Fraunhofer Institute for Applied Polymer Research IAP

Annual report 2021

We make materials fit for the future!

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We would be pleased to send you information on Fraunhofer IAP's current research topics.

Preface

Dear Readers,

As we proudly look back on an economically and scientifically successful year, I am pleased to present to you the Fraunhofer IAP annual report for 2021.

Unfortunately, the ongoing pandemic is not the only challenge that needs to be addressed. We must also take all levels of the climate crisis seriously. How can applied polymer research help to conserve resources, reduce carbon dioxide emissions and make Germany less dependent on fossil raw materials? We at Fraunhofer IAP are developing sustainable concepts and solutions for the bioeconomy, circular economy, energy transition and mobility sector. We collaborate as a reliable partner with numerous companies as well as universities and non-university institutions.

Lightweight construction technology offers great opportunities for conserving resources and reducing carbon dioxide emissions. In particular it helps to reduce the weight of components as the operation of lighter machines consumes less energy. In Wildau, we now offer our partners holistic solutions in the field of polymer-based lightweight construction. In May of last year, we moved into a new building in Wildau that comprises 2,700 square meters of office and laboratory space. This marks the end of an era at the Teltow site. Until now, our competencies in material development, design and manufacturing technologies were spread over two different locations in Teltow and Wildau. Now they are united under one roof.

Lightweight construction is also one of our contributions to structural change in the Lausitz coal region. Together with local companies and university partners, we demonstrate how decentralized energy generation can succeed: with wind turbines based on lightweight construction technologies. Their compact design makes them suitable for private gardens, for example. When combined with hydrogen technologies, completely energy-autonomous buildings can be achieved in the future. This is an example of how we are contributing our innovative strength both to the energy transition and to the success of regional structural change.

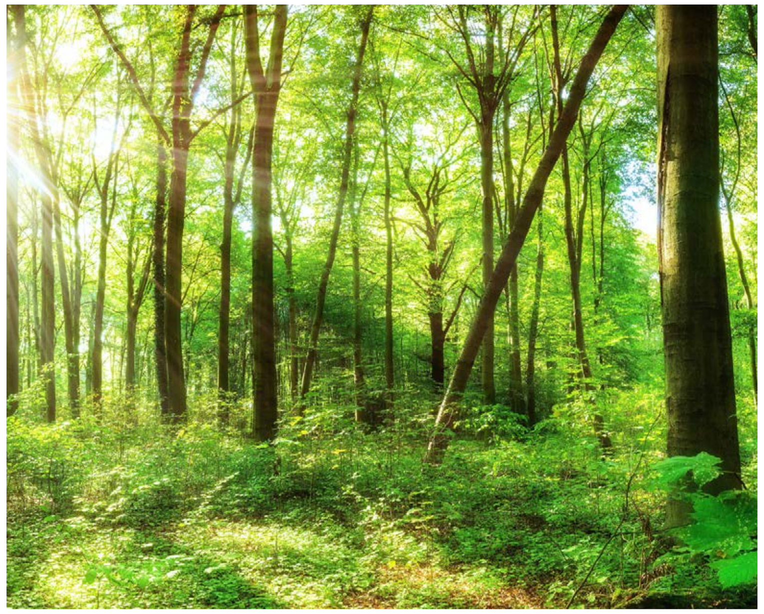
Last year, we laid the ground stone for making Fraunhofer IAP even more efficient for the future by implementing the Strategy Process 2026. Our employees established goals to further develop our research divisions and strengthen cooperation. One important result was to build up more expertise in the area of chemical and biological recycling. By recovering and recycling chemical building blocks from plastic products, we are supporting industry and society on the pathway to a sustainable value chain. Therefore, we will work even more intensively in teams from all of the institute's research divisions to find solutions for a circular economy of the future.

With this in mind, I wish you an exciting read of our Annual Report and hope that you will find many points of contact for cooperating with Fraunhofer IAP. //

Sincerely,

Prof. Dr. Alexander Böker
Director

»I would like to thank all of our employees for their creative thinking, innovative solutions and commitment; in particular for their involvement in the strategy process. Together, we have determined our path to the future. I look forward to walking alongside you.«




From innovative materials to solutions for the future

Creative solutions are the key to overcoming the challenges of the present and the future – wheter they be climate change, pandemics, the energy transition, structural change or new mobility concepts.

We focus on the following topics:

Bioeconomy and sustainability
We explore sustainable raw materials and facilitate a circular economy, in order to reduce the dependency on fossil energy sources.

Energy transition and mobility
The integration of innovative materials into components and products is a key to the energy transition and the evolution of new mobility concepts.

Health and quality of life
From arteries to wrist: For new active substances, products and processes for medicine, medical technology and cosmetics, we offer individual solutions from a single source.

Industry and technology
We are your competent partner along the entire value chain: from innovative materials to market-relevant prototypes.

Research divisions of Fraunhofer IAP

Biopolymers
In the research division Biopolymers, we develop sustainable materials based on renewable raw materials such as cellulose, lignin, starch or thermoplastics like polylactic acid (PLA). Using our decades of experience, we develop more effective processes as well as new and enhanced materials for new and existing applications. This is done in collaboration with our partners in the pulp and paper industry and the polymer processing industry and with end-product manufacturers.
Division director:
Prof. Dr. Johannes Ganster

Functional polymer systems
In the research division Functional Polymer Systems, we develop materials with special optical and electrical properties as well as processes, technologies and conceptual designs for customer-specific applications. These materials have semiconducting, chromogenic or phototropic properties or are able to emit light, convert sunlight, or react to mechanical pressure or temperature. We use new digital printing processes, for example, for the low-cost production of OLEDs or solar cells.
Division director:
Dr. Armin Wedel

Synthesis and polymertechnology
The activities of the research division Synthesis and Polymer Technology span the entire value chain - from polymer synthesis to process development, analysis and characterization. We rely on a balanced mix of competencies in our departments Polymer Synthesis, Shape Memory Polymers, Microencapsulation and Polysaccharide Chemistry, as well as Membranes and Functional Films. One focus of our activities is material-oriented and technology-driven research from a laboratory to a pilot plant scale.
Division director:
Dr. Thorsten Pretsch

Life Science und bioprocesses
In the research division Life Science and Bioprocesses, we use proven mechanisms from nature to expand the functional spectrum of polymers. Our focus is on integrating new biological functions into polymer materials. We develop processes, materials and key substances for biotechnology, chemical industry, textiles, medical devices, pharmaceuticals and cosmetics, as well as for environmental technologies and nanotechnologies.
Divison director:
Dr. Ruben R. Rosencrantz

PAZ
The Fraunhofer Pilot Plant Center for Polymer Synthesis and Processing PAZ in Schkopau is a joint initiative of the Fraunhofer Institutes IAP and IMWS. Its main activities in polymer synthesis include developing and optimizing polymer synthesis processes, upscaling and providing sample quantities.
Division director:
Prof. Dr.-Ing. Michael Bartke

PYCO
The research division Polymeric Materials and Composites PYCO provides key expertise in lightweight construction along the entire value chain – from monomers to high-performance components. Prototypes, including special polymers and semi-finished fiber composites developed in-house, can be designed and scaled to meet the demands of large-scale production. These synergies represent a unique selling point in the German research landscape.
Division director:
Prof. Dr.-Ing. Holger Seidlitz

CAN
Research at the Center for Applied Nanotechnology CAN focuses on the development of innovative, industrial-scale manufacturing processes for customized composites made of nanoparticles which can be used in displays, in lighting, in infrared sensors, as safety markings and in medical diagnostics.We also develop fuel cells with highly efficient nanocatalysts, polymers for cosmetic applications, and nanocapsules for the targeted release of active ingredients in medical applications.
Division director:
Prof. Dr. Horst Weller

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Status 11|2022

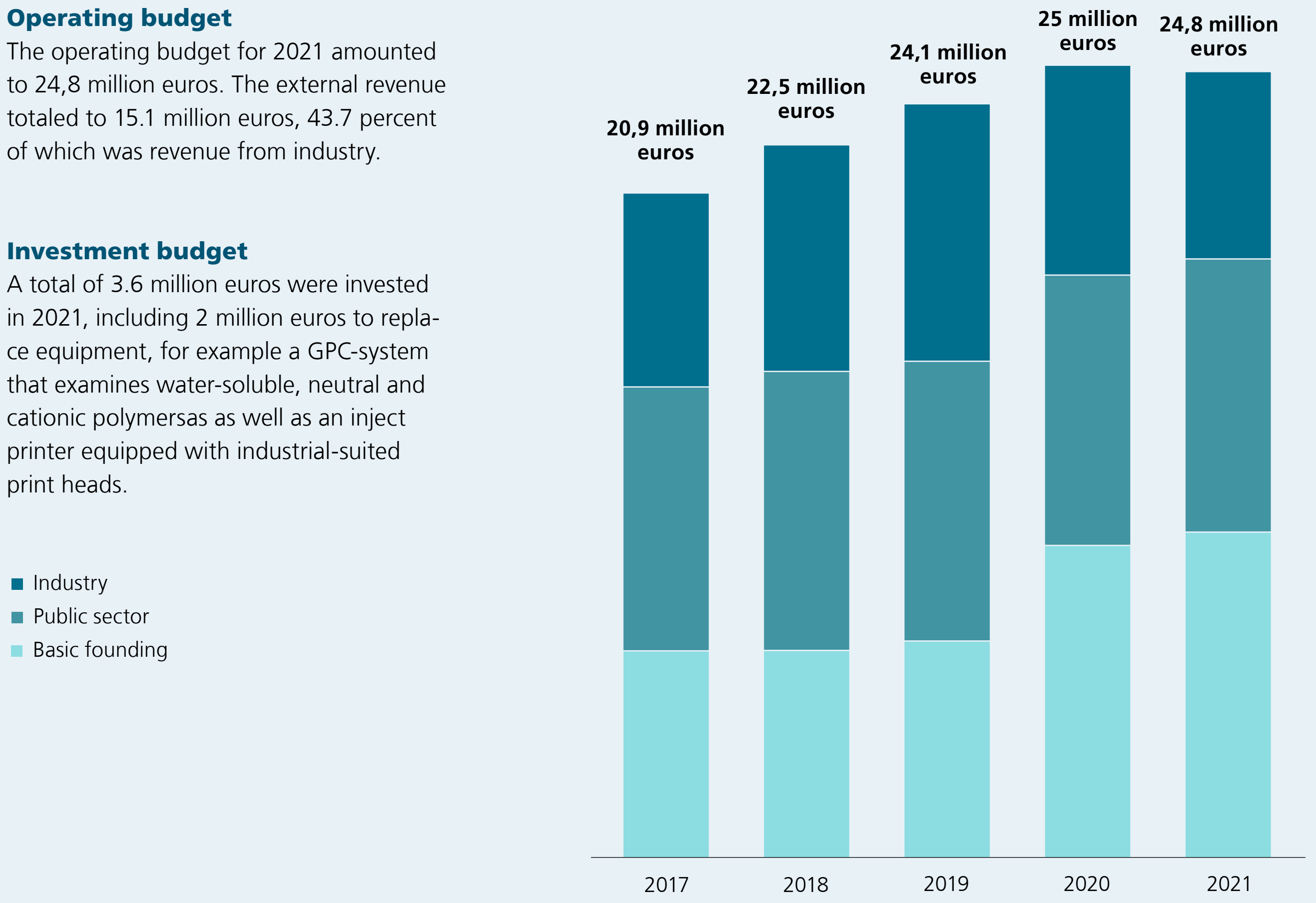
The institute in figures

Operating budget

The operating budget for 2021 amounted to 24,8 million euros. The external revenue totaled to 15.1 million euros, 43.7 percent of which was revenue from industry.

Investment budget

A total of 3.6 million euros were invested in 2021, including 2 million euros to replace equipment, for example a GPC-system that examines water-soluble, neutral and cationic polymersas as well as an inject printer equipped with industrial-suited print heads.



254 **People**
were employed at Fraunhofer IAP at the end of 2021.

124 Scientific staff

81 Technical staff

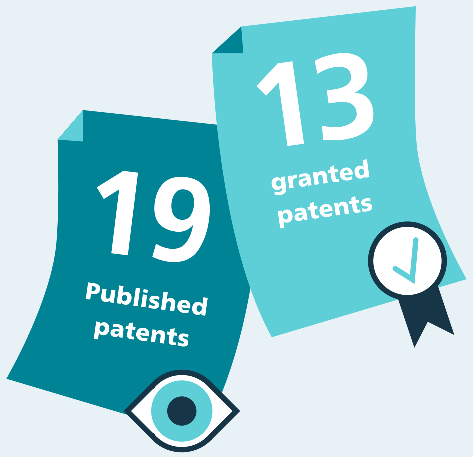
15 Ph.D. students

2 Apprentices

22 Administration/ scientific and technical services

10 Strategy und marketing

78 Bachelor's and master's students,research assistants and student research assistants, interns and guest researchers from Germany and abroad were also employed at the Fraunhofer IAP in 2021.



Fit for 2026

We make materials fit for the future! Our Strategy Process 2026, which was launched last year, sheds light on how this can be achieved, what competencies the institute currently possesses, and what goals will be pursued over the next five years.

Designing together

Our employees worked together in nine teams to develop the future orientation of Fraunhofer IAP. This enabled us to bundle the ideas and suggestions of more than 50 people – from all levels of the seven research divisions, the institute's management and the administration team. Together, they devised strategies on how to further develop the research divisions from both an economic and scientific perspective, while at the same time promoting the Fraunhofer spirit of research throughout the institute. Cooperation is the key. The institute-wide strategy therefore focuses on goals such as strengthening knowledge transfer, transparency, a sense of community, and the individual development of each employee. To do this, new internal processes are created and existing processes are improved.

»Our employees are at the heart of the strategy process. After all, it is their ideas, experience, knowledge and diverse perspectives that make Fraunhofer IAP vibrant and fit for the future.«

Dr. Jörg Rockenberger
Director Strategy and Marketing
Coordinator strategy process 2026

Synergies create added value

Fraunhofer IAP offers its customers and partners highly integrated solutions in four areas: bioeconomy and sustainability, energy transition and mobility, health and quality of life, and industry and technology. Our scientists have already been pooling their expertise in our seven research divisions; however, the new strategy process will enable the institute to promote and strengthen cooperation across research divisions to a greater degree. This is already reflected in newly established working groups in which several research divisions collaborate. Together, they work on specific topics that emerged from the strategy process in response to industry needs. For example, Fraunhofer IAP will expand its competencies in two new focus areas:

Priority topics across research divisions

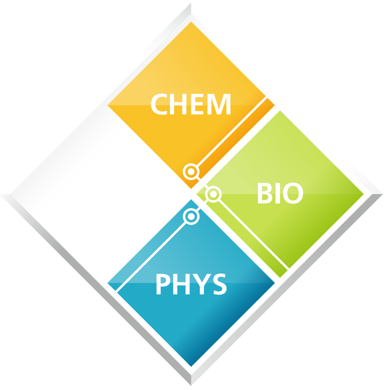
Chemical and biological recycling. Chemical and biological recycling is vital in achieving a plastics-based circular economy. Fraunhofer IAP will continue to develop the recovery of chemical building blocks from plastic products. These can be used to produce new polymers and reduce dependence on fossil raw materials.

Artificial intelligence and the digitalization of materials and process development. Artificial intelligence (AI) and digitalization have the potential to fundamentally change the way research and development are carried out. For example, a so-called digital twin helps reduce development time and costs. This entails creating a virtual replication and simulation of a real object with all its associated properties. Experts at Fraunhofer IAP are already using AI in the field of lightweight construction to select and optimize materials and process parameters, and to design components. The new interdisciplinary working group applies existing competencies and extends these to other topics in material and process development.

Service center strengthens customer acquisition and retention

Another insight gained from the strategy process is that customer acquisition and retention can and must be improved. Here, the High-Performance Center "Integration of Biological and Physical-Chemical Material Functions" will play a decisive role in the future. Transfer teams, financed and organized by the high-performance center, will directly support the research divisions in acquiring business from industry. Services include customer, market and funding research. The teams also support the individual research divisions in preparing and implementing events, trade fairs and customer workshops. Since 2017, Fraunhofer IAP has been jointly operating the high-performance center with Fraunhofer IZI-BB in the Potsdam Science Park. While the center previously supported cross-institute and cross-partner R&D projects and provided project-specific transfer support, the focus is now shifting to transfer activities. //

High-Performance Center for functional integration



Since 2017, the High-Performance Center "Integration of Biological and Physical-Chemical Material Functions" at the Potsdam Science Park has been promoting close cooperation between university and non-university research and industry.

As one of twenty high-performance centers at the Fraunhofer-Gesellschaft, the "Functional Integration" Center acts as a regional transfer hub for high-competence fields. At the Potsdam location, the High-Performance Center pursues the goal of manufacturing products with integrated material functions in as few process steps as possible. The two Fraunhofer Institutes IAP and IZI-BB cooperate in the Potsdam Science Park with the University of Potsdam, as an anchor university, and BTU Cottbus-Senftenberg.

In 2021, the High-Performance Center was in a pandemic-related transition phase, focusing on expanding services for managing innovation in the project teams. In addition, networking activities with partners from science and industry took place virtually.

The "Transfer Sprint" information platform, developed by the performance center continued in 2021. Here, transfer-supporting services, methods, tools and experts from Fraunhofer headquarters and its partner network are presented on a regular basis. This also included the presentation of the High-Performance Center as a transfer initiative at the Berlin Transfer Week, an exchange platform highlighting knowledge and technology transfer between science and industry in the region.

Joint events were held with partner institutions throughout the year. In September, the High-Performance Center's 4th Status Workshop took place and the Joint Lab BioF kicked off in partnership with the University of Potsdam. Current projects from the High-Performance Center and the transfer platform "Joint Lab BioF" were presented together with the team from the "Innovative University Potsdam". Topics included "health/environment", "energy/raw materials" and "mobility/transportation".

At the end of November, the High-Performance Center held a now traditional event on material design with the slogan "Good design is for eternity". The event was hosted in partnership with the VDI Bezirksverein Berlin- Brandenburg e. V. More than 70 participants discussed the challenges posed by the new design requirements for sustainable materials and products. The High-Performance Center was once again involved as a partner in the PSP Conference at the end of November, where research innovation, new products, collaborations and start-ups from in and around the Potsdam Science Park were presented. Starting in 2022, Fraunhofer's high-performance centers will undergo evaluations and transition into a permanent phase. //

Fraunhofer

Leistungszentrum
FUNKTIONSINTEGRATION
bio · phys · chem

Innovative University

Innovative University Potsdam – INNO-UP

Innovative University Potsdam (Inno-UP) is a project that is part of the federal-state initiative "Innovative University". Fraunhofer IAP has been a direct partner in the project of the funding initiative of the Federal Ministry of Education and Research and the Joint Science Conference since January 2018. Fraunhofer IAP is active in the "Technology Campus" sub-project, which involves the establishment and testing of so-called joint labs (JLs).

In 2021, Fraunhofer IAP's project activities focused mainly on the final commissioning of a joint lab for innovation cooperation in the field of biofunctional surfaces (JL BioF). Transfer concepts were developed in the project and gradually implemented in collaboration with the transfer team from the High-Performance Center "Functional Integration". For example, the concept of an innovation workshop was developed and successfully implemented. The platform is intended to support companies in their desire to innovate, even if the actual direction of innovation is not yet clear. Several concrete ideas for innovation projects were developed during the workshop in conjunction with partners from industry. One of these projects is already being implemented, while other projects are in the planning phase and are expected to start in 2022.

The close and successful collaboration between the University of Potsdam and the High-Performance Center is set to continue at other levels as well. This is demonstrated, among other things, by our involvement in the process of developing the University of Potsdam's new transfer strategy and the planning of an expanded joint utilization unit. //

Innovative University – Changes in technology transfer

The "Innovation Hub 13 – fast track to transfer" of the Wildau University of Technology and the Brandenburg University of Technology Cottbus-Senftenberg is an instrument of the federal-state initiative "Innovative University". The Leibniz Institute for Spatial Social Research, Fraunhofer IMW and Fraunhofer IAP's research division Polymeric Materials and Composites PYCO have joined forces to develop a regional innovation system that will sustainably strengthen knowledge and technology transfer (KTT) in the South Brandenburg region. This will enable the interdisciplinary transfer scout team to successfully address the topics "life sciences", "digital integration" and "lightweight construction". Companies in the region receive specific support in analyzing technology trends and future markets, conducting research projects, preparing project applications, and networking with research institutions. In 2021, new cooperation projects in the areas of hydrogen storage, material development for lightweight structures, and recycling were launched with companies from the Berlin-Brandenburg and Saxony regions. In addition, the range of digital networking formats was expanded to include an idea scouting tool, which further strengthened collaboration between universities, Fraunhofer institutes and industrial companies. //

Innovative Hochschule

GEFÖRDERT VOM

Bundesministerium für Bildung und Forschung

Gemeinsame Wissenschaftskonferenz GWK

Fraunhofer Cluster of Excellence

Circular Plastics Economy CCPE

The concept of circular value creation is playing an increasingly important role throughout the economy as a way to achieve the Sustainable Development Goals (SDGs) set out in the UN's Agenda 2030. This is particularly evident in the plastics industry. Plastic production is growing and is a major economic factor in many countries. Plastics for industrial and consumer goods have a broad range of optimized properties and in many cases they are difficult to substitute. Their low weight makes them indispensable for resource-efficient products. At the end of their life cycle, however, far too much plastic waste ends up in the environment. The desired transformation from the world's still largely linear system today to an efficient circular economy requires systemic, technical and social innovations.

The CCPE research cluster contributes in a crucial way towards this. The aim is to bundle the competencies, methods and products for the circular plastics economy across institutes. Fraunhofer IAP is responsible for the cluster's research department "Circular Polymers" and works closely with the Fraunhofer institutes LBF, ICT and UMSICHT. The work at Fraunhofer IAP focuses on biobased and biodegradable plastics. These aim at conserving fossil resources while reducing the CO_2 footprint. This ensures sufficiently rapid degradability in the environment and is particularly relevant in areas where a release of plastic into the environment, e. g. in the form of microplastics as a result of weathering and abrasion, cannot be avoided.

Specifically, Fraunhofer IAP is developing branched polybutylene succinates on the synthesis end in order to expand its range of applications, analogous to the approaches already established for polyethylene. New thermoplastic elastomers based on biobased furandicarboxylic acid represent another focus of activities. On the polymer processing end, methods are being used that spin fibers from polylactide (PLA) that have improved thermomechanical properties. The researchers at Fraunhofer IAP use fibers based on stereocomplex crystal structures (scPLA) for this. These are being tested as reinforcing fibers in monomaterial composite applications in cooperation with Fraunhofer ICT. The aim is to develop a composite material that consists entirely of PLA and is significantly easier to recycle than conventional fiber composites. Additivation to control degradability and the investigation of degradability itself are part of the work being conducted with the Fraunhofer institutes LBF and UMSICHT. The cluster underwent a successful evaluation in 2021 and is set to continue its research until October 2023.

Core institutes: Fraunhofer IAP, Fraunhofer ICT, Fraunhofer IML, Fraunhofer IVV, Fraunhofer UMSICHT. //

PLA-based monomaterial composite made from scPLA-PLA hybrid fabric

Programmable Materials CPM

The research cluster "Programmable Materials CPM" develops fundamental scientific approaches and technology that enables materials to replace the function of entire systems through their internal structuring.

Self-cleaning plaster-based exterior facades, a core topic of programmable transport properties, were developed further. These systems release an active ingredient in a controlled manner only when it rains. This makes the plaster more environmentally friendly than conventional materials and keeps it functional for longer. Preliminary results show twice the effectiveness, for example in combating algae on facades. In the area of self-switching membranes, focus was on enhancing programmability in line with the application. The polymer was improved so that it can be reprogrammed directly in the system. The end user now has the option of responding to different application scenarios with just one product.

In the field of 4D printing, it is now possible to produce objects from shape memory polymers that can change their shape once when heated up. The researchers developed a new polymer based on thermoplastic polyurethane (TPU) with shape memory properties. After 4D printing, the material exhibits an elongation-related shrinkage of 63 percent when heated. A 59-percent shrinkage was still achieved after mechanical recycling and renewed 4D printing. The team was also able to show transferability of their findings to another thermoplastic polymer by producing shrinkable printed objects from the bioplastic polylactic acid (PLA). Using the example of a shrinkable hands-free door opener, they demonstrated that the technology can be used equally well for assembly and disassembly purposes: once it has been reheated, the door opener detaches from the handle without leaving any residue. When the printed object is no longer needed, it can be ground down and reprocessed into filament, which can be 4D printed at least one more time. The future aim is to drive forward the establishment of a circular economy for functional materials. The technical equipment at Fraunhofer IAP was upgraded in order to further develop foams for thermally switchable rear ventilation or facade insulation. The institute's own reactive foam plant now produces three times faster than before. In the area of programmable friction, further efforts were made to develop polyalkylene glycols in terms of their optically switchable viscosity. Such polyalkylene glycols are widely used in lubricants. In addition to functionalizing them with light-switchable groups, the materials had to be tested to see if they were compatible with existing lubricant formulations so that they could be used in forming processes.

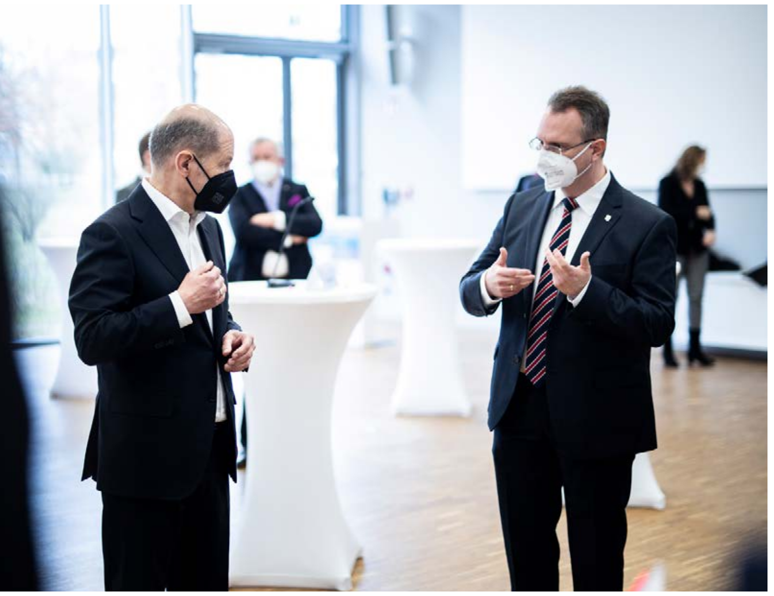
In 2022, the research cluster will undergo an evaluation to assess whether it should be extended for another four years. The goal will be to run the cluster independently as a cooperative project of several Fraunhofer institutes according to the Fraunhofer research and funding model.

Core institutes: Fraunhofer IAP, Fraunhofer IBP, Fraunhofer ICT, Fraunhofer ITWM, Fraunhofer IWM, Fraunhofer IWU. //

Fraunhofer IAP is further developing the process technology of 4D printing.

Innovation driver of the region

On March 18, 2021 the then Federal Minister of Finance and Vice Chancellor Olaf Scholz, Brandenburg's Minister of Science Dr. Manja Schüle, and the Mayor of Potsdam Mike Schubert visited the Potsdam Science Park.



Prof. Alexander Böker informs Finance Minister Olaf Scholz about Fraunhofer IAP's activities in health research and the energy transition. © photothek/Florian Gaertner

The research environment around the Potsdam Science Park is one of the fastest growing locations for innovation in the Berlin-Brandenburg metropolitan region. Fraunhofer IAP is also part of this success story. The institute supports companies in the region and the state with ideas and projects. "Research and development are vital for good jobs and for our fight against man-made climate change. Things are visibly progressing here in the region, with an excellent research and university landscape that ensures innovation," Olaf Scholz emphasized during his visit.

With core competencies far beyond traditional polymer research, the institute continuously demonstrates its importance: for society, industry and science. Current research projects that exemplify this were presented by the institute's director, Professor Alexander Böker, during a tour.

Applied research for the health sector and the energy transition

In the field of Covid 19 research, Fraunhofer IAP scientists are working on projects such as protective textiles, drug transport, filters for ventilation systems and rapid tests. On the topic of the energy transition, the institute presented its latest developments in quantum dots, printed electronics, organic solar cells and vivid displays.

Competent in questions of the future

Other focal points of Fraunhofer IAP include developments for the sustainable circular economy, lightweight construction, hydrogen storage, bio-based plastics and high-tech fibers, which ultimately also benefit structural change in Lusatia. In doing so, the institute covers several value chains. Fraunhofer IAP implements the projects of its customers and partners – from monomers, to application and the scale-up to industrial scale. //

Biofunctionalization of plastics

The BioPol project group, a collaboration between Fraunhofer IAP and BTU Cottbus-Senftenberg, underwent a successful interim evaluation by external experts in 2021, halfway through the five-year project period. The Fraunhofer project group is funded by the Ministry of Science, Research and Culture of the State of Brandenburg.

The experts gave the group's scientific and technical success in using enzymes as plastic additives a rating of outstanding and emphasized the innovative and ambitious work of the newly established group. The research focuses on the biofunctionalization of plastics using sugars and enzymes – particularly interesting classes of biomolecules. Sugars enable new bioinspired lubricants as well as targeted drug delivery, while enzymes provide additive plastics with additional functions, such as accelerated degradation. Another achievement of the project team is its successful procurement of follow-on projects, particularly in the areas of biomedicine and the replacement of fossil-based plastics with bio-based materials. BioPol is making a decisive contribution to advancing the range of applications and technologies brought about by the biotransformation of plastics.

In the future, the project group will direct its activities even further in the area of applications. The topics "biofunctional bulk polymers", and "biofunctional polymers in solution" are particularly suitable for this. While the former aims to develop self-degrading, biocatalytically additivated polymers, the latter investigates drug formulation and bioconjugation. Not only do both topics have high application potential and are promising for the future, they can be covered comprehensively by the partners involved. These include the Fraunhofer IAP with its expertise in biotechnology, medical materials and plastics processing, and the BTU Cottbus-Senftenberg with its outstanding research in the fields of materials chemistry and cell biology. //

Lightweight technologies for the structural change

The Center for Sustainable Lightweight Construction Technology (ZenaLeb) was launched at BTU Cottbus-Senftenberg on August 1. The Fraunhofer project group develops efficient, next-generation, lightweight structures. To this end, the researchers develop holistic and marketable system solutions along the entire value chain.

The focus is on novel manufacturing technologies in addition to polymer development, material preparation and processing. This also includes forward-looking optimization strategies such as data- driven modeling approaches, artificial intelligence methods, and machine learning.

The vision of ZenaLeb is significantly shaped by the structural change happening in Lusatia. As an interface between development and application, the center meets the needs of regional industry. It enables sustainable and practical solutions in lightweight construction, for example for Deutsche Bahn's new ICE manufacturing facility, for the Center for Hybrid Electric Systems Cottbus, and for local automotive manufacturers and their suppliers. The development and cooperation model is industry-oriented and forms the basis for rapid knowledge and technology transfer. The state of Brandenburg will fund ZenaLeb for an initial five years. After that, the plan is to continue running the center as a self-financed unit based on the Fraunhofer research and financing model. ZenaLeb directly addresses challenges arising from the phase-out of coal. In doing so, it opens up new avenues for a more sustainable energy industry. Sustainability and the energy transition are two of the major topics at Fraunhofer IAP. //

Science Minister Dr. Manja Schüle, Prof. Holger Seidlitz and Dipl.-Ing. Felix Kuke at the handover of the funding decision.

Lightweight competencies under new roof

Fraunhofer IAP's PYCO research division has combined its lightweight construction competencies which had previously been spread across several locations. Now all of these competencies are under one roof in a new building in Wildau. This results in many advantages for industry customers: In addition to laboratories for materials development, the spacious premises also have room for technologies for manufacturing larger components. Fraunhofer IAP thus offers complete solutions for lightweight construction from a single source.

- a new 2,700-square meter office and laboratory building with state-of-the-art technology.
- construction costs of 20.5 million euros, 80 percent of which is financed by the European Regional Development Fund and ten percent each by the federal government and the state of Brandenburg.
- the centerpiece is an impregnation line that is modular in design and can be used for coatings, impregnation and prepreg production.

EUROPEAN UNION
European Regional Development Fund

»

The new location will enable our activities to revolve even more tightly around the Wildau-Cottbus axis in the future and allow us to offer competencies in a wide range of areas. Thus, we are able to support the structural change activities even better than before."

Prof. Holger Seidlitz
Director Polymeric Materials and Composites
PYCO

Bioeconomy and sustainability

Fiber composite made from biobased polylactic acid

Polylactide (PLA) is a bio-based material that has a particularly promising future. The global market for this polymer is growing by around 10 percent a year. Up until now, PLA has been used primarily in the packaging sector, but it offers great potential in the development of biobased and degradable semi-finished products for technical applications. One prerequisite is improved temperature resistance. Based on a stereocomplex crystal structure, a team from the Biopolymers research division at Fraunhofer IAP is now developing fibers and films with a chemically identical fiber and matrix. Research is also being conducted into processing the newly developed fibers into a long fiber-reinforced granulate with a chemically identical fiber and matrix. The result is a self-reinforcing single-component composite material that promises great advantages for recycling; time-consuming separation steps become unnecessary.

The German Federal Ministry of Food and Agriculture provides intensive support for the development of biomaterials as part of its Renewable Resources Funding Program. The Agency for Renewable Resources is responsible for managing the project.

The automotive and textile industries are already signaling an interest in bio-based materials that are also easier to recycle. PLA is already competitive in terms of price. Now the material is being made technically sound for the new areas of implementation. Partners from industry are the companies Trevira GmbH, tesa SE and TechnoCompound GmbH. Together with the team of Fraunhofer researchers, they are striving to scale up the manufacturing processes to an industrial scale. This is a crucial prerequisite for making the biomaterial PLA available for more technically advanced mass applications. //

Dr. Evgueni Tarkhanov
Fiber Technology

Project: *Self-reinforcing single-component composite based on polylactic acid (AllPLACo)*
FKZ: *2220NR297X*
Partner: *Trevira GmbH, tesa SE, TechnoCompound GmbH*

Gefördert durch:
Bundesministerium für Ernährung und Landwirtschaft
aufgrund eines Beschlusses des Deutschen Bundestages
FNR Fachagentur Nachwachsende Rohstoffe e.V.

Fraunhofer IAP's novel biobased PLA fibers make it possible to produce a fiber composite made entirely out of PLA that can easily be recycled.

Dipl.-Ing. Thomas Büsse
Processing Pilot Plant for Biopolymers Schwarzheide

__Project:__ Regional entrepreneurial alliance for the development of value chains for technical bioplastics in Central Germany (RUBIO)
__FKZ:__ 03RU1U024A
__Partner:__ among others Polifilm ExtrusionGmbH, SauerGmbH&Co.KG, Kunststoff-Zentrum Leipzig gGmbh, Naue GmbH & Co. KG, Gramß GmbH, Technitex Sachsen GmbH, Optipack GmbH, Veolia Umweltservice Ost GmbH & Co. KG

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

Thermoplastic processing of novel PBS materials

Researchers at Fraunhofer IAP are establishing a value chain for the bioplastic polybutylene succinate (PBS) as part of the "RUBIO" project. The value chain encompasses the entire life cycle of the plastic, from the raw material base to recycling.

The institute's researchers are focusing on three areas: the synthesis of suitable PBS grades for various fields of application, plant and process development, and sample production on a pilot scale. They also seek to understand how newly developed plastic types and blends made from polybutylene succinate (PBS) and polylactide (PLA) can be thermoplastically processed.

Today, the market for PBS is monopolized by a single manufacturer and a very small variety of types. This significantly limits the application possibilities of PBS. As a result, the plastic's properties are not adapted to all potential applications. The raw material feedstocks are currently agricultural products, which pose the risk of the emergence of a "tank not plate" debate. In addition, the end-of-life scenario for this group of materials is inconsistently regulated and characterized by uncertainty. Researchers at Fraunhofer IAP are addressing these important issues.

The existing technologies for raw material treatment and monomer production as well as the preparation and processing of the plastic are coordinated and further developed alongside strong partners from research and industry – the latter often national and international market leaders in their sectors. This results in a wider variety of PBS bioplastic that is produced on a regional basis in Central Germany. It is made from plant-based recyclables and residues and fully meets the requirements of the market in terms of its range of properties. This also includes complete recyclability at the level of today's established petroleum-based plastics. //

PBS granules produced from regional reusable and residual plant materials which can be processed into a wide variety of products using the full range of processing technologies for thermoplastics.

Bioplastic resistance

As part of twelve subprojects within the BeBIO2 research network, Fraunhofer IAP is investigating how bioplastics and biocomposites can be optimized for use in durable products. It also seeks to understand which factors influence long-term durability. The University of Kassel (Institute of Materials Engineering), the University of Stuttgart (Institute of Plastics Engineering), Altair Engineering GmbH as well as more than 50 industrial partners are also contributing their expertise to the BeBIO2 research network.

The investigations are aimed at improving resistance to numerous factors, such as temperature, humidity, UV radiation, as well as biodegradation and resistance to chemicals. Depending on the industry, various influencing factors and aging scenarios are used to develop resistant plastics for the respective application using the information obtained. After all, components in a vehicle's engine compartment are subject to different influences (greases, oils) than children's toys (cleaning agents, saliva) or electrical items (temperature). In addition, both the material properties and durability are influenced by the structural properties, which can be specifically adjusted by the composition and processing. The researchers are testing various products from a wide range of industries in order to optimize bioplastics so that they can be used in the relevant product sectors and replace petroleum-based plastics in the future. Five of the twelve subprojects at Fraunhofer IAP focus on applications for office equipment, children's toys, power tool casings and the construction sector, among other things.

The network's research findings are incorporated into a database established by the plastics processing industry to make them readily accessible to companies. The aim is to promote the use of bio-based plastics and to facilitate the switch from conventional petroleum-based materials to ones that are sustainable. The BeBIO2 research network is funded by the German Federal Ministry of Food and Agriculture through the Fachagentur Nachwachsende Rohstoffe e. V. //

A bioplastic's tensile strength is tested in Fraunhofer IAP's mechanical testing laboratory.

Dr. Melanie Bartel
Material Development and Structure Characterization

__Project:__ Resistance of bioplastics and biocomposites (BeBIO2)
__FKZ:__ 2220NR089
__Partner:__ University Kassel (IfW), University Stuttgart (IKT), Altair Engineering GmbH

Gefördert durch:
Bundesministerium für Ernährung und Landwirtschaft
aufgrund eines Beschlusses des Deutschen Bundestages
FNR
Fachagentur Nachwachsende Rohstoffe e.V.

Dr. Christoph Herfurth
Polymer Synthesis

**Project:** CO2NIPU
**Partner:** Fraunhofer institutes ICT, IFAM and UMSICHT

Funded within the framework of the internal programs of the Fraunhofer Association (PREPARE 840071).

Biocompatible and sustainable plastics

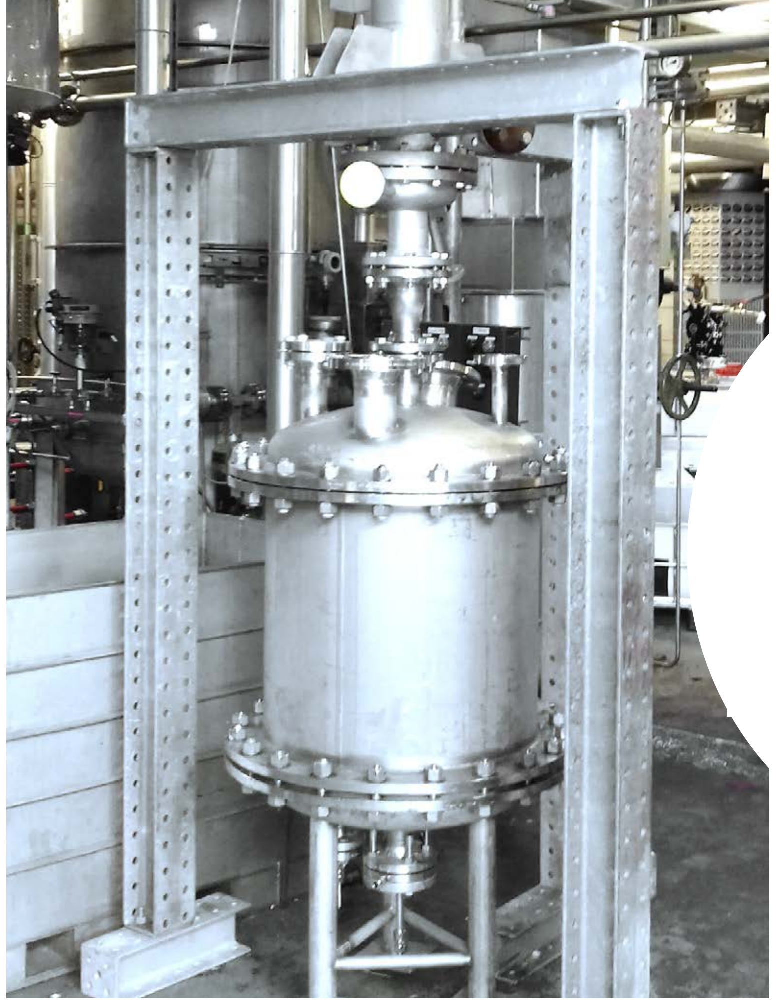
Polyurethane is a jack-of-all-trades. This class of plastic is used as mattress foam, packaging material, and as an elastic material for sporting goods. It is also used in sealants, paint, adhesives, construction foam and much more. The material is even used in medical applications – for example in tubes for intravenous catheters.

Fraunhofer researchers have developed a production method for polyurethanes that no longer uses toxic isocyanates. At the same time it uses carbon dioxide as a starting material. Polyurethanes with a consistent, reproducible quality are being developed together with partners from industry. Up to now, isocyanates, polyols and chain extenders have typically been used in the production of polyurethanes. Product properties can be controlled very precisely via the formulation and the process parameters. The product forms within a few minutes as a result of the high reactivity of the isocyanates. The drawback: isocyanates are toxic and sensitizing which means that they can trigger allergies and asthma. The research team replaced the isocyanates with dicarbamate. This not only creates a safer manufacturing process, but the polyurethane produced in this way can also be certified as being biocompatible. The researchers are also focusing on sustainability: instead of using fossil fuels such as crude oil or natural gas as a carbon source for the polyurethanes, they are using carbon dioxide and polyurethane recyclates. Carbon is thereby recycled so that less climate-damaging carbon dioxide is released into the atmosphere. //

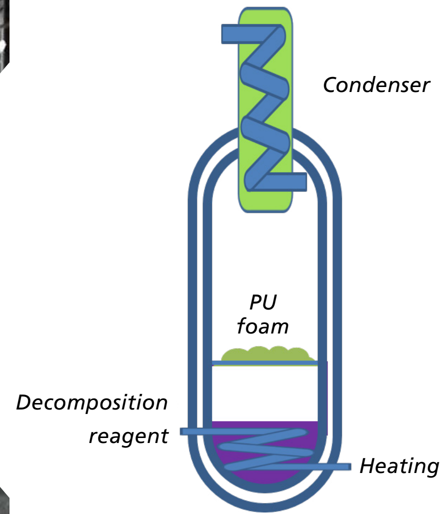
» Our new synthesis process means that we no longer need to use toxic isocyanates, thereby enabling safe production processes. Also, the polyurethane produced in this way can be certified as being biocompatible."

Dr. Christoph Herfurth

Tubes for medical purposes are one of a range of applications for polyurethanes.



A 200-liter reactor for pilot-scale solvolysis of materials.



Scheme for the solvolysis of polyurethanes.

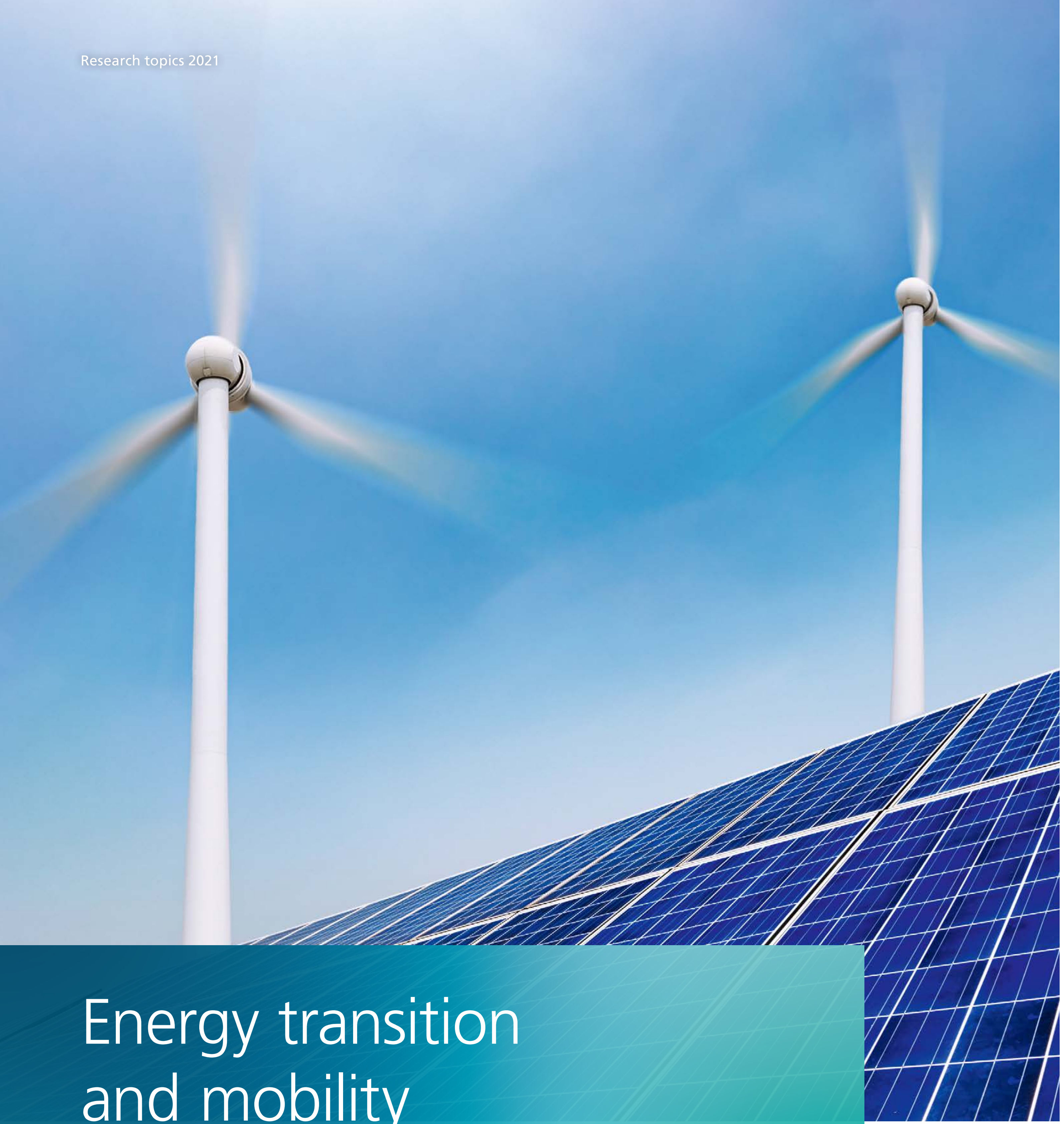
Recycling of biobased polyurethane foams

As part of the EU project "ReInvent", 19 project partners are jointly developing new materials from renewable raw materials - to the benefit of the environment and society. In the future, they will replace petroleum-based materials. The focus is on biofiller-reinforced and bio-based polyurethanes and foams. The partners are also working on composite materials for applications in the construction and automotive sectors, for example to insulate houses and pipelines, and to manufacture vehicle dashboards, roof linings and seat cushions. As part of the project, the researchers in the PYCO research division are looking at the recyclability of the new materials and comparing them with conventional materials. They are investigating on a laboratory scale the effectiveness of different methods of chemical and biological recycling – or a combination of both. They are also looking at ways to reuse the chemical building blocks recovered in the recycling process. Possible scenarios of use include recycled polyols or biobased hardeners for epoxy resins. Beyond the laboratory scale, Fraunhofer IAP's team of experts developed and installed a 200-liter reactor for solvolysis of the materials, demonstrating the scalability of the recycling processes under investigation. The key findings are incorporated into a comprehensive life cycle analysis to prove the economic viability and eco-efficiency of the technology – from the biobased raw material to a reusable recycled product. In the future, the technologies of the "ReInvent" project will be available to a wide range of users as an open innovation test bed within the framework of the EU project "BioMat". //

Dr. Sebastian Steffen
Tailored Materials

**Project:** Novel products for construction and automotive industries based on bio materials and natural fibers (ReInvent)
**Partner:** Joint project with Centro Ricerche FIAT as lead institute
**Additional contact:** Dr. Georg Werner (Synthesis und product development)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement ID 792049



Energy transition and mobility

New catalysts for fuel cells

Fuel cells are usually used to generate electrical energy from hydrogen or methanol. Nanoscale, platinum-based catalysts get the process going – but until now the quality of these materials has varied greatly. The CAN research division at Fraunhofer IAP is finding solutions to these problems using an optimized catalyst and a continuous, reproducible manufacturing process that has very good control over the material properties. Nanoparticles are ideal catalysts because they have a large surface area relative to the amount of material used. Their use saves both material and cost. The researchers at Fraunhofer IAP have also optimized the catalyst material itself; part of the platinum has been replaced by a less noble, and thus less expensive, metal. This not only has a positive effect on material costs, but also allows the catalyst to work more efficiently and increases its service life.

The proof of concept has already been provided and the researchers have tested the catalysts in direct methanol fuel cells – with success. Now, as part of long-term tests, they will analyze in detail how much the new materials and the optimized manufacturing process can save costs. The initial measurement results clearly show the developed catalysts are also highly relevant for use with hydrogen fuel cells. //

Dr. Christoph Gimmler
Nanoscale Energy
and Structure Materials

Project: *Development of composite nanoparticle systems for application in direct methanol fuel cells (HiKAB)*
FKZ: *03ET1435A*
Partner: *Forschungszentrum Jülich, Universität Hamburg, sfc energy GmbH*

Gefördert durch:

Bundesministerium
für Wirtschaft
und Klimaschutz

aufgrund eines Beschlusses
des Deutschen Bundestages

Characterization of fuel cells: A new test system makes it possible to test fuel cells with the new catalysts, thereby proving the consistent quality of the catalyst particles.

Prof. Dr.-Ing. Holger Seidlitz
Polymeric Materials
and Composites PYCO

Project: *Production of wound highly stressable pressure vessels in lightweight construction for hydrogen storage with integrated health monitoring (HoDH2)*
FKZ: *20.1.4.1*
Partner: *BTU Cottbus - Senftenberg, EAB Gebäudetechnik Luckau GmbH*

Gefördert durch:

Bundesministerium
für Wirtschaft
und Klimaschutz

aufgrund eines Beschlusses
des Deutschen Bundestages

Top: Innovative low-wind rotors and hydrogen tanks with built-in safety sensors will enable small wind turbines to be privately used in low-wind regions like Lusatia.

A hydrogen power plant for the garden

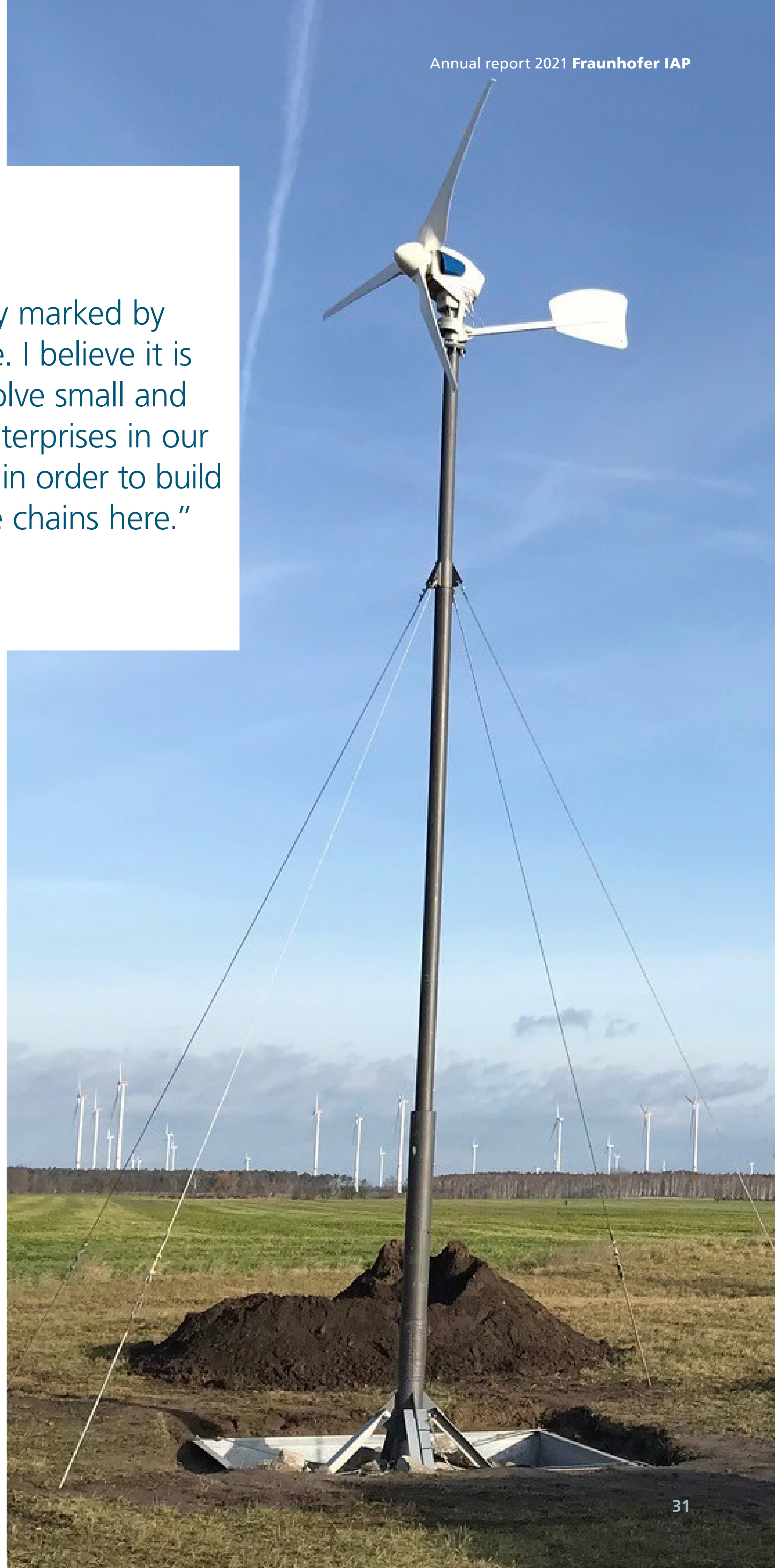
In the future, private customers will be able to use small wind turbines to produce and store hydrogen for their own use. Experts in lightweight construction from Fraunhofer IAP and BTU Cottbus-Senftenberg are developing the key technologies for this: small efficient rotors and safe tanks. The industrial partner is the company EAB Gebäudetechnik Luckau GmbH. The partners are developing a small, mobile, very efficient and safe hydrogen power plant whose capabilities range from the production of hydrogen to the storage of the valuable gas. The key to this lies in lightweight construction technology. This makes it possible to design a wind turbine for generating the electricity for hydrogen production which is so small that private individuals can also use it in their backyard. These experts in lightweight construction have designed a new propeller, made of a fiber composite, which starts moving even in a weak breeze. At the same time, the rotor can withstand strong winds. During storms, the rotor blades bend elastically and turn away from the wind. Complicated control technology and complex mechanics are no longer needed.

The hydrogen is produced on site in a small electrolyzer and stored in the tank. It powers a fuel cell located, for example, in the home. This fuel cell simultaneously produces heat and electricity. In the future, owners of hydrogen cars will be able to refuel their cars directly at home. In order for hydrogen tanks to be used in thousands of private households, they have to be pressure resistant and very safe. To this end, the team has developed tanks made of carbon fiber composites. Impregnated with synthetic resin, these harden into a container that can withstand many hundreds of bars of pressure. To detect leaks, the experts also have incorporated safety sensors directly into the fiber composite. This early warning system is an important prerequisite for future safe use by end customers. //

»

Lusatia is strongly marked by structural change. I believe it is important to involve small and medium-sized enterprises in our research projects in order to build end-to-end value chains here.”

Prof. Dr.-Ing. Holger Seidlitz



Prototype of a small wind turbine

Dr. Yohan Kim
Functional Materials and Devices

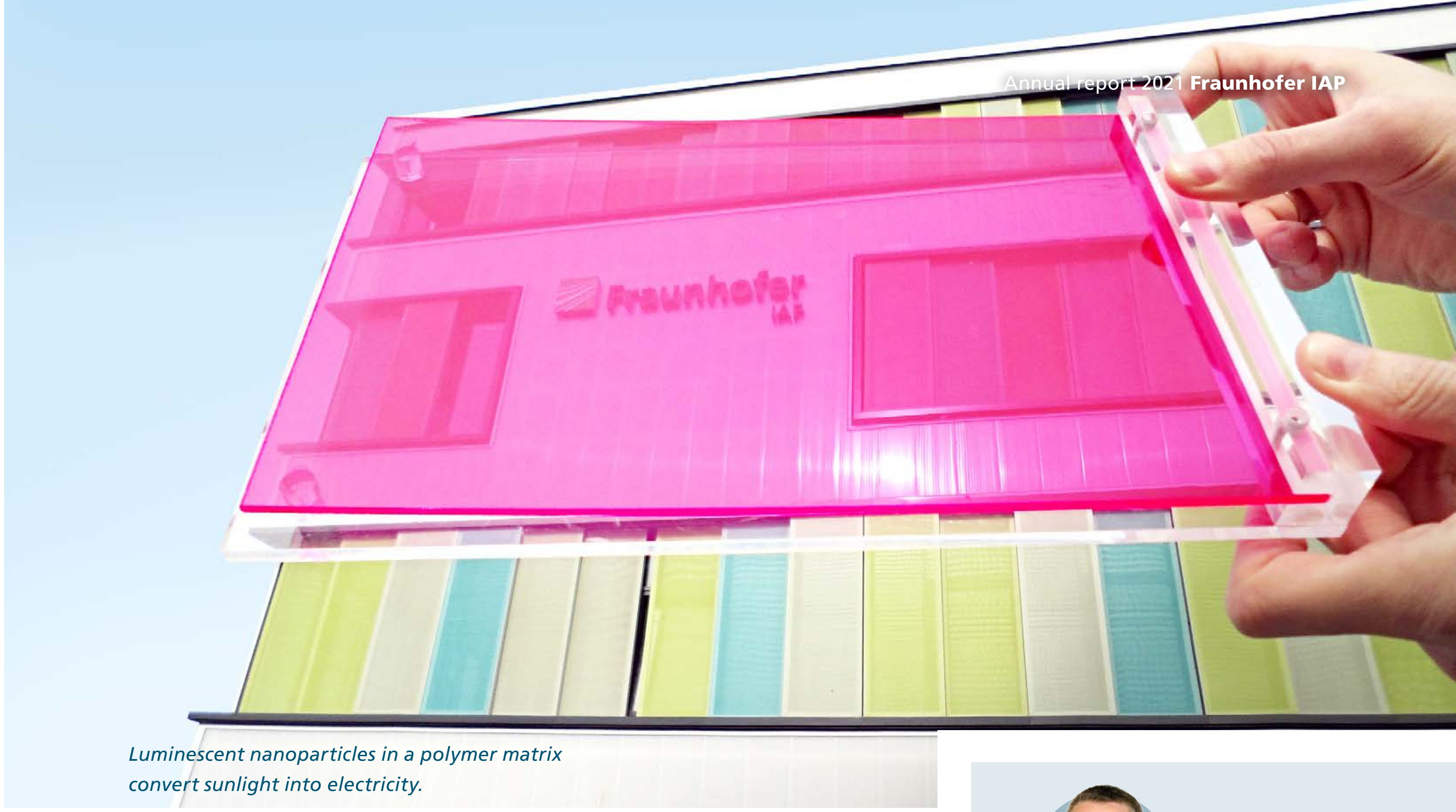
Project: *Color Converting for Microdisplays (CoCoMe)*
Partner: *Korea Electronic Technology Institute (KETI), Korea*
Additional contacts:
Dr. Jan Niehaus (Quantum Materials), Dr. Armin Wedel (Functional Materials and Devices)

Funded by the Ministry of Knowledge and Economy, Korea

Quantum dots for displays, photovoltaics und sensors

Quantum dots (QD) are nanomaterials whose absorption and emission properties are defined by particle size and whose quality is determined by the surface of the particle. Particles can be produced whose fluorescence covers virtually the entire visible spectral range up to the near infrared range. These unique properties enable them to be used in various applications, for example as luminescent materials, e.g. in the production of LEDs, in display technology, for up-conversion in photovoltaics, as a security feature for packaging, and in sensors. The project is now testing new methods for processing conventional cadmium selenide QDs and infrared-active QDs using digital printing technologies. One application for this is color filters for microdisplays. Here, high precision is essential as structures smaller than 50 micrometers are required. The project partners are also developing syntheses that replace the cadmium contained in the quantum dots with indium phosphide and infrared-active copper indium sulfide. Both substances are more environmentally friendly and less harmful to humans. The latter will also increase the efficiency of solar cells. //

Printed electroluminescent QD displays.



Luminescent nanoparticles in a polymer matrix convert sunlight into electricity.

Innovative building concepts for the energy transition

Dr. Armin Wedel
Functional Materials and Devices

Project: *Windows with integrated solar cells based on luminescent solar concentrator technology for energy harvesting (CoSoWin)*
FKZ: *03EE1027B*
Partner: *University of Kassel, Fraunhofer ISE, Technoform Glass Insulation Holding GmbH, Hans Walter & Sohn GmbH, x-cave Technology GmbH, Vonovia SE*

Gefördert durch:

Bundesministerium für Wirtschaft und Klimaschutz

aufgrund eines Beschlusses des Deutschen Bundestages

The multidisciplinary project "CoSoWin" focuses on the development and demonstration of smart, efficient, aesthetically pleasing, and multifunctional building-integrated photovoltaics. These are based on luminescent solar concentrator (LSC) technology. The windows, as building-integrated elements, capture and convert direct and diffuse sunlight. This is then transported to the front surface of the window, where highly efficient solar cells are located. Previously inaccessible surfaces can thus be additionally used to generate electricity. Windows that use LSC technology have a high potential for use both in modern architecture with large window areas and as a retrofit solution as part of energy-efficient renovations. For this application, luminescent nanoparticles are dispersed in a film that is applied to the interior side of multi-paned glazing. There, the particles absorb incident photons and emit them isotropically and with a red shift. The emitted light is absorbed at the edges by solar cells, which are integrated directly into the spacers of the glazing. The project will further develop several components required for the application of the LSC technology as well as their manufacturing technologies and join these together to form a complete system. The validation is carried out on the basis of building-integrated window surfaces. //

Health and quality of life

Personalized medicine

Fraunhofer IAP is driving forward the personalization and individualization of medicine. In the future, transplantable, autologous tissue will be grown in 3D-printed chambers that have customized shapes.

Tissue transplantation is sometimes unavoidable when soft tissue has been severely damaged. For the patient, it means a substantial medical intervention. In the future, the missing tissue could grow back directly in the patient's body – in isolation chambers implanted under the skin that are individually adapted to the wound geometry. Researchers at Fraunhofer IAP are currently evaluating and optimizing this technique as part of the BMBF-funded project "FlexLoop". Using photo-resin-based 3D printing, the shape of the chamber can now be personalized and adapted to the individual shape of the wound. Until now, only round isolation chambers have been used for tissue engineering. 3D printing offers the advantage of being able to specify the shape of the tissue.

The researchers are testing both the material itself and the various shapes of the isolation chambers. The mechanical properties of the chambers are also being investigated. The aim is to develop chambers that are biocompatible, easy to handle during surgery, and safe to use. No degradation products may be allowed to enter the patient's body, nor should rejection responses be induced. The initial results are promising. //

Dr. Wolfdietrich Meyer
Biofunctionalized Material and (Glyco)Biotechnology

Project: *FlexLoop*
FKZ: *03VP05962*
Partner:*Fraunhofer ILT, BG Klinik Ludwigshafen*

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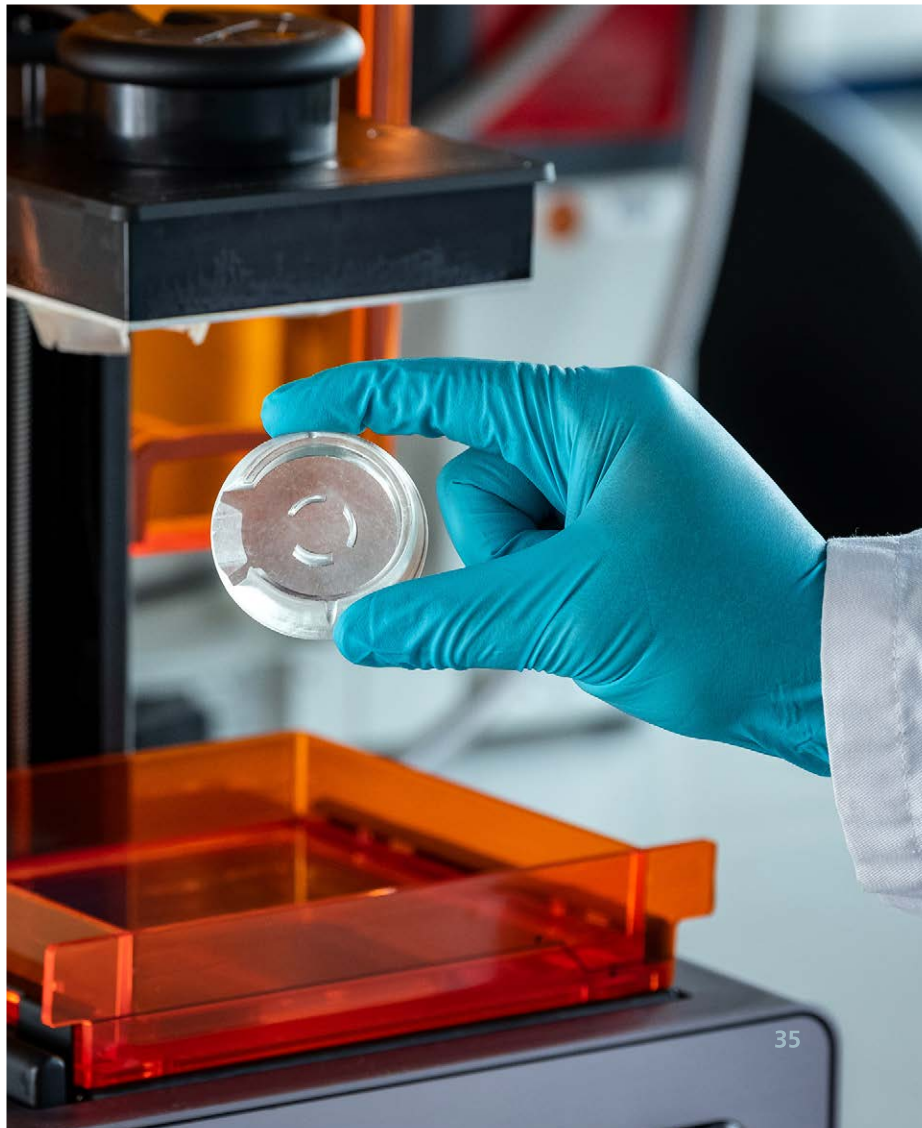
Bundesministerium für Bildung und Forschung



In the future, 3D-printed chambers in personalized shapes will be used to grow transplantable, autologous tissue that can take the shape of the wound that needs to be closed.

Dr. André Lehmann
Fiber Technology

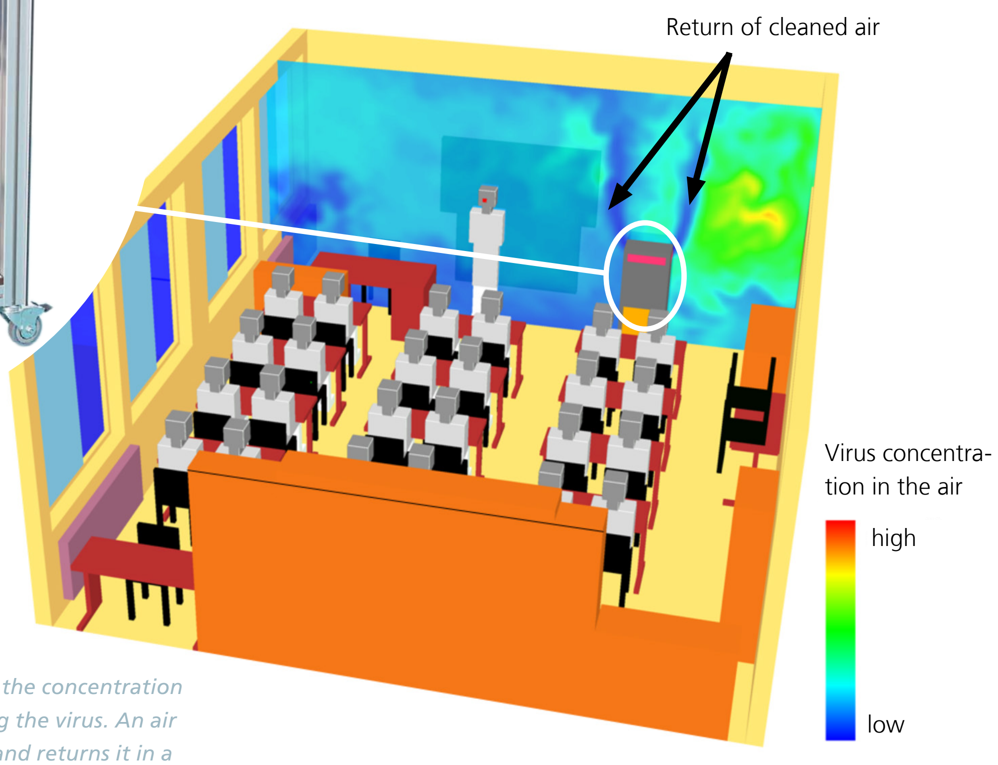
Effectively remove viruses from indoor air

What can be done to effectively rid indoor air of viruses? In the "AVATOR" project, Fraunhofer researchers from a total of 15 Fraunhofer institutes and research institutions are investigating and optimizing various filter and air purification technologies.

Here at Fraunhofer IAP, the focus is on traditional room filters. In order to better extract the aerosols that are emitted when breathing – above all the viral load they contain – additives have been added to the plastics that are used to manufacture the fleece. These additives modify the surface effects of the filter so that the tiny particles, which adhere to the filter material as a result of these surface effects, can be filtered out more efficiently. Since the overall filter performance is determined by the smallest particle size deposited on the filter – and these are usually very small particles (around 200 µm to 300 µm) – the coating can further increase filter efficiency. Even though additives are already being used to improve filter performance, such optimized filter fleeces are designed for the usual oil-based test aerosols. However, the aerosols that people release into the air are water-based and therefore behave differently. The research results showed an increase in the filter's efficiency, especially for these bio-aerosols. //

__Project:__ Anti-Virus-Aerosol: Testing, Operation, Reduction (Avator)
__Partner:__ Joint project with Fraunhofer IBP as lead institute

Funded within the framework of the internal programs of the Fraunhofer Association (Anti-Corona)



Mobile reactor plant for on-site use.

Numerical simulation of aerosol dispersion in a classroom: An infected person sits in the front right corner of the classroom. The slice plane shows the concentration distribution of the aerosol containing the virus. An air purifier filters the aerosol-laden air and returns it in a purified state.

Self-healing barrier layers

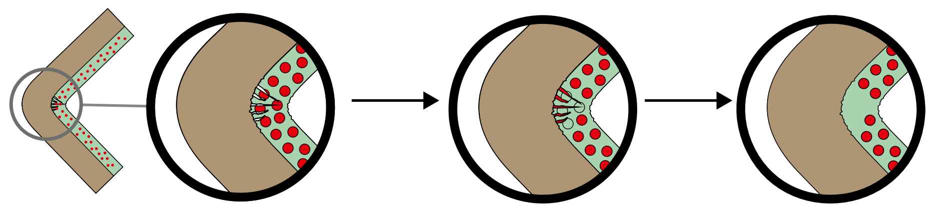
Dr. Kay Hettrich
Microencapsulation and Polysaccharide Chemistry

Many products need to be effectively protected, especially in the food sector. Effective protection of food packaging is achieved by applying special barrier coatings to the paper and carton used for this. However, the mechanical processing of such packaging materials often results in cracks, fractures and fissures that damage the barrier layer. In the case of food packaging, this damage to the barrier has a negative effect on the barrier properties and thus on the shelf life of the packaged products. The functional efficiency of the barriers must therefore be guaranteed over the entire life cycle of the packaging material.

A promising approach to prevent such quality degradation is to endow the barrier layer with self-healing properties. In the project, microencapsulated self-healing components are integrated into the barrier layer. If the barrier layer is damaged during the packaging or transport of the goods, the microcapsules break open and release the healing component in order to seal the cracks. Several healing concepts were considered during the project for different barrier layer requirements (hydrophilic or hydrophobic barrier). In order to improve sustainability, the coating is made up of the renewable raw materials starch and cellulose. Practice-relevant investigations for the food industry have already demonstrated that the system developed for fats and oils has very good barrier properties. //

__Project:__ Development of bio-based self-healing barrier layers for the food industry (Smart Barriers)
__FKZ:__ 22015118
__Partner:__ PTS, Mitsubishi HiTec Paper Europe GmbH, Prüfbau GmbH, Smurfit Kappa Hoya Papier und Karton GmbH, Solam GmbH, Follmann GmbH & Co. KG
__Additional contact:__
Dr. Juta Rottke (Microencapsulation and Polysaccharide Chemistry)

Gefördert durch:
Bundesministerium für Ernährung und Landwirtschaft
aufgrund eines Beschlusses des Deutschen Bundestages
FNR
Fachagentur Nachwachsende Rohstoffe e.V.



Formation of cracks in the barrier layer during the processing of paper or cardboard packaging and their possible self-healing by microencapsulated healing components.

Prof. Dr. Horst Weller
Nanomedical Applications

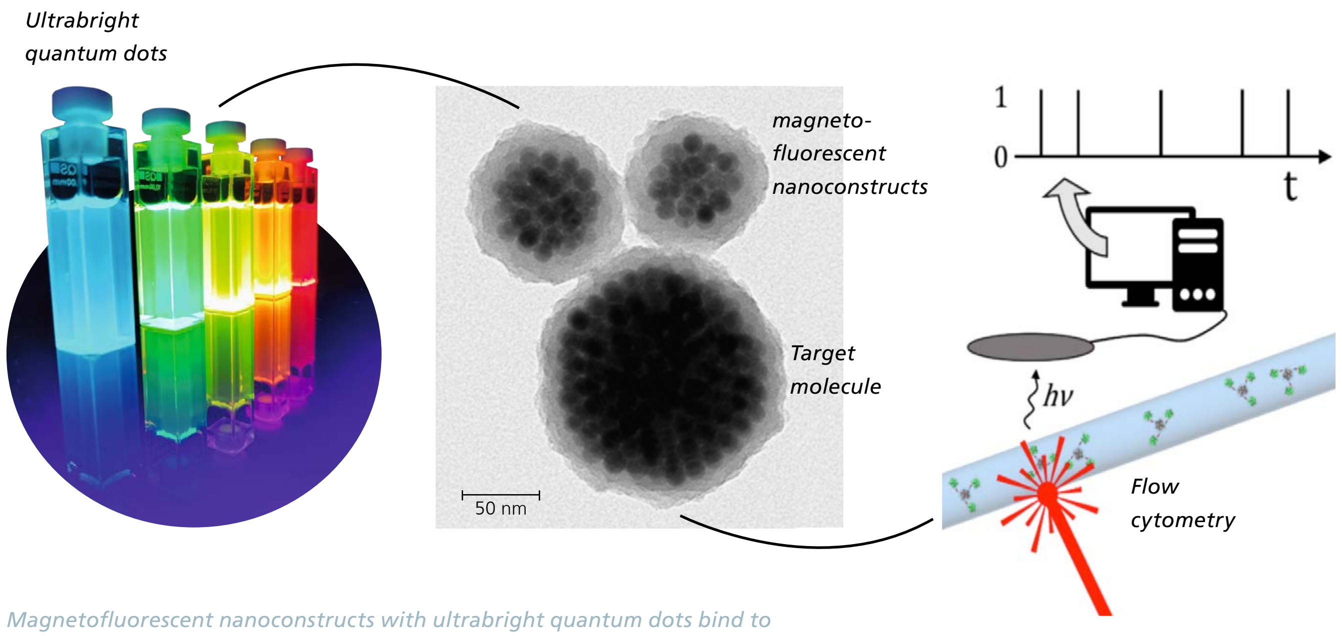
Project: Development of magneto-fluorescent nanoconstructs for the use in high content and point of care diagnostics (MANKIND)

Funded within the framework of the internal programs of the Fraunhofer Association (Discover)

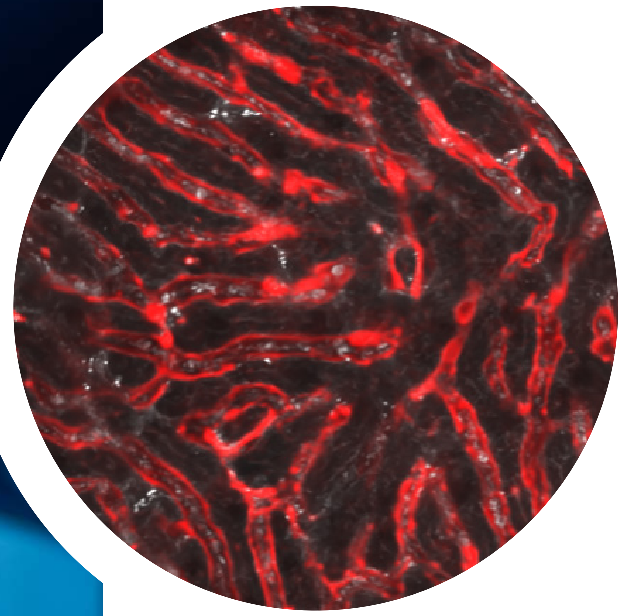
Platform technology for medical diagnostics

In medical diagnostics, fluorescent markers are often used that selectively bind to pathogens and cause them to glow. The fluorescence is measured integrally over the entire sample. These methods are characterized by high detection sensitivity, reliability and ease of use. However, even these methods are no longer sufficient if the pathogens are present in extremely low quantities, such as the ribonucleic acid (RNA) in a SARS-CoV2 sample. Complex methods such as polymerase chain reaction (PCR) are then used to reliably detect the pathogen.

In the "MANKIND" project, researchers from the CAN research division are developing a new method for detecting a pathogen's individual target molecules. The innovative approach of the new platform technology for medical fluorescence diagnostics is based on magnetofluorescent nanoconstructs that bind to target molecules. The advantage of this is that individual molecules labeled in this way can be detected as single fluorescence events in the flow-through – as is already common in flow cytometry for larger objects with greater signal intensities. Transferring this principle to the detection of single molecules is expected to improve the detection limit of an integral fluorescence measurement by several orders of magnitude while maintaining ease of use and a high-throughput capability. In technical terms, this allows normally undetectable, noisy, analog signals to be detected through temporal encoding and digitalization. //



Magnetofluorescent nanoconstructs with ultrabright quantum dots bind to target molecules and make them "glow". This enables individual target molecules to be detected.



Red-glowing vessels show the accumulation of polymer nanotransporters in the liver.

Xanthene dyes provide the necessary fluorescence of the polymer nanotransporters.

Polymer capsules as selective nanotransporters

The joint project "PolyAiD" has been working on developing a method to encapsulate hydrophilic substances, such as peptides, in a polymer matrix while, at the same time, retaining their effectiveness. Modifying the surface makes it possible to transport such active substances specifically into a physiological environment.

First, a micelle loaded with an active ingredient is formed and fixed, while the functionality of the active ingredient is retained. The surface is then modified with polycarboxylic acids. This makes it possible to achieve a suitable solubility profile for the nanotransporters and to adjust the zeta potential. The clinically proven polymer used to modify the surface allows liver sinusoidal endothelial cells (LSECs) to be specifically targeted. Since the fixation of the nanotransporters is unstable, the drug is released via cellular degradation processes after uptake into the target cells. In addition, the nanotransporters can be physiologically traced by labeling or co-loading them with fluorophores.

The nanotransporters developed at Fraunhofer IAP exhibit very good long-term stability in solution and can easily be stored in a cool place after freeze-drying. //

Dr. Marcus Janschel
Nanomedical Applications

Project: Polymer supported Autoantigen Delivery for the Curative Treatment of Autoimmune Diseases (PolyAiD)
FKZ: 13XP5079A
Partner: Uniklinikum Hamburg-Eppendorf, TOPAS Therapeutics GmbH

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

Industry and technology

Self-repairing rotor blades

Renewable energy is becoming increasingly important in the course of the energy transition. However, the useful life of wind turbines is limited due to weather and environmental influences, such as corrosion caused by salt water and hail. Simple and cost-effective repairs of these turbines are therefore needed so that they can be used for as long as possible.

This is precisely where the project "BioLightHeal" comes in. The project seeks to develop durable and low-maintenance components for lightweight structures that have a significantly longer service life. Transferring the biological principle of self-healing (e. g. wound closure by blood clotting or regrowth of lizard tails) to composite plastics provides a unique opportunity to develop new materials that repair themselves after damage without the need for expensive equipment or spare parts.

The basic mechanism behind this technology is based on special chemical bonds within the plastics, which are thermally activated and reform when the components cool down. Thus, cracks within the component can be closed quickly and easily. The mechanical properties of the components are restored and their function is maintained. Since this process can take place as often as required, damage is efficiently repaired in the long term.

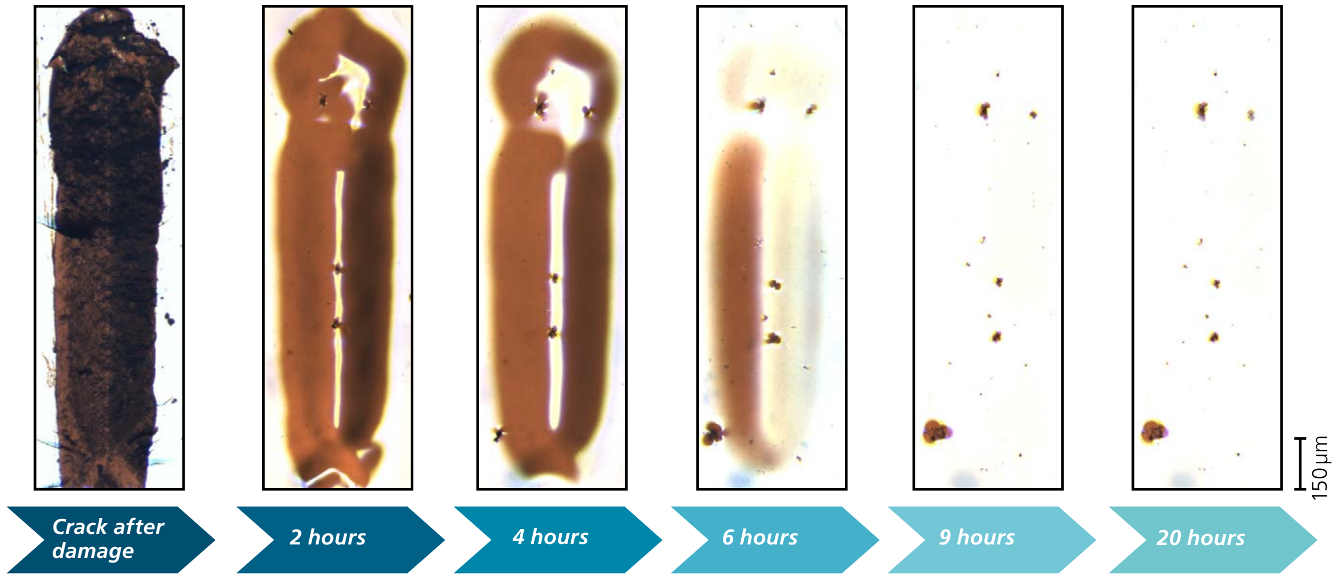
These novel materials, and the technology being developed here in Germany, are sustainable, protect the climate and help establish a global, resource-efficient energy industry. //

Dr. Mathias Köhler
Structural testing and Analytics

Projekt: *Bioinspired actively intrinsically self-healing composites (BioLightHeal).*
FKZ: *13XP5173A*
Partner: *Friedrich Schiller University Jena, thermoPre ENGINEERING GmbH*

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

Self-healing timeline of a polymer at 100 °C.



Microencapsulated additives

Dr. Alexandra Latnikova
Microencapsulation and Polysaccharide Chemistry

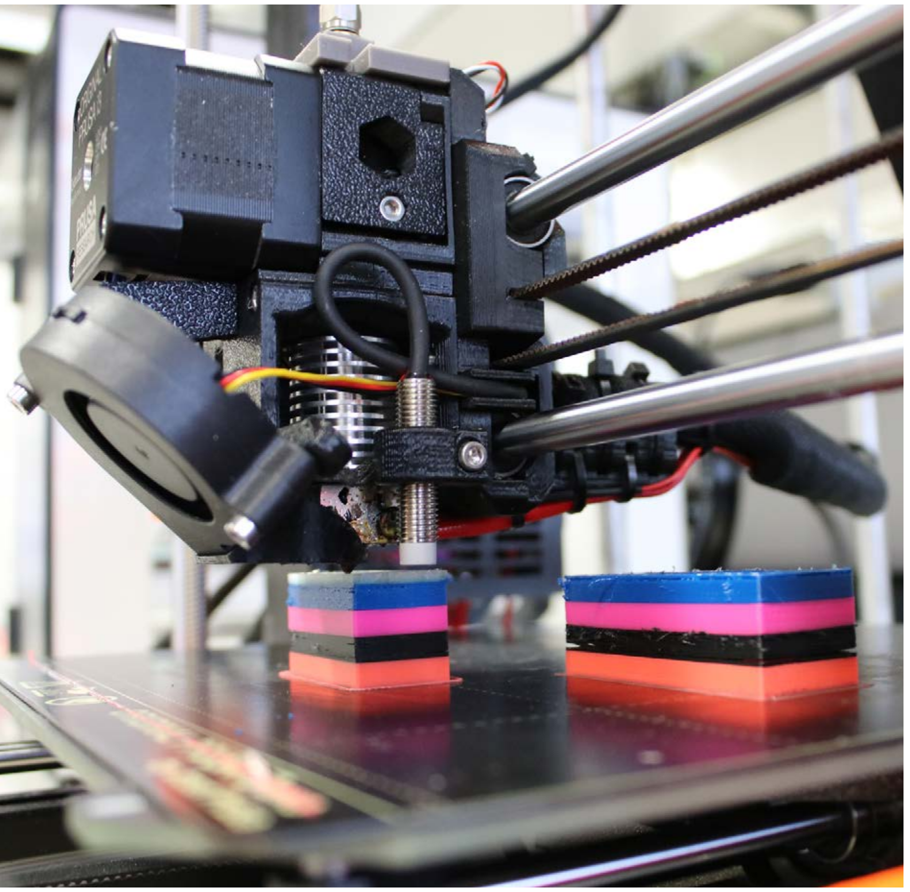
Project: *Testing of functional additives in fillament-based 3D printing (3DMics)*
FKZ: *21817 BG*
Partner: *Kunststoffzentrum SKZ*

Gefördert durch:
Bundesministerium für Wirtschaft und Klimaschutz
aufgrund eines Beschlusses des Deutschen Bundestages

Tailor-made materials for 3D printing are being developed by Fraunhofer IAP together with the SKZ Plastics Center. The aim is to increase customer acceptance of 3D printing processes through a broad range of highly functional filament materials and to expand market diversification.

3D printing is becoming increasingly important in the production of prototypes and final components. Additives such as colorants, fragrances, fillers, lubricants and biocides give the printed plastic objects individual functional properties. Incorporating these additives into the plastic is often difficult because many additives are not suitable for the filament-based 3D printing process. As part of extensive investigations, our researchers are now determining which additives can be used in 3D printing and how even complex additives can be incorporated into plastics using the microencapsulation technique.

In industry, additive manufacturing has become a standard part of product development. Its potential is increasingly unfolding wherever small quantities of customized components are required in complex or filigree shapes. Application-specific materials are intended to make it easier for particularly small and medium-sized companies to gain a foothold in additive manufacturing. The project addresses companies that are part of the production chain for filament-based 3D printing, i. e. microencapsulation specialists, manufacturers and distributors of plastic additives, compounding specialists, manufacturers of equipment systems, and service providers in the field of filament-based 3D printing. The German Federal Ministry for Economic Affairs and Climate Protection is funding the research project through the German Federation of Industrial Research Associations (AiF) as part of a program to promote joint industrial research (IGF). //

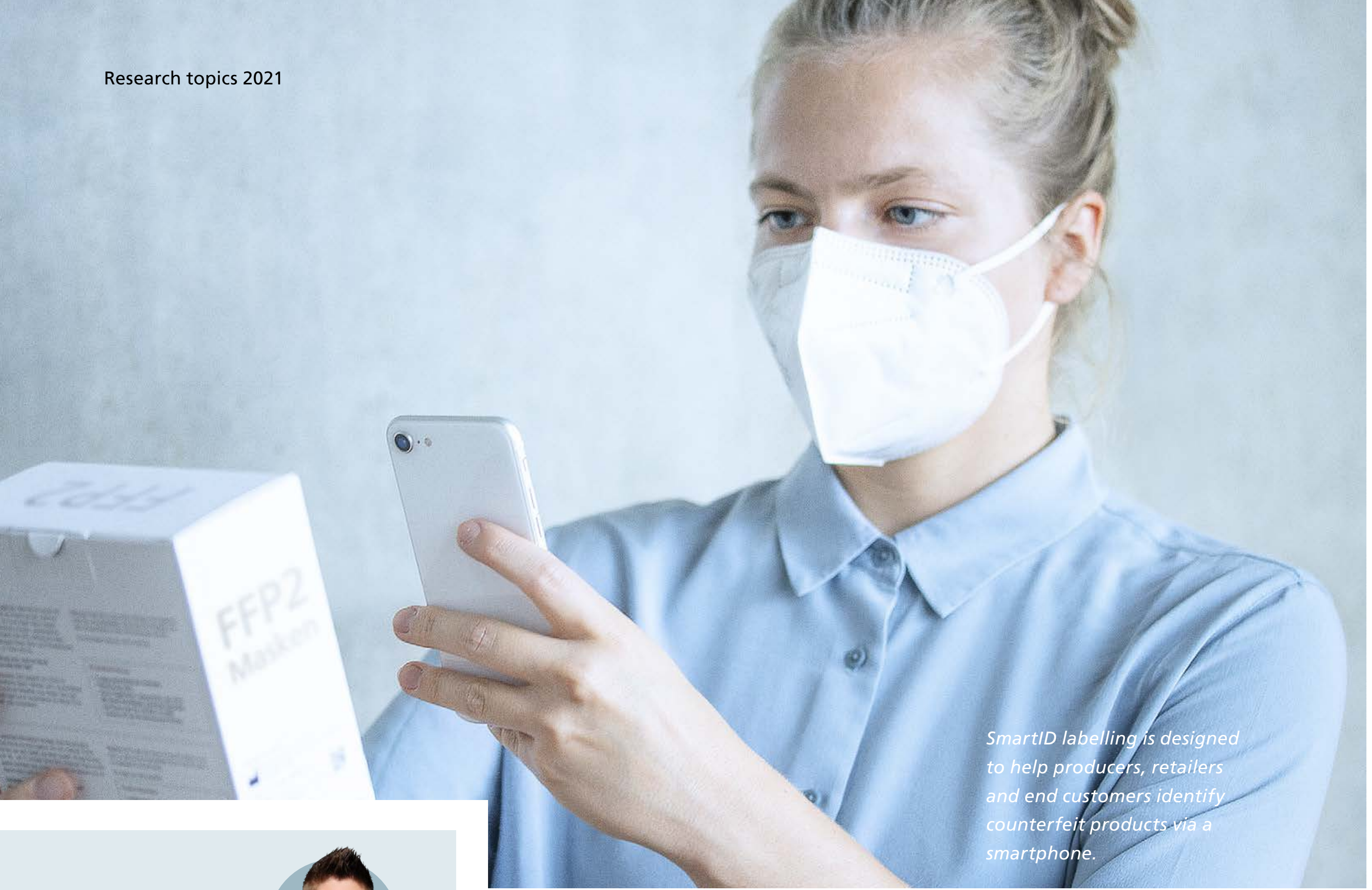


Extensive research is being conducted to determine how even complex additives can be incorporated into 3D-printed products.

» One ingenious trick is that we will also be able to introduce microencapsulated additives, such as lubricants, into filaments. This gives the printed component a new functionality: it can self-lubricate.”

Dr. Alexandra Latnikova

Additivierte Filamente für den FLM-Druck.



SmartID labelling is designed to help producers, retailers and end customers identify counterfeit products via a smartphone.

Dr. Tobias Jochum
Quantum Materials

Project: *SmartID*
(Industrie-) Beiratsmitglieder: *Fraunhofer institutes SIT und FOKUS, REA Elektronik GmbH, DNV, Domino Printing, Verband Deutscher Maschinen- und Anlagenbau*

Funded within the framework of the internal programs of the Fraunhofer Association (PREPARE)

Real or fake?

The goals of the Fraunhofer project "SmartID" are to create counterfeit-proof product authentication and resilient supply chains. Together with the Fraunhofer institutes for Secure Information Technology SIT and for Open Communication Systems FOKUS, Fraunhofer IAP is developing a novel identification system that can be used to detect the authenticity of products via a smartphone and offline, i. e. without the need to access a database.

In SmartID, each product is given a unique, tamper-proof identifier. The system can be embedded into existing track & trace infrastructures. Fraunhofer IAP is developing novel materials for forgery-proof labeling that can be detected using a smartphone.

In the first phase of the project, the partners are focusing on establishing secure and unique identifiers on product packaging and optimizing processes in terms of cost. One goal here is to print SmartID identifiers on packaging using conventional printing technologies. In the future, these identifiers could also be integrated directly into products or at least printed on their surface.

SmartID labeling enables comprehensive product protection that can be used by the producer, as well as by customs, wholesalers, retailers and end customers. In the future, everyone in this chain will be able to use their smartphone to securely authenticate a product. //

Switchable lubricants inspired by nature

Frictional effects occur in technical processes when moving parts are in contact with each other. Lubricants make it possible to adjust these as required in the interest of saving as much energy and wear and tear as possible. To make such adjustments, lubricants are substituted or modified in terms of how much is applied, based on the current state of the art. In order to be able to control friction values without these measures, Fraunhofer researchers are now creating a material whose mechanical properties can be adjusted within seconds when exposed to light. The biological model is snail slime, which can change its adhesive and anti-friction properties within seconds. The many benefits of this principle are now being transferred to synthetic materials. The concept has several advantages. Using light as an external switch is non-invasive and can easily be integrated into existing equipment. Light intensity, irradiated wavelength, duration and location of light exposure allow precise temporal-spatial control over the mechanical properties of the switchable material. This means that the type of lubricant and method of lubrication no longer have to be varied to adjust the friction coefficient. Existing technical processes are thus significantly more efficient in terms of time, energy and material consumption. //

Dr. Stefan Reinicke
Healthcare, Biomaterials and Cosmeceuticals

Project: *Lubricants with light-switchable viscosity für the optimization of industrial manufacturing processes*
FKZ: *13XP5169A*
Partner: *Fraunhofer IWM, Zeller+Gmelin*

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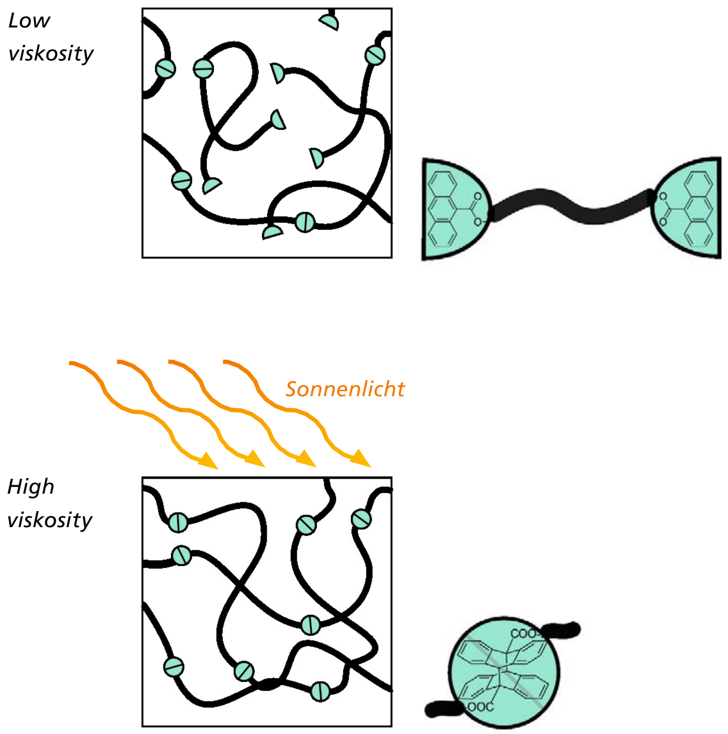


Schematic illustration of one of the two concepts pursued by the project. The light irradiation causes the ends of the polymer chains to join. The much longer chains increase the viscosity of the material.

The Fraunhofer-Gesellschaft

The Fraunhofer-Gesellschaft is the world's leading applied research organization. With its focus on developing key technologies that are vital for the future and enabling the commercial exploitation of this work by business and industry, Fraunhofer plays a central role in the innovation process. Based in Germany, Fraunhofer is an innovator and catalyst for groundbreaking developments and a model of scientific excellence. By generating inspirational ideas and spearheading sustainable scientific and technological solutions, Fraunhofer provides science and industry with a vital base and helps shape society now and in the future.

At the Fraunhofer-Gesellschaft, interdisciplinary research teams work together with partners from industry and government in order to transform novel ideas into innovative technologies, to coordinate and realize key research projects with a systematic relevance, and to strengthen the German and the European economy with a commitment to creating value that is based on human values. International collaboration with outstanding research partners and companies from around the world brings Fraunhofer into direct contact with the key regions that drive scientific progress and economic development.

Joseph von Fraunhofer (1787 – 1826)

The Fraunhofer-Gesellschaft owes its name to the Munich scholar Joseph von Fraunhofer, who was equally successful as a scientist, inventor and entrepreneur.

Founded in 1949, the Fraunhofer-Gesellschaft currently operates 75 institutes and research institutions. The majority of our 29,000 staff are qualified scientists and engineers who work with an annual research budget of 2.9 billion euros. Of this sum, 2.5 billion euros are generated through contract research. Around two thirds of Fraunhofer's contract research revenue is derived from contracts with industry and publicly funded research projects. The remaining third comes from the German federal and state governments in the form of base funding. This enables the institutes to work on solutions to problems that are likely to become crucial for industry and society within the not-too distant future.

Applied research also has a knock-on effect that is felt way beyond the direct benefits experienced by the customer: Our institutes boost industry's performance and efficiency, promote the acceptance of new technologies within society and help train the future generation of scientists and engineers that the economy so urgently requires.

Our highly motivated staff, working at the cutting edge of research, are the key factor in our success as a scientific organization. Fraunhofer offers researchers the opportunity for independent, creative and, at the same time, targeted work. We therefore provide our employees with the chance to develop the professional and personal skills that will enable them to take up positions of responsibility at Fraunhofer, at universities, in industry and within society. Students who work on projects at Fraunhofer Institutes have excellent career prospects in industry by virtue of the practical training they enjoy and the early experience they acquire of dealing with contract partners.

The Fraunhofer-Gesellschaft is a recognized non-profit organization that takes its name from Joseph von Fraunhofer (1787–1826), the illustrious Munich researcher, inventor and entrepreneur. //

Last update: January 2022

Board of trustees 2021

The board of trustees advises and supports the Fraunhofer-Gesellschaft as well as the institute´s directory. The following persons were members of the board of trustees of Fraunhofer IAP in 2021.

Networks and groups

Networking and knowledge exchange are important elements of successful research. Fraunhofer IAP cooperates with Fraunhofer Institutes from different fields as part of Fraunhofer groups and networks.

Our scientists also sit on many reputable committees and are involved in various associations and networks.

- Fraunhofer Strategic Research Field Bioeconomy
- Fraunhofer Group for Materials and Components – MATERIALS
- Fraunhofer-Cluster of Excellence »Circular Plastics Economy« CCPE
- Fraunhofer-Cluster of Excellence »Programmable Materials« CPM
- Fraunhofer Chemistry Alliance
- Fraunhofer Nanotechnology FNT
- Fraunhofer POLO®
- Research Area Technical Textiles
- Fraunhofer Sustainability Network
- Cultural Heritage Research Alliance

Fraunhofer Group for Materials and Components– MATERIALS

Fraunhofer IAP is a member of the Fraunhofer Group for Materials and Components – MATERIALS. This group combines the competencies of the Fraunhofer-Gesellschaft's materials science institutes and is active across the entire value chain – from the development of new and the improvement of existing materials, to suitable manufacturing processes on a quasi-industrial scale, the characterization of properties, and the evaluation of in-service behavior. This same applies to the components and products made from the materials and their behavior in the respective systems.

Numerical simulation and modeling techniques are equally utilized alongside experimental investigations in laboratories, technology centers and pilot plants at all scales - from the molecule through to the component, complex system, and process simulation. In terms of materials, the Fraunhofer MATERIALS Group covers the full spectrum of metals, inorganic non-metals, polymers, materials made from renewable raw materials, and semiconductor materials. Hybrid materials and composites have risen in importance in recent years.

The scientists working in the Group's institutes apply their know-how and expertise on behalf of customers in the areas of mobility, health, machine and plant engineering, construction and housing, microsystems technology, safety, and energy and the environment. They are well-connected at a national and international level and contribute to a wide range of material-related innovations and innovation processes. //

Key figures:

- *largest group within the Fraunhofer-Gesellschaft*
- *14 member institutes*
- *6 guest institutes*
- *more than 5 000 staff members*
- *approx. 2 639 researchers*
- *a budget in excess of 500 millionen euros*

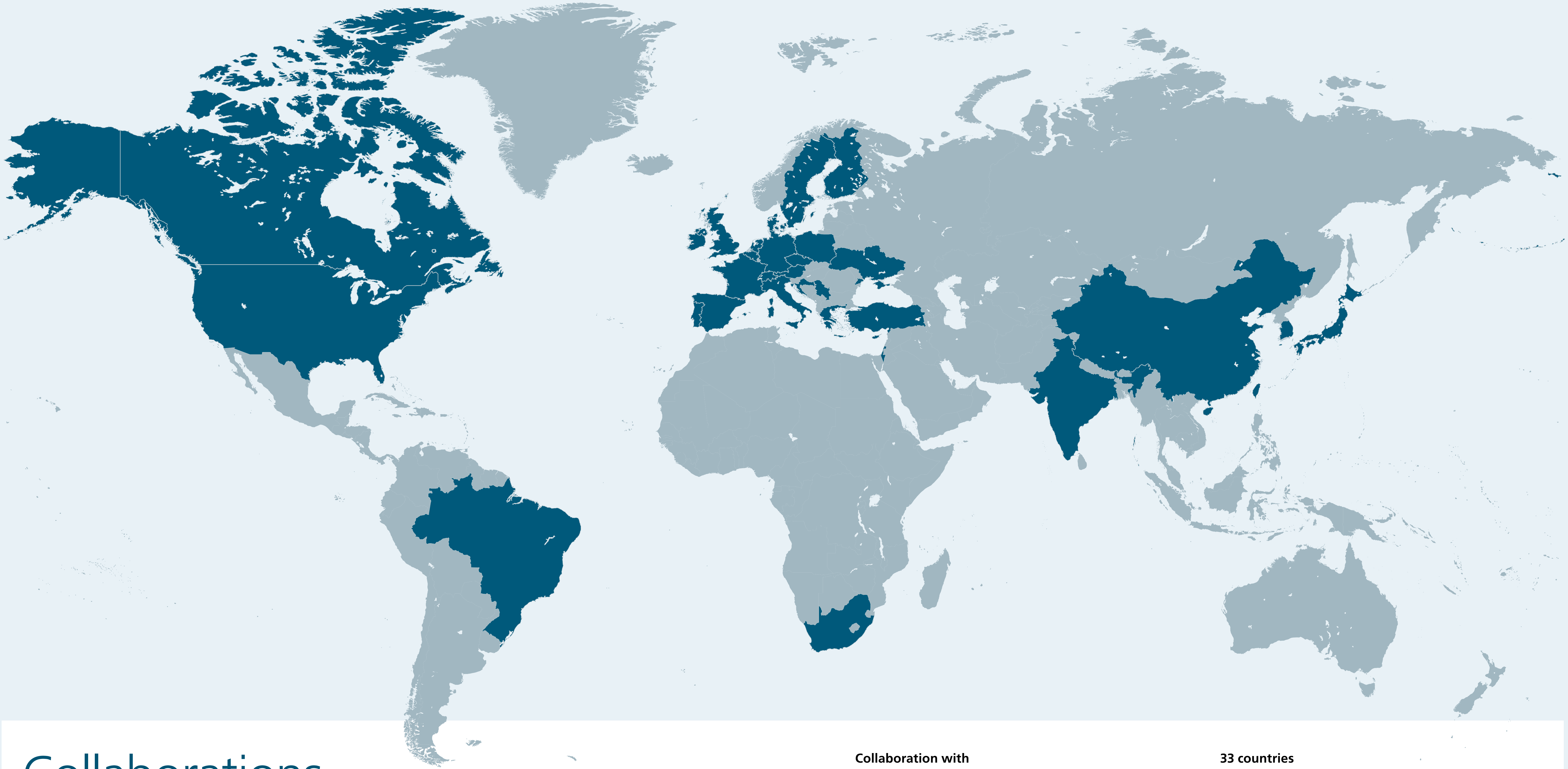
Fraunhofer Strategic Research Field Bioeconomy

Climate change as well as the scarcity of resources and agricultural land coupled with a growing world population are global challenges that demand sustainable value creation. To achieve this, a shift toward a bio-based way of producing, working and living – the bioeconomy – is necessary.

In the Fraunhofer-Gesellschaft's Strategic Research Field (SRF) "Bioeconomy", several institutes are working together to develop innovations for a sustainable and resource-efficient economy. The focus is on bio-based, machinable, functional and recyclable materials; water as a resource, food and feed; as well as chemistry and biotechnology. Professor Alexander Böker, director of Fraunhofer IAP, is one of the research field's spokespersons.

The scientists at Fraunhofer IAP contribute their expertise to the various topics, among other things, they develop new and innovative products that can be sustainably produced and recycled. Industry and science are increasingly focusing on materials made from renewable raw materials. In order to be able to compete on the market with fossil-based materials, the biobased alternatives need to have a high added value as well as special qualities and functionalities.

One of the most common biopolymers in nature is lignin. Lignin is also the only regenerative and biogenic source of biobased aromatics. These aromatics are an important chemical building block for applications in the areas of polymers, adhesives, coatings and antioxidants. The Strategic Research Field "Bioeconomy" is responsible for organizing lignin competencies across institutes and for advancing research. As a result, the Strategic Research Field "Bioeconomy" represents a central contact point for industrial customers. At Fraunhofer IAP, for example, focus is on the chemical modification of lignin for various applications and functionalities. //



Collaborations around the world

The scientists at Fraunhofer IAP are members of international networks and cooperate with research institutes, universities and companies in Germany, Europe and around the world. Many research topics are also tackled jointly within the Fraunhofer-Gesellschaft.

Collaboration with

327 Companies
108 Universities
55 Research Institutions

33 countries
Austria, Belgium, Brazil, Canada, China, Croatia, Czech Republik, Cyprus, Denmark, Finland, France, Germany, Greece, Great Britain, India, Ireland, Israel, Italy, Japan, Netherlands, Poland, Portugal, Republik Korea, Serbia, Singapore, Spain, South Africa, Sweden, Switzerland, Taiwan, Turkey, Ukraine, USA

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