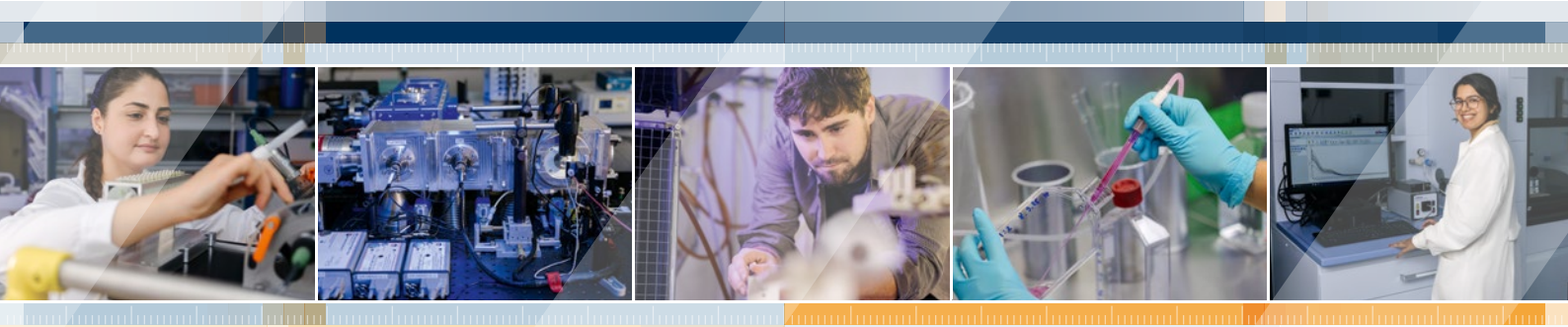




Leibniz Institute of
Surface Engineering



Biennial Report

2024/25



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Prof. Dr. André Anders
Scientific Director until
February 2025



Prof. Dr. Benjamin Dietzek-Ivanšić
Scientific Director since March
2025



Dr. Daniel Strecker
Administrative Director

Preface

The Leibniz Institute of Surface Engineering (IOM) is a member of the Leibniz Association. Its research focuses on engineering surfaces and thin films by ion beam, electron, photon and plasma techniques. The institute performs “application-oriented fundamental research” at the interesting and rewarding interface of fundamental and applied research with the goal of creating modified surfaces and new materials in economically relevant technology fields.

After the Leibniz evaluation of 2022 confirmed the general strategic direction, the institute worked on selected main topics while making efforts to become a more coherent research institution that leveraged its internal opportunities and strengthened external collaboration. Together with outstanding scientific results and publications, the steady and increasing work with industrial partners was remarkable, a sign of the value that our partners placed in the work done at IOM. Both the long-term expertise and the continued effort to maintain and upgrade modern research equipment played a role in this development. At times

of relatively flat funding, the industrial collaboration and the support by the sponsoring branches of the Federal and Saxonian Governments were great assets that allowed the institute to thrive.

Especially noteworthy was the approval of the “strategic expansion” proposal of the institute by the GWK (the grant-deciding conference of government officials). The proposal calls for a significant expansion of the size, role, and integration of the cross-sectional unit “Modelling and Simulation” with emphasis on the development and use of artificial intelligence (AI) in surface engineering. The expanded unit will strengthen the entire institute and extend its reputation beyond the well-known experimental and analytical capabilities. The leadership of the unit will be at the professor level, with a joint appointment at Leipzig University. The position was posted in early 2025 and – at the time of this writing – is about to be filled. The institute has also made arrangements to closely cooperate with key AI players in Saxony such as the Leipzig AI Center.

The years 2024/25 were also marked by changes in leadership. For one, we mourn the untimely passing of the head of administration, Ms. Kostka. Her work was taken over by Dr. Daniel Strecker, who was appointed as Administrative Director in August of 2024. With this appointment, the Board (“Vorstand”) was expanded to two persons. Furthermore, in a festive event on 3rd of March 2025, Prof. Dr. André Anders handed over the position of the scientific director to Prof. Dr. Benjamin Dietzek-Ivanšić.

The main research areas in 2024/25 included:

- Ultraprecision surfaces of the electronics and optics industries
- Barrier coatings and precision thin films, primarily in the context of renewable energy
- Biocompatible and bioactive surfaces for biomedical applications
- Porous polymer membranes, primarily for filtration of water
- Investigation of beam-deposited, mass-selected, switchable molecules with possible application in molecular electronics
- development of ion sources of improved lifetime, both for surface engineering and electric propulsion.

IOM would like to thank the Leibniz Association and all partners who supported its development. Special thanks go to Board of Trustees, the Scientific Advisory Board, and members of the IOM administration who stepped up at times of leadership change. Last but not least, we thank the staff of the institute for their dedicated efforts and excellent contributions in the last two years.

The biennial report, which you are about to enjoy, features exciting science and personal success stories. It provides an excellent overview of the topics, themes and activities that IOM was engaged in in 2024/25. We wish you an informative reading.



Prof. Dr. André Anders



Prof. Dr. Benjamin Dietzek-Ivanšić



Dr. Daniel Strecker



SCIENTIFIC HIGHLIGHTS

Ultra-precision Surfaces /Ion Beam and Plasma Jet-based Ultra-precision Surface Figuring

Plasma jet/laser hybrid processing of optical glass

OPTICAL PRECISION REQUIREMENTS

The production of ultra-precision-machined optical surfaces with complex aspheric and, above all, free-form designs, as well as microstructured surfaces, has gained significant importance in recent years. The relevance of this technology will continue to be apparent in a variety of applications in the future. For example, it will be used in optical systems in semiconductor manufacturing (lithography), as well as ground- and space-based telescopes, laser material processing, and laser fusion research. This necessitates accuracies in the single-digit nanometer range, and in some cases, in the sub-nanometer range on a vertical scale, in order to ensure optimal optical performance in applications within the short-wavelength spectral range. It is essential to minimize surface defects across the entire spatial wavelength range, encompassing long-wavelength surface topography, the mid-frequency wavelength range, and both micro- and nano-roughness.

MATERIAL REMOVAL USING A PLASMA JET

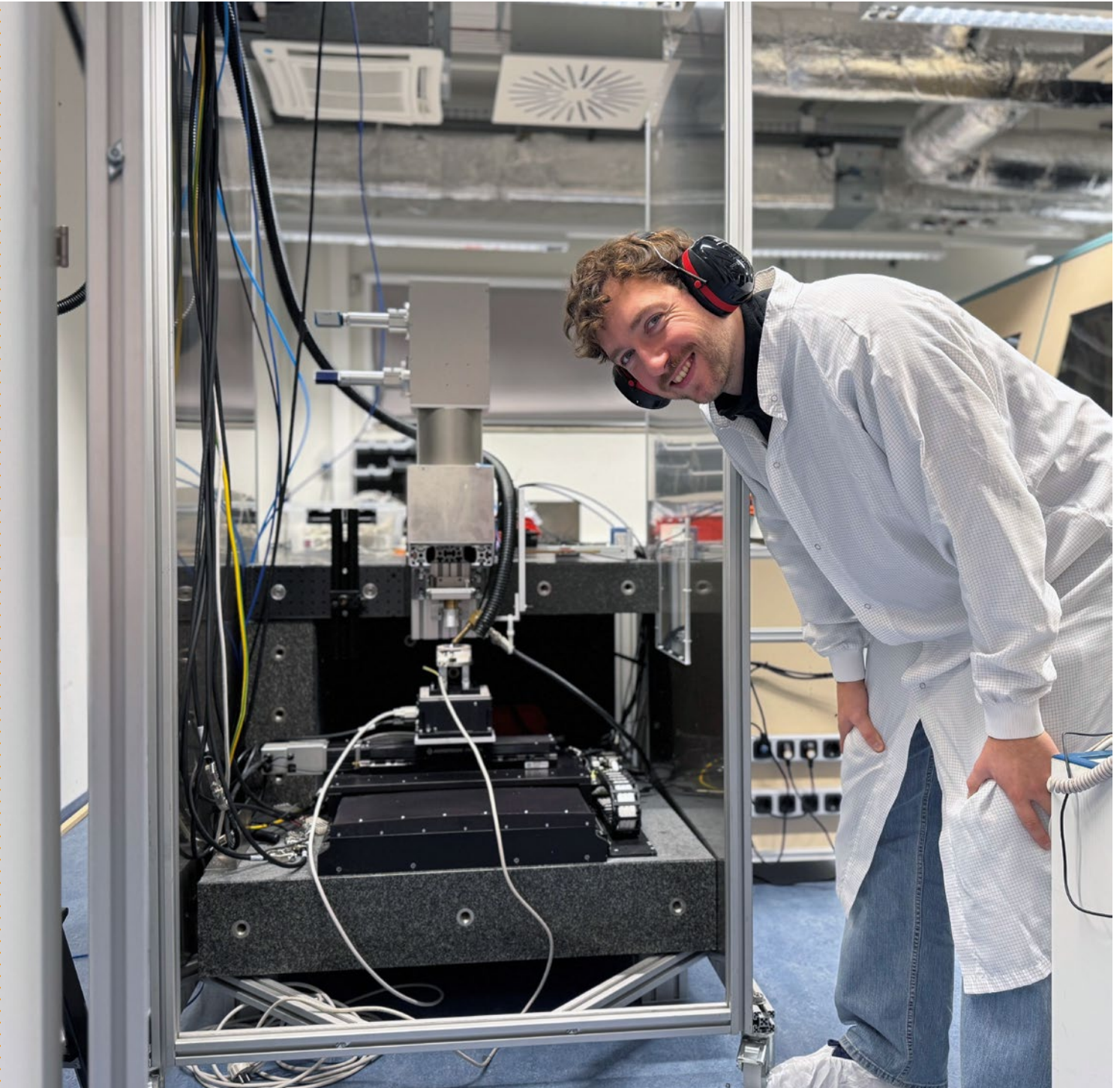
IOM is currently developing a technology for the precise processing of optical

surfaces. This technology is based on the dry etching process using a fluorine-containing atmospheric-pressure plasma jet that is moved across the surface. Chemical reactions between the fluorine radicals formed in the plasma and the atoms on the substrate surface produce volatile products. This process leads to localized material removal, which can be precisely controlled to create specific shapes or structures. This method is particularly effective with simple silicon compounds, such as Si, SiO₂, SiC.

CHALLENGES IN GLASS PROCESSING

However, during the plasma jet processing of various optical glasses, non-volatile reaction products are also formed due to their constituents, such as metal oxides. These remain as a layer on the surface, thereby preventing uniform, constant-rate material removal that is essential for maintaining surface smoothness.

The cause is attributed to the low kinetic energies of the reactive radicals and ions. Unlike in low-pressure plasmas, these particles are in the thermal range and contribute little to physical material removal effects such as sputtering or stimulated desorption of the reaction products.



Robert Heinke, research associate at the IOM, operates the plasma jet/laser experimental setup for surface structuring.

Photo: Thomas Arnold

"Our atmospheric pressure process combines plasma and laser technology to create a flexible alternative for ultra-precise optics manufacturing."

Prof. Dr. Thomas Arnold

LASER-ASSISTED PROCESS IMPROVEMENT

The employment of laser radiation, whether concurrent with, preceding, or following plasma etching, is designed to augment the process with additional energy. This allows for precise control of material removal, enhancing etching rates, selectivity, surface roughness, and homogeneity for optimal machining results. To this end, the complex physicochemical interaction processes involving the combined effects of a reactive atmospheric-pressure plasma jet and laser irradiation were fundamentally investigated for selected, technically relevant optical glasses. The initial objective was to gain scientific insights into this hybrid process, which is intended to be further developed into an innovative processing technology.

Systematic investigations into the treatment of surfaces made of the optical glass N-BK7 using a plasma jet and pulsed excimer laser radiation at a wavelength of 248 nm have shown that the fluoride layers forming on the surface during plasma etching can be partially removed. This enabled substantial increases in material

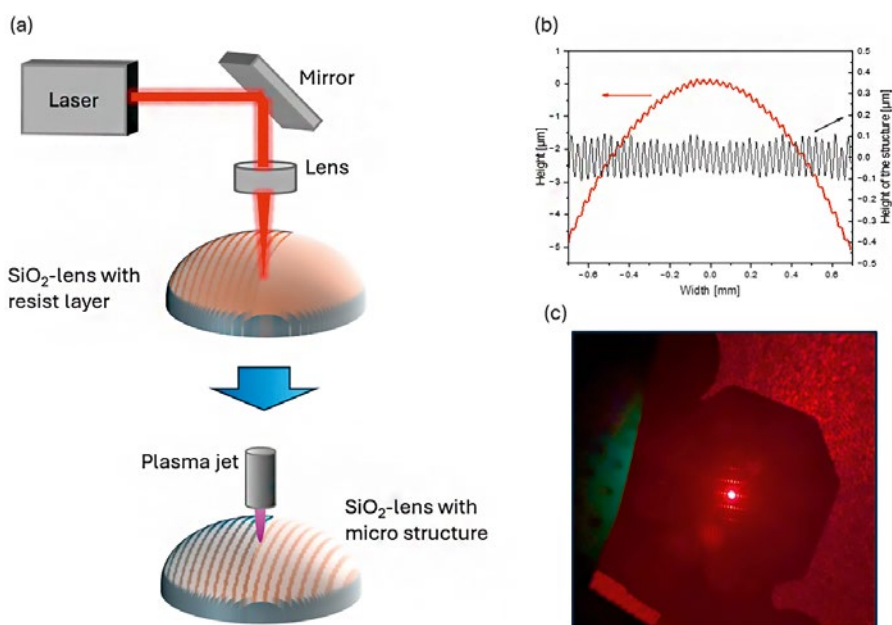
removal rates and enhanced machining efficiency. Studies on the dependence of laser fluence (energy per unit area) also demonstrated that the plasma-generated layers solidify at high fluences. This effect was leveraged to perform targeted surface texturing.

First, an excimer laser beam equipped with a structured aperture is directed at the surface with high fluence. This method exposes only specific areas of the surface. Concurrently, a plasma etching process occurs, resulting in the formation of a homogeneous residue layer composed of non-volatile reaction products. In the laser-irradiated areas, this layer undergoes modification. It solidifies and subsequently functions as an etching mask. In the subsequent step, a sequence of laser irradiation—now with low fluence—and reactive plasma jet etching is performed. During this process, the non-solidified areas of the layer are removed, and the underlying glass surface is plasma-chemically etched. In this manner, the structure is transferred into the depth. Finally, a wet chemical etching step is performed to completely remove the masking layer. This method enabled the creation of linear

structures measuring 2.5 μm in height and 25 μm in width.

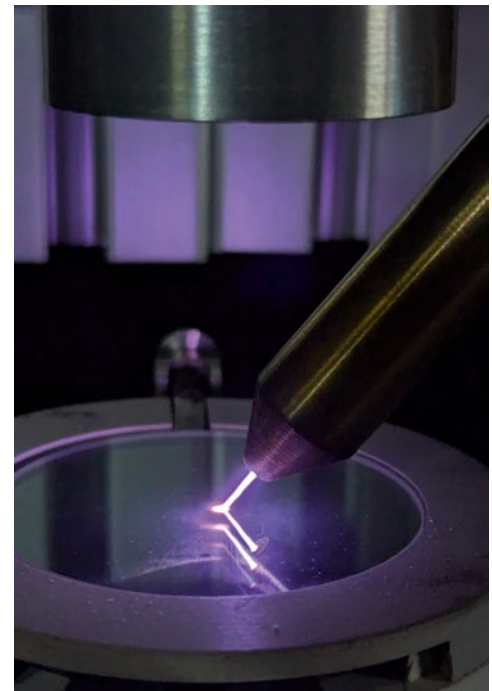
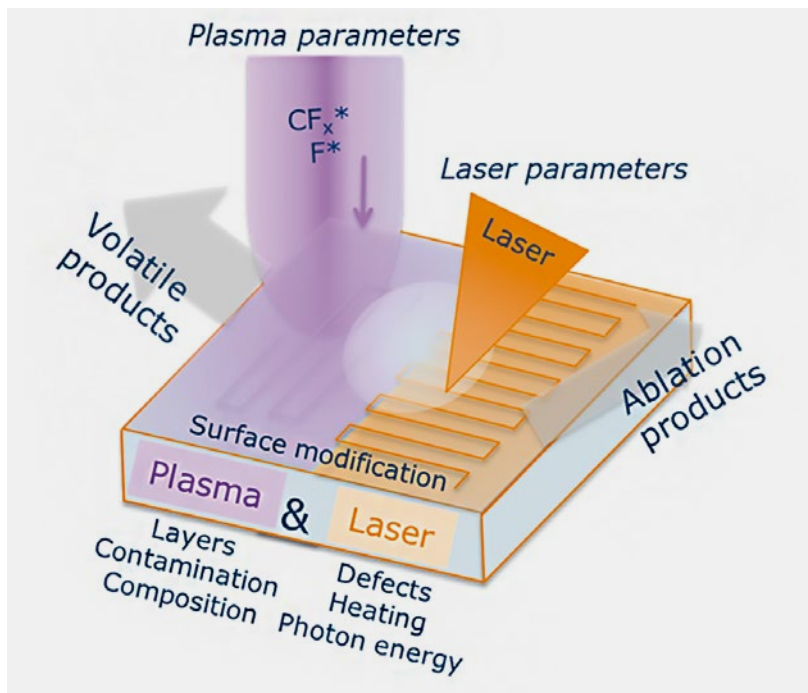
ALTERNATIVE STRUCTURING METHODS

In another process variant for the microstructuring of surfaces, a thin layer of resist was first applied to an optical lens via spin coating. This was then patterned using laser beam ablation. The resulting line pattern was subsequently transferred to the underlying material (quartz glass) using the reactive plasma jet. The combination of plasma and laser processing with CNC motion systems offers distinct advantages, including the ability to process curved surfaces. This breakthrough paved the way for the integration of diffractive structures into optical lenses. Current challenges regarding the homogeneity of the structures and the development of surface roughness are being addressed in ongoing research. Further investigations are underway. Achieving high aspect ratios necessitates optimizing resist materials to ensure stability during the etching process. In contrast to conventional methods, which are primarily based on vacuum processes, the process chain tested here



(a) Structuring process of a lens surface via laser ablation followed by pattern transfer using a plasma jet, (b) Detail of the lens surface profile showing the generated sinusoidal line structure, (c) Resulting diffraction pattern when a test laser is transmitted through the lens.

Fig.: Thomas Arnold, Robert Heinke



Experimental setup (schematic and actual) for the combination of plasma jet etching with simultaneous laser irradiation.

Fig.: Klaus Zimmer, Robert Heinke

for the first time takes place entirely in normal atmosphere. This innovation enables the more flexible, faster, and energy-efficient fabrication of complex optical elements with both imaging and light-diffracting properties. In the future, this technology could facilitate the production of specialized lenses for multispectral cameras used in quality control.

Publications

R. Heinke et al, EPJ Web Conf. 309 (2024) 03022

R. Heinke et al, Phys. Status Solidi A 221 (2024) 2300485



PROJECT LEADER

Prof. Dr. Thomas Arnold

holds a degree in physics and studied at the University of Leipzig. He is the head of the research division Ultra-precision Surfaces and holds the chair in Ultra-Precision Surface Processing with Ions and Plasmas at the Technical University of Dresden. His focus is on research into ion- and plasma-assisted shape-processing methods for the fabrication of optical surfaces, as well as on the development of the beam tools used in these processes.

Ultra-precision Surfaces / Laser-based Micro- and Nanostructuring

Laser plasmas for ultra-precise processing of optical materials

PRECISION FOR OPTICS AND PHOTONICS

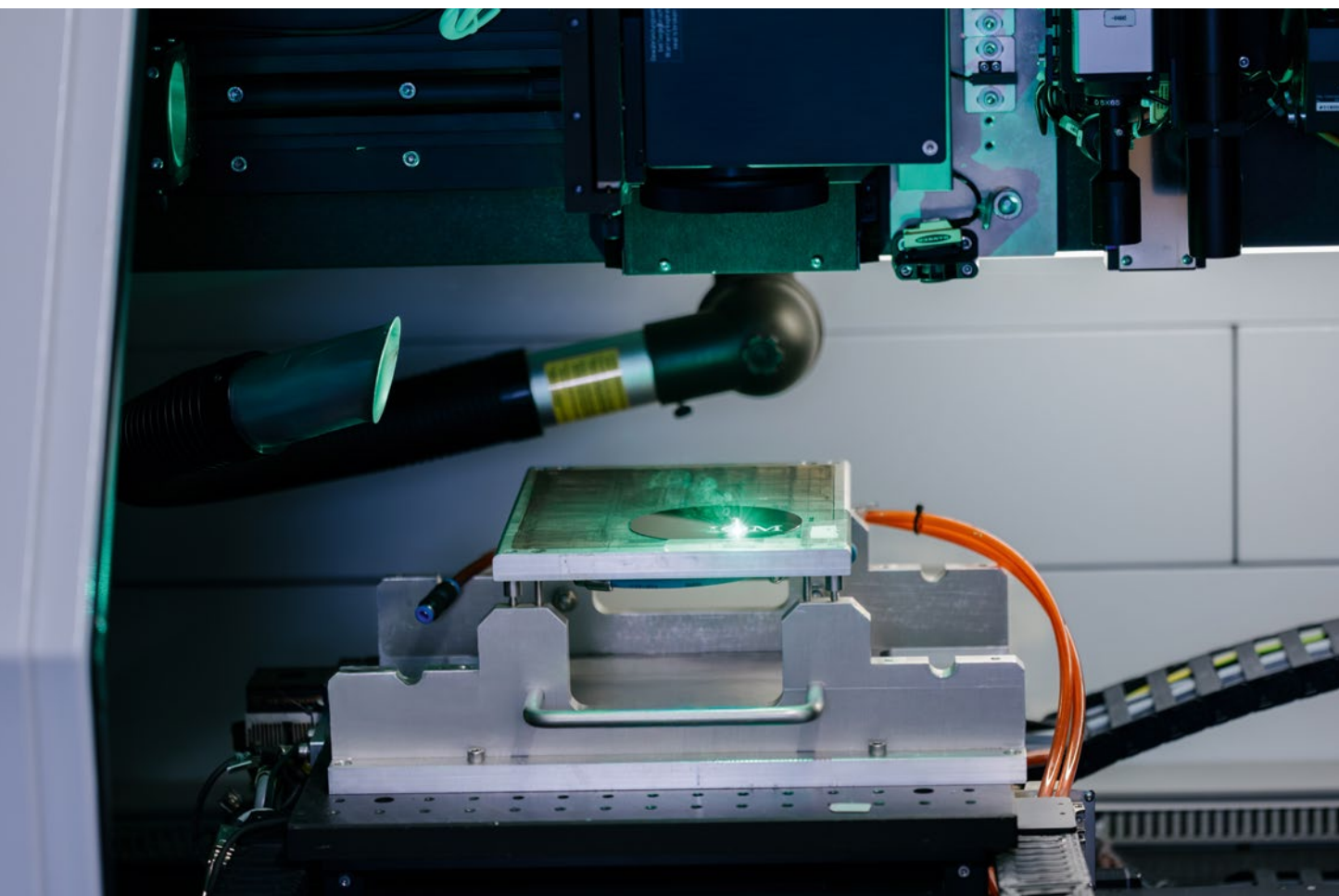
The increasing demands on surfaces, particularly in the fields of optics and photonics, require the development of new machining processes and tools. In addition to the size of the tool's effect on the surface, controllability and force-free tool engagement are key challenges for future machining processes.

LASER PLASMAS AS A MACHINING TOOL

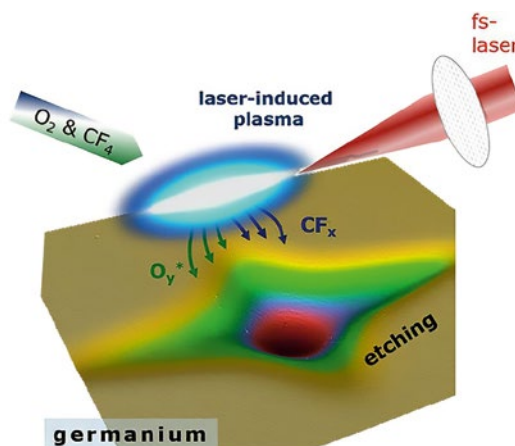
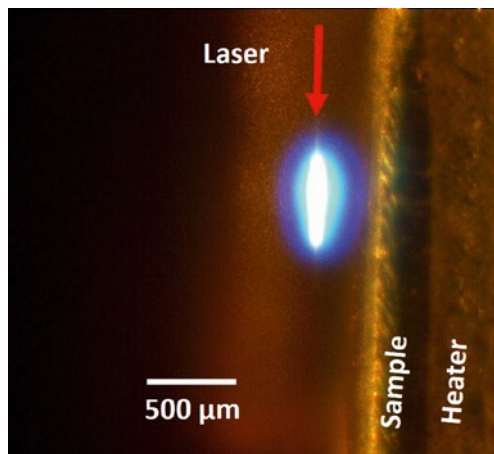
The plasma effect in laser ablation has long been a subject of research. The extremely high laser beam intensities now achievable with ultrashort-pulse lasers make it possible to ignite plasmas without the need for the electrical discharges typically used in such processes. The high intensities generated by the laser strip electrons from the atoms within a fraction of a

billionth of a second, which form the plasma. Furthermore, plasma etching processes are known to occur during electrical discharges, which are widely used in the manufacture of semiconductor chips.

This has led to the approach of using laser-induced plasmas at atmospheric pressure, utilizing reactive gases, for surface etching. This is entirely new in the scientific field and therefore offers significant technical application potential.



Laser system in operation at the IOM Laser Technology Center. Processing a silicon wafer surface with a laser beam. Photo: Erik Kazak



Left: Optical image of a laser-generated plasma in front of a substrate surface.

Right: The schematic illustration shows the etching of a substrate by a laser-generated reactive plasma. Fig.: Martin Ehrhardt, CC BY 4.0 (<https://creativecommons.org/licenses/by/4.0/>)

"Innovation in mechanical engineering is driven by the ongoing refinement of processes. Research into the scientific principles underlying the use of laser plasmas in reactive gases is opening up new possibilities for industry." Dr. Martin Ehrhardt

ATMOSPHERIC-PRESSURE PLASMAS FOR ETCHING

Laser-induced plasmas at atmospheric pressure represent such a plasma tool that, when using reactive gases, enables processes such as surface etching. The small size of the plasma in the range of around 100 μm, the freely selectable temporal and spatial control, and the abruptly adjustable intensity open up innovative possibilities for surface processing, such as shaping.

Laser-induced plasmas at atmospheric pressure, due to their good temporal and spatial controllability, the force-free tool interaction, and the rapid adjustment of the plasma effect, offer ideal conditions for the develop-

ment of industrially controllable processing methods.

Another area of future potential for this process lies in the fact that plasmas—including laser plasmas—not only remove material but also enable the deposition of layers and the modification of surfaces.

The use of ultrashort laser pulses to generate plasma at atmospheric pressure eliminates the need for electrodes to supply electrical energy or for vessel walls. Since a vacuum is no longer required for plasma processing, costs and energy are saved.



PROJECT LEADER

Dr. Martin Ehrhardt

holds a PhD in physics and has a background in engineering. Since completing his master's degree, he has been working on various problems related to ultraprecise surface processing using laser radiation. After focusing on laser ablation for many years, he is now dedicated to investigating plasma-based processing methods utilizing lasers. In addition to laser plasmas, he also researches laser-assisted combination processes.

Ultra-precision Surfaces /
Ion Beam-assisted Patterning and Smoothing

On the way to the next generation of chips: the EU project 10ÅCe

AT THE FRONTIER OF PHYSICALLY POSSIBLE

The European research project 10ÅCe (10 Ångstrom CMOS exploration) is dedicated to one of the central challenges of modern microelectronics: How can the ongoing miniaturization and performance enhancement of semiconductors be continued beyond current technological limits? The goal is to advance CMOS chip technology into the 10-Ångstrom range (1 nanometer)—that is, to a scale where structures consist of only a few atoms.

In this way, the project makes an important contribution to Europe's technological sovereignty, strengthens innovation capacity along the entire value chain, and lays the groundwork for new ultra-precise manufacturing technologies with significant industrial and societal benefits

INTERDISCIPLINARY AND EUROPEAN

To achieve this ambitious goal, the project brings together 30 partners from industry and research, including leading institutions such as imec, ASML, and ZEISS SMT. This close collaboration enables scientific findings to be directly transferred into industrial processes and paves the way for the next generation of microchips.

SCIENTIFIC PRINCIPLES AND PROGRESS

The work of the IOM builds on the results of the predecessor project IT2 (Information and Communication Technology for the 2 nm Node). In cooperation with ZEISS SMT, the foundations were laid for the use of extreme ultraviolet radiation (EUV, 13.5 nm wavelength), which today forms the basis of state-of-the-art lithography systems.

Within the framework of 10ÅCe, significant progress has now been made in optimizing the manufacturing of optics with a high numerical aperture. Through more precise control of ion beam-based manufacturing processes, the intensity of the coupled EUV radiation could be further increased—a significant step toward more powerful and energy-efficient microchips.



View into the process chamber of the universal diagnostic platform for reactive ion beam processes. Photo: Peter Birtel

SIGNIFICANCE AND FUTURE POTENTIAL

EUV lithography is the key technology for all modern microelectronics. It enables the production of processors and memory chips, which form the foundation for applications ranging from artificial intelligence and smart energy grids to energy-efficient communication technology. Projects such as 10ÅCe will enable Europe to remain independent and competitive in these future technologies.

WHAT'S NEW?

10ÅCe marks the transition from today's nanostructures to atomic precision in chip manufacturing. The project brings together Europe's leading expertise in physics, materials science, and precision technology to redefine the boundaries of semiconductor manufacturing.

Publication

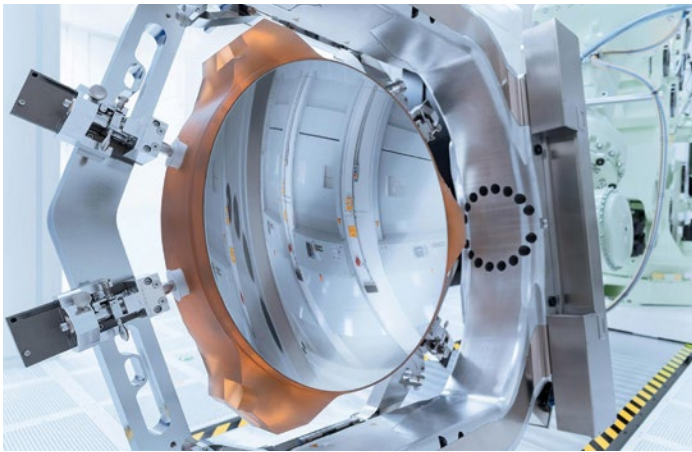
Peter Birtel, et al. *Surfaces and Interfaces*,
Volume 64, 2025, 106306



"It is impressive to see how consistently our European partners are advancing the field of microelectronics. At the same time, it is a valuable and exciting experience to be part of this strong and innovative network."

Dr. Frank Frost

Stephan Görsch, research associate, and Dr. Annemarie Finzel, research associate, at the IOM's RIBE 450 ion beam etching facility. Photo: Erik Kazak



The mirrors, manufactured with atomic precision and consisting of more than a hundred layers, are the heart of the machine for extreme ultraviolet lithography with a high numerical aperture.

(Source: High-NA EUV Lithography: Group 146, the next generation of EUV, ZEISS SMT)



PROJECT LEADERSHIP

Dr. Frank Frost

holds a PhD in physics and heads the research group on Ion Beam-assisted Patterning and Smoothing, which focuses on ion-surface interactions, ion beam-assisted ultra-precision machining, and material characterization. The goal of his work is to translate the scientific findings into manufacturing processes that can be applied in industry.

This project is funded by the EU project 10ÅCe (Grant Agreement ID 101139972) and supported by the Chips Joint Undertaking and its members, including additional funding from the BMFTR and SMWA, the Netherlands, Belgium, Germany, France, Austria, Ireland, and Israel.

Ultra-precision Surfaces/ Ion Beam-assisted Patterning and Smoothing

Ion beams sculpt new nanomaterials

Researchers at the IOM, in collaboration with partners from the U.S. and Germany, are developing new methods to precisely shape metal oxides at the nanoscale. The resulting structures are considered key components for sensor technology, photonics, quantum technology, and environmental engineering.

PRECISION THROUGH ION-BEAM-BASED STRUCTURING

The fabrication of highly ordered one-dimensional (1D) nanostructures requires the utmost control over material, morphology, and growth. To achieve this, the project combines low-energy ion beam etching and glancing-angle deposition (iG-LAD). The ion source performs several

functions simultaneously: it pre-patterns the substrate, controls phase and composition via reactive ion bombardment, and determines the size of the nanostructures by precisely shaping the ion beam.

METHODS FOR CONTROLLED GROWTH

The goal is to develop reproducible processes for the fabrication of homogeneous metal oxide nano-heterostructures. To precisely control nucleation, growth, and structural development, deposition is monitored in real time using spectroscopic ellipsometry. Monte Carlo simulations support the analysis of material transport and provide insights into the growth mechanisms. Furthermore, an

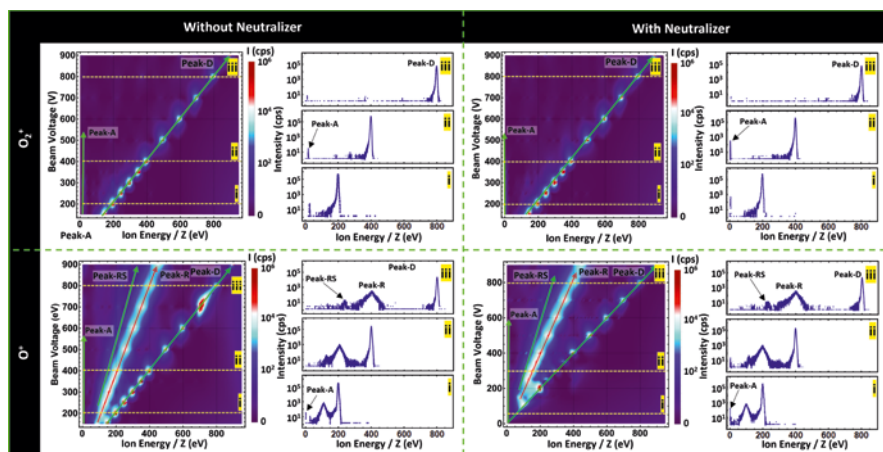
exact knowledge of the ion beam characteristics is essential for a fundamental understanding of the ion beam processes. Therefore, at the start of the project, the energy distributions and composition of the ion beam were determined. These parameters are key to the highly precise utilization of the ion beam in the various applications within the project.

WHY NANOSTRUCTURES ARE CRUCIAL

Thin-film nanoheterostructures combine a large surface area, material diversity, and quantum effects — a combination that leads to new electrical, optical, photonic, or magnetic functions. By carefully varying the material, structure, and size, the properties of these systems can be exactly tuned. Precise control of the chemistry and morphology is therefore central to modern materials and manufacturing concepts.

The project "Innovations in the Manufacturing of One-Dimensional Metal Oxide Heterostructures Based on Ion-Surface Interactions" is being carried out in collaboration with the University of Nebraska–Lincoln (USA) and the Fraunhofer IMWS in Halle/Saale. An intensive scientific exchange forms the core of the collaboration: While a U.S. researcher at the IOM utilized the institute's unique ion source diagnostics to analyze key process parameters, IOM scientists supported the construction of the new iGLAD facility in the U.S.

In parallel, initial fundamental insights into reactive ion beam etching processes during the nanostructuring of silicon and silicon oxide surfaces were gained — an important step toward being able to



Measured ion energy distributions for O^+ and O_2^+ ions from a Kaufman ion source operated with argon and O_2 as a function of beam voltage and the presence or absence of space charge compensation. Different peaks are visible in the energy distributions, allowing conclusions to be drawn about processes within the plasma and along the ion trajectory leading to energy-selective mass spectrometry; the ions were extracted without interactions (Peak D), originated outside the ion source (Peak A), or resulted from the dissociation of a more complex extracted molecular ion (Peak R). Fig. from: Raymond R. Smith et al., unpublished manuscript

effectively manage growth processes in the future. The resulting platforms enable material combinations with nanometer precision that can be used in the future in quantum computers, sensor systems, or photonic components. At the same time, they open up scalable and resource-efficient manufacturing methods. The bottom-up approach of ion beam processes holds the potential to complement or replace energy-intensive classical top-down methods in the long term.

The project expands existing synthesis methods to include targeted reactive ion processes for metal-oxide-semiconductor nanostructures and their heterostructures. The focus is on developing integrable, scalable manufacturing technologies that combine miniaturization, performance, and energy efficiency.



IOM scientists Peter Birtel (8th from left) and Erik Rohkamm (10th from left) together with the research group of Prof. Dr. Eva Schubert (2nd from right) in the ALD-GLAD laboratory at the University of Nebraska in Lincoln.

Photo: Erik Rohkamm

"The key to the project's success is the close international collaboration with the University of Nebraska-Lincoln on the U.S. side, which brings together complementary expertise in nanofabrication, ion technology, and process analysis."

Dr. Frank Frost



PROJECT LEADER

Dr. Frank Frost

holds a PhD in physics and heads the research group on Ion Beam-assisted Patterning and Smoothing, which focuses on ion-surface interactions, ion beam-assisted ultra-precision machining, and material characterization. The goal of his work is to translate the scientific findings into manufacturing processes that can be applied in industry.

Tools

New high-performance electric propulsion systems for future space missions



Lukas Pietzonka, research assistant, adjusting the optical components for laser-induced fluorescence spectroscopy. Photo: Erik Kazak

wear, such as the discharge chamber and the cathode, as well as the ability to use alternative fuels.

To this end, the IOM is contributing ion beam diagnostic investigations to characterize the thrusters in ground tests. The work builds on the Advanced Electric Propulsion Diagnostic (AEPD) platform, which was developed in two previous ESA-funded collaborative projects.

Among other things, these projects resulted in a Faraday probe for spatially resolved measurement of ion beam current density and a retarding potential analyzer for determining the ion energy distribution, both of which were comprehensively characterized.

"The detailed characterization of the thrusters' operational properties forms the basis for physics-based models that can be used to describe erosion processes and prevailing failure modes. In this way, time-consuming, costly ground tests can be reduced."

Dr. Daniel Spemann

For the future of space research and logistics, as well as to reduce the transport costs of future payloads in orbit, high-performance electric propulsion thrusters with an output power of 20 kW and more are needed. These are currently under development by European partners. Before they can be integrated into the propulsion systems of satellites or spacecrafts, their operational characteristics and service life must be verified through realistic ground tests.

These tests typically cover up to 150% of the planned on-off cycles and the cumulative operating time in space.

However, since the new missions require tens of thousands of hours of thruster operation, conducting ground tests over several years to qualify these high-performance thrusters is practically unfeasible. Therefore, new approaches must be developed that incorporate physics-based models of the key components subject to

In the current project, the Faraday probe concept was expanded into a semicircular arc with a radius of one meter. The arc carries 37 individual probes and can be swiveled in front of the thruster. This allows for high-resolution measurement of the thruster's emission characteristics in the forward half-sphere.

The retarding potential analyzer was positioned centrally on the arc and enables the measurement of the ion energy

distribution in the horizontal plane of the thruster. Both systems had to be specifically designed to withstand the very high beam power exposure in vacuum.

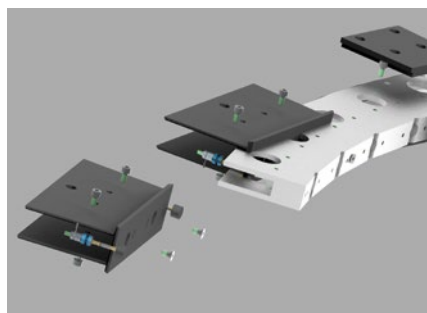
MODEL-BASED REDUCTION OF TEST TIMES

The precise characterization of operating parameters provides the basis for models that can be used to describe erosion processes and prevailing failure modes. This allows the previously time-consuming and cost-intensive ground tests to be shortened. This saves resources and also accelerates the transfer to market of thrusters for future space missions.

EUROPEAN INNOVATIONS FOR HIGH-PERFORMANCE ELECTRIC PROPULSION

As part of the collaboration among the participating partners, competitive European high-performance Hall ion thrusters in the 20-kW class with mission-optimized architectures are being developed for the first time.

In parallel, diagnostic procedures and standards for ground qualification are being further developed. In this way, the project contributes to strengthening Europe's technological sovereignty in the field of electric space propulsion.



Three-dimensional CAD representation of the individual components of the Faraday probe arc. The light grey part is the structural support and made from aluminum, the dark grey parts are made from graphite. Photo: R. Woyciechowski

Publications

S. Scaranzin et al.: Proceedings 39th International Electric Propulsion Conference, London, United Kingdom, 2025, Paper IEPC-2025-735.



A. Piragino et al: Proceedings 39th International Electric Propulsion Conference, London, United Kingdom, 2025, Paper IEPC-2025-647.



A Faraday probe arc with a motion system set up in the IOM's experimental hall.

Photo: D. Spemann



PROJECT LEADER

Dr. Daniel Spemann

is a physicist and has been working for 10 years on the development of ion beam sources and propulsion systems as well as their diagnostics. In addition, he has many years of experience in the modification of materials using energetic ions, ranging from the application of MeV protons to induce magnetic order through defect engineering in graphite to the development of deterministic single-ion implantation for quantum technologies.

Surfaces of Porous Membrane Filters

Removal of trace contaminants from water using photocatalysis and membranes



Amira Abdul Latif, technical staff member at the IOM, at the photocatalytic membrane reactor.
Photo: Erik Kazak

DRINKING WATER AND TRACE CONTAMINANTS

Access to clean water is recognized as a human right, but due to climate change, drinking water shortages are becoming increasingly common even in Germany. Producing drinking water from wastewater and surface water could be a solution. However, trace contaminants such as pharmaceutical residues, pesticides, and per- and polyfluorinated chemicals (PFAS) are not sufficiently removed during wastewater treatment and end up in the environment and our drinking water sources.

PHOTOCATALYTIC MEMBRANE REACTOR

The project “Photocatalytic Membrane Reactor for the Removal of Trace Contaminants from Water” combines two proven technologies: photocatalysis and

membrane filtration. Photocatalysis uses light and special photocatalysts to break down organic contaminants in water. Membrane technology enables the separation of the photocatalyst from the purified water in a single step. The continuous operation ensures reliable water treatment and efficient removal, as organic contaminants are transported directly to the photocatalyst and their degradation is accelerated.

LIMITATIONS OF EXISTING TECHNOLOGIES

In 2021 the German government decided on a sustainability strategy with the goal of improving access to clean water. This is also addressed in the Free State of Saxony’s innovation strategy as a topic for future development. Trace contaminants (e.g., pharmaceuticals, pesticides, PFAS) in wastewater are not removed at

completely or only inadequately by the wastewater treatment plants currently in use, and thus end up in the environment and drinking water. An additional treatment step is necessary, which in Germany has so far only been implemented in pilot projects. This is due to the high energy costs (ozone, nanofiltration/reverse osmosis), insufficient separation, and labor-intensive treatment (activated carbon) associated with the technologies currently used on an industrial scale (ozone, activated carbon, or membranes). Highly efficient photocatalytic membranes promise a significantly more energy- and cost-efficient solution; however, no scalable modules are currently available that would allow for meaningful pilot testing and thus a determination of resource and cost efficiency.

PILOT REACTOR IN ACTUAL OPERATION

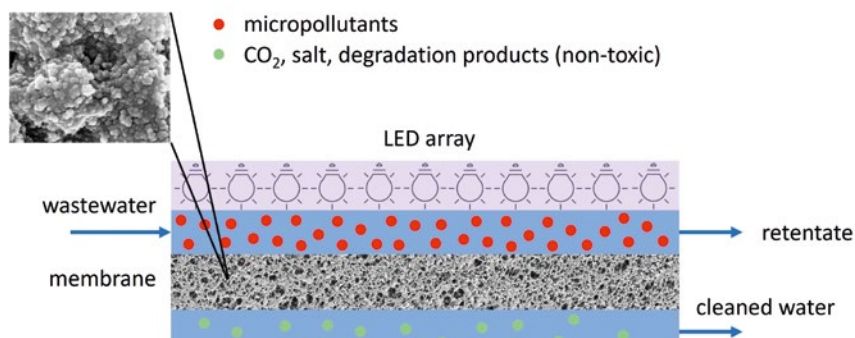
In this project, a continuous-flow membrane reactor for the photocatalytic degradation of trace contaminants such as pharmaceutical residues or pesticides was developed in pilot scale. Previous studies had been conducted exclusively on a laboratory scale and under ideal conditions. The researchers were able to demonstrate that the technology is also functional in a realistic scenario and efficiently reduces pharmaceutical residues such as the painkiller diclofenac.

The presented development has the potential to serve as a fourth purification stage in wastewater treatment. In this context, the combination of photocatalysis and membrane technology can fill the technological gap left by other technologies, such as the use of activated carbon (pollutants are removed but not destroyed) or ozone oxidation (potential for

the formation of toxic degradation products). In addition to municipal wastewater treatment plants, the treatment of industrial wastewater could also be of particular interest. The future outlook clearly lies in further upscaling and establishment of the technology in collaboration with partners from industry.

SCALABLE APPLICATION UNDER REAL-WORLD CONDITIONS

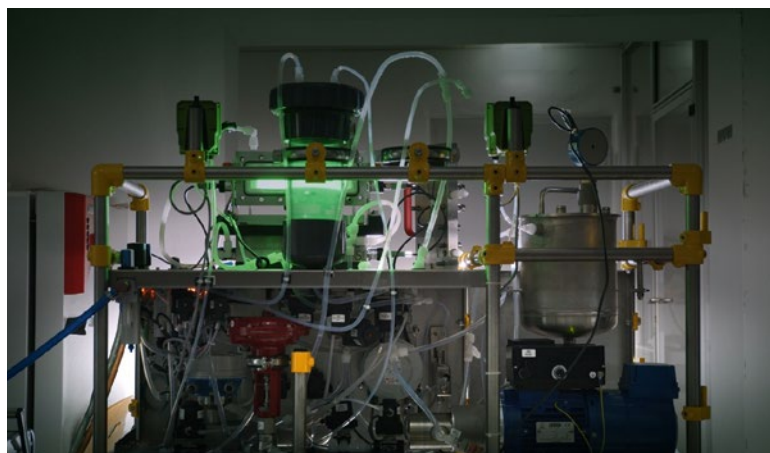
Previous work has primarily been conducted under laboratory conditions on a small scale of a few milliliters. The possibility of treating pollutants in a continuous process that can handle several liters per hour represents an important step toward a commercially viable technology. The use of real water samples containing substances that could interfere with the degradation of pollutants was a focus of the development. Here, too, the photocatalytic membrane reactor was able to demonstrate its effectiveness and confirm the positive results.



How the photocatalytic membrane reactor works. Fig.: Dr. Kristina Fischer

Publication:

S. Liu, et al, *Sep. Purif. Technol.* 378 (2025) 134589, 10.1016/j.seppur.2025.134589.



Photocatalytic membrane reactor for the removal of trace contaminants from water.

Photo: Steffen Becker/significant.pictures

"Removing pollutants from wastewater using photocatalytic membrane reactors protects human health and our ecosystems." Dr. Daniel Breite

Funding is provided by the Saxon State Ministry for Economic Affairs, Labor, Energy, and Climate Protection and the European Regional Development Fund (ERDF) as part of the "Validation Funding" program (grant number: 100711554).



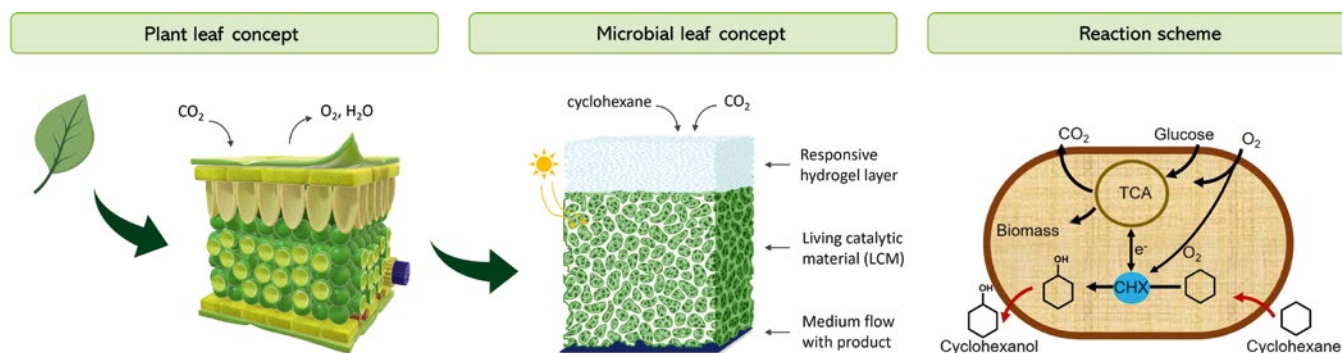
PROJECT LEADERS

Dr. Zahra Niavarani

Research associate and Dr. Daniel Breite, group leader at the IOM, both hold PhDs in chemistry and have been working on the removal of pollutants from water for several years. Together with the project team, they are working on the ongoing development of this research area at the IOM.

Surfaces of Porous Membrane Filters

Development of a self-regulating bioreactor using adaptive hydrogel membranes



The function of a plant leaf, including the planned "microbial leaf" and the underlying reaction scheme. Fig.: Malabika Bera and Lara Heiser

RELIABLE BIOCATALYSIS USING SUNLIGHT

Microbial (photo)catalysis is considered an efficient and sustainable alternative to energy- and resource-intensive chemical processes. For this potential to be realized both economically and ecologically, the systems must function reliably under real-world outdoor conditions, where sunlight is readily available and cost-effective. The concept faces several challenges: low concentrations of active biomass lead to low production rates, there is only limited resilience to fluctuating radiation and temperature, and the long-term performance of biocatalysis has been limited so far.

The German Research Foundation's priority program "Living Materials with Adaptive Functions" addresses precisely these issues: It develops strategies to increase cell density, mitigate environmental fluctuations, and stabilize catalytic activity over the long term.

To address these challenges, the self-regulatory principle of the plant leaf is being

applied to a living catalytic material. To this end, genetically modified, light-responsive biofilms—such as *Synechocystis* in combination with *Pseudomonas*—are cultivated at high cell densities within a porous polymer scaffold. At the bioreactor boundary, this scaffold is equipped with a hydrogel membrane that responds to external stimuli.

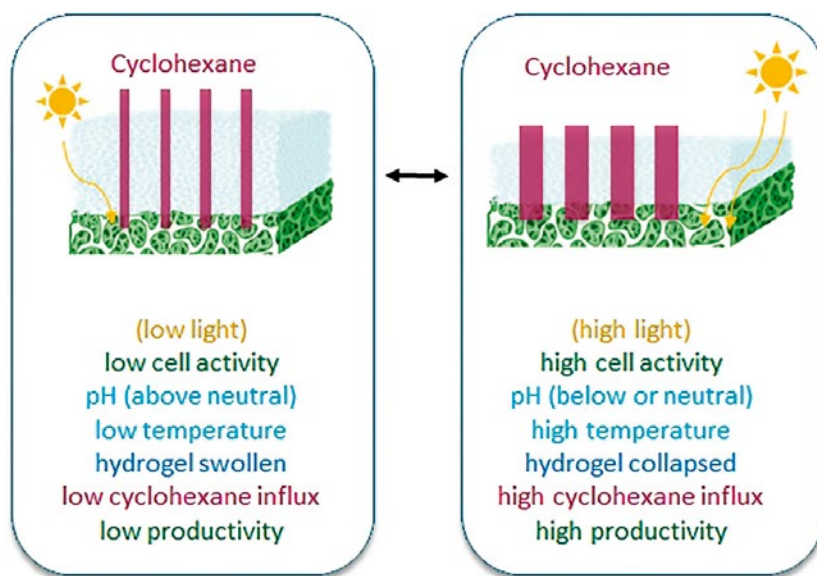
This membrane responds to pH and temperature changes resulting from the metabolic activity of the biofilms and varying light intensities. By switching between a swollen and a collapsed state, it regulates permeability to gases and substrates (e.g., CO_2 , O_2 , and cyclohexane) and forms a material-based feedback loop that automatically maintains the biofilm in a productive operating mode—similar to the "valve function" of stomata in a leaf. The hydrogel membrane is synthesized directly on the polymer scaffold via electron beam-initiated copolymerization of *N*-isopropylacrylamide and acrylic acid directly on the polymer scaffold. Transition zones, swelling degree, and layer thickness are adjusted so that day-night cycles (low/

high light) and different pH values induce specifically controllable switching states.

HYBRID MATERIALS WITH INCREASED STABILITY

At the IOM, electron beam treatment was developed as a technology platform for the targeted modification of polymer surfaces—for example, through hydrophilization, functionalization, or the immobilization of biomolecules and catalysts. In this process, hydrogel layers were produced initiator-free via electron beam polymerization, which ensures high biocompatibility and environmental friendliness due to the absence of toxic initiators and solvents.

By varying the radiation dose and monomer composition, it was possible to precisely control the mechanical properties, swelling capacity, and cross-linking of the hydrogels; when combined with biopolymers such as gelatin, this resulted in hybrid materials with enhanced stability.



Switching states of the hydrogel membrane and the associated self-regulated supply of cyclohexane as a trigger for the catalytic conversion to ϵ -caprolactone in the bioreactor.

Fig.: Malabika Bera and Lara Heiser

"We are applying the principle of self-regulation found in plant leaves to a living material that communicates with its environment - a biohybrid system that, like an artificial leaf, maintains its productive state autonomously." Dr. Agnes Schulze

This comprehensive expertise in electron beam-assisted material functionalization and in the development of porous, stimulus-responsive polymer materials now forms the basis for the biomimetic implementation of a self-regulating "microbial leaf" designed to sustainably control photocatalytic processes.

"MICROBIAL LEAF" AS A BIOCATALYTIC SYSTEM

In this case study, the pH- and light-driven, self-regulated supply of cyclohexane through the hydrogel serves as a trigger for the catalytic conversion to ϵ -caprolactone, a precursor to important polymer building blocks.

By combining material design, biofilm engineering, and transport and kinetic modeling, we are investigating how high cell densities, a dynamic supply of substrate and gas, and long-term stability can be achieved simultaneously.

The result is a "microbial leaf" that operates continuously, efficiently, and autonomously without complex external control systems—paving the way for sustainable, scalable bioprocesses. This leads to self-regulating bioreactors that sense their environment and dynamically adapt to changing conditions. Such systems have hardly been explored in biotechnological applications to date.



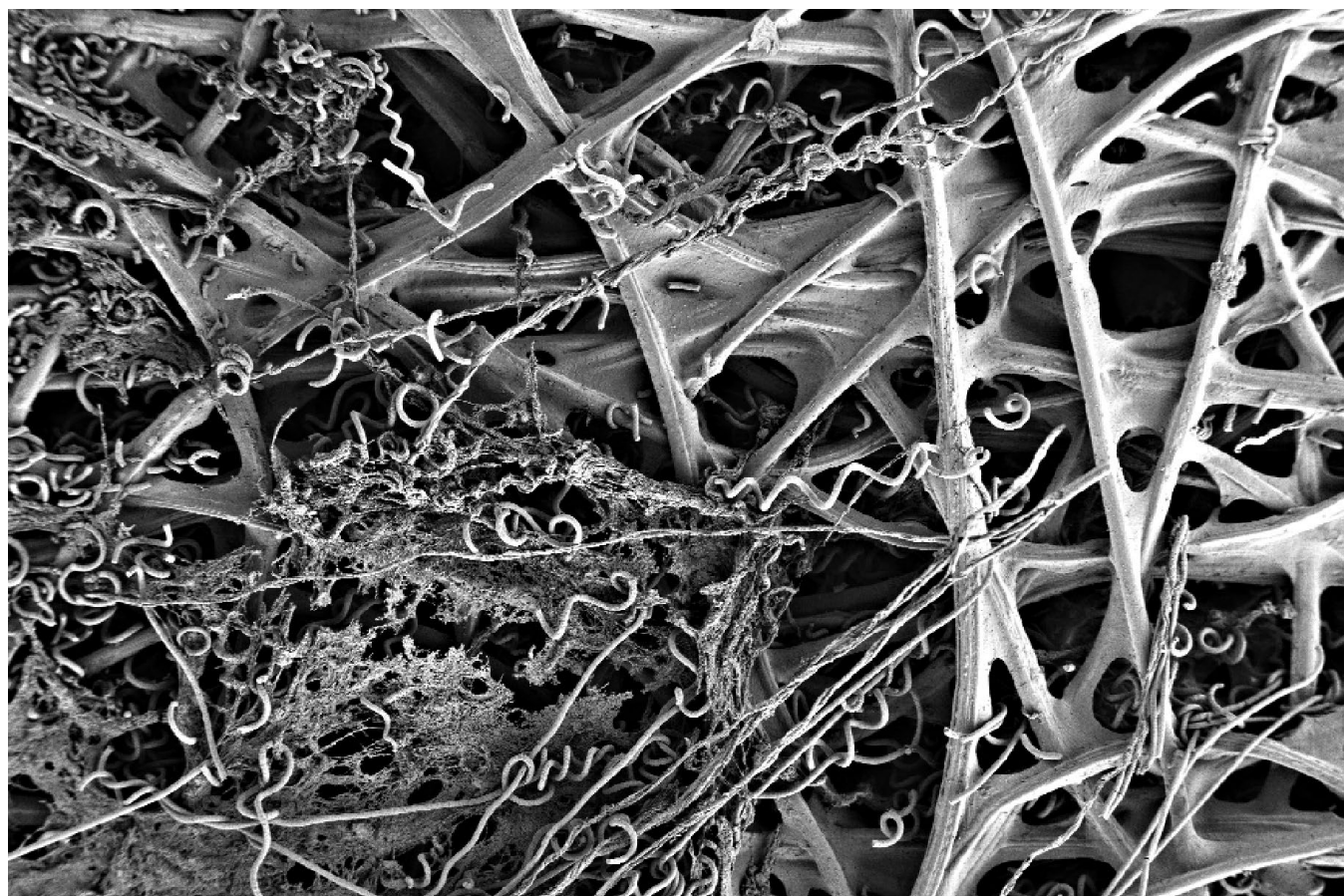
PROJECT LEADER

PD Dr. habil. Agnes Schulze

is head of the research group Surfaces of Porous Membrane Filters at the IOM and possesses extensive expertise in basic and applied research on porous polymers and membrane technology. She has in-depth experience in the immobilization of catalysts, enzymes, and nanoparticles, as well as in the functionalization and improvement of the biocompatibility of polymer materials.

Surfaces of Porous Membrane Filters

Living materials made from recycled plastic



SEM image of a biofilm within a porous polymer matrix. Photo: Andrea Prager

NEED FOR NEW SOLUTIONS

Scientific and technological innovations that help reduce greenhouse gases and plastic waste while providing a sustainable solution for the current feed production system are urgently needed to address the challenges of climate change, plastic pollution, and food security.

SEQUESTER GREENHOUSE GASES

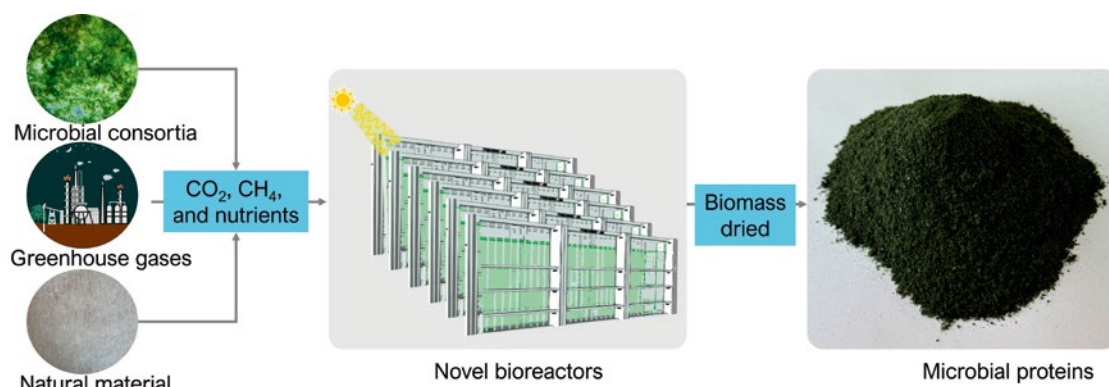
The REPLACER concept aims to synergistically cultivate biofilm consortia on porous, recycled plastic materials. The renewable,

living material developed in this way sequesters greenhouse gases such as carbon dioxide and methane and produces microbial proteins as high-quality animal feed. The porous 3D structure is produced exclusively from re-PET plastic composite membranes, which provide a scaffold with a high surface-to-volume ratio and adaptable surface structures and properties (biocompatibility). This ensures optimal gas-liquid separation for productive biofilm growth.

Living composites, also known as hybrid living materials (HLM), are innovative materials that combine biological

components (e.g., living cells, microorganisms, or biological molecules) with synthetic materials (such as polymers, gels, or inorganic structures). The goal is to create materials that are active, adaptive, and self-healing—similar to natural systems. They combine the functionality of living organisms (e.g., growth, metabolism, response to stimuli) with the stability and formability of engineering materials. Applications span the fields of architecture, environmental engineering, medicine, robotics, and sustainable materials development.

PET nonwoven materials developed and modified at the IOM have been



Schematic representation of the project idea: Microbial biofilm consortia are cultivated on porous polymer membranes to form a living material that metabolizes greenhouse gases such as carbon dioxide and methane into proteins that serve as high-quality animal feed. Fig.: Dr. Rohan Karande

"Climate change, plastic pollution, and food insecurity pose enormous challenges to the world. We are addressing these challenges by developing hybrid living materials and enabling the sustainable production of feed proteins." Dr. Agnes Schulze

successfully tested for use as living composites. Scanning electron microscopy images demonstrate that a wide variety of microorganisms can grow within the polymer matrix. Based on these findings, a cascade reactor was developed at the University of Leipzig that has an external surface area of 260 cm² and achieves a daily biomass production of up to 60 g/m².

CONTRIBUTION TO CLIMATE PROTECTION AND CIRCULAR ECONOMY

The REPLACER project contributes to the European Green Deal and the Circular Economy Action Plan of the European Union. And to the European

Commission's goals of developing advanced, resource-efficient technologies that support a circular economy. Furthermore, REPLACER aims to reduce greenhouse gas emissions and environmental pollution caused by plastics, as well as to produce high-value-added animal feed.

What makes the REPLACER project particularly innovative is the integration of recycled plastics, microorganisms, and AI-driven material design within a closed-loop development cycle. It aims to simultaneously sequester CO₂/CH₄, recycle plastic, and produce proteins for animal feed—a holistic, scalable approach to implementing the circular economy and climate neutrality.



PROJECT LEADER

PD Dr. habil. Agnes Schulze

is head of the research group Surfaces of Porous Membrane Filters at the IOM and possesses extensive expertise in basic and applied research on porous polymers and membrane technology. She has in-depth experience in the immobilization of catalysts, enzymes, and nanoparticles, as well as in the functionalization and improvement of the biocompatibility of polymer materials.

Surfaces of Porous Membrane Filters

Environmentally friendly production of biocatalytically active membranes for self-cleaning

CHALLENGES WITH OIL-CONTAINING WASTEWATER

The European food industry produces large volumes of oily wastewater. If this wastewater is not properly treated, it can cause significant environmental pollution. Although membrane technologies are considered an efficient method of separating oil-water emulsions, they have their limitations. Fouling can reduce performance, increase energy consumption, and necessitate chemical cleaning. Furthermore, conventional membranes are typically manufactured using harmful solvents, which negatively impacts their environmental footprint..

MEMBRANE MANUFACTURING WITH GREEN SOLVENTS

As part of this doctoral thesis polyether-sulfone (PES) hollow fiber membranes using N,N-dimethyl lactamide as an environmentally friendly solvent during the phase separation process were developed. The membrane fabrication process was based on a Design of Experiments (DoE) approach, which allowed investiga-

tion of the impact of key parameters, including PES concentration, PVP amount, PVP molecular weight, and bore liquid composition.

Notably, the molecular weight of the PVP was critical to the membrane's structure and mechanical stability. It has been demonstrated that the fabrication of homogeneous, macrovoid-free membranes is also achievable through the utilization of pure water as the bore liquid.

Furthermore, a method was developed that incorporated electron beam-induced immobilization of biomolecules into the manufacturing process itself. This method enabled the production of self-cleaning, biocatalytic membranes via a roll-to-roll process by integrating biomolecules into the water-based bore liquid.

WASTEWATER TREATMENT: CURRENT STATUS AND CHALLENGES

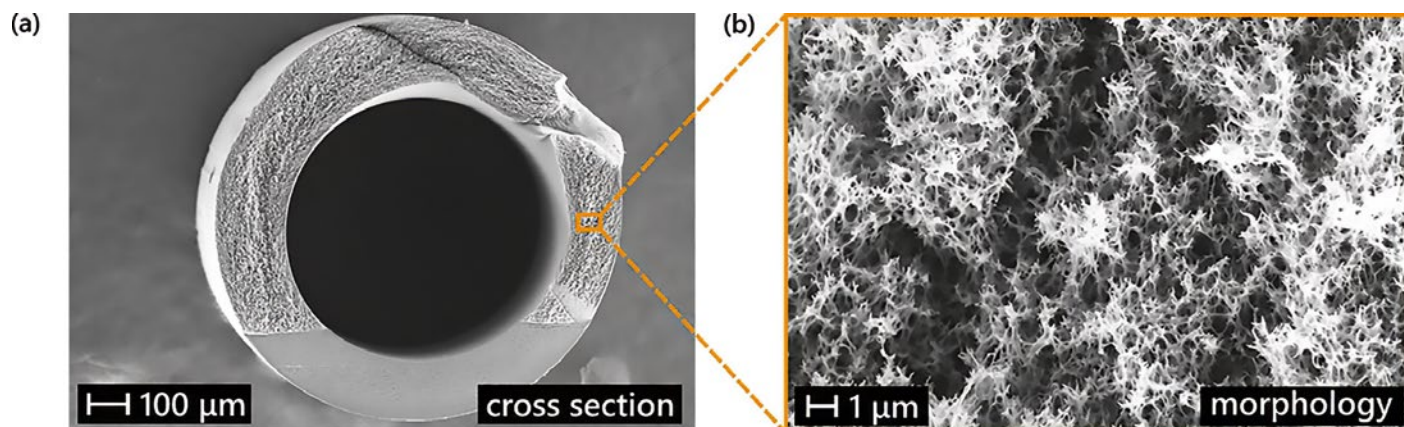
Membrane technology is widely regarded as one of the key technologies for fu-

ture water treatment. However, this requires addressing process-related issues such as fouling, optimizing the cleaning of fouled membranes, and simultaneously reducing the environmental impact of fabrication.

In order to address the previously mentioned challenges, the DoE of the membrane preparation was optimized for a sponge-like morphology. A morphology that has been demonstrated to enhance membrane performance. The elimination of additional solvents in the bore liquid resulted in a more sustainable process. The application of a simultaneous electron beam treatment led to the covalent immobilization of enzymes, thereby enabling the membrane to degrade oil contaminants independently. These findings suggest that high-performance, structurally stable membranes can be produced using environmentally friendly solvents.

POTENTIAL FOR SUSTAINABLE MEMBRANE TECHNOLOGIES

This newly developed method for the preparation of biocatalytic membranes



Scanning electron microscope images of a hollow fiber membrane in cross-section (a) and a detailed view of the structure (b).

Fig. from: Sep. Purif. Technol. (2025), 365, 132625

has been shown to reduce fouling and usage of cleaning chemicals, thereby extending the lifespan of the membrane. The data-driven DoE provides a tool for the targeted optimization of materials and process parameters. This resulted in sustainable alternatives to established polymer membranes, which are particularly relevant for the food industry, where large volumes of oil-containing wastewater are generated.

The IOM operates roll-to-roll scale equipment for both the continuous production of hollow fiber membranes and their modification via electron beam irradiation. With this infrastructure, specifically designed for this purpose, the scalability of the technology can be demonstrated beyond the successful implementation of the fundamental research.



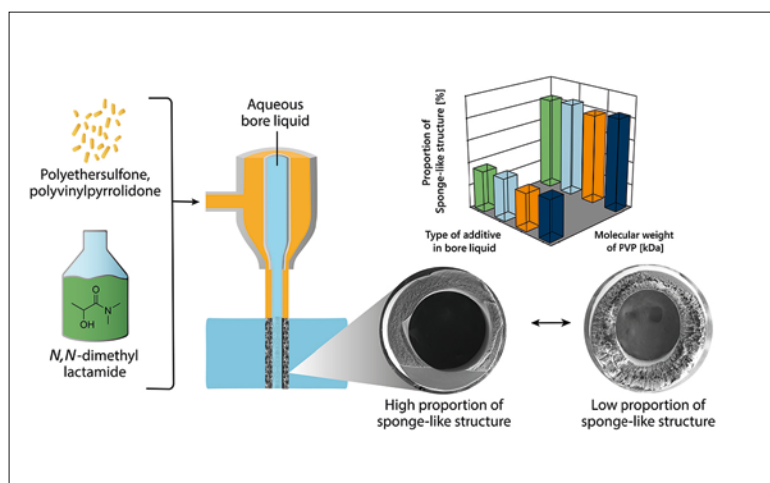
Konrad Leopold, research associate, at the pilot plant for the production of hollow fibers.

Photo: Steffen Becker/significant.pictures

"Combining membrane production and electron beam modification into a single process step contributes significantly to an increase in sustainability." Konrad Leopold

Publication:

K.H. Leopold, et al.: Sep. Purif. Technol. (2025), 365, 132625, DOI: 10.1016/j.seppur.2025.132625



Schematic of the production of hollow fiber membranes using a green solvent in a non-solvent-induced phase separation process. Fig. from: Sep. Purif. Technol. (2025), 365, 132625.

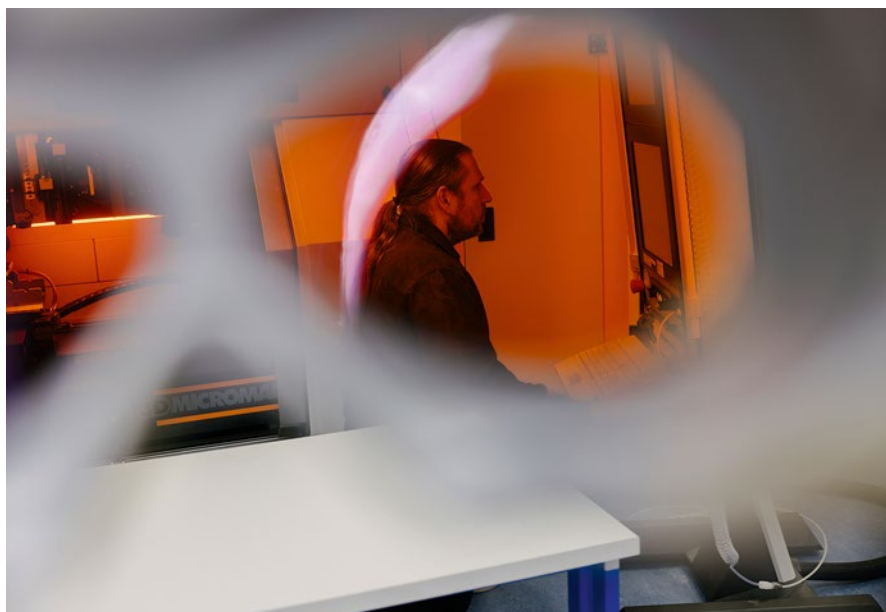


PROJECT LEADER Konrad Leopold

is a doctoral candidate in chemistry and received a fellowship from the German Federal Environmental Foundation (DBU) (July 2022–June 2025). He has been working at the IOM since November 2020, first on an advanced research project and subsequently on his master's thesis. His research focuses on membrane technology, particularly hollow fiber fabrication and electron beam modification of polymer membranes.

Ultra-precision Surfaces / Laser based Micro- and Nanostructuring

Titanium oxide nanotubes for water purification using UV light



Dr. Pierre Lorenz, research associate, setting up the laser system in the laser technology lab.

Photo: Erik Kazak

EFFICIENT DEPOSITION OF TITANIUM DIOXIDE LAYERS

Titanium dioxide nanotubes have emerged as a key material in modern water treatment due to their unique tubular structure and the resulting high specific surface area. Owing to their outstanding photocatalytic properties, they can generate reactive oxygen species under light irradiation, which efficiently degrade even persistent organic pollutants and microorganisms. This technology therefore offers a promising and sustainable approach to significantly enhancing the performance of conventional filtration systems in the removal of micropollutants. Photocatalytically active titanium dioxide layers on polymer membranes with high purification efficiency are essential for future developments in drinking water treatment. The deposition or synthesis of anatase nanotubes, a photocatalytically active modification of titanium dioxide, is efficiently achievable

only at high temperatures, which can lead to the destruction of polymer substrate layers. Therefore, innovative processes are becoming the focus of research to realize the crystalline structure of the nanotubes without thermally overloading the substrate. Successful integration of these active layers would pave the way for self-cleaning filtration systems that sustainably eliminate organic pollutants without the use of additional chemicals.

LASER-INDUCED CONVERSION TO ANATASE

Amorphous titanium dioxide nanotube layers are converted into photocatalytically active anatase nanotubes to enable water purification. This process is initiated by laser irradiation. The technological approach is designed to trigger the

transformation of amorphous titanium dioxide into crystalline titanium dioxide (anatase phase) in a targeted manner and only at the surface. A femtosecond laser with a wavelength of 515 nm was used for this purpose. The key to success was the use of a high repetition rate of 1 MHz in combination with a systematic variation of the laser scanning speed. This approach enabled precise control of the thermal input and thus low damage crystallization of the titanium dioxide. The results can be applied to multifunctional membrane surfaces that combine both particle filtration and purification of harmful substances. Annealing with ultrashort laser pulses induces a number of different processes in the amorphous titanium dioxide nanotubes, which are limited to near-surface effects, i.e., confined to the nanotube layer. As a result, the polymer substrate remains intact, and energy can be saved during fabrication. This also enables thermally sensitive materials such as polymers to be used as substrates for the photocatalytically active anatase nanotubes.

In addition to the anatase phase, laser irradiation also enables the formation of other crystalline phases, such as rutile. The crystalline properties of the titanium dioxide nanotubes can be tuned via the laser parameters. Conventionally, the annealing of amorphous titanium dioxide nanotubes is carried out thermally at high temperatures over extended periods to obtain the desired crystalline anatase phase, which provides the photocatalytic activity required for water purification. However, such high-temperature processes are not suitable for typical polymer-based membranes used in water treatment, as these materials undergo thermal degradation. Ultrashort laser pulses now provide a technology to induce the conversion of titanium dioxide into

"Laser technology is evolving into a tool for the cost-efficient optimization of nanostructures that contribute to achieving the United Nations Sustainable Development Goals."

Dr. Pierre Lorenz

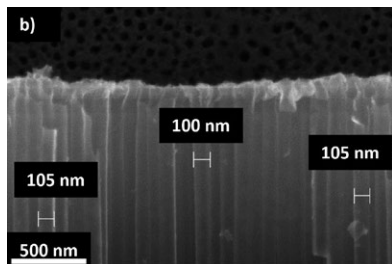
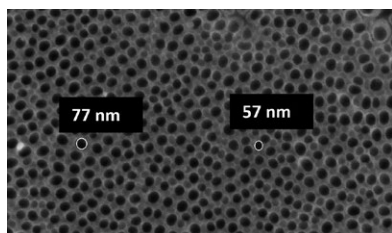
anatase in a controlled manner and only at the surface. The results can be used to create multifunctional membrane surfaces that combine particle filtration with the removal of harmful substances. A significant technological advantage is the drastic reduction in processing time. Thermal conversion of amorphous titanium dioxide nanotubes into anatase typically requires temperatures of around 450 °C and often takes several hours, whereas laser-induced crystallization enables near-instantaneous transformation at scanning speeds of up to 200 mm/s. The laser-based process is not only gentle on the material but also scalable for the industrial mass production of high-performance membranes.

MINIATURIZED, EFFICIENT WATER PURIFICATION

This laser-assisted approach to combining materials with specific properties in a very small space enables the development of products for water treatment in very small volumes and with improved purification performance. Laser annealing provides a process that can rapidly, within seconds, activate the photocatalytic properties of titanium dioxide nanotubes in small, localized areas as needed, without damaging the polymer substrates of the nanotube layer.

Publication

A. Bernhardt et al: *Laser & Photonics Reviews*, n/a (2024) 2300778.



Titanium dioxide nanotubes

Top: Top view showing typical pore diameters of around 60 nm.

Bottom: Cross-section of the nanotubes at a fracture edge, revealing the tubular structure with a tube spacing of around 100 nm.

Fig.: Pierre Lorenz



PROJECT LEADER

Dr. Pierre Lorenz

is a research scientist with a PhD in physics and has been working on the applications of ultrashort pulse lasers for more than a decade. In addition to his previous work on the micro- and nanostructuring of surfaces for microtechnology, his research is now increasingly focused on improving material properties for technical products as well as for applications in the life sciences.

Surfaces of Porous Membrane Filters

How light-activated gels kill bacteria in individual cells

Photodynamic therapy (PDT) is gaining importance in wound treatment due to increasing antibiotic resistance. PDT combines a light-activated dye (photosensitizer), light, and oxygen to generate reactive oxygen species that destroy the vital structures of microorganisms and thus kill them, making it an important complement or alternative to conventional antibiotics. To ensure that such photosensitizers act specifically on wounds, biocompatible, light-transparent hydrogels have been developed at the IOM that are suitable as wound dressings and can absorb and release active ingredients.

It remains unclear exactly how photosensitizer-loaded polyethylene glycol diacrylate (PEGDA) hydrogels act on individual bacterial cells, particularly directly at the hydrogel surface and depending on how the photosensitizer was incorporated into the hydrogel (reversibly loaded vs. irreversibly immobilized).

The study combines electron-beam-cross-linked PEGDA hydrogels that are either reversibly loaded or irreversibly immobilized within the polymer network, with measurements of release kinetics and singlet oxygen generation to character-

ize their photodynamic behavior. Subsequently, using single-cell, real-time fluorescence imaging and the Min protein system as a physiological reporter, the study investigates how *Escherichia coli* (*E. coli*) responds in situ to PDT in the different hydrogels, thereby uncovering mechanistic relationships between hydrogel properties, photosensitizer mobility, and bacterial photoinactivation.

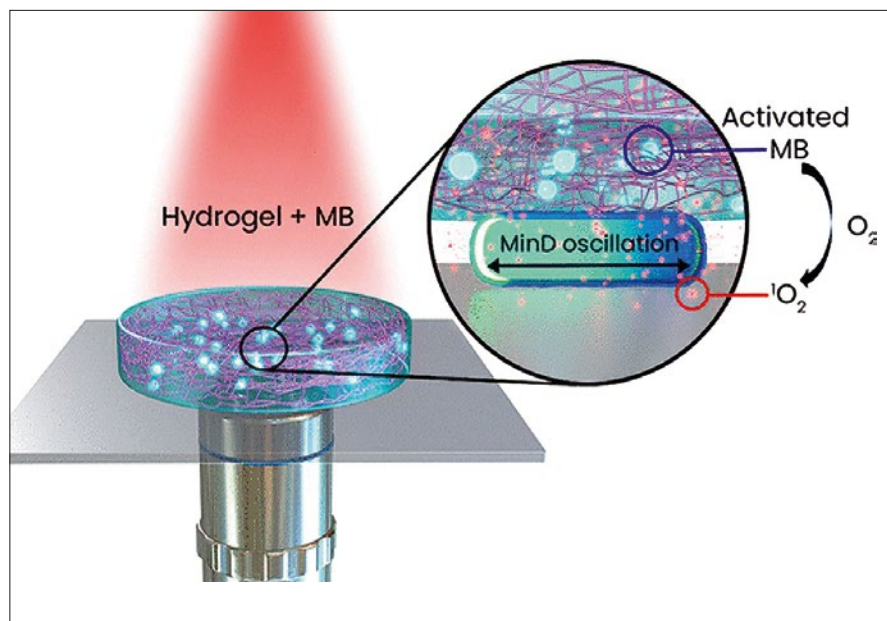
To carry out this work, a successful collaboration has been established with the Madrid Institute for Advanced Studies in Nanoscience.

HYDROGELS AND BACTERIAL STRESS

Previous studies have shown that hydrogels are highly suitable as wound dressings and for drug delivery, and that PEGDA hydrogels in particular are promising for light-based antimicrobial therapies due to their transparency.

It is also known that the Min protein system in *E. coli* is recognized for its ability to visualize subtle physiological changes under stress, such as those induced by light or photosensitizers. Nevertheless, there is currently insufficient understanding of exactly how photosensitizer-loaded hydrogels act directly on the surface of individual bacterial cells and how the manner in which the photosensitizer is embedded influences these processes.

The key finding is that the bactericidal effect depends heavily on how mobile the methylene blue (MB) is within the hydrogel: in the case of reversible loading the dye can freely diffuse to the bacterial membrane, leading to rapid inactivation, whereas when the dye is firmly embedded in the polymer network, it is pri-

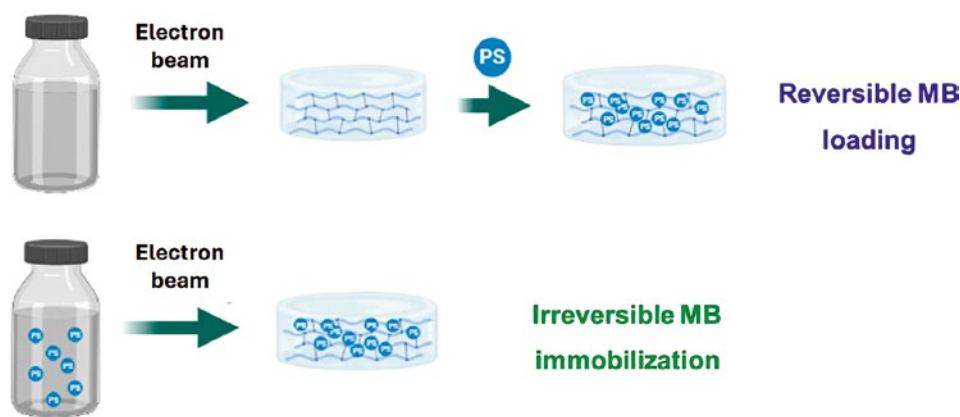


Study concept: Real-time investigation of the effect of light-activated methylene blue released from a hydrogel on bacteria. Fig.: Dr. Ingrid Ortega

Publication:

I.V. Ortega et al: ACS Appl. Mater. Interfaces
(2024) 16, 5677–5682





The two different methods used in the study to prepare the hydrogels: In the top example, the hydrogel was cross-linked by electron irradiation and subsequently loaded with the photosensitizer methylene blue (reversible loading). In the lower example, the hydrogel was cross-linked by electron irradiation in the presence of methylene blue. As a result, the photosensitizer is chemically anchored in the hydrogel and irreversibly immobilized within the 3D polymer network. Fig.: Dr. Ingrid Ortega

"We demonstrate how bacteria on the surface of photosensitizer-loaded hydrogels change in real time under the influence of light, and how the hydrogel preparation process determines bacterial inactivation."

Tuğçe Şener Raman

marily the diffusing reactive oxygen species that indirectly damage the bacterial membrane.

Using single-cell, real-time fluorescence imaging, it was thus clearly demonstrated for the first time how the method of hydrogel preparation determines the mechanism of photodynamic inactivation, an important insight for the targeted design of future antibacterial wound dressings.

POTENTIAL FOR MODERN WOUND THERAPIES

The results are particularly relevant for the development of smart wound dressings that can selectively kill bacteria using light without relying on traditional antibiotics.

Thus, the research offers a potential solution to the growing problem of antibiotic-resistant pathogens, especially in chronic or poorly healing wounds.

In the long term, the mechanistic insights gained could help to develop hydrogels tailored to specific needs, such as enabling rapid bacterial reduction or providing gentler, repeatable treatments.

Unlike many previous studies, which primarily investigated the general efficacy of hydrogels or their optical properties and antibacterial effects using simple endpoint assays (e.g., bacterial count determination), this study monitors processes directly at the hydrogel surface in real time at the single-cell level. Another novelty is that two different loading strategies for the photosensitizer (reversibly vs. irreversibly immobilized) are systematically compared, and their different mechanisms of action are visualized.

This not only demonstrates that the hydrogels kill bacteria but also shows how the method of preparation determines the course of photodynamic inactivation.



PROJECT LEADER Tuğçe Şener Raman

The chemist's research focuses on the electron beam-mediated synthesis and characterization of biocompatible hybrid hydrogels, their loading with various photosensitizers and silver nanoparticles, and their application in photodynamic therapy. To this end, she has established an interdisciplinary network with University Hospital Leipzig, the Materials Analysis Department at IOM, and the Madrid Institute for Advanced Studies in Nanoscience, and has collaborated in the respective laboratories.

Biocompatible and Bioactive Surfaces

Magnetic nanoparticles in hydrogels for applications in biomedical actuators, drug delivery, and sensors

FROM SOFT MATERIALS TO INTELLIGENT SYSTEMS

Hydrogels of biological origin—such as those made from collagen or cellulose—have enormous potential for applications in drug delivery and regenerative medicine.

They are characterized by their excellent biocompatibility, biosorbability, and biomimetic properties and can therefore be used directly in the body, for example as scaffolds for cells and tissues. The integration of biocompatible ferromagnetic or superparamagnetic nanoparticles into the hydrogel matrix results in so-called ferrobiohydrogels—novel, magnetically controllable materials that open up exciting possibilities for biomedical actuators. Using the electron irradiation technology established at the IOM, such bioferrohydrogels were specifically synthesized, characterized, and optimized for their potential as biomedical actuators.

USING ELECTRON IRRADIATION FOR MATERIAL CONTROL

Superparamagnetic iron oxide nanoparticles (SPIONs) in biological hydrogels, e.g., gelatin and collagen, have been permanently immobilized. This was achieved either through an electron-beam-induced

covalent bond or through a geometric lock within the matrix cross-linked by irradiation.

The ferrogel produced in this way functions as a magnetomechanical transducer that can be used in a variety of ways: as an actuator, force and strain sensor, viscoelastic damping element, heating system, or even as a controllable platform for drug delivery.

While ferrofluids have been established for technical applications for many years, biocompatible ferrohydrogels represent a new, highly interesting class of materials. Due to their mechanical and biochemical adaptability to biological tissues, they hold great potential for use within the body.

One of the greatest challenges lies in the biomimetic cross-linking of the hydrogels. This cross-linking must be designed in such a way that it allows biological cells to remodel the carrier scaffold—for example, made of reconstituted collagen. This is precisely where electron irradiation offers a decisive advantage: it allows cross-linking without the use of additional chemical reagents, which are often toxic or impair the biological functionality of the materials.

STRUCTURAL PROGRAMMING AND SHAPE MEMORY

Filaments made of reconstituted collagen have been synthesized whose mechanical properties can be adjusted or even programmed through targeted electron irradiation. If a mechanical pre-stress is applied during irradiation, the material can be specifically transformed into a desired structure—a principle that enables the control of material behavior at the

microlevel. Furthermore, an inverse, electron-beam-programmable shape memory effect was demonstrated for the first time in irradiated methylcellulose. This effect allows materials to be designed so that they can reversibly change their shape under certain conditions—a milestone for future intelligent biomaterials.

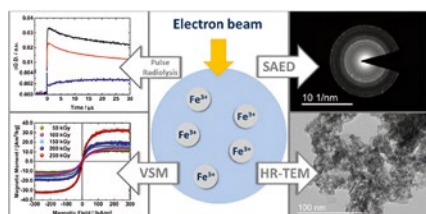
Furthermore, progress was made toward a one-step synthesis: In this process, the SPIONs and the hydrogel matrix are generated simultaneously in the electron beam, which significantly simplifies the manufacturing process and makes it more efficient.

ELECTRON BEAMS INSTEAD OF CHEMICALS – A NEW STANDARD

Until now, biocompatible hydrogels have typically been produced using chemical cross-linking agents such as glutaraldehyde. However, these substances are problematic for biological applications because they inhibit cellular remodeling and can be toxic.

The hydrolysis-based, electron beam-induced cross-linking developed at the IOM represents a true game-changer in this regard. It enables biomimetic cross-linking without any added chemicals, thereby opening up entirely new possibilities for cell-friendly, adaptive hydrogels.

This brings the vision of a bio-inspired, magnetically controllable actuator within reach.



Synthesis and properties of ferrohydrogels. Fig.: TOC plot from Dietrich et al., *Journal of Phys. Chem. C* 128, 17013, 2024

"High-energy electrons enable the chemical-free synthesis of biomimetic scaffolds for tissues and cells with intelligent, controllable properties."

Prof. Dr. Stefan G. Mayr

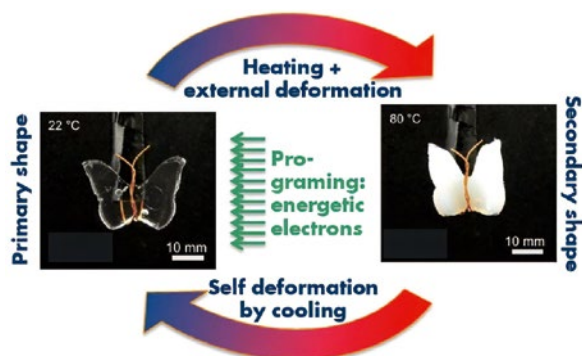
Friedrich Schütte, research assistant, measures collagen fibers on the Tensile Stage. Photo: Erik Kazak

Publications

Friedrich Schütte, et al: Springer-Nature Communications Medicine 5 197 (2025)



Svenja Dorn, et al: International Journal of Biological Macromolecules 285, 138078 (2025)



Inverse shape memory effect in electron-beam-patterned methylcellulose. Fig.: TOC plot from the publication by Dorn et al., International Journal of Biological Macromolecules 285, 138078, 2025



PROJECT LEADER

Prof. Dr. Stefan G. Mayr

studied physics at the University of Augsburg and completed his doctoral studies at the University of Göttingen and the California Institute of Technology (Caltech). After a one-year postdoc at the University of Illinois at Urbana-Champaign, he served as a lecturer there before receiving a faculty position at Göttingen. Since 2009, he has been Head of Research at the IOM. In addition, he holds a professorship in the field of surface physics at the University of Leipzig.

The project was funded by the German Research Foundation (DFG) as part of the Priority Program SPP 1681 "Field-Controlled Particle-Matrix Interactions" (DFG – SPP 1681 / MA 2432/6-3).

Tools

Quantum Sensing for Early Tumor Detection

How can cancerous tissue be quickly and reliably distinguished from healthy tissue, using as little tissue as possible from the patient?

QUANTUM TECHNOLOGY FOR CANCER DIAGNOSTICS

At the IOM, new methods are being tested to develop surface-modified nanodiamonds containing nitrogen vacancy centers (NV centers) for applications in modern sensor technology as well as in medical diagnostics and imaging. In the preparative field, the research focused on novel strategies for the surface modification of nanodiamonds through the use of electron irradiation. In parallel, targeted defect generation was utilized to precisely tune the sensory properties of the nanodiamonds. Furthermore, the bonding between polymers and nanodiamonds was systematically investigated. These targeted modifications yielded a wealth of new scientific insights.

In the field of sensor technology, a new method for magnetic field measurement using nanodiamonds, based on changes in the fluorescence lifetime of NV centers, was demonstrated. Furthermore, the application of polymer-modified nanodiamonds for imaging techniques was successfully demonstrated, including in PET/MR imaging. It was also shown that nanodiamonds enable temperature measurements down to the level of individual cells.

A particular highlight of the research conducted at the IOM is the participation in the EU project “NanoDetect,” launched in 2025. The project focuses on the

development of an innovative and forward-looking method for cancer diagnostics, which is intended to set new standards in the early and precise detection of tumor diseases.

The foundation is the promising concept of so-called T1 relaxation spectroscopy, which opens up new diagnostic possibilities at the cellular level. In this process, nanoscale diamonds are used as highly sensitive optical sensors directly within cells. With the help of targeted laser excitation, individual tumor cells can be identified that differ from healthy tissue due to altered cellular metabolism.

As part of the project, not only will the necessary sensor materials be further developed, but the entire diagnostic infrastructure will also be comprehensively optimized. This includes, in particular, the measurement methodology, its technical implementation, as well as improvements to the software, data analysis, and user-friendliness of the measuring instrument to facilitate future clinical application.

The project partners from Germany and the Netherlands are contributing expertise from various fields, including molecular biology, materials science, optics, electronics, and computer science.

NEW DIAGNOSTIC METHODS ARE URGENTLY NEEDED

Every year, around half a million people in Germany are diagnosed with cancer, and the trend is rising (2024: approx. 510,000 cases). The same trend is evident

worldwide. No two tumors are alike, which presents one of the greatest challenges in modern medicine.

Often, a large amount of tissue must be removed from the patient for diagnosis, which places a significant burden on the patient's health. Depending on the type of cancer, diagnostic procedures can take days and require large amounts of the patient's tissue. For a disease that becomes harder to treat as it progresses, this is a significant disadvantage. This is where our project comes in. It aims to pave the way for an effective, rapid and personalized





Dr. Christian Laube, research associate, preparing samples at the 10-MeV electron accelerator. Photo: Erik Kazak

"In our research, we combine modified biocompatible materials and (quantum) sensor technology with the primary goal of diagnosing diseases as early as possible and thereby save lives."

Dr. Christian Laube

tumor diagnostics using small tissue samples. The project is considered one of the first to use NV-center-based relaxometry as a quantum technology for early tumor diagnosis. It is therefore a crucial step toward transferring quantum technology approaches into everyday practice.

TUMOR DETECTION VIA MAGNETIC SIGNATURES

The measurement principle for tumor detection is the innovative core of the project. Tissue differentiation is not based on established tumor markers, but rather on the measurement of paramagnetic species that are produced in greater quantities within the tumor.

In this process, the extracted tissue samples are mixed with NV-center-containing nanodiamonds, and the nanodiamonds are then excited to fluoresce using laser light with an optimized pulse sequence. The emitted fluorescence signal contains information about the magnetic environment of the nanodiamonds (the so-called T1 relaxation time).

Reactive oxygen species (ROS) occur in increased amounts in tumor tissue, and these are often paramagnetic, which shortens the measured T1 relaxation time. This allows healthy tissue to be distinguished from tumor tissue at the microscopic level.

A problem in T1 relaxometry that has remained unresolved to date is the inhomogeneity of the T1 times of the NV centers in individual nanodiamonds. This inhomogeneity significantly complicates the reliable referencing of measurements in complex tissue, which substantially increases the statistical workload and thus necessitates longer measurement times and larger tissue samples in medical diagnostics.

The causes of this inhomogeneity are manifold and include, among other things, the surface functionality, the particle size, and the lattice quality of the nanodiamonds. The latter represents a decisive factor in the targeted manipulation of the particles' sensory properties. While changes in surface texture or particle size can have a direct influence on the uptake

of the particles into the target tissue (e.g., tumor tissue), defect density is a crystal lattice property that does not influence biological processes.

IRRADIATION FOR BETTER TUMOR SENSORS

At the IOM, the interaction between the defect concentration in nanodiamonds and the NV centers they contain is therefore being systematically investigated. To this end, NV centers are first generated in the nanodiamonds through a multi-step process consisting of irradiation and high-temperature treatments. This is followed by the targeted and quantitative creation of defect centers through electron irradiation at low temperatures.

The influence of these defects on the T1 relaxation times of the NV centers should make it possible to adjust the T1 times in each production batch and thus achieve significantly higher homogeneity for the relaxometric measurement. To comprehensively characterize the influence of defects on the sensitivity of the NV centers'

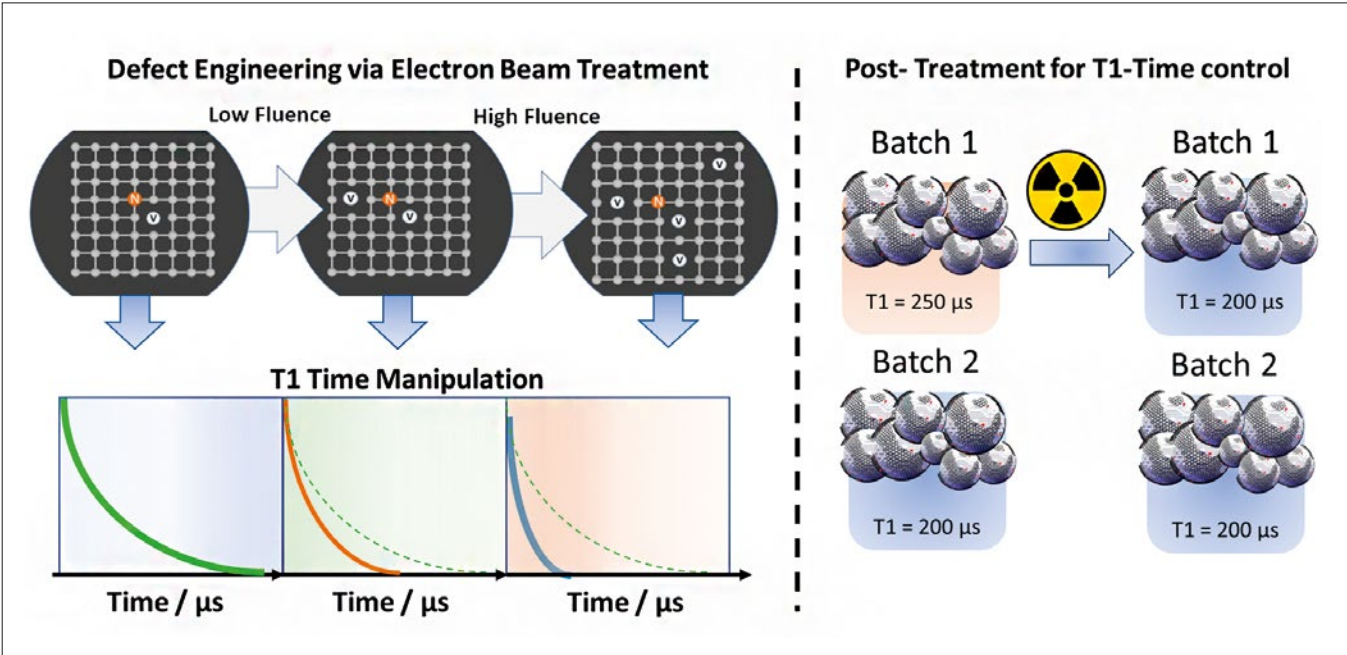
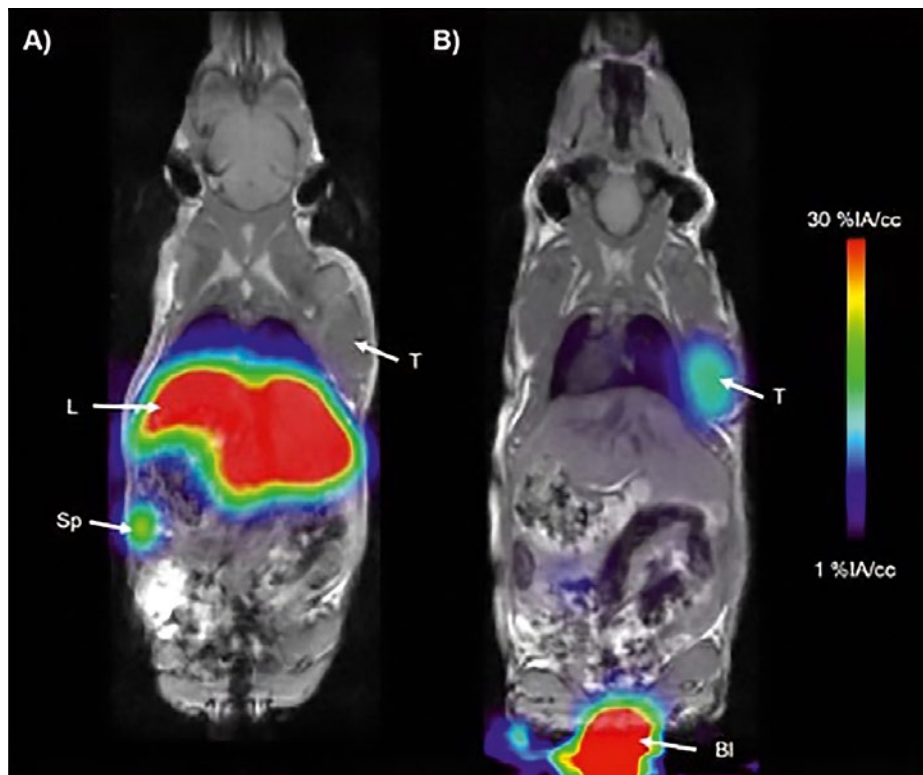


Illustration of T1 time manipulation of NV centers through the targeted creation of defects in nanodiamonds. This approach is being pursued in the project to produce homogeneous starting material for use in T1 relaxometry. Fig.: Christian Laube

Representative horizontal, co-registered PET/MR image showing the biodistribution of the modified nanodiamonds (A) [68Ga]Ga-DFO-ND-Oct and (B) [68Ga]Ga-DOTA-TOC in an AR42J tumor-bearing CD1 mouse. The radiation scale was set to 1–30% ID/cc. The organs of interest are marked with arrows: Sp—spleen, L—liver, T—tumor, Bl—bladder. Fig.: T. Wanek, et al, *Pharmaceuticals*, 2024, 17, 514



magnetic field sensing capabilities, quantum-sensing experiments are being conducted in addition to complex irradiation treatments. These include EPR, OD-MR, and T1 time measurements, as well as fluorescence measurements.

In addition to investigating the interaction between defects and NV centers, the IOM is also pursuing methodological strategies to achieve the most homogeneous NV center concentration possible, and the effects of surface functionality are incorporated into the investigations.

BROAD SPECTRUM OF APPLICATIONS AND COMMERCIAL RESEARCH POTENTIAL

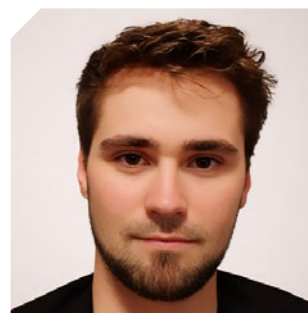
Tumor diagnostics based on NV-center-based T1 relaxometry hold promise

Patent

C. Laube, Creation of Defects in Diamonds (DE102024120092.8), German Patent and Trademark Office.

for broad applicability, as the reactive species detected by this method are widely distributed in tumor tissue. In addition to the obvious advantage of detecting tumors earlier and, in the best-case scenario, saving lives, this approach also holds significant commercial potential.

The analysis system to be developed in the project, which will be marketed through the startup QTSense, is to be designed so that it can be easily installed and operated in virtually all diagnostic laboratories.



PROJECT LEADER Dr. Christian Laube

earned his PhD at the IOM from 2015 to 2019 in the field of materials science and, following research stays in the USA, has been working as a postdoc and project manager since 2021. His research focuses on the application of electron beam technologies for surface modification and defect engineering of nano- and quantum-sensor materials.

Barrier and Precision Coatings

Biogenic raw materials: A resource-efficient solution for innovative tool coatings

UV-curable coatings have established themselves in numerous applications in terms of resource efficiency. In addition to the low process temperature, this technology is characterized by the fact that, in most cases, “100% systems” are used. These are solvent-free formulations in which only the atoms that form the coating material after curing are deposited on the substrate.

Given the fact that we need to prudently manage fossil resources, the question now arises as to whether—and under what conditions—bio-based raw materials can replace the fossil-based components currently used in formulation production, with the aim of further reducing the carbon footprint of the entire coating process.

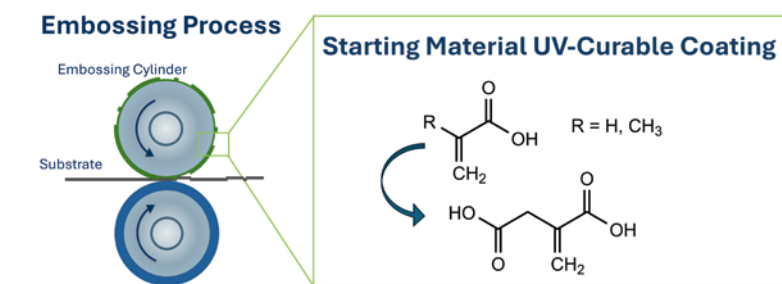
SUBSTITUTION OF FOSSIL RAW MATERIALS

This question was addressed in the “μBoss” project of the WIR! alliance GRAVOmer, which was dedicated to the development of innovative tool surfaces for roll-to-roll structuring processes.

A central goal of the work at IOM was to replace acrylic acid-based binder components with itaconic acid-based alternatives without compromising the coating’s demanding property profile, particularly with regard to adhesion, hardness, and abrasion resistance.

ITACONIC ACID AS A SUSTAINABLE BINDER

Itaconic acid is considered a promising synthetic building block for the production of biogenic binder raw materials, as its chemical structure resembles that of



Biogenic itaconic acid-based coatings for innovative embossing cylinders. Fig.: Mirko Naumann

acrylic acid derivatives, which are widely used in UV-curable coatings. Due to its double bond and two carboxyl groups, it can also be widely functionalized.

Biogenic itaconic acid is primarily produced by biotechnological fermentation of carbohydrates, such as glucose, using the fungus *Aspergillus terreus*. In 2024, global production volume stood at around 80,000 tons.

Various oligo- and polymeric esters can be produced from itaconic acid via condensation reactions with alcohols. Initial application scenarios demonstrate its suitability as a binder component, including in printing inks.

For the first time, researchers at the IOM succeeded in developing nanocomposite materials based on itaconic acid-containing binder components that meet the complex requirements of polymer-based embossing cylinder coatings.

A modification of the synthesis route for itaconic acid esters led to a significant 35% improvement in the reproducibility of the produced batches. In addition, a reactive surface modification of silicon oxide nanoparticles directly in the itaconic acid

ester was developed, thereby creating binding sites for covalent incorporation into the polymer matrix. This improves the mechanical properties while maintaining the processability of the coating material.

Furthermore, a suitable process window for the UV curing of the composite material was identified, enabling industrial curing levels with residual double-bond contents of $\leq 10\%$.

The incorporation of itaconic acid-based additives into fossil-based formulations at concentrations of up to 30% by weight resulted in long-term stable systems without compromising the coating’s property profile.

TECHNOLOGICAL POTENTIAL

Biogenic prepolymers open up new possibilities in the development of functional, UV-curable nanocomposite coatings. Potential applications range from industrial coatings and barrier layers to surfaces with optical effects.

The gradual substitution of fossil-based raw materials with biogenic ones could provide new impetus to the growing global market for UV-curing coating solutions,

which is projected to reach a volume of around 8 billion euros in 2024 with forecast growth rates of approximately 10%.

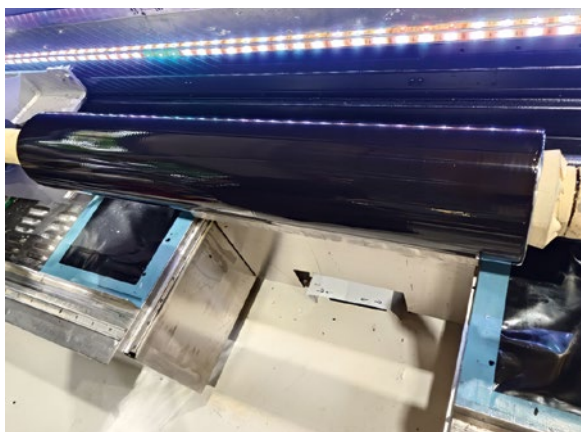
In addition to economic benefits, this approach offers significant potential for reducing CO₂ emissions.



Udo Trimper, technical staff member, at the roll-to-roll coating line in the IOM's application center.
Photo: Erik Kazak

"Coating manufacturers are currently challenged to adapt their product portfolios to the requirements of major brand owners with high sustainability goals."

Dr. Ulrike Helmstedt



Coated embossing cylinder with functional UV-curable coating material from Kaspar Walter Maschinenbau-fabrik GmbH & Co. KG.
Photo: Mirko Naumann

Publication:

Final Report "WIR! – GRAVOMER – Novel Embossing Dies with Microstructure-Based Functionalized Engraving for Material-Specific Optimization of Molding Properties – μBOSS, TV 4: Development of Polymer Embossing Patterns," TIB Hannover, 2025



PROJEKT LEADER

Dr. Ulrike Helmstedt

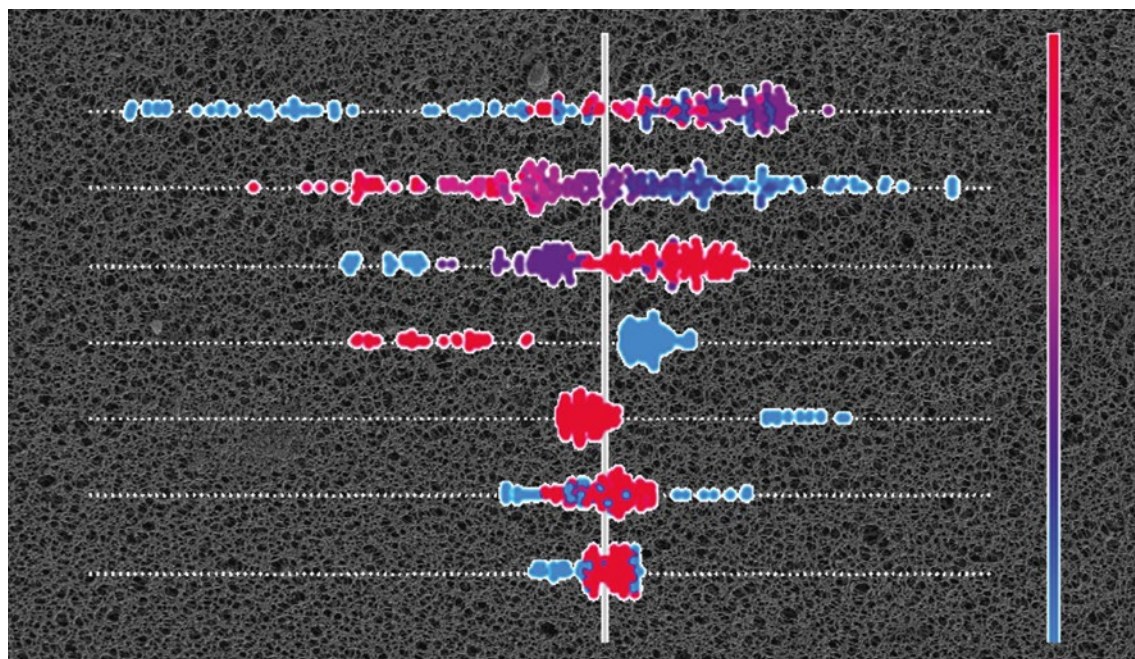
is head of the Barrier and Precision Coatings Research Division and conducts research on UV-based technologies for surface modification, particularly the UV curing of coatings and coating systems.

Mirko Naumann

is an engineer specializing in UV-curing printing and coating technologies and topographic surface characterization.

Surfaces of Porous Membrane Filters

Artificial intelligence supports the development of modern membrane filters



A SHAP analysis (Shapley Additive Explanations) supports the interpretation of machine learning (ML) models for modified membranes. Fig.: Martin Schmidt, Sarah Glaß

HIGH REQUIREMENTS ON MODERN MEMBRANE MATERIALS

The growing global water scarcity and increasing environmental pollution make the provision of clean water one of the greatest challenges of our time. Porous membrane filters are a promising tool for water purification, but their performance depends heavily on their surface properties.

Until now, it has been very challenging to predict how specific material or process changes would affect membrane performance. As a result, countless samples had to be laboriously produced and tested in the laboratory through a time- and cost-intensive process. Modern membrane science is now attempting to enable more efficient material development with the help of data-driven models.

In collaboration with the Helmholtz-Zentrum Hereon and the Karlsruhe Institute of Technology (KIT), the research team combined materials science with artificial intelligence, specifically machine learning (ML). The IOM utilized its established electron beam technology to modify the surfaces of conventional polymer membranes.

The goal was to produce membranes with a positive surface charge and, at the same time, a high water flux through surface grafting of amine-containing substances. The experimental data from the modified filters were used to train regression models and neural networks to identify correlations between manufacturing parameters, chemical structures, and material properties. Furthermore, the models were used to predict the properties of membranes modified with two new substances.

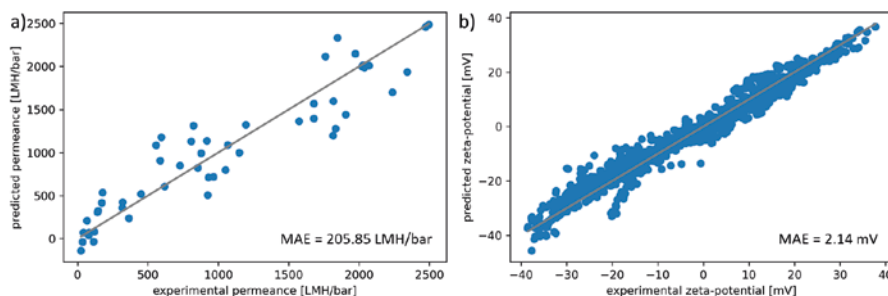
LIMITS OF CONVENTIONAL MEMBRANE DEVELOPMENT

For decades, porous polymer membranes have been used for water treatment. Depending on their pore size, they can efficiently remove bacteria, organic pollutants, and salts. However, conventional membranes often reach their limits, for example due to fouling or insufficient selectivity. A proven strategy is chemical surface modification, such as the introduction of positively charged groups that can bind pollutants.

The trained regression models provided very accurate predictions for key performance characteristics such as water permeance or surface charge. This was demonstrated in particular by plotting experimental against predicted values, as well as by the low mean absolute errors

(MAE). Even newly developed membrane modifications that were not included in the training dataset could be predicted with good accuracy and experimentally confirmed thanks to the neural networks. For instance, at typical water permeances of 1000–2000 L/(m² h bar), a mean error of 177 L/(m² h bar) was achieved.

Furthermore, the models were able to predict the surface charge of the membranes as a function of the pH value, and thus zeta potential curves.



Comparison between predicted and experimentally determined membrane properties (a: water permeance; b: surface charge). Fig. from: S. Glass et al., ACS Applied Materials & Interfaces 2024, 16, p. 20990

PRECISE PREDICTIONS DESPITE SMALL DATASETS

In addition to the targeted prediction of membrane properties, the use of ML methods such as SHAP analysis enables understanding the influence of experimental parameters on the target properties. The study further demonstrates that machine learning is capable of making reliable predictions even with comparatively small but precise datasets.

This distinguishes the work from other approaches, which mostly rely on large amounts of data.

This new approach enables an efficient, data-driven development path for membrane scientists that purposefully complements experiments rather than replacing them.

Publication:

S. Glass et al, ACS Applied Materials & Interfaces 2024, 16, p. 20990



„Machine learning can significantly accelerate the development of high-performance membranes and substantially reduce the associated resource requirements.“

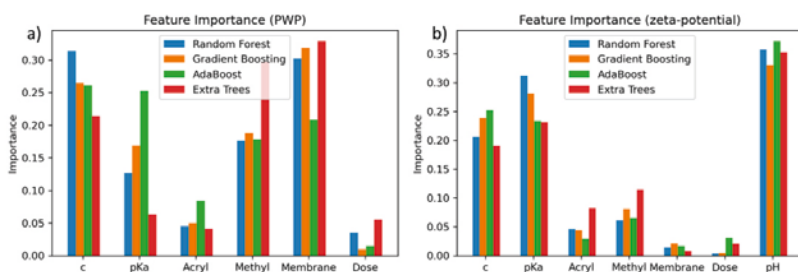
Dr. Martin Schmidt



PROJECT LEADER

Dr. Martin Schmidt

is a research scientist focusing on the development of novel functional materials, particularly adsorptive, catalytic, and bioactive membranes for the removal of micropollutants in water treatment, or biorefinery applications. To accelerate material development, he uses data-driven methods such as design of experiments and machine learning.



Influence of various parameters and models on the investigated membrane properties (a: water permeance; b: surface charge). Fig. from: S. Glass et al., ACS Applied Materials & Interfaces 2024, 16, p. 20990

The project was carried out as part of a scientific collaboration with the Helmholtz-Zentrum Hereon and the Karlsruhe Institute of Technology.

Modelling and Simulation

Modelling deep eutectic mixtures with machine learning interatomic potentials



The two co-directors of the Modeling and Simulation cross-disciplinary unit, Dr. Stefan Zahn and Dr. Martin Rudolph, evaluating their results. Photo: Erik Kazak

Deep eutectic solvents have a melting point significantly below their individual components. Most popular are mixtures of choline chloride and an organic component such as urea which form liquids close to room temperature. Furthermore, they are cheap and environmentally friendly.

Modelling these compounds is challenging due to the strong polarization of the vicinity of small ions such as the chloride anion or lithium cation.

Aim of the DFG project “Molecular Secrets of Deep Eutectic Solvents” was to develop an approach which can reliably describe the structure and dynamics of these systems without the need for experimental validation.

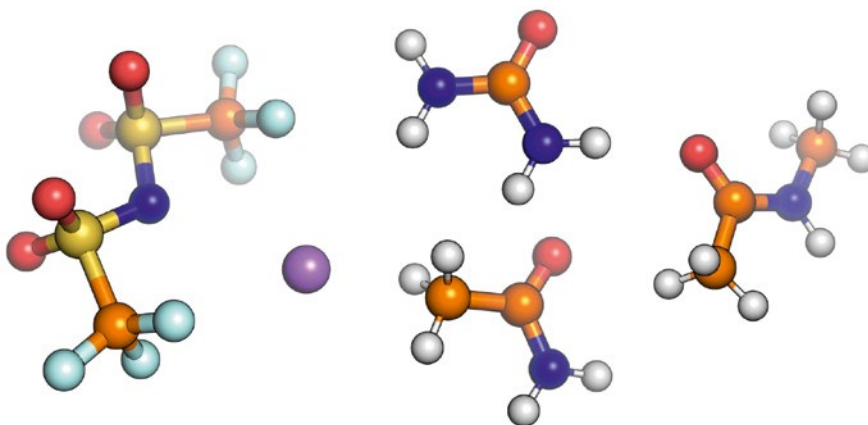
WHY DO CLASSICAL FORCE FIELDS FAIL?

Classical force field models for systems with ions can be adapted to experimental

properties like viscosity and conductivity by scaling the charge on the individual atoms. However, this results often at a poor description of the local structure.

Polarizable force fields tend to overestimate the interactions between small ions and hydrogen bonds. Therefore, a fit to structural data from molecular dynamics simulations based on quantum chemical methods is usually required. Significant computational resources are required to

Ball-and-stick model of the compounds within the investigated homologous series. White: H, purple: Li, orange: C, blue: N, red: O, cyan: F, yellow: S. Fig.: Stefan Zahn



obtain such a first principles molecular dynamics reference.

In 2023, we were able to demonstrate for the first time that machine learning interatomic potentials enable a reliable study of deep eutectic solvents. Nonetheless, the invariant model based on the Deep Potential Model required more than 10,000 reference data points for training.

In 2024, we show that the application of an equivariant model reduces the amount of the required training data by an order of magnitude compared to invariant models.

Furthermore, a cutoff radius of 6 Ångström is sufficient, even though the Allegro model is strictly local and does not indirectly account for interactions beyond this cutoff, unlike similar message-passing architectures.

RELIABLE STRUCTURE AND DYNAMICS WITH MACHINE LEARNING INTERATOMIC POTENTIALS

Short lithium-lithium cation distances of approximately 3 Å were found in the investigated homologous series based on lithium bistriflamide. This is not visible in classical force field models. Both lithium cations are linked via an oxygen atom of the carbonyl group in the organic component, such as urea. The strong coupling between the two lithium atoms results in an in-phase oscillation visible in the velocity autocorrelation and cross-correlation function.

"We can get a detailed understanding of processes at the atomic scale with machine learning interatomic potentials." Dr. Stefan Zahn

Furthermore, the diffusion mechanism within the homologous series is influenced by the strength of this coupling. Cation and anion move independently from each other for the urea system, while a correlated diffusion is observed in N-methylacetamide.

Furthermore, the lithium cation tends to move together with its solvation shell in the methylacetamide system while the rotational correlation time of the organic compound is smaller than the pair lifetime for the urea system. Therefore, not solely data efficient, equivariant machine learning interatomic potentials were established for simulating deep eutectic solvents, also the cation diffusion mechanism in lithium bistriflamide-based deep eutectic solvents was understood in detail.

Publication

O. Shayestehpour, S. Zahn, J. Chem. Phys., 2024, 161, 134505



PROJECT LEADER Dr. Stefan Zahn

The co-leader of the Modeling and Simulation cross-section unit holds a PhD in Theoretical Chemistry. His work focuses on simulations at the atomic level.

Modelling and Simulation

New modeling methodology for high-power plasmas

CHALLENGES IN HiPIMS PLASMAS

The modeling of plasma discharges is an enabler for understanding and optimizing modern coating processes. The gold standard here is the Particle-in-Cell (PIC) method, which can be used to model a wide variety of plasma discharges with high accuracy.

Its disadvantage, however, lies in the enormous computational effort: simulating large parameter ranges is virtually impossible. Particularly for discharges with high power densities, such as those occurring in high-power pulse magnetron sputtering (HiPIMS), the computational effort increases exponentially, rendering classical PIC models practically unusable.

This calls for new modeling approaches that better balance computational efficiency and physical accuracy.

GOAL: COMPUTATIONALLY EFFICIENT HiPIMS MODELS

The goal of a computationally efficient model for HiPIMS discharges is to elucidate the relationship between adjustable process parameters and plasma-physical and plasma-chemical mechanisms within the discharge.

This is based on a simplified description of the underlying physics using analytical equations. Plasma-chemical reactions between heavy particles and electrons are captured by simplified rate equations. Unknown model parameters are calibrated using experimental discharges.

A key advantage of this approach is that, despite the significant simplifications, the dominant physical interactions are explicitly taken into account. This makes it possible to reliably predict trends in discharge behavior without having to resort to

computationally intensive Particle-in-Cell codes.

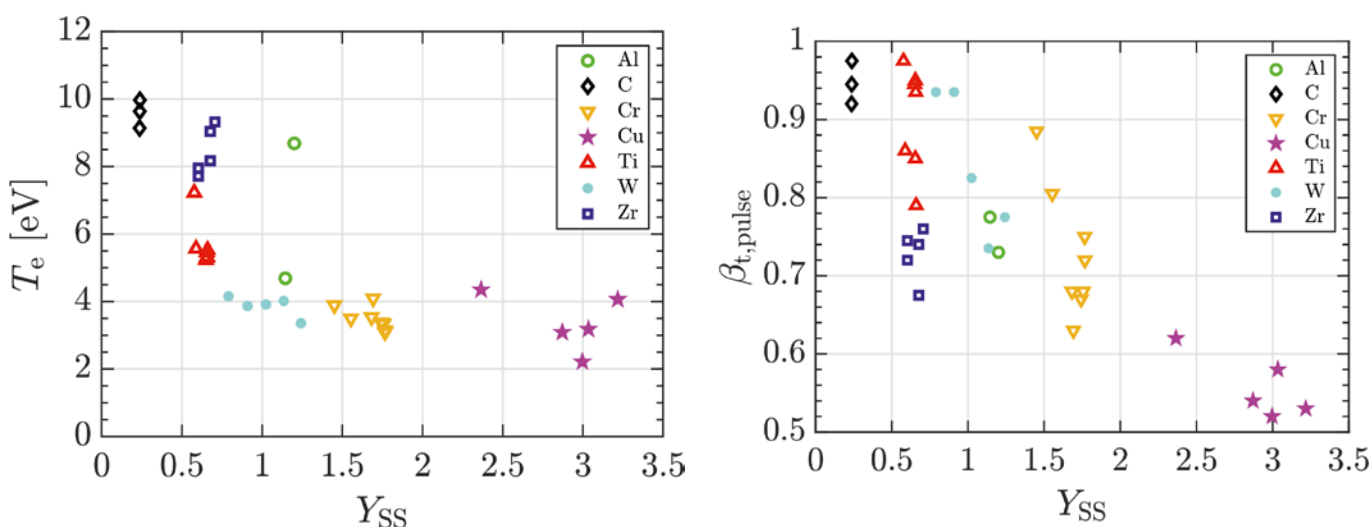
MATERIAL-DEPENDENT PROCESSES IN HiPIMS DISCHARGES

Cathode erosion in a HiPIMS discharge is highly material-dependent. Discharges with different cathode materials can therefore be either gas-dominated or metal-rich.

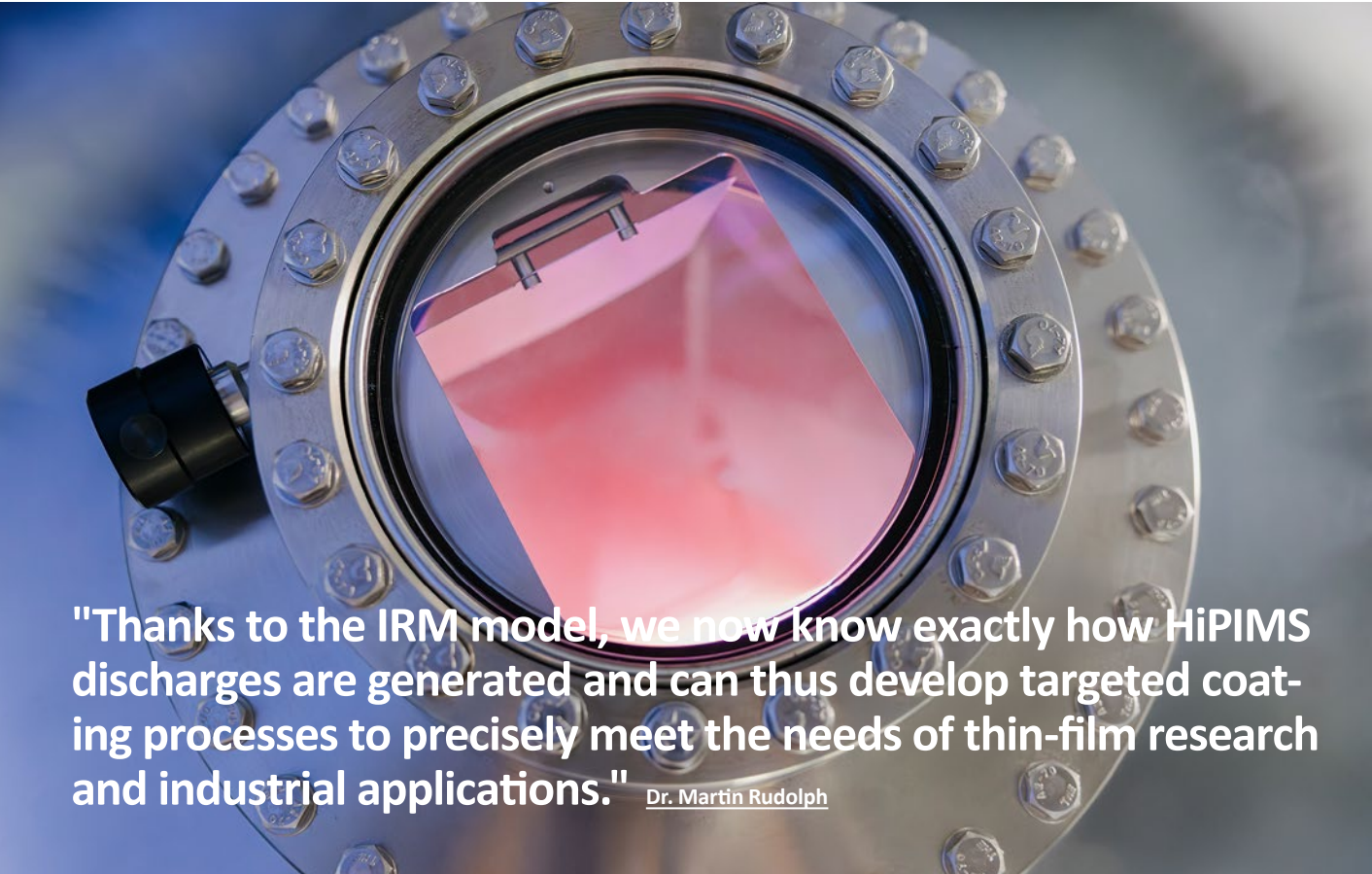
This raises the question of whether and to what extent this alters fundamental discharge characteristics. A particularly important parameter here is the electron temperature, which significantly determines the plasma chemistry.

ELECTRON TEMPERATURE AS A KEY PARAMETER

Modeling discharges with different cathode materials shows that the electron



Left: The electron temperature (T_e) in a HiPIMS discharge depends on the cathode material and the rate of cathode erosion (sputtered atoms per incident ion Y_{ss}). Right: A lower electron temperature results in a significantly reduced back-attraction of metal ions to the cathode (fraction of metal ions attracted to the cathode, $\beta_{t,pulse}$). Fig. from: K. Barynova et al. Plasma Sources Sci. Technology 34 (2025), © 2025 IOP Publishing Ltd.



"Thanks to the IRM model, we now know exactly how HiPIMS discharges are generated and can thus develop targeted coating processes to precisely meet the needs of thin-film research and industrial applications." Dr. Martin Rudolph

High-power pulsed magnetron sputtering of a titanium cathode in an argon atmosphere at low pressure. Photo: Erik Kazak

temperature is indeed strongly dependent on the rate of cathode erosion.

At lower erosion rates and correspondingly lower metal atom density in the discharge, the electron temperature is predominantly determined by the high ionization energy of the dominant argon atoms.

Metal atoms typically have a significantly lower ionization energy, which strongly dampens the rise in electron temperature in a discharge. A high metal atom density in discharges with a high erosion rate therefore leads to a noticeably lower electron temperature.

POTENTIAL FOR MORE EFFICIENT COATINGS

By precisely controlling the electrode temperature, it is possible to indirectly influence the proportion of metal ions that contribute to the coating.

In HiPIMS discharges, the majority of the positively charged metal ions are drawn back to the target due to its negative voltage, which undesirably leads to a low deposition rate.

A lower electron temperature has the advantage that the average distance between the cathode and the ionization region increases, and the back-attraction to the cathode decreases.

The findings obtained may therefore lead to higher efficiency in HiPIMS coating processes in the future.

Publication

K. Barynova, et al: Plasma Sources Sci. Technol. 34 (2025) 06LT01



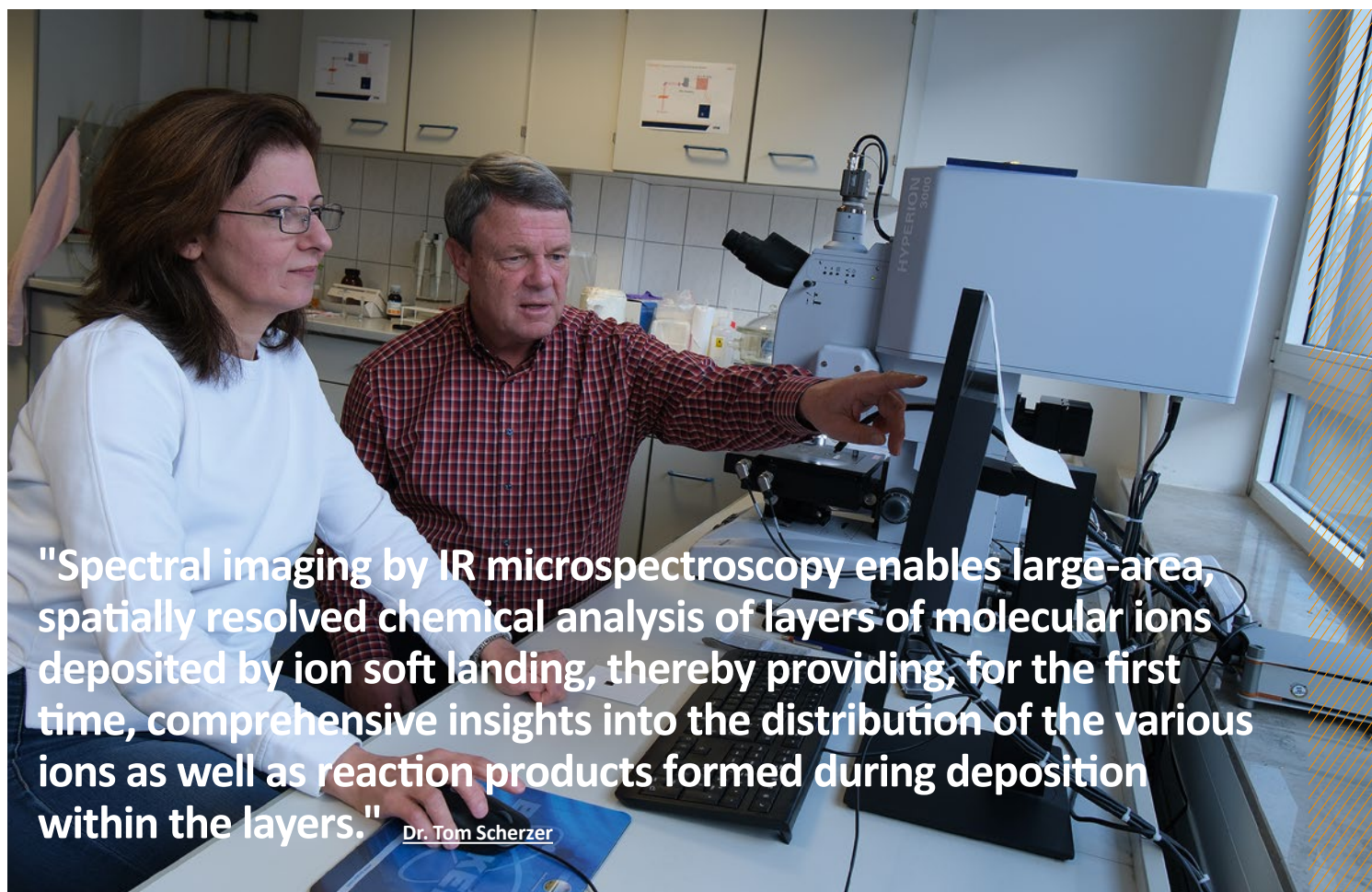
PROJECT LEADER

Dr. Martin Rudolph

The co-leader of the cross-section unit Modeling and Simulation is a plasma physicist and focuses on elucidating the plasma physics and plasma-chemistry in discharge plasmas.

Material Characterization and Analytical Service

New insights into ion soft landing layers



"Spectral imaging by IR microspectroscopy enables large-area, spatially resolved chemical analysis of layers of molecular ions deposited by ion soft landing, thereby providing, for the first time, comprehensive insights into the distribution of the various ions as well as reaction products formed during deposition within the layers."

Dr. Tom Scherzer

Dr. Olesya Daikos (left), research associate, and Dr. Tom Scherzer, research associate, at the IR microscope evaluating spectral images of ion soft landing layers. Photo: Jens Bauer

The composition of thin layers formed by ion soft landing of molecular ions has not yet been fully understood. The reason: complex charge-balancing processes, mostly redox reactions, determine the final structure and depend strongly on various parameters including layer thickness.

Existing analytical methods typically provide only integral information or completely destroy the layers. To address this issue, IR-based spectral imaging is employed to enable, for the first time, a spatially resolved and non-destructive analysis.

NON-DESTRUCTIVE IR SPECTROSCOPY

The aim of the project was to determine the molecular composition of ion soft landing layers non-destructively and with high spatial resolution.

The IR microscope at IOM uses a 64×64 -pixel focal plane array (FPA) detector for this purpose, which enables IR imaging spectroscopy of large areas. By sequential scanning of adjacent regions, areas of several square millimeters can be fully spectroscopically analyzed, and chemical structures can be mapped in detail.

If the layers are deposited on gold substrates, measurements in reflection are possible. However, this requires that the layers are deposited significantly thicker than usually – in a range of several micrometers rather than just a few nanometers – in order to achieve sufficient sensitivity of the IR measurements.

DEVELOPMENT IN THE JOINTLAB

In the JointLab "Surface Modification with Mass-Selected Molecular Ions," methods for the deposition of such ion layers are developed. The layers are comprehensively characterized subsequently.

However, for layers with thicknesses in the range of several hundred nanometers, there has been no method to date that is both non-destructive and capable of revealing the spatial distribution of various ions and potential impurities.

FIRST SPACE-RESOLVED IR ANALYSIS OF ION SOFT LANDING LAYERS

The investigations presented here enable, for the first time, a spatially resolved IR analysis of ion soft landing layers.

First, methodological optimizations were necessary to ensure that meaningful spectral images could be obtained despite the very low thickness of the original layers.

Layers of two types of molecular ions were investigated: the dianions $[B_{12}X_{12}]^{2-}$ ($X = F, Cl, Br, I$) and the dication $[Ru(bpy)_3]^{2+}$.

Both species were deposited individually or in combination—side by side or on top of each other. Using spectral imaging, the spatial distribution of the various ions could be clearly visualized. A main objective was the identification

and distribution of impurities and counterions resulting from reactions with air. These include numerous organic and inorganic species.

Ion soft-landing layers have great potential for applications in sensor technology, catalysis, and nanoelectronics. However, the current focus of the investigations is directed towards fundamental research. The new IR imaging results provide important insights into charge balancing processes and contribute significantly to our understanding of layer formation.



Prof. Dr. Jonas Warneke (right), scientific director of the “Molecular Ion Deposition” JointLab at the IOM and professor of physical chemistry of reactive intermediates at the University of Leipzig, and Dr. Evgeny Lugovoy (left) at the apparatus for depositing layers using ion soft landing. Photo: Erik Kazak

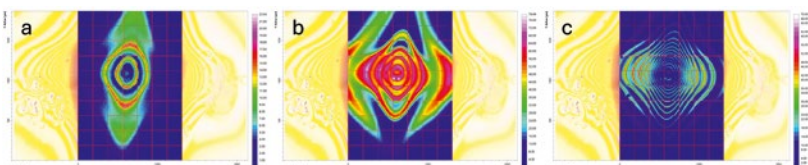
NON-DESTRUCTIVE ANALYSIS METHOD

Unlike previous methods, IR microspectroscopy is completely non-destructive and, for the first time, allows large-area, spatially resolved measurements of the sensitive layers. This enables the acquisition of insights that are inaccessible with destructive methods. Another advantage: The same layer can subsequently be examined using other analytical methods.



PROJECT LEADER Dr. Tom Scherzer

studied physics and earned his PhD in polymer physics. He was working at IOM since 1994 in various positions and on a broad range of topics. His current research focuses on the characterization of surfaces using various spectroscopic techniques, including the development of new methods required for this purpose.



Spectral images of ions deposited by ion soft landing: a) $[Ru(bpy_3)]^{2+}$, b) $[B_{12}X_{12}]^{2-}$, c) molecular species with a vibrational band around 3300 cm^{-1} , each based on absorption bands characteristic of the respective structure. The images were obtained by scanning the sample with the FPA detector (7×10 individual measurements, each with 4096 pixels), so they are based on nearly 300,000 IR spectra. Fig.: Dr. Olesya Daikos

Incubator: Explorative Projects

Molecular switches for smart surfaces

Smart surfaces that respond selectively to external stimuli such as electrical voltage, light, or chemical changes are emerging as key enablers for energy-efficient data storage, advanced information processing, and highly sensitive sensing technologies. A central challenge is achieving precise understanding and control of the coupled electronic and structural dynamics of redox-active molecules across diverse environments, ranging from the gas phase to surface-bound states.

FROM THE SINGLE MOLECULE TO THE SWITCHABLE SURFACE

The goal of this research is to establish the fundamental principles for functional surfaces in which individual molecules undergo well-defined redox reactions. To achieve this, we synthesize redox-active polyoxometalate (POM) molecules, immobilize them on surfaces, and systematically investigate with respect to their switching behavior.

We employ a multimodal approach combining surface functionalization, scanning probe microscopy, spectroscopic techniques, and scanning electrochemical cell microscopy (SECCM). This enables direct tracking of the evolution from isolated molecular entities to interactive surfaces exhibiting collective switching phenomena.

POM molecules are particularly well suited for this purpose, as they can reversibly accept and donate multiple electrons without significant structural rearrangement – an essential property for stable and reproducible multistate switching processes.

In close collaboration with research partners in Leuven and Warwick, the influence of targeted chemical modifications on POM properties has been systematically studied across different aggregation states. In parallel, SECCM has been further developed to assess redox responses of POMs in surface-confined microdroplets.

These approaches, for the first time, enable unprecedented control over the electronic properties of individual POM molecules, while allowing precise tuning of their interactions with the surrounding environment.

SWITCHING WITH NANOMETER PRECISION

The results demonstrate that molecular switching behavior can be precisely tuned through tailored surface functionalization. Using SECCM, the activity of individual switching sites can be mapped with nanometer-scale resolution.

This enables direct correlation between molecular structure, redox potential, and surface reactivity – marking a significant step toward programmable, intelligent surfaces.

PERSPECTIVES FOR LEARNING-CAPABLE MATERIALS

Redox-switchable surfaces open new possibilities for molecular data storage,

electrochemical sensing, and adaptive materials.

In the long term, such systems could serve as building blocks for neuromorphic electronics, where surfaces themselves operate analogously to synaptic networks – an approach for chemically controlled, “learning” materials.

FROM THE MOLECULE TO FUNCTIONAL INTELLIGENCE

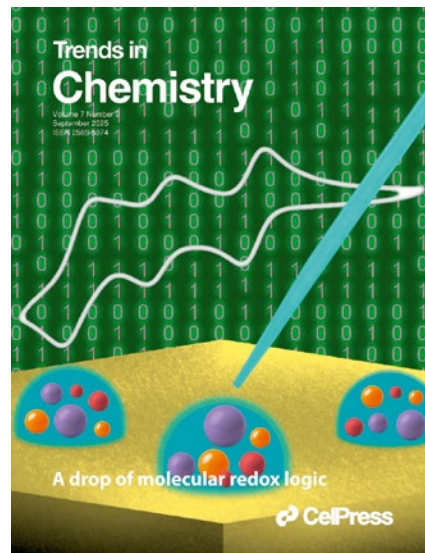
A key innovation of this work lies in its cross-scale approach, spanning from individual molecules to chemically tailored surfaces and functional switching architectures.

It demonstrates, for the first time, how the electronic properties of individual POM molecules can be controlled through targeted chemical modification and surface design, and how these processes can be monitored in situ and under ambient conditions

Patents:

E. Vogelsberg, C. Hackl, K. Y. Monakhov, Neue chemische Verbindung für einen elektrochemischen Sensor (DE102023114778.1), Deutsches Patent- und Markenamt.

E. Vogelsberg, K. Y. Monakhov, Polyoxovanadat als Photoinitiator in der Polymerisation von Monomeren bzw. Oligomeren (DE102023123638.5), Deutsches Patent- und Markenamt.



Digital encoding via redox states of POM molecules in surface-confined microdroplets. Fig. from: Trends in Chemistry, Cell Press



"When individual molecules on a surface learn to respond to electrical impulses, the boundary between chemistry and electronics is redrawn."

Dr. Kirill Monakhov

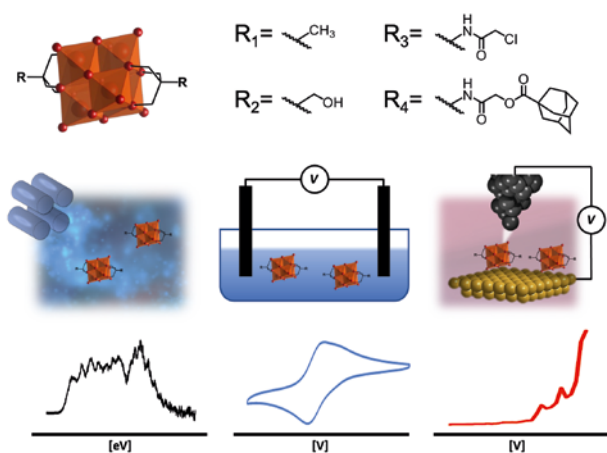
Dr. Yusen Luo, research associate, at the photoelectron emission microscopy (PEEM) system, which is used to study molecular layers and individual molecules on surfaces. Photo: Erik Kazak

Publications

F. Yang et al., Adv. Mater. Interfaces (2024) 11, 2400411.



N. Al-Shamery et al., Trends in Chemistry (2025) 7, 494–496



Behavior of various POM molecules in different states of matter.

Fig. from: Advanced Materials Interfaces, Wiley



PROJECT LEADER

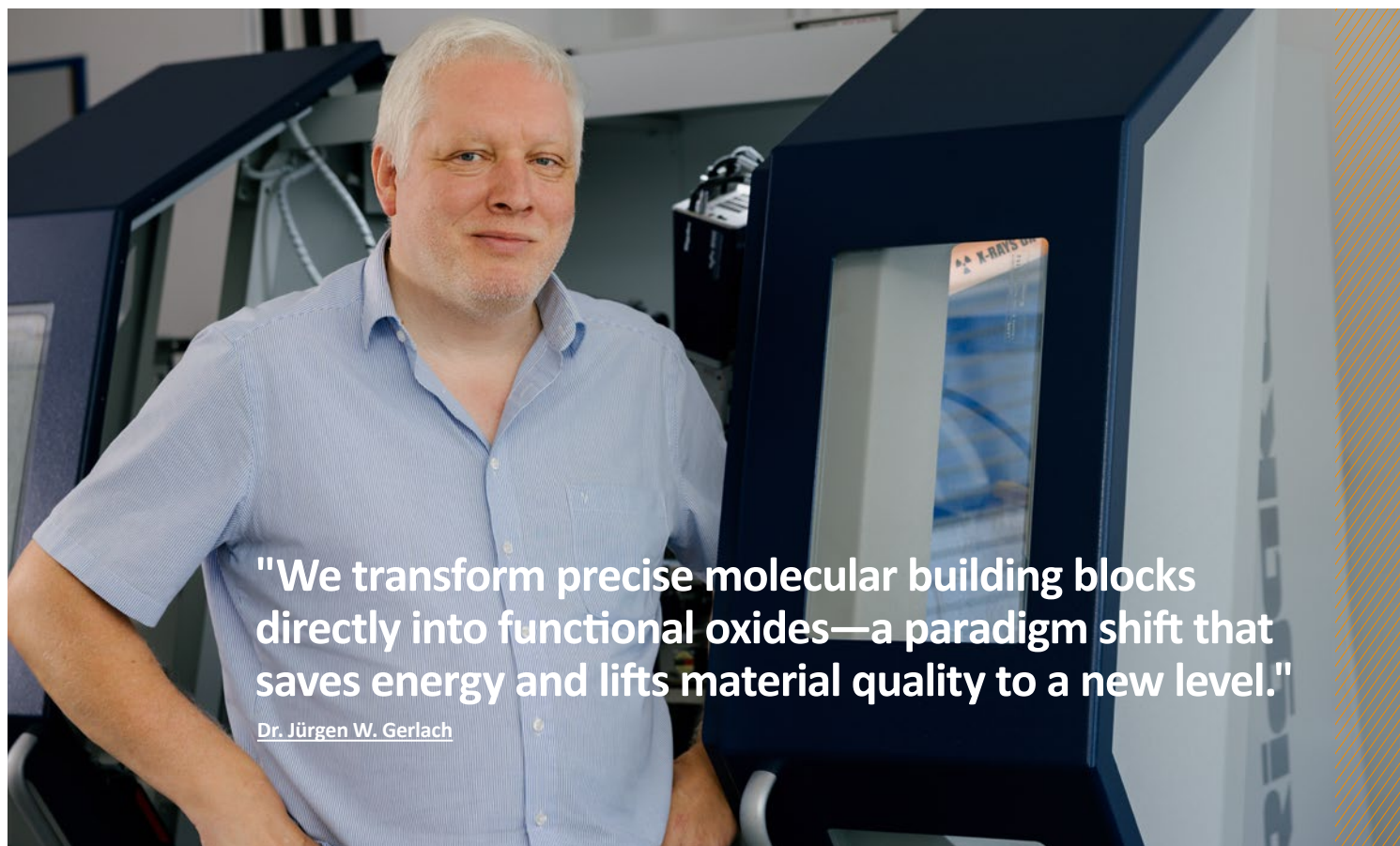
Dr. Kirill Monakhov

is a group leader at the IOM and a chemist. He focuses on the chemistry of molecular metal oxides and molecular-based hybrid materials and their application in materials science.

The project is funded by the Institute of Advanced Study (IAS) at the University of Warwick as part of the IAS Visiting Professorship Award, as well as by the DFG Priority Program SPP 2262 MemrisTec and the Transregional Collaborative Research Center TRR 368 HYP*MOL.

Incubator: Explorative Projects and
Barrier and Precision Coatings

From molecules to functional oxides: A new path to energy-efficient storage materials



"We transform precise molecular building blocks directly into functional oxides—a paradigm shift that saves energy and lifts material quality to a new level."

Dr. Jürgen W. Gerlach

Dr. Jürgen W. Gerlach, research scientist, at the X-ray diffractometer that is used to characterize thin films. Photo: Erik Kazak

The steadily growing demand for energy-efficient data storage poses major challenges for materials research. In particular, so-called memristive memory—materials that “remember” previous electrical states—are considered promising alternatives to conventional technologies. They are based on thin oxide films of transition metals that can be switched between different resistance states through controlled changes in metal valence. Existing fabrication methods, such as magnetron sputtering, pulsed laser deposition (PLD), or atomic layer deposition (ALD), are energy-intensive and require high process temperatures.

Furthermore, they result in non-uniform film compositions, which limits material quality and switching stability.

The goal of the DFG project “House of Oxides,” coordinated by the IOM, is to develop a low-energy yet precise method for fabricating mixed-metal oxide films.

MOLECULAR-BASED APPROACH FOR PRECISE OXIDE STRUCTURES

“House-of-Oxides” takes a molecular-based approach: Instead of depositing oxide films directly at high-temperature

conditions, precisely defined transition-metal oxo-clusters are first synthesized—small, stable molecular building blocks containing multiple metal centers in a precise arrangement.

They are deposited on various substrates and subsequently converted into highly ordered mixed-metal oxide films through moderate heat treatment at a maximum temperature of 300 °C or via UV light irradiation. This results in significant energy savings and thus offers decisive advantages. Transition metal oxides are key functional materials in electronics, catalysis, and energy storage. In recent years, it has

become apparent that mixed oxides—that is, combinations of different metals—can form particularly stable and switch-active films.

However, conventional methods rarely achieve a uniform distribution of metals at the atomic level. Here, the use of molecular clusters as “blueprints” for the subsequent oxide structure opens up a completely new dimension of precision in materials fabrication.

In the framework of the project, we synthesize zirconium- and cerium-based oxo-clusters containing various 3d, 4f, and/or alkaline earth metals, and then deposit them on different surfaces. Upon subsequent thermal or photochemical conversion, phase-pure, homogeneously mixed oxide films are formed—a decisive advance over previous high-temperature processes.

This method not only enables energy-efficient production but also allows for precise control of the material composition at the molecular level. The low-temperature routes developed in the project

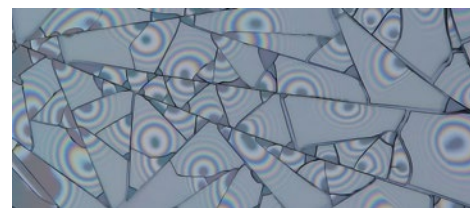
open up new perspectives for the sustainable production of modern electronic materials. In addition to resistive memory, the oxide layers produced in this way could also find applications in sensor technology, catalytic processes, or as transparent electrodes.

In the long term, the method contributes to establishing resource-efficient and scalable production processes for future electronic components.

The innovation lies in the use of atomically defined, organically functionalized metal-oxo clusters as precursors for solid-state oxide films.

This determines the composition of the resulting oxides derived from solution-processable molecules—a crucial difference from purely physical high-temperature processes.

Furthermore, the method combines chemical precision with low processing energy—a combination that is unique to date.



Networks of functionality from molecular fragments. Zr₆Co₆-derived oxide film on SiO₂/Si(100), produced by an energy-efficient low-temperature cluster approach (100 μm). Fig.: Mafaz Ahmed



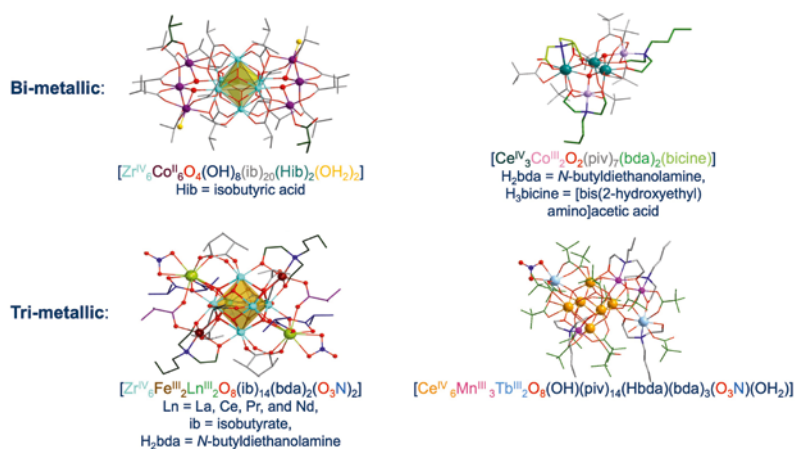
PROJECT LEADERS

Dr. Kirill Monakhov

is a group leader at the IOM and a chemist. He focuses on the chemistry of molecular metal oxides and molecular-based hybrid materials and their application in materials science.

Dr. Jürgen W. Gerlach

is a research scientist and physicist specialized in fundamental research on the deposition of thin films using various physical vapor deposition methods, as well as their characterization.



Structures of single-molecule precursors (metal-oxo clusters) based on Zr (left) and Ce (right) for the production of oxide films. Fig.: Kirill Monakhov

This project is funded by the German Research Foundation (DFG) (Grant No.: 537270815).

Material Characterization and Analytical Service / Leipziger nanoAnalytikum (LenA)

Rethinking layer structures: how atoms shape materials

Modern functional materials are increasingly based on complex, layered structures in which even the smallest atomic displacements significantly alter the electrical or thermal properties. Two recent studies at the Leipzig nanoAnalytikum (LenA) impressively demonstrate how such rearrangements and novel layered structures can be made directly visible for the first time, and what significance this has for future storage technologies and thermal applications.

Ge-Sb-Te: STORAGE MATERIALS CHANGE STRUCTURE

Phase-change materials based on Ge-Sb-Te (GST) form the core of novel data storage and neuromorphic memory concepts. They can switch between amorphous and crystalline states—a process in which atoms rearrange themselves in a characteristic manner. Although these mechanisms are central to the function of such memories, details of the crystalline-to-crystalline transitions have so far been described only theoretically.

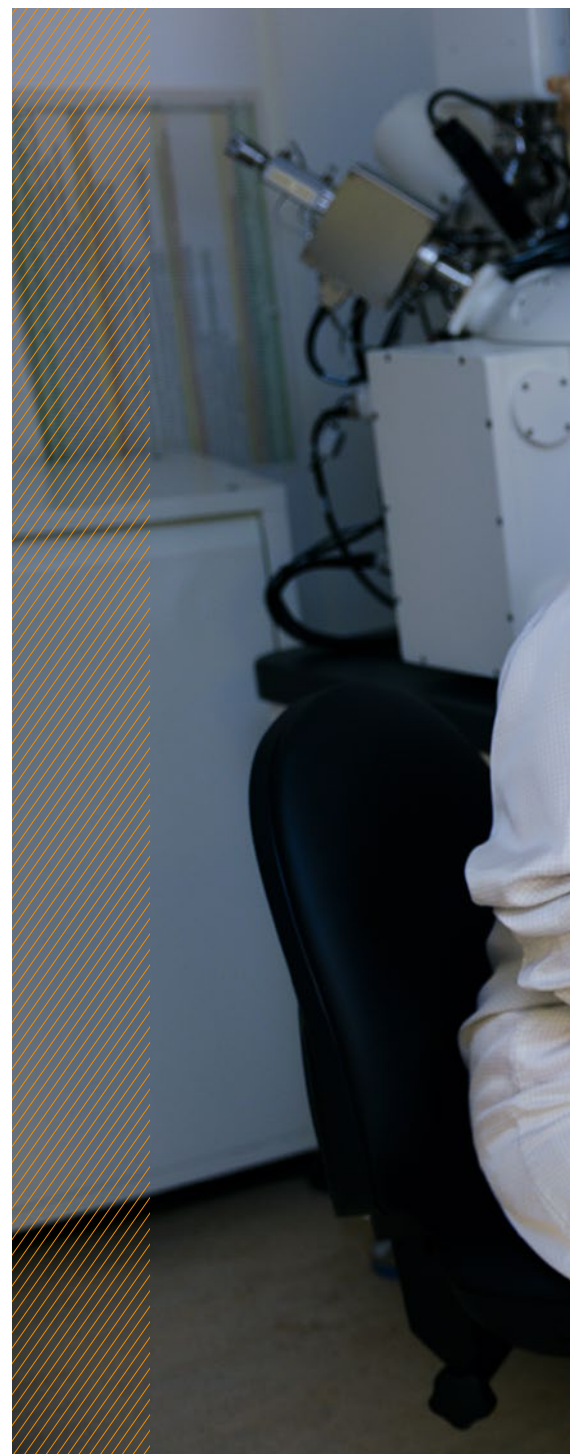
Using an *in-situ* heating module in a high-resolution transmission electron microscope, the researchers succeeded in

directly observing the structural changes during heating. Complementary *in-situ* X-ray measurements confirmed the results. This revealed how initially disordered vacancies transform into ordered, layered structures and which transient intermediate states enable this transition. The long-sought evidence that isolated vacancy layers collapse into van der Waals-like gaps was also experimentally demonstrated.

These findings provide a deep understanding of the atomic transformation mechanisms in GST and open up new possibilities for specifically controlling microstructure and stability—an important step toward faster, more reliable, and more energy-efficient storage technologies.

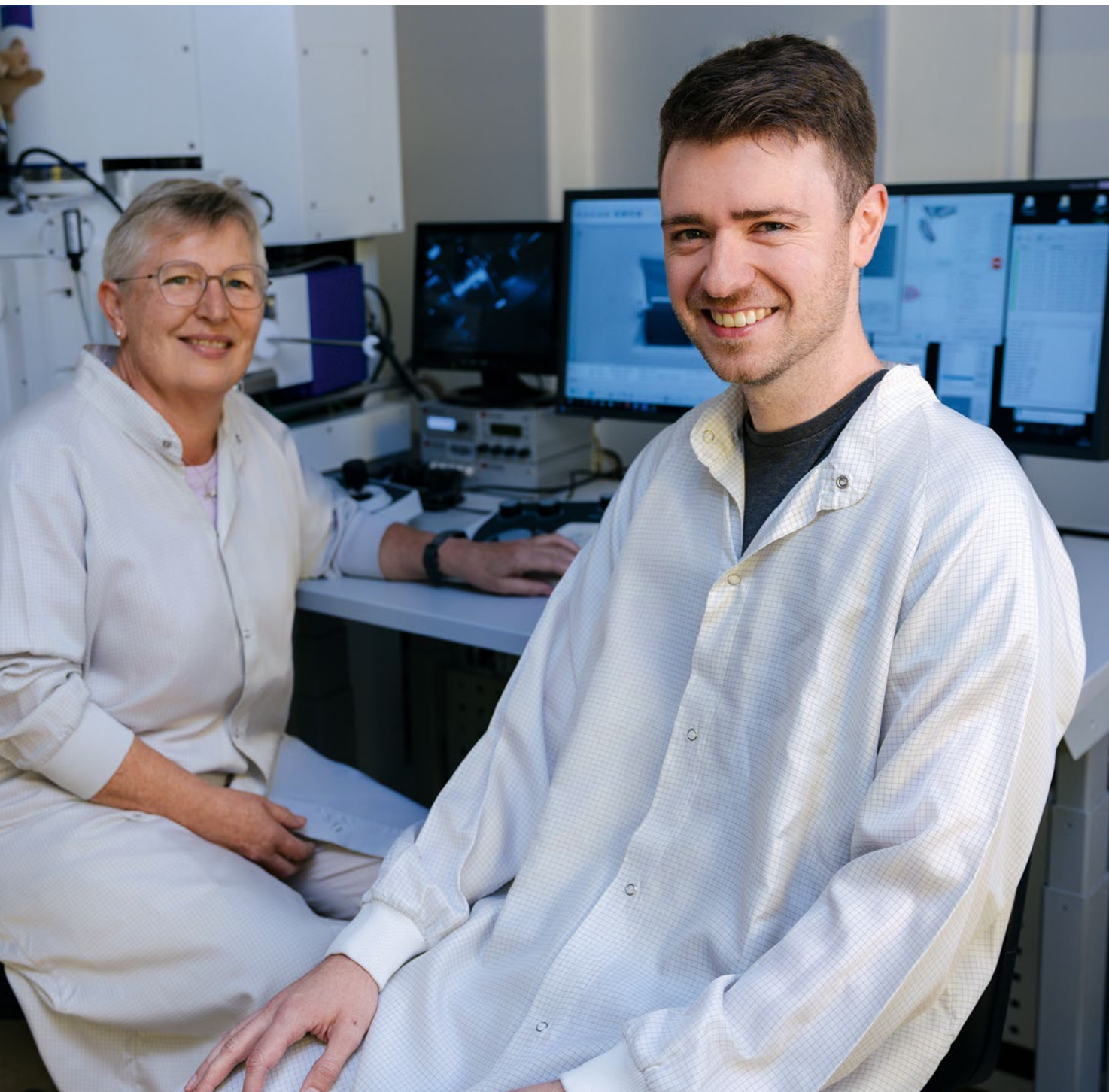
Cu₇Te₄: PRECISE CONTROL

While GST is primarily relevant for electronic memory devices, copper telluride plays an important role in areas where heat and charge transport must be precisely controlled. However, the structure of the material has so far been incomplete. Earlier models described exclusively two-layer phases—yet theoretical indications of further variants could never be unequivocally confirmed experimentally.



Using high-resolution electron microscopy and accompanying image simulations, experimental evidence of a three-layer Cu₇Te₄ structure has now been obtained for the first time. Not only did the sequence of the tellurium layers become visible, but also the order and disorder within the copper sublattice, as well as characteristic defects.

Furthermore, it was shown that the three-layer phase can transition into the known two-layer variant through short atomic movements.



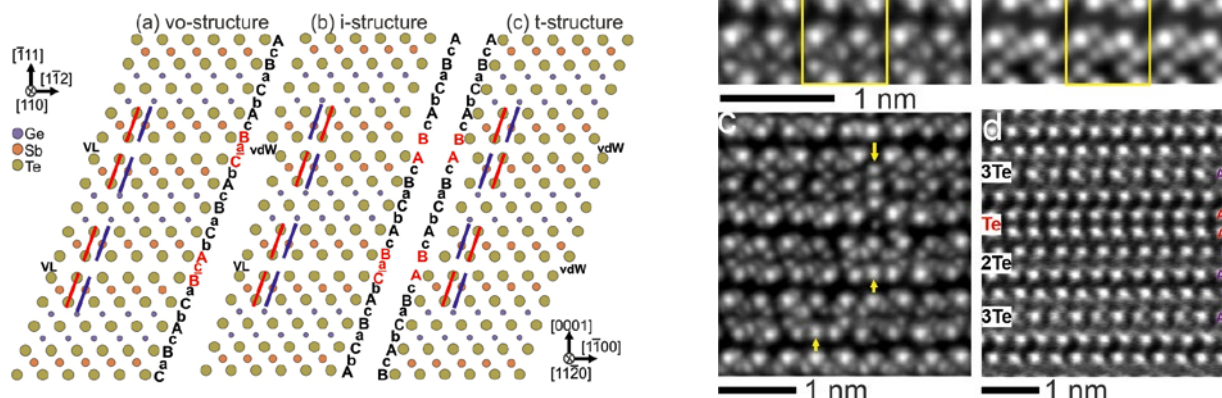
Agnes Mill, technical staff member, and Nils Braun, research associate, at the Focused Ion Beam facility, which is used for the preparation of TEM samples.
Photo: Erik Kazak

Publications:

A. Lotnyk et al: Acta Mater. 266
(2024) 119670

A. Lotnyk et al: ACS Appl. Nano Mater. 8
(2025) 11621-11628





Left: Schematic representation of the shear transformation mechanism in the GST system and the collapse of vacancy layers (VLs) into van der Waals-like gaps (vdW gaps). (a) vo-structure consisting of three GST units separated by VLs. (b) i-structure is an intermediate structure. (c) t-structure is the final stable structure.

Right: Atomic-resolution images. (a) Experimental image of the new Cu₇Te₄ structure and (b) simulated image based on the proposed structural model. Defects in the Cu₇Te₄ structure: (c) twin boundary and (d) stacking fault. Fig.: Andriy Lotnyk

These new insights open up prospects for applications in thermoelectrics, as structural defects specifically influence thermal conductivity and thus enable tailored material properties.

ATOMIC INSIGHTS FOR FUNCTIONAL MATERIALS

Both studies demonstrate how crucial atomic structural information is for understanding and further developing modern functional materials—whether for data storage or for controlling thermal properties. Using state-of-the-art electron microscopy and complementary analytical methods, it is possible to visualize previously hidden intermediate states, defects, and layered structures. The results form the basis for materials whose properties can be specifically tailored through their atomic architecture.

The development of innovative materials and surfaces requires a deep understanding of their atomic structures, defects, and interfaces, as these factors significantly determine the materials' properties. Research into nanoscale structures plays a

crucial role in this context. At the IOM, this expertise is concentrated within the LenA and is continuously being expanded.

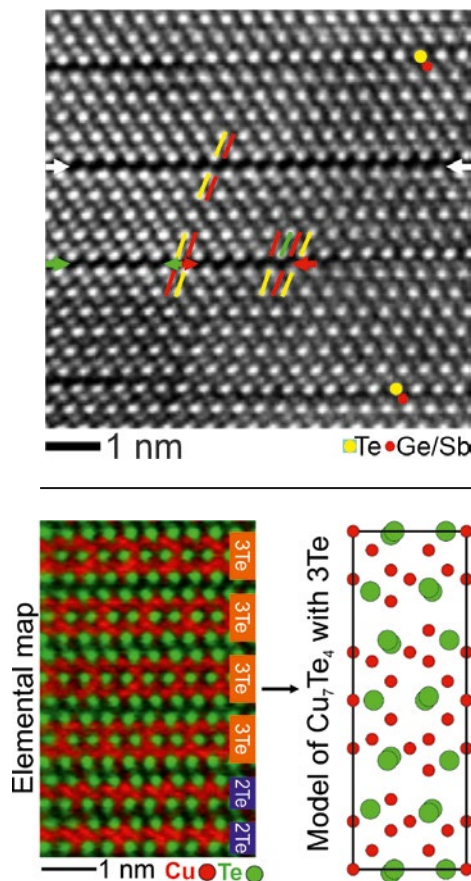
Research activities at LenA focus on elucidating the actual structure of a wide variety of material systems and on investigating dynamic processes using in-situ transmission electron microscopy (TEM). This allows structural changes to be observed directly and in detail under realistic conditions, such as during temperature changes or electron beam irradiation. Both fundamental and application-oriented questions are addressed.

Currently, research at LenA is focused on investigating the atomic structure of switchable surfaces, their influence on material properties, and the targeted fabrication and modification of such surfaces for applications in microelectronics.

In addition, LenA offers extensive capabilities for the structural and chemical characterization of functional materials and surfaces at the nanoscale. It provides access to state-of-the-art electron analytics, including aberration-corrected TEM,

Environmental Scanning Electron Microscopy (ESEM), as well as precise sample preparation using Focused Ion Beam (FIB), NanoMill, and ultramicrotomy. Through interdisciplinary collaboration within the IOM and with external partners, LenA makes a significant contribution to the development of materials and methods.

"Direct nanoscale observations provide insights into atomic rearrangements and local structures of newly forming phases; even the smallest changes form new arrangements and influence material properties." **Dr. Andriy Lotnyk**



Above: Atomic-resolution image of the transition region showing the shear transformation mechanism. The incomplete transition is evident from the additional Te planes in the core region (marked in green). Red arrows: transition region, green arrows: van der Waals gaps, white arrows: vacancy layer.

Below: Elemental map of Cu and Te in the three-layer Cu_7Te_4 (3Te) at atomic resolution, along with the corresponding structural model.

Fig.: Andriy Lotnyk



PROJECT LEADER

Dr. rer. nat. habil. Andriy Lotnyk

is head of the Leipziger nanoAnalytikum (LenA) at the IOM, where he studies the atomic structure of materials and how it influences their properties. His research also focuses on the fabrication and modification of switchable surfaces for applications in microelectronics.

This research was funded by the German Research Foundation (DFG) (grant numbers: 448667536 and 445693080) and is being conducted in collaboration with the GFZ Helmholtz Centre for Geosciences (Dr. Vladimir Roddatis) and the University of Kiel (Prof. Lorenz Kienle).



IOM
Leibniz Institute of
Surface Engineering

Publication Highlights

Publication Highlights 2024/25

Tools

Hertz Electron Beam Laboratory Contributes to New Research on Color Centers in SiC

Optically addressable spin defects in silicon carbide (SiC), such as silicon vacancy (V2) centers, represent a new platform for quantum information processing that is compatible with the nanomanufacturing processes and device controls used in the semiconductor industry. V2 centers in 4H-SiC, which exhibit excellent optical and bulk properties, were implanted via MeV electron irradiation without compromising their intrinsic spin-optical properties. These irradiations are performed at the Hertz Electron Beam Laboratory—a research infrastructure of the Leibniz Association.

Several publications in renowned journals, resulting from the intensive collaboration between the Wrachtrup Group (University of Stuttgart) and the IOM, address various aspects of the application of V2 centers.

Heiler et al. [1] describe the maximization of photonic efficiency through the integration of V2 centers into nanophotonic structures, i.e., into submicron silicon carbide membranes.

Hesselmeier et al. [2,3] investigate the interaction of V2 centers with their nuclear spin environment to gain insights into the control and high-precision readout of nuclear spin qubits. This work is a first step toward the future use of SiC as a multi-qubit memory and platform for quantum computers. To improve readout, Körber et al. [4] integrated V2 centers into a cavity-based optical antenna. The structure consists of a silver-coated, 135 nm-thin 4H-SiC membrane that functions as a planar cavity with a broadband resonance and provides a gain factor of 9.

Steidl et al. [5] embedded V2 color centers into a metal-semiconductor epitaxial wafer device (Au/Ti/4H-SiC) operating in a Schottky diode configuration. The work demonstrated the low-temperature integration of a Schottky application with optical microstructures for quantum applications. It paves the way for fundamentally scalable and reproducible optical spin-defect centers in solids.

These works underscore the strategic potential of V2 centers in SiC as an industry-relevant quantum technology and strengthen the role of the IOM as a key partner for scalable quantum materials.

[1] Spectral stability of V2-centres in sub-micron 4H-SiC membranes

J. Heiler, J. Körber, E. Hesselmeier, P. Kuna, R. Stöhr, P. Fuchs, M. Ghezellou, J. Ul-Hassan, W. Knolle, C. Becher, F. Kaiser, J. Wrachtrup
npj Quantum Mater. 9 (2024) 34

[2] Qudit-based spectroscopy for measurement and control of nuclear-spin qubits in silicon carbide

E. Hesselmeier, P. Kuna, I. Takács, V. Ivády, W. Knolle, N.T. Son, M. Ghezellou, J. Ul-Hassan, D. Dasari, F. Kaiser, V. Vorobyov, J. Wrachtrup
Phys. Rev. Lett. 132 (2024) 090601





Wolfgang Knolle, research assistant, at the 10 MeV electron accelerator in the Hertz Electron Beam Laboratory at the IOM.
Photo: Jan Woitas

[3] Fluorescence enhancement of single V2 centers in a 4H-SiC cavity antenna

*J. Körber, J. Heiler, P. Fuchs, P. Flad,
E. Hesselmeier, P. Kuna, J. Ul-Hassan,
W. Knolle, C. Becher, F. Kaiser,
J. Wrachtrup*
Nano Lett. 24 (2024) 9289-9295

[4] High-fidelity optical readout of a nuclear-spin qubit in silicon carbide

*E. Hesselmeier, P. Kuna, W. Knolle,
F. Kaiser, N.T. Son, M. Ghezellou,
J. Ul-Hassan, V. Vorobyov, J. Wrachtrup*
Phys. Rev. Lett. 132 (2024) 180804

[5] Single V2 defect in 4H silicon carbide Schottky diode at low temperature

*T. Steidl, P. Kuna, E. Hesselmeier-Hüttmann,
D. Liu, R. Stöhr, W. Knolle, M. Ghezellou,
J. Ul-Hassan, M. Schober, M. Bockstedte,
G. Bian, A. Gali, V. Vorobyov, J. Wrachtrup*
Nat. Commun. 16 (2025) 4669



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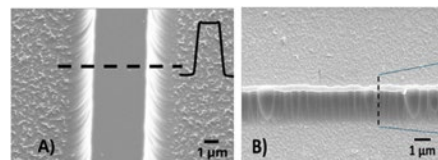
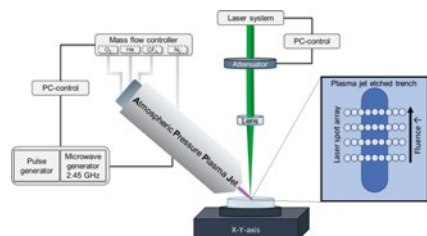
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Ultra-precision Surfaces

Applied Surface Science



Impact of the temperature on laser ablation of residues from APPJ-etched N-BK7 optical glass

R. Heinke, M. Ehrhardt, P. Lorenz,
K. Zimmer, T. Arnold
Appl. Surf. Sci. 702 (2025) 163321

The processing of optical materials such as quartz glass and silicon carbide using an atmospheric pressure plasma jet (APPJ) enables the production of free-form optical surfaces with excellent precision and low surface roughness. However, the conventional APPJ etching process of the commonly used optical glass N-BK7® with fluorine-containing gases has drawbacks, as metal fluoride residues remain on the surface due to the metal oxides contained in the glass, which hinder further processing. The goal of the fundamental study was to remove these residues using pulsed laser irradiation. Therefore, suitable laser parameters had to be identified. It was demonstrated that residual layers formed by plasma etching at various temperatures can be completely removed at laser wavelengths of 193 nm and 248 nm. These results were achieved as part of a DFG project that was successfully completed in 2025.

Low-energy ion beam erosion of Si with simultaneous co-deposition of metallic surfactants: Experimental and simulated data

F. Linß, C. Bundesmann, F. Frost
Appl. Surf. Sci. 646 (2024) 158923

Ion beam erosion of silicon combined with the co-deposition of other materials leads to the formation of surface patterns in the nanometer and micrometer ranges. This study investigated how the combination of ion beams and co-deposition materials such as aluminum, copper, steel, and other metals influences the surface structure of Si. To this end, Si samples and the co-deposition materials were simultaneously irradiated using an ion source. Scanning electron microscopy (SEM) and atomic force microscopy (AFM) showed that metals that form silicides enhance the surface structure and produce a rough surface. Metals that do not form silicides, on the other hand, resulted in a smooth surface. The rate at which Si is etched also depends on the co-deposition material used. Metals that scatter the primary ions more strongly promoted sputtering, while metals with lower atomic weights tended to promote so-called "self-sputtering," which led to lower Si erosion. These results were achieved as part of the successfully completed EU project "IT 2 - IC Technology for the 2 nm Node."

Transfer of micron pattern with reactive atmospheric plasma jets into fused silica

M. Ehrhardt, P. Lorenz, J. Zajadacz,
R. Heinke, T. Arnold, K. Zimmer
Appl. Surf. Sci. Adv. 23 (2024) 100636

Plasma etching is the key technology for transferring lithographic micromasks for microelectronics and similar microapplications. However, current plasma etching technologies require a vacuum, which consumes significant material and energy resources and limits throughput and application flexibility. Recent work by the IOM, shows that pattern transfer in fused silica (SiO₂) is possible even without vacuum conditions using a reactive atmospheric pressure plasma jet. In this approach, features with widths ranging from 2.5 µm to 50 µm were transferred from an aluminum mask to quartz glass using a plasma jet. The process combines a high etching rate of approx. 200 nm/s with high vertical precision. Etching depths of over 4 µm, which can also be adjusted locally, were achieved. These results demonstrate a cost-effective method for patterning quartz glass, which is of great interest for various microtechnological and optical applications. These findings, achieved in a DFG project successfully completed in 2025, offer a wide range of application opportunities for future green production.



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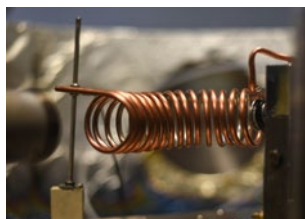


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Barrier and Precision Coatings

Applied
Physics Review

Glow, arcs, ohmic discharges: An electrode-centered review on discharge modes and the transitions between them

A. Anders

Appl. Phys. Rev. 11 (2024) 031310

This review combines empirical observations of gas discharges with a mechanistic approach based on electron emission. It introduces a new classification that takes complex plasma conditions into account and provides updated voltage-current diagrams that link fundamental discharge physics with modern plasma applications. Gas discharges are classified according to their optical appearance as well as their current and voltage levels. Glow and arc discharges are the best-known types in which electrodes play a role. They differ in their current and voltage levels; current-voltage characteristics are common representations of these relationships. The article defines glow discharges based on their specific electron emission mechanisms, such as secondary electron emission initiated by photons and primary ions and characterizes arcs through collective mechanisms such as thermionic or explosive electron emission. This paper was selected as a "Featured Article" by Applied Physics Reviews in 2024.

Intern. Journal of
Hydrogen Energy

Hydrogen permeation through uniaxially strained SiO_x barrier thin films photochemically prepared on PET foil substrates

P.C. With, T. Pröhl, J.W. Gerlach, A. Prager, A. Konrad, F. Arena, U. Helmstedt

Int. J. Hydrog. Energy 81 (2024) 405-410

Hydrogen permeation through uniaxially strained SiO_x gas barrier films, which were produced at room temperature and ambient pressure via UV photochemical conversion on PET foil substrates, was investigated using a dedicated measurement system. Hydrogen permeation measurements were performed as a function of the number of laminated SiO_x barriers, sample temperature, and mechanical stress. The results show a significant improvement in hydrogen barrier properties for both single and laminated SiO_x barrier films on PET foil. However, in stressed samples, the hydrogen barrier properties deteriorate due to stress-induced cracking in the films. This deterioration is most pronounced in single SiO_x barrier films but can be significantly reduced through lamination. This publication was produced as part of the SAB project "Stretchable gas barrier films for implementing the green hydrogen economy."

Surface and Coat-
ings Technology

Decoupling the effects of potential energy, kinetic energy, and ion flux on crystallinity of V-Al and V-Al-N thin films in pulsed filtered cathodic arc deposition

D. Kalanov, S. Mandazhiev, J. Franze, A. Anders, Y. Unutulmazsoy

Surf. Coat. Technol. 497 (2025) 131720

Pulsed cathodic arc deposition produces dense thin films with high adhesion, in which the influence of energetic ions plays a decisive role. To date, little research has been conducted on potential energy, particularly in the case of multiply charged metal ions. This is because generation of higher ion charge states in arcs is always associated with increased ion flux and kinetic energy. In this work, the effect of potential energy on the structural properties of thin films is investigated for the first time, while the average kinetic energy and ion flux remain constant. Two material systems are analyzed: metallic V-Al and V-Al-N in non-reactive and reactive deposition. For V-Al plasmas, the influence of the potential energy of the metal ions is determined. For V-Al-N, activated nitrogen species are additionally of importance for the crystal growth of the metastable cubic phase.



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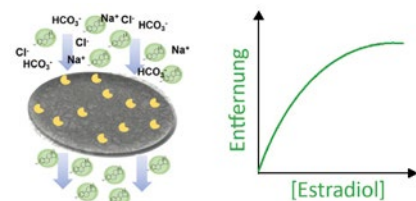
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Surfaces of Porous Membrane Filters

Water Research



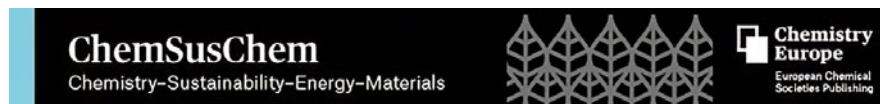
Ultrafiltration and composite microfiltration biocatalytic membrane activity and steroid hormone micropollutant degradation at environmentally relevant concentrations

A. Imbrogno, M. Schmidt, A. Schulze, M.T. Moreira, A.I. Schäfer
Water Res. 272 (2025) 122902

As part of a German-Spanish collaboration between the Department of Porous Membrane Filters at the IOM, the Karlsruhe Institute of Technology, and the University of Santiago de Compostela, research was conducted on the biocatalytic removal of pollutants from water. The study focused on the behavior of the hormone estradiol at realistic environmental concentrations using innovative enzyme-membrane reactors. The study showed that parameters such as hydraulic retention time, flow rate, and water composition are critical for reaction kinetics and enzyme activity. The results provide valuable insights for the further development of efficient biocatalytic membranes for modern water treatment.

Material Characterization and Analytical Service / Surfaces of Porous Membrane Filters

ChemSusChem



One-pot depolymerization of mixed plastics using a dual enzyme system

Y. Branson, J. Liu, L. Schmidt, J. Griebel, A. Prager, L. Stieler, D. Breite, T. Bayer, W. Besenmatter, W. Dong, U. Garscha, U. Bornscheuer, R. Wei
ChemSusChem 18 (2025) e202402416

Innovative approaches are crucial for sustainable waste management. Enzymatic depolymerization has emerged as a promising recycling method for polyester through monomer recovery under mild conditions. However, current research focuses primarily on the use of a single plastic feedstock, which can only be obtained through a complex and costly sorting process of plastic waste.

In this study, an international consortium involving the IOM investigated the enzymatic depolymerization of mixed plastics using a dual-enzyme system in a one-pot process.

Using the polyester hydrolase PES-H1 FY and the (poly)urethanase UMG-SP-2, mixed polymers consisting of polyethylene

terephthalate (PET), polybutylene adipate-co-terephthalate (PBAT), and thermoplastic polyester-polyurethane (TPU) were depolymerized into their monomers. Chromatographic quantification yielded a total yield of monomeric products of up to $39.8 \pm 4.4\%$ after 96 hours of reaction, which was consistent with the weight loss measurements of $40.9 \pm 2.5\%$.

Furthermore, it was shown that a modified dissolution-precipitation method could easily blend the three different polymers while simultaneously improving their degradability. This suggests that the use of mixed enzymes is a viable method for recycling mixed or co-contaminated plastic waste without the need for polymer sorting. Individual monomers can be separated and purified to produce new polymers, while their mixture in the hydrolysate can readily serve as a feedstock for microbial upcycling into value-added products.



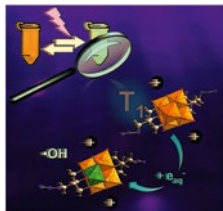
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Incubator: Explorative Projects

Advanced Science

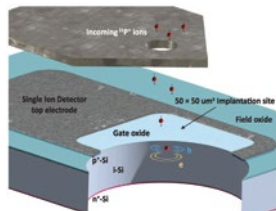

Reversible optical switching of polyoxovanadates and their communication via photoexcited states

E. Vogelsberg, J. Griebel, I. Engelmann, J. Bauer, F. Taube, B. Corzilius, S. Zahn, A. Kahnt, K. Y. Monakhov
Adv. Sci. (2024), 11, 2401595

In this study, conducted in collaboration with the University of Rostock, it is demonstrated for the first time that molecular vanadium oxide clusters (so-called polyoxovanadates) act as switchable, light-activated electron acceptors. Upon light excitation, these clusters directly exchange electrons with one another under anhydrous conditions—without the involvement of positively charged counterions. Additionally, in the presence of water or humidity, the excited cluster can oxidize OH[−] ions to highly reactive •OH radicals, whereby the electrons released in the process reduce the clusters. Such a direct, light-controlled electron transfer between inorganic clusters was previously known only from fullerenes, organic donor-acceptor compounds, or photosystems in nature. The detection of this phenomenon in a purely inorganic material opens up new perspectives for molecular circuits and biomimetic energy conversion. The study is part of the collaborative DFG-subproject within the HYP*MOL network (CRC/TRR 386).

Tools

Advanced Materials

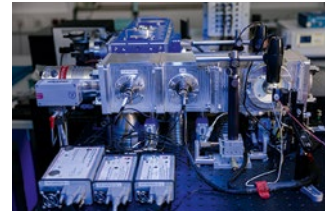

Scalable atomic arrays for spin-based quantum computers in silicon

A.M. Jakob, S.G. Robson, H.R. Firgau, V. Mourik, V. Schmitt, D. Holmes, M. Posselt, E.L.H. Mayes, D. Spemann, J.C. McCallum, A. Morello, D.N. Jamieson
Adv. Mater. 36 (2024) 2405006

Semiconductor spin qubits combine excellent quantum properties with the ability to fabricate quantum devices using industrially established metal-oxide-semiconductor (MOS) processes. This also applies to ion-implanted donor spins, which additionally exhibit long coherence times and a large Hilbert space dimension of their nuclear spin. The study combined several strategies for fabricating scalable donor-based quantum computers. By implanting ³¹PF₂ molecular ions, the detection efficiency was increased to 99.99%; comparable values were also achieved for heavy donors such as ¹²³Sb and ²⁰⁹Bi, which enable high-dimensional qudits. Furthermore, scalability was demonstrated through regular donor arrays spaced 300 nm apart. The work was carried out as part of a long-standing collaboration with the University of Melbourne, with the IOM making key theoretical contributions to the analysis of detection efficiency and donor arrangements.

Material Characterization and Analytical Service / Incubator: Explorative Projects

Angewandte Chemie


Control of intermediates and products by combining droplet reactions and ion soft-landing

F. Yang, R.D. Urban, J. Lorenz, J. Griebel, N. Koohbor, M. Rohdenburg, H. Knorke, D. Fuhrmann, A. Charvat, B. Abel, V.A. Azov, J. Warneke
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At JointLab, a novel methodological approach was implemented for the first time, specifically combining microdroplet chemistry with m/z-selective ion deposition. Accelerated reactions in charged microdroplets during electrospray ionization are used to generate reactive ionic intermediates, which are then mass-selected and allowed to react further on a substrate under gentle conditions. This work thus establishes mass spectrometry beyond its classical analytical role as a preparative tool for new synthetic routes. The proof-of-concept study allows, for the first time, the systematic comparison of reaction pathways of neutral and permanently charged reagents in microdroplets and in layers generated by ion soft landing. The results provide new mechanistic insights into the increased reactivity of partially solvated reagents on microdroplet surfaces and demonstrate a clear methodological breakthrough in preparative mass spectrometry.



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IOM

Leibniz Institute of
Surface Engineering

Communication & Media Highlights

Leadership Transition: Steering IOM Forward



A farewell ceremony for the outgoing Scientific Director, Prof. Dr. André Anders (left), and the introduction of his successor, Prof. Dr. Benjamin Dietzek-Ivanšić. (Photo: Stephan Görsch)



Guests from the worlds of politics, academia, and business attended the event. (Photo: Dietmar Hirsch)

On March 3, 2025, the ceremonial farewell of the outgoing Scientific Director, Prof. Dr. André Anders, and the inauguration of his successor, Prof. Dr. Benjamin Dietzek Ivanšić, took place. Numerous guests from politics, academia, and industry, including Saxon State Secretary Prof. Dr. Heike Graßmann and the Secretary General of the Leibniz Association, Dr. Bettina Böhm, paid tribute to Prof. Anders' achievements and welcomed the new leadership.

In the keynote speeches and technical presentations, the role of IOM as a key player in interdisciplinary materials and surface research was emphasized. Prof. Dietzek Ivanšić highlighted the importance of surface innovations and the commitment of the staff as crucial factors for success.

Investments: Expanded Research Infrastructure Boosts Innovation and Competitiveness at IOM

IOM is making targeted investments in its research infrastructure to further expand its leading role in materials and surface research. With financial support from the German federal government, the Free State of Saxony, the Saxon Development Bank (SAB), and the European Union as part of the ERDF and JTF funding programs, pioneering technologies and strategic initiatives are being implemented.

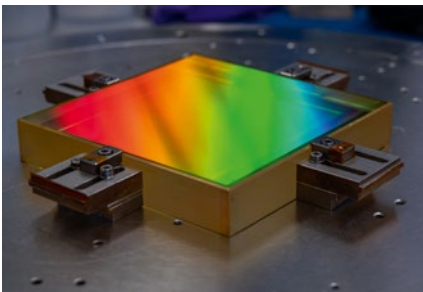
New ion beam research facility for sub nanometer precision

With around 2 million euros in funding from the Free State of Saxony, the Saxon Development Bank (SAB), and the European Union (European Regional Development Fund, ERDF), a new ion beam research facility is being established. It will enable, for the first time, the processing of optical components on a square meter scale with form and structural accuracies in the sub nanometer range. The core of the facility consists of novel processes in which reactive ion species with energies of up to 2000 eV remove material from surfaces with extremely high

precision. The optical elements produced in this way are used in semiconductor manufacturing, in ground based and space based telescopes, in diffractive optics, and in laser fusion research.

Commissioning of the facility is planned for the end of the three year project period. The development of the ion sources and beam diagnostics is being carried out in close collaboration between the Ultra Precision Surfaces research area and the Cross Sectional Unit Tools at IOM.

Advanced Ion Beam Etching for High-Performance Optics



Pulse Compression Gratings for Laser Applications
(Photo: Stephan Görsch)

In addition, the Free State of Saxony, supported by the Saxon Development Bank (SAB) and the European Regional Development Fund (ERDF), is investing around 825,000 euros in a new ion beam etching facility for structuring optical surfaces with diameters of up to 200 mm. This facility enables ultra precise processing with depth accuracies in the ångström range. A particular focus is on the development of processes for laser optics, such as anti reflective coatings and pulse compression gratings, which are essential for key technologies like laser inertial fusion power plants.

The modernization secures IOM's position as a globally leading institute in the ultra precision processing of large surfaces, a role that was recently reaffirmed during the evaluation by the Senate of the Leibniz Association.

Digital surface engineering: Strategic expansion for AI-based modeling and simulation

The Joint Science Conference (GWK) as well as the federal and state governments have approved funding for the strategic expansion project "Digital Surface Engineering," thereby increasing IOM's core funding by 2.7 million euros per year. The goal is to expand modeling and simulation capabilities with a focus on AI-based approaches.

Key elements include the development of new modeling methods, close integration with experimental surface research, and the establishment of a modern high performance computing infrastructure in collaboration with the AI Computing Center Leipzig (KIRZL) by 2027.

Additionally, IOM, together with the University of Leipzig, is filling a professorship in simulation and modeling and is strengthening interdisciplinary teams of theorists, data scientists, and software developers.

Partners such as ScaDS.AI, the Dresden Center for Computational Material Science (DCMS), and the Leibniz MMS network form a powerful ecosystem for data-driven materials and surface research. This initiative lays the foundation for advances in environmental technologies, health, optics, photonics, and quantum technologies.

Scientific Events: Networking, Knowledge Transfer, and Visibility in Research and Industry

In 2024 and 2025, numerous national and international specialist events shaped IOM's visibility within the scientific community. Whether in plasma and surface technologies, laser structuring, phase change materials, photonics, or AI methods, the institute actively contributed to shaping key discussions, took on organizational responsibilities, and provided impetus for innovation, collaboration, and technology transfer.

Exchange of experience on surface technologies with plasma and ion beam processes (OTPIP)



Participants at the 30th Exchange of Experience 2025 in Mühlleithen. (Photo: Jessica Niemann)

The traditional event in Mühlleithen takes place every March and has served since 1993 as a central platform for exchanging knowledge on plasma and ion beam processes and their diverse applications in surface engineering. Organized by the "Plasma Technology" working group at the Christian-Albrechts-University of Kiel and the Cross Sectional Unit Tools at IOM, the exchange of experience regularly provides participants with a comprehensive overview of current research findings, advances in diagnostics, modeling, and facility development, as well as topics from industrial practice.

In recent years, the focus has been on plasma and

ion beam sources and their diagnostics and modeling, plasma/ion beam–solid interactions, plasma chemical processes including reaction kinetics in the bulk and at surfaces, and the analysis and characterization of plasma- and ion beam-treated surfaces. Additionally, increasing importance is being placed on the development and qualification of electric propulsion systems for space applications.

The conference strengthens the integration of research, technology development, and industrial application, extending to innovations in electric propulsion technology for space missions.

12th Workshop on Laser-induced periodic surface structures

The LIPSS Workshop, held in September 2024, brought together scientists from six international and twelve national institutions. The focus was on the latest research findings regarding the formation mechanisms, characterization methods, and applications of laser-induced periodic surface structures. The program provided rich insights for methodological and

technological advancements and vividly demonstrated how interdisciplinary exchange drives innovation. The workshop was organized by the Laser-Assisted Micro- and Nanostructuring research group at IOM, with support from the German Research Foundation (DFG) and industry partners Trionplas Technologies GmbH and TOPAG Lasertechnik GmbH.

European Phase Change and Ovonic Symposium 2024

From September 22 to 25, 2024, EPCOS in Leipzig provided a leading forum for the international phase change community. Organized by IOM, the symposium brought together experts from science and technology to discuss current advances and perspectives in phase change materials research. Special attention was given to forward-looking topics such as neuromorphic computing, phase change memory, phase change photonics, and plasmonics. The event fostered interdisciplinary networking and contributed to the strategic development of the research field



Poster Session during the European Phase Change and Ovonic Symposium (EPCOS) 2024 at the University of Leipzig.

(Photo: Nils Braun)

UPOB – Cooperation for ultra precision surface processing



Meeting of the Members of the UPOB Competence Center for Ultra Precision Surface Processing at IOM. (Photo: Rudolf Meeß)

The Competence Center for Ultra Precision Surface Processing (UPOB) connects industrial companies, universities, and research institutions, including IOM, to advance highly precise manufacturing and measurement technologies. Research and work priorities include processing complex surface geometries, correcting polishing errors, coating technologies for optical components, as well as lithographic and online-supported measurement methods. The members' assembly in January 2025 at IOM focused on the strategic development of the association and the planning of joint technological activities.

INTERDISCIPLINARY AI COMPETENCIES IN THE LEIBNIZ NETWORK: Learning, connecting, applying



Participants of the Leibniz AI School 2025 during the joint workshop.
(Photo: Heike Kolossa)

How modern AI methods can be effectively applied in research and practice was the focus of several initiatives within the Leibniz Research Network Mathematical Modeling and Simulation. A highlight was the second Leibniz AI School 2025, which took place from October 6 to 9, 2025, in Leipzig and was jointly organized by Leipzig University, ScaDS.AI (Dresden/Leipzig), and the IOM. Participants from more than 20 Leibniz institutions deepened their expertise in high-performance computing, machine learning, deep learning, data wrangling, and visualization. The strongly practice-oriented format emphasized hands-on exercises using Python, scikit-learn, and PyTorch, once again establishing Leipzig as a hub for interdisciplinary knowledge exchange and methodological excellence.



Excursion participants and hosts in the Living Lab of ScaDS.AI Dresden.
(Photo: Siavash Ghiasvand)

As early as January 2024, doctoral researchers from the IOM had visited ScaDS.AI at TU Dresden as part of the Structured Doctoral Training Program and the AI Winter School. The excursion provided insights into current AI research projects on machine learning and neural networks, as well as their integration with domain knowledge from biology, chemistry, and physics. The program was complemented by information on the ScaDS.AI Graduate School and a tour of the Lehmann Center, TU Dresden's high-performance computing complex. Particular attention was given to the sustainable, water-cooled HPC infrastructure, whose waste heat is reused for building heating.

DUV/VUV Focus group of the photonics network Optence e.V.

On November 12, 2025, the IOM hosted the 44th working meeting of the DUV/VUV focus group of the photonics network Optence e.V. The program included scientific presentations from both research and industry, as well as guided laboratory tours at the institute. The joint contribution from the research area Ultra-precision Surfaces and the cross-sectional unit Tools focused on ion beam technologies and their applications.

For more than two decades, Optence has been successfully committed to knowledge transfer and collaboration along the entire value chain of optical technologies, connecting more than 100 members from research and industry.



Dr. Frank Frost, Head of the Ion Beam Assisted Patterning and Smoothing Group, presents his work to the participants.
(Photo: Martin Mitzschke)

Trade Fairs and Conferences: Visibility at International Forums and Strategic Presence in Key Technologies

The past two years have been marked by intensive participation of the IOM in trade fairs and conferences. At national and international professional forums, the institute presented its latest research results, strengthened its networking with industry and academia, and further expanded its position in technological innovation fields. The following key participations illustrate the thematic breadth and international relevance of IOM research.

16th Optatec 2024 – International trade fair for optical technologies

At the 16th Optatec in May 2024 in Frankfurt am Main, the IOM presented itself to an international professional audience from the photonics sector. With contributions in the fields of ion beam-assisted patterning and smoothing, as well as ion beam- and plasma jet-based ultra-precision figuring, the institute showcased its latest developments at the interface between engineering and fundamental physical research. In addition to presenting scientific results, the trade fair offered numerous opportunities for exchange with industry partners and for maintaining and expanding international contacts.



Exhibition showcase with exhibits. (Photo: Stephan Görsch)

LASER World of PHOTONICS 2025



Stephan Görsch (left) and
Felix Linß (right) at the IOM
exhibition booth.
(Photo: Gregor Dornberg)

From June 24 to 27, 2025, the research area Ultra-Precision Surfaces represented the IOM at LASER World of PHOTONICS in Munich, one of the world's leading trade fairs for optical technologies. At the joint booth of CC UPOB e.V., the researchers presented their methodological and technological expertise and held numerous discussions with professional visitors. Key trend topics included secondary sources, integrated photonics, biophotonics, and AI-based methods, fields in which the IOM is providing important momentum.

INTERNATIONAL RECOGNITION: IOM researchers at FMOCS VIII



Jonas Lorenz with his award. (Photo: Marco Moors)

The research group Switchable Molecularly Functionalized Surfaces successfully participated in the international conference Frontiers in Metal Oxide Cluster Science VIII (FMOCS VIII), held in Mainz from July 22 to 25, 2025. The conference is considered one of the most important forums in international polyoxometalate research. Presentations and poster contributions from the IOM received strong attention and contributed substantially to the scientific discourse. A particular highlight was the YoungFMOCS 2025 Best Presentation Award for Jonas Lorenz, underscoring the scientific excellence and international visibility of IOM research.

FOCUS ON THE FUTURE OF SPACEFLIGHT: IOM at IEPC 2025 in London

At the 39th International Electric Propulsion Conference (IEPC) in September 2025, the cross-sectional unit Tools presented its latest work on electric propulsion systems for space applications. The research aims to make electric propulsion more efficient, durable, and powerful—key prerequisites for future missions.

On the occasion of the IEPC, IOM researchers were invited, together with renowned international colleagues, to develop two recommended practices: one on the diagnostics of gridded ion thrusters and another on the application of LIF and TALIF spectroscopy. Contributions on both topics are planned for publication in the Journal of Electric Propulsion. With a total of eight scientific contributions and collaborations with 15 international partner institutions, the IOM demonstrated its significant role in the field of electric space propulsion.

The conference, attended by around 700 experts from around the world, is regarded as the leading platform for exchange on future propulsion technologies.



Dr. Christoph Eichhorn, Lukas Pietzonka and Dr. Daniel Spemann (from left to right) at IEPC 2025 in London. (Photo: Hans Leiter)

FUTURE SAX-INNOVATION FORUM: “Chemistry as a building block of the future”

At the futureSAX Innovation Forum in March 2024 in Delitzsch, representatives from industry and academia came together to discuss technology-oriented developments in chemistry. As part of the World Café, Dr. Agnes Schulze, head of the research area Surfaces of Porous Membrane Filters, contributed her expertise to discussions on technological solutions from Saxony. She also used the forum to establish connections for future innovation projects and gave an interview on the planned large-scale research center in Delitzsch.

IOM research sets accents at the international plasma and thin film conference PLATHINIUM 2025



Participants of the PLATHINIUM Conference 2025 in France. (Photo: © PLATINIUM)

From September 22 to 26, 2025, the Antipolis Congress Center in Antibes became a meeting point for leading experts in low-temperature plasma and thin film research. Around 230 participants and 40 industry exhibitors attended the PLATHINIUM conference, which is organized biennially by the Société Française du Vide. The IOM was strongly represented with four scientific contributions from the research area Barrier and Precision Coatings and the cross-sectional unit Tools.

The presented results on interactions of energetic particles with surfaces and on the advancement of modern coating processes demonstrated how fundamental scientific research can be translated into industrial applications. Through its contributions, the IOM further consolidated its position as an internationally recognized player in plasma and surface research, while also making an important contribution to the sustainable advancement of modern coating technologies.

Networks and Dialog: Strategic Partnerships, Research, and Promotion of Early-Career Scientists

Active participation in regional, national, and international networks is a central pillar of the IOM's scientific strategy. Through involvement in innovation alliances, research consortia, and professional organizations, the institute strengthens its position within the research ecosystem, promotes interdisciplinary exchange, and helps shape emerging technological fields. The following examples illustrate the breadth of IOM's networking activities in 2024 and 2025.

GRAVOmer – Competence network for functional polymer surfaces



GRAVOnet event at the Burg Giebichenstein University of Art and Design Halle. (Photo: ©GRAVOmer)

As an active member and co-founder of the WIR! alliance GRAVOmer, IOM is committed to the development of microstructured polymer surfaces and their application across various industries. The network enhances collaboration among regional companies, educational institutions, and research organizations, and makes a significant contribution to the advancement of value chains in Central Germany.

IOM regularly participates in network formats such as GRAVOnet—for example, in 2024 at Leipzig University of Applied Sciences (HTWK), where current project results were presented, and in 2025 at Burg Giebichenstein University of Art and Design Halle, with a keynote lecture on the potential of functional surfaces for product development.

Saxon competence networks



IOM is a research partner in the newly established Saxon Competence Network for Fusion Research, SAX-FUSION, which is funded with approximately €2.4 million by the European Union and the Free State of Saxony. The alliance aims to consolidate fusion research in Saxony, advance technological developments, and stimulate industrial innovation.

Under the coordination of the Helmholtz-Zentrum Dresden-Rossendorf (HZDR) and co-leadership of the Fraunhofer Institute for Material and Beam Technology IWS, SAXFUSION brings together leading research institutions in Saxony. IOM contributes its expertise in surface processing, precision optics, and the shaping of optical components—technologies that are essential for future fusion reactors. Through its participation, IOM helps position Saxony as a key location in European fusion research.



In December 2025, the ERDF-funded network SAX-QT – Quantum Saxony was officially launched at IFW Dresden. IOM is also actively involved in this quantum technology network, working with partners to advance quantum technologies in Saxony and strengthen cross-location collaboration.

At the accompanying Winter Quantum Colloquium, IOM was represented by Dr. Kirill Monakhov, whose lecture “Chemistry of quantum systems” presented key chemical concepts for functional quantum systems and materials, contributing to the development of new quantum effects and quantum materials.

International Spintronics-Initiative CHIROMAG

In October 2025, the IOM research group “Switchable Molecularly Functionalized Surfaces” was officially admitted to COST Action CA23136 “Magnetism and chirality: twisting spins, light, and lattices for faster-than-ever spintronics (CHIROMAG).” This initiative connects experts across Europe in the fields of ultrafast magnetism, spintronics, magnonics, photonics, and high-resolution spectroscopy.

IOM researchers actively contribute to the working groups “Magnetism in phases of broken symmetry” and “Spin control via ultrafast chiral excitations.” The focus is on polyoxometalate molecular magnets and functionalized surfaces as a basis for novel approaches to ultrafast spintronic applications, a research field with high potential for future data processing technologies.



LEIBNIZ RESEARCH NETWORK MMS: Impulses for Europe's AI research



As a member of the Leibniz Association, IOM contributes its expertise to the research network “Mathematical Modelling and Simulation” (MMS). Initiatives such as the Leibniz AI Schools, most recently held at IOM in October 2025, specifically promote skills development in key areas of artificial intelligence, ranging from digital materials research to data-driven applications in medicine and the natural sciences. These efforts provide important impetus

for the European research landscape and support the implementation of measures outlined in the 2024 position paper by the G6, the six leading European research organizations, on the strategic development of the European AI landscape. The proposed measures range from strengthening fundamental research and open data and computing infrastructures to establishing ethical guidelines and promoting sustainable AI use.

Strengthening IOM's presence in scientific committees



Through active participation in key professional committees, IOM continues to expand its national and disciplinary networks. At the general assembly of the German Society for Membrane Technology (DG-MT) in February 2025, Dr. Agnes Schulze was elected to the advisory board. With her recognized expertise in porous membrane filter surfaces, she provides valuable input for the strategic advancement of membrane technology and fosters exchange between basic research, industrial users, and international professional associations.



IOM has also increased its presence in plasma technology: in October 2024, Dr. Martin Rudolph was appointed to the PLASMA GERMANY committee, which met at IOM on that occasion. In addition to discussions on current developments, such as next-generation plasma generators, the focus was on networking and initiating new project ideas. At the general assembly in November 2025 at Zwickau University of Applied Sciences, Dr. Rudolph also presented current IOM activities in plasma physics and technology, including ion beam etching, thin-film deposition, and process modeling.

These activities underline IOM's role as an active driving force in key scientific networks and enhance its visibility in strategically important research fields.

Collaboration and Progress in Selected IOM Projects

In 2025, interdisciplinary collaboration and international networking were key priorities at IOM in order to advance innovative technologies for the future. Three project meetings highlighted the importance of cooperative partnerships between academia and industry.

Joint project “nanoAR”



Welcome of consortium partners by the Scientific Director, Prof. Dr. Benjamin Dietzek-Ivanšić.
(Photo: Stephan Görsch)

On May 20, 2025, the partners of the research project “nanoAR” met for their second consortium meeting in Leipzig,

hosted by IOM and Trionplas Technologies GmbH. The focus was on professional exchange regarding the development

of high-performance optical components for laser fusion power plants, a key project for the sustainable energy supply of the future.

Following an overview of the project’s progress, intensive discussions and a laboratory tour took place, during which participants visited state-of-the-art facilities at IOM and Trionplas. The project, funded with a total volume of six million euros by the Federal Ministry of Research, Technology and Space (BMFTR), brings together expertise across the entire innovation chain, from damage reduction in optical materials and nanostructuring to quality assurance.

The meeting emphasized the importance of close interdisciplinary collaboration and provided valuable input for the next phases of the project.

EU Joint project SORT4CIRC

Another forward-looking initiative is the Horizon Europe project SORT4CIRC, which was launched on December 1, 2025. In this project, IOM is involved through its cross-sectional unit for Material Characterization and Analytics, working alongside 14 partners from eight European countries. The aim of the project is to develop innovative technologies and artificial intelligence that enable precise and material specific separation of post consumer

textiles, including materials that have previously been difficult to identify, such as black textiles or elastane. This is intended to strengthen the EU-wide circular textile economy and significantly improve recycling processes.

At the end of the three-year project, the establishment of a demonstrator plant is planned, which will enable fully automated and comprehensive sorting of used textiles.



Dr. Tom Scherzer (left) and Dr. Olesya Daikos in the lab at IOM’s hyperspectral camera.
(Photo: Erik Kazak)

EU Joint project “10 Ångstrom CMOS Exploration”



EU consortium partners at the project meeting in Leuven. (Photo: Yansley Rosemain)

At the end of June 2025, the official review meeting of the EU-funded joint project “10 Ångstrom CMOS Exploration” took place at the research and innovation center imec in Leuven. Here, the 32 partners, including IOM, presented the current status of the project and coordinated the next steps with the EU reviewers. The IOM project leads presented progress in ion beam assisted etching technology. A particular highlight was the exclusive tour of imec, one of the world’s leading research centers for nanoelectronics, where participants were able to explore state of the art production facilities and current research projects.

The meetings and projects illustrate how IOM, through networked cooperation at both national and international levels, provides important momentum for technological progress and, together with its partners, advances key future fields such as sustainable energy supply, nanoelectronics, and the circular economy.

Outstanding Achievements: Awards 2024 and 2025

In 2024 and 2025, IOM once again honors outstanding individuals for their scientific and organizational contributions. Whether innovative research results, dedicated early career researchers, or exceptional achievements in non scientific fields, the awardees provide important momentum for the institute's success and visibility. From international distinctions to internal recognitions, these awards reflect the broad spectrum of excellence and commitment at IOM.



Prof. Dr. Andre Anders

PSE Leading Scientist Award 2024 auf der 19. Conference on Plasma surface engineering
for his outstanding achievements and influence within the scientific community



Lukas Paul Lingenfelder

Poster Prize in the category "Methods and Processes" at the **50th International Conference "Micro and Nano Engineering MNE 2024"** in Montpellier for the poster "Ion Beam Planarization using non-volatile, high-solvent containing Polymer Coatings"



Dr. Kirill Monakhov

Awarded in 2025 with a **visiting professorship** from the **Institute of Advanced Study IAS** and the **Department of Chemistry** at the **University of Warwick, United Kingdom**



Dr. Zahra Niavarani

IOM Award Early Career Researcher 2024 for her dissertation
"Design of Adsorptive Polymer Microfiltration Membranes using Electron Beam Modification"



Jonas Lorenz

YoungFMOCS 2025 Presentation Award at the conference **Frontiers in Metal Oxide Cluster Science** for his talk "Substrate-controlled self-organization of polyoxovanadates"



Verena Kühn

IOM Award Non Scientific Staff 2024
for her exceptional commitment in administration under challenging conditions



Dr. Omid Shayestehpour

IOM Award Early Career Researcher 2025 for his outstanding achievements during his doctoral research and his contribution to the positive external perception of IOM



Florian Hager

IOM Award Non Scientific Staff 2025

for his exceptional dedication, professional expertise, and team spirit in the workshop and during the transition to the research area of porous membrane filter surfaces

Sven Arnold

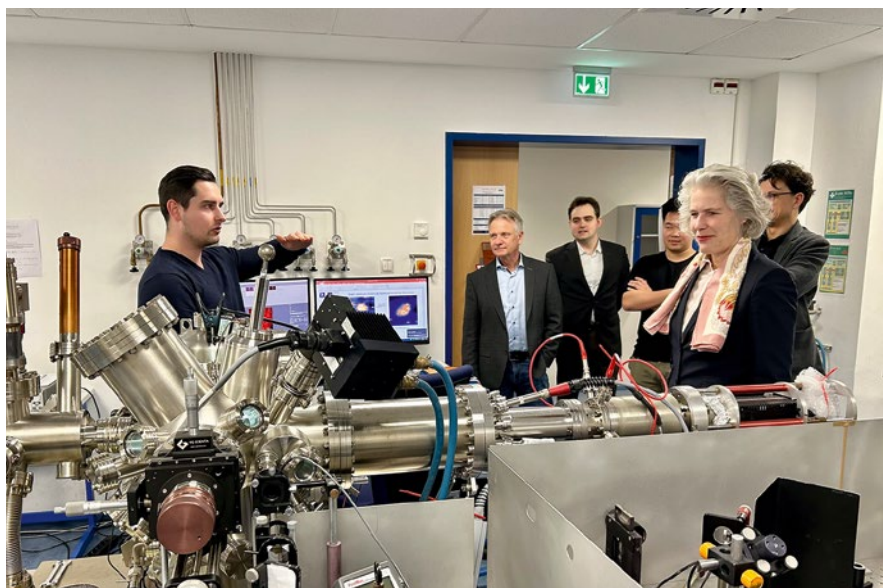
IOM Award Non Scientific Staff 2025

for his excellent and consistently solution oriented work in a wide range of IT related matters at IOM

Dialogue: Science Meets Politics

Continuous exchange between research institutions, universities, and political decision makers forms the foundation for successful scientific development and innovation promotion. Visits by high ranking representatives from science and politics to IOM in 2024 and 2025 highlighted the importance of strategic partnerships and dialogue on current scientific challenges. These encounters foster close collaboration and provide important impetus for the future viability of the Saxony research landscape.

STRATEGIC PARTNERSHIPS IN FOCUS: Visit of the rector of the University of Leipzig



In February 2024, Prof. Eva Inés Obergfell, Rector of the University of Leipzig, visited IOM. In discussions with the then IOM Director Prof. André Anders and the management team, the focus was on deepening strategic cooperation and the future joint appointment of professorships.

During a tour of the laboratories, Prof. Obergfell gained insights into current research projects and key technologies. The visit underscored the strong connection between the university and the institute and provided important impetus for further collaboration in research and teaching.

Tour of IOM with the Rector of the University of Leipzig, including the JointLab "Surface engineering with mass selected molecular ions". (Photo: Flemming Schock)

SCIENCE MEETS POLITICS: State Secretary Prof. Heike Graßmann Visits IOM

On May 20, 2025, Prof. Dr. Heike Graßmann, State Secretary at the Saxon State Ministry for Science, Culture and Tourism (SMWK), learned about IOM's research activities. Accompanied by Dr. Tim Metje, Head of the Department "Leibniz Institutes and State Funded Research Institutions," and Susan Wagner, SMWK staff member, the visit focused on open discussions about key research priorities and current challenges in science policy.

The dialogue set important accents for collaboration between politics and research and emphasized the relevance of IOM for the Saxony science landscape.



Prof. Dr. Heike Graßmann, State Secretary at the Saxon State Ministry for Science, Culture and Tourism (SMWK) (second from left) in the plasma lab at IOM. (Photo: Yvonne Bohne)

Exchange, Talent Development, and Global Networking at IOM

In 2024 and 2025, IOM established itself as a central hub for scientific exchange, interdisciplinary collaboration, early career support, and international cooperation. A wide range of activities and events reflect the institute's strong commitment to combining excellent research with training, networking, and sustainable career development.



Participants of the MemrisTec meeting.

(Photo: Heike Kolossa)

and bringing new momentum for future research initiatives.

Another example of the institute's interdisciplinary orientation was the visit of a delegation from the National Library of the Czech Republic on November 4, 2025. The focus was on innovative plasma processes for the restoration and preservation of sensitive historical materials, such as parchment. Expert presentations, laboratory tours, and discussion sessions highlighted the significant potential of collaboration between materials science and cultural heritage preservation and opened perspectives for future joint research projects.

A highlight in 2025 was the annual seminar of the DFG Priority Program MemrisTec (SPP 2262), held from November 25 to 27, 2025 at IOM in Leipzig. Doctoral, Master's, and diploma students presented their research and received qualified feedback from experienced scientists. The program was complemented by laboratory tours and keynote talks on career paths and the German research landscape. Particularly noteworthy was the scientific lecture by Dr. Kirill Monakhov on molecularly functionalized surfaces, which opened new perspectives for applications in quantum and neuromorphic computing. The seminar strengthened collaboration within the priority program and specifically supported the development of early career researchers.

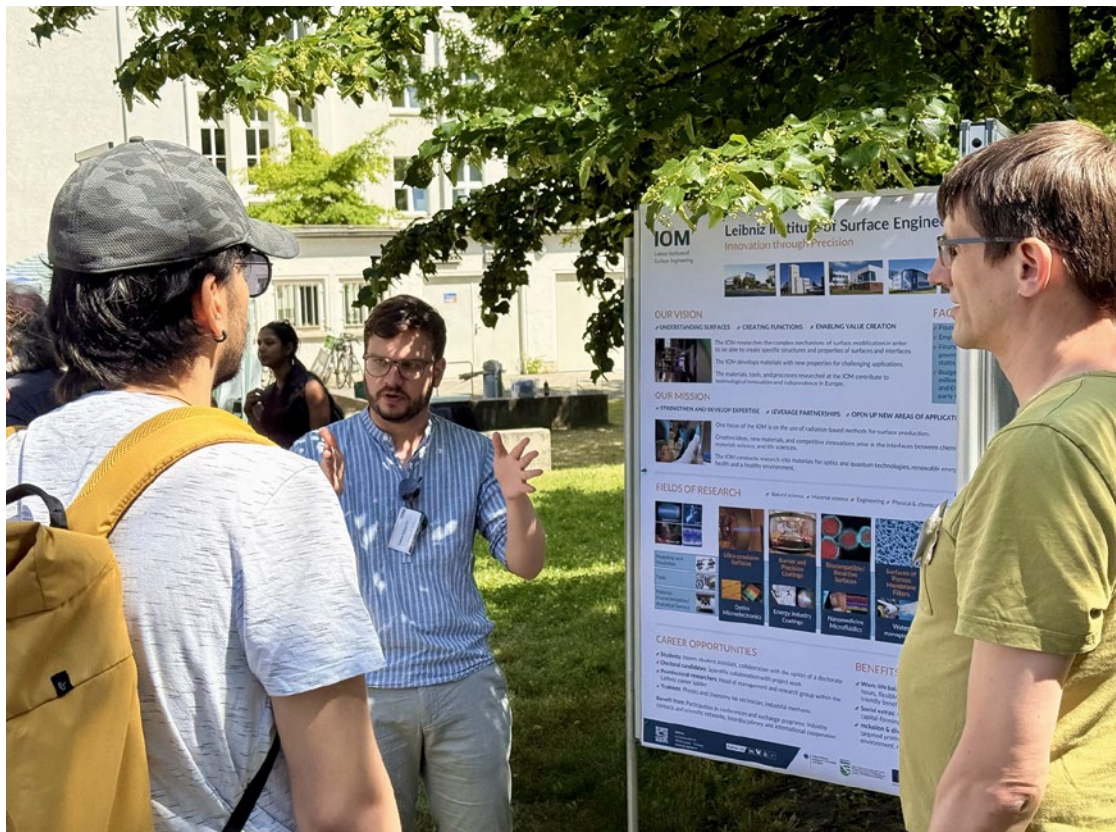
In the area of international networking, IOM intensified its collaborations. In May 2025, the Laser Assisted Micro and Nanostructuring group visited the Institute of Scientific Instruments of the Czech

Academy of Sciences in Brno. Initiated by Dr. Mojmír Šerý, the exchange provided in-depth insights into current research projects and led to intensive scientific discussions. In addition, a joint DFG project proposal was finalized, laying the foundation for long-term bilateral collaboration

In addition to these research oriented activities, IOM is strongly committed to supporting young talent and career development. As early as May 2024, the institute welcomed the Leipzig regional group of the Young German Physical Society (JDPG).



Tour of IOM for guests from Prague. (Photo: Heike Kolossa)



IOM researchers at the JobCafé at the University of Leipzig. (Photo: Erik Rohkamm)

Around 20 early career researchers gained practical insights into modern materials and surface research as well as career perspectives through expert talks and discussions.

In June 2025, IOM participated in the first JobCafé of the Faculty of Physics and Earth System Sciences at the University of Leipzig. Students learned about internships, student assistant positions, thesis opportunities, and entry pathways into science. Staff members were on hand to provide guidance and advice and highlighted the institute's diverse career opportunities.

On November 26, 2025, IOM was also represented at the career fair “Future Paths: Physics” at the University of Leipzig. The bilingual event allowed students from physics, chemistry, biochemistry, and biology to meet regional research institutions and companies. IOM provided detailed information on internships, student positions, and scientific career opportunities. The fair concluded with a lively panel discussion. Overall, these diverse activities demonstrate how IOM successfully combines excellent research, international cooperation, and sustainable early career support, thereby making an important contribution to the further development of the research landscape.



Dr. Carsten Bundesmann in conversation at the career fair at the University of Leipzig. (Photo: Alexander Thoms)

Interviews: Perspektiven from Research, Technology Transfer, and Science Policy

Interviews with experts from IOM shed light on current challenges and opportunities in research, technology transfer, and technological development. They illustrate how deeply the institute is engaged in societal, political, and industry related discourse, ranging from questions of international cooperation and space technologies to sustainable transfer structures.

Innovation must not become a security risk: Prof. André Anders in conversation with MDR



Prof. André Anders in an interview with a journalist from MDR.

In an interview with MDR in July 2024, Prof. André Anders, former director of IOM, discussed the growing sensitivity surrounding research collaborations with China and the central dual-use issue. According to Anders, Germany is caught between openness and security responsibility.

China leads in many future technologies and is an attractive base for scientific exchange, but at the same time represents a potential risk. Dual-use research can be applied in both civilian and military contexts: "An algorithm for analyzing medical data can just as easily be used in military applications". Against this background, German universities are increasingly

scrutinizing collaborations. Excessive restrictions, however, could reduce innovation capacity. Anders advocates for a balance between cooperation and control: clear rules, transparent contracts, and internationally binding standards. Only through this interplay can research remain globally connected while still being responsible.

The interview was broadcast on December 11, 2024 in the MDR magazine EXAKT in the segment "Security vs. Innovation – The Difficult Cooperation Between German and Chinese Universities" and on June 17, 2025 on the ARD program FAKT in the segment "Opportunity and Risk – Joint Research with China".



How iom researchers make satellite propulsion safer: Interview with Dr. Daniel Spemann (MDR WISSEN)

The rapid rise of commercial spaceflight raises new questions about orbital safety. In August 2025, Dr. Daniel Spemann, Head of the Cross-Sectional Unit Tools, explained in an interview with Clemens Haug of MDR WISSEN how his team is working to objectively evaluate electric satellite thrusters and establish a "TÜV for space".

A failure in orbit is almost impossible to repair and could cause enormous economic damage or generate space debris. While chemical rockets handle transport into orbit, highly efficient ion thrusters perform maneuvers in space. Until now, however, standardized measurement methods to reliably compare their performance have been lacking.

At IOM, thrusters are therefore tested under space-like conditions: vacuum chambers, laser diagnostics, and precise beam measurements provide detailed data on their operation. The DLR-funded joint project "Ref4EP" provides the foundation for this work. Together with partners from Giessen and Kiel, a reference engine is being developed to calibrate measurement procedures in the future.



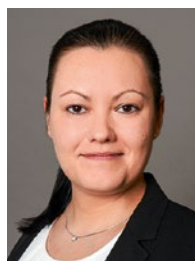
Left: Laser spectroscopic investigation of a xenon-powered RIT-10 EVO (provided by ArianeGroup GmbH) in a vacuum chamber at IOM Leipzig. (Photo: Lukas Pietzonka)
Right: IOM expert Dr. Daniel Spemann



In the long term, this could lead to a European standard and eventually a quality seal for electric satellite thrusters, making a key contribution to safety, reliability, and sustainability in the growing space industry. The interview was published on August 25, 2025 on MDR WISSEN "Welttraum" under the title "Private Spaceflight: Leipzig Researchers Develop 'TÜV' for Satellite Thrusters".



New paths are created by walking them: The IOM transfer team on innovation, networks, and effective structures



In an interview with the BMFTR funding line Innovation Orientation in Research (Innofo), Dr. Maria Meißler and Yvonne Bohne explained how the IOM transfer team makes research results visible and translates them into economic and societal applications.

Transfer is a core task of the institute that can only succeed through close exchange with researchers. A focus lies on establishing stable structures, strengthening cooperation with companies, and networking among transfer stakeholders. Particularly noteworthy is the evolved IOM transfer

structure: starting from the BMFTR project "Sectoral Utilization", it has been expanded through programs such as Innofo and is now an integral part of all research areas.

For the future, the team aims to remove existing transfer barriers and further develop supporting processes. Every successful transfer is proof of applied research in action. The guiding principle remains clear: only those who explore new paths can build sustainable bridges between research and practice.



Outreach and Events: Science in Dialogue and Public Engagement

IOM actively works to make science tangible and understandable for the public. Whether during open house days or in personal conversations, the researchers invite dialogue, present research approaches in a practical way, and support young talent. Through a variety of formats, the institute creates encounters between science and society, strengthens networks, and inspires young people to pursue careers in the natural sciences. IOM is not only an active participant in dialogue with the public, politics, and educational institutions, but also shows full commitment in sporting events.

IOM at SPIN2023 – Experiencing research firsthand



Science festival SPIN2030 in Dresden: The Prime Minister of Saxony, Michael Kretschmer (center), and Saxon Minister of Science, Sebastian Gemkow, open the event. (Photo: Yvonne Bohne)

At the SPIN2023 science festival in the Technical Collections Dresden, IOM presented exciting insights into its research in March 2024. As part of “Meet a Scientist,” visitors could engage directly with our researchers. The focus was on innovative membrane filters for the removal of micro-pollutants from water and the importance of plastics for sustainable energy technologies. The program was complemented by engaging insights into the use of plasmas in materials, electronics, and energy industries. Through hands-on examples, IOM demonstrated how research from Leipzig shapes the future—dialogue oriented and inspiring.

“Book a Scientist” – Making science understandable

In October 2024 and June 2025, the Leibniz Association’s “Book a Scientist” format again provided the opportunity for personal exchanges with IOM researchers. Interested participants could ask targeted questions and gain insights into current research areas such as innovative plasma technologies, sustainable plastics, and micro-pollutant removal. Direct dialogue makes complex topics accessible and strengthens the connection between science and society. Through regular participation, IOM supports open and practical access to research.



Strong together – Also in sports



At sporting events such as the Leipzig Science Cup 2025 and the Leipzig Company Run in 2024 and 2025, IOM demonstrated team spirit and commitment. Whether on the football field or the 4.9-kilometer course, the joint effort strengthened networking, a sense of community, and the institute’s visibility within Leipzig’s scientific and business landscape.

GIRLS'DAY: Discovering science and technology

Every April, IOM opens its doors to schoolgirls, making science and technology tangible. During Girls'Day, participants gain authentic insights into the daily work of female scientists, technicians, and laboratory staff. Through tours and discussions, they learn about the diversity of research work and are encouraged to explore less conventional career paths. IOM places special emphasis on sparking early interest in STEM careers and nurturing young talent.



Girls' Day offered insights into our research workshop (bottom left), membrane production (top left), and microscopy techniques (middle left). Another highlight: the launch of a water rocket (right).

(Photos: Yvonne Bohne and Anna Franziska Wenger)

Fascination spaceflight at IOM: Insights into electric satellite thrusters



Dr. Daniel Spemann explains the principle of an ion source to visitors. (Photo: Yvonne Bohne)

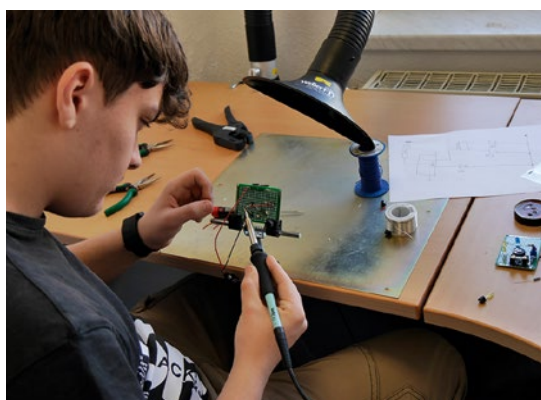
On "Space Day" on March 29, 2025, IOM invited visitors to explore innovative technologies in the field of space propulsion.

The highlight was a lecture on electric ion thrusters, accompanied by two displayed models, including a development by IOM in collaboration with DLR and Aerospace Innovation GmbH. Researchers presented measurement systems and were available to answer questions. The strong interest demonstrated the enthusiasm for space research at IOM, particularly motivating early career researchers.

Hands-on experiments: "SCHAU REIN!" – Career orientation at IOM

In March 2025, IOM participated for the first time in Saxony's largest career orientation initiative, "SCHAU REIN!" Seventeen students had the opportunity to experience professions such as chemical laboratory technician and physics laboratory technician firsthand.

In small groups, they conducted measurements to determine surface properties, titrated solutions, and tried their hand at soldering. The event sparked enthusiasm for science and technology and provided an engaging introduction to the professional world.



In several groups, students could participate in different activities across various laboratories during the Week of Open Companies and gain initial practical experience.

(Photos: Yvonne Bohne and Anna Franziska Wenger)

Long night of science 2025: An evening full of research and inspiration



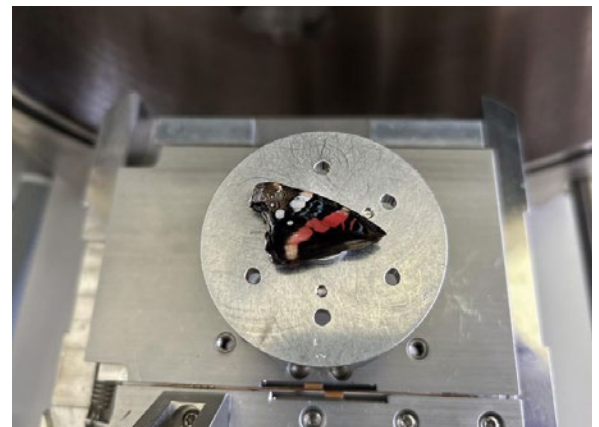
Tim Schreiber (right) demonstrates how a membrane is produced. (Photo: Yvonne Bohne)



Vicky Felthaus, Mayor for Youth, Schools and Democracy of the City of Leipzig (left), took the opportunity to visit the Ion Source Testing Laboratory, where Dr. Spemann explained how ion sources work. (Photo: Yvonne Bohne)

On June 20, 2025, IOM opened its doors for the Long Night of Science under the motto "Discover. Marvel. Understand." Visitors gained insights into current projects, such as the operation of ion thrusters, innovative methods for removing micro-pollutants, and high-resolution electron microscopy. Leipzig's Mayor for Youth, Schools, and Democracy, Vicky Felthaus, also took the opportunity to engage with researchers. The evening vividly demonstrated how exciting and accessible science at IOM is.

The finest structures of a butterfly wing examined under the microscope.
(Photo: Anna Franziska Wenger)



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Leipzig University, represented by Prof. Dr. Jens-Karl Eilers
City of Leipzig, represented by Dr. Torsten Loschke
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Representative of Young Scientists – Tim Schreiber
Diversity Officer – Dr. Yeliz Unutulmazsoy

FACTS AND FIGURES 2024 / 2025

FACTS AND FIGURES

Staff Statistics (Number)	2024	2025
Total Staff	137	142
Employees by Job Category		
Academic Staff	74	74
Research Support Staff	42	43
Administrative Staff	17	21
Staff Functions	4	4
Staff by Funding Source (Budget, Third-Party Funds)		
Budget	81	82
Third-Party Funds	56	60
Visiting Scholars	52	49
Trainees	2	2
Female Employees only		
Number	46	49
%	33.58 %	34.51 %
International Employees		
Number	16	23
%	11.68 %	16.20 %
Institutional Funding: Allocation (in Thousands of Euros)		
Federal and State	9,699.2	10,364.1
Other Revenue	702.1	1,494.5
<i>Equalization Item Investment Input tax refund</i>	0.0	1,257.4
Third-party funded Projects (in Thousands of Euros)	4,591.8	5,546.0
Total Revenue	14,993.1	18,662.1
Personnel Funds	8,924.5	9,933.8
Operating Funds	8,243.0	4,702.2
Investment Funds	1,866.5	2,313.4
<i>Investment Funds from Input tax refund</i>	0.0	1,257.4
Total Expenditures	19,034.0	18,206.9



APPENDIX

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PUBLICATIONS IN JOURNALS

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CONTRIBUTIONS IN ANTHOLOGIES

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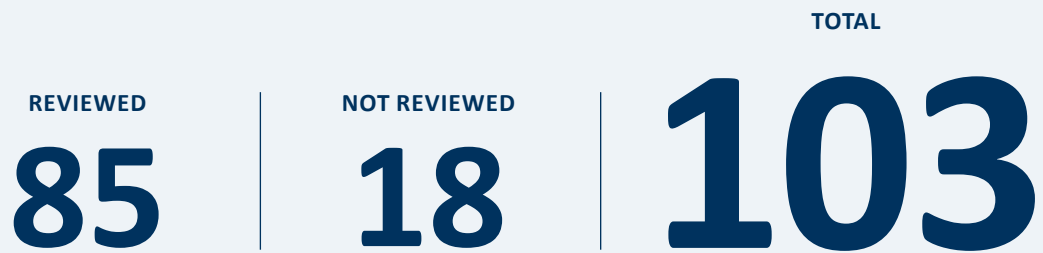
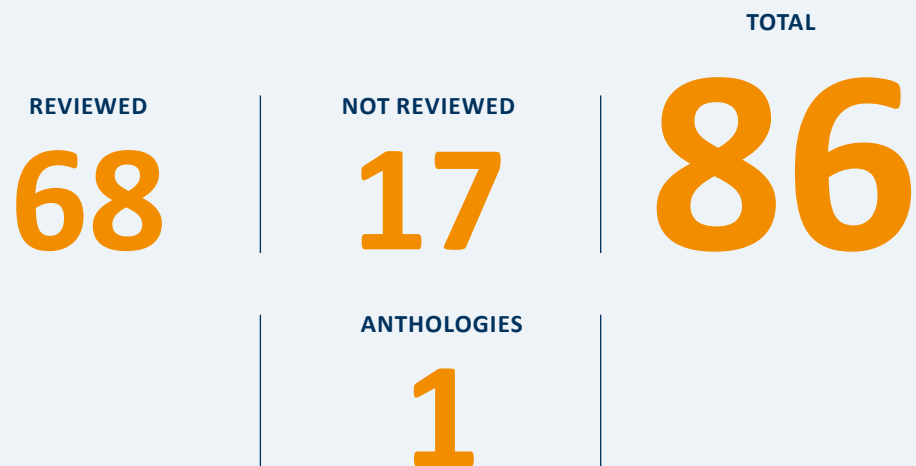
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2025

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Modifizierte Polymermembranen zur photokatalytischen Spurenstoffelimination

Paper Nr. S 6.2, 16. Aachener Tagung Wassertechnologie, Aachen, Germany, 11.-12.11. (2025) 211

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TALKS

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*A. Anders**, Ohmic discharges, XXIX. Erfahrungsaustausch Oberflächentechnologie mit Plasma- und Ionenstrahlprozessen, Mühlleithen, Germany, 11.-15.03.2024

*A. Anders**, Discharges modes relevant to plasma-based coatings: an analysis of their physics and economics, 50th Int. Conf. on Metallurgical Coatings and Thin Films, San Diego, CA, USA, 19.-24.05.2024

*A. Anders**, Glows, arcs, ohmic discharges: proposing an updated classification based on electron emission and power dissipation, 19th Int. Conf. on Plasma Surface Engineering, Erfurt, Germany, 02.-05.09.2024

*A. Anders**, Atomic scale heating in plasma deposition processes, 10th Int. Symposium on Functional Coatings and Surface Engineering, Montreal, Canada, 02.-05.06.2024

T. Arnold, R. Heinke, M. Ehrhardt, P. Lorenz, K. Zimmer*, Simultaneous atmospheric pressure plasma jet etching and laser irradiation for ultra-precise optical glass processing, European Optical Society Annual Meeting 2024, Naples, Italy, 09.-13.09.2024

K. Barynova, M. Rudolph, S.S. Babu, J. Fischer, D. Lundin, M.A. Raadu, N. Brenning, J.T. Gudmundsson*, On working gas rarefaction in high power impulse magnetron sputtering, 51st IEEE Int. Conf. on Plasma Science and 4th Asia-Pacific Conf. on Plasma and Terahertz Science, Beijing, China, 16.-20.06.2024

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*J. Bauer**, Surface characterization at the IOM - topography, structure, and composition, XXIX. Erfahrungsaustausch Oberflächentechnologie mit Plasma- und Ionenstrahlprozessen, Mühlleithen, Germany, 11.-15.03.2024

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TALKS AND POSTERS

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POSTERS	TALKS	TOTAL
27	78	105

 2025

POSTERS	TALKS	TOTAL
22	76	98

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*C. Bundesmann**, Insights into ion beam sputter deposition, Int. Conf. on Coatings on Glass and Plastics, Dresden, Germany, 24.-26.06.2024

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*O. Daikos, M. Naumann, U. Helmstedt, E. Lugovoy, J. Warneke, T. Scherzer**, Detection and analytics of thin surface layers by hyperspectral imaging techniques, Conf. on Spectral Imaging, Bilbao, Spain, 06.-10.07.2024

A. Dalke, H. Biermann, S. Mändl, D. Manova*, Surface segregation phenomena encountered during solid carbon active screen plasma nitrocarburizing of AISI 316L, MSE Congress - Materials Science and Engineering, Darmstadt, Germany, 24.-26.09.2024

G. Dornberg, E. Rohkamm, P. Birtel, F. Scholze, B. Klump, F. Frost*, Comparison of a Kaufman-type and a RF-ion source operated with CHF₃/O₂ in RIBE, XXIX. Erfahrungsaustausch Oberflächentechnologie mit Plasma- und Ionenstrahlprozessen, Mühlleithen, Germany, 11.-15.03.2024

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*K. Fischer, J. Lohmann, E. Schmidt, T.H. Blaich, C. Belz, I. Thomas, E. Vogelsberg, A. Schulze**, Enhancing biofouling resistance through electron beam grafting of polymer membranes with hydrogels - translating research results into practical applications, FILTECH, Köln, Germany, 12.-14.11.2024

*K. Fischer, Z. Niavarani, A. Abdul Latif, J. Griebel, A. Prager, O. Shayestehpour, S. Zahn, A. Schulze**, Visible-light active and stable Bi₂WO₆ composite polymer membranes for photocatalytic micropollutant removal, 19th Aachener Membran Kolloquium, Aachen, Germany, 03.-05.12.2024

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*C. Hackl**, Mikrostrukturierte Polymerfolien und ihre Anwendungen in biomedizinischen Assays, Projektwerkstatt 'Bioaktive funktionale Oberflächen für Life Science-Anwendungen', GRAVOmer Seminar, Freiberg, Germany, 30.10.2024

*C. Hackl**, UV-imprinting of microstructured polymer foils for biomedical disposables, POCT Meeting - Point-of-Care Diagnostics: Innovations from assays, microfluidics to production, Leipzig, Germany, 17.-18.04.2024

R. Heinke, M. Ehrhardt, P. Lorenz, T. Arnold, K. Zimmer*, Ultra-precise processing of technical glasses by combining atmospheric pressure plasma jet and laser, 11th European Seminar on Precision Optics Manufacturing, Degendorf Institute of Technology, Teisnach, Germany, 23.-24.04.2024

A.M. Jakob, S.G. Robson, H. Firgau, V. Mourik, V. Schmitt, D. Holmes, M. Posselt, E. Mayes, D. Spemann, A. Morello, D. Jamieson*, Engineered donor-qubit arrays for silicon quantum computing, 25th Congress of the Australian Institute of Physics Congress, Melbourne, Australia, 02.-05.12.2024

D. Kalanov, Y. Unutulmazsoy, J.W. Gerlach, A. Lotnyk, J. Bauer, A. Anders, C. Bundesmann*, Impact of energetic film-forming particles in ion beam sputter deposition of epitaxial Ga₂O₃ thin films, 50th Int. Conf. on Metallurgical Coatings and Thin Films, San Diego, CA, USA, 19.-24.05.2024

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P. Lorenz, J. Zajądacz, M. Ehrhardt, K. Zimmer*, Ultra-short pulse laser surface nanostructuring and its application, DPG Frühjahrstagung, Greifswald, Germany, 26.-29.02.2024

A. Lotnyk, T. Dankwort, V. Roddatis, N. Braun, S. Cremer, L. Voss, L. Kienle*, Nanoscale characterization of chalcogenide thin films for memory and energy applications, 2024 IEEE 14th Int. Conf. 'Nanomaterials: Applications & Properties', Riga, Latvia, 08.-13.09.2024

S. Mändl, D. Manova*, In-situ X-ray diffraction studies of high-alloy steels, XXIX. Erfahrungsaustausch Oberflächen-technologie mit Plasma- und Ionenstrahlprozessen, Mühlleithen, Germany, 11.-15.03.2024

S. Mändl, D. Manova*, In-situ X-ray diffraction studies during nitriding of super-austenitic, duplex and precipitation hardening steel, MSE Congress - Materials Science and Engineering, Darmstadt, Germany, 24.-26.09.2024

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*K.Y. Monakhov**, Integration of polyoxometalates into redox-based memory applications: challenges and progress, 5th Int. Conf. on Materials Science & Nanotechnology, Athens, Greece, 21.-25.10.2024

*K.Y. Monakhov**, Polyoxometalates - molecular redox capacitors and memristors, MemrisTec Summer School 2024, Groningen, Netherlands, 22.-29.09.2024

*K.Y. Monakhov**, *E. Vogelsberg*, Polyoxometalates as new molecular sensors for point-of-care diagnostics, 10. Mittel-deutsche Laborkonferenz, Halle, Germany, 18.-19.04.2024

*K.Y. Monakhov**, Transforming semiconductor electronics through sustainable chemical technology of molecular materials, European Colloquium on Inorganic Reaction Mechanisms, Toulouse, France, 08.-11.09.2024

*K.Y. Monakhov**, From 0D metal-oxygen coordination clusters to 2D metal-oxo/oxide layers. Responsible switching materials by chemical design, GDCh Conf. on Inorganic Chemistry, München, Germany, 16.-18.09.2024

*M. Moors**, Hybrid memristive device with multilevel-modulated electrical conductance of interfaced atomically thin 2D materials and molecular oxides (2DPOM-ristor), MemrisTec2024 Workshop, Nürnberg, Germany, 09.-12.04.2024

*H. Müller**, *Th. Arnold*, Characterization of manufacturing-induced microcracks in optical components, 11th European Seminar on Precision Optics Manufacturing, Deggendorf Institute of Technology, Teisnach, Germany, 23.-24.04.2024

*Z. Niavarani**, *D. Breite*, *A. Schulze*, Polymer membrane modification using electron beam irradiation for the removal of endocrine disruptors from water, 19th Aachener Membran Kolloquium, Aachen, Germany, 03.-05.12.2024

*S.K. Petrovskii**, *M. Moors*, *K.Yu. Monakhov*, Beyond standard click chemistry for post-modification of hexavavandates: expanding the diversity of available hybrid structures, GECOM-CONCOORD 2024, Ax-les-Thermes, France, 19.-24.05.2024

*L. Pietzonka**, *C. Eichhorn*, *F. Scholze*, *D. Spemann*, Xenon neutral gas characterization in a radiofrequency-driven gridded ion source using laser-induced fluorescence spectroscopy, 38th Int. Electric Propulsion Conf., Toulouse, France, 23.-28.06.2024

*L. Pietzonka**, *C. Eichhorn*, *F. Scholze*, *R. Woyciechowski*, *D. Spemann*, IOM's project segment within the Ref4EP consortium - Design of a gridded ion source as a reference tool for standardization of diagnostics in EP and LIF spectroscopy approaches, XXIX. Erfahrungsaustausch Oberflächentechnologie mit Plasma- und Ionenstrahlprozessen, Mühlleithen, Germany, 11.-15.03.2024

M. Popovych, *H. Kochubei**, *K. Shportko*, *A. Lotnyk*, *E. Venger*, *A. Stronsk*, Raman spectroscopy and X-ray diffraction studies of Ga-Ge-Te alloys, XI-th Int. Conf.: Topical Problems of Semiconductors Physics, Drohobych, Ukraine, 27.-31.05.2024

*D.A. Rolon**, *F. Hölzel*, *J. Kober*, *S. Kühne*, *M. Malcher*, *T.K. Naderi*, *T. Arnold*, *D. Oberschmidt*, Benchmarking rapidly solidified aluminium alloys for ultra-precision machining of UV mirrors and diffractive optical elements, EUSPEN - 24th Int. Conf. & Exhibition, Dublin, Ireland, 10.-14.06.2024

*M. Rudolph**, *W. Diyatmika*, *O. Rattunde*, *E. Schuengel*, *D. Kalanov*, *J. Patscheider*, *A. Anders*, Generating spokes in direct current magnetron sputtering discharges by an azimuthal strong-to-weak magnetic field strength transition, 50th Int. Conf. on Metallurgical Coatings and Thin Films, San Diego, CA, USA, 19.-24.05.2024

*M. Rudolph**, Generating spokes in direct current magnetron sputtering - paving the way for 'spokes engineering', Seminar, Thin Film Physics Division, Department of Physics, Chemistry and Biology, Linköping University, Linköping, Sweden, 25.01.2024

*M. Rudolph**, *W. Diyatmika*, *O. Rattunde*, *E. Schuengel*, *D. Kalanov*, *J. Patscheider*, *A. Anders*, Intentionally exciting spokes at a magnetic field step along the racetrack in magnetron sputtering, 19th Int. Conf. on Plasma Surface Engineering, Erfurt, Germany, 02.-05.09.2024

*M. Rudolph**, Machine learning of optical emission spectra to predict electron density and temperature in a low-temperature plasma, Leibniz MMS Days 2024, Kaiserslautern, Germany, 10.-12.04.2024

*M. Rudolph**, *W. Diyatmika*, *O. Rattunde*, *E. Schuengel*, *D. Kalanov*, *J. Patscheider*, *A. Anders*, Excitation, suppression and generation of spokes in direct current magnetron sputtering discharges, 17th European Vacuum Conf., Harrogate, UK, 17.-21.06.2024

M. Schmidt, *A. Prager*, *A. Abdul Latif*, *N. Schönherr*, *S. Zahn*, *A. Schulze**, Functionalization of polymer membranes with proteins and enzymes using electron beam irradiation, Euromembrane 2024, Prague, Czech Republic, 08.-12.09.2024

*M. Schmidt**, *A. Prager*, *A. Abdul Latif*, *S. Zahn*, *A. Schulze*, Polymer membrane surface functionalization with proteins and enzymes by electron beam irradiation, 19th Aachener Membran Kolloquium, Aachen, Germany, 03.-05.12.2024

*F. Scholze, F. Pietag, H. Adirim, M. Kreil, M. Kron, R. Woyciechowski, D. Spemann**, IonJet-Evo: Development and qualification of a cost-efficient gridded ion thruster propulsion system for small satellites, 38th Int. Electric Propulsion Conf., Toulouse, France, 23.-28.06.2024

*F. Scholze, F. Pietag, H. Adirim, M. Kreil, M. Kron, R. Woyciechowski, D. Spemann**, IonJet-Evo: Development of an engineering qualification model for a cost-efficient gridded ion thruster propulsion system for small satellites, XXIX. Erfahrungsaustausch Oberflächentechnologie mit Plasma- und Ionenstrahlprozessen, Mühlleithen, Germany, 11.-15.03.2024

*T. Schreiber, M. Schmidt, A. Poidevin, J. Becker-Jahn, K. Leopold, E. Couallier, A. Schulze**, Enzyme-functionalized polymer membranes for enhanced protein recovery from microalgae, Euromembrane 2024, Prague, Czech Republic, 08.-12.09.2024

*T. Schreiber, M. Schmidt, A. Poidevin, J. Becker-Jahn, K. Leopold, E. Couallier, A. Schulze**, Bioactive polymer membranes for enhanced protein recovery from microalgae, IEA IETS Task 17 Meeting - Membrane processes in biorefineries, online, 18.09.2024

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T. Schreiber*, M. Schmidt, A. Schulze, A. Prager, A. Poidevin, E. Couallier, Enzyme-functionalized polymer membranes for enhanced protein recovery from microalgae, 20th Network Young Membranes Meeting, Prague, Czech Republic, 04.-06.09.2024

O. Shayestehpour*, S. Zahn, Machine learning potentials for molecular dynamics simulations of deep eutectic systems, Int. Leopoldina Symposium on Molecular Machine Learning, Halle, Germany, 04.-06.03.2024

K. Shportko, A. Lotnyk*, C. Bundesmann, A. Stronski, E. Venger, Optical characterization of Ga-Ge-Te alloys within the glassy domain, European Phase Change and Ovonic Symposium, Leipzig, Germany, 22.-25.09.2024

L. Voss*, S. Cremer, O. Gronberg, A. Lotnyk, L. Kienle, Challenges and pitfalls of in-situ electrical switching of PCM cells, European Phase Change and Ovonic Symposium, Leipzig, Germany, 22.-25.09.2024

S. Zahn*, O. Shayestehpour, Uncovering secrets of deep eutectic solvents, 60th Symposium on Theoretical Chemistry, Braunschweig, Germany, 02.-06.09.2024

W. Zhang, H. Müller*, S. Frank, D. Thelemann, Th. Arnold, J. Bliedtner, IGF-Projekt tiger - Multiskalige Risscharakterisierung in der Optikfertigung, F.O.M.-Konferenz 2024, Forschungsvereinigung Feinmechanik, Optik und Medizintechnik e.V., Berlin, Germany, 06.11.2024

2025

M. Ahmed*, J.W. Gerlach, J. Bauer, O. Daikos, U. Helmstedt, Photochemical conversion of single-molecule precursors using vacuum ultraviolet irradiation into metal oxide thin films, Science Forum Chemistry 2025, Gesellschaft Deutscher Chemiker e.V., Karlsruhe, Germany, 29.09.-01.10. (2025).

M. Bera*, L. Heiser*, R. Karande, T. Pompe, A. Schulze, Combining stimuli-responsive hydrogels and scaffold-supported microbial biofilms for a self-controlled catalytic activity of a microbial leaf, 1st Annual Meeting des DFG-Schwerpunktprogramms 2451, 22.-23.09.2025

O. Daikos, T. Scherzer*, In-line Monitoring of Converting Processes by Hyperspectral Imaging, 22nd Int. Conf. on Near Infrared Spectroscopy, Rome, Italy, 08.-12.06.2025

R. Heinke, M. Ehrhardt, P. Lorenz, T. Arnold, K. Zimmer*, Etching of optical glass by reactive plasmas at atmospheric pressure, 51st Int. Micro and Nano Engineering Conf., Southampton, UK, 15.-18.09.2025

R. Heinke, M. Ehrhardt, P. Lorenz, Th. Arnold, K. Zimmer*, Mechanism of laser ablation of atmospheric pressure etched N-BK7 surfaces for ultra-precise surface processing applications, E-MRS Spring Meeting 2025, Strasbourg, France, 26.-30.05.2025

F. Hölzel*, G. Böhm, H. Paetzelt, S. Görsch, T. Arnold, Reactive ion beam figuring and plasma jet machining, EU-SPEN - 25th Int. Conf. & Exhibition, Zaragoza, Spain, 09.-13.06.2025

L. Lingenfelder*, A. Finzel, G. Dornberg, J. Zajadacz, F. Frost, Ion beam planarization using non-volatile, high-solvent containing polymer coatings, 51st Int. Micro and Nano Engineering Conf., Southampton, UK, 15.-18.09.2025

I. Litovko*, M. Rudolph, A. Anders, A. Goncharov, Modelling the evaporation of vacuum arc macroparticles by a beam of energetic electrons, Plasma 2025 - Int. Conf. on Research & Applications of Plasmas, Warsaw, Poland, 15.-19.09.2025

I. Litovko*, M. Rudolf, A. Anders, A. Goncharov, Modeling of evaporation of macroparticles of vacuum arcs by an electron beam, 36th Int. Conf. on Phenomena in Ionized Gases, Aix en Provence, France, 20.-25.07.2025

*J. Lorenz**, *R. Rößler*, *B. Corzilius*, *K. Monakhov*, Suppressing nuclear spin relaxation by light-driven switching of multi-spin DNP agents, Hyp*Mol Status Meeting 2025, Leipzig, Germany, 31.03.-02.04.2025

*J. Lorenz**, *M. Moors*, *D. A. Ryndyk*, *K. Monakhov*, Substrate-controlled self-organization of polyoxovanadates into hysteretic switchable materials, Frontiers in Metal Oxide Cluster Science VIII, Mainz, Germany, 22.-25.07.2025

*J. Lorenz**, *R. Rößler*, *B. Corzilius*, *K. Monakhov*, *K. Zimmer**, *J. Zajadacz*, *M. Ehrhardt*, *P. Lorenz*, *T. Smausz*, *B. Hopp*, Pattern transfer by laser ablation: demonstration of a vacuumless process for micropatterning from lithographic masks, 51st Int. Micro and Nano Engineering Conf., Southampton, UK, 15.-18.09. 2025

*Lotnyk**, *T. Dankwort*, *M. Behrens*, *L. Voß*, *S. Cremer*, *L. Kienle*, In situ atomic-scale TEM observation of structural transformations in $\text{Ge}_2\text{Sb}_2\text{Te}_5$ phase change memory alloys, Microscopy Conf. 2025, Karlsruhe, Germany, 31.08.-04.09.2025

*A. Lotnyk**, *N. Braun*, *V. Roddatis*, *S. Cremer*, *D. Kalanov*, *H. Bryja*, Microstructural evolution in $\text{Cu-Sb}_2\text{Te}_3$ thin films studied by atomic-resolution transmission electron microscopy, Microscopy Conf. 2025, Karlsruhe, Germany, 31.08.-04.09.2025

*A. Lotnyk**, Electron beam induced structural changes in chalcogenides for phase change memory applications, IKZ International Fellowship Award & Summer School 2025: Artificial Intelligence & Transmission Electron Microscopy, Leibniz-Institut für Kristallzüchtung, Berlin, Germany, 05.-07.05.2025

*S. Mändl**, *D. Manova*, Stability of expanded austenite during annealing in vacuum, 4th Plasma Thin Film Int. Union Meeting, Antibes, France, 22.-26.09.2025

D. Manova, *H. Kersten*, *S. Mändl**, Time-resolved measurements of secondary electron emission during ion bombardment, 4th Plasma Thin Film Int. Union Meeting, Antibes, France, 22.-26.09.2025

*M. Moors**, *J. Lorenz*, *V.K. Bandari*, *O.G. Schmidt*, *K. Monakhov*, Polyoxovanadates - molecular multilevel switches for highly energy-efficient data storage, MAIN-Fokustag 'Energieeffiziente Elektronik', Forschungszentrum für Materialien, Architekturen und Integration von Nanomembranen (MAIN), Chemnitz, Germany, 26.08.2025

*M. Moors**, *J. Lorenz*, *K. Monakhov*, Polyoxovanadates as redox-active devices in molecular electronics applications, Frontiers in Metal Oxide Cluster Science VIII, Mainz, Germany, 22.-25.07.2025

*E. Rohkamm**, *F. Scholze*, *D. Spemann*, *F. Frost*, Reactive ion beam processing of optical relevant materials: correlation of ion beam composition and etching results, 38th Int. Microprocesses and Nanotechnology Conf., Tokio, Japan, 17.-20.11.2025

K. Shportko, *S. Cremer*, *A. Lotnyk**, Optical characterization of $\text{GeTe-Sb}_2\text{Te}_3$ heterostructures prepared by pulsed laser deposition, European Phase-Change and Ovonic Symposium (E\PCOS), Marseille, France, 23.-26.09.2025

*S. Zahn**, *O. Shayestehpour*, LiTFSI-based deep eutectic electrolytes investigated by machine-learned interatomic potential simulations, 2nd Conf. on Artificial Intelligence in Materials Science and Engineering, Bochum, Germany, 18.-19.11.2025

PATENTS

 2024

5

APPLICATIONS,
of which 4
national,
1 European

6

GRANTED,
of which
2 national,
1 European,
3 international

70

TOTAL PORTFOLIO,
including 32 natio-
nale, 25 European,
11 international,
2 utility models

9

PATENT FAMILIES

 2025

7

APPLICATIONS,
of which
3 national,
1 European,
1 unitary patent,
2 international

5

GRANTED,
of which
1 national,
2 European,
1 unitary patent,
1 international

83

TOTAL PORTFOLIO,
including 35 natio-
nale, 37 European,
1 unitary patent,
8 international,
2 utility models

15

PATENT FAMILIES

PATENTS

PATENTE

GRANTED

ERTEILT

2024

C. Laube

Verfahren zur Herstellung eines Wirkstoff-Nanodiamant-Konjugats (DE102023100630.4),
Deutsches Patent- und Markenamt

D. Breite, A. Schulze, M. Krause

Herstellungsverfahren für eine PET-Membran mittels eines Phaseninversions-Prozesses und eine nach dem Verfahren erhaltene PET-Membran (DE102020118948.6),
Deutsches Patent- und Markenamt

M. Ehrhardt, K. Zimmer, P. Lorenz, J. Zajadacz, A. Anders
Verfahren zur Behandlung einer Festkörperoberfläche (EP3789157), Europäisches Patentamt

U. Helmstedt, H. Herrnberger, A. Freyer, O. Fechner, C. Gschossmann

Printing Plate and Polymeric Coating Material for Same (3150141), Patentamt Kanada

U. Helmstedt, H. Herrnberger, A. Freyer, O. Fechner, C. Gschossmann

Printing Plate and Polymeric Coating Material for Same (11202202648V), Patentamt Singapur

U. Helmstedt, H. Herrnberger, A. Freyer, O. Fechner, C. Gschossmann

Druckform und polymeres Beschichtungsmaterial dafür (10-2717343), Patentamt Korea

2025

L. Prager, U. Trimper, R. Heller, U. Helmstedt, P. With
Technisches Verfahren zur Umsetzung der Photokonversion von molekularen Präkursoren zu Elementoxidschichten (DE102023134414.5),
Deutsches Patent- und Markenamt

D. Breite, A. Schulze, M. Krause

Herstellungsverfahren für eine PET-Membran mittels eines Phaseninversions-Prozesses und eine nach dem Verfahren erhaltene PET-Membran (EP3939694),
Europäisches Patentamt

D. Breite, A. Schulze, K. Leopold

Verfahren zur Herstellung und Veredelung von Polymer Filtermaterialien (EP4299166),
Europäisches Patentamt

D. Breite, A. Schulze, K. Leopold

Verfahren zur Herstellung und Veredelung von Polymer Filtermaterialien (Einheitspatent 4299166),
Europäisches Patentamt

U. Helmstedt, H. Herrnberger, A. Freyer, O. Fechner, C. Gschossmann

Druckform und polymeres Beschichtungsmaterial dafür (7629004), Patentamt Japan

QUALIFICATIONS / GRADUATES

QUALIFIKATIONEN / ABSOLVENTEN

HABILITATION

HABILITATION

2024

Schulze, Agnes

Membrane Surface Engineering Using Electron Beam Irradiation

Universität, Leipzig, Fakultät für Chemie

DOCTORAL THESES

PROMOTIONEN

2024

Alvermann, Christian

Optimale Steuerung in der Bearbeitung von Werkstücken mittels Ionenstrahlen

Universität Leipzig, Fakultät für Mathematik und Informatik

Bez, Elena

Laser-induced surface structuring for electron cloud mitigation in particle accelerators

Universität Leipzig, Fakultät für Physik und Erdsystemwissenschaften

Glöß, Maria

Assembly Behavior and Electronic Characteristics of Polyoxometalates with Vanadium Centers on Surfaces

Universität Leipzig, Fakultät für Chemie und Mineralogie

Holm, Alexander

Ab initio modeling of non-equilibrium structure-property relationships in the functional biomaterials TiO_2 and Fe_7Pd_3 at the nanoscale

Universität Leipzig, Fakultät für Physik und Erdsystemwissenschaften

Niavarani, Zahra

Design of Adsorptive Polymer Microfiltration Membranes using Electron Beam Modification

Universität Leipzig, Fakultät für Chemie und Mineralogie

Schütte, Friedrich

Tailoring mechanics in collagen and cellulose-based systems with energetic electrons: from stress-strain response to shape memory and diagnostic perspectives

Universität Leipzig, Fakultät für Physik und Erdsystemwissenschaften

Yang, Fangshun

Ion Soft-Landing: Same Polarity Ion-Ion Reactions and Ion-Surface Interactions of Deposited Ions

Universität Leipzig, Fakultät für Chemie und Mineralogie

2025

Dietrich, Johannes

Synthesis and characterization of superparamagnetic iron oxide nanoparticles towards one-step ferrogel synthesis

Universität Leipzig, Fakultät für Physik und Erdsystemwissenschaften

Friebe, Sabrina

Impact of Stresses on Porcine Retina and Human Aneurysmatic Aortic Tissue Explants: From Mechanical Response to Potential Perspectives for Diagnosis

Universität Leipzig, Fakultät für Physik und Erdsystemwissenschaften

Hossain, Mohammad

Afaq Plasma Diagnostics of Femtosecond Laser-Induced Plasmas with Applications to Etching

Universität Leipzig, Fakultät für Physik und Erdsystemwissenschaften

Kupferer, Astrid

Ion-Implanted Amorphous Titania Nanotube Arrays - Tailoring Morphology, Chemical Composition and Electrical Conductivity for Advanced Biomedical Implants

Universität Leipzig, Fakultät für Physik und Erdsystemwissenschaften

Rohkamm, Erik

Characterisation of the reactive species of an RF-excited broad beam ion source and their influence on the etching behaviour of optical relevant materials

Universität Leipzig, Fakultät für Physik und Erdsystemwissenschaften

Shayestehpour, Omid

Deep Eutectic Solvents: from Empirical to Machine-Learned Interatomic Potentials

Universität Leipzig, Fakultät für Chemie

DIPLOMA AND MASTER THESES

DIPLOM- UND MASTERARBEITEN

2024

Bublikova, Anastassiya

Alignment and High Energy Electron Beam Cross-linking of Collagen Type I Fibrils

Universität Leipzig, Fakultät für Physik und Erdsystemwissenschaften

El Mouzavak, Dennis

Controlled Preparation of Ionic Layers for X-Ray Photoelectron Spectroscopy using Ion Soft-Landing

Universität Leipzig, Fakultät für Chemie und Mineralogie

Kirkayak, Özgü

Enhancing hydrophilicity and hydrophobicity of polyethylene hollow fiber membranes through electron beam modification

Universität Leipzig, Fakultät für Chemie und Mineralogie

Li, Yuqi

Determination of the resistance of laser microstructured and chemically functionalized stainless Steel surfaces to mechanical and/or Chemical stresses

Technische Universität Dresden, Fakultät Maschinenwesen

Schreiber, Tim

Untersuchung zur Rolle von auf Nylon-Mikrofiltrationsmembranen immobilisierten Enzymen in der Proteingewinnung durch sequenzielle Filtration von Tetraselmis chuii

Universität Leipzig, Fakultät für Chemie und Mineralogie

Schäferjohann, Pia K.

Reaktivität elektrophiler Anionen in der kondensierten Phase

Universität Leipzig, Fakultät für Chemie und Mineralogie

Wagner, Tobias

Untersuchungen zum Quellverhalten organisch modifizierten Montomorillonits in UV-härtbaren Monomeren und zu deren Verarbeitung zu Nanokompositen für Gasbarriere-Anwendungen

Universität Leipzig, Fakultät für Chemie und Mineralogie

Wadsack, Myriam

Aufbau und Inbetriebnahme einer Vakuumkammer zur Speicherung und gepulsten Extraktion massenselektierter Fragmentionen

Universität Leipzig, Fakultät für Chemie und Mineralogie

2025

Anthofer, Alexander

Untersuchungen zur laserunterstützten Plasmabearbeitung von optischen Gläsern

Technische Universität Dresden, Fakultät Maschinenwesen

Günther, Leonard

Untersuchungen zur laserunterstützten reaktiven Ionenstrahlbearbeitung optischer Substrate

Technische Universität Dresden, Fakultät Maschinenwesen

Henriksen, A.

Application of the 3-omega Method to Identify Phase Transitions in Polymers

Universität Leipzig, Fakultät für Physik und Erdsystemwissenschaften

Neubert, Lukas

Einfluss des Neutralteilchen/Ionen-Dichteverhältnisses auf Ätzzraten und Selektivitäten beim reaktiven Ionenstrahlätzen mit einer HF-angeregten Breitstrahlionenquelle

Westfälische Hochschule Zwickau

Neshovski, Jane

Synthesis and Testing of Double-Target Molecularly Imprinted Polymer (MIP) Membranes

Universität Leipzig, Fakultät für Chemie

BACHELOR THESES

BACHELORARBEITEN

2024

Adamczewski, Johannes

Spezifische Anpassung der viskoelastischen Eigenschaften von Gelatine-Glucose-Hydrogelen mittels hochenergetischer Elektronenbestrahlung

Technische Universität Dresden, Fakultät Maschinenwesen

Anthofer, Alexander

Laserunterstütztes Plasmaätzen von optischen Gläsern

Technische Universität Chemnitz, Professur Werkstoff- und Oberflächentechnik

Bialas, Toni

Modifizierung der Oberfläche Itaconsäureesterbasierter Beschichtungen mit Hilfe von VUV-Strahlung

Hochschule für Technik, Wirtschaft und Kultur Leipzig, Fakultät Informatik und Medien

QUALIFICATIONS

 2024

1

HABILITATION

7

DOCTORAL THESES

8

DIPLOMA /
MASTER THESES

16

BACHELOR THESES

 2025

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DOCTORAL THESES

5

DIPLOMA /
MASTER THESES

5

BACHELOR THESES

Franze, Julius

Investigation of the Effects of Ion Flux, Ion Potential Energy, and Ion Kinetic Energy on the Structural Properties of Thin Films

Universität Leipzig, Fakultät für Physik und Erdsystemwissenschaften

Haia, Hiba

Untersuchung von biobasierten UV-härtenden Nanokompositen

Hochschule für Technik, Wirtschaft und Kultur Leipzig, Fakultät Informatik und Medien

Hauser, Hannes Timothy

Perforated polymer slides with transparent titania nanotube array coating for biological applications

Universität Leipzig, Fakultät für Physik und Erdsystemwissenschaften

Hristov, Daniel

Depth Resolved Phase Analysis of Expanded Austenite

Universität Leipzig, Fakultät für Physik und Erdsystemwissenschaften

Lansangan, David Raphael

Combinatorial Deposition by Magnetron Sputtering and Characterization of Ti-Nb Thin Films

Universität Leipzig, Fakultät für Physik und Erdsystemwissenschaften

Mandazhiev, Slavi Dragomirov

Deconvoluting the impact of higher ion charge states and ion flux on thin film growth in pulsed filtered cathodic arc deposition

Universität Leipzig, Fakultät für Physik und Erdsystemwissenschaften

Mattes, Hannah

Immobilisierung von Doxorubicin an die Oberfläche von Nanodiamanten

Universität Leipzig, Fakultät für Chemie und Mineralogie

Netto, Dennis

Precise laser ablation of glass materials with ultrashort laser pulse

Universität Leipzig, Fakultät für Physik und Erdsystemwissenschaften

Oh, Hyemin

Stability of Expanded Austenite Phase Formed by Plasma Nitriding

Universität Leipzig, Fakultät für Physik und Erdsystemwissenschaften

Robachuk, Natasha Alexandra Hrycan

Implementation of Artificial Intelligence for Defect Detection

Universität Leipzig, Fakultät für Physik und Erdsystemwissenschaften

Rößler, Lisa

Entwicklung und Charakterisierung von Membranmaterialien zur Abtrennung von Sauerstoff in gedruckten Mikroreaktoren

Universität Leipzig, Fakultät für Chemie und Mineralogie

Schneider, Kerstin

Untersuchung der Härtung von biobasierten UV-härtenden Beschichtungen

Hochschule für Technik, Wirtschaft und Kultur Leipzig, Fakultät Informatik und Medien

Sliusar, Iryna

Investigations of oxygen-containing atmospheric pressure plasma for the conversion of silicon-based precursor layers into silicon oxide

Universität Leipzig, Fakultät für Physik und Erdsystemwissenschaften

2025

Bialas, Tony

Modifizierung der Oberfläche Itaconsäureesterbasierter Beschichtungen mit Hilfe von VUV-Strahlung

Hochschule für Technik, Wirtschaft und Kultur Leipzig, Fakultät Informatik und Medien

Kraut, Samuel

Validierung der optischen Emissionsspektroskopie für die Charakterisierung einer RF-ICP-Ionenquelle beim Betrieb mit reaktiven Prozessgasen

Technische Hochschule Aschaffenburg, Fakultät Ingenieurwissenschaften

Mörke, Emma Beate

Magnetron Sputtered Ti-Nb Thin Films: Structural and Compositional Characterization, and In-situ Oxidation Measurements

Universität Leipzig, Fakultät für Physik und Erdsystemwissenschaften

Samangani, Nahera

Machine Learning basierte Quantifizierung der Wasserstoffbrückenbindungsenergie

Hochschule für Technik, Wirtschaft und Kultur Leipzig, Fakultät Informatik und Medien

Zib, Mathew

Machine Learning Analysis of Catalyst and Reactor Parameters on Plasma-Catalytic Dry Reforming of Methane
Universität Leipzig, Fakultät für Physik und Erdsystemwissenschaften

Florian Hager

IOM-Preis Nichtwissenschaftliche Mitarbeiter*in

für seinen außergewöhnlichen Einsatz, seine fachliche Professionalität und seinen Teamgeist in der Werkstatt sowie beim Übergang in den Forschungsbereich „Oberflächen poröser Membranfilter“

AWARDS

AUSZEICHNUNGEN

2024

Prof. Dr. Andre Anders

PSE Leading Scientist Award 2024

auf der 19. Conference on Plasma surface engineering für seine herausragenden Leistungen und seinen Einfluss in der wissenschaftlichen Gemeinschaft

Lukas Paul Lingenfelder

Posterpreis in der Kategorie “Methods and Processes”

auf der 50. Internationalen Konferenz “Micro- and Nano Engineering MNE 2024” in Montpellier für das Poster „Ion Beam Planarization using non-volatile, high-solvent containing Polymer Coatings“

Verena Kühn

IOM-Preis Nichtwissenschaftliche Mitarbeiter*in

für ihr außerordentliches Engagement in der Administration unter erschwerten Bedingungen

Dr. Zahra Niavarani

IOM-Preis Nachwuchswissenschaftler*in

für ihre Dissertation „Design of Adsorptive Polymer Micro-filtration Membranes using Electron Beam Modification“

2025

Dr. Kirill Monakhov

mit Gastprofessur vom Institute of Advanced Study (IAS) und dem Department of Chemistry der University of Warwick, Großbritannien ausgezeichnet

Jonas Lorenz

YoungFMOCS 2025 Vortragspreis

auf der 8. Internationalen Konferenz Frontiers in Metal Oxide Cluster Science FMOCS VIII für seinen Vortrag “Substrate-controlled self-organization of polyoxovanadates”

Omid Shayestehpour

IOM-Preis Nachwuchswissenschaftler*in

für seine herausragenden Leistungen im Rahmen seiner Promotion und seinen wichtigen Beitrag zur positiven Außenwahrnehmung des IOM

Sven Arnold

IOM-Preis Nichtwissenschaftliche Mitarbeiter*in

für seine hervorragende, immer lösungsorientierte Arbeit für die unterschiedlichsten IT-Angelegenheiten des IOM

EVENTS

VERANSTALTUNGEN

SCIENTIFIC EVENTS

WISSENSCHAFTLICHE VERANSTALTUNGEN

2024

XXIX. Erfahrungsaustausch zu Oberflächentechnologien mit Plasma- und Ionenstrahlprozessen (OTPIP) 2024

12.-15. März 2024, Mühlleithen

12. Workshop „Laser-Induced Periodic Surface Structure“ (LIPSS)

11.-13.09.2024, Leipzig

European Phase Change and Ovonic Symposium (E\PCOS)

22.-24.09.2024, Leipzig

PLASMA GERMANY Komitee Sitzung

09.10.2024, Leipzig

2025

Mitgliederversammlung des Vereins Kompetenzzentrum Ultrapräzise Oberflächenbearbeitung e.V. (UPOB)

15.01.2025, Leipzig

XXX. Erfahrungsaustausch zu Oberflächentechnologien mit Plasma- und Ionenstrahlprozessen (OTPIP) 2025

11.-14. März 2025, Mühlleithen

AI School 2025

06-09.10.2025, Leipzig

Fokusgruppe DUV/VUV

12.11.2025, Leipzig

KOLLOQUIEN

KOLLOQUIEN

2024

Prof. Dr. Eva Schubert, University of Nebraska-Lincoln, USA

Advanced Manufacturing and Technical Applications of Highly Porous Material Platforms

15.01.2024

Prof. Dr. rer. nat. Evgeny Gurevich, Fachhochschule Münster

Laser Induced Periodic Surface Structures: Mechanisms and applications

04.01.2024

Dr. Jens Zosel, Kurt-Schwabe-Institut für Mess- und Sensortechnik Meinsberg e.V., Waldheim

Sensors for the growing hydrogen economy

11.01.2024

Prof. Dr.-Ing. Thomas von Unwerth, Technische Universität Chemnitz

Hydrogen as future energy carrier – potentials for energy and mobility transition

07.03.2024

Dr. MacKenzie, Helmholtz-Zentrum für Umweltforschung GmbH UFZ, Leipzig

PFAS - How to deal with this substance class from the treatment perspective?

26.04.2024

Dr. Peter Pecher, Singulus Technologies AG, Kahl am Main

Coating in Industry – Lab and Production

23.05.2024

Prof. Pascal Friederich, Karlsruher Institut für Technologie (KIT)

Machine Learning for Simulation, Understanding, and Design of Molecules and Materials

06.06.2024

Dr. Wjatscheslaw Sakiew, Cutting Edge Coatings GmbH, Hannover

Modelling particle fluxes in ion beam sputter deposition

14.11.2024

Prof. Dr. André Ludwig, Dr. Richard Brennecke, Universität Leipzig, Institut für Wirtschaftsinformatik

AI tools and other tools in the research process potentials and risks

12.12.2024

2025

Prof. Dr. Stefanie Gräfe, Friedrich-Schiller-Universität Jena
Tip-Enhanced Raman Scattering – a theoretical description accessing the chemical and electromagnetic contributions

16.01.2025

Prof. Dr. Markus Gregor, Fachhochschule Münster

Using NV-Centers in Microdiamonds for Magnetic Field Sensing Applications

23.01.2025

Prof. Dr. Sibylle Gemming, Technische Universität Chemnitz

Interface or interphase? - Structure formation in confined space

06.02.2025

Dr. Dorothea Golze, Technische Universität Dresden

Accurate theoretical spectroscopy methods for complex materials

13.02.2025

Prof. Dr. Julia Westermayr, Universität Leipzig

Machine Learning for (Photo)Chemical Sciences: From Theoretical Foundations to Practical Solutions

20.02.2025

Prof. Dr. Maren Podewitz, Technische Universität Wien

Capturing Reality in Silico: Development of More Realistic Computational Models for (Transition-Metal) Chemistry

27.02.2025

Prof. Dr. Carolin Müller, Friedrich-Alexander-Universität Erlangen-Nürnberg

Excited-State Odyssey: Charting Maps with Data-Driven Strategies

06.03.2025

Prof. Dr. Doreen Mollenhauer, Friedrich-Schiller-Universität Jena

Computational Approaches for Next-Generation Materials

20.03.2025

Dr. Eva von Domaros, Friedrich-Schiller-Universität Jena
From atomistic understanding to design principles: The theory of materials and surfaces

03.04.2025

Prof. Pramod Padmanabha Pillai, Indian Institute of Science Education and Research, Pune

Visible-Light Photocatalysis with Surface-Engineered Quantum Dots

12.06.2025

Prof. Dr. Selin Kara, Leibniz-Universität Hannover

Enzymatic Synthesis in Deep Eutectic Solvents: Catalysis Across Hydrophilic to Hydrophobic Realms

24.07.2025

Prof. Ferdi Karadas, Bilkent University, Türkei

Non-thermal modifications of the defect density in Prussian blue derivatives

21.08.2025

Prof. Dr. Fedor Jelezko, Universität Ulm

Spin qubits in diamond

28.08.2025

Dr. Mojmír Šerý, Institute of Scientific Instruments of the Czech Academy of Sciences, Brno

Advanced spectral methods and instrument design for measurement of microorganisms

24.09.2025

Prof. Dr. Anjana Devi, Leibniz-Institut für Festkörper- und Werkstoffforschung Dresden e. V. (IFW), Technische Universität Dresden

Nanostructured functional materials triggered by precursor chemistry

13.11.2025

Dr. Diana Cialla-May, Leibniz-Institut für Photonische Technologien e.V. (Leibniz-IPHT), Jena

Surface enhanced Raman spectroscopy (SERS) in complex bio samples

27.11.2025

Dr. Mario Ziegler, Leibniz-Institut für Photonische Technologien e.V. (Leibniz-IPHT), Jena

Synthesis of plasmonic and photocatalytic active 3D nanostructures by MS-ALD

27.11.2025

TRADE FAIR PRESENTATIONS

MESSEAUFTTRITTE

2024

16. Optatec – Internationale Fachmesse für Optische Technologien 14-16.06.2024, Frankfurt/Main

2025

LASER World of PHOTONICS

24.-27.06.2025, München

EVENTS FOR THE GENERAL PUBLIC

VERANSTALTUNGEN FÜR DIE ALLGEMEINE ÖFFENTLICHKEIT

2024

SPIN2030 Wissenschaftsfestival

08.-09.03.2024

Vorstellung der Forschungsthemen "Innovative Membranfilter", "Kunststoffe in der nachhaltigen Energiegewinnung" sowie „Anwendung von Plasmen“ im Rahmen des Formats "Meet a Scientist"

Girls`Day – Mädchen-Zukunftstag

25.04.2024

Einblicke in verschiedene Forschungsbereiche und Austausch mit weiblichen Vorbildern in MINT-Berufen.

Book a Scientist

15.10.2024

Speed Dating mit der Wissenschaft – ein Format der Leibniz-Gemeinschaft. Persönliche Gespräche mit Experten*innen des IOM.

2025

Woche der offenen Unternehmen - SCHAU REIN!

17.-18.03.2025

Vorstellung der Berufsgruppen Chemie- und Physikalaborant am IOM, im Rahmen der Initiative des Bundeslandes Sachsen zur Berufsorientierung.

Tag der Raumfahrt

29.03.2025

Veranstaltungen des Deutschen Zentrums für Luft- und Raumfahrt (DLR) und des Bundesministeriums für Wirtschaft und Klimaschutz (BMWK). Vorstellung elektrischer Raumfahrtantriebe sowie Messsysteme zur Charakterisierung von elektrischen Ionentriebwerken.

Girls`Day – Mädchen-Zukunftstag

03.04.2025

Einblicke in verschiedene Forschungsbereiche und Austausch mit weiblichen Vorbildern in MINT-Berufen.

Book a Scientist

03.06.2025

Speed Dating mit der Wissenschaft – ein Format der Leibniz-Gemeinschaft. Persönliche Gespräche mit Experten*innen des IOM.

Lange Nacht der Wissenschaften

20.06.2025

Eine Veranstaltung der Leipziger Wissenschaftseinrichtungen in Kooperation mit der Stadt Leipzig. Geführte Rundgänge durch das IOM, mit Einblicken in aktuelle Forschungsthemen.

TEACHING**LEHRTÄTIGKEIT****PROFESSORSHIPS****PROFESSUREN**

Universität Leipzig Fakultät für Physik und Erdwissenschaften

Prof. Dr. Benjamin Dietzek-Ivanšić Professur für Angewandte Physik

Prof. Dr. André Anders Professur für Angewandte Physik

Prof. Dr. Stefan G. Mayr Professur für Oberflächenphysik

Technische Universität Dresden Fakultät Maschinenwesen

Prof. Dr. Thomas Arnold Professur für Ultrapräzisionsbearbeitung von Oberflächen mit Ionen und Plasmen (GB/IOM Leipzig)

LECTURE SERIES**VORLESUNGEN****Prof. Dr. André Anders**

Plasmas Physics, Thin Film Deposition and Characterization

Universität Leipzig, Fakultät für Physik und Geowissenschaften

Winter 2023/24, Summer 2024, Winter 2024/25

Prof. Dr. Thomas Arnold

Ultrapräzisionsbearbeitung

Technische Universität Dresden, Fakultät Maschinenwesen

Winter 2023/24, Winter 2024/25

Nanotechnologien

Technische Universität Dresden, Fakultät Maschinenwesen

Winter 2023/24, Winter 2024/25

Prof. Dr. Thomas Arnold und Dr. Carsten Bundesmann

Photonische Messtechnik

Technische Universität Dresden, Fakultät Maschinenwesen

Summer 2024, Summer 2025

Dr. Jens Bauer (with support from Dr. Frank Frost Dr. and Dr. Jürgen W. Gerlach)

Analytik und Spektroskopie: Oberflächen- und Dünnschichtanalytik (Aufbaustudium)

Universität Leipzig, Fakultät für Chemie und Mineralogie

Winter 2024/25

Dr. Ulrike Helmstedt

Function Control at Complex Surfaces Universität Leipzig, Fakultät für Chemie und Mineralogie

Winter 2023/24, Winter 2024/25

PD Dr. Axel Kahnt

Aktuelle Entwicklungen in der Chemie Universität Leipzig, Fakultät für Chemie und Mineralogie

Winter 2023/24, Winter 2024/25

PD Dr. Stephan Mändl

Plasmas Physics, Thin Film Deposition and Characterization

Universität Leipzig, Fakultät für Physik und Geowissenschaften

Winter 2023/24, Winter 2024/2025, Winter 2025/26

Prof. Dr. Stefan G. Mayr

Experimentalphysik 5

Universität Leipzig, Fakultät für Physik und Geowissenschaften

Winter 2023/24

Experimentalphysik 4

Universität Leipzig, Fakultät für Physik und Geowissenschaften

Summer 2024, Summer 2025

Oberflächen, Nanostrukturen und Dünne Schichten

Universität Leipzig, Fakultät für Physik und Geowissenschaften

Winter 2024/25, Winter 2025/26

Dr. Kirill Monakhov

Polyoxometalates: From Synthesis to Function

Universität Leipzig, Fakultät für Chemie und Mineralogie

Winter 2025/26

Dr. Agnes Schulze

Funktionskontrolle an komplexen Oberflächen

Universität Leipzig, Fakultät für Chemie und Mineralogie

Winter 2023/24, Winter 2024/25

Dr. Daniel Spemann

Teilchenphysik

Universität Leipzig, Fakultät für Physik und Geowissenschaften, Summer 2024, Summer 2025

Experimentalphysik VII – Kern- und Teilchenphysik

Universität Leipzig, Fakultät für Physik und Geowissenschaften

Winter 2023/24, Winter 2024/25, Winter 2025/26

Dr. Unutulmazsoy, Yeliz

Plasmas Physics, Thin Film Deposition and Characterization, Universität Leipzig, Fakultät für Physik und Geowissenschaften

Summer 2024, Winter 2024/25, Winter 2025/26

SEMINAR SERIES

SEMINARE

Prof. Dr. André Anders

Plasmas Physics, Thin Film Deposition and Characterization, Universität Leipzig, Fakultät für Physik und Geowissenschaften

Winter 2023/24, Summer 2024, Winter 2024/25

Dr. Ulrike Helmstedt

Function Control at Complex Surfaces

Universität Leipzig, Fakultät für Chemie und Mineralogie
Winter 2023/24, Winter 2024/25**PD Dr. Stephan Mändl**

Plasmas Physics, Thin Film Deposition and Characterization, Universität Leipzig, Fakultät für Physik und Geowissenschaften

Winter 2023/24, Winter 2024/2025, Winter 2025/26

Prof. Dr. Stefan G. Mayr

Seminar Oberflächenphysik, Nanostrukturen und Dünne Schichten, Universität Leipzig, Fakultät für Physik und Geowissenschaften, Winter 2024/25, Winter 2025/26

Seminar zu Experimentalphysik 5

Universität Leipzig, Fakultät für Physik und Geowissenschaften, Winter 2023/24

Seminar zu Experimentalphysik 4

Universität Leipzig, Fakultät für Physik und Geowissenschaften, Summer 2024, Summer 2025

Dr. Agnes Schulze

Funktionskontrolle an komplexen Oberflächen

Universität Leipzig, Fakultät für Chemie und Mineralogie
Winter 2023/24, Winter 2024/25**Dr. Daniel Spemann**

Teilchenphysik

Universität Leipzig, Fakultät für Physik und Geowissenschaften

Summer 2024, Summer 2025

Experimentalphysik VII – Kern- und Teilchenphysik

Universität Leipzig, Fakultät für Physik und Geowissenschaften

Winter 2023/24, Winter 2024/25, Winter 2025/26

STRUCTURED DOCTORAL TRAINING PROGRAM: „SURFACE ENGINEERING“**Prof. Dr. Thomas Arnold, Dr. Frank Frost and Dr. Klaus Zimmer**Modul “Beam-based ultra-precision surface machining”
Leibniz Institute of Surface Engineering (IOM), 2024**Dr. Stefan Zahn and Dr. Martin Rudolph**

AI school of the MMS network Leibniz Institute of Surface Engineering

Leibniz Institute of Surface Engineering (IOM), 2025

COMMITTEE WORK**GREMIENARBEIT****Prof. Dr. André Anders**

- Editor-in-Chief, Journal of Applied Physics, published by AIP Publishing, New York, USA
- Member of the Advisory Board, International Conference on Metallurgical Coatings and Thin Films (ICMCTF)
- Member of the Advisory Board of the International Conference on Plasma Surface Engineering (PSE)
- Member of Advisory Committee, Plathinium, The Plasma, Thin Films and Related Processing Union Meeting
- Member, Advisory Committee, European Research Society for Thin Films (EFDS)
- Scientific Chair, Association “Plasma Germany”
- Interim Editor-in-Chief, Physics of Fluids, published by AIP-Publishing, New York
- Director of the American Vacuum Society (AVS)
- Chair, Awards Committee, the Executive Committee of Advanced Surface Engineering of the AVS, 2025

Prof. Dr. Thomas Arnold

- Member of the Nanotechnologie Kompetenzzentrum Ultrapräzise Oberflächenbearbeitung e.V.
- Member of the Optical Society of America (OPTICA)
- Member of the German Branch of the European Optical Society (DGaO)

- Member of Scientific Committee EUSPEN SIG Meeting “Micro/Nano Manufacturing”, 2025
- Member of Evaluation Commission, Institute of Plasma Physics IPP, Czech Academy of Science, Prague, 2025
- Reviewer in the Review Board of the DFG
- Reviewer in the Review Board of the Thüringer Aufbau-bank

Dr. Daniel Breite

- Speaker of the working group “Membranes for Climate” for the Topic “Advances in membrane and module production (including recycling)” at Deutsche Gesellschaft für Membrantechnik DGMT

Dr. Carsten Bundesmann

- Fächerübergreifende Arbeitsgemeinschaft Halbleiterforschung Leipzig (FAHL, Interdisciplinary Workgroup on Semiconductor Research Leipzig), Personal Member

Prof. Dr. Benjamin Dietzek-Ivanšić

- Editor "Chemical Physics Letters"
- Fachkollegiat der DFG, Physikalische Chemie von Molekülen und Grenzflächen
- 2. Vorsitzender der Deutschen Bunsengesellschaft für Physikalische Chemie
- International Advisory Board, Institute of Physical Chemistry Polish Academy of Sciences
- Member of the Steering Committee, International Symposium of Photochemistry and Photophysics of Coordination Compounds

Dr. Frank Frost

- Member of the Program committee “The European Optical Society Annual Meeting – EOSAM: Optical System Design, Tolerancing and Manufacturing”
- Fächerübergreifende Arbeitsgemeinschaft Halbleiterforschung Leipzig (FAHL, Interdisciplinary Workgroup on Semiconductor Research Leipzig), Personal Member

Dr. Ulrike Helmstedt

- Member of the Advisory Board of the Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technology FEP, Dresden

Dr. Wolfgang Knolle

- Member of the Editorial Board “Radiation Physics and Chemistry”

Dr. Andriy Lotnyk

- Second speaker of the working group “High-Resolution Transmission Electron Microscopy” (German Society for Electron Microscopy)”
- Member of the German Society for Electron Microscopy (DGE)
- Member of the European Microscopy Society (EMC)
- Member of the German Association of University Professors and Lecturers (DHV)
- Member of the Editorial Board “Compounds” MDPI
- Programme committee member of the European Phase-Change and Ovonic Symposium (E\PCOS)
- Chair of the Local organising committee of the European Phase-Change and Ovonic Symposium (E\PCOS) (2024)

Dr. Darina Manova

- Member of the Editorial Board “Surface and Coatings Technology” Elsevier
- Editor of Special Issue of “Surface and Coatings Technology” – Women Leaders in Surface and Coatings Technology

Dr. Kirill Monakhov

- Member of Scientific Committee, Frontiers in Metal Oxide Cluster Science VIII Conference, July 22–25, Mainz, Germany
- Mentor in the International Younger Chemists Network (IYCN)
- Member of the Collaborative Research Center (TRR 386) “Hyp*Mol - Hyperpolarization in Molecular Systems”
- Member of the German Chemical Society (GDCh)
- Reviewer for the National Research and Development Agency (ANID) of the Ministry of Science, Technology, Knowledge and Innovation of Chile
- Reviewer for the Alexander von Humboldt Foundation
- Reviewer for the German Research Foundation
- Reviewer for the National Science Centre Poland
- Reviewer for Agence nationale de la recherche (ANR)
- Reviewer for M-ERA.NET

Dr. Martin Rudolph

- Member of the expert panel of Plasma Germany
- Member of the Program Committee of the International Conference on Metallurgical Coatings and Thin Films, San Diego

Dr. Tom Scherzer

- Advisory Board of the European European Symposium of Photopolymer Science
- Advisory Board of the International Symposium on Photopolymerization

Dr. Agnes Schulze

- Member of Deutsche Gesellschaft für Membrantechnik DGMT
- Member of the German Chemical Society (GDCh)
- Member of ZIM-Innovationsnetzwerk „Technologien zur nachhaltigen Nutzung auf Aufbereitung von Wasser“
- Board of Graduate School BuildMoNa, Uni Leipzig
- Review Editor of Advanced Functional Materials / Frontiers in Chemistry / Polymer Chemistry
- Reviewer of the DFG / NWO
- Member of the Institute's 2023 internal Evaluation Committee of the Competence Center Textile Chemistry, Environment & Energy of Deutsche Institute für Textil- & Faserforschung, DITF, Denkendorf
- Member of the Advisory Board of the Institute for Advanced Membrane Technology (IAMT), Karlsruhe Institute of Technology (KIT), Eggenstein-Leopoldshafen

Dr. Klaus Zimmer

- Member of the Editorial Board “Surfaces and Interfaces” Elsevier
- Reviewer in the Review Board of the DFG
- Reviewer in the Review Board of the Bayrische Forschungsstiftung

IMPRESSUM

IMPRINT

HERAUSGEBER PUBLISHER

Der Vorstand des *The board of directors of the*

Leibniz-Instituts für Oberflächenmodifizierung e.V. *Leibniz Institute of Surface Engineering (IOM)*

Prof. Dr. Benjamin Dietzek-Ivanšić, Wissenschaftlicher Direktor, *Scientific Director*

Dr. Daniel Strecker, Kaufmännischer Direktor, *Administrative Director*

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BILDERVERZEICHNIS IMAGE DIRECTORY

Umschlag *Cover from left to right:*

Amira Abdul Latif, a technical staff member, at the photocatalytic membrane reactor. Photo: Erik Kazak

Equipment for depositing layers using ion soft landing. Photo: Erik Kazak

Dr. Christian Laube, research associate, preparing samples at the 10 MeV electron accelerator. Photo: Erik Kazak

Cell culture workflow at the laminar flow hood. Photo: Erik Kazak

Master's student Anupriya Sukumaran at the UV-Vis spectrophotometer, which is used for kinetic studies of redox-active polyoxometalates. Photo: Erik Kazak

Seite Page 02: Microfluidics prototype for cryoprinting. Photo: Erik Kazak

Seite Page 06: Dr. Paul Räcke, research associate at the IOM. Photo: Erik Kazak

Seite Page 56/57: A view inside the measurement chamber of a time-of-flight secondary ion mass spectrometer (TOF-SIMS). Photo: Erik Kazak

Seite Page 64/65: Dmitry Kalanov, a research assistant, looks into a chamber for plasma-assisted coating deposition. Photo: Erik Kazak

Seite Page 90: Laser-machined surface. Photo: Erik Kazak

REDAKTIONSSCHLUSS EDITORIAL DEADLINE

17.02.2026

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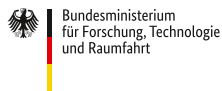
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