JAHRESBERICHT
ANNUAL REPORT

24

INM Leibniz-Institut für Neue Materialien

Leibniz Gemeinschaft

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LIEBE LESERINNEN UND LESER, WILLKOMMEN ZUM JAHRESBERICHT DES INM!

Das INM blickt auf ein besonderes Jahr 2024 zurück.

Wissenschaftliche Highlights wie die Entwicklung einer selbst-befeuchtenden Kontaktlinse gegen das Trockene-Augen-Syndrom, neue Technologien und Materialien zur Rückgewinnung von Lithium aus ausgedienten Batterien und Akkus oder der Einsatz von Tintenstrahldruckern für die Herstellung industrieller Perowskit-Silizium-Tandemsolarzellen zeigen einmal mehr die Vielfalt und Innovationskraft der Forschung am INM. Auch aus finanzieller Sicht war das Jahr erfolgreich. Die Drittmitteleinnahmen konnten weiterhin auf einem hohen Niveau gehalten werden.

DEAR READERS, WELCOME TO THE ANNUAL REPORT OF THE INM!

The INM looks back on a special year 2024.

Scientific highlights such as the development of a self-lubricating contact lense against dry-eye-syndrom, new technologies and materials for the recovery of lithium from used batteries or the use of inkjet printers for the production of industrial perovskite silicon tandem solar cells once again demonstrate the diversity and innovative strength of research at the INM. The year was also successful from a financial perspective. Third-party funding income was maintained at a high level.

Personell gab es 2024 Veränderungen: Für die Leitung der Core Facility *Accelerated Research Foundry* konnte Dr. Alvaro Banderas gewonnen werden. Nach über zwanzig Jahren Tätigkeit am INM, zuletzt als Leiter der Core Facility *Physikalische Analytik*, verließ Dr. Marcus Koch das Institut. Die Leitung der Core Facility – nunmehr Core Facility *Elektronenmikroskopie* – wurde zur Neubesetzung ausgeschrieben. Die Leitung der vakanten Forschungsabteilung *Innovative Elektronenmikroskopie* wurde ebenfalls ausgeschrieben. Auch für die Etablierung weiterer neuer Forschungsgruppen für *Materialien in der Digitalen Umgebung* und für *KI-getriebenes Materialdesign* wurden 2024 wichtige Weichen gestellt.

Die Vorbereitungen zur Evaluierung des INM im Juni 2024 begannen bereits Mitte des Vorjahres und traten mit dem Jahreswechsel 2024 in die „heiße Phase" ein. Die im Vorjahr entwickelte Strategie erwies sich dabei als wertvolle Grundlage für die Strategiediskussion im Selbstbericht. Nach Einreichung des finalen Selbstberichts des INM im April wurde der zentrale Evaluierungsschritt vorbereitet, der aus dem Besuch der Gutachtergruppe am 13. und 14. Juni bestand. Beirat und Kuratorium begleiteten das INM als Berater und Sparringspartner bei der Vorbereitung. Noch vor Redaktionsschluss dieses Berichtes erreichte uns im März 2025 die Senatsstellungnahme zur Evaluierung des Institutes, in der Bund und Ländern empfohlen wird, die gemeinsame Förderung des Instituts für weitere sieben Jahre fortzusetzen.

2024 war auch wieder ein Jahr des Beginns neuer Großprojekte. Hierbei ist vor allem der seit 2020 von der Leibniz-Gemeinschaft und dem Saarland geförderte und erfolgreich arbeitende Leibniz WissenschaftsCampus *„Lebende Therapeutische Materialien"* zu nennen, der nunmehr in die zweite Förderperiode eintrat, die sich über vier Jahre bis 2028 erstreckt. Neben der Fortführung des Forschungsprogramms aus der ersten Förderperiode wird nun ein besonderer Fokus auf den Ausbau des Know-hows in Transfer- und regulatorischen Fragen gelegt.

Auch auf der Ebene der Forschungsabteilungen und -gruppen gab es erfolgreiche Einwerbungen von Mitteln. Hier sei exemplarisch die Förderung von Dr. Oskar Staufer (Forschungsgruppe *Immuno-Materialien*) und Dr. Gerardo Asensio (Forschungsabteilung *Dynamische Biomaterialien*) durch die innovate! Academy der Joachim-Herz-Stiftung genannt, die in diesem Zusammenhang speziell auf die Förderung des Transfers neuer Materialien für Medizinanwendungen aus dem Labor in die Anwendung zielt.

Weitere Einblicke in Neues und Spannendes aus dem INM bieten Ihnen die nachfolgenden Seiten. Wir wünschen Ihnen eine anregende Lektüre.

There were personnel changes in 2024: Dr. Alvaro Banderas was appointed Head of the Core Facility *Accelerated Research Foundry*. After more than twenty years at the INM, Dr. Marcus Koch left the institute. The Head of the Core Facility *Physical Analysis* – now *Electron Microscopy* – was newly advertised. The appointment of the Head of the *Innovative Electron Microscopy* research department is also still pending. Important steps were also taken in 2024 to establish further new research groups for *Materials in the digital environment* and for *AI-driven material design*.

Preparations for the evaluation of the INM in June 2024 began in the middle of the previous year and entered the "hot phase" at the start of 2024. The strategy developed in the previous year proved to be a valuable basis for the strategy discussion in the self-evaluation report. Following the submission of the INM's final self-evaluation report in April, preparations were made for the central evaluation step, which consisted of a visit by the expert group on June 13 and 14. The Advisory Board and Board of Trustees supported the INM as advisors and sparring partners during the preparations. In March 2025, before this report went to press, we received the Senate's opinion on the evaluation of the institute, which recommended that the federal and state governments continue to jointly fund the institute for another seven years.

2024 was also another year in which new major projects were launched. In particular, the Leibniz ScienceCampus *"Living Therapeutic Materials"*, which has been successfully funded by the Leibniz Association and Saarland since 2020, has now entered its second funding period, which will run for four years until 2028. In addition to continuing the research program from the first funding period, a special focus is now being placed on expanding expertise in transfer and regulatory issues.

Various funds were also successfully acquired at the level of the research departments and groups. One example of this is the funding of Dr. Oskar Staufer (*Immuno-Materials* research group) and Dr. Gerardo Asensio (*Dynamic Biomaterials* research department) by the innovate! Academy of the Joachim Herz Foundation, which in this context specifically aims to promote the transfer of new materials for medical applications from the laboratory to application.

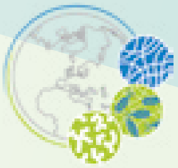
The following pages offer you further insights into new and exciting developments at the INM. We wish you a stimulating read.

Scientific profile of INM / Das wissenschaftliche Profil des INM

INM VISION

A better world through new materials.

Eine bessere Welt dank neuer Materialien.



INM MISSION

We explore new materials from chemical and living components that overcome frontiers in functionality, performance, and sustainability.We design our materials to drive sustainable technologies and solve societal and technological challenges in synergy with academic and industrial partners.

Wir erforschen neue Materialien aus chemischen und lebenden Komponenten, um Grenzen in Bezug auf Funktionalität, Leistungsfähigkeit und Nachhaltigkeit zu überwinden. Wir entwickeln unsere Materialien, um nachhaltige Technologien voranzutreiben und gesellschaftliche und technologische Herausforderungen in Synergie mit akademischen und industriellen Partnern zu meistern.

INM DEPARTMENTS AND GROUPS / ABTEILUNGEN UND GRUPPEN DES INM

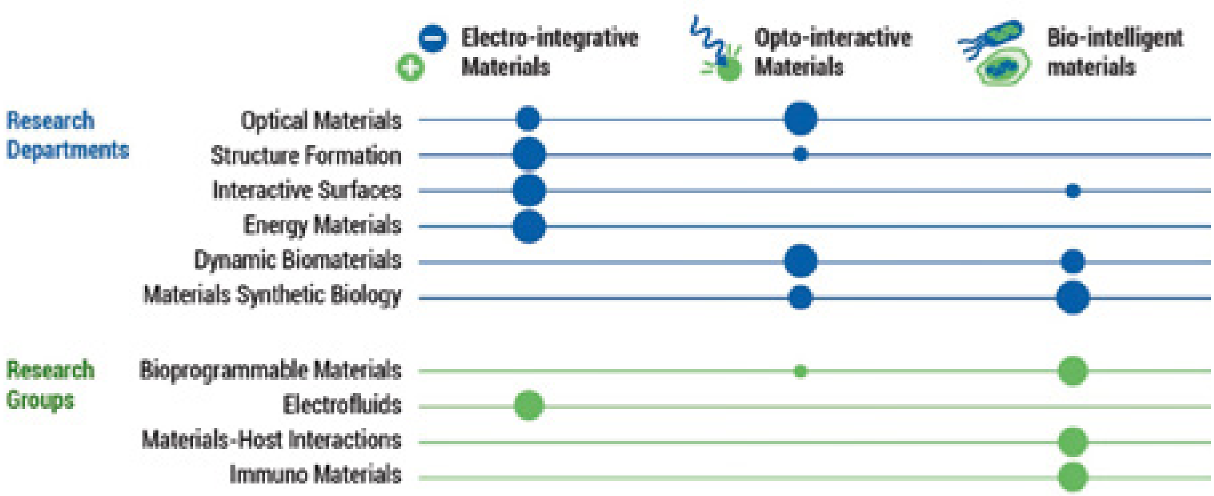
COMPETENCE AREAS OF INM / KOMPETENZFELDER

INM has identified three competence areas in which it aims for strategic leadership:

- **Opto-interactive materials:** We develop materials that modulate light behavior, or that are modulated upon interaction with light.
- **Electro-integrative materials:** We develop materials that integrate high-density ion management and stimulus-responsive conductivity.
- **Bio-intelligent materials:** We design materials that can instruct biological systems and program living organisms to interface materials and augment their properties.

Das INM hat drei Kompetenzbereiche identifiziert, in denen es strategische Führung anstrebt:

- **Opto-interaktive Materialien:** Wir entwickeln Materialien, die das Verhalten von Licht modulieren oder die durch die Interaktion mit Licht moduliert werden.
- **Elektro-integrative Materialien:** Wir entwickeln Materialien, die ein hochdichtes Ionenmanagement und eine auf Reize reagierende Leitfähigkeit integrieren.
- **Bio-intelligente Werkstoffe:** Wir entwickeln Materialien, die biologische Systeme anleiten und lebende Organismen programmieren können, um Materialien zu verbinden und ihre Eigenschaften zu verbessern.



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Berichte der Wissenschaftlichen Einheiten / Reports of the Scientific Units

Bioprogrammierbare Materialien / Bioprogrammable Materials

Dr. Shrikrishnan Sankaran

ZUSAMMENFASSUNG

Die Forschungsgruppe *Bioprogrammierbare Materialien* nutzt die synthetische Biologie, um genetisch programmierte Funktionalitäten in Materialien für biomedizinische Anwendungen einzubringen. Die Gruppe steht im Mittelpunkt der INM-Forschung zu Biointelligenten Materialien mit Schwerpunkt auf der Entwicklung „lebender therapeutischer Materialien“ (LTM) und erweitert die Toolbox zur Herstellung intelligenter / reaktionsfähiger Materialien mit genetisch veränderten Komponenten. Die Gruppe konzentriert sich auf zwei Hauptforschungsbereiche: (i) die Entwicklung probiotischer Bakterienstämme für die ferngesteuerte Synthese und Verabreichung von Medikamenten und (ii) Studien zum Verständnis der Verhaltensänderungen von Bakterien, die in Polymermatrizen eingekapselt sind.

MISSION

The *Bioprogrammable Materials* research group uses synthetic biology to introduce genetically programmed functionalities into materials for biomedical applications. The group is at the heart of INM's biointelligent materials research with a focus on the development of “living therapeutic materials”(LTMs) and expands the toolbox for producing smart / responsive materials with genetically modified components. The group focuses on two main research areas: (i) the development of probiotic bacterial strains for remotely controlled synthesis and delivery of drugs, and (ii) studies to understand behavioral changes of bacteria encapsulated in polymer matrices.

CURRENT WORK

In the past year, the research group *Bioprogrammable Materials* developed advanced tools for programming therapeutic functions in probiotic bacteria and enhancing their performance via encapsulation.

In *E. coli Nissle 1917*, we developed an efficient thermo-amplifier genetic circuit for controlled production and release of a novel antibiotic, Darobactin (Dey et al., J. Biol. Eng., 2024). This circuit addressed leaky expression in the OFF state and low production in the ON state seen in prior switches. Remarkably, it achieved near-zero leakiness at 37 °C and pathogen-inhibitory production at 40 °C. The circuit also sustained its exceptional performance even in bile acids and under low-nutrient conditions, showcasing its robustness in intestinal environments. These advances not only enhance the therapeutic potential of probiotic bacteria but also demonstrate their exciting capacity to produce complex compounds under physiological conditions.

For *L. plantarum*, we identified a high-performance phage-derived promoter-repressor system, achieving the highest protein production levels reported in

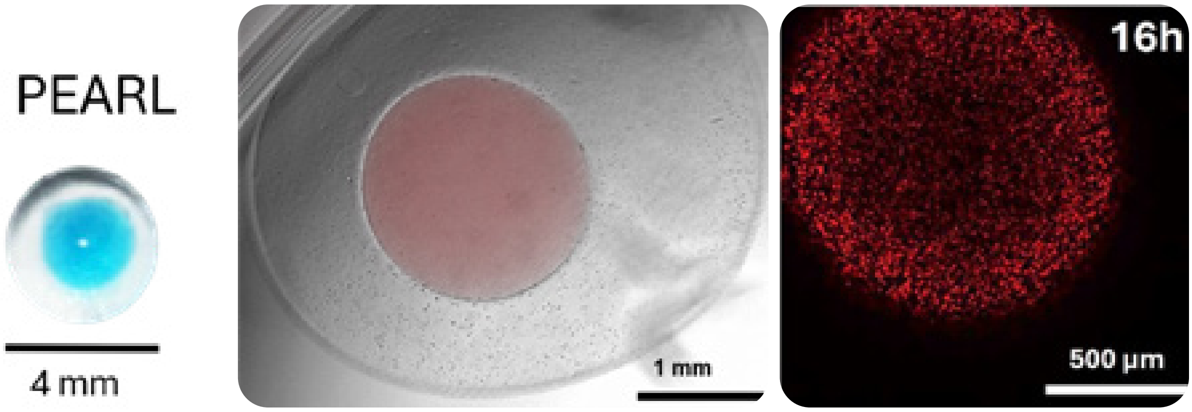
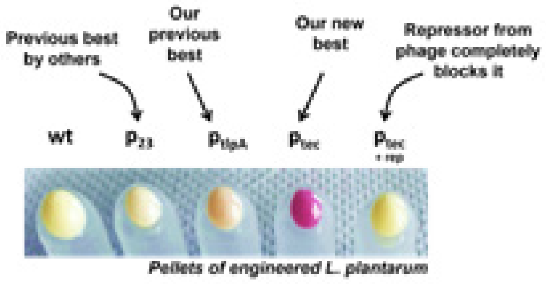


Fig. 1: Bacterial pellets of *L. plantarum* engineered to produce a fluorescent protein regulated by different promoters and a repressor.

Fig. 2: Photo and microscopy images of the core-shell alginate PEARL system containing fluorescent *L. plantarum*.



this species to date, which is almost completely repressed by the repressor (Blanch-Asensio et al., Microb. Cell Fact., 2024). By modifying the repressor with a thermo-responsive domain, protein production could be regulated over a range of 10-fold from 30 °C to 40 °C. In collaboration with Prof. Rahmi Lale (NTNU/Syngens, Norway), we also developed novel switches responsive to food-grade chemicals like cumate (Blanch-Asensio et al., bioRxiv, 2025), paving the way for precise, inducible gene control in lactobacilli for living biotherapeutics.

These lactobacilli were then engineered to secrete therapeutic proteins (e.g., nucA, elafin, α-MSH) and encapsulated in alginate core-shell beads to develop the PEARL (Protein Eluting Alginate with Recombinant Lactobacilli) system (Tadimarri et al. bioRxiv, 2024). The PEARLs achieved sustained, controlled protein release for 14 days while ensuring robust bacterial biocontainment. Most excitingly, encapsulation stabilized protein release profiles and minimized leaky expression compared to non-encapsulated bacteria, indicating that the bacteria were maintained in a unique active yet non-growth metabolic state. Furthermore, encapsulation even reduced potential cytotoxicity of the bacteria towards mammalian cells (coop. research group *Materials-Host Interactions*) and even Zebrafish embryos (coop. Prof. Rolf Müller, HIPS).

In terms of understanding bacterial behavior under confinement, in our SFB 1027 subproject, we investigated bacterial growth and metabolism in hydrogels mimicking natural biofilms. Mechanical restrictions in hydrogels profoundly affected *E. coli* compared to *L. plantarum* in terms of growth rates, colony morphology, and protein production. Metabolic heat measurements (coop. Prof. Rolf Müller, HIPS) revealed important factors contributing to these fascinating differences.

OUTLOOK

The progress over the last year has established our ability to engineer therapeutic functions in probiotic bacteria and create functional LTMs. In the coming years, the development of LTMs will focus on the transfer of this technology. For this, we will further demonstrate the potential of these LTMs for antimicrobial, regenerative, and immunomodulatory applications *in vitro* and *in vivo* through collaborations within the Leibniz Science Campus. To ensure the safety of these genetically modified bacteria, we will implement features including metabolic auxotrophy and kill-switches to prevent them from thriving outside the material that contains them (SPP 2451 project, coop. Meike Koenig, KIT). Additionally, we will continue to study the influence of the encapsulating materials on the bacteria to improve the performance of LTMs. These studies and safety features will help to guide the regulation of these devices for eventual testing in humans.

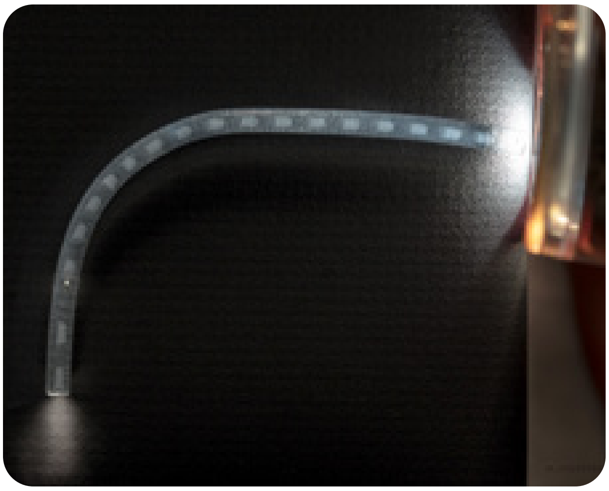
Dynamische Biomaterialien / Dynamic Biomaterials

Prof. Dr. Aránzazu del Campo

ZUSAMMENFASSUNG
Die Forschungsabteilung *Dynamische Biomaterialien* entwickelt synthetische Mikroumgebungen mit programmierter Bioaktivität und Mechanik, um lebende Zellen einzukapseln und zu instruieren. Wir untersuchen, wie lebende und nicht lebende Materie auf verschiedenen Ebenen interagieren und wie diese Interaktionen genutzt werden können, um zelluläre Funktionen zu steuern und letztendlich therapeutische Vorteile zu erzielen. Die Gruppe verfügt über wichtige Kompetenzen in den Bereichen Hydrogelsynthese, Photoschalter, Biofabrikationstechnologien und Zellbiologie. Wir arbeiten eng mit synthetischen Biologen, Biophysikern, Arzneimittelentwicklern und Klinikern rund um die Welt zusammen. Unsere Arbeit leistet sowohl aus der Perspektive der Grundlagenforschung als auch der Anwendung einen Beitrag zum Bereich der nachhaltigen Arzneimittelverabreichung für abfallfreie Therapeutika.

MISSION
The Research Department *Dynamic Biomaterials* develops synthetic hydrogels to encapsulate and instruct living cells. We create synthetic microenvironments with programmed bioactivity and study how living and non-living matter interact at various levels, and how we can exploit such interactions to direct cellular functions by materials engineering. We apply this knowledge to develop living materials with therapeutic and environmental advantages. The group has major competences in hydrogel synthesis and functionalization, photo switches, biofabrication, and cell biology. We cooperate with synthetic biologists, biophysicists, drug developers and clinicians around the world. Our work contributes to the field of sustained drug delivery devices for zero-waste therapeutics, both from fundamental research and application perspectives.

CURRENT RESEARCH
Living Therapeutic Materials
We develop hydrogels and biofabrication technologies to encapsulate drug biofactories into functional devices for long-term drug delivery. These living hydrogels produce and sustain the release of biotherapeutics, while containing the active organism long term. They are conceived as implantable drug delivery devices for zero-waste pharmacology. We work on (i) understanding how material design affects bioactivity of biofactories, (ii) the parallelization of in vitro experimental testing in simulated physiological conditions for future data-driven material design, and (iii) the development of upscalable materials and process to living devices. In this field, we cooperate with *Bioprogrammable Materials* and *Materials-Host Interactions* at INM (*Biomat Adv 2024*). We focus on living materials for ocular drug delivery, with drug-eluting living contact lenses as first prototypes (*Adv Mater 2024*). Innovation steps based on this technology are supported by the innovate" Akademie (Joachim Herz Stiftung). The group leader



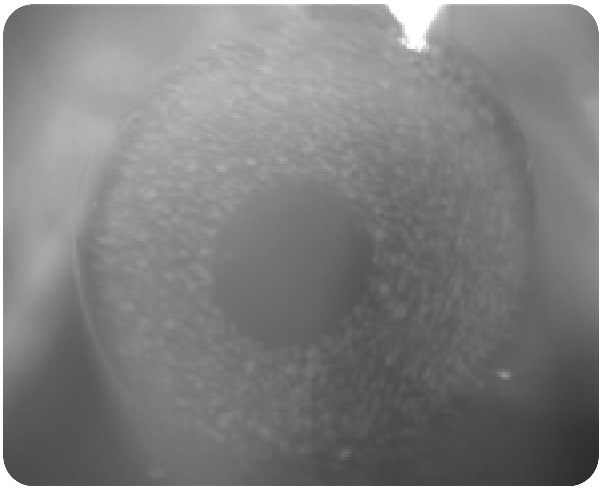


Fig. 1: Multimaterial printed hydrogel fiber optic with integrated scattering segments and in-coupled light from a mobile phone
Fig. 2: Cross section of a living therapeutic optical fiber. Core: optical waveguide, Intermediate layer: contains light-regulated drug biofactories, outer layer: prevents biofactory outgrowth.

coordinates the *Leibniz ScienceCampus Living Therapeutic Materials*, which successfully entered the second funding period in 2024. She also coordinates the DFG-funded Priority Programm *Engineered Living Materials with Adaptive Functions* (2024-27) and contributes to the establishment and shaping of the emerging scientific community in this field. As reelected member of the review board, she supports the DFG Area Biomaterials (2024-28).

Materials for light management and optopharmacology

The regulation of materials-cell communication by light is a core competence of the group. We develop soft hydrogel waveguides with customized side emission profiles for photo- and photothermal pharmacology inside the body. These are based on printable inks and multimaterial extrusion printing that integrate segments with waveguiding, scattering or plasmonic functions along continuous processed optical fibers (*Adv Mater 2024*). In this area, we cooperate with the Research Departments Optical Materials in characterization of optical properties and Structure Formation in the use of gold nanorods for photothermal conversion. In cooperation with *Bioprogrammable Materials* we incorporated optosensitive and thermosensitive biofactories into additional functional layers of printed optical fibers and realized new living device designs for optopharmacology.

Precision, in situ forming hydrogels

Cell encapsulation requires material precursors mixeable with living cells and formeble into desired geometries with customizable derivatization. Hydrogels with regulable kinetics are key elements in this process, as they allow to tune the rate of network formation to the needs of encapsulation technology. We work with thiol-based crosslinkable systems (thiolene and thiolarylmethylsulfone) and formulate advanced hydrogel inks for digital light processing (*Macromol Biosci 2024*) and cell culture (*Adv Mater Inter 2024*) in cooperation with industrial (*BMBF funded KMU Innovative*) and academic partners in the Leibniz Association (*IPF and DWI as part of Leibniz SAW Transfer*).

OUTLOOK

The development of synthetic microenvironments for encapsulation and control of cell growth and function remains our major topic. We will reinforce our activity in dynamic crosslinks to remotely regulate cellular function and advance in materials and device design for biocontainment. An important milestone is the performance analysis of living therapeutic devices in body fluids (i.e. tear fluid for contact lenses) under various conditions representing the diversity of patients and external conditions. Establishing assays in this direction will facilitate preclinical assessment of our living therapeutic material prototypes and support future steps for technology transfer. With the progress in printed fibers, different designs of living ocular devices for drug delivery will be tested. A longer term vision is the combination of therapeutic and diagnostic functions within ocular devices.

Elektrofluide / Electrofluids

Jun.-Prof. Dr. Lola González-García

ZUSAMMENFASSUNG

Die Forschungsgruppe *Elektrofluide* erforscht – gefördert vom European Research Council (ERC) – flüssige Alternativen zu den herkömmlichen festen Metall- und Halbmetallmaterialien der Elektronik. Sie entwickelt damit elektronische Komponenten und robotische Aktuatoren für vollständig weiche Maschinen. „Elektrofluide" sind Suspensionen fester, leitfähiger Partikel, die Elektronentransport ermöglichen, wie Flüssigkeiten strömen und oft nicht-Newtonsches Verhalten zeigen, das wir ausnutzen. Eine ausreichende Leitfähigkeit erreichen wir durch hohe Konzentrationen von Partikeln, die bei handhabbarer Viskosität transiente leitfähige Netzwerke bilden. Der Zusammenhang zwischen der Struktur und den rheoelektrischen Eigenschaften von Elektrofluiden steht im Mittelpunkt unserer Forschung. Die Gruppe untersucht die Wechselwirkungen von Partikel-Partikel-Reibung, Kontaktwiderstand, Perkolation, Volumenwiderstand und Suspensionsviskosität, um Ad-hoc-Elektrofluide für konkrete Anwendungsfälle zu entwickeln.

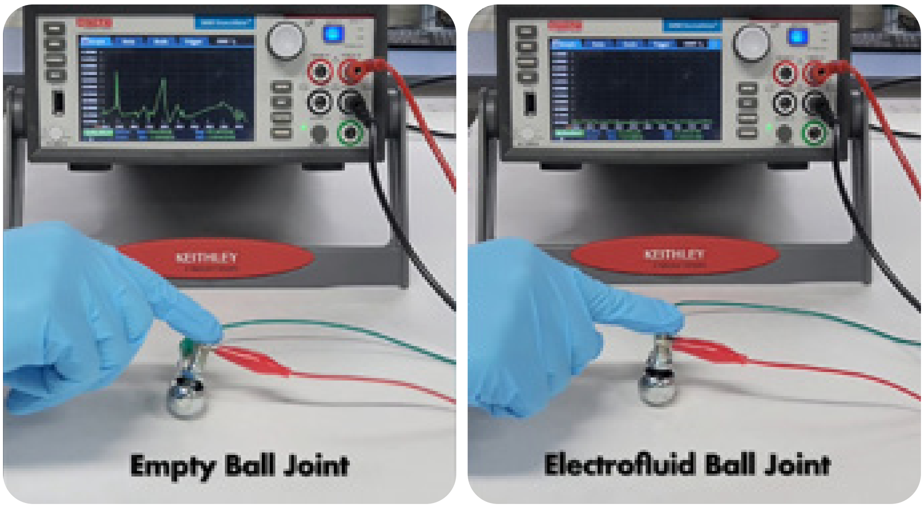
MISSION

The Research Group *Electrofluids* funded by the ERC, investigates liquid alternatives to the traditional metal and semiconductor solid materials used in electronic components and robotic actuators to enable soft devices. "Electrofluids" are suspensions of solid conductive particles that allow the electron transport while flowing as liquids and often exhibit non-Newtonian behaviour, that we also exploit. We achieve sufficient conductivity using high concentrations of particles that form transient conductive networks at manageable viscosity. The connection between the structure and the rheoelectrical properties of electrofluids is at the heart of our research. The group investigates the interplay between particle-particle friction, contact resistance, percolation, bulk resistance, and suspension viscosity to design *ad hoc* electrofluids for actual applications.

CURRENT RESEARCH

Carbon Nanotube Suspensions: electric vs. mechanical networks

Carbon nanotubes are common fillers in conductive composites due to their high aspect ratio. Recently, we studied the interplay between mechanical and electrical networks in electrofluids (EFs) composed of carbon nanotubes (CNTs) suspended in glycerol. These networks, that dominate the mechanoelectrical response of the electrofluids, form at different filler concentrations. We found that electrical conductivity occurs without a rigid mechanical network, enabling CNT suspensions to remain conductive even under flow. Through rheoelectrical measurements, we tracked the evolution of mechanical and electrical networks under deformation. We identified three distinct regimes based on the dominant networks influencing the EFs' properties: in Regime I, where neither electrical nor mechanical networks are present, the material flows, but does not present electrical conductivity; EFs in Regime II are electrically conductive (presence of an electrical network) and exhibit liquid-like behavior (no mechanical



European Research Council
Established by the European Commission

Fig.: Electrical response recorded on the screen for an empty metal ball joint connection under rotation and for the same joint filled with CNT-based electrofluids. The electrofluid dampens the electrical signal changes by 82 % during rotation.

network); and in Regime III, where both electrical and mechanical networks are present, EFs are electrically conductive with solid-like behavior. We propose that shear deformation induces a transition of electrofluids from Regime III to Regime II, which reverts shear release. We demonstrated the application of these electrofluids as fluid, conductive interconnections in metal ball joints, reducing the change in electrical resistance under movement by 82 % compared to an empty ball (see Figure).

S. Lago-Garrido, D.S. Schmidt, L. González-García, Multi-Walled Carbon Nanotubes Suspensions as Liquid Conductors: Electrical and Mechanical Network Interplay. INMdok. 2024; doi: 10.57954/opus-1086

Additive manufacturing of electrofluids: direct ink writing

Soft electrical components are in high demand for human-machine interaction devices. Our EFs are soft and adaptable and can be fabricated with tuned mechanoelectrical responses. As they remain liquid under working conditions, encapsulation and the manufacturing of complex patterns are challenging but could enable a wider range of applications.

We applied direct ink writing (DIW) as a method to manufacture carbon-based EFs. We conducted simple shear flow and Fourier-Transform (FT) rheology to evaluate the printability of EFs containing various concentrations of carbon black and graphene powder by DIW. The EFs exhibited three key characteristics for DIW manufacturing: yield stress behavior (confirmed by flow curves), high brittleness, and rapid mechanical recovery. We developed printability maps to differentiate between printable and non-printable EFs and used the printable EFs to create complex patterns. To demonstrate the significant potential of combining EFs and DIW, we compared simple and multiline strain gauges, enhancing the sensitivity of EFs as strain sensors by 400 %.

N. Hautz, L. González-García, Direct Ink Writing of Carbon-Based Electrofluids for Soft Electrical Component Manufacturing. INMdok. 2024; doi:10.57954/opus-1087

OUTLOOK

We will expand the *Electrofluids* portfolio by using immiscible liquids as a matrix. Inspired by the double percolation polymer systems, the conductive filler will be dispersed in one the liquids, while the other liquid phase will act as volume taker reducing the electrical percolation threshold.

Metal structures will also be used. The high intrinsic conductivity of silver will lead to better conductors; however, its high density represents a challenge for the formulation of stable suspensions. We plan to chemically modify their surface to tune particle interactions. Electrofluid reutilization and particle recovery will be addressed in the next years to develop more sustainable electrofluids.

Energie-Materialien / Energy Materials

Prof. Dr. Volker Presser

ZUSAMMENFASSUNG

Die Forschungsabteilung *Energie-Materialien* entwickelt elektrochemische Materialien für die Energiespeicherung, Wassertechnologien und umweltfreundliches Recycling. Unsere Hybrid- und Nanomaterialien ermöglichen den effizienten Transport und die Speicherung von Ionen und elektrischen Ladungen. Wir verbinden die Materialsynthese mit umfassender Charakterisierung, elektrochemischen Tests und In-situ-Analysen. Einen besonderen Schwerpunkt bilden 2D-Materialien wie MXene und MBene für fortschrittliche Natrium-Ionen- und Lithium-Schwefel-Batterien. Auch eröffnen diese Materialien innovative Möglichkeiten für die elektrochemische Entsalzung und Rückgewinnung wertvoller Ionen aus Wasser. Mit einem breiten Spektrum an Analysemethoden schaffen wir ein tiefgreifendes Verständnis der Materialeigenschaften. Digitale Werkzeuge zur prädiktiven Materialforschung beschleunigen den Innovationsprozess. Unsere Kooperationen erstrecken sich von internationaler Grundlagenforschung bis hin zu industriellen Entwicklungsprojekten – stets mit dem Ziel, den Weg zu einer nachhaltigen Energiezukunft zu ebnen.

MISSION

The Research Department *Energy Materials* develops electrochemical materials for energy storage, water technologies, and eco-friendly recycling of spent batteries. Our hybrid and nanomaterials enable efficient transport and storage of ions and electrical charges. We combine material synthesis with comprehensive characterization, electrochemical testing, and in-situ analysis. A key focus is on 2D materials like MXene and MBene, which play a pivotal role in advanced sodium-ion and lithium-sulfur batteries. These materials also open up new possibilities for electrochemical desalination and the recovery of valuable ions from water, such as lithium or ions of rare earth elements. Digital tools for predictive material research further accelerate the innovation process. Our collaborations span international fundamental research to industrial development projects – all with the goal of paving the way for a sustainable energy future.

CURRENT RESEARCH

Electrochemical ion separation

Electrochemical interfaces and materials play a pivotal role not only in energy storage but also in advanced environmental water technologies. Our research focuses on developing advanced technologies to recover valuable components and remove pollutants. Central to these efforts is the use of versatile materials, including abundant carbon nanomaterials, cost-effective metal oxides, and cutting-edge 2D nanostructures with ion selectivity. The design of ion-selective electrode materials requires a deep understanding of nanoconfinement to target specific ions effectively (Ren et al., Desalination, 2024). A major focus of our work is on sustainable battery recycling (Arnold et al., Ecomat, 2024). We also aim to develop low-energy ion separation processes that enable the recovery of critical materials, such as cobalt, nickel, and lithium, from spent lithium-ion batteries (EFRE project ELIFLOW). This approach not only supports the circular economy but also significantly reduces the environmental impact of battery production. Our research is driven by close collaboration with leading academic and industrial partners to ensure scalable, real-world impact.

Advanced batteries

Pioneering the next generation of battery technology is essential to achieve superior performance (M-ERA.NET project ALISA), longer lifespan, enhanced recyclability (Joint BMBF-project AdRecBat with *Structure Formation*), and reduced dependency on critical raw materials. Our research drives advancements in high-performance lithium-sulfur pouch cells, leveraging cross-sector collaboration with industry and academia. This initiative aims to set new standards for battery efficiency and sustainability. We are also pushing beyond conventional lithium-based systems to develop future-proof energy storage technologies. Our work centers on layered materials such as advanced metal oxides, MXene, MBene, and heterostructures — each designed to deliver exceptional conductivity, stability, and energy density (Liang et al., Advanced Science, 2024). To achieve a scalable synthesis of metal oxide electrodes, we are pioneering continuous production methods like microjet reactors and plasma-in-liquid processes. Our development of MXene / graphene heterostructures is unlocking new potential for hybrid materials (Obraztsov et al., Energy & Environmental Science, 2024), while carbon/metal oxide spherogels promise breakthrough performance for lithium-ion batteries (FWF-DFG Project SPHEROGELS). In parallel, we are innovating high-performance and environmentally friendly anode materials to drive forward the evolution of lithium-ion technology together with industry partners.

OUTLOOK

Our electrochemical materials advance ion selectivity for water purification, resource recovery, and next-generation energy storage. By refining ion-selective interfaces, we aim to create a versatile platform for cutting-edge sensor technologies, efficient ion separation systems, and breakthrough post-lithium battery designs. This is essential for the recovery of critical materials like lithium, cobalt, and nickel, for example, from spent batteries. To accelerate innovation, we are embedding data science into our research workflow, harnessing predictive modeling to optimize the material design and accelerate discovery processes (BMBF Project DIGIBATMAT with *Structure Formation*). We are dedicated to integrating eco-friendly materials and energy-efficient synthesis methods, ensuring that both our technologies and processes contribute to a greener future. By combining material science, digital tools, and sustainability principles, we aim to lead the development of next-generation electrochemical systems with reduced environmental impact.

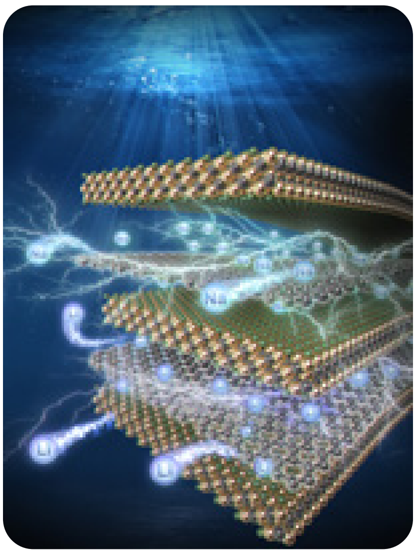


Fig. 1: Electrochemical element recovery from spent batteries.
Fig. 2: Lithium- and sodium-ion storage in graphene / MXene heterostructure battery electrodes.

Immuno-Materialien / Immuno Materials

Dr. Oskar Staufer

ZUSAMMENFASSUNG

Die Forschungsgruppe *Immun-Materialien* ist Teil der pharmazeutischen Forschungsallianz Saarland und wird seit November 2023 im Rahmen des Emmy Noether Programms der Deutschen Forschungsgemeinschaft gefördert. Die Gruppe kombiniert Expertisen in der bottom-up-synthetischen Biologie und der zellulären Immunologie zur Entwicklung neuer Biomaterialien im Anwendungsbereich der Immuntherapie. Schwerpunkte sind die Entwicklung biomimetischer Materialien zur gezielten Aktivierung von Immunzellen sowie die Entwicklung neuer Methoden, um physikalische und chemische Signale in der Tumormikroumgebung zu messen. Die Gruppe hat hierzu emulsionsbasierte künstliche Immunzellen und Ansätze entwickelt, um diese in künstliche Gewebe in Form von künstlichen Lymphknoten umzubauen. Außerdem konnten 3D-Hybrid-Zellkultursysteme etabliert werden, um Krebs-Immuninteraktionen in Pankreastumoren zu untersuchen.

MISSION

The research group designs and develops emulsion-based biomimetic materials to fabricate synthetic cell components, aiming to advance immunological understanding and create innovative therapeutic strategies. We utilize synthetic lipids, emulsions, and inorganic silica colloidosomes in combination with living T cells and cancer cells to engineer functionalities at the interface between living and non-living matter, spanning various length scales from molecules to tissues.

CURRENT WORK

In 2024, our research makes significant progress in creating biomimetic particles with immune properties. We develop oil-in-water emulsions with micrometer-sized droplets, enabling the deposition of lipid bilayers on their surfaces, and establish approaches for constructing synthetic tissues from these particles. This work is supported by an internal collaboration with the Research Department *Structure Formation*. Our team continues to develop strategies for integrating these biomimetic particles into hydrogels to better mimic cellular microenvironments in inflammation and cancer. Using a similar strategy, we apply our biomimetic synthetic cells to cancer 3D cultures, uncovering a key co-signaling mechanism between PD-1 and CD2 that drives therapeutic resistance in pancreatic cancer cells. Additionally, in collaboration with Prof. Tanja Weil (Max Planck Institute for Polymer Research), we investigate the application of self-assembling peptide nanostructures for controlled T cell activation in cancer immunotherapy. This work reveals a novel mechanism for intracellular stiffening, which modulates immune cell function through biophysical tuning. A central breakthrough this year, achieved in collaboration with Prof. Stephen Mann's group (University of Bristol), involves the development of silica-based synthetic cells and their integration into 3D microfluidic devices. These innovations pave the way for synthetic modular lymph

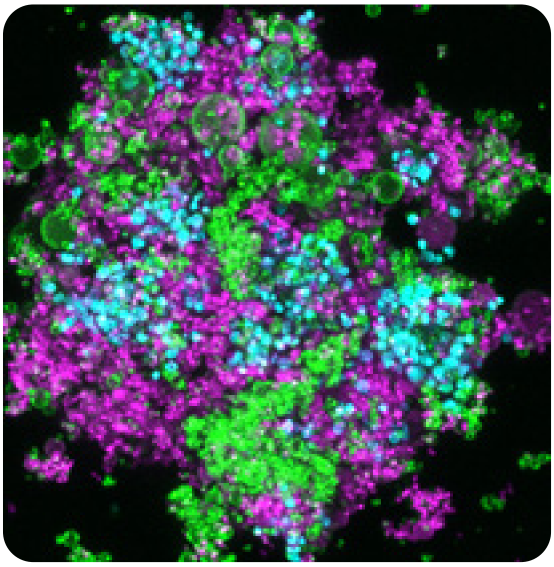


Fig. 1: Artificial lymph nodes formed from synthetic cells into which human T cells have infiltrated for *ex vivo* expansion. T cells are shown in cyan and two types of synthetic cells in magenta and green.

node technologies, demonstrating their potential to activate therapeutically relevant T cells.

OUTLOOK

Our research is progressing toward advancing artificial cell systems for the controlled stimulation and modulation of immunological environments *in vitro*. This approach aims to uncover key signaling mechanisms within tumor immune microenvironments and their responses to immunotherapy. A key focus will be the development of artificial lymph nodes to investigate chemotherapy resistance driven by adhesion in acute lymphatic leukemia, alongside testing natural products from the Helmholtz Institute for Pharmaceutical Research to identify compounds capable of overcoming cancer cell resistance. A significant aspect of our future work will involve applying synthetic cells to measure force distributions in 3D cancer models, providing new insights into the biophysical underpinnings of cancer therapy resistance. This dual focus is expected to enhance our understanding of cell interactions and behaviors within a more physiologically representative three-dimensional context. As these systems evolve, we will increasingly apply them to functionally relevant studies and therapeutic applications. We will also leverage our lipid membrane engineering expertise to deepen our understanding of exosome signaling in cancer and the biophysical mechanisms underpinning their role in cancer-immune interactions. Building on this foundation, we aim to develop innovative strategies to engineer exosomes with polymers and incorporate them into next-generation silica-based delivery vehicles. Ultimately, our research seeks to harness artificial cell systems to generate novel insights into cancer therapy and drug resistance, contributing to the advancement of more personalized and effective treatment strategies.

Interaktive Oberflächen / Interactive Surfaces

Prof. Dr. Roland Bennewitz

ZUSAMMENFASSUNG

Die Forschungsabteilung *Interaktive Oberflächen* nutzt die Strukturierung und Funktionalisierung von Oberflächen in der Verbindung mit dem Verständnis physikalisch-chemischer Mechanismen. Ziel ist es, die mechanischen Eigenschaften von Materialien wie Reibung und Adhäsion zu bestimmen und in praktische Anwendung umzusetzen. Die Interaktionen an Oberflächen werden für Biomaterialien wie Hydrogele oder für mathematisch definierte Rauigkeiten auf Oberflächen aus dem 3D-Drucker untersucht. Die Projekte basieren auf unserer Expertise in der experimentellen Nanomechanik und neuartigen Experimenten im Bereich der haptischen Wahrnehmung von Materialien. Zu den wichtigsten Ergebnissen des Jahres 2024 gehört der die Messung der Reibung eines einzelnen DNA-Moleküls über eine Oberfläche. Weiterhin wurde eine Wahrnehmungskonstanz für die Wahrnehmung von Reibung auf Materialien mit variierender Abhängigkeit der Reibung von der Geschwindigkeit gezeigt.

MISSION

The Research Department *Interactive Surfaces* explores new materials with specific adhesion and friction properties and investigates the function of surface materials in haptics. We focus on molecular functionalization and structuring at the micrometer scale and investigate the physical chemistry of friction, wear, lubrication, deformation, and adhesion as well as the role of sliding friction in tactile perception. Materials of interest range from hydrogels to additively manufactured microstructures and materials with switchable roughness. The projects draw on our expertise in experimental nanomechanics and novel tactile perception experiments. Single-molecule force spectroscopy is used in soft matter for biophysical applications.

CURRENT RESEARCH

Molecular friction of single molecules

Friction between soft matter materials depends critically on the intermittent adhesion of fluctuating polymers at one surface to the surface of opposite, sliding surface. The description of these phenomena is currently limited to models of ensembles of polymers and to scaling laws derived from polymer physics. With the advances of single-polymer force spectroscopy, we were now able to measure the friction of a single fluctuating polymer interacting with a nanoporous membrane. In cooperation with Marcus Gallei of Saarland University, we implemented the experiment with a DNA polymer attached to an AFM tip and a self-assembled membrane. We demonstrated how rare attachment events contribute to friction and quantified forces and rate dependencies in the light of single-molecule thermodynamics (Schellnhuber *et al.*, Langmuir 2024).

Perceptual constancy in friction during active tactile exploration
In a large collaborative project supported by the *Volkswagen Foundation*, we explore materials for the future of tactile communication. A key ingredient is the role of fingertip friction in the haptic perception of materials. We investigate the mechanisms for the perception of friction itself by human participants. We produced different materials with positive and negative correlation between speed and friction and asked participants of our study to indicate the change in friction when they varied the speed of fingertip movement. In contrast to the expectation that the extra effort in moving the finger faster might mask the ranking perception of friction, we found that friction differences of 20 % and more are reliably identified. Since friction coefficients were ranked correctly, independent of applied speed applied force, we concluded the humans can rely on a perceptual constancy in fingertip friction (Fehlberg et al., IEEE Transactions on Haptics 2024).

ONGOING PROJECTS
In our nanomechanics projects, we will explore mechanisms of friction and adhesion on hydrogels and biomaterials by force spectroscopy and friction measurements on length scales ranging from individual polymer chains to full biofilms. We image nano-scale structures such as micelles in hydrogels produced by the Research Division *Bioprogrammable Materials* and measure the role of glycans in the friction on contact lens materials with *Dynamic Biomaterials*. Exploring materials for the future of tactile communication, our project, supported by the *Volkswagen Foundation*, investigates the tactile stimulus of switchable surface roughness by EEG experiments and explores the role of thermal conductivity in the perception of pleasantness. A DFG-funded project is dedicated to the idea of a “tactile white”, i.e. a surface material that gives a minimal tactile impression.

OUTLOOK
We will continue to investigate the mechanisms that link the structure and dynamics of surfaces to adhesion, friction, and wear in novel materials. Our efforts will expand into the realm of soft matter nanomechanics, where we will employ experimental methods to investigate the role of polymer entanglement in hydrogel friction. Mechanical functionalities of Engineered Living Materials, which may be enhanced by the action of encapsulated bacteria, will be traced to local interaction mechanisms. Our research on the haptics of materials will focus on surface softness and include cross-modal perception. For example, signals generated by sliding touch will be rendered as sound to enhance the experience of touch.

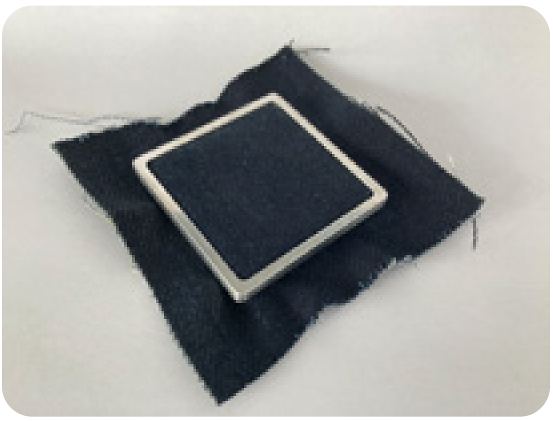


Fig. 1: Functional model of light-driven molecular motor shown to guests to explain underlying mechanisms.
Fig. 2: Can hydrophobic coating of a denim fabric be felt in sliding touch with the fingertip? This question was addressed in a psychophysical experiment.

Materialien-Host Interaktionen / Materials-Host Interactions

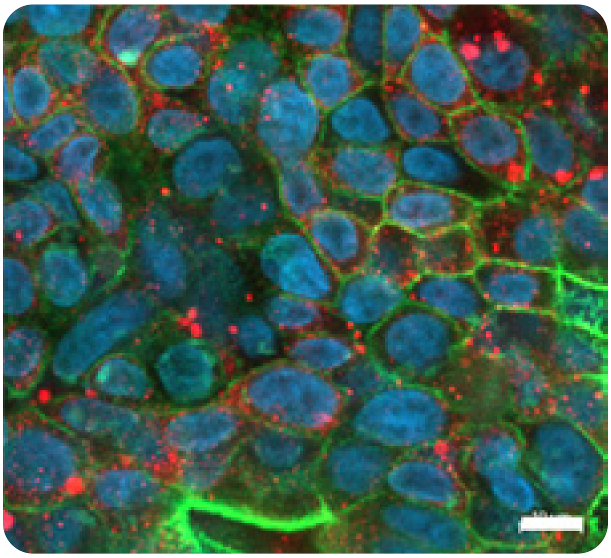
Dr. Sara Trujillo

ZUSAMMENFASSUNG
Die Forschungsgruppe *Materialien-Host Interaktionen* erforscht, wie sich Therapien auf der Grundlage von Biomaterialien auf Zellen und Gewebe auswirken. Sie konzentriert sich auf die Entwicklung von Gewebemodellen und Methoden, mit denen sich die Sicherheit und Wirksamkeit dieser neuen Therapien bestimmen lässt. Wir verwenden Hochdurchsatz- und automatisierbare Techniken wie Proteomarrays und High-Content-Imaging, um die Reaktion des Wirts zu bewerten. Außerdem validieren wir in-vitro-Ergebnisse anhand von in-vivo-Modellen. Einen Schwerpunkt unserer Arbeit stellt das menschliche Auge dar. Wir zielen darauf ab, Hornhaut-Modelle zur Bewertung von okulären Therapien und zur Untersuchung von entzündlichen und angiogenen Prozessen zu entwickeln. Unter den biomaterialbasierten Therapien, fokussieren wir auf lebende therapeutische Materialien. Wir möchten die neuen Herausforderungen und Sicherheitsrisiken angehen, welche diese Klasse von Materialien mit sich bringt.

MISSION
The Research Group *Materials-Host Interactions* explores how biomaterials-based therapies affect cells and tissues. It focusses on the development of tissue models and methodologies capable of assessing and determining the safety and efficacy of these new therapies. We use high-throughput and automatable techniques such as proteome arrays and high-content imaging to evaluate host responses. We also validate results obtained in vitro using in vivo models. One focus of our work is the human eye. We aim at developing cornea models for evaluation of ocular therapies and for examination of inflammatory and angiogenic processes. Among the biomaterial-based therapies, we work on living therapeutic materials (LTMs) as this class of materials present new challenges and safety risks that we aim to tackle.

CURRENT WORK
During its first two years this group has made significant progress towards the development of methodologies to assess the safety of Living Therapeutic Materials (LTMs). These activities are part of the DFG NWA project and are performed in collaboration with the research department *Dynamic Biomaterials*, providing the LTMs. We analyse LTM stability under physiological conditions and assess the toxicity of the by-products released by the LTMs over time using stromal and immune cells. In this context, we are comparing responses triggered by Gram-negative bacteria that are either producing a normal lipopolysaccharide or are blocked in its production by genetic engineering. Lipopolysaccharides are one of the major pyrogenic molecules of Gram-negatives.

Furthermore, this work aims to bridge the gap between the fast-growing bacteria used in LTMs and the highly demanding culture conditions of mammalian tissue models. Therefore, we are developing methodologies



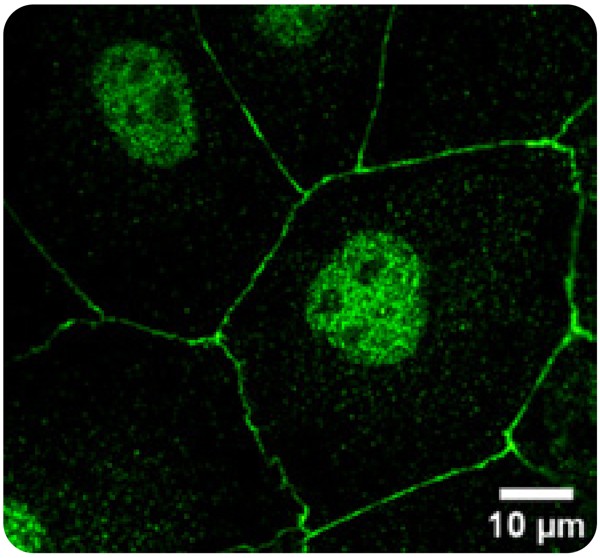


Fig. 1: Monolayer of human epithelial cells after 14d of air-liquid interface culture. Scale bar: 10 um.
Fig. 2: Detail of an epithelial cell expressing tight junction ZO-1 in green. Scale bar: 10 um.

for the rapid assessment of compatible conditions to culture both LTM and tissue models in vitro. First of all, we have established a 96-well plate methodology, enabling us to study viability, growth, and recombinant protein production of LTMs in various cell culture media and at different temperatures in parallel. With this information, we can select the most compatible conditions for both LTM and mammalian cells to investigate their interactions in vitro. In addition to the development of this screening setup, we have developed a workflow for the cytocompatibility assessment of LTMs.

In collaboration with the Research Group *Bioprogrammable Materials*, we are developing an in vitro assay using macrophages to study inflammatory processes, triggered by the use of genetically modified bacteria secreting anti-inflammatory peptides. This assay will help us to understand how inflammation is triggered and whether we can reduce it using various anti-inflammatory molecules delivered by bacteria.

Finally, we are developing a 3D cornea model, which we aim to establish by culturing corneal stromal cells embedded in a collagen hydrogel together with corneal epithelial cells deposited on the apical side of the hydrogel and corneal endothelial cells seeded on the basal side of the hydrogel. We have optimized culture conditions to differentiate human corneal epithelial cells and we are working on the encapsulation of corneal fibroblasts in collagen hydrogels. In parallel, we are starting first co-cultures of corneal epithelial cells and living materials.

OUTLOOK

Our tools and methodologies are designed to assay biomaterial-based therapies or drug delivery systems in vitro and to be easily adaptable to the requirements of the biomaterial. During our first year, we made significant progress in developing methods to understand how LTMs can co-exist in vitro with mammalian cells. We have also gained insights into their safety thresholds, and we started focusing on specific models such as the cornea. During our second year, we have developed several methodologies: (i) a screening setup to find suitable culture conditions for LTMs and host tissue models; (ii) a workflow for the cytocompatibility assessment of LTMs and (iii) an in vitro assay to characterize the anti-inflammatory properties of several drug candidates. In addition, we have modelled the first layer of the cornea, and we are investigating the first co-cultures of corneal epithelium with LTMs applied to the eye. Next, we aim to model the other two cellular layers of the cornea (stroma and endothelium) and build a human cornea-on-chip, as part of our project funded by the Dr Rolf Schwiete Stiftung. By doing so, we will be able to study not only toxicity but also absorption rate and permeability in a standardized way.

Materialorientierte Synthetische Biologie / Materials Synthetic Biology

Prof. Dr. Wilfried Weber

ZUSAMMENFASSUNG

Die Forschungsabteilung *Materialorientierte Synthetische Biologie* fokussiert auf das Design und die Anwendung von Zellen und Materialien, die kommunizieren und Informationen verarbeiten. Der Schlüssel zu diesen Funktionen ist die Integration von biohybriden Sensoren und Schaltern sowie programmierten Zellen mit Polymeren oder anorganischen Oberflächen. Ein besonderer Schwerpunkt liegt auf molekularen optogenetischen Technologien zur Programmierung der Eigenschaften und Funktionen von Zellen und Materialien durch Licht. Hierbei werden quantitative mathematische Modelle eingesetzt, um geeignete Designparameter effizient zu identifizieren. Unsere Forschung fokussiert auf drei Anwendungsbereiche: (i) Selbst-regulierende oder extern steuerbare Depots für die Verabreichung von Medikamenten, (ii) Molekulare Sensoren zum Nachweis von Medikamenten oder Schadstoffen und (iii) 3D programmierbare, lebende Konstruktionsmaterialien.

MISSION

In the research department *Materials Synthetic Biology* we focus on the design and application of cells and materials that communicate and process information through synthetic biology. To these aims, we functionally integrate synthetic biology-derived biohybrid switches and cells with polymers or inorganic surfaces. We particularly focus on molecular optogenetics for programming the properties and functions of cells and materials using light. We apply quantitative mathematical models to efficiently identify suitable design parameter sets. Our research focusses on three areas of application: (i) Self-regulated oder externally triggered drug depots, (ii) molecular sensors for drugs and pollutants, and (iii) 3D programmable, living construction materials.

CURRENT RESEARCH

Our inspiration is the ability of organisms and the materials they are made of to adapt to dynamic environmental conditions. This adaptivity is based on the cells' ability to sense environmental information, to process and integrate this information with genetic programs and to finally produce a targeted response. In our research, we engineer nature's molecular sensing, processing, and actuation machinery to precisely control the function and properties of cells and materials. We applied these newly developed technologies in various fields of research.

Light-responsive intracellular coacervates to control pathway-specific gene expression in mammalian cells.

In order to externally control signaling pathway-specific activation of gene expression in mammalian cells, we engineered natural transcription factors of important signaling pathways to undergo phase separation in response to blue light. We demonstrated that liquid transcription factor "droplets" led to several-fold

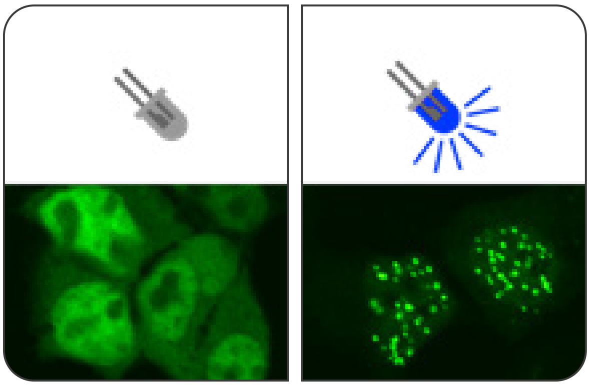


Fig. 1: Blue light-dependent formation of transcription factor-based coacervates in mammalian cells.

increased gene expression levels whereas gel-like transcription factors correlated with strongly reduced gene expression levels. We demonstrate this materials property-dependent effect on transcription factor activity at the example of the NFkB pathway and showed, that this approach can be used to regulate the activity of endogenous target genes in response to light (*Fischer et al., Small 2024, Figure 1*).

Engineering molecular sensor materials and devices
We developed a network of signal-transducing biohybrid materials to detect clinically relevant (micro)RNAs indicative of medulloblastoma or corona infection. To this aim, we developed a biohybrid material module which, based on a Crispr-CAS mechanisms, triggered the (micro)RNA-specific release of a protease that diffused to the next module to release a fluorescent reporter protein which could be detected in the supernatant. With the help of a quantitative mathematical model, we determined optimized compositions of the signal-transducing material and demonstrated its functionality and signal amplification by e.g. the detection of medulloblastoma-specific biomarkers in patient samples (*Mohsenin et al., Adv. Mater. Technol 2024*). In a complementary study, we pioneered the development of a light-powered ELISA-like bioassay, in which the addition and removal of the reagents was performed in response to light instead of using mechanically complex pump systems. The addition or removal was based on molecular photoreceptors, that released or recruited assay components in response to illumination with light of specific wavelength. In collaboration with the group of Prof. Can Dincer (TU Munich), we developed a smartphone-controlled device for running and analyzing the bioassay (*Urban et al., Science Advances 2024, Figure 2*).

Drug delivery devices
In a newly granted, BMBF-funded consortium led by our group, we collaborate with the Ophtamology Department of the University Hospital in Freiburg on the development of a drug depot for anti-VEGF drugs. The depot will be based on biopolymers engineered to release the drug in a sustained manner. We expect this depot to prolong the injection intervals in therapies against age-related macular degeneration (BMBF-funded project Billard, https://biologisierung-der-technik.de/de/biologisierung-der-technik/verbundprojekte/billard).

OUTLOOK
In our future research we will continue to work on both, fundamental and application-driven research on ELMs. Whereas the work around the ERC Advanced Grant STEADY will focus on developing fundamental design rules for ELMs and establishing gene-material correlations, we will in parallel strive towards promoting our research towards application in the context of structural and functional ELMs with application fields in construction, biosensing, or therapeutics.

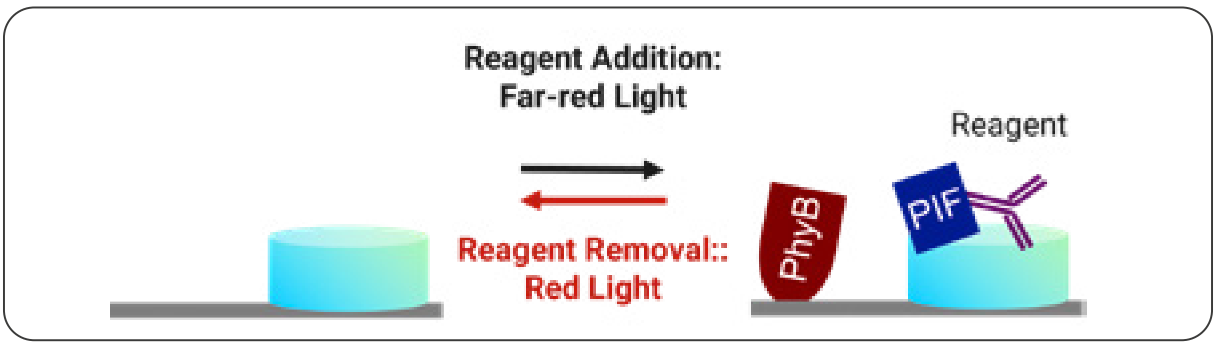


Fig. 2: OptoAssay: light-based reagent addition and removal using the optogenetic switch PhyB/PIF. In response to far-red light, the reagent is released and can react with the assay components. Illumination with red light triggers reagent removal thus replacing the typical washing step in ELISA-like setups.

Optische Materialien / Optical Materials

Dr. Peter W. de Oliveira

ZUSAMMENFASSUNG

Optische Materialien (OM) als technologieorientierte Forschungsabteilung zielt auf die Entwicklung von Metamaterialien, Beschichtungsverfahren und Bauelementen für Optik und Elektrooptik ab. Erkenntnisse über die Wechselwirkung von Licht und Strukturmaterialien mit angepassten physikalischen Eigenschaften sollen den Weg vom Fundamentalen zu Produkten ebnen. Daher soll durch eine verstärkte Betonung der Grundlagenforschung die TRLs über die Stufen 3 bis 5 angehoben werden. Im letzten Jahr wurde unter anderem an der Weiterentwicklung von Beschichtungen mit speziellen Diffussionssperreigenschaften, energieeffizienten Prozessen und Bestandteilen für elektrische verformbare Spiegelelemente gearbeitet. Ausgehend von der Grundlagenforschung strebt diese Arbeit stets eine Validierungsorientierung in Zusammenarbeit mit Wissenschaft, Industrie und speziell KMUs an. Dabei wurde die resultierende, neue Akquisestrategie, welche Marktanalysen, proaktive Schritte zur Gewinnung neuer Kooperationspartner und veränderte Transfermechanismen umfasst, weiter präzisiert.

MISSION

The mission of *Optical Materials* as a technology-oriented research department is the development of metamaterials, coating processes and devices for optical and electro-optical applications. The insights into the interaction of light and structured materials with adapted physical properties should establish a path from basic research to products. Therefore, an increased emphasis on basic research efforts shall raise the TRLs above levels 3 to 5.

The aim of providing impetus for new material classes is based on inorganic, organic or inorganic-organic hybrid materials which are structured by incorporating nano entities or using techniques such as coating or embossing. Expertise in modelling of optoelectronic components, the synthesis of hybrid matrices using wet-chemical processes and the production of chemically modified nanoparticles enable the development of new materials with adapted physical properties, e.g. refractive index or conductivity. The group's expertise ranges from basic research to applied research with the aim of utilization and validation in cooperation with science, industry and especially SMEs. The new acquisition strategy, which includes market analyses, proactive steps to gain new cooperation partners and modified transfer mechanisms, has been further sharpened.

CURRENT RESEARCH

These topics were investigated in 2024:

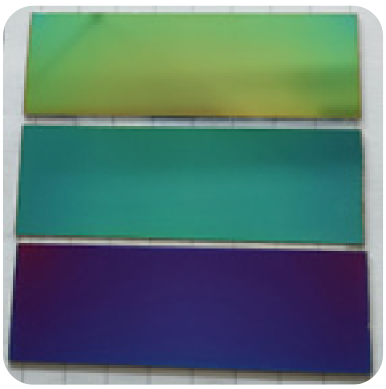
Optical interference coatings via new energy-efficient StackCure process

A thermal stack curing process for wet-chemical sol-gel multilayer interference filter systems was developed in order to significantly reduce energy costs. As part of a ZIM funded project, seven-layer interference filters could be produced on a laboratory scale that are comparable to classically multi step high-temperature treatment produced samples. It was found that a critical total layer thickness is the main factor for cracking during the final stack curing step. This critical total layer thickness is individual for the coating sols.

Hydrogen Barrier Layers
In the future hydrogen economy devices will be needed to withstand very high pressures but still showing excellent barrier properties against hydrogen diffusion. For the use in piezoresistive sensors for pressure vessels, novel **glass like sol-gel coatings** were developed to improve the barrier properties of V4A steel foils against hydrogen. Applications on flat 200 µm steel foils showed promising results with excellent coating adhesion, long term corrosion protection and indication for non-permeation properties. Improvement of these properties compared to non-coated steel foils could be obtained mostly with a coating composition containing glass-like potassium silicate and SiO_2/TiO_2-particles. This work is/was funded by the “National Innovation Program Hydrogen and Fuel Cell Technology” (Support Code 03B11030C)

Elements for new lightweight, hybrid and self-correcting mirrors
The development of highly reflective optical surfaces with minimized light scattering are the goal of the European Pathfinder Project “Live Mirror” for a future use in construction of deformable mirrors for telescopes. Such optical surfaces are made of fire polished float glass with a very high surface quality sputtered with silver and/or aluminum. The high surface quality of float glass can be maintained through the sputtering process after careful optimization of sputtering parameters. This optimization was carried out considering two main factors, the reflectivity of the coatings and the intensity of the light scattered by them. In addition, good thermal stability was also desirable to be able to withstand the subsequent high-temperature stages in the manufacturing of proofs of concept. (GAP-101099220)

OUTLOOK
The focus of the research and development tasks of *Optical Materials* in 2025 and beyond lies on novel materials with tailored optical properties. The developments represent the Department’s patent strategy, which aims to use existing patent bases and expand them into market relevant research fields by new patents. This is accompanied by an improved digital presence of *Optical Materials* and its adapted acquisition strategy to make it visible to industry especially in application fields such as display technology, energy conversion, and active optics; thereby not neglecting cooperation with German and international universities and research institutes. *Optical materials* will remain visible to industry and science, particularly in application areas such as display technology, energy conversion and active optics. In addition, the inclusion of biological aspects in material development is becoming increasingly important, such as biologically driven self-organizing coatings.



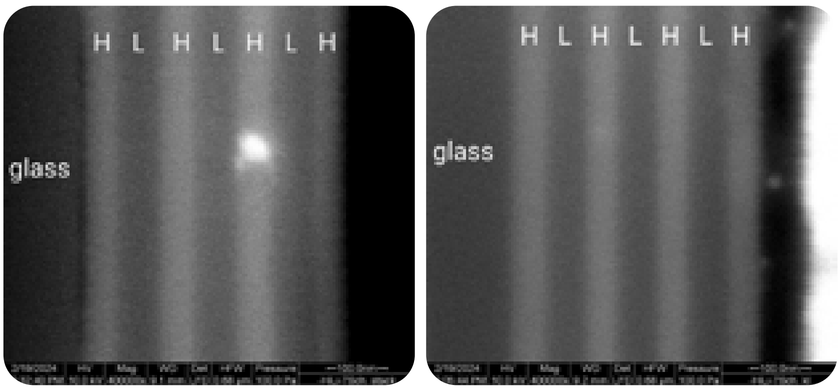


Fig. 1: Live Mirror: Silver mirrors coated with several layers of different thicknesses of aluminum and aluminium oxide
Fig. 2: StackCure: Comparison of the SEM images of the cross-section preparation of seven-layer (HL)3H 50/70 on borofloat glass produced a) via stack curing treatment, b) via classical high-temperature treatment of each individual layer

Strukturbildung / Structure Formation

Prof. Dr. Tobias Kraus

ZUSAMMENFASSUNG

Die Forschungsabteilung *Strukturbildung* erforscht, wie sich dispergierte Partikel und Moleküle zu Funktionsmaterialien verbinden. Durch Streuung, Mikroskopie, und systematische Variation von Struktur und Zusammensetzung unter in situ-Beobachtung untersuchen wir Wechselwirkungen dispergierter Komponenten in Materialvorstufen. Wir klären ihre Anordnung auf Längenskalen von Nanometern bis Millimetern auf. Durch Anpassung molekularer Grenzflächen, lokaler Geometrie und hierarchischer Struktur verändern wir mechanische, elektrische und optische Materialeigenschaften. Wir führen gezielt Grenzflächen ein, um die Trennung von Komponenten beim Recycling zu erleichtern. Mit dem so gewonnenen Verständnis strukturieren wir Materialien zum Beispiel für weiche Elektronik, Robotik und Umwelt-Sensorik. Dazu entwickeln wir ressourceneffiziente Materialsynthesen nahe Raumtemperatur und an Luft. Wir verleihen den Materialen so Multifunktionalität, Haltbarkeit und „Recyclability by Design", damit sie am Ende ihrer Lebensdauer wieder in nutzbare Bausteine zerlegt werden können.

MISSION

The Research Department *Structure Formation* investigates how dispersed particles and molecules join to form functional materials. We use scattering, microscopy, and systematic variation of structure and composition with in situ observation to elucidate interactions of dispersed components in material precursors. Through adapation of molecular interfaces, local geometry, and hierarchical structure, we change mechanical, electrical and optical material properties. We specifically introduce interfaces to facilitate the separation of components during recycling. Our insights enable us to structure materials for soft electronics, robotics, optics, and sensors on length scales between nanometers and millimeters. We develop resource-efficient material synthesis processes near room temperature and in air. We give the materials multifunctionality, durability and "recyclability by design" so that they can be split into usable building blocks at the end of their service life.

CURRENT RESEARCH

Optical sensor materials for environmental parameters
Data on the environment enable precision agriculture, remediation of contaminations, and indicate ecological diversity and the effects of climate change. We are synthesizing "sensor materials" to provide such data efficiently and sustainably: fluorescent upconverting, lanthanide doped nanoparticles combined with plasmonic metal nanoparticles in biodegradable polymer matrices (Figure 1A). When excited with a laser beam, the resulting sensor materials emit light with a color that depends on temperature, humidity, or mercury concentration. We are collaborating with Prof. Barbara Mazzolai (Italian Institute of Technology) to integrate these sensor materials into 3D-printed soft robots (Figure 1B) (*Cikalleshi et al., Science Advances, 2023*) and with *Materials Synthetic Biology* to make them specifically sensitive to complex molecules.

Nanowire gels

Ultrathin gold nanowires resemble both polymers and wires: Their cores are < 2 nm thick, more than 1 µm long, carry an organic shell and can be dispersed in solvents. In 2024, we demonstrated that they can form gels when their shells are "cross-linked" by weak bonds. In the future, we will cooperate with Prof. Dominik Munz and other members of the recently granted RTG 3082 "Engineering Covalent Bonds in Molecules and Materials" on how to tune these bonds while keeping the wires stable, and with the University of Sydney on how these interactions can be tuned using molecular additives (*Knapp et al., Langmuir, 2024*).

Stretchable and printable conductors

Batteries, car seats, and soft robots contain electrically conductive materials that must deform without damage. We are working with the *Energy Materials* department on structures and recyclability of such materials and we are studying the "carbon-binder" domain in batteries and with industry (Continental and others). In the DFG's SPP 2100 "Soft Material Robotics", we are cooperating with TU Dresden and others to print soft, conductive materials in robots. Digital methods help to link properties with material components and structures. We are cooperating with battery manufacturers and data scientists of AWSi in the BMBF-project DaMaStE to manage, combine, and analyze the production, structures, and properties of batteries (https://onlinelibrary.wiley.com/doi/10.1002/adem.202401813).

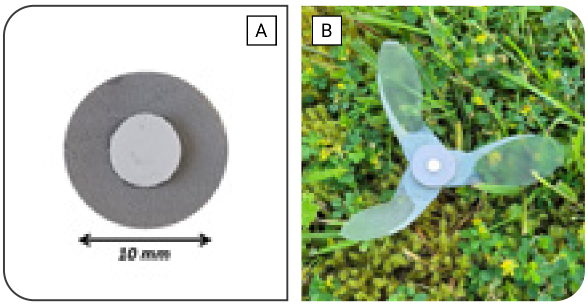


Fig. 1: A sensor material of INM makes an I-Seed sensitive to Hg vapors. (A) The sensor material contains a stack of layers composed of fluorescent and plasmonic nanoparticles. (B) I-Seeds are soft robots inspired from plants that allow distributed monitoring of environmental parameters. Infrared excitation causes an emission that we analyze to report environmental parameters.

Fig. 2: Weakly sintered silver conductors enable the recovery of printable metal powders. Conventional sintering prevents redispersion.

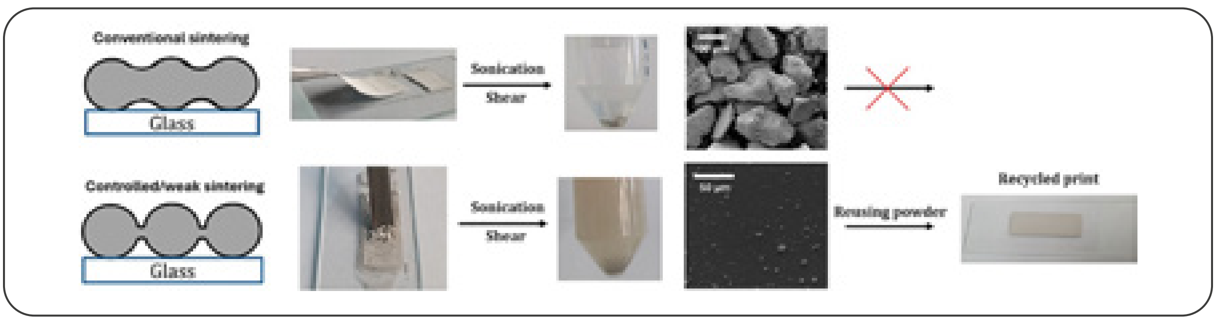
Soft sintering for recyclable printed electronics

Printed conductors often contain silver, a precious metal with significant environmental impact. We have joined forces with GSB Wahl, an SME that produces printing pastes, to investigate how the silver can be recovered from printed tracks. In 2024, we demonstrated that it is possible to sinter the printed structures only softly, so that the bridges between metal particles remain weak (*van Impelen et al., Adv Electron Mater, 2024*). The resulting tracks are sufficiently conductive for applications, but can also be redispersed and printed again (Figure 2). Low-temperature sintering is so gentle that it can also be used for particles with copper cores and thin silver shell (*Van Impelen et al., J Mat Chem C, 2024*).

OUTLOOK

Soft electronics is an emerging technology with challenging (demanding) material requirements. We are working with the Saarland University and the industry to combine our soft conductors with actuators and sensors and bring them to markets. Current work is focused on stability, while future projects are aimed at integration into "smart skins". A second focus is recycling: we are collaborating with ZeMA and industry on the degradation of soft conductors in fuel cells and their recycling.

In future flexible devices, electronic and optical functionality is expected to be combined. We are researching new materials that combine both through a rational assembly of optically active and electrically conductive particles. The fundamental studies required for such combinations will be supported by new capabilities: Ultra Small-Angle X-ray Scattering and robotic dispersion handling will be available at the INM in the near future.



InnovationsZentrum INM / InnovationCenter INM

Dr. Carsten Becker-Willinger, Dr. Peter W. de Oliveira

ZUSAMMENFASSUNG

Das *InnovationsZentrum INM* bildet die Schnittstelle zwischen den wissenschaftlichen Einheiten des Instituts und der Industrie. Es initiiert, koordiniert und realisiert geförderte Projekte mit industrieller Beteiligung. Gemeinsam mit den wissenschaftlichen Einheiten werden hierzu Strategien erarbeitet, wie der Technologiereifegrad der Grundlagen-Entwicklungen (TRL 1) gezielt auf ein Niveau angehoben werden kann, das den Einstieg in eine Industriekooperation ermöglicht (TRL 4). Im Rahmen dieser Projekte übernimmt das *InnovationsZentrum* die Skalierung von Synthesen auf den Pilotmaßstab sowie die material-bezogene Optimierung von Produktionsprozessen. Bereits vor Projektbeginn unterstützt es die die wissenschaftlichen Einheiten beim Aufbau von Materialplattformen, der Realisierung von Demonstratoren für Messeauftritte und der Findung geeigneter Industriepartner. Zur Förderung des Technologietransfers organisiert das *InnovationsZentrum INM* Präsentationen bei spezifischen Fachmessen und bereitet bei TechTransfer-Tagen am INM wichtige Instrumente. Um transferrelevante Themen voranzubringen, besteht eine enge Vernetzung mit der Patentabteilung des INM (FFPV).

Dr. Carsten Becker-Willinger

Dr. Peter W. de Oliveira

MISSION

The *InnovationCenter INM* is the interface between INM's units and industry. It initiates, coordinates and implements projects with industrial partners. In collaboration with the scientific units, strategies are developed to advance the technology readiness level of fundamental research (TRL 1) to a stage that enables industrial cooperation (TRL 4). Within these projects, the *InnovationCenter* is responsible for scaling up syntheses to pilot scale and the material-related optimization of production processes. Before the project initiation, the scientific units are supported in establishing material platforms, realization of demonstrators for trade fairs and in finding suitable industry partners. To strengthen technology transfer, the *InnovationCenter* organizes INM's participation in specialized trade fairs and prepares TechTransfer days at the INM. Additionally, it maintains a close collaboration with INM's patent department (FFPV) to drive forward transfer-relevant topics.

CURRENT RESEARCH & DEVELOPMENT

On current industry project at *InnovationCenter INM* utilizes the patented NaMiComp platform technology to develop sustainable alternative inorganic binders that as replacement for cement in classical cement bonded wood fiber boards used in construction. The technology development within the project has led to optimized processing times and curing procedures, ultimately enabling mass production of large-area boards suitable for building and construction industry to start. Currently upscaling and process optimization, plant engineering are performed in collaboration with the end-user and its equipment manufacturer, with the goal of initiating production by 2026.

In another industry project, novel nanoparticulate additives with intrinsic electronic defect structure are being developed to enhance the dielectric strength of

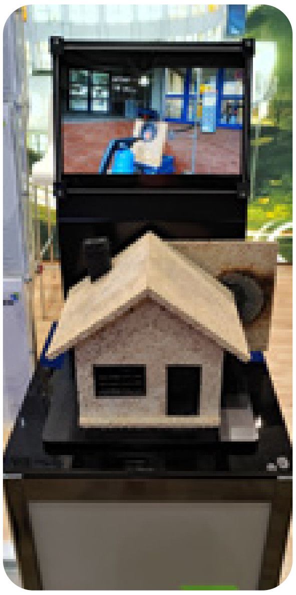


Fig. 1: Demonstrator on concepts for recyclable electronics (ReIn-e).
Fig. 2: Demonstration of NaMiComp technology on Hannover fair.

polymer composite-based electrical insulators used in medium to high-voltage overhead and underground applications, such as ground-mounted electric power distribution transformers. Nano-scaled zinc oxide is currently being investigated as a cost-effective alternative to nano-scaled yttrium-doped zirconia, aiming to achieve a competitive end product.

A technology transfer project is currently being performed for an industry partner investigating in a production line for silicon carbide-based anodes for application in high-performance Lithium-ion batteries. During an earlier development phase, *InnovationCenter INM* successfully scaled up a sol-gel-based synthesis for silicon carbide gel-type precursors followed by thermal processing of the resulting gels up to 1000 °C. This intermediate product is further subjected to carbo-thermal treatment and final electrochemical characterization in the Research Department *Energy Materials*. During the transfer project *InnovationCenter INM* is developing an appropriate quality assurance program and providing consulting related to the acquisition of production equipment by the industry partner.

Another successful collaboration involves transparent and conductive coating based on cost saving transparent silver meshes, produced via continuous electrospinning integrated in roll-to-roll process on plastic foil using *InnovationCenter INM's* coating machine in cooperation with the Research Department *Optical Materials*. The metal mesh coated foil serves as the core component in electronic devices such as touch sensors and proximity sensors.

InnovationCenter INM is also participating in a joint DFG project (Patents4Science) together with other Leibniz institutes (FIZ, INP, IWT) on the topic "Building an information infrastructure for the use of patent knowledge in science". INM's focus in this project is on "Battery Materials" with the first phase involving the development of a seed entity list, annotation process using named entity recognition (NER) and setup of a demonstrator web server, running until the end of 2025. As accompanying projects for the work at *InnovationCenter INM*, the FFPV group initiated the BMBF project InnoLeit to work on a legally sustainable transfer strategy for the INM in practical use cases including several SME industry partners and the project KITIE to identify and evaluate potential industry partners based on patent information.

OUTLOOK

In recent years, research at INM, supported by the *InnovationCenter INM* has made remarkable progress towards commercial application in emerging fields like printed electronics, optical technologies, and sustainable building materials. An key task is the continuous refinement and adaptation of the acquisition and technology transfer strategy to remain flexible and responsive to market changes , ensuring effective commercialization of INM's research outcomes.

Zentrale Einrichtungen / Core Facilities

Accelerated Research Foundry

Dr. Alvaro Banderas

Die Core Facility *Accelerated Research Foundry* ist das neu eingerichtete Automatisierungslabor des INM, das Methoden an der Schnittstelle von Materialwissenschaften, synthetischer Biologie und künstlicher Intelligenz entwickelt. Es nutzt die robotergestützte Entwicklung biologischer und chemischer Bausteine, um hybride Materialien mit fortschrittlichen Funktionen, Leistungen und Nachhaltigkeit zu schaffen. Weiterhin beinhalten die Methoden modulares Klonieren im Hochdurchsatz, gerichtete Evolution, zellbiologisches Screening und Protein-Engineering sowie kombinatorische Matrix / Polymer-Formulierungen und Nanoindentation im Hochdurchsatz. Durch maschinelles Lernen geführte Design-Build-Test-Learn-Zyklen werden zur Vorhersage gewünschter Materialeigenschaften eingesetzt. Das Labor entwickelt sich derzeit zu einer vollständig integrierten, modularen Anordnung von Instrumenten, die einer breiteren wissenschaftlichen Gemeinschaft zur Verfügung stehen.

Chemische Analytik / Chemical Analytics

Dr. Claudia Fink-Straube

Die Core Facility *Chemische Analytik* bietet analytische Dienstleistungen für alle wissenschaftlichen Einheiten des INM, die Universität sowie Externe an. Die analytische Begleitung und Unterstützung interner Forschungsprojekte bis hin zur Qualitätskontrolle entwickelter Materialien gelingt durch moderne Analyseverfahren der Elementanalytik (AAS, CHNOS GFAAS, ICP-OES), Chromatographie (GC, HS / SPME-GC, HPLC, GPC / MALLS) und Kopplungsverfahren mit Massenspektrometrie (GC / MS, LC-ESI HR-Q-TOF). Dies schließt Präparationsmethoden wie diverse Aufschluss- und Extraktionsverfahren via Säure / Schmelze, Mikrowelle, Hochdruck und SPE ein. In regelmäßigen Praktika werden Schüler, Azubis und Studierende in die Methodik chemisch-analytischer Verfahren am INM eingeführt.

Elektronenmikroskopie / Electron microscopy

Dr. Marcus Koch (bis 09/2024) / N. N.

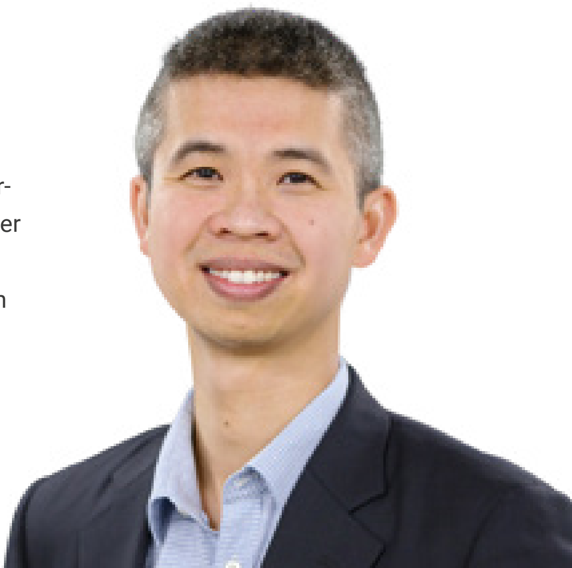
Die Core Facility *Elektronenmikroskopie* (vormals *Physikalische Analytik*) ist für alle Mitarbeiterinnen und Mitarbeiter aus dem INM und dem universitären Umfeld Anlaufstelle bei elektronenmikroskopischen Fragestellungen. Die Proben können mit Hilfe eines Plunge-Freezers, einer Nanomill, eines Ultramikrotoms, eines Zweistahlgerätes (FIB) und verschiedener Sputter- bzw. Metallbeschichtungsanlagen sowie Schleif- und Einbettapparaturen in vielfältiger Weise vorbereitet werden. Als Untersuchungsmethoden stehen die Rasterelektronen- und Transmissionselektronenmikroskopie zur Verfügung, die Einblicke in Materialaufbau und -zusammensetzung von flüssigen und festen Proben bis in den Nanometerbereich ermöglichen. Wie das genau funktioniert, wird auch im Rahmen von Führungen oder Praktika gezeigt.

Dr. Marcus Koch verlies das INM Ende September 2024.
Die Leitung der Core Facility soll baldmöglichst nachbesetzt werden.

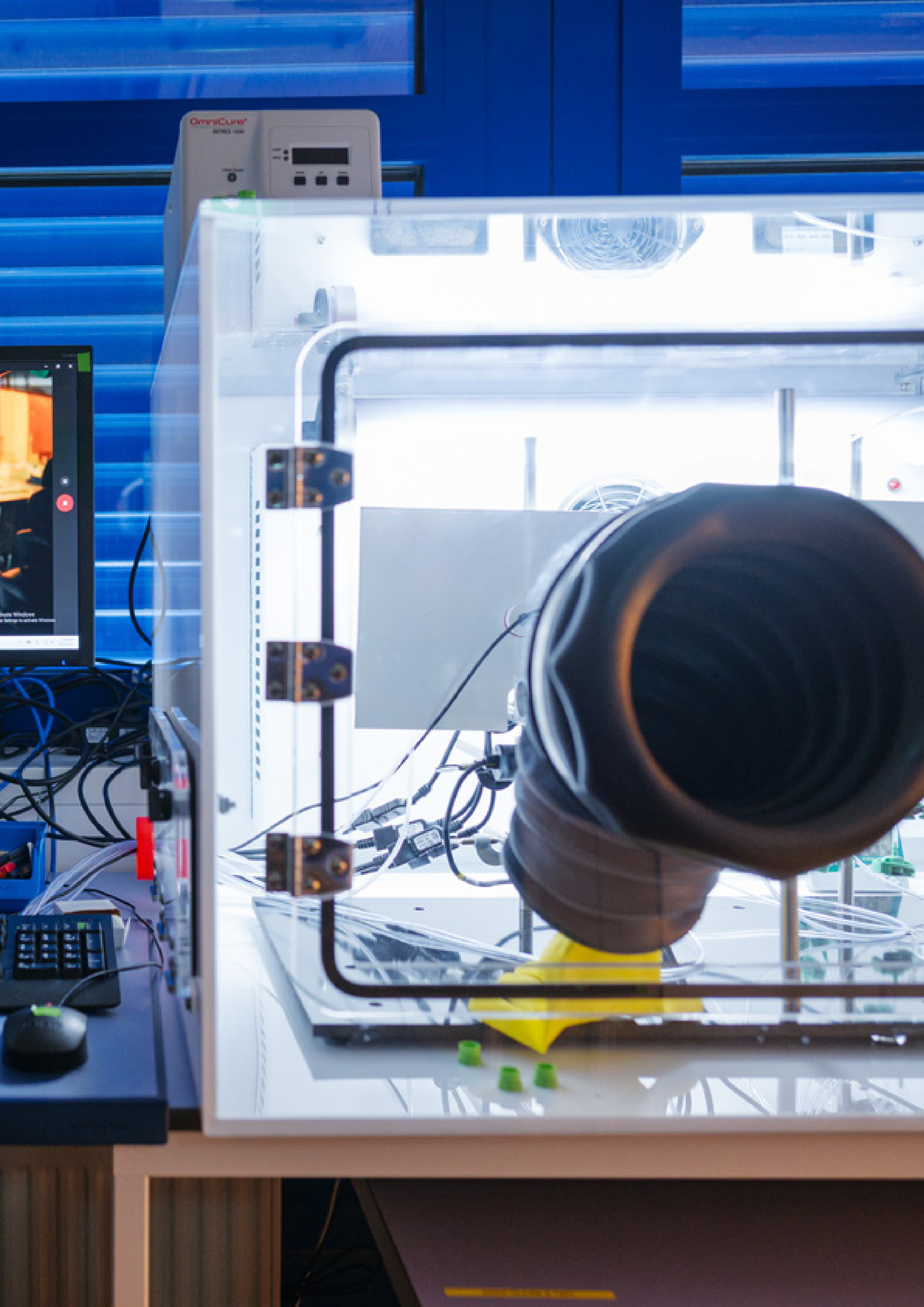
Fluoreszenzmikroskopie / Fluorescence Microscopy

Dr. Cao Nguyen Duong

Die Core Facility *Fluoreszenzmikroskopie* unterstützt Forscher am INM und externe Nutzerinnen und Nutzer mit modernsten Bildgebungsverfahren (Weitfeld, Total Internal Reflection Fluorescence (TIRF), Laser Scanning Confocal, Zwei-Photonen, Light-sheet, Hochdurchsatz-Bildgebung, Photomanipulation und Photostrukturierung). Wir begleiten die Nutzerinnen und Nutzer während des gesamten Prozesses der mikroskopischen Bildgebung einschließlich der Planung, Probenvorbereitung, Auswahl und Einsatz des Mikroskopes, Bildverarbeitung, Bildanalyse und Visualisierung, sowie dem Datenmanagement. Darüber hinaus, veranstalten wir einen Fluoreszenzmikroskopie-Kurs und organisieren Workshops zur Bildanalyse, um Nutzerinnen und Nutzer zu helfen, sich mit den theoretischen Grundlagen vertraut zu machen und die sachgemäß, eigenständige Nutzung komplizierter Mikroskope und mikroskopischer Anwendungen.



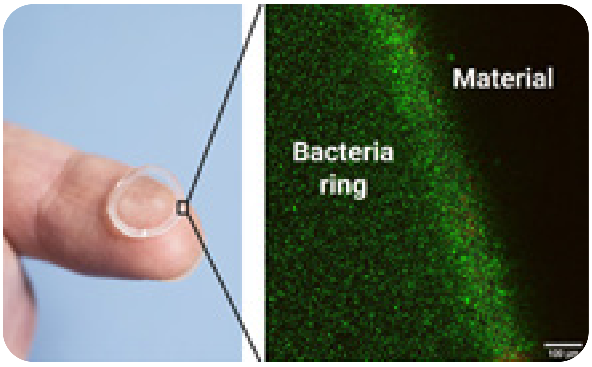
02| Highlights


OmniCure

Self-lubricating contact lenses

Maria Puertas, Lara Teruel and Aránzazu del Campo

Dynamic Biomaterials



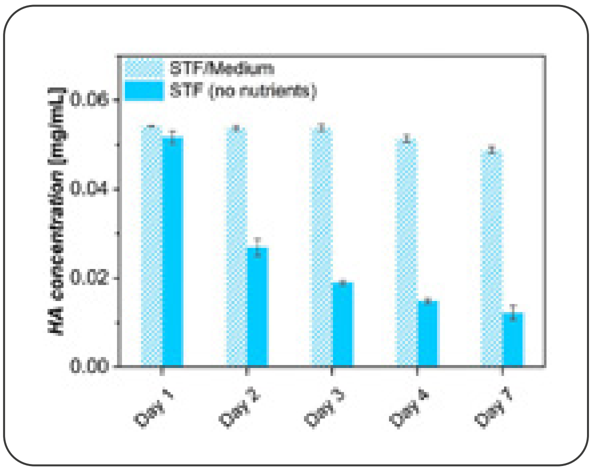


Fig. 1: Contact Lens with embedded biofactories at the rim.

Fig. 2: Sustained release of hyaluronic acid for several days in contact lenses embedded overnight in a care solution containing nutrients.

Contact lens users frequently use eye drops to provide wetting and lubricating agents to the eye surface and improve comfort. However, the wetting and lubrication effects of eye drops last for a few minutes to one hour in best case. The Research Department *Dynamic Biomaterials* works on an alternative solution for sustained lubrication of hydrogel materials. Inspired by the mucus glands on the skin of earthworms and fishes, we have embedded self-replenishing lubricant reservoirs in the contact lens material that can autonomously produce and release a natural lubricating agent. Such reservoirs are living biofactories (bacteria) genetically engineered to produce and release hyaluronic acid (HA), the natural wetting and lubrication agent used as the gold standard in ophthalmic applications. The release of HA is passively regulated by the composition and crosslinking of the hydrogel network. The hydrogel controls the activity of the biofactories and the diffusion rate of the lubricant, and it determines the rate of self-replenishment and renewal of the surface lubricant layer. The group has fabricated self-lubricating contact lens prototypes and envisions the extension of this concept to the delivery of other ocular biotherapeutics.

Self-lubricating surfaces are also relevant in other medical devices. Urinary catheters or implants for cartilage replacement also need low friction surfaces to contact human tissue. Embedded biofactories can also help in these cases. Materials and processing technologies to fabricate self-lubricating prototypes for other medical conditions are under development at INM.

M Puertas-Bartolomé, I Gutiérrez-Urrutia, L L Teruel-Enrico, C N Duong, K Desai, S Trujillo, C Wittmann,A del Campo, Adv. Mater. (2024) 36, 2313848

Electrofluids with tailored rheoelectrical properties: Liquid composites with tunable network structures as stretchable conductors

Dominik S. Schmidt, Tobias Kraus and Lola González-García

Electrofluids and Structure Formation

Liquid metals, printed conductive structures, or composites are alternatives to stiff electronic components for wearables and soft robots. We introduce a new concept: "Electrofluids", consisting of highly concentrated suspensions of conductive particles in solvents, which conduct electricity while flowing. Electrical conductivity is ensured through the 3D percolative networks of the solid filler. The contacts between the particles are transient, allowing movement in the liquid and rearrangement under mechanical stress, preserving electrical conductivity.

We used Carbon Black (CB) as conductive filler and two different liquid carriers, nonpolar polydimethylsiloxane (PDMS) and polar glycerol (Gly). The filler-matrix interaction determines the network formation, leading to tailored rheoelectrical properties. High affinity toward nonpolar liquids led to smaller agglomerates and increased both the percolation threshold (4.93 vol% of CB in PDMS) and stiffness at higher volume fractions. In polar liquids, low filler-matrix affinities led to larger agglomerates, reducing the percolation threshold (0.41 vol% of CB in Gly). In situ rheoelectrical measurements showed a close connection between the mechanical and electrical networks, giving a direct correlation between stiffness and electrical conductivity. Polar solvents delivered an improved figure of merit, i.e., higher conductivity at comparable stiffness.

We exploited the differences in the dynamics of the networks formed by CB in different liquid carriers to develop a demonstrator, where electrofluids with the same filler act as a strain sensor (using an electrofluid with large piezoresistivity) and a stable conductor (with low piezoresistivity). This single-component approach lowers production costs and promotes more sustainable materials, making recycling processes simpler.

D. S. Schmidt, T. Kraus, L. González-García,
ACS Appl. Mater. Interfaces (2024) 16, 33, 43942–43950.

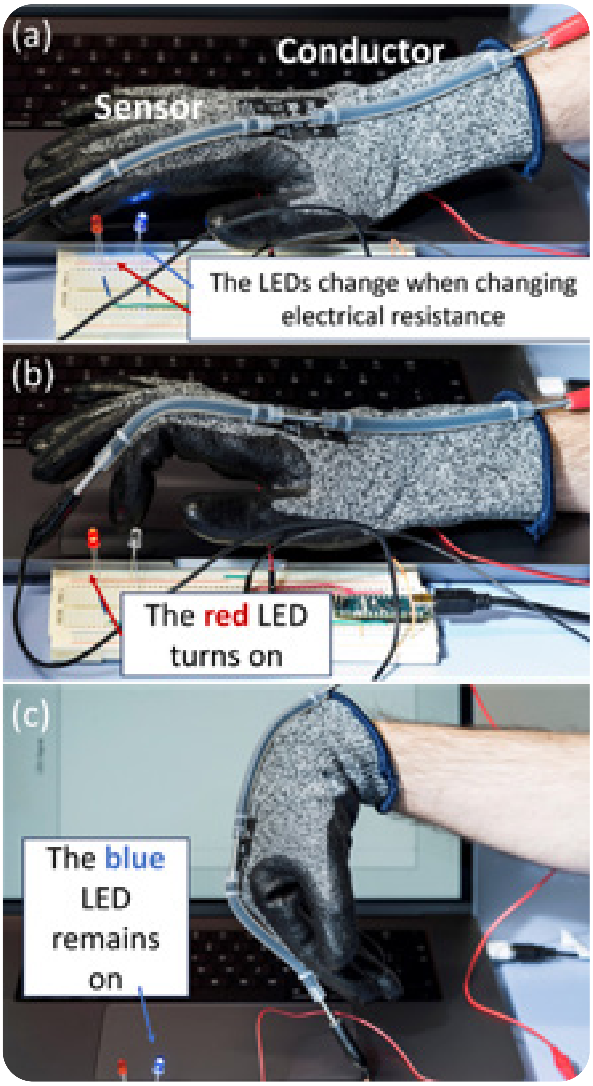
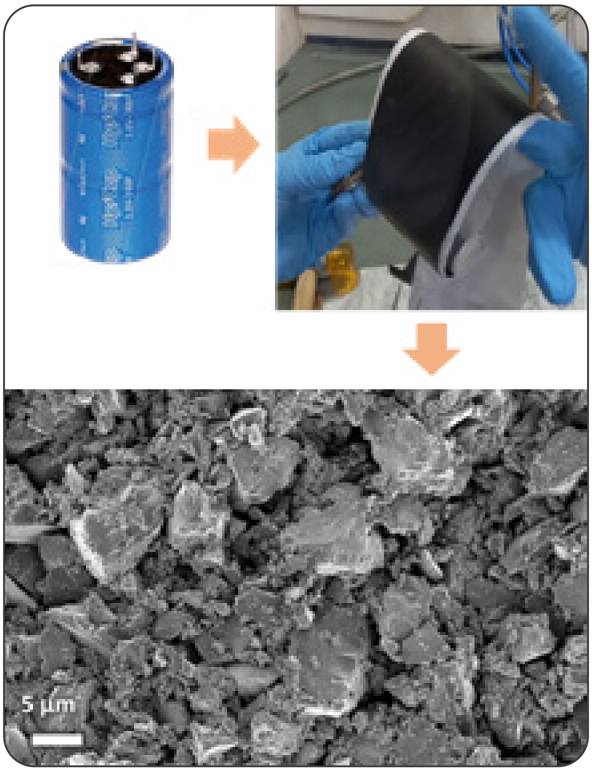


Fig. 1: (a) Glove prototype integrating sensitive and stable conductor electrofluids.
(b) Finger movement sensed via piezoresistive electrofluid.
(c) Non-sensed wrist movement using a stable electrofluid.

Life after death: Re-purposing end-of-life supercapacitors for electrochemical water desalination

Panyu Ren, Mohammad Torkamanzadeh, Stefanie Arnold,
Emmanuel Pamete and Volker Presser

Energy Materials



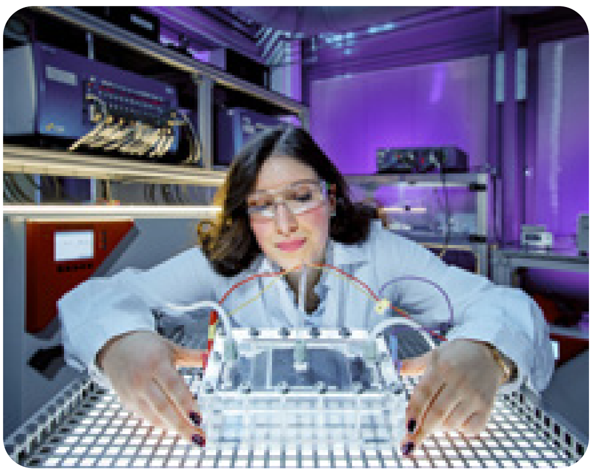


Fig. 1: Disassembled supercapacitor with extracted carbon electrodes.
Fig. 2: Electrochemical desalination cell.

The transition towards a circular economy calls for innovative approaches to material reuse, especially for electronic components reaching the end of their lifespan. The Research Department *Energy Materials* has explored an environmentally sustainable method to repurpose commercial supercapacitors at the end of their life cycle into electrochemical desalination cells. This strategy enables the recovery of valuable electrode materials while contributing to resource efficiency and water purification.

In our study, a commercial 500-Farad supercapacitor was disassembled, and its nanoporous carbon electrodes were subjected to various degrees of modification. A straightforward approach involved NaOH-etching of the aluminum current collector to produce free-standing carbon films, while more advanced modifications included CO_2 activation and wet processing with a polymer binder. These processed electrodes were then employed in capacitive deionization, a promising electrochemical desalination technique. The NaOH-etched electrodes demonstrated a desalination capacity of 6 mg/g (related to NaCl removal) and a charge efficiency of 80 %. In contrast, CO_2-activated electrodes exhibited a higher desalination capacity of 8 mg/g and charge efficiency above 90 %, maintaining stable performance over 20 cycles.

This work highlights the feasibility of using recycled supercapacitor electrodes for sustainable desalination applications. By extending the life of carbon electrodes, this method reduces electronic waste, enhances the value of discarded energy storage devices, and contributes to cleaner water solutions. Future research will focus on optimizing electrode modifications to further improve desalination efficiency and scalability.

P. Ren, M. Torkamanzadeh, S. Arnold, E. Pamete and V. Presser
Life After Death: Re-Purposing End-of-Life Supercapacitors for Electrochemical Water Desalination
Batteries & Supercaps (2024) 7, (12), e202400506

A materials-based layer for controlling gene expression

Alexandra Fischer and Wilfried Weber

Materials Synthetic Biology

Technologies to control gene expression in mammalian cells are a cornerstone for biotechnological and biomedical applications. The Research Department *Materials Synthetic Biology* has developed a novel materials-centric framework for controlling gene expression by engineering the material properties of transcription factor condensates. By applying concepts from soft matter physics and polymer science, the team demonstrates that the viscoelasticity and phase behavior of protein-based condensates can directly influence transcriptional outcomes in living systems.

Using optogenetically inducible systems, the authors modulate the phase-separated states of transcription factors in response to illumination. This tuning enables the formation of condensates with a continuum of material states – from dynamic, liquid-like assemblies to more arrested, gel-like structures. These condensates localize at specific DNA promoter regions and act as functional materials that either potentiate or repress gene expression.

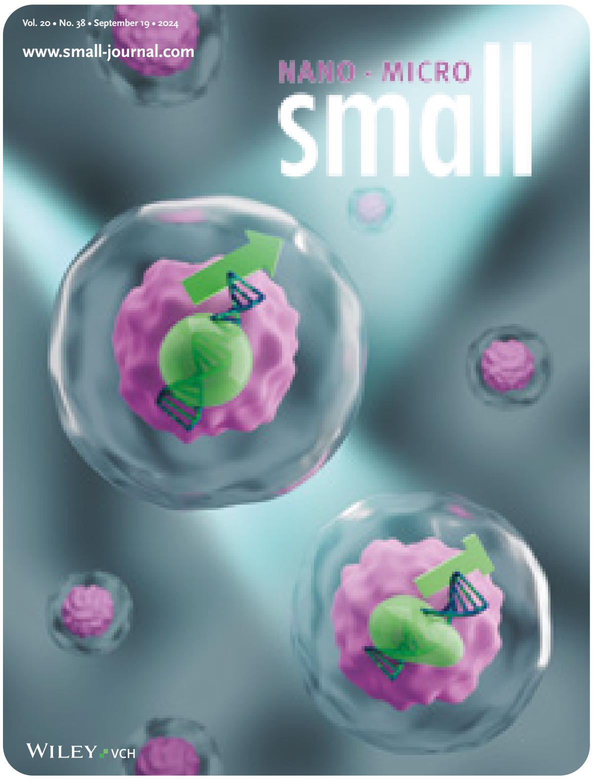


Fig. 1: Cover Picture of *Small* Volume 20, Issue 38 illustrating the concept of transcription factor condensates influencing gene expression

Strikingly, liquid-like condensates enhance transcription, likely due to favorable molecular diffusion and increased cofactor recruitment within the soft, dynamic environment. In contrast, stiffer, less dynamic condensates suppress gene expression despite proper localization and equivalent molecular composition. This stiffness-dependent behavior holds across synthetic systems and native transcription factors such as RelA, STAT3, and STAT6, and impacts both synthetic reporters and endogenous gene loci.

The findings reveal gene regulation as a materials-tunable process. For materials scientists, this opens exciting opportunities to integrate phase behavior, viscoelastic tuning, and stimulus-responsive assembly into bioengineering strategies – bridging molecular materials design and synthetic biology.

A.A. Fischer, H.B. Robertson, D. Kong, M.M. Grimm, J. Grether, J. Groth, C. Baltes, M. Fliegauf, F. Lautenschläger, B. Grimbacher, H. Ye, V. Helms and W. Weber
Engineering Material Properties of Transcription Factor Condensates to Control Gene Expression in Mammalian Cells and Mice
Small (2024), 20, 38, 2311834

Digitalization in battery research: Structured data and domain knowledge on conductive networks

Lisa Beran, Tobias Kraus

Structure Formation

The digitalization of materials science requires documenting physical objects and activities in machine-readable formats. Ontologies are a suitable framework: they define concepts, categories, and their relationships within a domain, providing a structured framework for AI applications. An example is the Battery Processing and Characterization Ontology (BPCO) that models battery production by linking materials, processes, and characterization methods. (Fig. 1)

We use BPCO to analyze the formation, structure, and properties of the Carbon-Binder-Domain (CBD) that lends battery electrodes much of its electronic conductivity. For example, changing the processing solvent from NMP to DMSO increased the bulk conductivity of Carbon Black (CB) as a single component by 150 % and additionally impacts multiple process steps. We used BPCO to study why this increases the conductivity of CB in the binder by 250 %.

The relevant components CB, binder, and solvents, are represented as “items” and the processes they undergo are modeled as “steps” (Fig. 2), with relevant data directly linked. Hypotheses relate the chemical properties of CB, binders and solvents to the overall electrode conductivity. For example, we tested whether solvent-dependent CB agglomeration of CB affects the conductive network. Smaller aggregates that pack more densely could explain the increase in conductivity far above the percolation threshold, for example.

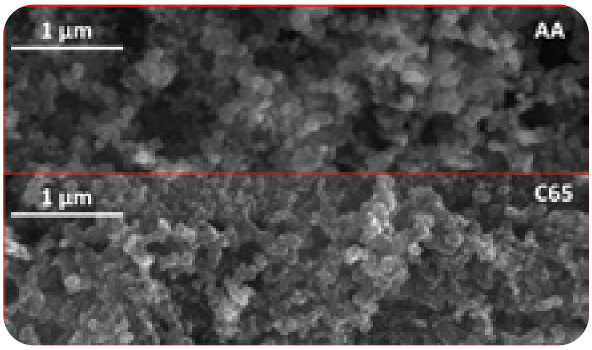
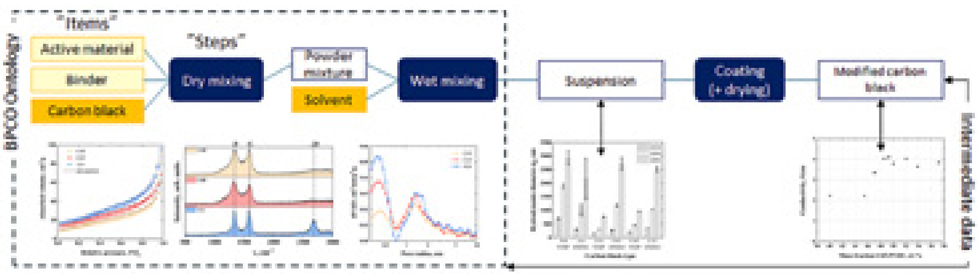


Fig. 1: Electron micrographs of conductive networks formed by two different Carbon Black types (AA and C65).
Fig. 2: The Battery Processing and Characterization Ontology describes the materials and processes that lead to batteries. We use it to guide research on physico-chemical processes underlying material properties using linked data and additional experiments (outside the box).

L. Beran, T.V. Knapp, A. Nexha, M. Lay, B.-J. Niebuur, T. Kraus, Adv Eng Mater (2025), 2401813



Focus on new people: Alvaro Banderas

Alvaro Banderas studied Biotechnology and Microbiology at the University of Chile and gained a PhD from Heidelberg University. After a short postdoc at the Max Planck Institute for Terrestrial Microbiology he became postdoc at Université Paris Cite and Institut Curie. After his involvement in the setup of the Paris Biofoundry (site Curie), he now leads the Core Facility *Accelerated Research Foundry*.

1. Could you please give the reader a short description of the tasks for the new Core Facility *Accelerated Research Foundry*?

The Core Facility-*Accelerated Research Foundry (ARF)* is an innovative research and service laboratory that merges material sciences automation (materials acceleration platforms, MAPs) and synthetic biology automation (Biofoundries). Our principal tasks involve automating, miniaturizing, and increasing the throughput of methods and workflows for chemical formulation and analysis of various materials and the bioengineering and characterization of their living components. Through the development of high-throughput methods, we rapidly test and analyze numerous chemical and biological formulations to discover new materials with desired properties. By integrating artificial intelligence tools, we aim to predict outcomes and optimize processes much faster than traditional methods, while at the same time better understanding underlying mechanisms.

2. Which INM research departments and groups would profit most from your methods?

The beauty of the ARF is that it benefits all research departments and groups at INM. Every group can leverage our high-throughput capabilities and advanced computational methods to answer specific research questions and explore the design parameter-space. For instance, groups can use our bioengineering automation to develop new bio-based materials or benefit from our rapid chemical formulation techniques. Thus, our facility acts as a catalyst, enhancing the research capabilities across the entire institute.

3. Where do you see your Core Facility *Accelerated Research Foundry* in five years?

In five years, I envision the *Accelerated Research Foundry* as a leading hub for innovation in materials science and bioengineering. We aim to become a self-driving lab, where automated systems and humans co-design, execute, and analyze experiments. This will significantly speed up the discovery process and allow us to tackle more complex scientific challenges. Our goal is to create an interface between MAPS and biofoundries, enabling the development of hybrid materials that combine the best of both worlds, while welcoming collaborations with academic institutions, startups, and industry partners to drive forward the frontiers of the field.

4th International Conference on Engineered Living Materials

Shrikrishnan Sankaran, Wilfried Weber, Aránzazu del Campo

Leibniz ScienceCampus Living Therapeutic Materials

Fig. 1: ELM 2024 participants gathered in the Aula of the Saarland University for a group picture.
Fig. 2: Poster Session during the ELM Conference.

The 4th International conference on Engineered Living Materials (ELMs), hosted by INM in September, was met with incredible enthusiasm from this vibrant community. As applications exceeded our capacity at the Aula of Saarland University around 200 scientists from 14 countries were selected, an increase of 60 % compared to 2022 (Fig. 1). The conference featured 30 outstanding speakers and 70 posters, promoting invigorating discussions and scientific connections (Fig. 2). These contributions covered the topics of Microbes in Confinement, ELM Co-Cultures, Enhanced Functions with ELMs, Algal ELMs, ELM Fabrication, and Living Therapeutic Materials, the largest session featuring 9 speakers from 5 countries. Additionally, a pre-conference symposium was held by the European Innovation Council (EIC), which included presentations from the projects of their ELM portfolio.

A unique highlight of the event was a roundtable discussion on “Driving change towards living materials adoption”, with experts in science, architecture, design, funding, therapeutics, and regulatory affairs. Moderated by Elena Bondareva, a specialist in driving disruptive technologies, they discussed the numerous benefits and anticipated challenges in transitioning ELMs from the lab to real-world applications. The panel concluded that despite several technical, regulatory, and societal hurdles, the potential of ELMs to offer sustainable solutions for major global challenges promises a bright future for this technology. On request from several participants, a recording of the event has been made available on the INM YouTube channel.

The next edition of the conference is planned for 2026, anticipating significant progress in this rapidly advancing field.

The conference was organized by the Leibniz Science Campus “*Living Therapeutic Materials”* and the *Priority Program “Engineered Living Materials with Adaptive Function”*, and chaired by Aránzazu del Campo, Shrikrishnan Sankaran and Wilfried Weber from INM.

Leibniz Science Campus: Living Therapeutic Materials enters its second funding phase

Hannah Jahn-Kelleter, Shrikrishnan Sankaran, Aránzazu del Campo

Bioprogrammable Materials, Dynamic Biomaterials

Good news for biomedical research in Saarland: The Leibniz Science Campus (LSC) "Living Therapeutic Materials" has entered its second funding phase after four years of successful research. The INM – Leibniz Institute for New Materials, Saarland University (UdS), and the Helmholtz Institute for Pharmaceutical Research Saarland (HIPS) launched this second phase in October with €1.6 million funded by the Leibniz Association and the Saarland government, supplemented by contributions from the partner institutions, bringing the total funding to €3 million.

LifeMat
LEIBNIZ-SCIENCE CAMPUS
LIVING THERAPEUTIC MATERIALS
SAARBRÜCKEN

The LSC develops engineered living materials that can produce and release medications within the body. While fundamental research remains a focus, the next phase aims to transition these innovations into medical applications by preparing for clinical testing, exploring regulatory pathways, and enhancing biosafety. Discussions with regulatory authorities and industry partners are already underway. Minister of Economic Affairs, Innovation, Digitalization, and Energy, Jürgen Barke, sees this as a valuable investment in Saarland as a research hub. Saarland University President, Ludger Santen, emphasizes the importance of the Leibniz Science Campus for the research focus on NanoBioMed at Saarland University.

One example of Living Therapeutic Materials (LTM) is a self-lubricating contact lens that produces hyaluronic acid – a proven treatment for dry eyes. Unlike traditional eye drops, where 95 % of the medication is lost, this approach ensures targeted drug delivery.

The implementation of the goals of the LSC involves 19 senior researchers from the partner institutions, along with three research groups and 21 doctoral candidates. Hosting the international conference on Engineered Living Materials at the UdS campus in September ensured the exchange of knowledge with 200 experts from around the world and increased the visibility of the location globally.

The Working Group Visibility: Making the invisible visible

Shrikrishnan Sankaran, Oskar Staufer

Bioprogrammable Materials, Immuno Materials

Fig. 1: Representative social media channels established by the visibility working group.
Fig. 2: Filming of the Material Minds Podcast.

The INM – Leibniz Institute for New Materials is at the forefront of materials science research, and the Working Group Visibility ensures that its impact is widely recognized. Composed of dedicated INM members, the group enhances engagement with the scientific community and the public.

The working group's efforts began with an internal survey in 2023 to assess INM's visibility strengths and needs. Following this, an agile management workshop with the first members of the group aligned its goals for 2024. Key milestones of the group include the establishment of social media guidelines and channels (LinkedIn, Instagram, YouTube, Twitter / X), the redesign of the website and logo, the setup of a media creation room, a workshop on video editing, the creation of the Material Minds podcast, and the organization of INM's participation in local sports events (Firmenlauf, Cross Against Cancer charity run). These initiatives were planned to enhance visibility of activities and achievements at INM both locally in Saarland and within the global research community, while enabling members at INM to promote their own work. The social media channels highlighted accomplishments like publications and awards, job opportunities, scientific events, and public outreach initiatives. The podcast guided the setup of the media creation room with audio-visual equipment, provided a long-form format for passionate scientists at INM to promote their research, and generated high-quality content for INM's visibility.

Looking ahead, the visibility working group aims to inspire more INM colleagues to join the group, leverage these achievements to enhance INM's online reach, and strengthen local engagement with the public. By continuously evolving its outreach strategies, the Visibility Working Group ensures INM's contributions to materials science are widely recognized and celebrated.

Ten years BMBF student internship “Materials Vacation” at the INM (2014 – 2024)

Mario Quilitz

This is a great occasion to look back on the ten-year history of the student internship “Materials Vacation”. It all started in 2013 when the VDI, organizing the internships on behalf of the BMBF, asked us whether we would take part in the project for a one-week internship. INM offered a variety of topics in materials science with links to chemistry, physics and biology, and a minimum of three days in the lab for students beyond the age of 16 (secondary level II) was agreed on. INM started this activity together with a few other materials research institutes, mostly from the Leibniz and the Helmholtz Association. Over time INM became sort of a “founding partner”. The operational work started with the first internship in the autumn break of 2014. From the very beginning, the first day of the program consisted of a series of talks introducing “science”, “materials science”, and the activities at INM to the students. This rather theory-loaded day was rounded off with a “hands on” look at materials and by tours through the institute and the city. At that time, the internship was called “Student Internship Nano- and Materials Technology”, and most of the three days in the lab were designed and conducted by the Research Departments *Optical Materials* and *Nanomers*, as well as the Service Group *Physical Analytics*. The Research Department *Biomineralization* also contributed on a smaller scale during the first two years, before being replaced by *Nano Cell Interactions* in 2016. The Friday program, lasting only a few hours, was dedicated to a format where the students could interact with young scientists – doctoral researchers and young postdocs – who presented their work at INM and provided valuable insights into studies and the daily work of a scientist in a research environment. From 2018 onwards, the internship was renamed “Student Internship Material Holidays”.

Of course, the Covid-19 pandemic directly affected the internship program. Instead of shutting down the project due to the lockdowns in 2020, we completely transitioned to a virtual format. The lab days were replaced by transmissions from the labs, demonstrating the methods online, while the entire one-week program was condensed into two days. Fortunately, we were able to conduct the complete program including lab days again in 2021 and every year since. However, the “Virtual Lab Day” in September – about six weeks before the one week internship in October – has remained as an opportunity to introduce all the institutes. This allows the students not only to visit the institute of their choice but also to gain a broader overview of all the participating research institutes.

The next Student Internship Materials Vacation is already planned for the autumn of 2025. As in 2024, the biological Research Departments *Materials Synthetic Biology* and *Dynamic Biomaterials* will further expand their share in the program. This reflects the expansion of the INM research portfolio by including biological approaches to materials sciences.

Fig. 1: “Theory part” on the first day opened to a more “hands on” approach to materials.
Fig. 2: However the experimental work in the labs was at the core of the internship.

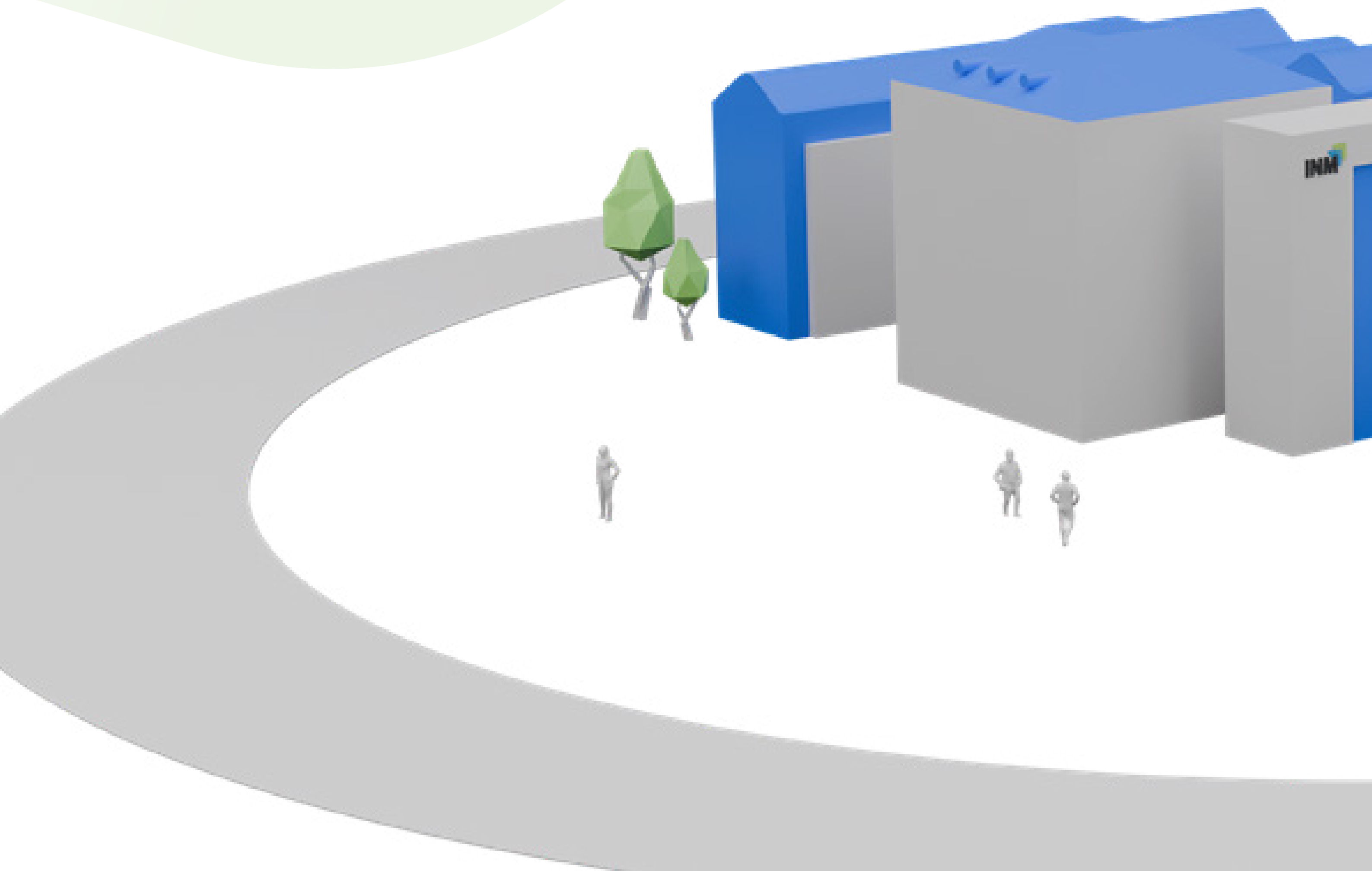
03|

Fakten & Zahlen / Facts & figures

238
employees from
37 countries (48 % female)

120
scientists (46 % female)
thereof: **53** doctoral students

21
events



28.01
million € total turnover
6.03 million € third party funding

132
publications in total
98 thereof in peer-reviewed publications

53
invited talks
182 other talks

2
patent applications
7 granted patents

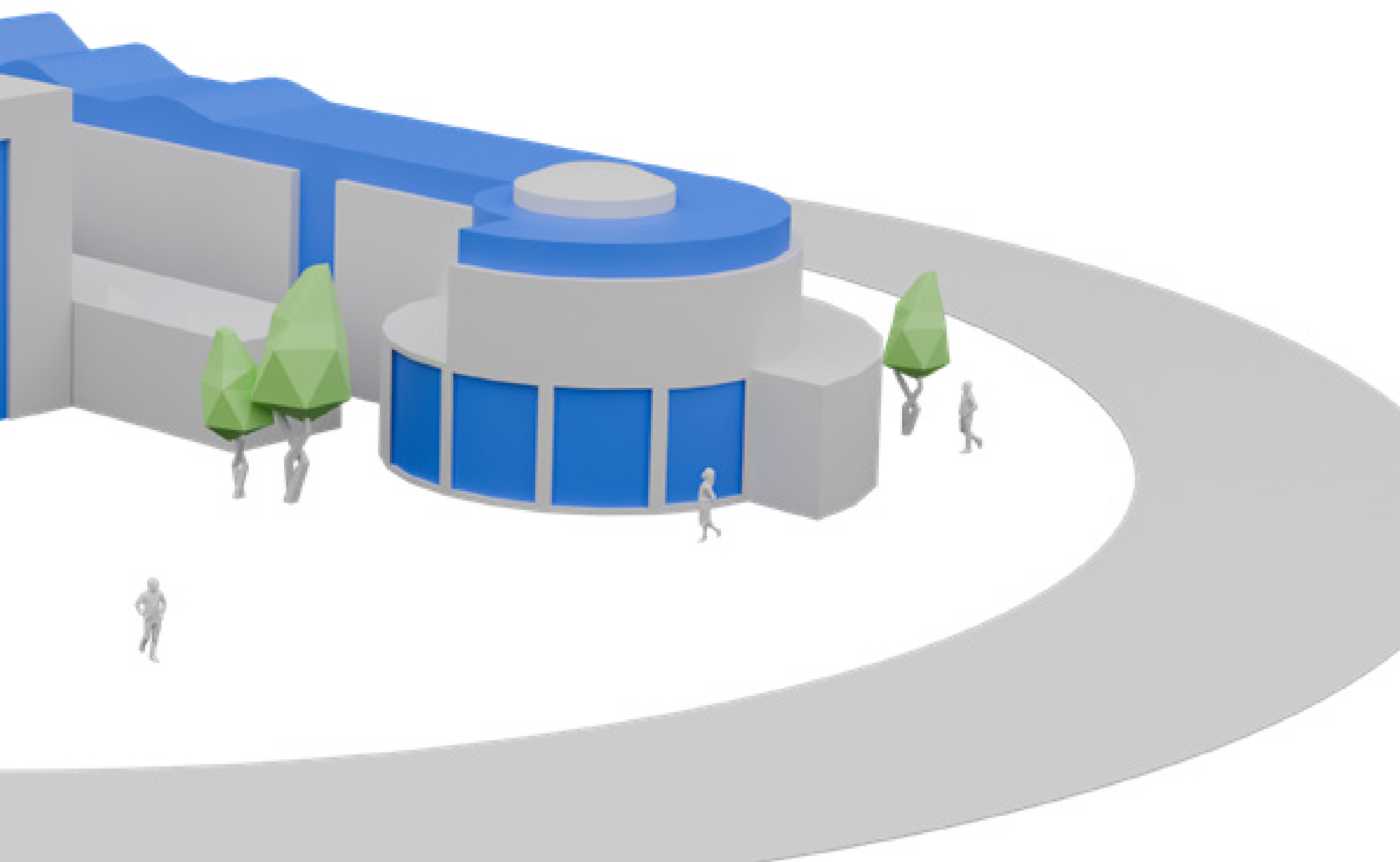
52
cooperation projects and **6** joint professors with Saarland University

52
International cooperations with institutions from **21** countries

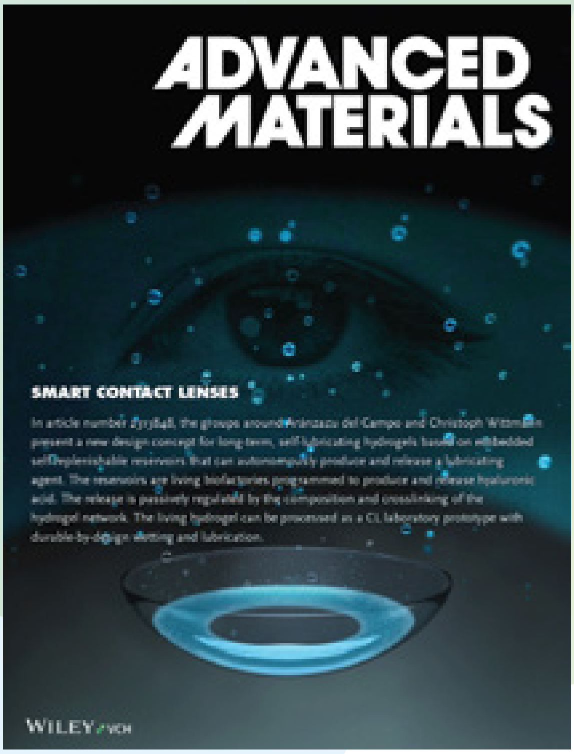
56
Cooperations with 56 institutions in Germany

49.4
weekly teaching hours per year

9
doctoral theses
5 master theses
1 bachelor theses



Ausgewählte Publikationen / Selected Publications



S. Dey and S. Sankaran

Engineered bacterial therapeutics with material solutions

Trends in Biotechnology, 2024, 42, (12), 1663-1676
doi:10.1016/j.tibtech.2024.06.011

J. Y. Kasper, M. W. Laschke, M. Koch, L. Alibardi, T. M. Magin, C. M. Niessen and A. del Campo

Actin-templated Structures: Nature's Way to Hierarchical Surface Patterns (Gecko's Setae as Case Study)

Advanced Science, 2024, 11, (10), 2303816
doi:10.1002/advs.202303816

M. Puertas-Bartolomé, I. Gutierrez-Urrutia, L. L. Teruel-Enrico, C. Nguyen Duong, K. Desai, S. Trujillo, C. Wittmann and A. del Campo

Self-Lubricating, Living Contact Lenses

Advanced Materials, 2024, 36, (27), 2313848
doi:10.1002/adma.202313848

C. Kök, L. Wang, J. G. A. Ruthes, A. Quade, M. E. Suss and V. Presser

Continuous Lithium-Ion Extraction From Seawater and Mine Water With a Fuel Cell System and Ceramic Membranes

Energy & Environmental Materials, 2024, 7, (6), e12742
doi:10.1002/eem2.12742

P. Ren, B. Wang, J. G. De Andrade Ruthes, M. Torkamanzadeh and V. Presser

Cation selectivity during flow electrode capacitive deionization

Desalination, 2024, 592, 118161
doi:10.1016/j.desal.2024.118161

A. Burgstaller, N. Piernitzki, N. Küchler, M. Koch, T. Kister, H. Eichler, T. Kraus, E. C. Schwarz, M. Dustin, F. Lautenschlaeger and O. Staufer

Soft Synthetic Cells with Mobile Membrane Ligands for Ex Vivo Expansion of Therapy-Relevant T Cell Phenotypes

Small, 2024, 20, (37), 2401844
doi:10.1002/smll.202401844

H. Mohsenin, H. J. Wagner, M. Rosenblatt, S. Kemmer, F. Drepper, P. Huesgen, J. Timmer and W. Weber

Design of a Biohybrid Materials Circuit with Binary Decoder Functionality

Advanced Materials, 2024, 36, (14), 2308092
doi:10.1002/adma.202308092

M. Klos, L. González-Garcia and T. Kraus

Mechanically Robust, Inkjet-Printable Polymer Nanocomposites with Hybrid Gold Nanoparticles and Metal-like Conductivity

ACS Applied Materials & Interfaces, 2024, 16, (24), 31576-31585
doi: 10.1021/acsami.4c04692

A. A. M. Fischer, H. B. Robertson, D. Kong, M. M. Grimm, J. Grether, J. Groth, C. Baltes, M. Fliegauf, F. Lautenschlaeger, B. Grimbacher, H. Ye, V. Helms and W. Weber

Engineering Material Properties of Transcription Factor Condensates to Control Gene Expression in Mammalian Cells and Mice

Small, 2024, 20, (38), 2311834
doi:10.1002/smll.202311834

H. Mohsenin, J. Pacheco, S. Kemmer, H. J. Wagner, N. Höfflin, T. Bergmann, T. Baumann, C. Jerez-Longres, A. Ripp, N. Jork, H. J. Jessen, M. Fussenegger, M. Köhn, J. Timmer and W. Weber

PenTag, a Versatile Platform for Synthesizing Protein-Polymer Biohybrid Materials

Advanced Functional Materials, 2024, 34, (35), 2308269
doi:10.1002/adfm.202308269

D. S. Schmidt, T. Kraus and L. González-García

Electrofluids with Tailored Rheoelectrical Properties: Liquid Composites with Tunable Network Structures as Stretchable Conductors

ACS Applied Materials & Interfaces, 2024, 16, (33), 43942-43950
doi:10.1021/acsami.4c07230

Das INM in Zahlen / INM in Figures

Stand / As of: 13.03.2025

Im Jahr 2024 betrug der **Gesamtumsatz** des INM **28,01 Mio. €**.

Erlöse aus der gemeinsamen Finanzierung durch den Bund und die Länder (**institutionelle Förderung**): **21,88 Mio. €**,
- davon Personal- und Sachaufwendungen: **16,01 Mio. €**
- und für Investitionen: **5,87 Mio. €.**

Erlöse aus Drittmittelvorhaben: 6,03 Mio. €
- davon **4,24 Mio. €** aus Förderungen für die Grundlagenforschung und anwendungsbezogene Forschung
- und **1,79 Mio. €** aus Förderungen mit Industriekooperationen.

Sonstige betriebliche Erträge: **0,09 Mio. €**

Das INM hatte Ende 2024 **238 Beschäftigte** (**123 m, 115 w**), davon
- **67** Wissenschaftler/innen (**38 m, 29 w**),
- **53** Promovierende (**27 m, 26 w**),
- **47** Beschäftigte (**24 m, 23 w**) in den Bereichen Labor, Technik und Service,
- **34** Beschäftigte (**11 m, 23 w**) in der Verwaltung und den Sekretariaten,
- **29** Hiwis (**17 m, 12 w**) und **8** Auszubildende (**6 m, 2 w**).

In 2024, the total turnover of INM added up to **28.01 million €**.

Proceeds from the joint financial support by the federal government and the federal states (**institutional funding**): **21.88 million €**,
- including expenses for personnel and materials: **16.01 million €**
- and for investments: **5.87 million €.**

Proceeds from third party funding: 6.03 million €
- including **4.24 million €** from funding for basic and applied research
- and **1.79 million €** from funding within the framework of industrial cooperations.

Other operating income: **0.09 million €**.

At the end of 2024, **238 employees** (**123 m, 115 f**) worked at INM including:
- **67** scientists (**38 m, 29 f**),
- **53** doctoral researchers (**27 m, 26 f**),
- **47** employees (**24 m, 23 f**) in laboratories and technical services,
- **34** employees (**11 m, 23 f**) in administration and secretarial offices,
- **29** graduate assistants (**17 m, 12 f**) and **8** apprentices (**6 m, 2 f**).

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

Kuratorium & Wissenschaftlicher Beirat / Board of Trustees & Scientific Advisory Board

Mitglieder des Kuratoriums / Members of the Board of Trustees

Stand / As of: 31.12.2024

Mitglieder des Wissenschaftlichen Beirats / Members of the Scientific Advisory Board

Stand / As of: 31.12.2024

Dissertationen / Doctoral Theses

Habilitation / Habilitation

Dr. Stefan Lohse
Myeloische Zellen in der Entstehung und Therapie maligner Erkrankungen
Universität des Saarlandes, 11.11.2024

Dissertationen / Doctoral Theses

Sourik Dey
Engineering Probiotic Bacteria as Living Therapeutic Agents
Universität des Saarlandes, 20.12.2024
Prof. Dr. Aránzazu del Campo

Priyanka Dhakane
Light-regulated Pro-angiogenic Engineered Living Materials
Universität des Saarlandes, 23.02.2024
Prof. Dr. Aránzazu del Campo

Alexandra Fischer
Control of cell signaling and transcription using optogenetic phase separation tools
Universität des Saarlandes, 19.04.2024
Prof. Dr. Wilfried Weber

Carolina Jerez-Longres
Engineering protein- and peptide-based materials for therapy-oriented and bottom-up synthetic biology
Universität des Saarlandes, 06.08.2024
Prof. Dr. Wilfried Weber

Adrian de Miguel Jimenez
Tetrazole Methylsulfone - Thiol crosslinked hydrogels for automated and high-throughput 3D cell culture
Universität des Saarlandes, 01.10.2024
Prof. Dr. Aránzazu del Campo

Zhang Long
Tuning the Structure and Conductivity of Carbon-Elastomer Composites
Universität des Saarlandes, 02.05.2024
Prof. Dr. Tobias Kraus

Christian Müller
Contact mechanics of thin films, viscoelastic materials, and frictional interfaces via Green's function molecular dynamics
Universität des Saarlandes, 04.11.2024
Prof. Dr. Martin H. Müser

Mohammad Torkamanzadeh
2D Nanolamellar Materials Toward Water-Energy Nexus Applications
Universität des Saarlandes, 09.02.2024
Prof. Dr. Volker Presser

Archana Yanamandra
Response of immune killer cells to mechanical cues and living therapeutic materials
Universität des Saarlandes, 10.04.2024
Prof. Dr. Markus Hoth, Dr. Bin Qu

Abschlussarbeiten / Theses

Bachelorarbeiten / Bachelor Theses

Leon Germann
Triggeradditiv-basierte Primerschichten für $LiFeP0_4$-Kathoden zur verbesserten Ablösbarkeit von der Stromableiterfolie
Hochschule Kaiserslautern
Prof. Dr. Tobias Kraus, Prof. Dr. Thomas Stumm

Masterarbeiten / Master Theses

Antoine Bagard
Synthesis and characterization of soft electroactive polymers
Universität des Saarlandes
Jun.-Prof. Dr. Lola González-García /
Prof. Dr.-Ing. Markus Gallei

Léane Chastagner
Characterization and improvement of the surface structure of pluronic diacrylate hydrogels
Universität des Saarlandes
Prof. Dr. Roland Bennewitz

Yan Fett
Friction on Pluronic F127 Diacrylate Hydrogel Surfaces
Universität des Saarlands
Prof. Dr. Roland Bennewitz

Agathe L. A. Guillemet
Si/MXene batteries: Enhancing performance and sustainability
Universität des Saarlands
Prof. Dr. Volker Presser

Jessica Thomas
3D Printing of Carbon Nanotube-Based Electrofluids
Universität des Saarlands
Jun.-Prof. Dr. Lola González-García / Prof. Dr. Jürgen Steimle

Pablo Vega Hernandez
Porous carbon electrodes for the selective removal of rare-earth elements by means of electrochemical water desalination
Universität des Saarlands
Prof. Dr. Volker Presser

Andreas Weyand
Data-driven analysis of the role and effects of conductive carbon additives in anodes using the digital platform DigiBatMat
HTW Saar
Prof. Dr. Christian Köhler / Prof. Dr. Tobias Kraus

Auszeichungen / Awards

Stefanie Arnold
73rd Lindau Nobel Laureate Meeting,
30 June – 5 July 2024
Council for the Lindau Nobel Laureate Meetings

Stefanie Arnold
Eduard Martin Preis der Universität des Saarlandes 2024
Universitätsgesellschaft des Saarlandes & Universität des Saarlandes

Gerardo Asensio Martín
Förderung im Rahmen des Innovate! Academy Programms, Joachim-Herz-Stiftung

Lisa Beran
Poster Prize
Project DigiBatMat: Digital Platform for Battery Materials and Processing Data
Vollversammlung Plattform MaterialDigital am 18./19. September.2024, Berlin

Aránzazu del Campo Bécares
Member of Program Committee of the BioInspired Materials Conference BioINSP 2024

Krupansh Desai
DAAD Congress travel grant
The Company of Biologists travel grant

Ketaki Deshpande
Best oral presentation and travel grant
Leibniz Research Network "Stem Cells and Organoids"

Tobias Kraus
Outstanding Reviewer for Nanoscale
Nanoscale Journal

Tobias Kraus
Wahl zum Vorsitzenden
der DECHEMA-Fachsektion Funktionale Materialien

Tobias Kraus
Wahl zum Stellvertretenden Vorsitzenden
der Kolloid Gesellschaft

Dominik Perius
Best Oral Presentation Award
in Symposium R-Synthesis and characterization of functional nanocomposites, E-MRS 2024 Fall Meeting Warsaw, Poland

Manar Samri
Eduard Martin Preis der Universität des Saarlandes 2024, Universitätsgesellschaft des Saarlandes & Universität des Saarlandes

Oskar Staufer
Förderung im Rahmen des Innovate! Academy Programms, Joachim-Herz-Stiftung

Lara Teruel
Gewinnerin Pitch-Wettbewerb
Ryon Green Tech Accelerator

Gracita Raquel Tomboc
Outstanding Reviewer Energy Advances
Royal Society of Chemistry

Wilfried Weber
Wahl in die Deutsche Akademie der Technikwissenschaften (acatech)

Wilfried Weber
Wahl in den Vorstand der Gemeinsame Fachgruppe Synthetische Biologie der DECHEMA, GDCh, GBN, VAAM und DBG

Referierte Publikationen / Peer-reviewed Publications

Stand / As of: 14.03.2025

132
Publikationen / Publications

davon / including

98
Publikationen in referierten Zeitschriften / publications in peer-reviewed journals

34
sonstige Publikationen / other publications

100
Publikationen im Open Access veröffentlicht / publications published in Open Access

davon / including

74
Beiträge in referierten Zeitschriften / contributions in peer-reviewed journals

Bioprogrammierbare Materialien / Bioprogrammable Materials

S. Bhusari, M. Hoffmann, P. Herbeck-Engel, S. Sankaran, M. Wilhelm and A. del Campo
Rheological behavior of Pluronic/Pluronic diacrylate hydrogels used for bacteria encapsulation in engineered living materials
Soft Matter, 2024, 20, (6), 1320-1332 [JIF: 02.90 (2023)]
doi:10.1039/D3SM01119D

M. Blanch Asensio, S. Dey, V. S. Tadimarri and S. Sankaran
Expanding the genetic programmability of Lactiplantibacillus plantarum
Microbial Biotechnology, 2024, 17, e14335 [JIF: 04.80 (2023)]
doi:10.1111/1751-7915.14335

M. Blanch-Asensio, V. S. Tadimarri, A. Wilk and S. Sankaran
Discovery of a high-performance phage-derived promoter / repressor system for probiotic lactobacillus engineering
Microbial Cell Factories, 2024, 23, (42), 1-13 [JIF: 04.30 (2023)]
doi:10.1186/s12934-024-02302-7

S. Dey and S. Sankaran
Sustainable protein regeneration in encapsulation materials
Cell systems, 2024, 15, (3), 211-212 [JIF: 09.00 (2023)]
doi:10.1016/j.cels.2024.02.004

S. Dey and S. Sankaran
Engineered bacterial therapeutics with material solutions
Trends in Biotechnology, 2024, 42, (12), 1663-1676 [JIF: 14.30 (2023)]
doi:10.1016/j.tibtech.2024.06.011

S. Dey, C. E. Seyfert, C. Fink-Straube, A. M. Kany, R. Müller and S. Sankaran
Thermo-amplifier circuit in probiotic E. coli for stringently temperature-controlled release of a novel antibiotic
Journal of Biological Engineering, 2024, 18, (1), 66 [JIF: 05.70 (2024)]
doi:10.1186/s13036-024-00463-y

Dynamische Biomaterialien / Dynamic Biomaterials

S. Bhusari, M. Hoffmann, P. Herbeck-Engel, S. Sankaran, M. Wilhelm and A. del Campo
Rheological behavior of Pluronic / Pluronic diacrylate hydrogels used for bacteria encapsulation in engineered living materials
Soft Matter, 2024, 20, (6), 1320-1332 [JIF: 02.90 (2023)]
doi:10.1039/D3SM01119D

H. S. U. B. Farrukh, F. Milos, A. D. Álvarez, S. Pearson and A. del Campo
Biofunctional Polyacrylamide Hydrogels using Tetra-zole-Methylsulfone Comonomer for Thiol Conjugation
Advanced Materials Interfaces, 2024, 11, (13), 2301024
[JIF: 04.30 (2023)], doi:10.1002/admi.202301024

J. Y. Kasper, M. W. Laschke, M. Koch, L. Alibardi, T. M. Magin, C. M. Niessen and A. del Campo
Actin-templated Structures: Nature's Way to Hierarchical Surface Patterns (Gecko's Setae as Case Study)
Advanced Science, 2024, 11, (10), 2303816
[JIF: 14.30 (2023)], doi:10.1002/advs.202303816

F. Milos and A. Del Campo
Polyacrylamide Hydrogels as Versatile Biomimetic Platforms to Study Cell-Materials Interactions
Advanced Materials interfaces, 2024, 11, (34), 2400404
[JIF: 04.30 (2023)], doi:10.1002/admi.202400404

M. Puertas-Bartolomé, I. Gutierrez-Urrutia, L. L. Teruel-Enrico, C. Nguyen Duong, K. Desai, S. Trujillo, C. Wittmann and A. del Campo
Self-Lubricating, Living Contact Lenses
Advanced Materials, 2024, 36, (27), 2313848
[JIF: 27.40 (2023)], doi:10.1002/adma.202313848

A. K. Yanamandra, J. Zhang, G. Montalvo, X. Zhou, D. Diedenweg, R. Zhao, S. Sharma, M. Hoth, F. Lautenschläger, O. Otto, A. del Campo and B. Qu
PIEZO1-mediated mechanosensing governs NK-cell killing efficiency and infiltration in three-dimensional matrices
European Journal of Immunology, 2024, 54, (3), e2350693 [JIF: 04.50 (2023)]
doi:10.1002/eji.202350693

Elektrofluide / Electrofluids

T. Grammes, J. H. Maurer, L. González-García and T. Kraus
Solvent Vapor Annealing and Plasma Treatment Stabilize Silver Nanowire Layers
Particle & Particle Systems Characterization, 2024, 41, (11), 2400091 [JIF: 02.70 (2023)]
doi:10.1002/ppsc.202400091

M. Klos, L. González-García and T. Kraus
Mechanically Robust, Inkjet-Printable Polymer Nanocomposites with Hybrid Gold Nanoparticles and Metal-like Conductivity
ACS Applied Materials & Interfaces, 2024, 16, (24), 31576–31585 [JIF: 08.30 (2023)]
doi:10.1021/acsami.4c04692

D. S. Schmidt, T. Kraus and L. González-García
Electrofluids with Tailored Rheoelectrical Properties: Liquid Composites with Tunable Network Structures as Stretchable Conductors
ACS Applied Materials & Interfaces, 2024, 16, (33), 43942-43950 [JIF: 08.50 (2023)]
doi:10.1021/acsami.4c07230

D. Van Impelen, L. González-García and T. Kraus
Low-temperature sintering of Cu@Ag microparticles in air for recyclable printed electronics
Journal of Materials Chemistry C, 2024, 12, (33), 12882-12889 [JIF: 05.70 (2023)]
doi:10.1039/D4TC02028F

Energie-Materalien / Energy Materials

S. Arnold, J. G. De Andrade Ruthes, C. Kim and V. Presser
Electrochemical recycling of lithium-ion batteries: Advancements and future directions
EcoMat, 2024, 6, (11), e12494 [JIF: 10.70 (2023)]
doi:10.1002/eom2.12494
B. Bornamehr, S. Arnold, C. Dun, J. J. Urban, G. A. Zickler, M. S. Elsaesser and V. Presser
High-Performance Lithium-Ion Batteries with High Stability Derived from Titanium-Oxide- and Sulfur-Loaded Carbon Spherogels
ACS Applied Materials & Interfaces, 2024, 16, (5), 5881-5895 [JIF: 08.30 (2023)]
doi:10.1021/acsami.3c16851

R. J. Bragg, K. Griffith, I. Hwang, M. Leketas, P. Kaeper, V. Presser, R. A. W. Dryfe and J. M. Griffin
Solvation effects on aqueous ion adsorption and electrosorption in carbon micropores
Carbon, 2024, 229, 119531 [JIF: 10.50 (2023)]
doi:10.1016/j.carbon.2024.119531

J. G. De Andrade Ruthes, S. Arnold, K. Prenger, A. C. Jaski, V. Klobukoski, I. C. Riegel-Vidotti and V. Presser
Functional Gel-Based Electrochemical Energy Storage
Chemistry of Materials, 2024, 36, (12), 5861-5877 [JIF: 07.20 (2023)], doi:10.1021/acs.chemmater.4c00321

J. Farahbakhsh, F. Arshadi, Z. Mofidi, M. Mohseni-Dargah, C. Kök, M. Assefi, A. Soozanipour, M. Zargar, M. Asadnia, Y. Boroumand, V. Presser and A. Razmjou
Direct lithium extraction: A new paradigm for lithium production and resource utilization
Desalination, 2024, 575, 117249 [JIF: 08.30 (2023)]
doi:10.1016/j.desal.2023.117249

H. Kim, S. Kim, B. Lee, V. Presser and C. Kim
Emerging Frontiers in Multichannel Membrane Capacitive Deionization: Recent Advances and Future Prospects
Langmuir, 2024, 40, (9), 4567-4578 [JIF: 03.70 (2023)]
doi:10.1021/acs.langmuir.3c03648

N.-Y. Kim, I. Kim, B. Bornamehr, V. Presser, H. Ueda, H.-J. Lee, J. Y. Cheong and J.-W. Jung
Recent Advances in Nanoengineering of Electrode-Electrolyte Interfaces to Realize High-Performance-Li-Ion Batteries
Energy & Environmental Materials, 2024, 7, (3), e12622
[JIF: 13.00 (2023)], doi:10.1002/eem2.12622

C. Kök, L. Wang, J. G. A. Ruthes, A. Quade, M. E. Suss and V. Presser
Continuous Lithium-Ion Extraction From Seawater and Mine Water With a Fuel Cell System and Ceramic Membranes
Energy & Environmental Materials, 2024, 7, (6), e12742
[JIF: 13.00 (2023)], doi:10.1002/eem2.12742

K. Liang, T. Wu, S. Misra, C. Dun, S. Husmann, K. Prenger, J. J. Urban, V. Presser, R. R. Unocic, D.-e. Jiang and M. Naguib
Nitrogen-Doped Graphene-Like Carbon Intercalated MXene Heterostructure Electrodes for Enhanced Sodium- and Lithium-Ion Storage
Advanced Science, 2024, 11, (31), 2402708_1-10
[JIF: 14.30 (2023)], doi:10.1002/advs.202402708

E. Lopez, M. Gómez, I. Becar, P. Zapata, J. Pizarro, Navlani-García, D. Cazorla-Amorós, V. Presser, T. Gómez and C. Cárdenas
Removal of Mo(VI), Pb(II), and Cu(II) from wastewater using electrospun cellulose acetate/chitosan biopolymer fibers
International journal of biological macromolecules, 2024, 269, (Part 2), 132160 [JIF: 07.70 (2023)]
doi:10.1016/j.ijbiomac.2024.132160

V. H. N. Martins, M. M. da Silva, D. A. Goncalves, V. Presser, S. Husmann and V. H. R. Souza
Freestanding Films of Reduced Graphene Oxide Fully Decorated with Prussian Blue Nanoparticles for Hydrogen Peroxide Sensing
ACS Omega, 2024, 9, (29), 31569-31577
[JIF: 03.70 (2023)], doi:10.1021/acsomega.4c01457

I. Obraztsov, R. Langer, J. G. De Andrade Ruthes, V. Presser, M. Otyepka, R. Zboril and A. Bakandritsos
Harnessing enhanced lithium-ion storage in self-assembled organic nanowires for batteries and metal-ion supercapacitors
Energy & Environmental Science, 2024, 17, 8874-8884
[JIF: 32.40 (2023)], doi:10.1039/D4EE02777A

P. Ren, M. Torkamanzadeh, S. Arnold, E. Pameté and V. Presser
Life After Death: Re-Purposing End-of-Life Supercapacitors for Electrochemical Water Desalination
Batteries & Supercaps, 2024, 7, (12), e202400506
[JIF: 05.10 (2023)], doi:10.1002/batt.202400506

P. Ren, B. Wang, J. G. De Andrade Ruthes, M. Torkamanzadeh and V. Presser
Cation selectivity during flow electrode capacitive deionization
Desalination, 2024, 592, 118161 [JIF: 14.60 (2023)]
doi:10.1016/j.desal.2024.118161

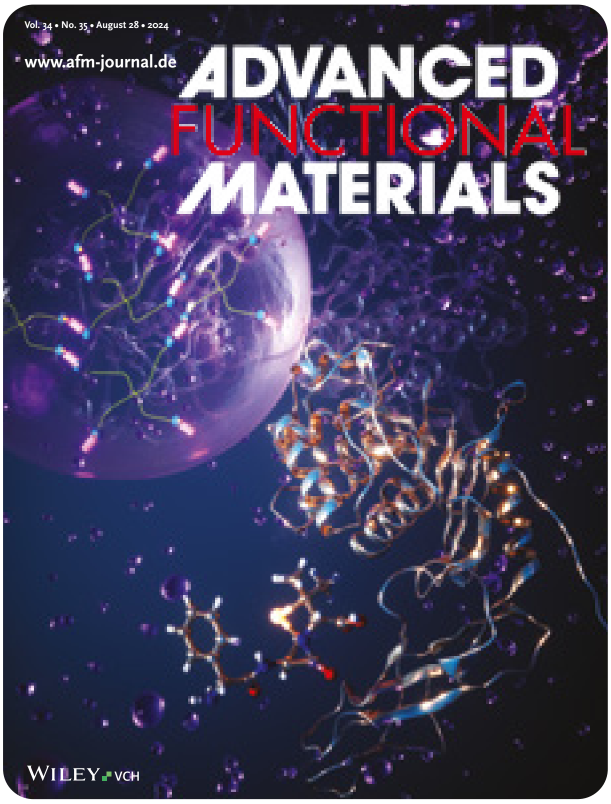
M. Salihovic, E. Pameté, S. Arnold, I. Sulejmani, T. Bartschmid, N. Hüsing, G. Fritz-Popovski, C. Dun, J. J. Urban, V. Presser and M. S. Elsaesser
Black goes green: single-step solvent exchange for sol-gel synthesis of carbon spherogels as high-performance supercapacitor electrodes
Energy Advances, 2024, 3, (2), 482-494 [JIF: 03.20 (2023)]
doi:10.1039/D3YA00480E

A. Senol Gungor, J.-M. von Mentlen, J. G. A. Ruthes, F. García-Soriano, S. Drvaric Talian, V. Presser, L. Porcar, A. Vizintin, V. Wood and C. Prehal
Understanding Rate and Capacity Limitations in Li–S Batteries Based on Solid-State Sulfur Conversion in Confinement
ACS Applied Materials & Interfaces, 2024, 16, (49), 67651–67661 [JIF: 08.50 (2023)]
doi:10.1021/acsami.4c13183

S. Stock, M. Seyffertitz, N. Kostoglou, M. V. Rauscher, V. Presser, B. Demé, V. Cristiglio and O. Paris
Hydrogen densification in carbon nanopore confinement: Insights from small-angle neutron scattering using a hierarchical contrast model
Carbon, 2024, 221, 118911 [JIF: 10.50 (2023)]
doi:10.1016/j.carbon.2024.118911

H. Wang, S. Man, H. Wang, V. Presser and Q. Yan
A sustainable approach: Repurposing harmful algal biomass as carbon-based catalysts for nitrogen fertilizer electrosynthesis from nitrate and CO_2
Chemical Engineering Journal, 2024, 497, 154455
[JIF: 13.30 (2023)], doi:10.1016/j.cej.2024.154455

K. Xu, R. Oestreich, T. Haj Hassani Sohi, M. Lounasvuori, J. G. De Andrade Ruthes, Y. Zorlu, J. Michalski, P. Seiffert, T. Strothmann, P. Tholen, A. O. Yazaydin, M. Suta, V. Presser, T. Petit, C. Janiak, J. Beckmann, J. Schmedt auf der Günne and G. Yücesan
Polyphosphonate covalent organic frameworks
Nature communications, 2024, 15, 7862
[JIF: 14.70 (2023)], doi:10.1038/s41467-024-51950-1



Immuno-Materialien / Immuno Materials

A. Burgstaller, N. Piernitzki, N. Küchler, M. Koch, T. Kister, H. Eichler, T. Kraus, E. C. Schwarz, M. Dustin, F. Lautenschlaeger and O. Staufer
Soft Synthetic Cells with Mobile Membrane Ligands for Ex Vivo Expansion of Therapy-Relevant T Cell Phenotypes
Small, 2024, 20, (37), 2401844 [JIF: 13.00 (2023)]
doi:10.1002/smll.202401844

N. Hakami, A. Burgstaller, N. Gao, A. Rutz, S. Mann and O. Staufer
Functional Integration of Synthetic Cells into 3D Microfluidic Devices for Artificial Organ-On-Chip Technologies
Advanced Healthcare Materials, 2024, 13, (22), 2303334
[JIF: 10.00 (2023)], doi:10.1002/adhm.202303334

K. Jahnke and O. Staufer
Membranes on the move: The functional role of the extracellular vesicle membrane for contact-dependent cellular signalling
Journal of extracellular vesicles, 2024, 13, (4), e12436
[JIF: 15.50 (2023)], doi:10.1002/jev2.12436

N. Piernitzki and O. Staufer
From Theory to Therapy: The Advancements of Extracellular Vesicles in Immunotherapy
Advanced Therapeutics, 2024, 7, (3), 2300340
[JIF: 03.70 (2023)], doi:10.1002/adtp.202300340

O. Staufer
Breaking the bottleneck of synthetic cells
Nature nanotechnology, 2024, 19, 3-4 [JIF: 38.10 (2023)]
doi:10.1038/s41565-023-01509-w

O. Staufer
Synthetic Immunology – Building Immunity from the Bottom-Up with Synthetic Cells
Advanced NanoBiomed Research, 2024, 4, (9), 2400037
[JIF: 04.00 (2023)], doi:10.1002/anbr.202400037

J. A. Welsh, … et al. , K. W. Witwer and O. Staufer
Minimal information for studies of extracellular vesicles (MISEV2023): From basic to advanced approaches
J of Extracellular Vesicles, 2024, 13, (2), e12404
[JIF: 15.50 (2023)], doi:10.1002/jev2.12404

Interaktive Oberflächen / Interactive Surfaces

M. Fehlberg, E. Monfort, S. Saikumar, K. Drewing and R. Bennewitz
Perceptual Constancy in the Speed Dependence of Friction During Active Tactile Exploration
IEEE Transactions on Haptics, 2024, 17, (4), 957-963 [JIF: 02.40 (2023)], doi:10.1109/TOH.2024.3493421

K. Schellnhuber, J. Blass, H. Hübner, M. Gallei and R. Bennewitz
Single-polymer friction force microscopy of dsDNA interacting with a nano-porous membrane
Langmuir, 2024, 40, (1), 968-974 [JIF: 03.70 (2023)] doi:10.1021/acs.langmuir.3c03190

Material-Host Interaktionen / Materials Host Interactions

M. Puertas-Bartolomé, I. Gutierrez-Urrutia, L. L. Teruel-Enrico, C. Nguyen Duong, K. Desai, S. Trujillo, C. Wittmann and A. del Campo
Self-Lubricating, Living Contact Lenses
Advanced Materials, 2024, 36, (27), 2313848 [JIF: 27.40 (2023)], doi:10.1002/adma.202313848

Materialorientierte Synthetische Biologie / Materials Synthetic Biology

A. Armbruster, A. K. Ehret, M. Russ, V. Idstein, M. Klenzendorf, D. Gaspar, C. Juraske, O. S. Yousefi, W. W. Schamel, W. Weber and M. Hörner
OptoREACT: Optogenetic Receptor Activation on Nonengineered Human T Cells
ACS Synthetic Biology, 2024, 13, (3), 752-762 [JIF: 03.70 (2023)], doi:10.1021/acssynbio.3c00518

A. Armbruster, A. M. E. Mohamed, H. T. Phan and W. Weber
Lighting the way: recent developments and applications in molecular optogenetics
Current Opinion in Biotechnology, 2024, 87, 103126 [JIF: 07.10 (2023)], doi:10.1016/j.copbio.2024.103126

A. A. M. Fischer, H. B. Robertson, D. Kong, M. M. Grimm, J. Grether, J. Groth, C. Baltes, M. Fliegauf, F. Lautenschlaeger, B. Grimbacher, H. Ye, V. Helms and W. Weber
Engineering Material Properties of Transcription Factor Condensates to Control Gene Expression in Mammalian Cells and Mice
Small, 2024, 20, (38), 2311834 [JIF: 13.00 (2023)] doi:10.1002/smll.202311834

S. Lohse, J. N. Mink, L. Eckhart, M. C. Hans, L. Jusufi, A. Zwick, T. Mohr, I. A. Bley, O. Khalmurzaev, V. B. Matveev, P. Loertzer, A. Pryalukhin, A. Hartmann, C.-I. Geppert, H. Loertzer, H. Wunderlich, H.-P. Lehnhof, C. M. Naumann, H. Kalthoff and K. Junker
The impact of the tumor microenvironment on the survival of penile cancer patients
Scientific Reports, 2024, 14, 22050 [JIF: 03.80 (2023)] doi:10.1038/s41598-024-70855-z

S. Lohse and W. Weber
An engineered surrogate poly(A) tail to wag translation initiation
Cell Research, 2024, 34, (95-96), 95-96 [JIF: 28.10 (2023)] doi:10.1038/s41422-023-00903-2

H. Mohsenin, J. Pacheco, S. Kemmer, H. J. Wagner, N. Höfflin, T. Bergmann, T. Baumann, C. Jerez-Longres, A. Ripp, N. Jork, H. J. Jessen, M. Fussenegger, M. Köhn, J. Timmer and W. Weber
PenTag, a Versatile Platform for Synthesizing Protein-Polymer Biohybrid Materials
Advanced Functional Materials, 2024, 34, (35), 2308269 [JIF: 18.50 (2023)], doi:10.1002/adfm.202308269

H. Mohsenin, H. J. Wagner, M. Rosenblatt, S. Kemmer, F. Dreppe, P. Huesgen, J. Timmer and W. Weber
Design of a Biohybrid Materials Circuit with Binary Decoder Functionality
Advanced Materials, 2024, 36, (14), 2308092 [JIF: 27.40 (2023)], doi:10.1002/adma.202308092

F.-J. Schmitt, A. Shah Mehmood, C. Tüting, H. T. Phan, J. Reisdorf, F. Rieder, F. G. Golmohamadi, R. Verma, P. L. Kastritis and J. Laufer
Effect of Molecular Dynamics and Internal Water Contact on the Photophysical Properties of Red pH-Sensitive Proteins
Biochemistry, 2024, 63, (1), 82-93 [JIF: 02.90 (2023)] doi:10.1021/acs.biochem.3c00444

N. Urban, M. Hörner, W. Weber and C. Dincer
OptoAssay—Light-controlled dynamic bioassay using optogenetic switches
Science Advances, 2024, 10, (39), eadp0911 [JIF: 11.70 (2023)], doi:10.1126/sciadv.adp0911

A. Valcenko, A. Zwick, L. Schneider, M. Linxweiler and S. Lohse
The tumor cell killing capacity of head and neck cancer patient-derived neutrophils depends on tumor stage, gender and the antibody isotype
Oral Oncology, 2024, 159, 107042 [JIF: 04.0 (2023)] doi:10.1016/j.oraloncology.2024.107042

Optische Materialien / Optical Materials

S. Bhusari, M. Hoffmann, P. Herbeck-Engel, S. Sankaran, M. Wilhelm and A. del Campo
Rheological behavior of Pluronic/Pluronic diacrylate hydrogels used for bacteria encapsulation in engineered living materials
Soft Matter, 2024, 20, (6), 1320-1332 [JIF: 02.90 (2023)] doi:10.1039/D3SM01119D

Strukturbildung / Structure Formation

C. L. Bassani, G. v. Anders, U. Banin, D. Baranov, Q. Chen, M. Dijkstra, M. S. Dimitriyev, E. Efrati, J. Faraudo, O. Gang, N. Gaston, R. Golestanian, G. I. Guerrero-Garcia, M. Gruenwald, A. Haji-Akbari, M. Ibanez, M. Karg, T. Kraus, B. Lee, R. C. VAan Lehn, R. J. Macfarlane, B. M. Mognetti, A. Nikoubashman, S. Osat, O. V. Prezhdo, G. M. Rotskoff, L. Saiz, A.-C. Shi, S. Skrabalak, I. I. Smalyukh, M. Tagliazucchi, D. V. Talapin, A. V. Tkachenko, S. Tretiak, D. Vaknin, A. Widmer-Cooper, G. C. L. Wong, X. Ye, S. Zhou, E. Rabani, M. Engel and A. Travesset
Nanocrystal Assemblies: Current Advances and Open Problems
ACS Nano, 2024, 18, (23), 14791–14840 [JIF: 15.80 (2023)], doi:10.1021/acsnano.3c10201

Y. Brasse, M. Laguna Moreno, S. Blum, T. Horter, F. Janek, K. Gläser, C. Emmerechts, J.-M. Clanet, M. Verhaert, B. Grymonprez and T. Kraus
Recyclable in-mold and printed electronics with polymer separation layers
RSC Sustainability, 2024, 2, (6), 1883-1894 [JIF: -] doi:10.1039/D4SU00092G

A. Burgstaller, N. Piernitzki, N. Küchler, M. Koch, T. Kister, H. Eichler, T. Kraus, E. C. Schwarz, M. Dustin, F. Lautenschlaeger and O. Staufer
Soft Synthetic Cells with Mobile Membrane Ligands for Ex Vivo Expansion of Therapy-Relevant T Cell Phenotypes
Small, 2024, 20, (37), 2401844 [JIF: 13.00 (2023)] doi:10.1002/smll.202401844

B. Demeler, D. Gebauer, E. Brookes, J. Fagan, J. Walter, J. García de la Torre, J. M. García-Ruiz, K. Schilling, M. Chen, L. Dobler, O. Byron, S. E. Harding, T. Zemb, T. Kraus, T. Laue and T. R. Patel
An obituary: Dr. Helmut Cölfen 1965–2023
European Biophysics Journal, 2024, [JIF: 02.20 (2023)]
doi:10.1007/s00249-024-01712-0

S. Gödrich, D. Brodoceanu, V. Kuznetsov, T. Kraus and G. Papastavrou
Defined Transfer of Colloidal Particles by Electrochemical Microcontact Printing
Advanced Materials Interfaces, 2024, 11, (22), 2400202 [JIF: 04.30 (2023)], doi:10.1002/admi.202400202

T. Grammes, J. H. Maurer, L. González-García and T. Kraus
Solvent Vapor Annealing and Plasma Treatment Stabilize Silver Nanowire Layers
Particle & Particle Systems Characterization, 2024, 41, (11), 2400091 [JIF: 02.70 (2023)]
doi:10.1002/ppsc.202400091

P. Groppe, J. Reichstein, S. Carl, C. Cuadrado Collados, B.-J. Niebuur, K. Zhang, B. Apeleo Zubiri, J. Libuda, T. Kraus, T. Retzer, M. Thommes, E. Spiecker, S. Wintzheimer and K. Mandel
Catalyst Supraparticles: Tuning the Structure of Spray-Dried Pt/SiO_2 Supraparticles via Salt-Based Colloidal Manipulation to Control their Catalytic Performance
Small, 2024, 20, (23), 10813 [JIF: 13.00 (2023)]
doi:10.1002/smll.202310813

F. Hartmann, R. Dockhorn, S. Pusse, B.-J. Niebuur, M. Koch, T. Kraus, A. Schießer, B. N. Balzer and M. Gallei
Design and Self-Assembly of Second-Generation Dendrimer-like Block Copolymers
Macromolecules, 2024, 57, (15), 7098–7111
[JIF: 05.10 (2023)], doi:10.1021/acs.macromol.4c00944

L. Hong, H. Zhang, T. Kraus and P. Jiao
Ultra-Stretchable Kirigami Piezo-Metamaterials for Sensing Coupled Large Deformations
Advanced Science, 2024, 11, 2303674 [JIF: 14.30 (2023)]
doi:10.1002/advs.202303674

M. Klos, L. González-García and T. Kraus
Mechanically Robust, Inkjet-Printable Polymer Nanocomposites with Hybrid Gold Nanoparticles and Metal-like Conductivity
ACS Applied Materials & Interfaces, 2024, 16, (24), 31576–31585 [JIF: 08.30 (2023)]
doi:10.1021/acsami.4c04692

T. V. Knapp, M. Rashedul Hasan, B.-J. Niebuur, A. Widmer-Cooper and T. Kraus
Stabilization of Apolar Nanoparticle Dispersions by Molecular Additives
Langmuir, 2024, 40, (26), 13527-13537 [JIF: 03.70 (2023)]
doi:10.1021/acs.langmuir.4c00996

D. S. Schmidt, T. Kraus and L. González-García
Electrofluids with Tailored Rheoelectrical Properties: Liquid Composites with Tunable Network Structures as Stretchable Conductors
ACS Applied Materials & Interfaces, 2024, 16, (33), 43942-43950 [JIF: 08.50 (2023)]
doi:10.1021/acsami.4c07230

A.-L. Thömmes, T. Büttner, B. Morgenstern, O. Janka, G. Kickelbick, B.-J. Niebuur, T. Kraus, M. Gallei and D. Scheschkewitz
Near-Infinite-Chain Polymers with Ge=Ge Double Bonds
Angewandte Chemie International Edition, 2024, 63, (51), e202415103 [JIF: 16.1 (2023)]
doi:10.1002/anie.202415103

A.-L. Thömmes, T. Büttner, B. Morgenstern, O. Janka, G. Kickelbick, B.-j. Niebuur, T. Kraus, M. Gallei and D. Scheschkewitz
Nahezu unendlich lange Polymere mit Ge=Ge-Doppelbindungen
Angewandte Chemie, 2024, 136, (51), e202415103 [JIF: -]
doi:10.1002/ange.202415103

D. Van Impelen, L. González-García and T. Kraus
Low-temperature sintering of Cu@Ag microparticles in air for recyclable printed electronics
Journal of Materials Chemistry C, 2024, 12, (33), 12882-12889 [JIF: 05.70 (2023)]
doi:10.1039/D4TC02028F

Nicht an wissenschaftliche Einheiten gebunden / Not linked to scientific units

Chemische Analytik / Chemical Analytics

S. Dey, C. E. Seyfert, C. Fink-Straube, A. M. Kany, R. Müller and S. Sankaran
Thermo-amplifier circuit in probiotic E. coli for stringently temperature-controlled release of a novel antibiotic
Journal of Biological Engineering, 2024, 18, (1), 66
[JIF: 05.70 (2024)], doi:10.1186/s13036-024-00463-y

S. Dey, C. E. Seyfert, C. Fink-Straube, A. M. Kany, R. Müller and S. Sankaran
Thermo-amplifier circuit in probiotic E. coli for stringently temperature-controlled release of a novel antibiotic
bioRxiv, 2024, September 2, 2024
doi:10.1101/2024.02.13.579303

Y. E. Silina, E. V. Butyrskaya, M. Koch, C. Fink-Straube, N. Korkmaz, M. G. Levchenko and E. V. Zolotukhina
Mechanistic aspects of glycerol oxidation on palladium electrocatalysts in model aqueous and fermentation media solutions
Electrochimica Acta, 2024, 497, 144479
[JIF: 05.50 (2023)], doi:10.1016/j.electacta.2024.144479

E. Tiganescu, S. Safinazlou, A. Y. Abdin, R. Lilischkis, K.-H. Schäfer, C. Fink-Straube, M. J. Nasim and C. Jacob
Selenium Disulfide from Sustainable Resources: an Example of "Redneck" Chemistry with a Pinch of Salt
Materials, 2024, 17, (23), 5733 [JIF: 03.10 (2023)]
doi:10.3390/ma17235733

E. V. Zolotukhina, E. Butyrskaya, C. Fink-Straube, M. Koch and Y. E. Silina
Towards controlled and simple design of non-enzymatic amperometric sensor for glycerol determination in yeast fermentation medium
Analyticcal and bioanalytical chemistry, 2024, 416, 3619-3630 [JIF: 03.80 (2023)]
doi:10.1007/s00216-024-05316-7

Fluoreszenzmikroskopie / Fluorescence Microscopy

M. Puertas-Bartolomé, I. Gutierrez-Urrutia, L. L. Teruel-Enrico, C. Nguyen Duong, K. Desai, S. Trujillo, C. Wittmann and A. del Campo
Self-Lubricating, Living Contact Lenses
Advanced Materials, 2024, 36, (27), 2313848
[JIF: 27.40 (2023)], doi:10.1002/adma.202313848

Physikalische Analytik / Physical Analytics

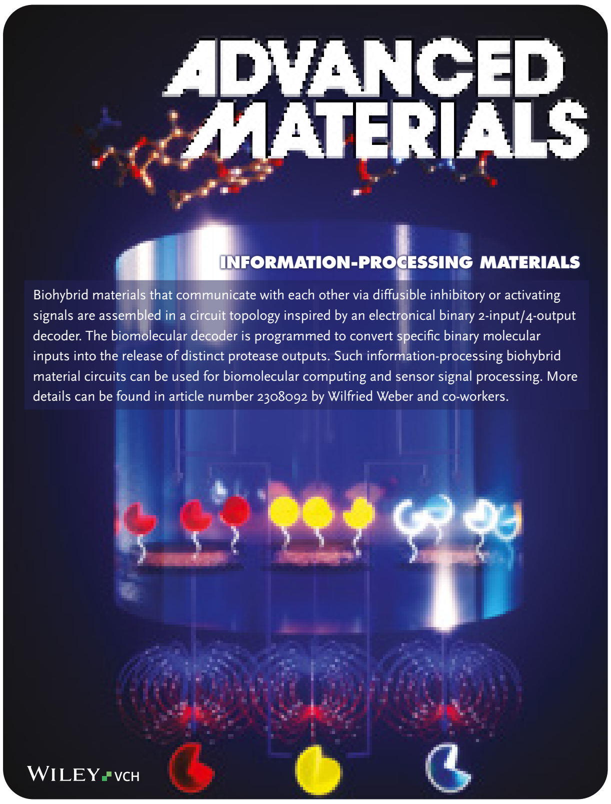
S. Afra, M. Koch, J. Zur-Pinska, M. Dolatshahi, A. Reza Bahrami, J. Es Sayed, A. Moradi, M. M. Matin and M. K. Wlodarczyk-Biegun
Chitosan/Nanohydroxyapatite/Hydroxyethyl-cellulose-based printable formulations for local alendronate drug delivery in osteoporosis treatment
Carbohydrate polymer technologies and applications, 2024, 7, 100418 [JIF: 06.20 (2023)]
doi:10.1016/j.carpta.2023.100418

M. Andima, A. Boese, P. Paul, M. Koch, B. Loretz and C.-M. Lehr
Targeting Intracellular Bacteria with Dual Drug-loaded Lactoferrin Nanoparticles
ACS Infectious Diseases, 2024, 10, (5), 1696–1710 [JIF: 04.30 (2023)], doi:10.1021/acsinfecdis.4c00045

A. Burgstaller, N. Piernitzki, N. Küchler, M. Koch, T. Kister, H. Eichler, T. Kraus, E. C. Schwarz, M. Dustin, F. Lautenschlaeger and O. Staufer
Soft Synthetic Cells with Mobile Membrane Ligands for Ex Vivo Expansion of Therapy-Relevant T Cell Phenotypes
Small, 2024, 20, (37), 2401844 [JIF: 13.00 (2023)]
doi:10.1002/smll.202401844

K. Danz, J. Fleddermann, M. Koch, E. Fecioru, L. Maahs, N. Kinsinger, J. Krämer, A. Kraegeloh and S. Wagner
Evaluation of the Transport and Binding of Dopamine-Loaded PLGA Nanoparticles for the Treatment of Parkinson's Disease Using In Vitro Model Systems
Pharmaceutics, 2024, 16, (5), 571_1-15
[JIF: 04.90 (2023)], doi:10.3390/pharmaceutics16050571

S. Engel, M. Koch and O. Janka
Nominal CaAl$_2$Pt$_2$ and Ca$_2$Al$_3$Pt – two new Intermetallic Compounds in the Ternary System Ca–Al–Pt
Zeitschrift Für Anorganische und Allgemeine Chemie, 2024, 650, (18), e202400094 [JIF: 01.10 (2023)]
doi:10.1002/zaac.202400094



J. Es Sayed, A. Mukherjee, S. El Aani, N. Vengallur, M. Koch, A. Giuntoli and M. Kamperman
Structure–Property Relationships of Granular Hybrid Hydrogels Formed through Polyelectrolyte Complexation
Macromolecules, 2024, 57, (7), 3190-3201
[JIF: 05.10 (2023)], doi:10.1021/acs.macromol.3c02335

F. Hartmann, R. Dockhorn, S. Pusse, B.-J. Niebuur, M. Koch, T. Kraus, A. Schießer, B. N. Balzer and M. Gallei
Design and Self-Assembly of Second-Generation Dendrimer-like Block Copolymers
Macromolecules, 2024, 57, (15), 7098–7111
[JIF: 05.10 (2023)], doi:10.1021/acs.macromol.4c00944

J. Y. Kasper, M. W. Laschke, M. Koch, L. Alibardi, T. M. Magin, C. M. Niessen and A. del Campo
Actin-templated Structures: Nature's Way to Hierarchical Surface Patterns (Gecko's Setae as Case Study)
Advanced Science, 2024, 11, (10), 2303816
[JIF: 14.30 (2023)], doi:10.1002/advs.202303816

M. Koch and Y. E. Silina
Uric acid detection by hydrogen peroxide independent biosensors: Novel insights and applications
Microchemical Journal, 2024, 207, 112091
[JIF: 04.90 (2023)], doi:10.1016/j.microc.2024.112091

M. Kravicz, L. Taiarol, J. S. R. Viegas, G. Sierri, M. Mauri, M. Koch, C. Steinkühler and F. Re
Nanostructured lipid carrier formulation for delivering poorly water-soluble ITF3756 HDAC inhibitor
Journal of Drug Delivery Science and Technology, 2024, 101, 106238 [JIF: 04.50 (2023)]
doi:10.1016/j.jddst.2024.106238

T. Kuhn, A. Aljohmani, N. Frank, L. Zielke, M. Mehanny, M. W. Laschke, M. Koch, J. Hoppstädter, A. K. Kiemer, D. Yildiz and G. Fuhrmann
A cell-free, biomimetic hydrogel based on probiotic membrane vesicles ameliorates wound healing
Journal of controlled release, 2024, 365, 969-980
[JIF: 10.50 (2023)], doi:10.1016/j.jconrel.2023.12.011

R. Leiner, S. Witayakran, S. Verwaayen, L. Siegwardt, C. C. Ribeiro, C. Dietz, M. Koch, A. Kulachenko and M. Gallei
Tailored Interaction between Cellulose Nanowhiskers and Core–Shell Particles Determines the Optical and Mechanical Properties in Hybrid Films
ACS Applied Materials & Interfaces, 2024, 16, (46),
[JIF: 08.50 (2023)], doi:10.1021/acsami.4c16816

V. Mashayekhi, A. Schomisch, S. Rasheed, E. Aparicio-Puerta, T. Risch, D. Yildiz, M. Koch, S. Both, N. Ludwig, T. M. Legroux, A. Keller, R. Müller, G. Fuhrmann, J. Hoppstädter and A. K. Kiemer
The RNA binding protein IGF2BP2/IMP2 alters the cargo of cancer cell-derived extracellular vesicles supporting tumor-associated macrophages
Cell Communication and Signaling, 2024, 22, 344
[JIF: 08.20 (2023)], doi:10.1186/s12964-024-01701-y

R. A. Mohamed Yunus, M. Koch, P. Dieudonné-George, D. Truzzolillo, R. H. Colgy and D. Parisi
Water-Driven Sol-Gel Transition in Native Cellulose/ 1-Ethyl-3-methylimidazolium Acetate Solutions
ACS Macro Letters, 2024, 13, (2), 219-226
[JIF: 05.10 (2023)], doi:10.1021/acsmacrolett.3c00710

M. Norouzian, M. A. Elahi, M. Koch, R. Mahin Zaeem and S. Kedziora
Data-driven analysis of surface roughness influence on weld quality and defect formation in laser welding of Cu–Al
Proceedings of the Institution of Mechanical Engineers, Part L: Journal of Materials: Design and Applications, 2024, 238, (12), 2471–2486 [JIF: 02.50 (2023)]
doi:10.1177/14644207241236l3

T. Rittner, K. Ghulam, M. Koch and M. Gallei
Amine-containing block copolymers for efficient catalyst-free hydroamination and preparation of functional metallopolymers
Polymer Chemistry, 2024, 15, (35), 3519-3528
[JIF: 04.10 (2023)], doi:10.1039/d4py00780h

G. Sierri, I. Saenz-de-Santa-Maria, A. Renda, P. Sommi, M. Koch, M. Mauri, D. Salerno, C. Zurzolo and F. Re
Nanoparticle's Shape Is the Game-Changer for a Customized Delivery through Tunneling Nanotubes among Glioblastoma Cells
9th World Congress on Recent Advances in Nano-technology (RAN 2024), London <GBR> April 8-10, 2024
https://avestia.com/RAN2024_Proceedings/files/paper/NDDTE/NDDTE_130.pdf

Y. E. Silina, E. V. Butyrskaya, M. Koch, C. Fink-Straube, N. Korkmaz, M. G. Levchenko and E. V. Zolotukhina
Mechanistic aspects of glycerol oxidation on palladium electrocatalysts in model aqueous and fermentation media solutions
Electrochimica Acta, 2024, 497, 144479
[JIF: 05.50 (2023)], doi:10.1016/j.electacta.2024.144479

F. Viale, M. Ciprandi, L. Leoni, G. Sierri, A. Renda, F. Barbugian, M. Koch, S. Sesana, L. Salvioni, M. Colombo, F. Mantegazza, L. Russo and F. Re
Biodegradable SPI-based hydrogel for controlled release of nanomedicines: A potential approach against brain tumors recurrence
Journal of Drug Delivery Science and Technology, 2024, 96, 105672 [JIF: 04.50 (2023)]
doi:10.1016/j.jddst.2024.105672

X. Wu, M. Koch, F. P. Perona Martínez, R. Schirhagl and M. K. Wlodarczyk-Biegun
Quantum Sensing Unravels Antioxidant Efficacy Within PCL/Matrigel Skin Equivalents
Small, 2024, 20, (49), 2403729 [JIF: 13.00 (2023)]
doi:10.1002/smll.202403729

X. Wu, W. Li, L. Herlah, M. Koch, H. Wang, R. Schirhagl and M. K. Włodarczyk-Biegun
Melt electrowritten poly-lactic acid / nanodiamond scaffolds towards wound-healing patches
Materials Today Bio, 2024, 26, 101112 [JIF: 08.70 (2023)]
doi:10.1016/j.mtbio.2024.101112

T. Yildirim, A. Bali, M. Koch, P. Paul, L. Latta, N. Scheider-Daum, M. Gallei and C.-M. Lehr
A New Class of Polyion Complex Vesicles (PIC-somes) to Improve Antimicrobial Activity of Tobramycin in Pseudomonas Aeruginosa Biofilms
Small, 2024, 20, (40), 2401926 [JIF: 13.00 (2023)]
doi:10.1002/smll.202401926

E. V. Zolotukhina, E. Butyrskaya, C. Fink-Straube, M. Koch and Y. E. Silina
Towards controlled and simple design of non-enzymatic amperometric sensor for glycerol determination in yeast fermentation medium
Analyticcal and bioanalytical chemistry, 2024, 416, 3619-3630 [JIF: 03.80 (2023)]
doi:10.1007/s00216-024-05316-7

INM Fellows

S. Bandyopadhyay, S. Chatterjee, A. K. Dutta, M. Karmakar, H. Rieger and R. Paul
Ordering kinetics in the active Ising model
ArXiv, 2024, 24.01.2024
doi:10.48550/arXiv.2401.13471

S. Bandyopadhyay, S. Chatterjee, A. K. Dutta, M. Karmakar, H. Rieger and R. Paul
Ordering kinetics in the active Ising model
Physical Review E, 2024, 109, (064143),
[JIF: 02.20 (2023)], doi:10.1103/PhysRevE.109.064143

A. Fins Carreira, A. Wysocki, C. Ybert, M. Leocmach, H. Rieger and C. Cottin-Bizonne
How to steer active colloids up a vertical wall
Nature Communications, 2024, 15, 1710
[JIF: 14.70 (2023)], doi:10.1038/s41467-024-045872-1

M. Karmakar, S. Chatterjee, R. Paul and H. Rieger
Consequence of anisotropy on flocking: the discretized Vicsek model
New Journal of Physics, 2024, 26, 043023
[JIF: 02.80 (2023)], doi:101088/1367-2630/ad3ea7

M. Karmakar, S. Chatterjee, R. Paul and H. Rieger
Consequence of anisotropy on flocking: the discretized Vicsek model
arXiv, 2024, May 6, 2024, doi:10.1088/1367-2630/ad3ea7

M. Mangeat, S. Chakraborty, A. Wysocki and H. Rieger
Stationary particle currents in sedimenting active matter wetting a wall
Physical Review E, 2024, 109, (1), 014616
[JIF: 02.20 (2023)], doi:10.1103/PhysRevE.109.014616

H. Meyer and H. Rieger
Should you hire new searchers? Optimal number of agents in a collective search, and when to launch them
ArXiv, 2024, January 11, 2024
doi:10.48550/arXiv.2401.05851

Z. Sadjadi and H. Rieger
Topotaxis of active particles across long distances by sliding along obstacles
Physical Review Research, 2024, 6, (1), 013178
[JIF: 03.50 (2023)]
doi:10.1103/PhysRevResearch.6.013178

Weitere / Others

A. Batool, S. Qureshi, A. Ahmad, S. Zubaid, L. Saeed, K. Ayub, T. Rasheed and T. A. Sherazi
DFT-based designed surface functionalized carbon black for electrochemical detection of Arsenic and its experimental validation
Surfaces and Interfaces, 2024, 52, 104843 [JIF: 05.70 (2023)], doi:10.1016/j.surfin.2024.104843

R. Niese, K. Deshpande and M. Müller
An Enzymatic Cofactor Regeneration System for the in-Vitro Reduction of Isolated C=C Bonds by Geranylgeranyl Reductases
ChemBioChem, 2024, 25, (1), e202300409 [JIF: 02.06 (2023)], doi:10.1002/cbic.202300409

A. Batool, A. Ahmad, S. Zubaid, N. Ul Ain, A. Ur Rehman Chaudhary, H. Ahmad and T. A. Sherazi
Inverted growth of nickel cobaltite and cobalt sulfide in a hybrid nanostructure and its influence on energy storage application
Journal of Energy Storage, 2024, 100 A, 113553 [JIF: 08.90 (2023)], doi:10.1016/j.est.2024.113553

P. Kunnas, N. de Jonge and J. P. Patterson
The effect of nanochannel length on in situ loading times of diffusion-propelled nanoparticles in liquid cell electron microscopy
Ultramicroscopy, 2024, 255, 113865 [JIF: 02.10 (2023)] doi:10.1016/j.ultramic.2023.113865

S. Miyamoto, D. Naisbitt and A. Kraegeloh
Women in Toxicology Special Issue: published as part of Chemical Research in Toxicology virtual speical issue “Women in Toxicology”
Chemical Research in Toxicology, 2024, 37, 1229-1230 [JIF: 4.1 (2022)], doi:10.1021/acs.chemrestox.4c00288

V. Presser
Reflecting on a year of innovation and looking ahead: the exciting future of energy materials and green energy
Energy Advances, 2024, 3, (1), 11-13 [JIF: 03.20 (2023)] doi:10.1039/D3YA90053C

A. Salvadori, C. Bonanno, M. Serpelloni and R. M. McMeeking
On the generation of force required for actin-based motility
Scientific Reports, 2024, 14, 18384 [JIF: 03.80 (2023)] doi:10.1038/s41598-024-69422-3

J. Stella, M. Ayman Mohamed Ezzat Abdelaal, M. A. Mostafa Kamal, K. Shehu, A. Alhayek, J. Haupenthal, A. K. H. Hirsch and M. Schneider
Spray drying of a zinc complexing agent for inhalation therapy of pulmonary fibrosis
European Journal of Pharmaceutical Sciences, 2024, 202, 106891 [JIF: 04.30 (2023)], doi:10.1016/j.ejps.2024.106891

H. Quan, X. Liang, X. Zhang, M. A. Meyers, R. M. McMeeking and E. Arzt
The shape of Nature’s stingers revealed
Proceedings of the National Academy of Sciences of the United States of America : PNAS, 2024, 121, (7), 2316320121 [JIF: 09.40 (2023)] doi:10.1073/pnas.2316320121

M. Veith, T. Kirs, B. Morgenstern and V. Huch
Structural Studies of Piperidino-Alanes with Halide, Amide and Hydride as further Ligands at Aluminum
Zeitschrift Für Anorganische und Allgemeine Chemie, 2024, 650, (20), e202400090 [JIF: 01.10 (2023)] doi:10.1002/zaac.202400090

Eingeladene Vorträge / Invited Talks

Stand / As of: 14.03.2025

235
Vorträge / talks

davon / including

98
eingeladene Vorträge / invited talks

182
sonstige Vorträge / other talks
davon **142** Industrievorträge

Patente / Patents

2

Patentanmeldungen /
patent applications

7

erteilte Patente / granted patents
3 in Europa / in Europe
4 international / international

53

Patentfamilien /
patent families

Erteilte europäische Patente / Patents granted in Europe

Europäisches Patent Nr. 3237652 B1
Titel: *„METHOD FOR PRODUCING ANISOTROPIC ZINC PHOSPHATE PARTICLES AND ZINC METAL MIXED PHOSPHATE PARTICLES AND USE THEREOF"*
Erfinder: S. Albayrak, C. Becker-Willinger, D. Bentz, E.M. Perre

Europäisches Patent Nr. 3559101 B1
Titel: *„COMPOSITE MATERIALS"*
Erfinder: Th. Kister, T. Kraus, J. Hubertus

Europäisches Patent Nr. 3774998 B1
Titel: *„NANOSTRUCTURED COMPOSITE MATERIALS WITH SELF-HEALING PROPERTIES"*
Erfinder: C. Becker-Willinger, A. Budiman, J. Brunke, G. Wenz, D. Hero

Erteilte internationale Patente / Patents granted internationally

Südkoreanisches Patent Nr. 102721369 B1
Titel: *„CONDUCTIVE NANOCOMPOSITES"*
Erfinder: B. Reiser, T. Kraus, L. González-Garcia, J. Maurer, I. Kanelidis

Südkoreanisches Patent Nr. 102659512 B1
Titel: *„METHOD FOR THE PRODUCTION OF CONDUCTIVE STRUCTURES"*
Erfinder: P. W. de Oliveira, J. Atchison

Südkoreanisches Patent Nr. 102709066 B1
Titel: *„CONDUCTIVE MATERIALS MADE OF NB-DOPED TIO2-PARTICLES"*
Erfinder: P. W. de Oliveira, J. Staudt

Japanisches Patent Nr. 102709066 B1
Titel: *„NANOSTRUCTURED COMPOSITE MATERIALS WITH SELF-HEALING PROPERTIES"*
Erfinder: C. Becker-Willinger, A. Budiman, J. Brunke, G. Wenz, D. Hero

Lehrveranstaltungen / Teaching

Wintersemester / Winter semester 2023/2024

Lola González-García, Tobias Kraus und INM-Kolleg/innen
NanoBioMaterialien 1
Universität des Saarlandes, Vorlesung, 2 SWS

Eduard Arzt und Mitarbeiter/innen
Einführung in die Materialwissenschaft für (Studierende der) Mikrotechnologie und Nanostrukturen
Universität des Saarlandes, Vorlesung und Übung, 4 SWS

Carsten Becker-Willinger
MC07: Technologie der Polymere und Komposite
Universität des Saarlandes, Vorlesung, 2 SWS

Lola González-García, Tobias Kraus und INM-Kolleg/innen
NanoBioMaterialien-P
Universität des Saarlandes, Praktikum, 4 SWS

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

Aránzazu del Campo, Shrikrishnan Sankaran und INM-Kolleg/innen
Biomedizinische Polymere
Universität des Saarlandes, Vorlesung, 2 SWS

Marcus Koch (mit F. Breinig, Univ. des Saarlandes)
Zellbiologie
Universität des Saarlandes, Vorlesung, 2 SWS

Tobias Kraus (mit G. Jung, C. Kay, Univ. des Saarlandes)
Advanced Topics in Classical Physical Chemistry (PC 03)
Universität des Saarlandes, Vorlesung, 2 SWS

Tobias Kraus (mit G. Jung, C. Kay, S. Stopkovicz, Univ. des Saarlandes)
Advanced Topics in Physical Chemistry (PC 06)
Universität des Saarlandes, Vorlesung, 4 SWS

Tobias Kraus
Functional Coatings (Beschichtungen)
Universität des Saarlandes, Vorlesung und Übung, 4 SWS

Tobias Kraus
Kolloide und Grenzflächen
Universität des Saarlandes, Praktikum, 2 SWS

Tobias Kraus (mit G. Jung, C. Kay, S. Stopkovicz, Universität des Saarlandes)
Masterpraktikum Physikalische Chemie
Universität des Saarlandes, Praktikum, 2 SWS

Tobias Kraus
Vertiefungspraktikum Werkstoffchemie (WCV)
Universität des Saarlandes, Praktikum, 2 SWS

Volker Presser
Seminar Energie-Materialien
Universität des Saarlandes, Seminar, 2 SWS

Lola González-García und INM-Kolleg/innen
Material Science Master Praktikum
Universität des Saarlandes, Praktikum, 3 SWS

Sommersemester / Summer semester 2024

Annette Kraegeloh, Wilfried Weber und INM-Kolleg/innen
NanoBioMaterialien-2
Universität des Saarlandes, Vorlesung, 2 SWS

Stefan Lohse
„HIV-Infektion“, Seminar.Innere Medizin I
Universität des Saarlandes, Seminar, 0.29 SWS

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

Aránzazu del Campo, Shrikrishnan Sankaran und INM-Kolleg/innen
LiveMat: Engineered Living Materials for Biomedicine
Universität des Saarlandes, Vorlesung, 2 SWS

Aránzazu del Campo und Mitarbeiter*innen
Vertiefungspraktikum Biomaterialien
Universität des Saarlandes, Praktikum, 2 SWS

Tobias Kraus
Vertiefungspraktikum Werkstoffchemie (WCV)
Universität des Saarlandes, Praktikum, 2 SWS

Volker Presser (mit M. Gallei, G. Rizzello, Univ. des Saarlandes)
Smart Materials and Polymers (MC06)
Universität des Saarlandes, Blockvorlesung, 2 SWS

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

Volker Presser
Seminar Energie-Materialien
Universität des Saarlandes, Seminar, 2 SWS

Lola González-García
Printing of Functional Materials
Universität des Saarlandes, Seminar, 2 SWS

Wintersemester / Winter semester 2024/2025

Lola González-García, Tobias Kraus und INM-Kolleg/innen
NanoBioMaterialien 1
Universität des Saarlandes, Vorlesung, 2 SWS

Wilfried Weber, Annette Kraegeloh und INM-Kolleg/innen
NanoBioMaterialien-P
Universität des Saarlandes, Praktikum, 4 SWS

Carsten Becker-Willinger
MC07: Technologie der Polymere und Komposite
Universität des Saarlandes, Vorlesung, 2 SWS

Stefan Lohse
„HIV-Infektion“, Seminar.Innere Medizin I
Universität des Saarlandes, Seminar, 0.29 SWS

Lola González-García
“Synthesis of Materials and Nanostructures”, Master program: Science and Technology of New Materials
University of Sevilla, Seminar, 0.86 SWS

Lola González-GarcÍa und INM-Kolleg/innen
Material Science Master Praktikum
Universität des Saarlandes, Praktikum, 3 SWS
(L.Gonzalez-Garcia: 1 SWS)

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

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

Aránzazu del Campo, Shrikrishnan Sankaran und Mitarbeiter*innen
Biomedizinische Polymere
Universität des Saarlandes, Vorlesung, 2 SWS

Tobias Kraus und Bart-Jan Niebuur (mit G. Jung, C. Kay, Universität des Saarlandes)
Advanced Topics in Classical Physical Chemistry (PC 03)
Universität des Saarlandes, Vorlesung, 2 SWS

Tobias Kraus (mit G. Jung, C. Kay, S. Stopkovicz, Universität des Saarlandes)
Advanced Topics in Physical Chemistry (PC 06)
Universität des Saarlandes, Vorlesung, 4 SWS

Tobias Kraus
Functional Coatings (Beschichtungen)
Universität des Saarlandes, Vorlesung und Übung, 4 SWS

Tobias Kraus
Kolloide und Grenzflächen, 2 SWS
Universität des Saarlandes, Praktikum

Tobias Kraus (mit G. Jung, C. Kay, S. Stopkovicz, Universität des Saarlandes)
Masterpraktikum Physikalische Chemie
Universität des Saarlandes, Praktikum, 2 SWS

Tobias Kraus
Vertiefungspraktikum Werkstoffchemie (WCV)
Universität des Saarlandes, Praktikum, 2 SWS

Volker Presser (mit K. Lienkamp)
Grundlagen der Thermodynamik
Universität des Saarlandes, Vorlesung und Übung, 4 SWS

Volker Presser
Seminar Energie-Materialien
Universität des Saarlandes, Seminar, 2 SWS

Veranstaltungen / Events

Januar – Februar

Mini Workshop on Engineered Living Materials 2024
A del Campo, W. Weber – Aula der Universität des Saarlandes, Saarbrücken, 16.01.2024

Review Colloquium des SPP (Schwerpunktprogramm) 2451 Lebende Materialien mit adaptiven Funktionen
A del Campo – Aula der Universität des Saarlandes, Saarbrücken, 17.01.2024

Schülerpraktikum I
S. Blum, E. Bubel, M. Hauck, P. Kalmes
Saarbrücken, 29.01. – 09.02.2024

Nanotech 2024 – International Nanotechnology Exhibition and conference
M. Amlung, C. Becker-Willinger, M. Klos, M. Laguna Moreno, Th. Müller – Tokyo, 31.01. – 02.02.2024

März – April

LOPEC 2024
M. Laguna Moreno, P. Rogin
München, 06. – 07.03.2024

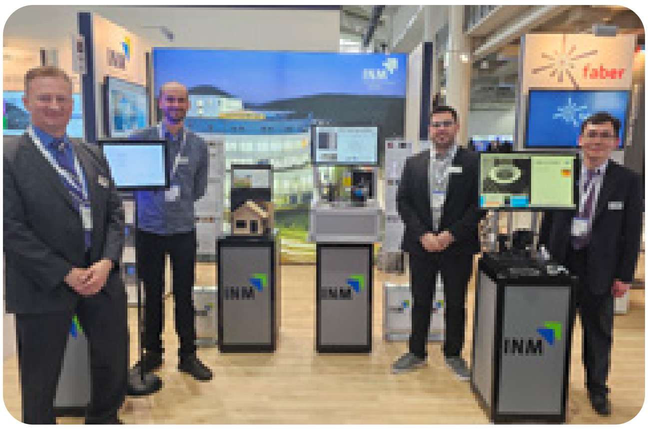
Schülerpraktikum II
D. Beckelmann, S. Blum, C. N. Duong, M. Fehlberg, A. Haettich, M. Hauck, K. Jost, P. Kalmes, A. May, H. Meyer, C. Muth, M. Quilitz, F. Riedel, A. Rutz, S. Saikumar, R. Schmachtenberg, L. Sold, M. Sude
Saarbrücken, 04. – 15.03.2024

BioINSP 2024, Bioinspired Materials Conference 2024
A. del Campo (Program Committee), Hybrid conference Deutsche Gesellschaft für Materialkunde, Löwenstein, Germany, 18. – 20.03.2024

Mai – Juni

Auftritt der INM Band auf dem Leibniz-Frühlingsempfang 2024 der Leibniz-Gemeinschaft
J. Berrar, R. Reiber, G. Weber
Haus der Leibniz-Gemeinschaft
Berlin, 16.05.2024

Tag der Offenen Tür der Universität des Saarlandes
L. Gonzalez-Garcia und Team, C. Hartmann, M. Koch, T. Kraus und Team, V. Presser und Team, M. Quilitz, S. Sankaran und Team, S. Trujillo, W. Weber und Team
Saarbrücken, 08.06.2024



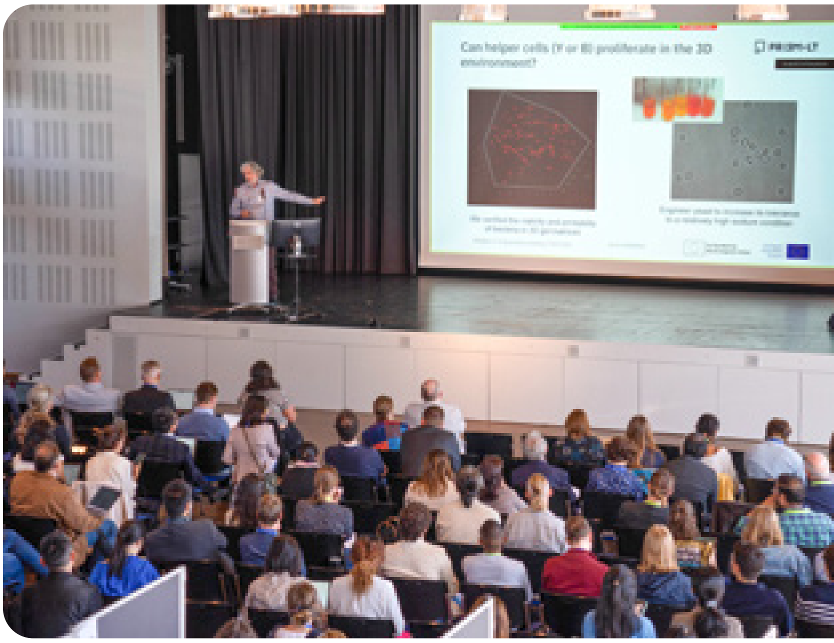
Hannover-Messe 2024
M. Amlung, C. Becker-Willinger, S. Blum, Y. Brasse, M. Laguna Moreno, Th. Müller, S. Selzer, B. Reinhard
Hannover, 22. – 26.04.2024

Girls' Day 2024
M. Koch, S. Schumacher, S. Siegrist
Saarbrücken, 25.04.2024

Juli – August

Besuch von Teilnehmenden der Summer School für Studierende der Kyung Hee University, Seoul, Korea an der Universität des Saarlandes
M. Koch, M. Quilitz (mit Universität des Saarlandes)
Saarbrücken, 24.07.2024

Besuch von Teilnehmenden der EUSMAT Intergration Week des AMASE Programms 2024 an der Universität des Saarlandes
V. Presser, M. Quilitz (mit Universität des Saarlandes)
Saarbrücken, 23.08.2024



September – Oktober

Virtual Lab Day des BMBF-VDI
M. Koch, M. Quilitz (mit VDI, BMBF)
virtuell, 10.09.2024

Symposium R Synthesis and characterization of functional nanocomposite materials auf der E-MRS Fall Meeting 2024
L. Gonzalez-Garcia (Co-Organisation)
Warsaw, Poland, 16. – 19.09. 2024

Kick off Meeting des SPP (Schwerpunktprogramm) 2451 Lebende Materialien mit adaptiven Funktionen
A. del Campo, W. Weber
Aula der Universität des Saarlandes
Saarbrücken, 17.09.2024

EIC ELMs Portfolio Symposium (2nd ELMs Portfolio Annual Meeting)
Aula der Universität des Saarlandes
H. Pham, W. Weber
Saarbrücken, 18.09.2024

Conference on Engineered Living Materials 2024
A. del Campo, S. Sankaran, W. Weber
Aula der Universität des Saarlandes
Saarbrücken, 18. – 20.09.2024

Particle-Based Materials 2024
T. Kraus (Co-Organisator)
Particle-Based Materials Symposium 2024 – Universität Bremen
Bremen, 23. – 24.09.2024

Besuch von Teilnehmenden der SERENADE Training School an der Universität des Saarlandes
G. Heppe, T. Kraus, B. J. Niebuur, M. Quilitz, D. Schmidt (mit Universität des Saarlandes)
Saarbrücken, 27.09.2024

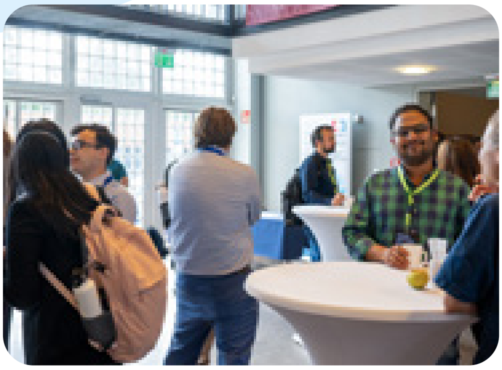
BMBF Schülerpraktikum Werkstoffferien 2024
S. Arnold, Y. Curto, A. Haettich, S. Kiefer, A. Kraegeloh, Th. Mueller, M. Quilitz, S. Schumacher, K. Sorg, Th. Steudter, W. Weber (mit VDI, BMBF)
Saarbrücken, 14.10. – 18.10.2024

INM-Kolloquien / INM Colloquia

At the nexus of genes, aging and environment: Understanding transriptomic and epigenomic regulation in health and disease
Prof. Dr. Julia Schulze-Hentrich
Saarland University
20.02.2024
Host: Prof. Dr. Aránzazu del Campo

Engineering lipid membranes: From biophysicalproperties to biotechnological applications
Dr. Kevin Jahnke
Harvard University, Boston, MA, USA
05.06.2024
Host: Prof. Dr. Aránzazu del Campo

Dynamic materials and systems inspired by Cephalopods
Prof. Dr. Alan A. Gorodetsky
University of California, USA
11.06.2024
Host: Prof. Dr. Aránzazu del Campo



Macrocyclic and Hybrid Organic-Inorganic Materials for Molecular Sensing Applications in Biofluids
Dr. Jan Biedermann
Institute of Nanotechnology (INT), Karlsruhe Institute of Technology (KIT)
29.10.2024
Host: Prof. Dr. Aránzazu del Campo

Multiscale Modeling of Polymer Materials: Status and Perspectives
Prof. Dr. Kurt Kremer
Max-Planck-Institute for Polymer Research, Mainz
09.12.2024
Host: Prof. Dr. Aránzazu del Campo

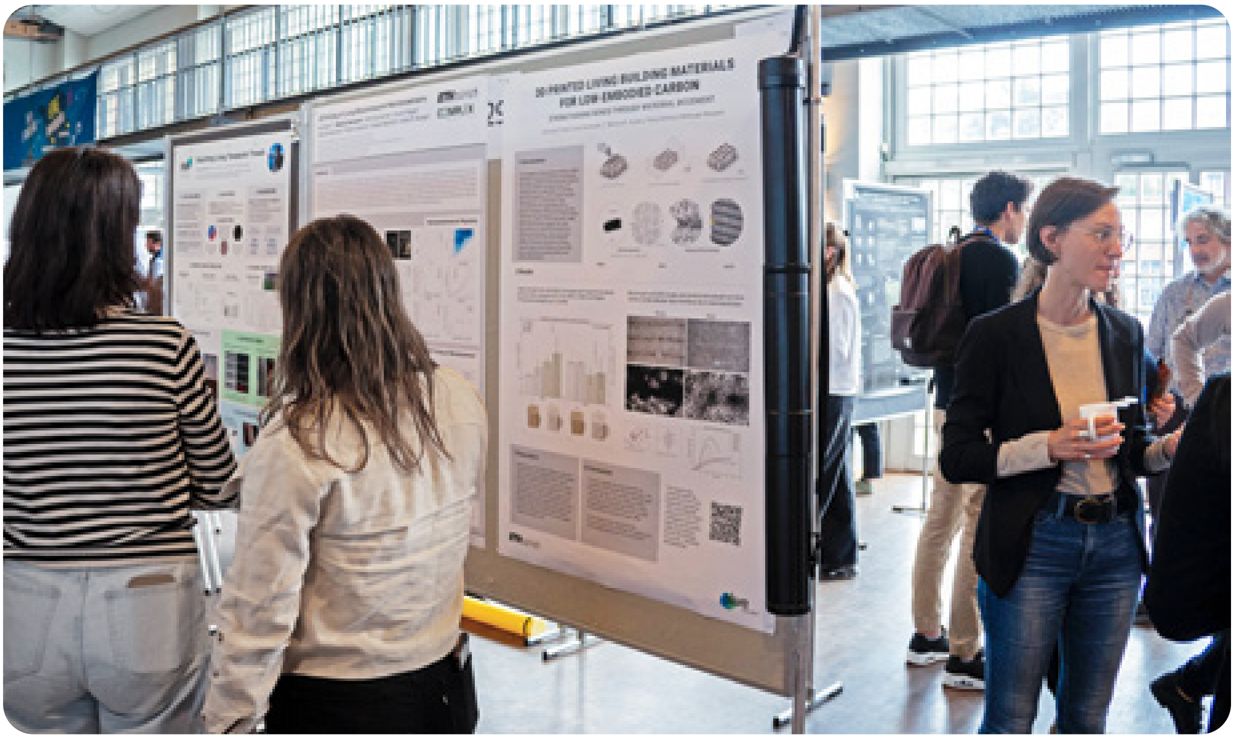
Additive chemical nanomanufacturing
Dr. Felix Loeffler
Max-Planck-Institute of Colloids and Interfaces, Potsdam
10.12.2024
Host: Prof. Dr. Wilfried Weber, Prof. Dr. Tobias Kraus

LSC Vorträge, Kolloquien des LSC / LSC talks, Colloquia of the LSC

Publishing in Nature Journals
Dr. Bart Verberck
Springer Nature Group, Berlin
Saarbrücken, 05.03.2024

Sonstige Seminare / Seminars

Modelling Cancer-Microbe Interactions with Organoids and Organs-on-Chips
Dr. Jens Puschhof
German Cancer Research Center (DKFZ), Heidelberg, Germany
04.09.2024



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Das INM in den neuen Medien / INM in the New Media

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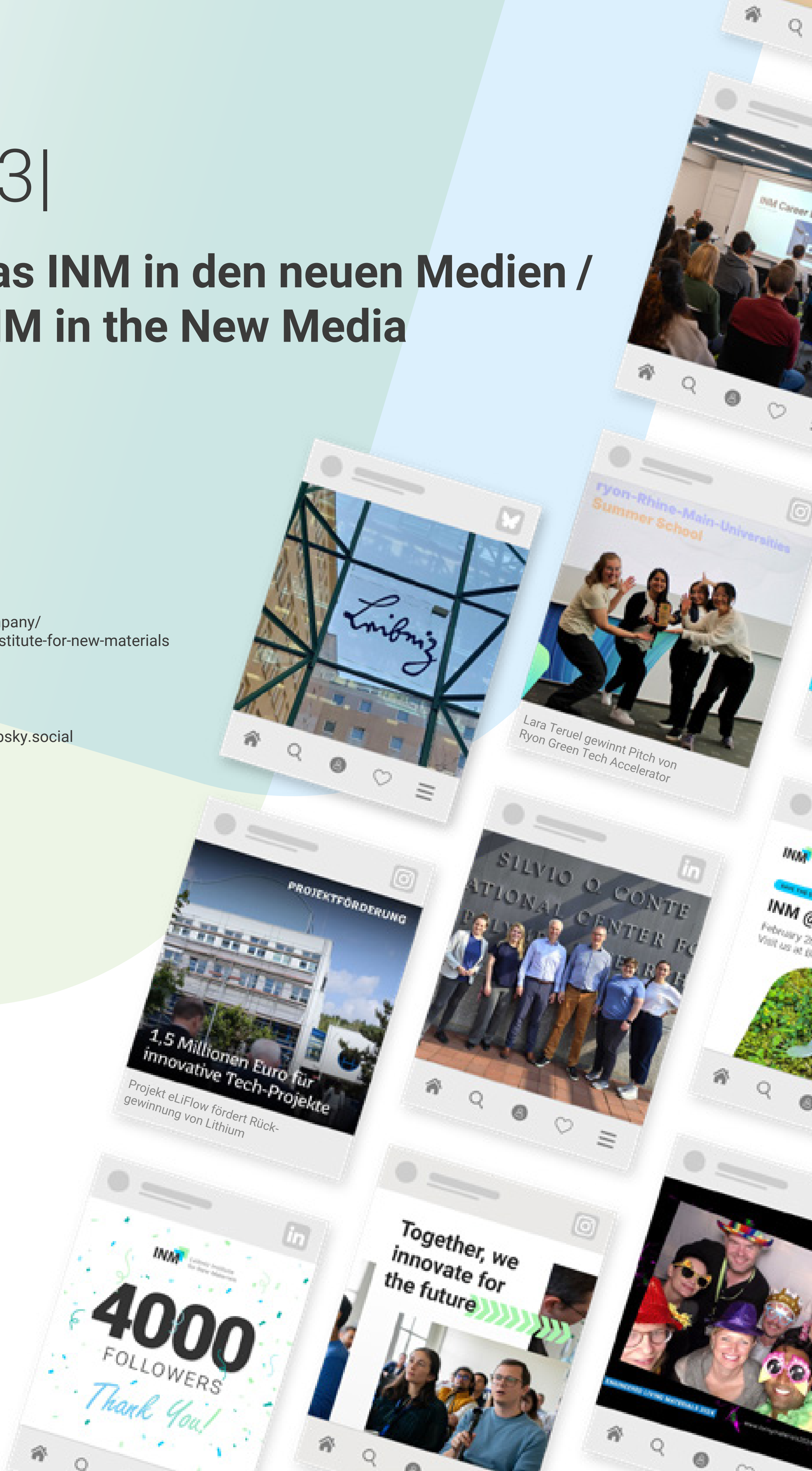

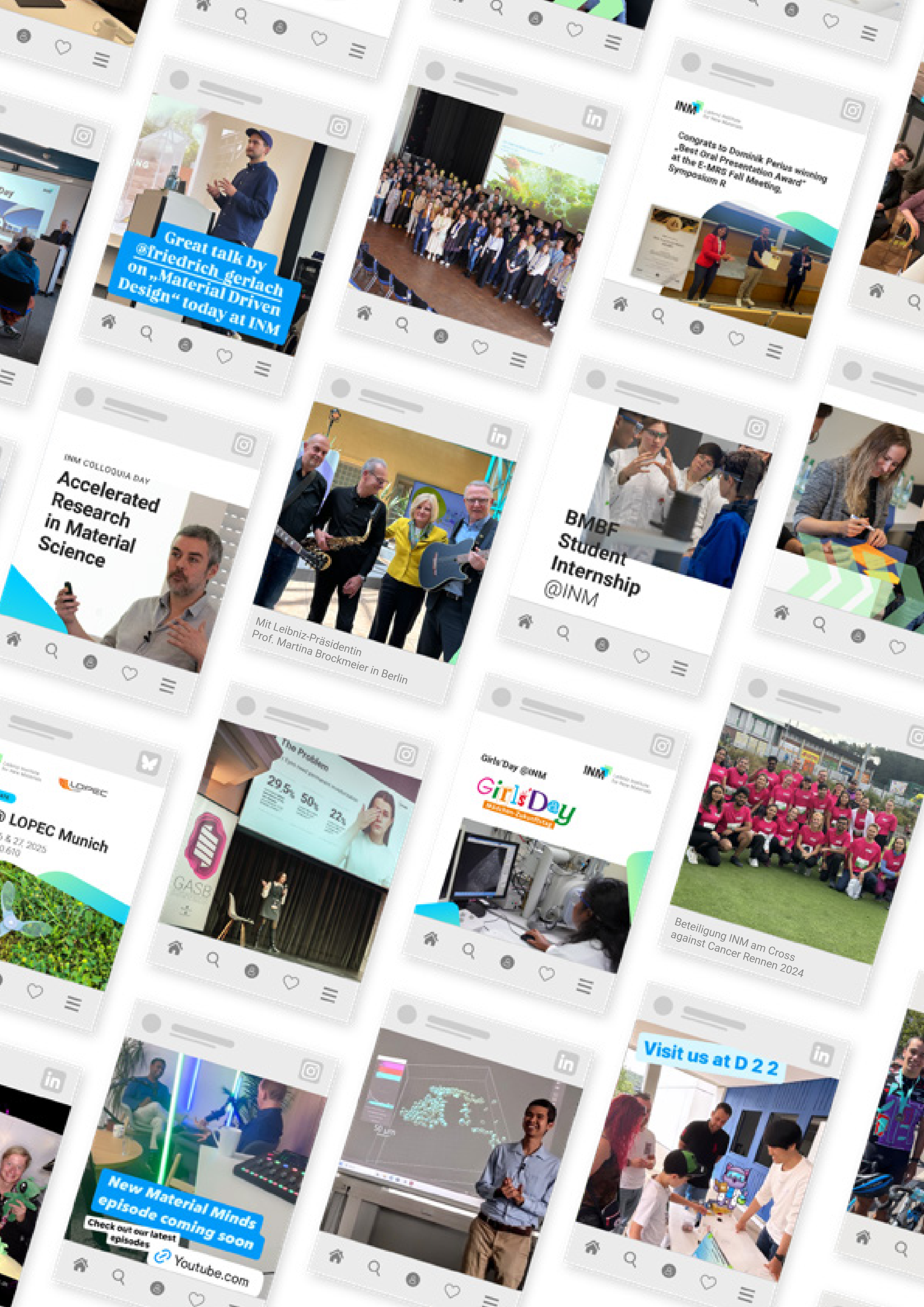

Great talk by @friedrich_gerlach on „Material Driven Design“ today at INM
INM
Congrats to Dominik Perius winning „Best Oral Presentation Award“ at the E-MRS Fall Meeting, Symposium R
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Für den Inhalt verantwortlich / Responsible for the content: Prof. Dr. Aránzazu del Campo, Prof. Dr. Wilfried Weber, Michael Marx

Redaktion / Editing: Dr. Mario Quilitz

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Grafik / Graphics: Lars Knaack

Layout & Satz / Layout & typesetting: FBO GmbH • Marketing und Digitales Business, Saarbrücken

Druck / Printing: repa Druck GmbH, Saarbrücken

Fotos / Photos: INM, außer / INM, except:
Oliver Dietze (S. / p. 6/7, 8, 16, 20, 22, 31 unten / bottom, 32/33, 39, 48, 54, 66, 72)
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Uwe Bellhäuser (S. / p. 15)

Titelseite / Front page: Zelle für elektrochemische Blei-Entfernung /
Cell for electrochemical lead removal. Foto: Uwe Bellhäuser

SAARLAND

Großes entsteht immer im Kleinen.

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Prof. Dr. Wilfried Weber, Michael Marx

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ISSN: 1864-255x