der Zellen beeinflussen, und aufzuklären, welche Mechanismen die Aufnahme und Lokalisation von Nanoobjekten vermitteln. Als Untersuchungsobjekt werden gezielt anorganische Nanopartikel hergestellt und charakterisiert. Zur Lokalisation von Partikeln und Zellstrukturen werden vor allem lichtmikroskopische Techniken eingesetzt. Eine Besonderheit der Gruppe ist die Nutzung hochauflösender Stimulated Emission Depletion (STED)-Mikroskopie für diesen Zweck. Zur weiteren Analyse der Zellantwort werden darüber hinaus chemische, biochemische und molekularbiologische Techniken eingesetzt.



MISSION

The Program Division *Nano Cell Interactions* explores the effects of engineered nano-objects on human cells to enable safe applications of nanomaterials in technical and biomedical fields. It strives to understand how particle properties influence structure and biochemistry of cells and to elucidate mechanisms that affect the uptake or location of nano-objects: Our purpose is to pave the way for the design of safer nanomaterials. For this reason, well-defined inorganic nanoparticles are prepared and characterized. Light microscopy techniques, for example Stimulated Emission Depletion (STED) microscopy, are used to localize particles and to analyze cellular structures. Further chemical, biochemical, and biomolecular techniques are used for the analysis of the cellular responses.

CURRENT RESEARCH

NanoDopa – dopamine-loaded nanoparticles for advanced therapy of Parkinson’s disease

Parkinson’s disease is a neurodegenerative disease, hallmarked by a loss of dopamine producing neurons in the brain. Treatment by application of dopamine is impeded by the blood-brain-barrier, which is impermeable for dopamine. Therefore, some current therapies are based on the application of the prodrug Levodopa, which is able to overcome this barrier and can be subsequently converted into dopamine. NanoDopa aims at the development of efficient dopamine transport into the brain. The project started in 2018 and is conducted in collaboration with Fraunhofer Institute for Biomedical Engineering and two companies in frame of the NanoPharm ZIM (Central Innovation program for SMEs) cooperation

Fig.: Safe-by-Design in the development of nanomaterials by balancing aspects of functionality and safety.

network. One main role of INM is the microscopy analysis of model brain tissue in order to evaluate the transport efficiency.

Development of safe nanomaterials

The Horizon 2020 project NanoReg2 aims at the establishment of Safe-by-Design (SbD) as a fundamental pillar in the validation of novel nanomaterials as well as in the regulatory context. In cooperation with the project partners, in particular the National Institute for Public Health and the Environment (RIVM, The Netherlands) and the *Innovation Center INM*, the *Nano Cell Interactions* group has developed a concept allowing the balancing of safety and functionality aspects of nanomaterials during the innovation process. This concept is based on a structured stage-gate model supporting the implementation of SbD early in the innovation process. It was recently extended by inclusion of information needed for decision making at the gates (decision points). Furthermore, it highlights SbD actions aiming at reducing potential risks of nanomaterials during their envisaged life-cycle. (Fig.)

Leibniz-Research Alliance Nanosafety

In order to strengthen the Leibniz Research Alliance Nanosafety, two new partner institutes were affiliated: the Leibniz Institute for Materials Engineering (IWT), Bremen and the Leibniz Institute of Polymer Research (IPF), Dresden. Recent activities of the Leibniz-Research Alliance Nanosafety in the field of data infrastructure are led by the Leibniz-Institute for Information Infrastructure (FIZ), Karlsruhe. One topic is directed towards the development of quality standards for nanosafety research data, which is of high relevance for the generation of meaningful scientific data as well as for the further development of regulatory standards. Related to the public perception of nanotechnologies and nanosafety, the Leibniz Institut für Wissensmedien (IWM), Tübingen is conducting research on the handling of scientific information in the field of nanosafety. Recently, nanotechnology experts at INM participated in a scientific survey on this topic.

OUTLOOK

A real understanding of the mechanisms involved in the generation of nanomaterial effects on cells, tissues or even human health demands understanding of the involved physical, chemical, and biological mechanisms. One important aspect is the correlation between the location of the nanomaterials and the induced response on a cellular and tissue level. Therefore, one main objective of future work is to further develop and optimize light microscopy-based testing platforms including analysis of the nanomaterial location within the cellular context. More general objectives are to contribute to the development of safe nanomaterials and to strengthen the biomedical application potential of nanomaterials.

Carsten Becker-Willinger
Head *Nanomers*

Peter W. de Oliveira
Head *Optical Materials*

"OUR RESEARCH FIELD DESIGNS NEW COMPOSITES WITH FUNCTIONALIZED PARTICLES THAT TUNE E. G. OPTICAL, ELECTRONIC OR PROTECTIVE PROPERTIES. OUR MATERIALS CAN REACT TO EXTERNAL STIMULI OR CHANGE THEIR PROPERTIES WHEN REQUIRED. IN COOPERATION WITH INDUSTRY, WE ADAPT AND TRANSFER THEM TO THE MARKETS."

Tobias Kraus
Head *Structure Formation*

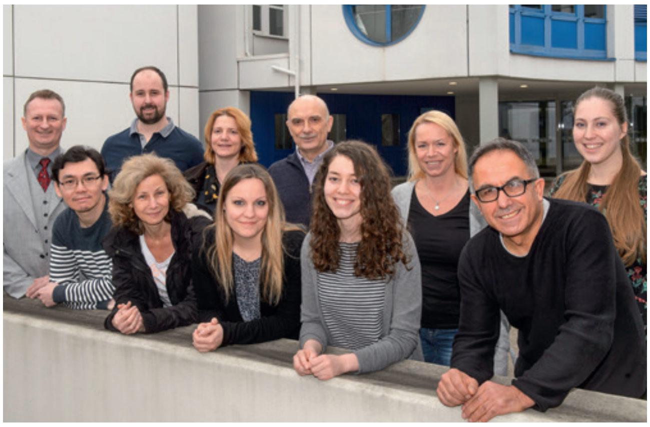
NANOKOMPOSIT-TECHNOLOGIE / *NANOCOMPOSITE TECHNOLOGY*

NANOMERE / NANOMERS

DR.-ING. CARSTEN BECKER-WILLINGER

ZUSAMMENFASSUNG

Der Programmbereich *Nanomere* entwickelt multifunktionelle Schutzschichten, Kompaktwerkstoffe sowie Materialien für additive Fertigungsverfahren auf Basis von Kompositen mit polymeren und hybriden Matrizes sowie nano- und mikroskaligen, funktionellen Additiven. Bei der Erzielung neuer Werkstoffeigenschaften steht der Anwendungsbezug deutlich im Vordergrund. Die funktionellen Additive sind keramischer, metallischer Natur oder auch halbleitend. Neben kugelförmigen Teilchen sind auch solche mit plättchenförmiger Morphologie von besonderem Interesse. Mit einer maßgeschneiderten Oberfläche versehen, erlauben die Teilchen den Übertrag festkörperphysikalischer Eigenschaften anorganischer Materialien in Polymere und Beschichtungen. Schwerpunkt der Entwicklungsaktivitäten sind schwermetallfreie, aktive Korrosionsschutzsysteme für Stahl und hochfeste Aluminiumlegierungen, temperaturbeständige, brandschützende Bindemittel, transparente, selbstheilende Beschichtungen und polymerbasierte Materialien für die additive Fertigung.



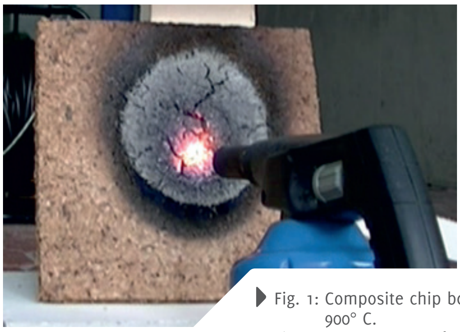
MISSION

Activities of the Program Division *Nanomers* comprise the development of functional coatings and bulks based on the polymer matrix composite concept. A strong focus is put on application oriented projects for materials used in industry. Functions of interest are heavy metal free corrosion protection optionally with low friction performance for steel and high strength aluminum alloys, temperature stable and fire resistant binders, and transparent self-healing surfaces. Applications are in electronics, medicine, optics, automotive, construction, engineering, and additive manufacturing.

CURRENT RESEARCH

Heavy metal free corrosion protection

Our concept for heavy metal free corrosion protection is based on the introduction of physical barriers in polymer coating matrices using inorganic platelets on the one hand and establishing a repassivating mechanism in coatings by anisotropic phosphate pigments on the other hand. The concept should help to design new types of passive diffusion barrier coatings combined with an active corrosion protection mechanism. The active corrosion protection of the anisotropic, flake-type phosphate particles was investigated with Electrochemical Impedance Spectroscopy, potentiometric analysis and standard corrosion tests. Results were presented at EUROCORR 2018. A corresponding industry project on corrosion protection for mild steel for metal fittings was continued in 2018 and actually reaches the end of its screening phase. A new project supported by the state of Saarland started in 2018 with the focus on corrosion protection coatings for fasteners made of high strength aluminum alloys.



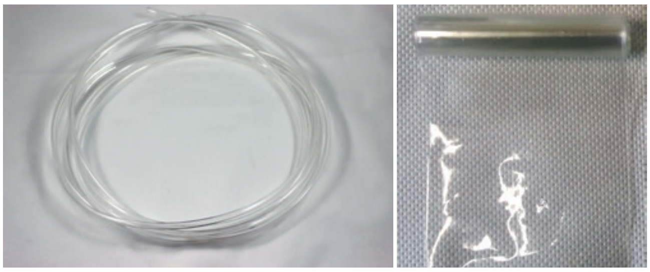


Fig. 1: Composite chip board from Namibian Acacia encroacher bush in fire resistance test after 20 min at 900° C.
Fig. 2: Demonstrators from BMBF-BioPolyMed from biodegradable polymers with anti-microbial sur-face function a) extruded catheter tube, b) extruded foil.

BioPolyMed

The BMBF-project BioPolyMed (cooperation with the University Hospital Greifswald), was successfully finished in October 2018. Catheters and connectors from biodegradable thermoplastic polymers with anti-microbial surface modification and a biodegradable packaging material were developed. The materials compositions were fully characterized concerning their mechanical, thermomechanical and degradation properties. The project results are a very promising contribution to minimize the risk of nosocomial infections of patients during stay in intensive care units, as verified by our project partners.

Self-healing polyrotaxane based coatings

The BMBF-VIP+-project Polyrotaxanlack in close cooperation with Saarland University focuses on a new class of materials to establish the concept of self-healing, scratch resistant hard coatings as a new technology platform. The polyrotaxanes were hydrophobised and combined with suitable cross-linkers as well as UV-absorbing nanoparticles to achieve hard coatings that show complete self-healing of superficial scratches within 60 s when heated up to 90° C. The pure polymers were combined with organic-inorganic silane structures as well as nanoparticles in order to improve their mechanical, weathering properties and self-healing ability with respect to the intended applications. Results were presented at the SMT32 Conference on Surface Modification Technologies 2018 and at ETCC European Technical Coatings Congress 2018.

NaMiComp II

The BMZ-GIZ-project NaMiComp I in cooperation with the University of Namibia (UNAM) focused on capacity development for the set-up of a materials research laboratory at the UNAM Southern Campus in Keetmanshop was finished in early 2018. The follow-up project NaMiComp II, supported by BMZ-GIZ and Saarland Ministry of Economy, started in the last quarter of 2018. An additional expert visit is planned to train the Namibian partners in synthesis and analytical methods. The operational start of the materials research lab at UNAM is envisaged for the end of 2019. The first application case in focus of this framework is the development of natural fiber and sand composites as construction materials for affordable housing in Namibia and sub-Saharan African countries. The work in this project is in line with Leibniz in Africa initiative.

OUTLOOK

The polymer composite approach as a tool box will be further followed for materials development. Self-healing hard coatings based on polyrotaxane slide-ring gels will be transferred from the basic level into application oriented projects. Functionalized nanoparticles will be developed to improve weathering ability of self-healing coatings and as active corrosion protection additives in coatings for high strength light metals suitable for electro mobility applications. The platform of materials for 3D-printing will be widened towards printing of vulcanisable elastomers and 3D-printable transparent hybrid materials based on reactive curing.

OPTISCHE MATERIALIEN / OPTICAL MATERIALS

DR. PETER W. DE OLIVEIRA

ZUSAMMENFASSUNG

Der Programmbereich *Optische Materialien* gestaltet und verbessert Beschichtungs- und Bulkmaterialien auf der Basis von Nanokompositen. Diese Materialien erhalten ihre spezifischen Merkmale und Funktionalitäten über die Wechselwirkung mit sichtbarem Licht oder elektromagnetischer Strahlung im Allgemeinen. Die Kompetenzen der Gruppe liegen in den Bereichen mathematischer Berechnungen optischer Eigenschaften sowie der Materialsynthese bis hin zur Entwicklung und Optimierung neuer Auftrags-, Anwendungs- und Strukturierungstechniken durch iterative multiparametrische Anpassungen. So konnte unter anderem ein Ersatz für ITO (Zinn-dotiertes Indiumoxid) gefunden werden, indem Silbergitter mit verschiedenen TCO (transparent conducting oxides) Schichten kombiniert wurden, um einen Flächenwiderstand unter 10 Ω/sq zu erzielen. Die Arbeiten wurden im Rahmen des EU-Projekts INFINITY am INM durchgeführt.

MISSION

The mission of the Program Division *Optical Materials* comprises the development and optimization of nano-composite materials with specially designed optical and electro-optical properties. These materials find uses as coatings and in the bulk for applications, which require interactions with visible light or electromagnetic radiation in general. The expertise of *Optical Materials* lies in the modelling of optical properties, material formulation and synthesis, the modification of existing processes as well as the elaboration of new methods of application and structuring. The merge of these skills allows for new approaches to meet the demand for appropriate materials by designed physical properties like electrical impedance, refractive power, transmittance or light sensitivity, and suitable chemical compositions resulting in novel materials for specific products and processes.

CURRENT RESEARCH

The following highlight topics were investigated in 2018:

Development of screen printing pastes for the preparation of transparent conductive structures

New cars that enter the European Union market must have an emergency call technique which requires an antenna that could be placed on the car's rear window as this part tends to remain intact after a crash. The antenna could be printed by screen printing with a suitable paste. The aim of this project is the development of a paste that enables screen printing of transparent conductive antenna structures on polycarbonate substrates. The sheet resistance should be below 5 Ω/sq and the transmission higher than 65 %. The curing temperature should not exceed 130° C.

Continuous flow synthesis of zirconia nanoparticles

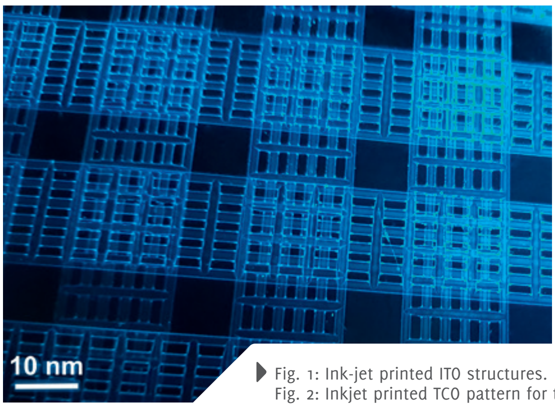
Batch processes are widely used for nanoparticle synthesis. Due to the simple setup and the sound knowledge, batch processes are a good option for lab scale studies. When batch processes are scaled up, local variations in concentration and temperature can arise. Moreover, long heating and cooling times are needed and due to the large volume safety becomes an issue. Continuous flow processes can overcome these challenges. Because of the small volumes of simultaneously processed solutions they are much easier to control. Local variations of concentration and temperature are avoided and short heating and cooling times provide good control over nucleation and particle growth. To avoid clogging of the microfluidic system, it is essential to prevent agglomeration and sedimentation.

Hybrid conductive layer systems of printed silver grids with wet chemically deposited TCO coatings

Even with ITO, which is the most commonly used TCO material, because of its high conductivity and high optical transmission, a sheet resistance below 10 Ω/sq is difficult to obtain. Because indium is an expensive material, significant efforts are made to develop alternative materials for transparent electrodes. For In-free TCO coatings an improvement of the sheet resistance is often required because of their higher resistivity. Therefore the combination of a silver grid with various TCO coatings was studied. The aim of this work, which was done as part of the EU project INFINITY, was the development of hybrid layer systems by combination of an inkjet printed silver grid with various TCO coatings to obtain transparent conductive layer systems with a sheet resistance below 10 Ω/sq. As alternative TCO material aluminum doped zinc oxide (AZO) will be tested and the properties will be compared with those of ITO coatings of the INM. In the EU project the INM is partly responsible for the fabrication of the TCO inks and mainly for the printing of the inks.

OUTLOOK

The research strategy of the Program Division *Optical Materials* focuses on applications of optical effects by systematic development and processing of materials with addressable optical properties. *Optical Materials* targets application fields such as display technology, energy conversion, and active optics. The Program Division's way to implement and to handle R&D projects leads to a differentiation in the quality of the research results and to an added value for partners and customers. The group is looking for intense cooperation with German and international universities and research institutes in order to build up a strong cooperation network. It is further targeting the fields of security and information technologies. Materials with novel optical functions will increase in importance and in market potential in the coming years. The advancement of the group's new materials will be complemented by the adaption and development of novel coating and printing techniques.



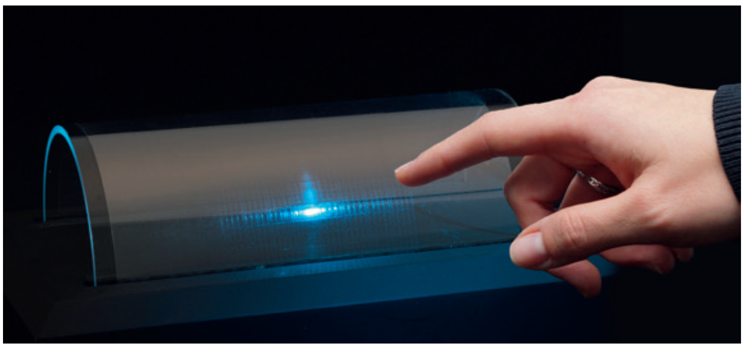


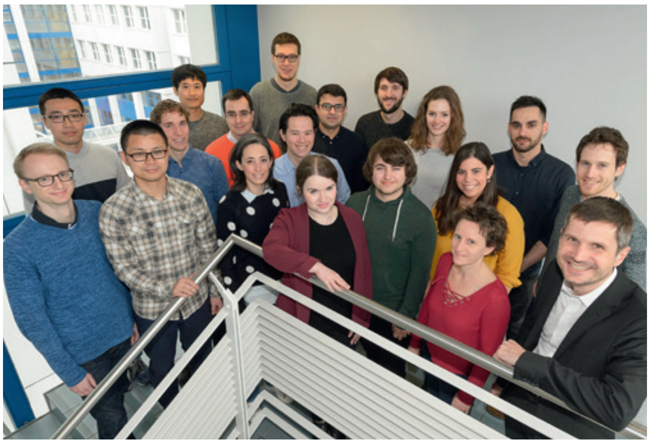
Fig. 1: Ink-jet printed ITO structures.
Fig. 2: Inkjet printed TCO pattern for touch screen devices.

STRUKTURBILDUNG / STRUCTURE FORMATION

PROF. DR. TOBIAS KRAUS

ZUSAMMENFASSUNG

Der Programmbereich *Strukturbildung* erforscht die Anordnung kolloidaler Dispersionen in neuen Materialien. Wir kombinieren anorganische Partikel mit organischen Molekülen zu flüssigen Vorstufen. Beim Drucken, Beschichten, Imprägnieren oder Kompoundieren bilden sich daraus Hybridmaterialien. Unsere Methoden erlauben es, die Bildung von Mikrostruktur und inneren Grenzflächen in situ zu beobachten. Durch systematische Variation von Größe, Geometrie, Zusammensetzung und Anordnung der Komponenten klären wir den Einfluss der Struktur auf die Materialeigenschaften auf und lernen, diesen auf verschiedenen Skalen zu nutzen. Partikel und Moleküle werden daraufhin so angepasst, dass sie Anordnung und Eigenschaften verbessern. So entstehen zum Beispiel transparent leitfähige Schichten aus ultradünnen Metalldrähten, Suprapartikel aus optisch aktiven Nanopartikeln oder aktive Materialien, deren Strukturen und Eigenschaften sich bei Bedarf schalten lassen.



MISSION

The Program Division *Structure Formation* investigates the assembly of colloidal dispersions into new materials. We combine inorganic nanoparticles with organic molecules to prepare liquid precursors. Printing, coating, impregnating, or compounding converts them into hybrid materials. Our methods allow us to observe *in situ* how microstructures and internal interfaces form. Systematic variation of size, geometry, composition, and arrangement of the components provides relationships between structure and material properties that we use to tune functionality at different scales. Particles and molecules are adapted such that they positively affect assembly and properties. For example, we prepare transparent conductive coatings from ultrathin metal wires, supraparticles of optically active nanoparticles, and active materials with structures and properties that can be switched on demand.

CURRENT RESEARCH

Active nanocomposites

Nanocomposites are a success story of INM: Inorganic particles developed at INM lend them useful properties, from high refractive index in optics to scratch resistance. In 2018, the *Structure Formation* Group demonstrated a radically new type of nanocomposite. For the first time, inorganic particles in this composite move rapidly to respond to external stimuli. The material was introduced to the public through a publication in Advanced Materials (Adv. Mater., 2018).

First, nanoparticles were synthesized that react to stimuli by rearranging. Then, emulsions were created to enclose the "active" particles in liquid droplets that were then embedded in a solid gel. The resulting material changes its color reversibly at a specific temperature (Fig.). Current research is aimed at new stimuli, for example, to create materials that indicate the presence of toxins.

Tuning hard materials with soft shells

One of the reasons for the success of nanocomposites is that inorganic nanoparticles reliably provide strong properties without degradation, but such particles are not easy to handle. For example, most inorganic nanoparticles are not stable in organic solvents. A very successful trick for making them more amendable to material synthesis is to cover them with a thin organic shell. There has been limited understanding, however, why this works.

In 2018, our group collaborated with theoreticians (Dr. A. Widmer-Cooper, University of Sydney) and an expert on semiconductor nanoparticles (Prof. P. Mulvaney, University of Melbourne) to explain the stability of metal nanoparticles with organic shells. It turns out that the organic shells only work if they dominate the particles' interaction ("shell-dominated regime"), and that organic molecules can be used to further improve stability.

A surprising twist in the story was investigated together with Prof. N. Fleck, University of Cambridge. We studied very thin inorganic gold wires with an organic shell. Contrary to intuition, this "soft" shell can stabilize the "hard" metal core and protect the wire from falling apart (J. Mech. Phys. Solids, 2018).

Inkjet printing of sinter-free inks

Research in a BMBF-funded project ("NanoSpekt") in the last years has led to a new type of electronic material, "sinter-free electronic inks". These are liquid dispersions that become electrically conductive immediately upon drying. A collaboration with the *InnovationCenter INM* enabled us to prepare the ink in quantities that are sufficient for testing. In 2018, we collaborated with partners from industry and applied research organizations to better adapt our hybrid ink for Drop on Demand ("Inkjet") Printing.

Fig.: This active nanocomposite reversibly changes its color upon stimulus (in this case, when a certain temperature is reached). It contains mobile "plasmonic" metal nanoparticles that rearrange and change the color.

OUTLOOK

Printing as a route to patterned materials will be in the focus of the group in 2019. We have started projects to print conductive patterns on paper and other complex substrates; wetting and porosity strongly affect the preparation of high-quality materials on such substrates.

The successful collaboration with Saarland's steel industry will continue, too. In 2017, Dillinger Hütte and INM patented a new method for the analysis of small particles in steels. In 2019, we will focus on very small particles that are very hard to characterize.

We will further strengthen our link to Saarland University (UdS) beyond the successful collaborations with Prof. Steimle (Computer Science), the UdS-led steel alliance, and the joint INM-UdS laboratories in the Department of Chemistry.

INNOVATIONSZENTRUM INM / INNOVATIONCENTER INM

DR. PETER W. DE OLIVEIRA, PROF. DR. TOBIAS KRAUS

ZUSAMMENFASSUNG

Das *InnovationsZentrum INM* wurde 2014 als Schnittstelle zwischen den Technologieplattformen des INM und dem Markt ins Leben gerufen. Nach kritischer Evaluierung der in den Forschungsabteilungen des INM erzielten Resultate, knüpft das *InnovationsZentrum* Kontakte zu geeigneten Partnern in Handwerk und Industrie. Gemeinsam werden Entwicklungsprojekte gestaltet, um das Wissen des INM in die Wirtschaft zu transferieren. Die enge Kooperation mit den Forschungsgruppen des INM gewährleistet einen exzellente Unterstützung durch Expertise und Grundlagenforschung. Hauptarbeitsgebiete im Berichtszeitraum waren die Vermarktung der Gecomer-Strukturen, von dekorativen Schichten und funktionalisierten Nanomaterialien. Im Rahmen des laufenden BMBF-Projekts Science4KMU konnten Standardprozesse zur Unterstützung von Innovationen in kleinen und mittleren Unternehmen (KMU) erarbeitet werden. Das wichtigste Ziel des *InnovationsZentrum INM* besteht in der frühzeitigen Erkennung und Verwertung disruptiver Erkenntnisse der Grundlagenforschung.

MISSION

The *InnovationCenter INM* was established in 2014 to link INM's scientific and technological base with industry and to sharpen the institute's competitiveness in the acquisition of industrial projects. In this sense the *InnovationCenter* assists INM's research groups in science-to-business by continuous evaluation of the markets and actively presenting their results at trade fairs and conferences. The *InnovationCenter INM* adapts the technology platforms of the INM to cater for the particular requirements of industry following its innovation strategy focussing on the institute's competences. Feedback obtained from industrial contacts provides supplemental impulses for the direction of future basic research. The InnovationCenter guides project partners the route from basic concepts to quality control and validation of the production processes.

CURRENT RESEARCH & DEVELOPMENT

Upscaling of Gecomer Technology

One objective was the up-scaling of the size and quantity of micropatterend dry adhesives of the Gecomer technology. For transfer into industrial application, e. g. robotic pick&place systems, a further development of the biomimetic adhesive micro structures to large area fabrication is an important step. The project aims on the manufacture of structured dry adhesives in a continuous fabrication process on a roll-to-roll pilot coating line by replication from a master structure on PET foils. The adhesive structures were made of UV-curable polyurethane acrylates. With optimized embossing parameters mushroom-shaped structures could be reproduced using flexible silicone rubber molds formed from a Nickel shim master. The pillars have 50 µm diameter, 50 µm height and a spacing of 100 µm (Fig. 1) as well as good adhesive properties (pull-off stress 200 kPa) (Materials, 2019).

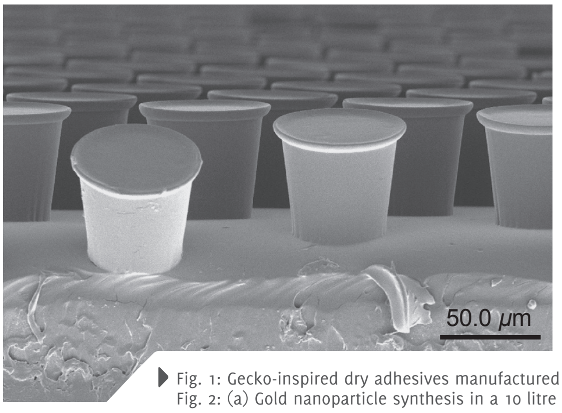


Fig. 1: Gecko-inspired dry adhesives manufactured in a roll-to-roll pilot coating line.
Fig. 2: (a) Gold nanoparticle synthesis in a 10 litre reactor. (b) Scanning electron micrograph of the final hybrid gold nanoparticles.

Hybrid sinter-free inks

The synthesis of hybrid sinter-free inks for electronics has been scaled in collaboration with the Program Division *Structure Formation*. Starting from a protocol developed at the laboratory scale (Chem. Sci., 2016), the production of the ink consists of two steps, the synthesis of the gold particles and a ligand exchange with the conductive polymers. Purification is required in both steps. The process was optimized and adapted first to a 1 litre and then to a 10 litre reactor (Fig. 2). While yielding rods with the original process, the scaled synthesis aims at more spherical particles; it remains possible to tune the gold particle size in a certain range by varying reaction parameters. Gold nanoparticles with diameters below 100 nm can now be obtained at an amount of approximately 5–6 g of gold per synthesis, which satisfies the demand of ink samples for potential commercial partners. The particles meet the requirements for the conductive ink as well as for scientific research or chemical assays. Current experiments aim at other metals to complement the gold-based inks that are now available.

Science4KMU

The aim of the project is the improvement of innovation potential of research institutes in intersectional disciplines in cooperation with small and medium-sized enterprises (SME). The scope of the project covers the development of a process for identification of potential partner SMEs in two ways: Top-down with a big data-based approach, and bottom-up, based on a questionnaire for the SMEs, with a classification to identify SMEs willing to integrate innovation. To establish a cooperation model, strategies for building contacts between the research institute and SMEs will be developed, tested and validated with the aim of trustful partnering. Afterwards, the model will be further developed into a more generalized form for transfer and to make it available as a tool box for other research institutes. Science4KMU cooperates with IBO-Institute of Industry Informatics and Operation Organization, and the Centre for European Economic Research (ZEW).

The *InnovationCenter* offers a wide range of INM's analytical services for our industry customers. The available capabilities allow companies an improvement of the quality and competitiveness of their products.

OUTLOOK

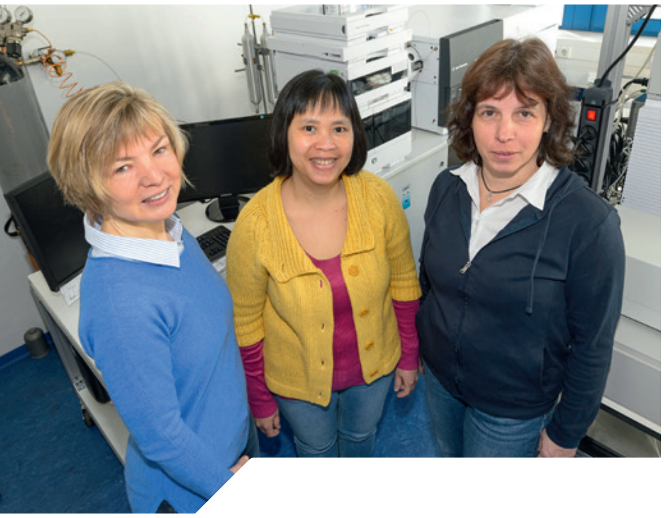
The *InnovationCenter INM's* continuing task is to establish an innovation-network using the relationship between development, engineering, and industrial collaboration. An expanding network of stakeholders inside and outside of INM forms the foundation for partnerships with industry. The *InnovationCenter* analyses the requirements of SMEs, provides assistance in identifying funding for innovation, and manages the process. The *InnovationCenter* unites specific teams from INM to prepare and run projects and provides them with the required information, resources, and facilities.

Peter W. de Oliveira, Tobias Kraus

SERVICEBEREICHE / SERVICE GROUPS

CHEMISCHE ANALYTIK / CHEMICAL ANALYTICS

DR. CLAUDIA FINK-STRAUBE



Die Servicegruppe *Chemische Analytik* nutzt vielfältige moderne Verfahren zur Elementanalytik und zur Strukturaufklärung für die Materialcharakterisierung. Wir bieten analytischen Service für das INM, die Universität und Externe sowie die Entwicklung neuer analytischer Methoden an. Die Elementanalytik führt routinemäßig die quantitative Bestimmung nahezu aller stabilen Elemente mit ICP-OES, FL- und GF-AAS durch. Elementverteilungen im Ultraspurenbereich werden mit HR-SF ICP-MS analysiert. Zur Identifizierung, Massebestimmung und Strukturaufklärung organischer Moleküle kommen GC-MS, LC-ESI-MS und LC-ESI HR-Q-TOF zum Einsatz. Gängige Aufschluss- und Extraktionsverfahren (MW, HT Aufschluss, HS, LE, SPE, SPME) zur Probenvorbereitung runden das Portfolio ab.

PHYSIKALISCHE ANALYTIK / PHYSICAL ANALYTICS

DR. MARCUS KOCH

Innerhalb der Servicegruppe *Physikalische Analytik* werden elektronenmikroskopische und röntgendiffraktometrische Untersuchungen für INM-Beschäftigte, Wissenschaftler/innen aus dem universitären Umfeld und Firmen im Rahmen von Serviceuntersuchungen durchgeführt. Für die Charakterisierung der vielfältigen Proben stehen verschiedene Lichtmikroskope, ein Transmissions- (TEM) sowie ein Rasterelektronenmikroskop mit variablem Kammerdruck (ESEM) zur Verfügung. Die Probenvorbereitung kann u. a. mittels Zweistrahlgerät (FIB), Ultramikrotomie und Schockfrieren (Kryo-Elektronenmikroskopie) erfolgen. Darüber hinaus werden Einweisungen in die Geräte gegeben sowie im Zuge von Führungen und Praktika die praktischen Aspekte der vorhandenen Untersuchungsmethoden gezeigt.

ENGINEERING / ENGINEERING

DIPL.-ING. KARL-PETER SCHMITT

Die zentralen Aufgaben des Servicebereiches *Engineering* mit den Arbeitsbereichen Konstruktion, mechanische Werkstatt und Elektrowerkstatt bestehen in der Entwicklung und Herstellung wissenschaftlicher Anlagen und Komponenten für die Forschung und Projekte der Gruppen des INM. Die Bandbreite der Arbeiten reicht dabei von kleinen Laborgeräten bis hin zu Pilotanlagen. Aus den Vorgaben der Forschung werden mittels der CAD-Software CATIA-V5 Konstruktionen erstellt und in den INM-Werkstätten umgesetzt. Hierfür steht eine moderne Ausstattung wie ein CAM-System, eine 5-Achs-HSC-Präzisionsfräsmaschine oder eine Funkenerosionsanlage zur Verfügung. Weiterhin werden im Rahmen einer Kooperation Werkstattarbeiten für den Lehrstuhl *Technische Physik* der Universität des Saarlandes durchgeführt.

NTNM-BIBLIOTHEK / NTNM LIBRARY

DIPL.-BIBL. MA ELKE BUBEL

NTNM
CAMPUS-BIBLIOTHEK

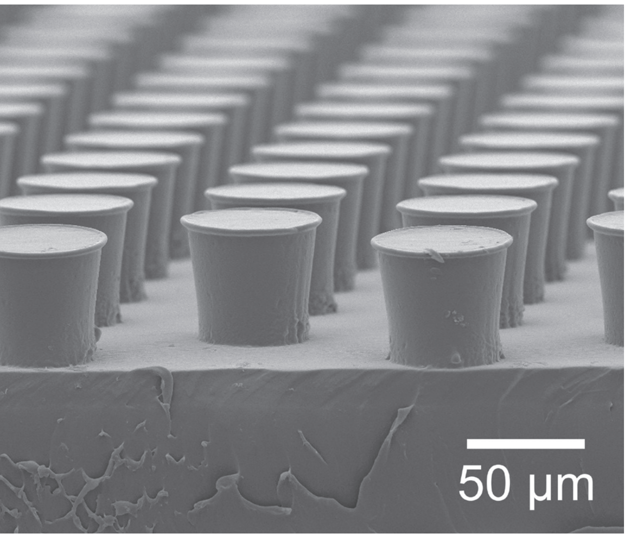
Die NTNM-Bibliothek hat sich als gemeinsame Bibliothek für Naturwissenschaft und Technik des INM und der NT-Fakultät der Universität des Saarlandes etabliert. Sie versorgt Studierende und Angehörige beider Einrichtungen mit Print- und elektronischen Medien für Lehre und Forschung. Für Beschäftigte des INM erbringt sie zudem Service- und Beratungsleistungen im Bereich Wissenschaftliches Publizieren und Open-Access (OA). Die Servicezeiten wurden im Berichtsjahr von 45 auf 56 Wochenstunden erhöht. Die NTNM-Bibliothek wird im Rahmen des BMBF-Projektes visOA in der Umsetzung von Maßnahmen zur Erhöhung der Sichtbarkeit von OA-Publikationen gefördert. Mitarbeiterinnen und Mitarbeiter der NTNM-Bibliothek sind aktiv vertreten in den bibliotheksspezifischen Arbeitskreisen der Leibniz-Gemeinschaft.

HIGHLIGHTS

ROLL-TO-ROLL MANUFACTURING OF MICROPATTERNED ADHESIVES

D. YU[1], D. BECKELMANN[2], M. OPSÖLDER[2], B. SCHÄFER[2], K. MOH[1], R. HENSEL[1], P. W. DE OLIVEIRA[2] AND E. ARZT[1]

[1]FUNCTIONAL MICROSTRUCTURES, [2]INNOVATION CENTER INM



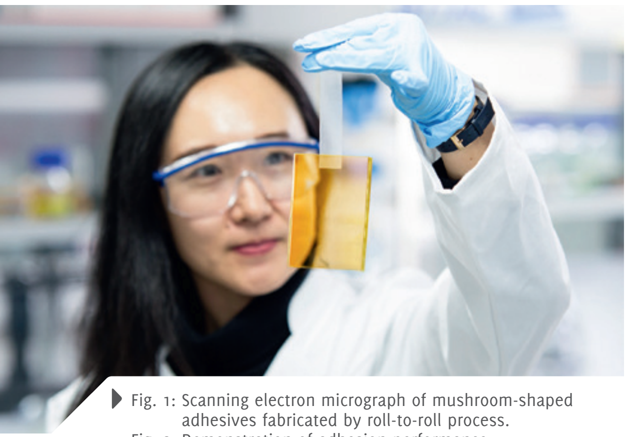


Fig. 1: Scanning electron micrograph of mushroom-shaped adhesives fabricated by roll-to-roll process.
Fig. 2: Demonstration of adhesion performance.

Reliable and reversible adhesion is a prerequisite for grippers to manipulate or pick-and-place objects. Inspired by the locomotion of geckoes, the fibrillar structure of their toe pads provides a promising concept for creating temporary adhesives without the need of intrinsically adhesive materials. The approach has attracted much attention over the last decades worldwide. At INM, fundamental insights into contact mechanics, new fibrillar designs and various fields of application scenarios have been explored. INM's patented *Gecomer Technology* has been validated for numerous pick & place operations to demonstrate its potential in various fields of technology.

Now, INM has established a large-scale fabrication process for creating adhesive micropatterned films. An imprint process, commonly used for generating micropatterned adhesives, was successfully implemented into a roll-to-roll pilot plant located in the *Innovation Center* at INM. For this purpose, the UV-curable material and process parameters were carefully adapted to allow continuous fabrication of micropatterned dry adhesive films with complex geometries (Fig. 1 and 2). Following extensive optimization, the films showed remarkable normal and shear adhesion strength (to smooth glass) of about 250 kPa and 100 kPa. In the project funded by the Leibniz Association, we investigated how the mechanics of the flexible template affected the morphology of the microstructures and how the material composition could be tuned to enhance the cross-linking kinetics. Both parameters are essential to preserve the microstructural integrity for best adhesion performance. We also demonstrated reliable endurance of the adhesive films with more than 100,000 attachment-detachment cycles, paving the way for emerging applications.

D. Yu et al., Materials, 12 (2019) 97

RESOLUTION IN LIQUID CELL TRANSMISSION ELECTRON MICROSCOPY

N. DE JONGE
INNOVATIVE ELECTRON MICROSCOPY

An international group of scientists has discussed the achievable resolution of a newly established microscopy method capable of imaging specimen in liquid with sub-nanometer spatial resolution. The team consisted of Prof. N. de Jonge, INM, Dr. L. Houben, Weizmann Institute of Science, Israel, Prof. R. Dunin-Borkowski, Forschungszentrum Juelich, and Prof. F. Ross, MIT, USA.

Liquid cell electron microscopy combines high spatial and temporal resolution thus providing a unique view of static structures and dynamic processes in liquids. Optimizing the resolution in liquids requires consideration of both the microscope performance and the properties of the sample. The group surveyed the competing factors that determine spatial and temporal resolution for transmission electron microscopy (TEM) in liquids. Important factors included the effects of sample thickness, stability and dose sensitivity on spatial and temporal resolution. The potential of using spherical- and chromatic aberration correction to further improve the resolution was extensively evaluated. It was shown that for some liquid samples, spatial resolution can be improved by aberration correction. However, other benefits offered by aberration correction may be even more useful for liquid samples, such as the greater image interpretability offered by spherical aberration correction and the improved dose efficiency for thicker samples offered by chromatic aberration correction. A key aspect of the discussion was the question how to improve the spatial resolution and also the temporal resolution for experiments involving dynamics. Here, important factors would include advanced data processing and the use of state-of-the-art detectors.

N. de Jonge, L. Houben, R.E. Dunin-Borkowski, F.M. Ross, Nat. Rev. Mat. 4, 61-78, 2019.

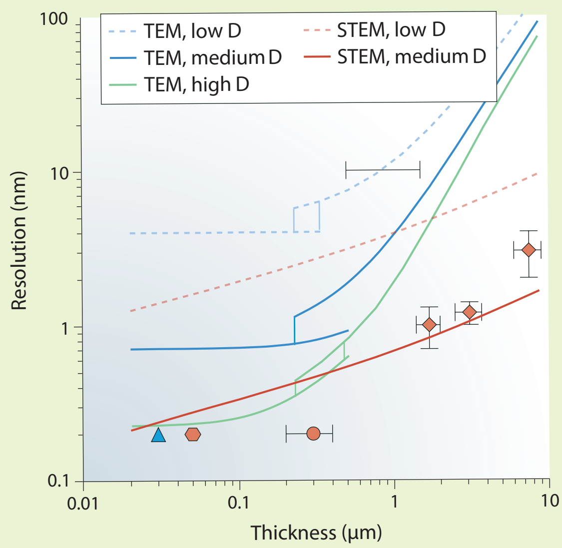


Fig.: Theoretical maximum image resolution vs water thickness. Calculated TEM and STEM resolutions for spherical nanoobjects of gold in water. Resolutions calculated for various electron densities D. Experimental data points at approx. corresponding D included for comparison.

LIVING HYDROGELS WITH THERAPEUTIC FUNCTIONS

S. SANKARAN AND A. DEL CAMPO
DYNAMIC BIOMATERIALS

Living hydrogel contains engineered E coli able to produce the drug Deoxiviolacein (purple color) upon light exposure:
a) hydrogel;
b) living hydrogel containing bacteria;
c) living hydrogel after light exposure.

Biopharmaceuticals represent 30 % of new drugs entering the market, and steeply growing at 10 % annual rate. Clinical translation of biopharmaceuticals, however, is slow and very much hindered by high production costs and short term stability of biopharmaceuticals *in vivo* (a no-go issue for prolonged therapies).

Dynamic Biomaterials at INM work on a fundamentally different concept to overcome these limitations using living hydrogels. In a living hydrogel, bacteria are embedded in a synthetic polymer matrix that supports life cycle of the bacteria, but prevents their escape. Bacteria inside the hydrogel are metabolically engineered to produce the drug, and optogenetically engineered to do this on-demand upon light exposure. The permeable hydrogel matrix sustains a viable and functional bacterial population and permits diffusion and delivery of the synthesized drug to the surrounding medium at quantities regulated by blue light dose. The living hydrogels maintain considerable levels of drug production and release for months. Since the drug is synthesized *in-situ*, costs related to drug isolation or stabilization can be avoided. A successful example has been realized in cooperation with Biology Faculty at Saarland University.

Our results evidence the potential and flexibility that living materials containing engineered bacteria can offer for advanced therapeutic applications. INM is currently supporting research and translational efforts in this field.

S. Sankaran, J. Becker, C. Wittmann, A. del Campo, Small 2019, 15, (5), 1804717
S. Sankaran, A. del Campo, Advanced Biosystems 2019, 3, (2), 1800312
S. Sankaran, S. Zhao, C. Muth, J. Paez and A. del Campo, Advanced Science 2018, 5, (8), 1800383

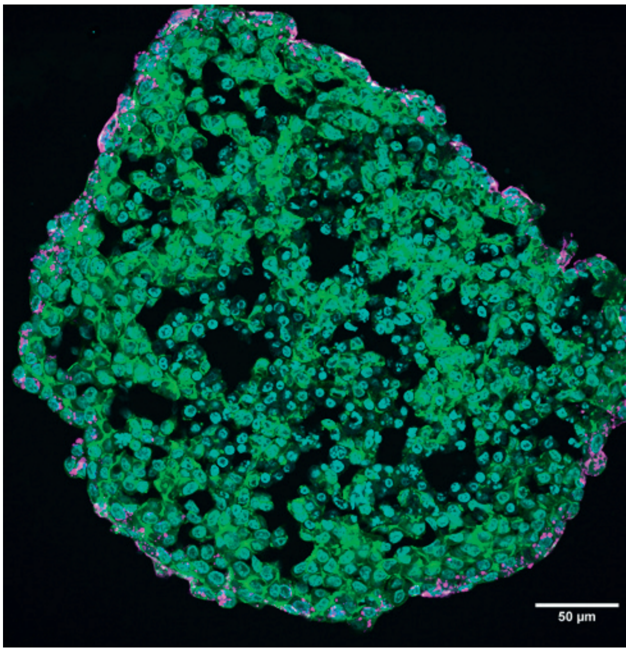
A MULTIPARAMETRIC PLATFORM FOR SAFETY TESTING OF NANOPARTICLES

J. FLEDDERMANN AND A. KRAEGELOH
NANO CELL INTERACTIONS

Synthetic nanoparticles (NPs) are used in many technical and biomedical applications. Evaluating their potential hazards at an early stage will provide standards for production processes and preclinical development of NPs. To assess the hazards we developed a multiparametric platform based on a 3D liver tissue model that features two key advantages: 1) It allows the combined measurement of classical, functional, and morphology markers. 2) In contrast to commonly used 2D cell culture, nanoparticle penetration into the tissue can be studied. Knowledge of NP distribution in tissue is of relevance e.g. for their potential drug delivering efficiency to target tissues in biomedical applications as well as for understanding the mechanisms of NP effects in nanosafety issues.

The test platform was established addressing different aspects: 1) characterization of spheroids, 2) cytotoxicity, 3) function, and 4) NP penetration. Model NPs with various characteristics (SiO_2, TiO_2, Ag) were tested on the platform. Liver microtissues were prepared by 3D cell culture using hanging-drop method of human hepatocarcinoma HepG2 cells resulting in a simple in vitro liver model. Microscopic analysis revealed 400 µm sized spheroids with presence of liver-specific bile canaliculi. Cytotoxicity of the model NPs was comprehensively studied addressing cell viability, oxidative stress and inflammatory responses. Only Ag NPs caused cellular effects. As a functional marker we analyzed the gene expression of an important liver-specific CYP P450 enzyme for metabolism of xenobiotics: Cyp1A2. In presence of all tested model NPs the Cyp1A2 gene expression was not altered. Combination with modern imaging techniques allowed us to locate the NPs inside the spheroids and to study NP penetration into tissue. SiO_2 NP penetration was shown to be limited to about 20µm from the spheroid border.

J. Fleddermann, J. Susewind, H. Peuschel, M. Koch, I. Tavernaro, A. Kraegeloh, Int. J. Nanomed, 2019, 14, 1411-1431



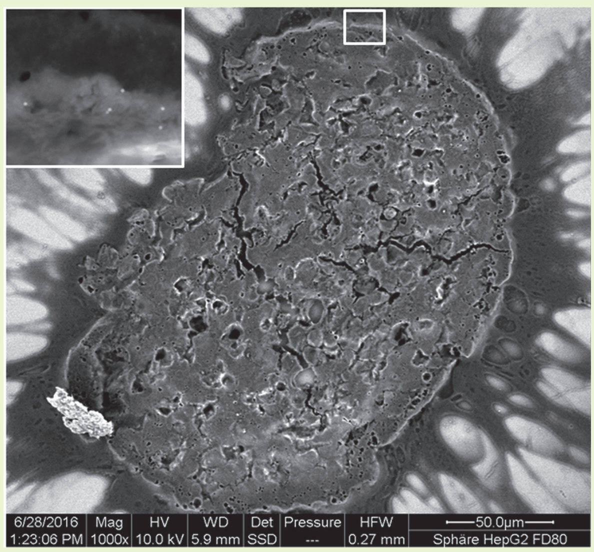
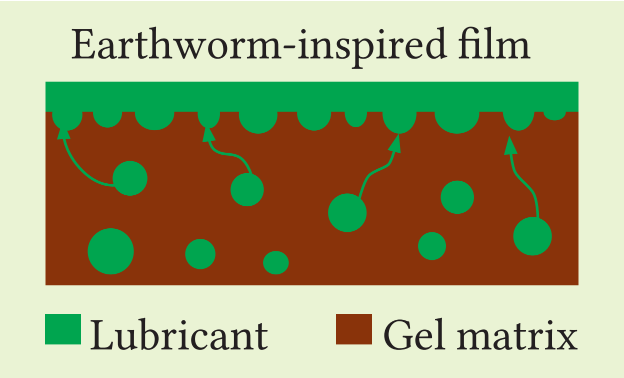


Fig. 1: Fluorescence image of HepG2 cell spheroid exposed to fluorescent silica nanoparticles. NPs located at spheroid border. Magenta: nanoparticles. Green: cytoskeleton, Cyan: cell nuclei.

Fig. 2: Electron microscopy image of HepG2 cell spheroid exposed to silica nanoparticles. Individual nanoparticles visible in outer rim of spheroid (detail on top left).

SECRET FROM SECRETION: EARTHWORM-INSPIRED LUBRICATION

H. ZHAO AND J. CUI
SWITCHABLE MICROFLUIDICS



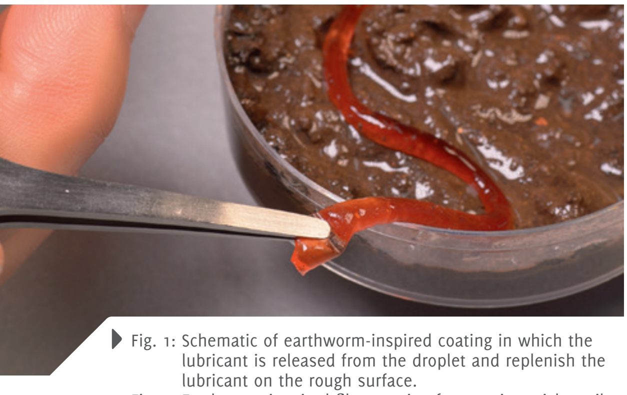


Fig. 1: Schematic of earthworm-inspired coating in which the lubricant is released from the droplet and replenish the lubricant on the rough surface.
Fig. 2: Earthworm-inspired fiber coming from moist, sticky soil.

Earthworms are always clean, due to their unique lubricating mechanism, even if they come from moist, sticky soil. The mechanism is based on their sophisticated epidermal glands that can continually secrete mucus under external mechanical stimuli and a rough skin consisting of macroscopic annuli and micro ripples which can stabilize the secreted mucus to form a thick slippery layer.

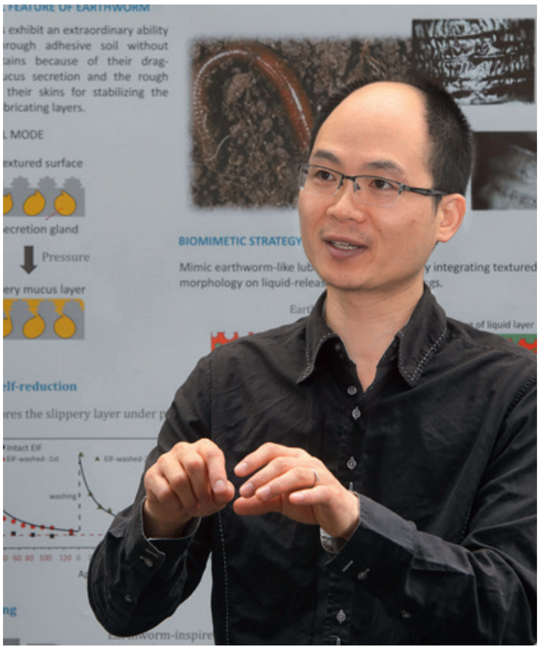
The *Switchable Microfluidics* group attempted to mimic this unique lubricating mechanism by introducing a textured structure on a kind of liquid-releasable polymer coatings (Fig. 1). In the earthworm-inspired coatings, lubricants are stored as discrete droplets in a supramolecular polymer matrix crosslinked by hydrogen-bonds. Under compression, the supramolecular matrix is open to release the lubricant in the droplet. These released lubricant molecules are stabilized on the textured surface to mimic the thick slippery layer of earthworms. This kind of coating is prepared by simple one-pot casting in which four physical processes, i.e. solvent evaporation, phase separation, gelation, and water condensation, occur together. The coatings obtained exhibit fast and site-specific liquid release under external mechanical stimulus. The resulting thick lubricating layers can significantly reduce friction and enhance wearing resistance. The coatings also exhibit excellent anti-fouling property in the sticky soil environment (Fig. 2).

Differing from the currently available water-repellent coatings which are only promising in a fluid environment, earthworm-inspired coatings represent a novel example that can be applied under solid conditions. In addition, the coatings are soft and biocompatible. We thus envision their applications in areas such as energy-efficiency and health care.

H. Zaho, Q. Sun, X. Deng, J. Cui, Advanced Materials 2018, 30 (29), 1802 141

THREE QUESTIONS TO Jiaxi Cui

Jiaxi has been head of the Junior Research Group *Switchable Microstructures* since 2015. For more than five years, he has worked on transferring secretion mechanisms of living organisms to artificial materials. In his latest research, he investigated the secretion mechanism of earthworms.



WHAT FASCINATES YOU ABOUT THIS KIND OF RESEARCH?

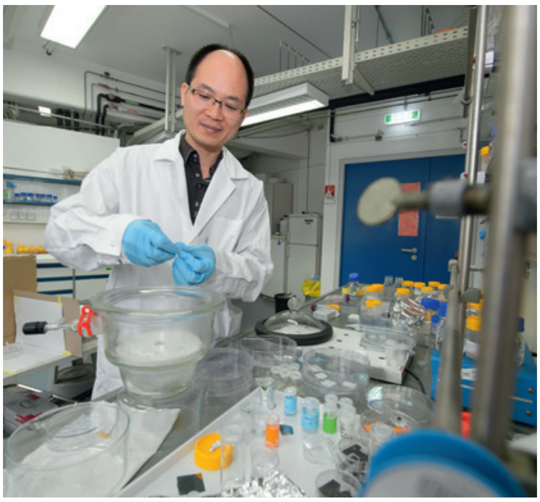
As a scientist, I am driven by curiosity to disclose the mechanisms behind interesting phenomena. On the other hand, we should contribute to things that are useful in the near future. The fascinating thing in this kind of research is the combination of the beauty of science and great potential in applications. Doing this kind of research pleases me and also our supporters.

HOW DID YOU COME TO ORIENT YOUR RESEARCH ON THE EARTHWORM?

Many nature systems are masters in friction reduction, like for example the superhydrophobic lotus leaf. However, the methodologies developed from these nature models are normally suitable for applications under fluid conditions. I always wanted to push the study from fluid to solid since we are basically living in a solid environment. The earthworm has a strong secretion system and an extraordinary capability in drag-reduction in a solid environment. It was just obvious to try to mimic the underlying mechanisms.

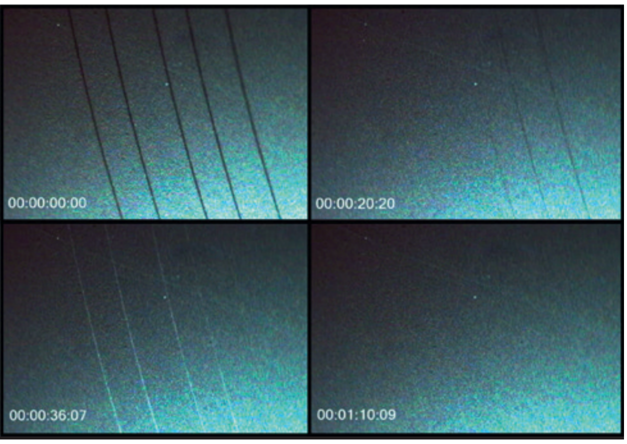
FOR WHICH PURPOSES COULD YOUR MATERIAL BE USED IN THE FUTURE?

We foresee applications on medical devices, because our materials are biocompatible and show mechanical properties similar to human tissue. One example for the use of our materials could be a coating on artificial cartilages. A cartilage is super slippery but not able to regenerate and the currently available artificial cartilage is not slippery enough. Our material could contribute to resolve this medical issue.



SELF-HEALING POLYROTAXANE PAINT

B. ALI[1], J. BRUNKE[1], N. MÜLLER[2], P.W. DE OLIVEIRA[2] AND C. BECKER-WILLINGER[1]
[1]NANOMERS, [2]INNOVATIONCENTER INM



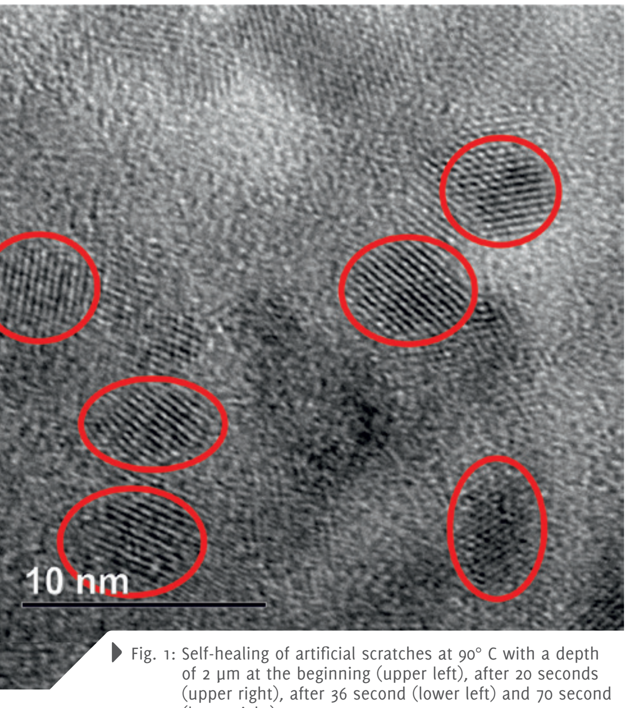


Fig. 1: Self-healing of artificial scratches at 90° C with a depth of 2 µm at the beginning (upper left), after 20 seconds (upper right), after 36 second (lower left) and 70 second (lower right).

Fig. 2: Polyrotaxane SRG filled with 5 wt.-% modified CeO_2 nanoparticles; CeO_2-crystallite (red circle).

Rigid surface coatings with glossy appearance showing self-healing behavior of superficial micro-scratches are desired for many applications such as e. g. car body paints or smartphone covers. A physical approach towards self-healing based on a stress relaxation mechanism is provided by so called "slide-ring gels" (SRGs), which are composed of cross-linked polyrotaxanes (PRs). PRs are supramolecular assemblies which comprise a ring-shaped molecule and a polymer. The ring-shaped molecules, e. g. cyclodextrins (CDs), are threaded onto the polymer main chain like beads on a necklace. The PRs are accessible by one-pot emulsion polymerization where monomers are complexed by CDs and afterwards co-polymerized with a bulky co-monomer. The work is conducted under the BMBF-VIP+-project "Polyrotaxanlack" in co-operation with Prof. G. Wenz of Saarland University who provided the basic PR-polymers. The Nanomers group modified the PR-polymers by blending with heteropolysiloxanes and inorganic nanoparticles to improve the UV-stability. The *InnovationCenter INM* optimized the spray coating technology and performed artificial weathering tests.

Scratching and self-healing experiments were performed on nanocomposite coatings applied as top-coat after spray coating on pre-painted surfaces and thermal curing up to 120° C. Various mixtures of PRs and increasing amounts of surface modified nanoparticles were investigated. The coatings show Martens hardness between 150 MPa and 250 MPa depending on the composition. Partial hydrophobization of the threaded CDs with monofunctional isocyanates prior to coating and cross-linking resulted in improved hydrolytic stability, while maintaining mechanical surface properties, and led to faster self-healing. Complete self-healing of superficial micro-scratches was achieved by thermal treatment at 100° C for only 60 s.

ACTIVE NANOCOMPOSITES: A NEW CLASS OF RESPONSIVE MATERIALS

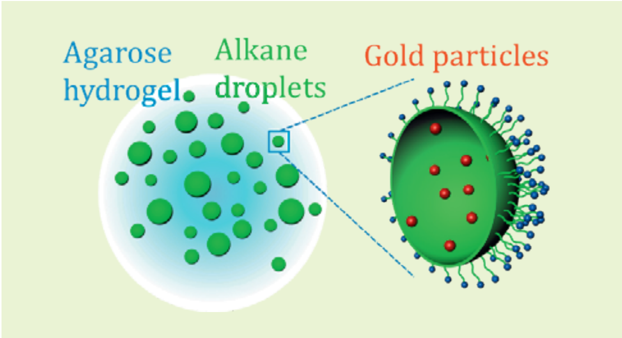
D. DOBLAS JIMÉNEZ AND T. KRAUS
STRUCTURE FORMATION

Stimulus-responsive materials react to physical or chemical signals by changing their properties. Few such materials exist, and most of them are based on polymers that undergo molecular transitions upon stimulation. The Structure Formation Group has introduced a new class of stimulus-responsive materials: composites with parts that can rearrange and thereby change their properties.

The difficulty in making composites respond is that in most of them, little is moving. In contrast, the new "active nanocomposites" are teeming with motion: they contain small particles that connect or separate, thus changing the color of the entire material. The composite consists of a solid hydrogel with small "holes" that are filled with liquid (Fig. 1). Gold nanoparticles move within the liquid inclusions. Particle motion is thus decoupled from the matrix, and the particles move rapidly while the overall structure of the material remains stable. A very thin organic shell on the gold particles makes them sensitive to temperature.

The naked eye can discern neither the droplets nor the nanoparticles inside, and the entire composite is translucent. But when the temperature drops, the small particles attract each other and form larger "agglomerates". These agglomerates have a dark, blue-brown color, while the individual particles are bright red. In effect, the entire material changes its color in response to the temperature change (Fig. 2). This unusual response mechanism is versatile. Temperature causes the particles to agglomerate because the structure of their organic shell changes. Other organic shells are less sensitive to temperature but react to chemical substances. Future nanocomposites may be used to directly visualize the presence of chemical substances and toxins with a color change in packaging films, for example.

D. Doblas, J. Hubertus, T. Kister, T. Kraus, *Advanced Materials* (2018) 30, 1803159



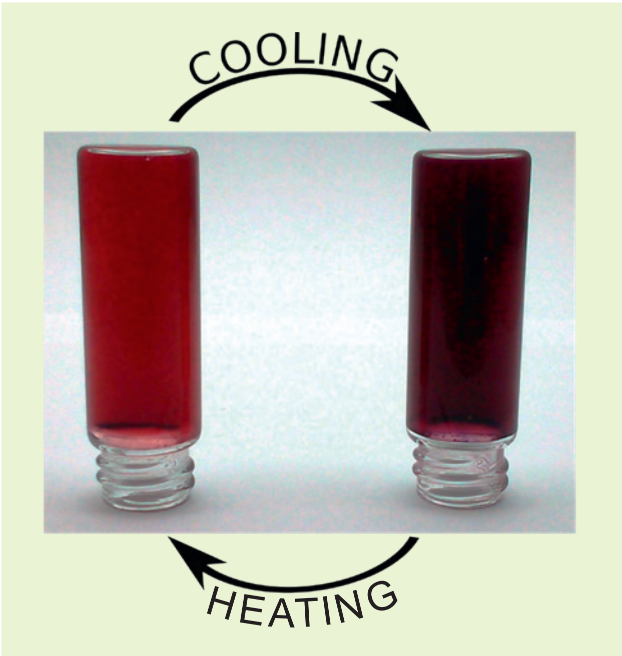
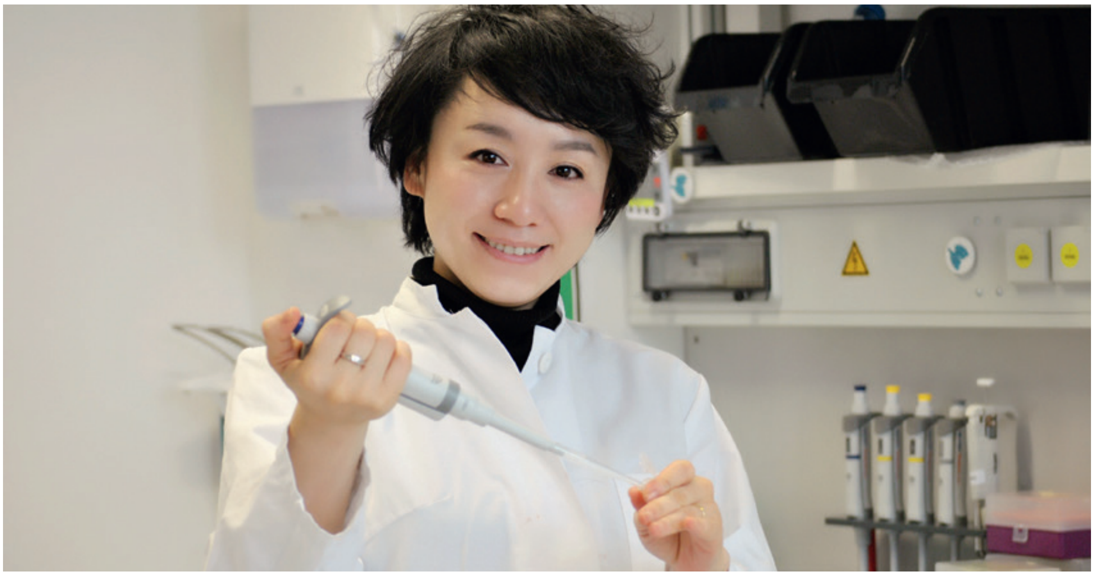


Fig. 1: Illustration of the particle-filled liquid droplets inside the hydrogel matrix of an "active nanocomposite".
Fig. 2: Color changes with temperature because the particles reversibly agglomerate in the droplets.

INM FELLOW BIN QU INVESTIGATES SIGNPOSTS FOR KILLER CELLS

C. JUNG AND B. QU



The immune system of the human body fights diseased cells with natural killer cells. These migrate through body tissues and search for cancer cells, for example, which they kill on contact. In their search, the killer cells cross extracelluler spaces and encounter biological materials and other cells. In cooperation with the INM, INM Fellow Bin Qu hopes to find out what role the microenvironment plays in this process. Together with INM's research groups *Dynamic Biomaterials* and *Cytoskeletal Fibers*, she will investigate how killer cells behave on designed biomaterials that mimic the natural environment. Long-term this research could guide the development of biomaterials able to regulate the body's innate ability to heal and regenarate.

Dr. Bin Qu completed her Master of Science in Cell Biology at the Institute of Biochemistry and Cell Biology, Chinese Academy of Sciences, in Shanghai, China. She received her PhD in Biology from Saarland University in 2010, where she continued working as a postdoctoral researcher in Biophysics. Since 2013, she has been an independent group leader at the Center for Integrative Physiology and Molecular Medicine at the Medical Faculty of Saarland University. In 2018, INM appointed Dr. Qu as the fifth INM Fellow to strengthen the cooperation with the medical faculty of Saarland University.

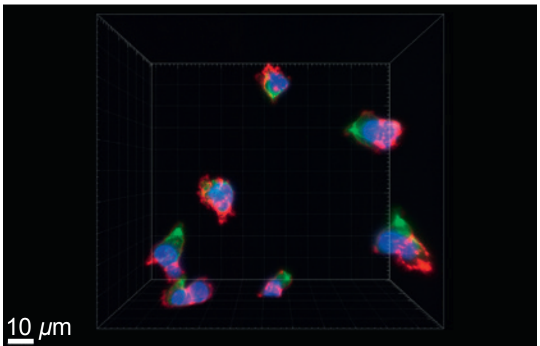


Fig.: Migrating killer cells in 3D.

CISCEM 2018 – 4TH CONFERENCE ON IN SITU AND CORRELATIVE ELECTRON MICROSCOPY

N. DE JONGE AND C. HARTMANN
INNOVATIVE ELECTRON MICROSCOPY

How can methods to study protein function in cells be improved? How to image soft materials in liquid by electron microscopy? What are the possibilities to analyze in processes involving, for example, catalytic nanoparticles? More than 100 scientists from 17 countries took the opportunity to discuss the future directions of *in situ* electron microscopy from different perspectives at the 4th Conference on *In Situ* and Correlative Electron Microscopy (CISCEM), hosted by INM on October 10-12, 2018.

CISCEM is about understanding a particular process under native and realistic conditions. In so-called *in-situ* methods, measurements are carried out in a gaseous environment, at high temperatures or in a liquid. The common goal of biologists, materials scientists, chemists and physicists is to further improve *in-situ* electron microscopy, for example, by combining electron microscopy with fluorescence microscopy or by incorporating advanced data acquisition and processing algorithms.

The highlight of the conference was the keynote lecture by Prof. Robert Sinclair on "High resolution *in situ* and transmission environmental electron microscopy of material reactions". The topics of the other lectures and posters included soft materials and biological samples, nanocatalysts, spectroscopy, innovations in *in situ* microscopy and data processing, high-speed or high-temperature electron microscopy, and dynamic processes of nanomaterials.

CISCEM was organized by N. de Jonge (INM), K. Mølhave (Denmark Technical University), and D. Alloyeau (Université Paris Diderot) and financially supported by the European Microscopy Society, the Deutsche Gesellschaft für Elektronenmikroskopie and ten partners from industry. The abstracts are published as online volume of the journal Microscopy and Microanalysis.

Fig. 1+2: Impressions from the conference and participants of CISCEM 2018.

BMBF-CITIZEN'S DIALOGUE "HIGH-TECH MATERIALS FOR THE WORLD OF TOMORROW"

M. QUILITZ

Fig. 1: Experts ready to discuss with the audience.
Fig. 2: The experiments of the "Physikanten" were a visitors' magnet.

The Federal Ministry of Education and Research (BMBF) selected the INM as the first location and co-organizer of the so called "Bürgerdialog" (citizen's dialogue) in Saarland. The event, which was conceived as a discussion platform for both the public and experts in the field, focused on "High-Tech Materials for the World of Tomorrow – Opportunities, Risks and Perspectives". In brief keynote speeches, experts informed about current developments in the field of new high-tech materials and made their opportunities for society and our everyday life but also their challenges and risks transparent. Subsequently, the interested public had the opportunity to discuss with the experts. Around 150 visitors were offered a very versatile program consisting of film contributions, keynote speeches, discussions and exhibits on the central theme.

Topics included: electronic circuits directly from the printer, solar cells of the future, new insights into the lotus effect, nano-robots: fiction and reality, as well as contributions to the safety of nanoparticles and their imaging in the electron microscope. An overview over the research activities at INM completed the program.

A highlight of the event was certainly the performance of the "Physikanten", who presented spectacular live experiments with the option for participation. In addition, there was more to find out about research at the INM at experimental stations in the foyer of the institute.

The Bürgerdialog was organized by INM in cooperation with the Association of German Engineers (VDI), which took over the organization on behalf of the BMBF. The event took place on May 26th, when the Saarland University and the INM jointly celebrated their Open Day.

WHY IS THE JOURNAL IMPACT FACTOR (JIF) INCREASING?

L. NIEDNER, H. HEINTZ AND E. BUBEL
NTNM LIBRARY

The Journal Impact Factor (JIF) is a parameter that tells us about the influence of a particular scientific journal. In practice, the JIF is often used to evaluate the rate of publication in scientific journals. To this end, the NTNM Library ascertains the average JIF of all INM publications for each year. In the years from 2003 to 2017 the JIF for INM publications increased by 287 % (Fig. 1).

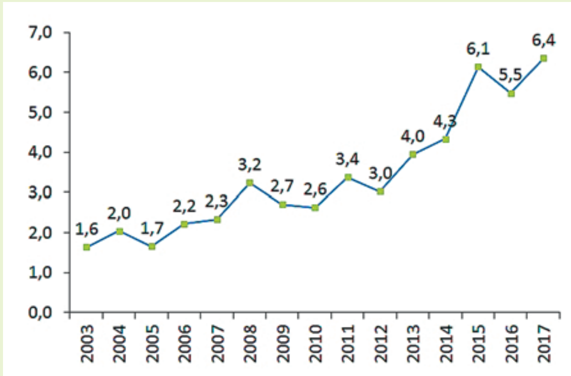
The question arose whether this increase could be due to the fact that INM authors had selected more influential journals for their publications during that time, or whether the increase in the JIF is a generally observable phenomenon in the domain of scientific publication. For comparison purposes, we created three publication periods, 2003-2007, 2008-2012 and 2013-2017. Within these periods, we produced a ranking of the top 25 journals in which INM authors had published the most. We compared the composition and the five-year JIFs of each of the three journal portfolios created here. The five-year JIF shows the long-term citation trend for a journal.

We found that the top 25 journals within the three publication periods studied have a low degree of overlap. This demonstrated a high degree of willingness among INM authors to change their choices of publishers during that time.

In addition we found that a generally observable increase in the five-year JIF could not be confirmed. All periods compared include journals whose five-year JIF was higher in a previous year than in the current year.

On the other hand, we found that the journals in the latest journal setting 2013-2017 in particular had higher five-year JIF values overall compared with the portfolios of both previous periods, and that they also showed significantly higher dynamics of increase (Fig. 2).

Sources: ISI Web of Science, Journal Citation Reports, Clarivate Analytics



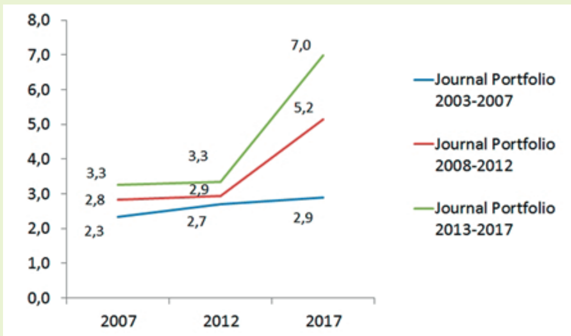


Fig. 1: Average of INM's Journal Impact Factor from 2003 to 2017.
Fig. 2: Increasing of the 5-year JIF portfolios.

FAKTEN UND ZAHLEN / FACTS AND FIGURES

DAS INM IN ZAHLEN / INM IN FIGURES

DAS INM IN ZAHLEN

Im Jahr 2018 betrug der **Gesamtumsatz** des INM 24,82 Mio. Euro.

Erlöse aus der gemeinsamen Finanzierung durch den Bund und die Länder (**institutionelle Förderung**): 18,47 Mio. €,

- davon Personal- und Sachaufwendungen: 14,62 Mio. €,
- und für Investitionen: 3,85 Mio. €

Erlöse aus Drittmittelvorhaben: 6,18 Mio. €

- davon 3,92 Mio. € aus öffentlichen Projektförderungen,
- und 2,26 Mio. € aus Vereinbarungen mit Industrieunternehmen.

Sonstige betriebliche Erträge: 0,17 Mio €

Das INM hatte Ende 2018 **266 Beschäftigte** (136 m, 130 w), davon

- 88 Wissenschaftler/innen (54 m, 34 w),
- 38 Promovierende (20 m, 18 w),
- 54 Beschäftigte (27 m, 27 w) in den Bereichen Labor, Technik und Service,
- 33 Beschäftigte (8 m, 25 w) in der Verwaltung und den Sekretariaten,
- 45 Hiwis (22 m, 23 w) und 8 Auszubildende (5 m, 3 w).

INM IN FIGURES

In 2018, the **total turnover** of INM added up to 24.82 million euro.

Proceeds from the **joint financial support** by the federal government and the federal states (institutional funding): 18.47 million €,

- including expenses for personnel and materials: 14.62 million €,
- and for investments: 3.85 million €.

Proceeds from **third party funding:** 6.18 million €

- including 3.92 million € from public grants,
- and 2.26 million € from industrial contacts.

Other operating income: 0.17 million €

At the end of 2018, **266 employees** (136 m, 130 f) worked at INM including:

- 88 scientists (54 m, 34 f),
- 38 doctoral students (20 m, 18 f),
- 54 employees (27 m, 27 f) in laboratories and technical services,
- 33 employees (8 m, 25 f) in administration and secretarial offices,
- 45 graduate assistants (22 m, 23 f) and 8 apprentices (5 m, 3 f).

m = männlich, w = weiblich / m = male, f = female

KURATORIUM & WISSENSCHAFTLICHER BEIRAT / BOARD OF TRUSTEES & SCIENTIFIC ADVISORY BOARD

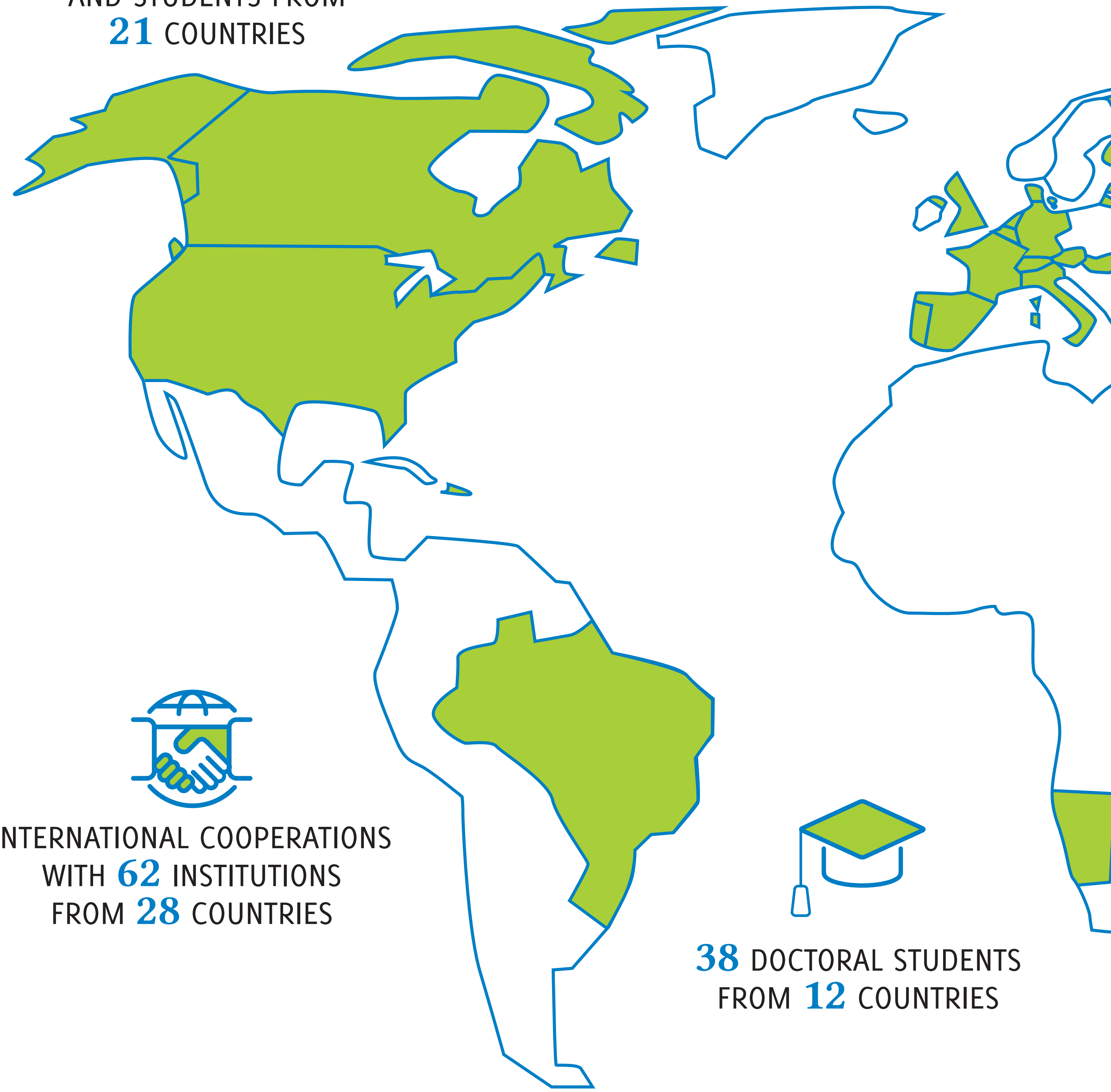
Stand / As of: 31.12.2018

MITGLIEDER DES KURATORIUMS / MEMBERS OF THE BOARD OF TRUSTEES

MITGLIEDER DES WISSENSCHAFTLICHEN BEIRATS / MEMBERS OF THE SCIENTIFIC ADVISORY BOARD

INM INTERNATIONAL

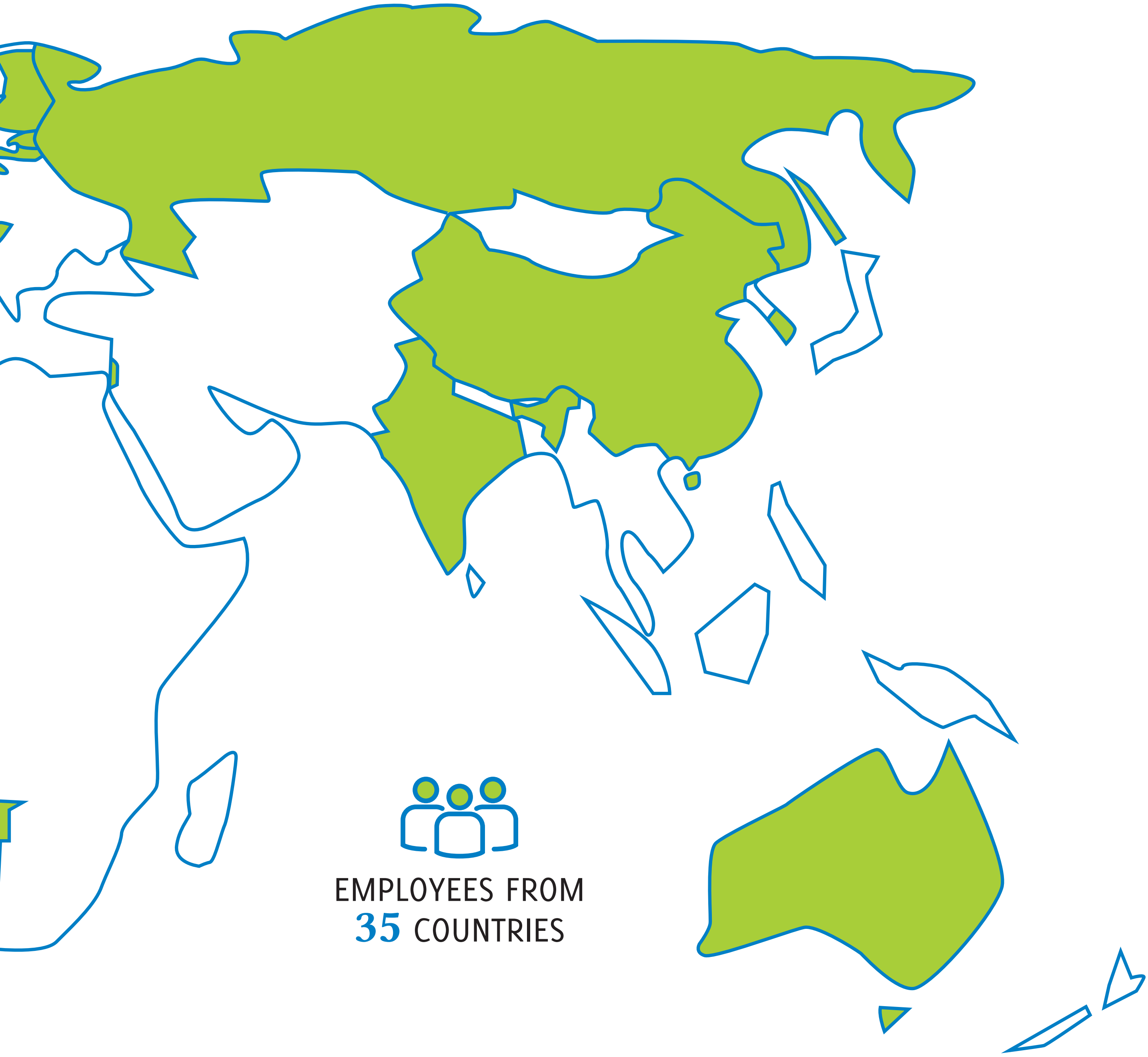
35 VISITING SCIENTISTS AND STUDENTS FROM **21** COUNTRIES



INTERNATIONAL COOPERATIONS WITH **62** INSTITUTIONS FROM **28** COUNTRIES

38 DOCTORAL STUDENTS FROM **12** COUNTRIES

COOPERATIONS
WITH **41** INSTITUTIONS
IN GERMANY



EMPLOYEES FROM
35 COUNTRIES

States with institutional cooperation (not included: cooperations with industry)

DISSERTATIONEN / DOCTORAL THESES

Sarah Fischer
New Designs for Bioinspired Microstructures with Adhesion to Rough Surfaces
Universität des Saarlandes
Prof. Dr. E. Arzt

Simon Fleischmann
Hybridization of Electrochemical Energy Storage: Nanohybrid Materials and Hybrid Cell Architectures for High Energy, Power, and Stability
Universität des Saarlandes
Prof. Dr. V. Presser

Andreas Hegetschweiler
Colloidal Analysis of Particles Extracted from Microalloyed Steels
Universität des Saarlandes
Prof. Dr. T. Kraus

Nicolas Jäckel
Structure and Properties of Supercapacitor and Lithium-Ion Battery Electrodes: The Role of Material, Electrolyte, Binder, and Additives
Universität des Saarlandes
Prof. Dr. V. Presser

Benjamin Krüner
Polymer-derived Carbides and Carbons with and without Nitrogen-doping for Electrochemical Energy Applications
Universität des Saarlandes
Prof. Dr. V. Presser

Juhan Lee
Redox Electrolytes for Non-Flow Electrochemical Energy Storage
Universität des Saarlandes
Prof. Dr. V. Presser

Beate Reiser
Tailored Ligands for Hybrid Materials from Colloidal Inks
Universität des Saarlandes
Prof. Dr. T. Kraus

Kai Rittgen
Surface Oxidation of Metallic Glasses and its Effects on Nanotribology
Universität des Saarlandes
Prof. Dr. R. Bennewitz

Aura Tolosa Rodriguez
Electrospun Carbon Hybrid Fibers as Binder-free Electrodes for Electrochemical Energy Storage
Universität des Saarlandes
Prof. Dr. V. Presser

Oya Ustahüseyin
Tuning Mechanical Properties of Hydrogels
Johannes Gutenberg Universität, Mainz
Prof. Dr. A. del Campo

Mathias Widmaier
Improvement of Hybrid Supercapacitors by Optimization of Electrode Design and Material Properties
Universität des Saarlandes
Prof. Dr. V. Presser

Shifang Zhao
Microenvironments to Regulate Cellular Behavior for Neural Development and Regeneration
Universität des Saarlandes
Prof. Dr. A. del Campo

ABSCHLUSSARBEITEN / THESES

MASTERARBEITEN / MASTER THESES

Natalia Estefania Alvarado Reyes
Correlating the Rheological Properties of Polymer-nanoparticle Mixtures with the Spinnability in Electrospining
Universität des Saarlandes
Prof. Dr. E. Arzt, Dr. P. W. de Oliveira

Angelika Gedsun
Tactile Perception and Fingertip Friction of Microstructured Elastomers
Universität des Saarlandes
Prof. Dr. R. Bennewitz

Reza Hosseinabadi
Material System for Molds Used in Imprinting Processes for Photometallization
Universität des Saarlandes
Prof. Dr. E. Arzt, Dr. P. W. de Oliveira

Milad Mehrfam
The Impact of Temperature on Gecko-inspired Micro-patterned Dry Adhesives and Development of New Structure Designs
Fachhochschule Kärnten, Villach, Österreich
Prof. J. Zarbakhsh, Dr. R. Hensel

Enkeleda Meziu
Visualisierung von Mukus unter nativen Bedingungen
Universität des Saarlandes
Prof. Dr. M. Schneider, Dr. A. Kraegeloh

Mike Nadig
Struktur-Eigenschaftsbeziehungen in einer thermoplastischen Polyurethanmatrix mit plättchenförmigen Füllstoffen über das Compoundierungsverfahren
Universität des Saarlandes
Prof. Dr. G. Kickelbick, Dr. C. Becker-Willinger

Sarah Schmidt
Synthesis and Surface Functionalization of Small Gold Nanoparticles and Gold Nanoclusters Applied to Cancer Therapy
Universität des Saarlandes
Prof. Dr. T. Kraus

Laura Weiter
Entwicklung einer Elektrospinning-Einheit zur Herstellung transparenter und homogener Faserablagerungen auf flexiblen Substraten in einer Rolle-zu-Rolle-Anlage
Universität des Saarlandes
Prof. Dr. E. Arzt, Dr. P. W. de Oliveira

BACHELORARBEITEN / BACHELOR THESES

Carsten Baltes
Role of the Cytoskeleton on Polarity of Cells
Universität des Saarlandes
Jun.-Prof. Dr. F. Lautenschläger

Janos Funk
Plasma Based Surface Modification of Polystyrene
Universität des Saarlandes
Prof. Dr. T. Kraus, Dr. V. Naik

Celine Haag
Nanopartikel Auswirkungen auf die Genexpression in Leberzellen
Hochschule Kaiserslautern
Prof. Dr. K.-H. Schäfer, Dr. A. Kraegeloh

Svenja Lösch
Untersuchung der Langzeitbiokompatibilität nach Plasmabehandlung von Silikon-Elastomeren
Hochschule Kaiserslautern
Prof. Dr. K.-H. Schäfer, Dr. K. Kruttwig

Aubin Prot
Haptic Perception of 3D-printed Surfaces with Well-defined Roughness
Universität des Saarlandes
Prof. Dr. R. Bennewitz

REFERIERTE PUBLIKATIONEN / PEER-REVIEWED PUBLICATIONS

147 Publikationen
publications
davon / *including*

115 Publikationen in referierten Zeitschriften
publications in peer-reviewed journals

32 sonstige Publikationen
other publications

28 Publikationen im Open Access veröffentlicht
publications published in Open Access
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22 Beiträge in referierten Zeitschriften
contributions in peer-reviewed journals

(Stand / As of 15.03.2019)

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A list of all publications is available on our website http://www.leibniz-inm.de/en/publications

GRENZFLÄCHENMATERIALIEN / INTERFACE MATERIALS

Energie-Materalien / Energy Materials

M. E. Casco, F. Badaczewski, S. Grätz, A. Tolosa, V. Presser, B. M. Smarsly and L. Borchardt
Mechanochemical synthesis of porous carbon at room temperature with a highly ordered sp2 microstructure
Carbon 2018, 139, 325-333 [JIF: 07.082 (2017)]
doi:10.1016/j.carbon.2018.06.068

S. Choudhury, P. Srimuk, K. Raju, A. Tolosa, S. Fleischmann, M. Zeiger, K. I. Ozoemena, L. Borchardt and V. Presser
Carbon onion/sulfur hybrid cathodes via inverse vulcanization for lithium-sulfur batteries
Sustainable Energy Fuels 2018, 2, (1), 133-146 [JIF: -]
doi:10.1039/c7se00452d

T. S. Dörr, S. Fleischmann, M. Zeiger, I. Grobelsek, P. W. Oliveira and V. Presser
Ordered Mesoporous Titania/Carbon Hybrid Monoliths for Lithium-ion Battery Anodes with High Areal and Volumetric Capacity
Chem Eur J 2018, 24, (24), 6358-6363 [JIF: 05.160 (2017)]
doi:10.1002/chem.201801099

S. Fleischmann, A. Tolosa and V. Presser
Design of Carbon/Metal Oxide Hybrids for Electrochemical Energy Storage
Chem Eur J 2018, 24, (47), 12143-12153 [JIF: 05.160 (2017)]
doi:10.1002/chem.201800772

S. Fleischmann, M. Zeiger, A. Quade, A. Kruth and V. Presser
Atomic Layer-Deposited Molybdenum Oxide/Carbon Nanotube Hybrid Electrodes: The Influence of Crystal Structure on Lithium-Ion Capacitor Performance
ACS Appl Mater Interfaces 2018, 10, (22), 18675-18684 [JIF: 08.097 (2017)]
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C. Kim, P. Srimuk, J. Lee, M. Aslan and V. Presser
Semi-continuous capacitive deionization using multi-channel flow stream and ion exchange membranes
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B. Krüner, T. S. Dörr, H. Shim, J. Sann, J. Janek and V. Presser
Gyroidal Porous Carbon Activated with NH_3 or CO_2 as Lithium–Sulfur Battery Cathodes
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B. Krüner, C. Odenwald, N. Jäckel, A. Tolosa, G. Kickelbick and V. Presser
Silicon Oxycarbide Beads from Continuously Produced Polysilsesquioxane as Stable Anode Material for Lithium-Ion Batteries
ACS Appl Energy Mater 2018, 1, (6), 2961-2970 [JIF: -]
doi:10.1021/acsaem.8b00716

B. Krüner, C. Odenwald, A. Quade, G. Kickelbick and V. Presser
Influence of Nitrogen-Doping for Carbide-Derived Carbons on the Supercapacitor Performance in an Organic Electrolyte and an Ionic Liquid
Batteries & Supercaps 2018, 1, (4), 135-148 [JIF: -]
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B. Krüner, A. Schreiber, A. Tolosa, A. Quade, F. Badaczewski, T. Pfaff, B. M. Smarsly and V. Presser
Nitrogen-containing novolac-derived carbon beads as electrode material for supercapacitors
Carbon 2018, 132, 220-231 [JIF: 07.082 (2017)]
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J. Lee, S. Badie, P. Srimuk, A. Ridder, H. Shim, S. Choudhury, Y.-C. Nah and V. Presser
Electrodeposition of hydrated vanadium pentoxide on nanoporous carbon cloth for hybrid energy storage
Sustainable Energy Fuels 2018, 2, (3), 577-588 [JIF: -]
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J. Lee, P. Srimuk, S. Carpier, J. Choi, R. L. Zornitta, C. Kim, M. Aslan and V. Presser
Confined Redox Reactions of Iodide in Carbon Nanopores for Fast and Energy-Efficient Desalination of Brackish Water and Seawater
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E. Lim, H. Shim, S. Fleischmann and V. Presser
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doi:10.1039/c8ta02293c

C. Prehal, C. Koczwara, H. Amenitsch, V. Presser and O. Paris
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Ordered Mesoporous TiO_2 Gyroids: Effects of Pore Architecture and Nb-Doping on Photocatalytic Hydrogen Evolution under UV and Visible Irradiation
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T. S. Dörr, A. Pelz, P. Zhang, T. Kraus, M. Winter and H.-D. Wiemhöfer
An Ambient Temperature Electrolyte with Superior Lithium Ion Conductivity based on a Self-Assembled Block Copolymer
Chem Eur J 2018, 24, (32), 8061-8065 [JIF: 05.160 (2017)]
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D. J. Gerstner and T. Kraus
Rapid nanoparticle self-assembly at elevated temperatures
Nanoscale 2018, 10, (17), 8009-8013 [JIF: 07.233 (2017)]
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L. Imholt, T. S. Dörr, P. Zhang, L. Ibing, I. Cekic-Laskovic, M. Winter and G. Brunklaus
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T. Kister, J. H. M. Maurer, L. González-García and T. Kraus
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T. Kister, D. Monego, P. Mulvaney, A. Widmer-Cooper and T. Kraus
On the Colloidal Stability of Apolar Nanoparticles: The Role of Particle Size and Ligand Shell Structure
ACS Nano 2018, 12, (6), 5969-5977 [JIF: 13.709 (2017)]
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D. Monego, T. Kister, N. Kirkwood, P. Mulvaney, A. Widmer-Cooper and T. Kraus
Colloidal Stability of Apolar Nanoparticles: Role of Ligand Length
Langmuir 2018, 34, (43), 12982-12989 [JIF: 03.789 (2017)]
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S. Wintzheimer, T. Granath, M. Oppmann, T. Kister, T. Thai, T. Kraus, N. Vogel and K. Mandel
Supraparticles: Functionality from Uniform structural motifs
ACS Nano 2018, 12, (6), 5093-5120 [JIF: 13.709 (2017)]
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QUERSCHNITTSBEREICH / CROSS LINKING UNIT

InnovationsZentrum INM / InnovationCenter INM

Y. E. Silina, M. Koch, P. Herbeck-Engel and C. Fink-Straube
Multi-dimensional hydroxyapatite microspheres as a filling material of minicolumns for effective removal at trace level of noble and non-noble metals from aqueous solutions
Journal of Environmental Chemical Engineering 2018, 18, (2), 1886-1897 [JIF: -]
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M. Veith, M. Opsölder and V. Huch
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ZAAC 2018, 644, 1549-1556 [JIF: 01.179 (2017)]
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T. Weller, L. Deilmann, J. Timm, T. S. Dörr, P. A. Beaucage, A. S. Cherevan, U. B. Wiesner, D. Eder and R. Marschall
A crystalline and 3D periodically ordered mesoporous quaternary semiconductor for photocatalytic hydrogen generation
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doi:10.1039/c7nr09251b

PROGRAMMBEREICHSUNGEBUNDEN / NOT LINKED TO A PROGRAM DIVISION

Chemische Analytik / Chemical Analytics

H. Ben Abdallah, H. J. Mai, T. Slatni, C. Fink-Straube, C. Abdelly and P. Bauer
Natural Variation in Physiological Responses of Tunisian Hedysarum carnosum Under Iron Deficiency
Front Plant Sci 2018, 9, (1383), [JIF: 03.677 (2017)]
doi:10.3389/fpls.2018.01383

D. Semenova, K. V. Gernaey and Y. E. Silina
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D. Semenova and Y. E. Silina
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D. Semenova, A. Zubov, Y. E. Silina, L. Micheli, M. Koch, A. C. Fernandes and K. V. Gernaey
Mechanistic modeling of cyclic voltammetry: A helpful tool for understanding biosensor principles and supporting design optimization
Sensors Actuators B 2018, 259, 945-955 [JIF: 05.667 (2017)]
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Y. E. Silina, M. Koch, P. Herbeck-Engel and C. Fink-Straube
Multi-dimensional hydroxyapatite microspheres as a filling material of minicolumns for effective removal at trace level of noble and non-noble metals from aqueous solutions
Journal of Environmental Chemical Engineering 2018, 18, (2), 1886-1897 [JIF: -]
doi:10.1016/j.jece.2018.02.044

Physikalische Analytik / Physical Analytics

C. Petzold, M. Koch and R. Bennewitz
Friction force microscopy of tribochemistry and interfacial ageing for the SiO_x/Si/Au system
Beilstein J Nanotechnol 2018, 9, 1647-1658 [JIF: 02.970 (2017)]
doi:10.3762/bjnano.9.157

E. Schulz, A. Goes, R. Garcia, F. Panter, M. Koch, R. Müller, K. Fuhrmann and G. Fuhrmann
Biocompatible bacteria-derived vesicles show inherent antimicrobial activity
J Control Release 2018, 290, 46-55 [JIF: 07.877 (2017)]
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S. Schwebke, S. Winter, M. Koch and G. Schultes
Piezoresistive granular metal thin films of platinum–boron nitride and platinum–alumina at higher strain levels
J Appl Phys 2018, 124, (23), 235308 [JIF: 02.176 (2017)]
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Mechanistic modeling of cyclic voltammetry: A helpful tool for understanding biosensor principles and supporting design optimization
Sensors Actuators B 2018, 259, 945-955 [JIF: 05.667 (2017)]
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Multi-dimensional hydroxyapatite microspheres as a filling material of minicolumns for effective removal at trace level of noble and non-noble metals from aqueous solutions
Journal of Environmental Chemical Engineering 2018, 18, (2), 1886-1897 [JIF: -]
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H. Yasar, A. Biehl, C. De Rossi, M. Koch, X. Murgia, B. Loretz and C.-M. Lehr
Kinetics of mRNA delivery and protein translation in dendritic cells using lipid-coated PLGA nanoparticles
J Nanobiotechnol 2018, 16, (1), 72 [JIF: 05.294 (2017)]
doi:10.1186/s12951-018-0401-y

INM Fellows / INM Fellows

M. Á. Fernández-Rodríguez, R. Elnathan, R. Ditcovski, F. Grillo, G. M. Conley, F. Timpu, A. Rauh, K. Geisel, T. Ellenbogen, R. Grange, F. Scheffold, M. Karg, W. Richtering, N. H. Voelcker and L. Isa
Tunable 2D binary colloidal alloys for soft nanotemplating
Nanoscale 2018, 10, (47), 22189-22195 [JIF: 07.233 (2017)]
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C. Law, S. Lim, A. Abell, N. H. Voelcker and A. Santos
Nanoporous Anodic Alumina Photonic Crystals for Optical Chemo- and Biosensing: Fundamentals, Advances, and Perspectives
Nanomaterials 2018, 8, (10), 788 [JIF: 02.207 (2017)]
doi:10.3390/nano8100788

C. Lehser, E. Wagner and D. J. Strauss
Somatosensory Evoked Responses Elicited by Haptic Sensations in Mid–Air
IEEE transactions on rehabilitation engineering 2018, 26, (10), 2070-2077 [JIF: 03.972 (2017)]
doi:10.1109/tnsre.2018.2869992

Z. Mortezapouraghdam, F. I. Corona-Strauss, K. Takahashi and D. J. Strauss
Reducing the Effect of Spurious Phase Variations in Neural Oscillatory Signals
Front Comput Neurosci 2018, 12, (82), [JIF: 02.073 (2017)]
doi:10.3389/fncom.2018.00082

N. Özgün, D. J. Strauss and R. Bennewitz
Tribology of a Braille Display and EEG Correlates
Tribology letters 2018, 66, (1), 16, 1-10 [JIF: 03.246 (2017)]
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Weitere / Others

J. B. Berger and R. M. McMeeking
Mechanical characterization of a bonded tailorable coefficient of thermal expansion lattice with near optimal performance
J Mater Res 2018, 33, (20), 3383-3397 [JIF: 01.495 (2017)]
doi:10.1557/jmr.2018.327

J. B. Berger, H. N. G. Wadley and R. M. McMeeking
Berger et al. reply: Replying to G.W. Milton, Nature 564
Nature 2018, 564, (7734), E2-E4 [JIF: 41.577 (2017)]
doi:10.1038/s41586-018-0725-7

L. Lin, N. Ecke, S. Kamerling, C. Sun, H. Wang, X. Song, K. Wang, S. Zhao, J. Zhang and A. K. Schlarb
Study on the impact of graphene and cellulose nanocrystal on the friction and wear properties of SBR/NR composites under dry sliding conditions
Wear 2018, 414-415, 43-49 [JIF: 02.960 (2017)]
doi:10.1016/j.wear.2018.07.027

L. Lin and A. K. Schlarb
The roles of rigid particles on the friction and wear behavior of short carbon fiber reinforced PBT hybrid materials in the absence of solid lubricants
Tribol Int 2018, 119, 404-410 [JIF: 03.246 (2017)]
doi:10.1016/j.triboint.2017.11.024

A. Salvadori, R. M. McMeeking, D. Grazioli and M. Magri
A coupled model of transport-reaction-mechanics with trapping. Part I – Small strain analysis
J Mech Phys Solids 2018, 114, 1-30 [JIF: 03.556 (2017)]
doi:10.1016/j.jmps.2018.02.006

SUPPLEMENT 2017

136 Anzahl Publikationen insgesamt (statt 127)
Publications in total (instead of 127)
davon / *including*

99 Beiträge in referierten Zeitschriften (statt 92)
contributions in peer-reviewed journals (instead of 92)

37 sonstige Publikationen (statt 33)
other publications (instead of 33)

(Stand/As of 15.03.2019)

Dynamische Biomaterialien / Dynamic Biomaterials

Z.-S. Wu, Y. Zheng, S. Zheng, S. Wang, C. Sun, K. Parvez, T. Ikeda, X. Bao, K. Müllen and X. Feng
Stacked-Layer Heterostructure Films of 2D Thiophene Nanosheets and Graphene for High-Rate All-Solid-State Pseudocapacitors with Enhanced Volumetric Capacitance
Adv Mater 2017, 29, (3), 1602960, 1-7 [JIF: 21.950 (2017)]
doi:10.1002/adma.201602960

Nano Zell Interaktionen / Nano Cell Interactions

A. J. Omlor, D. D. Le, J. Schlicker, M. Hannig, R. Ewen, S. Heck, C. Herr, A. Kraegeloh, C. Hein, R. Kautenburger, G. Kickelbick, R. Bals, J. Nguyen and Q. T. Dinh
Local Effects on Airway Inflammation and Systemic Uptake of 5 nm PEGylated and Citrated Gold Nanoparticles in Asthmatic Mice
Small 2017, 13, (10), 1603070 [JIF: 09.598 (2017)]
doi:10.1002/smll.201603070

A. S. Schulze, I. Tavernaro, F. Machka, O. Dakischew, K. S. Lips and M. S. Wickleder
Tuning optical properties of water-soluble CdTe quantum dots for biological applications
J Nanopart Res 2017, 19, (2), 70 [JIF: 02.127 (2017)]
doi:10.1007/s11051-017-3757-2

INM Fellows / INM Fellows

C. Bernarding, D. J. Strauss, R. Hannemann, H. Seidler and F. I. Corona-Strauss
Neurodynamic evaluation of hearing aid features using EEG correlates of listening effort
Cogn Neurodyn 2017, 11, (3), 203-215 [JIF: 02.000 (2017)]
doi:10.1007/s11571-017-9425-5

D. J. Strauss and A. L. Francis
Toward a taxonomic model of attention in effortful listening
Cogn Affective Behav Neuroscience 2017, 17, (4), 809-825 [JIF: 02.565 (2017)]
doi:10.3758/s13415-017-0513-0

Weitere / Others

M.-L. Lemloh, A. Verch and I. M. Weiss
Aqueous ball milling of nacre constituents facilitates directional self-assembly of aragonite nanoparticles of the gastropod Haliotis glabra
J R Soc Interface 2017, 14, (136), [JIF: 03.355 (2017)]
doi:10.1098/rsif.2017.0450

J. Nomai and A. K. Schlarb
Environmental stress cracking (ESC) resistance of polycarbonate/SiO_2 nanocomposites in different media
J Appl Polym Sci 2017, 134, (43), 45451 [JIF: 01.901 (2017)]
doi:10.1002/app.45451

EINGELADENE VORTRÄGE / INVITED TALKS

314 Vorträge
talks
davon / *including*

97 eingeladene Vorträge
invited talks

217 sonstige Vorträge
other talks

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http://www.leibniz-inm.de/en/publications

GRENZFLÄCHENMATERIALIEN / INTERFACE MATERIALS

Energie-Materialien / Energy Materials

B. Krüner, C. Odenwald, G. Kickelbick and V. Presser
Carbide-derived carbon beads with tunable nanopores from continuously produced polysilsesquioxanes for energy storage devices
Carbon 2018;
July 01-06, 2018; Madrid, <ESP>

V. Presser
Nanoconfined redox electrolytes for high performance energy storage
Helmholtz Institute Ulm Electrochemical Energy Storage;
October 23, 2018; Ulm

Funktionelle Mikrostrukturen / Functional Microstructures

E. Arzt
Leibniz Institute for New Materials – Research at the Interface of Basics & Innovation
1ers Entretiens franco-allemands de Nancy;
February 22, 2018; Nancy, <FRA>

E. Arzt
Innovative adhesive surfaces from bioinspiration to robotics and medicine
41^{th} Annual Meeting of the Adhesion Society & 6^{th} World Congress on Adhesion and Related Phenomena (WCARP);
February 28, 2018; San Diego, CA, <USA>

E. Arzt
Bioinspired micropatterned adhesives – from micromechanics to robotic function
APS March Meeting 2018, Convention Center;
March 09, 2018; Los Angeles, CA, <USA>

E. Arzt
Micropatterned adhesive surfaces – from bioinspiration to robotics
Physikalisches Kolloquium, Universität Duisburg-Essen;
May 16, 2018; Duisburg

E. Arzt
Research at INM – Leibniz Institute for New Materials: Physical / Chemical / Bio Interfaces
Dagstuhl Seminar: On-Body interaction: embodied cognition meets sensor/actuator engineering to design new interfaces (18212), Schloss Dagstuhl;
May 22, 2018; Wadern

E. Arzt
Insights to highlight the important aspects of international industrial collaborations
STS Forum 2018, Kyoto International Conference Center;
October 07, 2018; Kyoto, <JPN>

E. Arzt
Bioinspired micropatterned adhesives – from micromechanics to robotic function
Tohoku University, Institute for Materials Research (IMR); October 10, 2018; Sendai City, <JPN>

E. Arzt
Unbeschränkte Haftung – vom Vorbild Natur zu neuen Materialien und Systemen : Keynote Lecture
Technische Universität Graz
November 16, 2018; Graz, <AUT>

L. Barnefske
Smart materials inspired by nature
Young Polymer Scientist Forum, RWTH Aachen;
June 28-29, 2018; Aachen

L. Barnefske and R. Hensel
Time relevant mechanisms for dry adhesion
Workshop on Modeling Adhesion, Grip and Related Topics; October 28-31, 2018; Santa Barbara, CA, <USA>

R. Hensel
Biologisch inspiriertes innovatives Greifen von Mikrobauteilen
MIKROmontage;
May 15, 2018; Ettlingen

R. Hensel
Composite pillars with a tunable interface for adhesion to rough substrates
12th European Adhesion Conference and 4th Luso-Brazilian Conference on Adhesion and Adhesives; September 07, 2018; Lisbon, <POR>

R. Hensel
Bio-inspired micropatterned adhesives – mechanistic insight and new designs
University of British Columbia;
October 02, 2018; Vancouver, <CAN>

R. Hensel
Adhesion to rough surfaces by confined elastic layers
Workshop on Modeling Adhesion, Grip and Related Topics;
October 28-31, 2018; Santa Barbara, CA, <USA>

K. Kruttwig
Characterization of thin film silicone elastomer composites for adhesion to skin and the treatment of eardrum perforations
In-adhesive;
February 21, 2018; München

K. Kruttwig
Thin film elastomeric composition and application in eardrum perforation treatment
Medtech Europe;
April 19, 2018; Stuttgart

K. Kruttwig
Thin film silicone elastomer composites for adhesion to skin and tissues
Synthetic Biology Conference – Turning Science Fiction to Reality;
October 11-12, 2018; Bremen

K. Moh and M. Schöneich
Innocise – business case GECOMER Technology
Business Development Workshop;
October 05, 2018; Berlin

M. Schöneich
Short fiber reinforced composites with fiber-matrix interphase & engineering of fibrillar dry adhesives
European Alliance for Thermoplastic Composites – Expert Task Force Meeting;
February 08, 2018; Frankfurt a.M.

V. Tinnemann
In-situ observation of local detachment mechanisms in micropatterned adhesives
Workshop on Modeling Adhesion, Grip and Related Topics;
October 28-31, 2018; Santa Barbara, CA, <USA>

Y. Wang
New designs with superior adhesion in dry and wet conditions
Workshop on Modeling Adhesion, Grip and Related Topics;
October 28-31, 2018; Santa Barbara, CA, <USA>

Nanotribologie / Nanotribology

R. Bennewitz
Fingertip friction
NanoGoa 2018 – Nanoscale Effects in Macrotribology, International Nanotribology Forum , Dona Sylvia Beach Resort;
January 08-12, 2018; Goa, <IND>

R. Bennewitz
The role of single-asperity experiments in tribology
NanoBrücken 2018: A Nanomechanical Testing Conference & Bruker Hysitron User Meeting, Friedrich-Alexander-Universität Erlangen-Nürnberg,;
February 20-22, 2018; Nürnberg

R. Bennewitz
Force microscopy of shear in nanometer-confined liquids
Symposium on Microscopic Properties of solid-liquid interfaces, University of Twente ;
March 22, 2018; Twente, <NED>

R. Bennewitz
Friction, molecular adhesion, reversible bonds, and multivalency
IRTG-Seminar “Soft Matter Sciences”, Albert-Ludwigs-Universität;
May 09, 2018; Freiburg

R. Bennewitz
Mechanisms of Lubrication at the Nanometer Scale
2018 STLE Annual Meeting;
May 20-24, 2018; Minneapolis, MN, <USA>

R. Bennewitz
Fingertip Friction of a Braille Display and Neural Correlates
2018 STLE Tribology Frontiers Conference;
October 28-31, 2018; Chicago, IL, <USA>

J. Blass
How molecular kinetics determine adhesion and friction
Leibniz-Institut für Polymerforschung Dresden;
August 03, 2018; Dresden

Innovative Elektronenmikroskopie / Innovative Electron Microscopy

E. Cepeda-Perez and N. de Jonge
Long-range interactions between nanoparticles observed by liquid-phase STEM
XXVII International Materials Research Congress (IMRC 2018);
August 19-24, 2018; Cancún, <MEX>

I. N. Dahmke
Correlative fluorescence and electron microscopy for graphene-enclosed whole cells for high resolution analysis of cellular proteins
CISCEM 2018 – 4th International Conference on In Situ and Correlative Electron Microscopy;
October 10-12, 2018; Saarbrücken

N. de Jonge
Liquid-phase electron microscopy of cells and nanomaterials in liquid
Seminar University of Manchester / School of Materials;
January 16, 2018; Manchester, <GBR>

N. de Jonge
Liquid-phase electron microscopy of cells and nanomaterials in liquid
Seminar Max Planck Institute for the Structure and Dynamics of Matter;
April 11, 2018; Hamburg

N. de Jonge
Liquid-phase electron microscopy of cells and nanomaterials in liquid
Seminar Matériaux et Phénomènes Quantiques, University Paris Diderot;
May 30, 2018; Paris, <FRA>

N. de Jonge
Studying membrane proteins and drug responses in individual breast cancer cells using liquid-phase electron microscopy
Deutsches Krebsforschungszentrum;
September 10, 2018; Heidelberg

N. de Jonge
Studying membrane proteins and drug responses at the single molecule- and single cell level in whole cells using liquid-phase electron microscopy
Technische Universität;
October 31, 2018; Darmstadt

P. Kunnas, I. N. Dahmke and N. de Jonge
Liquid-phase electron microscopy for studying colloidal dynamics to transmembrane proteins in whole SKBR3 cells
Turku BioImaging Core;
November 26, 2018; Turku, <FIN>

D. B. Peckys, I. N. Dahmke, D. Alansary, B. A. Niemeyer and N. de Jonge
Combining graphene dots and liquid phase electron microscopy to study membrane protein interaction in intact cells
Microscopy Characterization of organic-inorganic interfaces, Queen Mary University;
February 22-23, 2018; London, <GBR>

D. B. Peckys, I. N. Dahmke, D. Alansary, B. A. Niemeyer and N. de Jonge
Application of liquid phase scanning transmission electron microscopy methods for the quantitative study of membrane proteins in whole cells
M&M Conference, Microscopy & Microanalysis;
August 05-09, 2018; Baltimore, MD, <USA>

BIOGRENZFLÄCHEN / BIO INTERFACES

Dynamische Biomaterialien / Dynamic Biomaterials

A. del Campo
Optoregulated interfaces
Max-Planck-Institute of Colloids and Interfaces;
January 18, 2018; Potsdam

A. del Campo
Addressing cells with optoregulated hydrogels
A Theodore von Kármán Discussion Conference, Materials for Life “Bioinspired and Biomimetic Hydrogels”;
April 15-18, 2018; Bergisch-Gladbach

A. del Campo
Using light to trigger cell responses in biomaterials
Research Seminar at the Instituto Universitariío Fernández-Vega, Universidad de Oviedo;
May 10, 2018; Oviedo, <ESP>

A. del Campo
Theoria cum praxi: retos y oportunidades en el modelo Leibniz
Wissenschaft, Technologie, Unternehmen und Staat: Von der staatlichen Förderung der Forschung und Entwicklung zum Technologietransfer, Deutsche Botschaft in Madrid;
May 13, 2018; Madrid, <ESP>

A. del Campo
Fine tuning properties of catechol-based tissue adhesives
International Workshop on bioinspired adhesives and functional coatings based on catechols, Catalan Institute of Nanoscience and Nanotechnology;
October 22, 2018; Barcelona, <ESP>

A. del Campo
Materials: Reconstructing cell-matrix and cell-cell interfaces with synthetic materials
Sino-German Symposium "Polymers and Interfaces – Construction, Characterization and Functionalization";
November 07-09, 2018; Mainz

A. del Campo
Engineering living materials
13th IPF Colloquium "Smart Polymer Systems", IPF Leibniz-Institute for Polymer Research;
November 22, 2018; Dresden

A. del Campo
Engineering living (nano)materials
Colloquium CIC nanoGune Nanoscience Cooperative Research Center;
November 26, 2018; San Sebastián, <ESP>

A. del Campo
Biomaterials with optoregulated functions
Seminar of the CIC biomaGune Center for Cooperative Research in Biomaterials;
November 27, 2018; San Sebastián, <ESP>

S. Sankaran
Biomaterials, where we are and how we got here!
FunMat Winter School on Materials and Cell Interactions;
March 20-21, 2018; Turku, <FIN>

S. Sankaran
Genetically engineered biomaterials, Hijacking nature a little
FunMat Winter School on Materials and Cell Interactions;
March 20-21, 2018; Turku, <FIN>

S. Sankaran
Dynamic Biomaterials, the way forward?
FunMat Winter School on Materials and Cell Interactions;
March 20-21, 2018; Turku, <FIN>

M. K. Włodarczyk-Biegun
3D bioprinting of medical adhesives
The 4th International Society for Biomedical Polymers and Polymeric Biomaterials (ISBPPB) Conference;
July 15-18, 2018; Krakow, <POL>

M. K. Włodarczyk-Biegun
Melt electrostatic writing of a human trabecular meshwork
International Conference on Biofabrication;
October 28-31, 2018; Würzburg

Schaltbare Mikrofluidik / Switchable Microfluidics

J. Cui
Crystal/polymer hybrid hydrogels: force sensitivity and property post modulation
2018 Materials Research Society (MRS): Spring Meeting;
April 2-6, 2018; Phoenix, AZ, <USA>

J. Cui
Transport and conversion of liquid in dynamic polymer networks
Brazilian-German Frontiers of Science and Technology Symposium;
October 08-11, 2018; Florianópolis, <BRA>

J. Cui
More than self-healing: molecule-transport and interconversion in dynamic polymer gels
Sino-German Symposium on "Polymers and Interfaces: construction, Characterization and Functionalization";
November 07-09, 2018; Mainz

Zellskeletale Fasern / Cytoskeletal Fibers

F. Lautenschläger
The cytoskeleton in cellular functions
Seminar University of Copenhagen / Niels Bohr Institute;
May 04, 2018; Copenhagen, <DEN>

F. Lautenschläger
Krebszellen unter dem Mikroskop
Tag der Offenen Tür, Universität des Saarlandes;
May 26, 2018; Saarbrücken

F. Lautenschläger
Molecular motors
Cuban-German Graduate School in Cellular-Biophysics, University Havana;
October 01-05, 2018; Havana, <CUB>

F. Lautenschläger
Structure and dynamics of the cytoskeleton
Cuban-German Graduate School in Cellular-Biophysics, University Havana;
October 01-05, 2018; Havana, <CUB>

F. Lautenschläger
Aspects of cell migration
Schiemann Symposium at Max-Planck Society Meeting;
October 25, 2018; Berlin

Nano Zell Interaktionen / Nano Cell Interactions

A. Kraegeloh
Nano Cell Interactions
Nanopharm Netzwerk-Treffen;
March 20, 2018; Mainz

A. Kraegeloh
Nanotechnologie – aber sicher!
BMBF-Bürgergespräch „Hightech-Werkstoffe für die Welt von Morgen – Chancen, Risiken und Perspektiven“, Universität des Saarlandes;
May 26, 2018; Saarbrücken

A. Kraegeloh
Nanomaterial induced mechanisms: focus on nano cell interactions
256th ACS National Meeting;
August 19-23, 2018; Boston, MA, <USA>

NANOKOMPOSIT-MATERIALIEN / NANOCOMPOSITE MATERIALS

Optische Materialien / Optical Materials

M. H. Jilavi, S. H. Mousavi, T. S. Müller and P. W. Oliveira
Using sol gel technology for production of dual functional antireflective coatings with additional photocatalytic effect in a single layer on glass substrate
European Coatings Future Dialogue – Where Industry meets Science;
November 22-23, 2018; Amsterdam, <NED>

Strukturbildung / Structure Formation

L. Gonzalez-Garcia
Nanostructured oxide thin films: fabrication and applications
International Workshop on Oxide Surfaces (IWOX-XI);
January 22-26, 2018; Granada, <ESP>

T. Kraus
Composites of the future: towards soft-hard hybrids with molecular definition for electronics, optics, and health
15th Annual iNANO meeting;
January 10, 2018; Aarhus, <DEN>

T. Kraus
Protein-inspired material design with hybrid nanoparticles
Kolloquium Technische Universität Chemnitz;
May 16, 2018; Chemnitz

T. Kraus
Inks for printed, soft, and transparent electronics
3rd Thin Film Technology Forum;
June 07, 2018; Karlsruhe

T. Kraus
Opportunities for particle-based materials: Printed soft devices, nonlinear mixing rules, and active composites
Particle Based Materials Symposium;
September 20-21, 2018; Erlangen

T. Kraus
Dynamic hybrid particles and composites
Deutsch-Chinesisches Joint-Symposium;
November 07-09, 2018; Mainz

P. Zhang
Wet-based polymer nanoparticle hybrid materials for electronics
Satellite meeting “SAXS/WAXS/GISAXS-User Workshop @ DESY”;
January 25, 2018; Hamburg

P. Zhang
Study the nanoscale structure formation in soft matter with x-ray scattering
TSE Seminar, Korea Institute of Science and Technology;
February 20, 2018; Saarbrücken

QUERSCHNITTSBEREICH / CROSS LINKING UNIT

InnovationsZentrum INM / InnovationCenter INM

P. W. Oliveira and M. Opsölder
Transparent and electrically conducting coatings through wet chemical nanotechnology / Transparente und leitfähige Schichten durch nasschemische Nanotechnologie
Forum TechTransfer, Hannovermesse;
April 23-27, 2018; Hannover

PROGRAMMBEREICHSUNGEBUNDEN / NOT LINKED TO A PROGRAM DIVISION

Chemische Analytik / Chemical Analytics

Y. E. Silina
Exploring the potential of electroplated noble metal-semiconductor hybrids within bio- and environmental sensing
Korea Institute of Science and Technology;
May 08, 2018; Saarbrücken

Y. E. Silina
Organic and inorganic mass spectrometry as a helpful tool for bio and environmental sensors design optimization
7th World Congress on Mass Spectrometry;
June 20-22, 2018; Rome, <ITA>

Y. E. Silina
Removal of heavy and radioactive metals from the aqueous solutions by means of alginate scavengers
Fraunhofer Institut für Biomedizinische Technik (IBMT);
November 06, 2018; St. Ingbert

Y. E. Silina
Analytics for Analyst: The role of analytical and bioanalytical chemistry in modern biotechnology, bio sensing, bio- and environmental screening
Technical University of Denmark / Process and Systems Engineering Center (PROSYS), Department of Chemical and Biochemical Engineering;
November 29, 2018; Lyngby, <DEN>

INM Fellows / INM Fellows

B. Qu
Non-target bystander cells enhance tumor killing mediated by natural killer cells
Sino-German Symposium: Cell fate and tumorigenesis from animal models to human diseases;
February 08, 2018; Chongqing, <CHN>

B. Qu
Impact of high clucose on cytotoxic T lymphocytes
1st Affiliated Hospital, University of Science and Technology of China;
July 03, 2018; Hefei, <CHN>

B. Qu
Novel regulatory factors of killer cell function: intrinsic and external
Nanjing Medical University;
July 04, 2018; Nanjing, <CHN>

B. Qu
Lylsosome-related organelle tethering controls directionally distinct cytokine transport in T cells
5th European Congress of Immunology;
September 03, 2018; Amsterdam, <NED>

N. H. Voelcker
Tales of porous silicon in medicine
Porous semiconductors - Science and Technology (PSST);
March 11-16, 2018; La Grande Motte, <FRA>

N. H. Voelcker
Targeted drug delivery to solid tumours using porous silicon nanoparticles
Nanotech-2018: 3rd International Nanotechnology Conference & Expo;
May 07-09, 2018; Rome, <ITA>

N. H. Voelcker
Nanostructured silicon in nanomedicine
CSIRO Symposium, Chinese Academy of Science;
June, 2018; Guangzhou, <CHN>

N. H. Voelcker
Engineering porous silicon nanoparticles for smart drug delivery
1st Controlled Release Asia Meeting;
September 24-25, 2018; Singapore, <SGP>

N. H. Voelcker
Porous silicon based optica lbiosensors
Cutting edge Symposium on molecular sensing of biological environments;
October 02-03, 2018; Hobart, <AUS>

N. H. Voelcker
Nanostructured silicon in Nanomedicine
NanoIsrael.IL.2018;
October 10-11, 2018; Jerusalem, <ISR>

N. H. Voelcker
Nanomaterials to measure and control inflammation
NIMS-CSIRO Symposium on Materials for biomedical applications;
October 22-23, 2018; Melbourne, <AUS>

NTNM-Bibliothek / NTNM library

E. Bubel
NTNM-Library in General, Open Access and Impact Factor in Real Life
Deutscher Akademischer Austauschdienst (DAAD) / Library Workshop 2018, Universität des Saarlandes / Europa Institut;
December 17, 2018; Saarbrücken

U. Geith
Open Access an der Bibliothek des INM – Leibniz-Institut für Neue Materialien (NTNM-Bibliothek)
12. Mitgliederversammlung und Frühjahrstagung des Vereins Bibliotheken der Region Bodensee; March 15, 2018; Winterthur, <SUI>

U. Geith
Sichtbarmachung von Open-Access-Publikationen in den Nachweisinstrumenten einer Bibliothek – visOA
Vernetzungstreffen des vom BMBF geförderten Open-Access-Ideenwettbewerbs, Bundesministerium für Bildung und Forschung;
December 05, 2018; Berlin

Physikalische Analytik / Physical Analytics

M. Koch
Cryo-electron microscopy at INM
Institutsseminar HIPS;
May 24, 2018; Saarbrücken

M. Koch
Den Nanopartikeln auf der Spur
BMBF-Bürgergespräch „Hightech-Werkstoffe für die Welt von Morgen – Chancen, Risiken und Perspektiven";
May 26, 2018; Saarbrücken

M. Koch
E(S)EM – Exciting (Scanning) Electron Microscopy: The use of modern electron microscopic methods for biotechnology and life science
Technical University of Denmark / Process and Systems Engineering Center (PROSYS), Department of Chemical and Biochemical Engineering
November 29, 2018; Lyngby, <DEN>

M. Koch
Das ESEM – ein Mikroskop für Neugierige!
Institutsseminar Thermische Verfahrenstechnik, Technische Universität;
December 10, 2018; Kaiserslautern

AUSZEICHNUNGEN / AWARDS

Lena Barnefske
Leibniz Young Polymer Scientist Forum
DWI and Evonik Industries

Roland Bennewitz
Lehrpreis der Fachschaft aller physikalischen Studiengänge
Universität des Saarlandes

Simon Bettscheider
EUSMAT-Preis der Europäischen Schule für Materialforschung
Universität des Saarlandes

Öznil Budak
Posterpreis, Doktorandentag der NT-Fakultät
Universität des Saarlandes

Aleeza Farrukh
Auswahl zum 68th Lindau Nobel Laureate Meeting
Stiftung Lindauer Nobelpreisträgertagungen

Aleeza Farrukh
Leibniz-Promotionspreis
Leibniz-Gemeinschaft

Sarah Fischer
DGM-Nachwuchspreis
Deutsche Gesellschaft für Materialkunde

Jana Fleddermann
Travel Grant Nanotox 2018
DECHEMA

Mitchell Han
Humboldt-Forschungsstipendium für Postdoktoranden
Alexander von Humboldt-Stiftung

René Hensel
Adhesion Innovation Award 2018
EURADH & FEICA

Robert McMeeking
Humboldt Alumni Award 2018 for innovative networking initiatives
Alexander von Humboldt Foundation

Volker Presser
Highly Cited Researcher
Clarivate Analytics

Malgorzata Włodarczyk-Biegun
For Women in Science Award
Christiane Nüsslein-Volhard Foundation and L'Oréal Germany

PATENTE / PATENTS

1 Patentanmeldungen
patent applications

8 erteilte Patente
granted patents

4 europäische
european

4 internationale
international

65 Patentfamilien
patent families

ERTEILTE EUROPÄISCHE PATENTE / PATENTS GRANTED IN EUROPE

Europäisches Patent Nr. 11791507.4
Titel: *„Verfahren zur Herstellung von metallischen Strukturen“*
Erfinder: Peter William de Oliveira, Karsten Moh, Eduard Arzt

Europäisches Patent Nr. 11791506.6
Titel: *„Verfahren zur Herstellung von metallischen Strukturen“*
Erfinder: Peter William de Oliveira, Karsten Moh, Sarah Schuhmacher, Eduard Arzt

Europäisches Patent Nr. 06700851.6
Titel: *„Kompositzusammensetzung für mikrogemusterte Schichten mit hohem Relaxationsvermögen, hoher chemischer Beständigkeit und mechanischer Stabilität“*
Erfinder: Carsten Becker-Willinger, Pamela Kalmes, Helmut Schmidt, Etsuko Hino, Noguchi Mitsutoshi, Sito Yoshikazu, Norio Ohkuma

Europäisches Patent Nr. 14812423.3
Titel: *„Vorrichtung zum Beschichten von planaren Substraten“*
Erfinder: Peter William de Oliveira, Mohammad Hossein Jilavi, Karl Peter Schmitt, Robert Drumm, Herbert Beermann, Dietmar Serwas

ERTEILTE INTERNATIONALE PATENTE / PATENTS GRANTED INTERNATIONALLY

US Patent Nr. 15/314,141
Titel: *“Device and method for the stoichiometric analysis of samples”*
Erfinder: Niels de Jonge, Diana B. Peckys

AU Patent Nr. 2013358693
Titel: *“Metal-Nanoparticle-Arrays and production of metal-nanoparticle-arrays”*
Erfinder: Daniel Brodoceanu, Tobias Kraus, Cheng Fang, Nicolas Hans Völcker

US Patent Nr. 15/124,697
Titel: *„Vorrichtung für die korrelative Raster-Transmissionselektronenmikroskopie (STEM) und Lichtmikroskopie “*
Erfinder: Niels de Jonge

US Patent Nr. 13/808,105
Titel: *“Method for producing finley structured surfaces”*
Erfinder: Eduard Arzt, Elmar Kroner, Peter William de Oliveira, Ebru Devrim Sam, Florian Büsch, Dieter Urban, Reinhold Schwalm, Benedikt Blaesi, Michael Nitsche, Hannes Spieker, Claas Müller

LEHRVERANSTALTUNGEN / TEACHING

WINTERSEMESTER 2017 / 2018

Eduard Arzt, Aránzazu del Campo
INM-Kolloquium
Universität des Saarlandes, Kolloquium, 2 SWS

Eduard Arzt und Mitarbeiter/innen
NanoBioMaterialien-1
Universität des Saarlandes, Vorlesung / Übung, 2 SWS

Eduard Arzt, Annette Kraegeloh und Mitarbeiter/innen
NanoBioMaterialien-P
Universität des Saarlandes, Praktikum, 4 SWS

Eduard Arzt und Mitarbeiter/innen
Einführung in die Materialwissenschaft für (Studierende der) Mikrotechnologie und Nanostrukturen
Universität des Saarlandes, Vorlesung / Übung, 5 SWS

Carsten Becker-Willinger (mit G. Wenz, UdS)
MC07: Technologie der Polymere und Komposite
Universität des Saarlandes, Vorlesung, 2 SWS

Carsten Becker-Willinger
Non Destructive Testing: Polymer Materials Part 1
DIU – Dresden International University, Blockvorlesung, 1 SWS

Roland Bennewitz
Nanomechanik
Universität des Saarlandes, Vorlesung / Übung, 4 SWS

Roland Bennewitz
Gute Wissenschaftliche Praxis
Universität des Saarlandes, Blockseminar, 1 SWS

Aránzazu del Campo und Mitarbeiter/innen
Biomedizinische Polymere
Universität des Saarlandes, Vorlesung, 2 SWS

Niels de Jonge
Experimentalphysik I: Mathematische Ergänzungen
Universität des Saarlandes, Vorlesung / Übung, 2 SWS

Marcus Koch (mit F. Breinig, UdS)
Zellbiologie
Universität des Saarlandes, Vorlesung, 4 SWS

Annette Kraegeloh (mit C. Wittmann, UdS)
Biochemie-1
Universität des Saarlandes, Vorlesung, 2 SWS

Tobias Kraus
Beschichtungen (Functional Coatings)
Universität des Saarlandes, Vorlesung, 2 SWS

Tobias Kraus
Kolloquium der Gesellschaft Deutscher Chemiker (GDCh)
Universität des Saarlandes, Kolloquium, 1 SWS

Franziska Lautenschläger
Einführung in die Biologie I
Universität des Saarlandes, Vorlesung, 2 SWS

SOMMERSEMESTER 2017 / 2018

Eduard Arzt, Aránzazu del Campo
INM-Kolloquium
Universität des Saarlandes, Kolloquium, 2 SWS

Roland Bennewitz
Good Scientific Practise and Communication
Universität des Saarlandes, Blockseminar, 1 SWS

Aránzazu del Campo und Mitarbeiter/innen
Biopolymere & Bioinspirierte Polymere (BioPol)
Universität des Saarlandes, Vorlesung, 2 SWS

Aránzazu del Campo und Mitarbeiter/innen
Praktikum Biomaterialien (BiomatP)
Universität des Saarlandes, Blockpraktikum, 5 SWS

Annette Kraegeloh, Eduard Arzt und Mitarbeiter/innen
NanoBioMaterialien-2
Universität des Saarlandes, Vorlesung, 2 SWS

Tobias Kraus
Praktikum Kolloide und Grenzflächen
Universität des Saarlandes, Praktikum, 3 SWS

Tobias Kraus
Kolloquium der Gesellschaft Deutscher Chemiker (GDCh)
Universität des Saarlandes, Kolloquium, 1 SWS

Franziska Lautenschläger
Praktikum Einführung in die Biologie (für Bachelor Plus Mint)
Universität des Saarlandes, Praktikum, 2 SWS

Franziska Lautenschläger (mit J.-B. Fleury, A. Ott, UdS)
Seminar zu aktuellen Fragen der Biophysik
Universität des Saarlandes, Seminar, 2 SWS

Franziska Lautenschläger
Einführung in die Biologie II (für Bachelor Plus Mint)
Universität des Saarlandes, Vorlesung, 2 SWS

Volker Presser
Grundlagen der Thermodynamik
Universität des Saarlandes, Vorlesung / Übung, 4 SWS

Volker Presser (mit R. Hempelmann, D. Scheschkewitz, UdS)
Werkstoffe für effiziente Energienutzung (EnTV)
Universität des Saarlandes, Vorlesung, 2 SWS

Volker Presser (mit R. Hempelmann, UdS)
Praktikum Materialien und Systeme der Energietechnik (EnTP)
Universität des Saarlandes, Praktikum, 4 SWS

Volker Presser, René Hensel (mit G. Wenz, UdS)
Smart Materials and Polymers (MC06)
Universität des Saarlandes, Blockvorlesung, 2 SWS

WINTERSEMESTER 2018 / 2019

Eduard Arzt, Aránzazu del Campo
INM-Kolloquium
Universität des Saarlandes, Kolloquium, 2 SWS

Eduard Arzt und Mitarbeiter/innen
NanoBioMaterialien-1
Universität des Saarlandes, Vorlesung / Übung, 2 SWS

Eduard Arzt und Mitarbeiter/innen
Einführung in die Materialwissenschaft für (Studierende der) Mikrotechnologie und Nanostrukturen
Universität des Saarlandes, Vorlesung / Übung, 5 SWS

Eduard Arzt, Annette Kraegeloh und Mitarbeiter/innen
NanoBioMaterialien-P
Universität des Saarlandes, Praktikum, 4 SWS

Carsten Becker-Willinger (mit G. Wenz, UdS)
MC07: Technologie der Polymere und Komposite
Universität des Saarlandes, Vorlesung, 2 SWS

Carsten Becker-Willinger
Non Destructive Testing: Polymer Materials Part 1
DIU – Dresden International University, Blockvorlesung, 1 SWS

Roland Bennewitz
Experimentalphysik IV a (Festkörperphysik I)
Universität des Saarlandes, Vorlesung / Übung, 3 SWS

Roland Bennewitz
Gute Wissenschaftliche Praxis und Kommunikation
Universität des Saarlandes, Blockseminar, 1 SWS

Aránzazu del Campo und Mitarbeiter/innen
Biomedizinische Polymere
Universität des Saarlandes, Vorlesung, 2 SWS

Niels de Jonge
Experimentalphysik I: Mathematische Ergänzungen
Universität des Saarlandes, Vorlesung / Übung, 2 SWS

Niels de Jonge und Mitarbeiter/innen
Mikroskopie
Universität des Saarlandes, Vorlesung / Praktikum, 4 SWS

Marcus Koch (mit F. Breinig, UdS)
Zellbiologie
Universität des Saarlandes, Vorlesung, 4 SWS

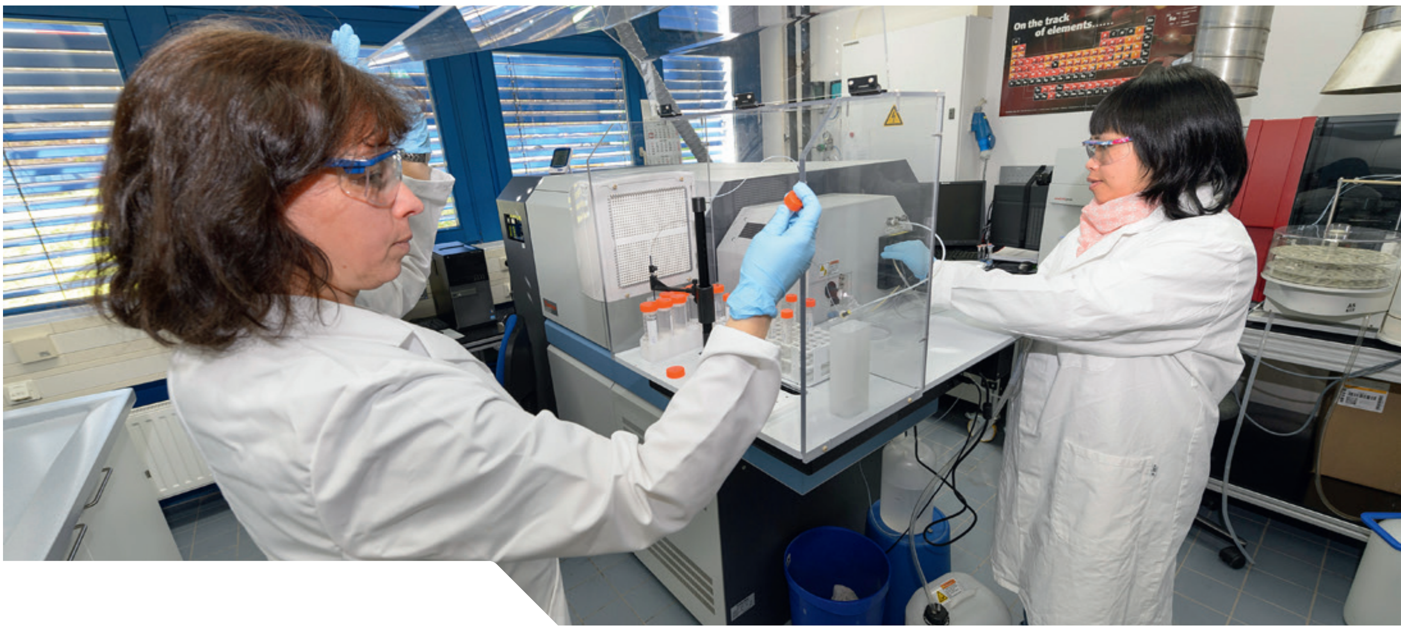
Tobias Kraus
Beschichtungen (Functional Coatings)
Universität des Saarlandes, Vorlesung, 2 SWS

Tobias Kraus
Kolloquium der Gesellschaft Deutscher Chemiker (GDCh)
Universität des Saarlandes, Kolloquium, 1 SWS

Tobias Kraus (mit G. Jung, C. Kay, H. Natter, M. Springborg, UdS)
Masterpraktikum Physikalische Chemie
Universität des Saarlandes, Praktikum, 2 SWS

Tobias Kraus (mit G. Jung, C. Kay, H. Natter, M. Springborg, UdS)
Vorlesung zum Pflichtmodul PC V
Universität des Saarlandes, Vorlesung, 4 SWS

Franziska Lautenschläger
Einführung in die Biologie I
Universität des Saarlandes, Vorlesung, 2 SWS



VORTRÄGE IM INM-KOLLOQUIUM / INM COLLOQUIUM TALKS

Prof. Dr. Nigel D. Browning, University of Liverpool, UK
Using sub-sampled STEM and inpainting to control the kinetics and observation efficiency of dynamic processes in liquids
January 09, 2018, Host: Prof. Dr. Niels de Jonge

Prof. Dr. Anne-Sophie Duwez, University of Liège, Belgium
Probing single molecules with AFM: Force, motion, dynamics and function
January 16, 2018, Host: Prof. Dr. Roland Bennewitz

Prof. Dr. Stefan Kins, TU Kaiserslautern
The Alzheimer's Disease associated Amyloid-β Precursor Protein (APP) functions as synaptic cell adhesion molecule
January 19, 2018, Host: Prof. Dr. Aránzazu del Campo

Prof. Dr. Eric C. Garnett, University of Amsterdam, The Netherlands
What can nano really do for solar?
February 06, 2018, Host: Prof. Dr. Tobias Kraus

Prof. Dr. Harald Gießen, Universität Stuttgart
Merging micro- and nano-optics: Fundamental aspects and applications
February 20, 2018, Host: Prof. Dr. Eduard Arzt

Prof. Dr. Lorenzo Alibardi, Comparative Histolab Padova und University of Bologna, Italy
Mapping proteins localization in adhesive setae of geckos and their possible influence on the mechanism of adhesion
March 22, 2018, Host: Prof. Dr. Aránzazu del Campo

Prof. Dr. Kohzo Ito, University of Tokio, Japan
Slide-Ring Materials: Novel Molecular Concept for Tough Polymers
March 26, 2018, Host: Dr. Carsten Becker-Willinger

Dr. Bob C. Schroeder, Queen Mary University of London, UK
Organic semiconductors – How we turned black soot into electronic skin
April 24, 2018, Host: Prof. Dr. Tobias Kraus

Prof. Dr. Oliver G. Schmidt, Leibniz-Institut für Festkörper- und Werkstoffforschung, Dresden
Microtubular nanomembranes: From 3D device architectures to cellular cyborg machinery
May 08, 2018, Host: Prof. Dr. Eduard Arzt

Prof. Dr. Sylvain Gabriele, University of Mons, Belgium
Feel the force: How matrix stiffness and physical confinement modulate cell functions
May 15, 2018, Host: Prof. Dr. Aránzazu del Campo

Prof. Dr. Salazar Alvarez, Stockholm University, Sweden
From synthesis to large, ordered self-assembled arrays of nanoparticles
June 05, 2018, Host: Prof. Dr. Tobias Kraus

Prof. Dr. Alfons van Blaaderen, Utrecht University, The Netherlands
Surprises in the self-assembly of particles in spherical confinement
June 12, 2018, Hosts: Prof. Dr. Niels de Jonge / Prof. Dr. Tobias Kraus

Prof. Dr. Zoltán D. Hórvölgyi, Budapest University of Technology and Economics, Hungary
Transparent mesoporous Sol-Gel coatings: Preparation and properties
June 19, 2018, Host: Dr. Peter W. de Oliveira

Prof. Dr. Ximin He, University of California, Los Angeles, USA
Bioinspired adaptive materials based on smart hydrogels: Sensing, sorting, and harvesting
July 02, 2018, Host: Dr. Jiaxi Cui

Prof. Dr. Taher Saif, University of Illinois at Urbana-Champaign, USA
Living micromachines
July 06, 2018, Host: Prof. Dr. Eduard Arzt

Prof. Dr. Wilfred G. van der Weil, University of Twente, The Netherlands
Evolving functionality in disordered nanomaterial networks
July 10, 2018, Host: Prof. Dr. Tobias Kraus

Prof. Dr. Paul Mulvaney, University of Melbourne, Australia
Gold nanocrystals: Single particle electrochemistry and large scale self-assembly
July 13, 2018, Host: Prof. Dr. Tobias Kraus

Dr. Gabriel Lozano, University of Seville, Spain
Photonic materials for energy-saving applications
July 17, 2018, Host: Prof. Dr. Tobias Kraus

Dr. Wendong Wang, Max Planck Institute for Intelligent Systems, Stuttgart
Dynamic Material Systems: FLIPS and collective microrobots
August 01, 2018, Host: Dr. Jiaxi Cui

Prof. Dr. Benedikt Berninger, King's College London, UK
Engineering neurogenesis for the postnatal brain
August 20, 2018, Host: Prof. Dr. Aránzazu del Campo

Prof. Dr. Kristina Lorenz, ISAS Dortmund
Targeting of protein kinases in cardiovascular disease – a double edged sword?
October 18, 2018, Host: Prof. Dr. Aránzazu del Campo

Dr. Katja Schenke-Layland, Universität Tübingen
Imaging in tissue engineering
October 30, 2018, Host: Prof. Dr. Aránzazu del Campo

Dr. Ohid Yaqub, University of Sussex, Falmer, UK
Serendipity
November 13, 2018, Host: Prof. Dr. Tobias Kraus

Dr. Helen Minsky, ESPCI, Paris, France
Failure of pressure sensitive adhesives (PSAs) under shear loading
November 27, 2018, Hosts: Prof. Dr. Eduard Arzt / Dr. René Hensel

Dr. Kristian Franze, University of Cambridge, UK
The physical regulation of neuronal development and regeneration
December 11, 2018, Host: Jun.-Prof. Dr. Franziska Lautenschläger

Prof. Dr. Stefan Wiemann, Deutsches Krebsforschungszentrum, Heidelberg
Targeted proteomics in personalized oncology
December 18, 2018, Host: Prof. Dr. Niels de Jonge

VERANSTALTUNGEN / EVENTS

JANUAR – FEBRUAR

Praktikum für Schüler/innen der Klassenstufe 9
B. Abt, D. Beckelmann, J. Blass, J. Dollmann, M. Geerkens, A. Heib, M. Jochum, A. Jung, P. Kalmes, S. Kiefer, M. Koch, C. Muth, H. Rimbach-Nguyen, A. Rutz, R. Sander, C. Scherrer, A. Schreiber, S. Selzer, S. Siegrist, L. Sold
Saarbrücken, 22.01. – 09.02.2018

APRIL

Printed Electronics Europe
A. Escudero, M. Opsölder, P. Rogin
Berlin, 11. – 12.04.2018

Hannover Messe
L. Barnefske, J. Brunke, A. Escudero, T. Martins Amaral, M. Opsölder, A. Schreiber, R. Strahl, L. Weiter
Hannover, 23. – 27.04.2018

Girls' Day: Oberflächen begreifen und verändern
M. Jochum, J. Mohrbacher, C. Sauer-Hormann, S. Siegrist, V. Tinnemann, S. Zeiter-Semmet
Saarbrücken, 26.04.2018

JUNI

Praktikum für Schüler/innen der Klassenstufe 9
A. Altpeter, D. Beckelmann, A. Colbus, J. Dollmann, M. Geerkens, A. Haettich, A. Jung, P. Kalmes, C. Muth, R. Muth, B. Reinhard, H. Rimbach-Nguyen, A. Rutz, C. Scherrer, A. Schreiber, S. Schumacher, S. Siegrist, M. Sude, E. Terriac, T. Trampert, A. Weyand
Saarbrücken, 04.-21.06.2018

Schülerpraktikum zur Elektronenmikroskopie für Schüler des Otto-Hahn-Gymnasium Saarbrücken
N. de Jonge, I. N. Dahmke
Saarbrücken, 19.06.2018

MÄRZ

NanoReg2 Workshop – Safe by Design
P. Herbeck-Engel, A. Kraegeloh, I. Tavernaro
Aix en Provence, France, 07.03.2018

Dekorativer Korrosions- und Verschleißschutz von Metallen und Legierungen
M. Amlung, L. Barnefske, D. Beckelmann, J. Mohrbacher, P. W. de Oliveira, R. Sander, W. Seitz, G. Weber (mit saar.is und und ibo Institut für Industrieinformatik und Betriebsorganisation)
Saarbrücken, 08.03.2018

Praktikum für Schüler/innen der Klassenstufe 9
B. Abt, S. Albayrak, B. Ali, D. Beckelmann, J. Blau, J. Dollmann, P. Kalmes, G. Krämer,

MÄRZ

M. Koch, C. Muth, R. Sander, C. Scherrer, A. Schreiber, S. Selzer, L. Sold, E. Terriac, T. Trampert, M. Twardoch
Saarbrücken, 12. – 23.03.2018

LOPEC 2018
A. Escudero, M. Opsölder, W. Seitz
München, 13.-15.03.2018

MAI

Tag der Offenen Tür
J. Berrar, R. Buchheit, C. Ersfeld, C. Hartmann, M. Koch, A. Kraegeloh, T. Kraus, F. Lautenschläger, E. Meziu, A. Pyttlik, M. Quilitz, C. Schmitz, G. Weber, L. Weber
Saarbrücken, 26.05.2018

Bürger treffen Experten: Hightech-Werkstoffe für die Welt von Morgen
C. Hartmann, M. Koch, A. Kraegeloh, T. Kraus, M. Quilitz (mit BMBF und VDI)
Saarbrücken, 26.05.2018

JULI

Veranstaltung für die Teilnehmenden der Summer School "Technology Transfer & Entrepreneurship" der Univ. des Saarlandes
J. Mohrbacher, M. Quilitz, C. Schmitz, V. Tinnemann (mit KWT und Univ. des Saarlandes)
Saarbrücken, 10.07.2018

Nano Korea
M. Amlung, P. W. de Oliveira, M. Opsölder
Seoul, 11. – 13.07.2018

AUGUST

Progress in Materials Science Editors Meeting
E. Arzt
Saarbrücken, 27.08.2018

Veranstaltung für Studierende der Programme des EUSMAT der Universität des Saarlandes
L. Gonzalez-Garcia, M. Koch, J. Mohrbacher, M. Quilitz (mit Univ. des Saarlandes)
Saarbrücken, 29.08.2018

SEPTEMBER

Veranstaltung(en) für die Teilnehmenden der 130. Jahresversammlung der GDNÄ – Gesellschaft Deutscher Naturforscher und Ärzte
J. Fleddermann, M. Koch, K. Moh, P. W. de Oliveira, V. Presser, M. Quilitz
Saarbrücken, 15. – 17.09.2018

Workshop Leibniz-Forschungsverbund Nanosicherheit
A. Kraegeloh (mit IUF Düsseldorf)
Düsseldorf, 17.09.2018

Veranstaltung für eine Delegation der Faculty of Chemistry der University Warsaw
J. Feng, D. Joseph, J. Paez, M. Quilitz, S. Sankaran, L. Stankevicins, M. K. Włodarczyk-Biegun
Saarbrücken, 20.09.2018

SEPTEMBER

"Research in Germany" at the MSE 2018
M. Quilitz (mit DFG, Deutsche Forschungsgemeinschaft)
Darmstadt, 26.-28.09.2018

MSE Symposium: Wet Processing of Nanostructured Materials
T. Kraus, L. Gonzáles-García (mit G. Lozano, Institute of Materials Science of Sevilla, H. Wolf, IBM Research, Zurich)
Darmstadt, 28.09.2018

OKTOBER

Material im Prozess. Neue Materialien aus Forschung und Wissenschaft
R. Bennewitz, C. Becker-Willinger, N. Müller, P. W. de Oliveira, P. Rogin, R. Sander, R. Strahl (mit H. Käfer, T. Vollmer, HBKsaar)
Hochschule der Bildenden Künste Saar, Saarbrücken, WS 2018/2019

Beilstein-Symposium: Molecular Mechanisms in Tribology
R. Bennewitz (mit A. de Wijn, Norwegian Univ. of Science and Technology)
Potsdam, 02. – 04.10.2018

BMBF Ferienpraktikum Werkstoffwoche 2018
I. Backes, M. Koch, T. Müller, M. Quilitz, C. Sauer-Hormann, C. Schmitz, S. Schumacher, S. Siegrist, A. Zimmermann (mit VDI)
Saarbrücken, 08. – 12.10.2018

Veranstaltung für Studierende der Programme Atlantis und I.DeAr der UdS
M. Quilitz (mit EUSMAT und Univ. des Saarlandes)
Saarbrücken, 10.10.2018

OKTOBER

Conference on In-Situ and Correlative Electron Microscopy – CISCEM 2018
N. de Jonge, C. Hartmann (mit K. Mølhave, Technical Univ. of Denmark, D. Alloyeau, Univ. Paris Diderot)
Saarbrücken, 10. – 12.10.2018

Reibungsmindernde Funktionsschichten für Metalle und Kunststoffe
M. Amlung, L. Barnefske, N. Müller, T. Müller, P. W. de Oliveira, R. Sander, G. Weber (mit saar.is und ibo Institut für Industrieinformatik und Betriebsorganisation)
Saarbrücken, 18.10.2018

NOVEMBER

Veranstaltung für Teilnehmerinnen des Mento-MINT-Programmes der Universität des Saarlandes
M. Quilitz, C. Schmitz, J. Staudt, V. Tinnemann (mit Univ. des Saarlandes)
Saarbrücken, 15.11.2018

Besuch des Ministerpräsidenten Tobias Hans
E. Arzt, A. del Campo, N. de Jonge, A. Kraegeloh, P. W. de Oliveira, G. Weber
Saarbrücken, 21.11.2018

Workshop Leibniz-Forschungsverbund Nanosicherheit
E. Arzt, A. Kraegeloh, C. Petzold
Berlin, 28.11.2018

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