Fraunhofer
IMWS

FRAUNHOFER INSTITUTE FOR
MICROSTRUCTURE OF MATERIALS AND SYSTEMS IMWS

HIGHLIGHTS 2019

ANNUAL REPORT

DEAR READERS,

Staff, projects, buildings and equipment – 2019 was marked by important changes at the Fraunhofer Institute for Microstructure of Materials and Systems IMWS. Our former Director Prof. Ralf B. Wehrspohn took up the new post of Executive Vice President, Technology Marketing and Business Models of the Fraunhofer-Gesellschaft. As the former Deputy and new Director of the Institute, for the first time I can now present a selection of our activities and project results. First I would like to take this opportunity to thank Ralf Wehrspohn for his track record since 2006. Under his leadership the institute's operating budget rose from around 5 million to 24 million euros. In January 2016 we also became the second independent Fraunhofer Institute in Saxony-Anhalt.

Our considerable success in 2019 was also due to the dedicated efforts of all our staff. We were able to further consolidate the scientific excellence of our team and successfully conclude numerous projects on behalf of our industrial and public clients. An important strategic move was the opening of the extension to the Fraunhofer Center for Applied Microstructure Diagnostics CAM. The additional space and excellent technical facilities will allow us to be ideally equipped over the coming years in our core competence microstructure diagnostics even on an international level. I would like to thank everybody who has made a contribution, above all our sponsors, who, with this investment, have underlined how important the research funding received by our institute is for industry and society at large.

In the new building, the division »Electronic Materials and Components« with its new director Frank Altmann, has begun its work. The same goes for the unit headed by Prof. Thomas Höche »Optical Materials and Technologies«, which was set up at the beginning of 2019 as a new business unit and continued to enhance its profile since then.

The same can be said of the business unit »Chemical Conversion Processes« directed by Prof. Bernd Meyer, who also heads the new branch specializing in carbon cycle technologies at the TU Bergakademie Freiberg. Together, we are in the process of combining our new fields of competence in hydrogen and carbon technologies and developing them so as to meet future needs in the area of recyclable processes. In doing so, our aim is to make an active contribution to the process of structural change in our region and to the changeover to a sustainable industrial society in close collaboration with the Executive Board of the Fraunhofer-Gesellschaft and the Center for Economics of Materials, which in the future will be based at the Fraunhofer IMW. You can find a few examples of the projects initiated with this in mind on the following pages.

Given the need for research into materials and improved technologies in areas such as future mobility, renewable energy, the intelligent management of limited resources or public health there are more than enough subject areas requiring the expertise we can offer in our key competencies in microstructure analytics and design. This is why we also gave new impetus in 2019 to our strategic development. Together with you, we hope to take up these challenges and, by pooling our endeavors, to develop successful solutions.

I would like to express my sincere thanks for our cooperation over the last year and look forward to exciting research topics, inspirational meetings and bold projects, but above all to the opportunity to make a contribution to the sustainability, progress and competitiveness of our clients.

Prof. Dr. Matthias Petzold

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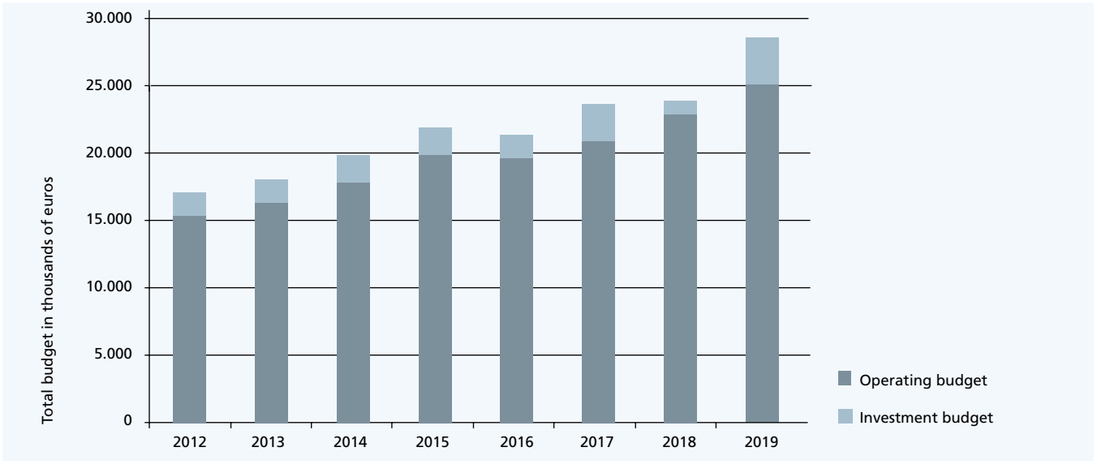
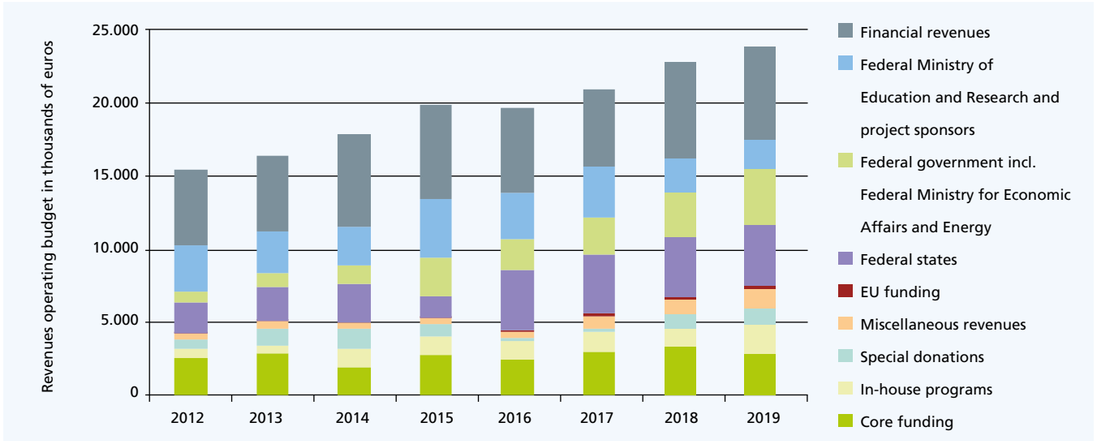
THE INSTITUTE IN FIGURES

Budget

The budget of the Fraunhofer IMWS is made up of an operating budget and an investment budget. The Fraunhofer IMWS operating budget for 2019 was EUR 24.0 million. The operating budget comprises all personnel and material expenses. It is financed through external revenues from industry and the public sector and through institutional funding (core funding). The proportion of revenues from industry in the 2019 budget was 27%. The investment budget for 2019 was EUR 3.4 million.

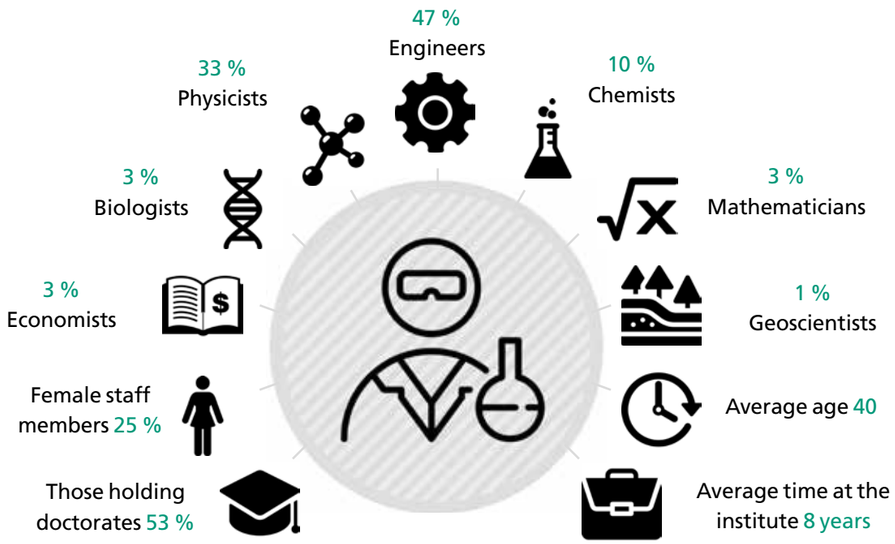




Personnel development

At the end of 2019 there were a total of 258 permanent staff members at the Fraunhofer IMWS. This figure includes 119 scientists. If trainees, scientific assistants and interns are included, the institute's workforce numbers 335 persons.

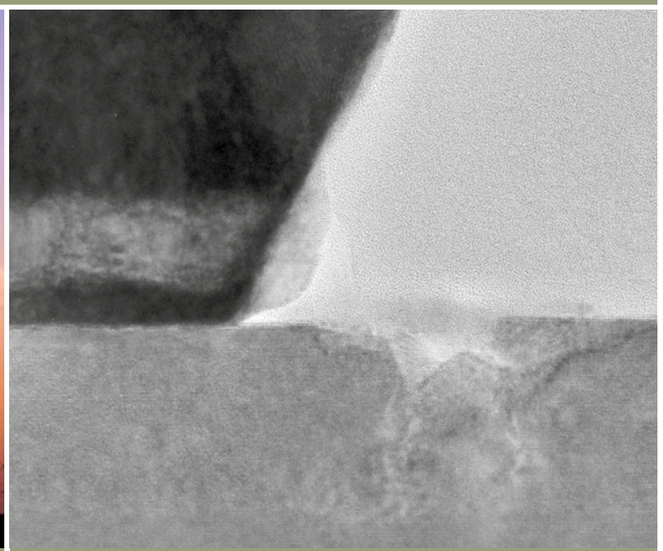
The scientific personnel at the Fraunhofer IMWS comprise...



A SELECTION OF RESEARCH SUCCESS STORIES

08 | The annex to the Fraunhofer CAM was inaugurated in September 2019. It offers more space for laboratories and staff members and enhances the institute's analytical capabilities.

10 | If electronic components are exposed to corrosive processes, such as in wind turbines, this can lead to their failure.



11 | In the project entitled »Ultimate GaN« gallium nitride is researched as a potential semiconductor material.

»WE WILL SUCCESSFULLY DEPLOY NEW TECHNICAL POSSIBILITIES ON BEHALF OF OUR CLIENTS«

Interview with Head of business unit Frank Altmann

2019 saw many changes at the Fraunhofer IMWS. What remains most strongly in your memory in your particular business unit?
For me personally it was the transfer of our former business unit director Prof. Matthias Petzold to the post of Institute Director. As his former deputy I filled the post he vacated and have been the acting business unit director since October. A highlight that will undoubtedly characterize our work for years to come was the opening of the CAM annex. First, we have grown strongly over the past few years and so in a certain respect the new building is testimony to our success in working with industry. Moreover, the enhancement of our facilities with ultramodern research equipment will offer us even more opportunities to support our industry and research partners and to make available new solutions in the field of failure diagnostics.

What markets are you focusing on and what are the benefits that companies can gain by working together with the Fraunhofer IMWS?
Our customers comprise the entire electronics supply chain from semiconductors right down to components. The automobile industry is a core area because of its high expectations in terms of process quality, reliability and the lifespan of components. This means that failure diagnostics with a broad theoretical basis and high-performance failure diagnostics, which forms part of our key competences, is all the more important. Our knowhow in relation to the microstructure of materials and the resulting properties of materials enables us to detect/discern defect mechanisms, recognize the risk of failure and the »physics of failure« as a basis for these processes.

Autonomous driving is something that you are particularly keen to support. How do you envisage your contribution in this area?
We support our customers above all as regards the reliability and quality assurance of electronic components. In this respect the challenges are immense: more performance from components in a smaller space while at the same time guaranteeing strict requirements in terms of reliability, with ever shorter innovation cycles. This requires the optimization of materials and manufacturing processes and the availability of newer, more efficient failure diagnosis methods, e.g. supported by AI-based signal analytics.

What is planned for 2020?
2019 was characterized above all by personnel changes and the inauguration and commissioning of our new wing. Now the emphasis will be successfully deploying new technical possibilities on behalf of our customers.

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NEW EQUIPMENT, NEW LABORATORIES: FRAUNHOFER CAM CONSOLIDATES ITS LEADING POSITION AS A CENTER FOR MATERIALS DIAGNOSTICS

The Fraunhofer CAM celebrated the inauguration of its new wing with guests from industry, science and politics.

The new wing at the Fraunhofer Center for Applied Microstructure Diagnostics CAM signals the intention of the Fraunhofer Institute for Microstructure of Materials and Systems IMWS in Halle (Saale) to expand its leading international position in the field of microstructure diagnostics. The new equipment and new premises will present it with even greater opportunities to study materials right down to the atomic level and, for example, to increase the reliability and lifespan of components used in autonomous vehicles. A total of 9.9 million euros was invested for this purpose.

»What Went Wrong?« is the phrase written by the artist Michael Krenz on the wall of the new building. This is precisely the question that the staff at the Fraunhofer CAM grapple with when studying the materials and components used in electronics and optical materials and technologies: using the very latest diagnostic methods and ultramodern analytical equipment, they investigate how defects arise, what changes in the microstructure of materials occur during manufacturing and in use and how more efficient materials can be developed.

»For example, components can only function reliably in modern driver-assistance systems in the automobile sector if our understanding of the behavior of the materials used extends right down the finest detail. We offer this know-how to our clients. With our new facilities we will take the competences already existing in Halle in the investigation of microstructures to a new level. This is a thrilling prospect and I would like to thank everybody who has contributed to the expansion of the Fraunhofer CAM«, says Prof. Ralf B. Wehrspohn, the director of the Fraunhofer IMWS up to the end of September 2019 when the new wing was inaugurated.

Dr. Reiner Haseloff, the Minister-President of Saxony-Anhalt, stressed the contribution that the research institute will make to key issues in the future such as digitalization, new mobility concepts and energy-efficient and CO_2-lean manufacturing processes: »With its internationally recognized expertise the Fraunhofer CAM does not only support leading global corporations but also hidden champions in the region. The expansion will lead to the creation of an even better interface between scientific excellence and clients from industry. This will enable us to unlock potential for growth in key industries.«

Frank Altmann presents the high-resolution transmission electron microscope now available for use in the new building.

Since construction work began in February 2017, 778 m^2 of additional useable space have been added. The expansion led to the creation of 25 new high-tech posts. The total costs amounted to approx. 9.9 million euros of which around 4.5 million euros were invested in new equipment. The entire project was supported with funds from the federal government, the federal state of Saxony-Anhalt and the European Fund for Regional Development (EFRE).

The new research equipment includes a probe-corrected high-resolution transmission electron microscope, the first of its kind in Europe, a time-of-flight secondary ion mass spectrometer for analyzing surfaces and a scanning electron microscope for nanoprobing, which can be used in combination with focused ion beam technology. The expanded range of equipment will allow the Fraunhofer CAM to occupy a position as one of the world's foremost technological poles and consolidate its reputation as a center of excellence with a distinct identity. This will enable it to meet the sharp increase in demands from clients who rely on the Fraunhofer CAM as a partner when it comes to satisfying the very highest requirements in terms of safety and reliability.

> *»Without reliable electronics it will never be possible to get to grips with the challenges of digitalization or improved resource efficiency.«*

It will also create excellent framework conditions for the development, together with equipment manufacturers, of newer and more efficient materials and defect analysis methods. The importance of the quality assurance of electronic components continues to increase, not only for autonomous vehicles or electromobility. The challenges of digitalization or improved resource efficiency will never be mastered without reliable electronics with understandable and predictable material reactions.

The new wing will also house the business unit Optical Materials and Technologies founded in 2018 as part of the Fraunhofer IMWS. This is where high-tech components and materials used in nanotechnologies are studied and developed, especially with a view to highly complex optical applications such as mirrors for extreme ultraviolet light, modern spectacle glasses, glass-ceramics or effect coatings. »Such applications are based on complex layer systems consisting of just a few layers of atoms or nanostructured components. In order to master the manufacturing processes involved or evaluate the market potential of new solutions high-resolution analytics is essential«, says Prof. Thomas Höche, the business unit's director. »In the same way that materials continually change and become more efficient, we must continue to refine our analytical tools and methods. At the new Fraunhofer CAM we are in an excellent position to achieve these goals.«

SACHSEN-ANHALT

EUROPÄISCHE UNION
EFRE
Europäischer Fonds für regionale Entwicklung

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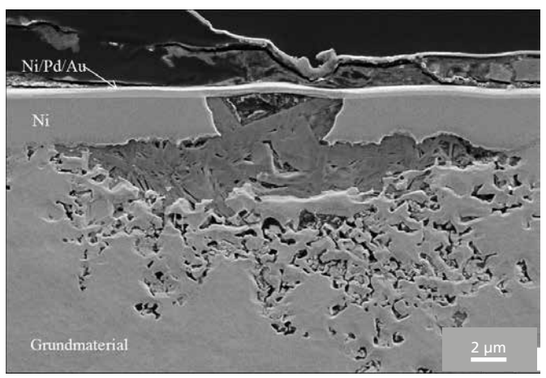
FASTER RECOGNITION OF SUSCEPTIBILITY TO CORROSION

Materials in electronic components are exposed to corrosive processes due to environmental conditions such as dampness, temperature and pollution. Corrosion – also the materials reaction to its environment – usually occurs locally and results in components and systems being significantly affected; this increasingly is the cause of failure of electronic components.

The proportion of faults due to corrosive processes has clearly increased in the past five years. The reason for this is the progressive miniaturisation and broad use of control electronics in automobile and power electronics.

Standard tests to examine corrosion have hitherto been very lengthy, expensive and could not deliver sound evidence on the corrosion behaviour of actual assembly modules. Plug connectors or circuit boards – components, which are difficult to access for chemical analysis - pose particular problems. Fraunhofer IMWS together with ECH Elektrochemie Halle GmbH is working on the research project »Developing an electrochemical rapid test for high reliability electronic application – analyses and method development for electrochemical processes in components for automobile and performance electronics« (ESAMKA) in order to establish a more efficient and environmentally-friendly test method to explore local electrochemical processes on automobile and power electronic components and contacts when they are exposed to corrosive media agents.



Scanning electron microscopy (REM) analysis of defect formation on the cross-section of a corroded layer system Bronze-Ni-NiPd-Au.

The test method is based on standardised electrochemical measurements. A locally usable, miniaturised corrosion-measuring cell must be developed for this. In the first instance, the main emphasis is focused on the development of a local micro test method for typical coating systems in the electronics industry, with thin metallised top layers in gold, which are a few nanometres thick. Here, questions on monitoring of coatings, density and failure phenomena such as the Black Pad Effect – the corrosion of deposited nickel/gold layers without current – will be examined. The newly developed measuring method and the relevant ECH GmbH measuring instruments are tested at Fraunhofer IMWS using comparison measurements and associated high resolution physical methods (scanning electron microscopy, energy dispersive x-ray analysis, transmission electron microscopy).

The new miniaturised testing device allows, for the first time, the characterisation of corrosive processes in the smallest of electronic components without having to rely on the costly preparation of model samples or reference test specimens. This allows the much accelerated and more efficient evaluation of new materials and material combinations regarding their corrosion behaviour.

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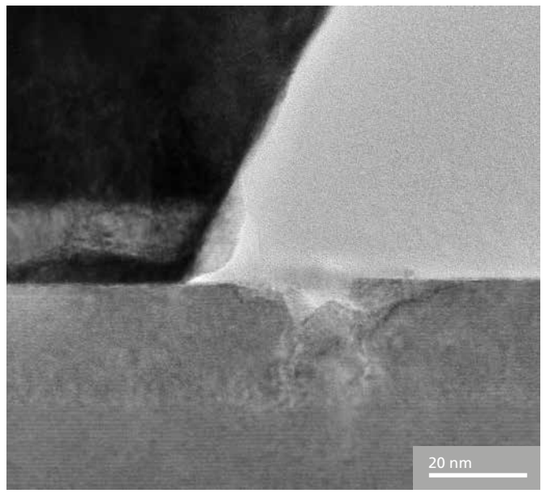
POWER SEMICONDUCTORS MADE OF GALLIUM NITRIDE CAN HELP IMPROVE ENERGY EFFICIENCY

Energy-efficient chips based on the semiconductor material gallium nitride (GaN) are being developed by 26 partners from nine European countries in the project UltimateGaN. The Fraunhofer Institute for Microstructure of Materials and Systems IMWS in Halle (Saale) is one of the project's partners, sharing its know-how in failure diagnostics and the development of analytical methods.

Digitalization in industry and private households, electrification for enhancing mobility and the increased use of electricity from renewable energies generate the need for power semiconductors that are capable of converting electricity more efficiently than previous solutions. In order to make available this technology for a range of applications at competitive prices, 26 partners came together in »UltimateGaN«, one of Europe's largest research projects. They have placed their hopes on gallium nitride (GaN), a new semiconductor material, to enable use of innovative power and high-frequency electronics technology and hence the development of a new generation of energy-efficient chips. The possible applications of these new energy-efficient chips are myriad and include for example shorter charging times for electric vehicles, quicker data transfers between plants, buildings and machines or more efficient grid feed-ins of electricity from renewable energies.

For its part, the Fraunhofer IMWS brings many years of experience in high-resolution microstructure analysis and complex error diagnostics for electronic components, together with its know-how in the development of new study methods. The special material properties of GaN, which enable higher power densities, are the key to more efficient components. Components based on GaN can be housed in smaller and lighter component structures, enabling electricity to be switched more efficiently and higher data transmission rates. Power losses are reduced by up to one half. The work by the Fraunhofer IMWS centers on structure characterization and high-resolution failure analytics of lateral and vertical GaN architectures and contributes to a deeper understanding of failure modes and degradation mechanisms. This includes the characterization of interface properties at gate and ohmic contacts and between GaN stack and passivation, the development of specially adapted analytical methods enabling the localization and physical analysis of defects and the determination of defect risks in wire bonding over active GaN structures.



Pitting defect on the gate of a high-electron-mobility transistor (HEMT) made of GaN. This pitting arises due to mechanical tensions and electrochemical oxidation.

The project is financed with investments from industry, grants from the German federal states involved and the ECSEL Joint Undertaking (Electronic Components and Systems for European Leadership).

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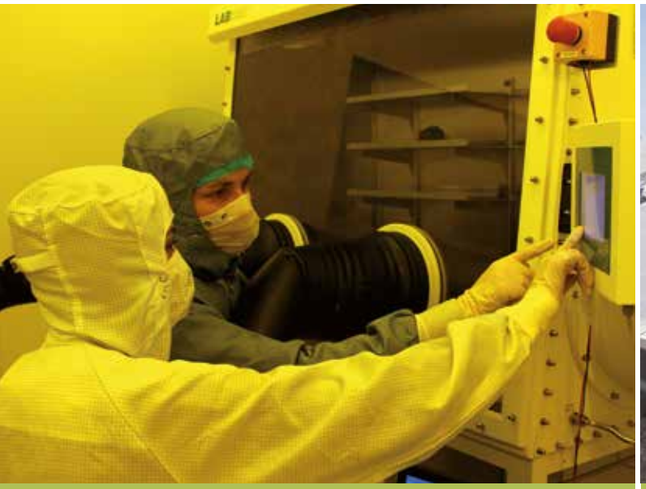
A SELECTION OF RESEARCH SUCCESS STORIES



14 | The plasma etching of silicon nitride can increase the light output of solar cells.

16 | Anti-soiling coatings can improve the efficiency of solar panels in desert regions.

17 | Precursors based on pentachlorodisilane offer potential for more powerful microelectronics.

»RELIABILTY AND THE OPERATIONAL MANAGEMENT OF SYSTEMS ARE ACQUIRING EVER GREATER IMPORTANCE«

Interview with Head of business unit Prof. Ralph Gottschalg

Looking back at 2019 at the Fraunhofer CSP what stands out most vividly in your mind?
The extremely intensive strategic process we went through in 2019 will stand us in good stead for the tasks ahead of us.
I am proud of the acknowledgement of our technical expertise: in 2019 colleagues from our business unit won a total of six science awards. Personally, I was very happy about my election as Vice-Chair of the »Operation and Maintenance and Asset Management Task Force« at Solar Power Europe. It will now be my task to support this industry association in drafting quality guidelines.

Which markets are you focused on and what advantages can companies gain by working together with the Fraunhofer CSP?
First, we are an established partner for the photovoltaics industry in Germany and Europe in terms of ensuring ongoing improvements in the quality and reliability of products and risk reduction – starting from the choice of materials, encompassing production processes, right down to the installation of systems and the avoidance of warranty claims. We possess outstanding expertise in measurement and evaluation methods and our excellent facilities allow us to set standards in solar cell diagnostics and metrology, fault diagnostics and the physical investigation of the causes of defects and degradation processes.
We can also offer competent support in materials traceability, polymer and chemical analysis and the evaluation and automation of processes, including the possible integration of Industry 4.0 approaches.

What major trends can you discern – beyond increases in efficiency and cost reduction – in photovoltaics?
The emphasis will be less on the manufacture of a competitive product and more on the maintenance and maximization of its value. This increases the importance of reliability and the maintenance of photovoltaic systems and issues relating to the sustainability of technology. The second trend, hopefully, is that it will finally be possible to support the amazing performance of German companies operating downstream, e.g. in system planning and construction, operational management or maintenance, enabling them to hold their own in the face of international competition. Previously, there was a heavy focus on module production. But now a much greater contribution can be made downstream at regional level in adding value and creating new jobs.

What is in the pipeline for 2020?
Simulation is becoming ever more important, both in terms of guaranteeing reliability and forecasting energy yields and hence providing support downstream. We will concentrate our efforts on unlocking the potential of machine learning and artificial intelligence more effectively for the market.

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MORE LIGHT OUTPUT IN SOLAR CELLS THROUGH PLASMA TEXTURING OF SILICON NITRIDE

In order to reduce the reflection of light, silicon solar cells are coated with a surface treatment. A research project by the Fraunhofer Center for Silicon Photovoltaics CSP and the Anhalt University of Applied Sciences is pursuing a new approach: Instead of treating the silicon itself, an overlying layer of silicon nitride (SiN) could be textured with a plasma. This could make it possible for the first time to use plasma texturing in industrial solar cell production.

Solar cells should reflect as little light as possible so that a large part of the incident light energy can be converted into electricity. To reduce the reflection, the surfaces of crystalline silicon solar cells are specially adapted. Wet-chemical texturing using hydrofluoric acid / nitric acid (HF/HNO_3) or potassium hydroxide / isopropyl alcohol (KOH/IPA) is customary for creating surface structures on a µm scale. The light is deflected several times within these structures; Layer thickness, structure width and refractive index are chosen so that light that was originally reflected can in turn be directed back into the cell. In this way, the overall reflection of a solar cell can be reduced. On an untreated surface, depending on the wavelength, between 25 and 80 percent of the incoming light is reflected; after wet chemical processing, these values are significantly lower.

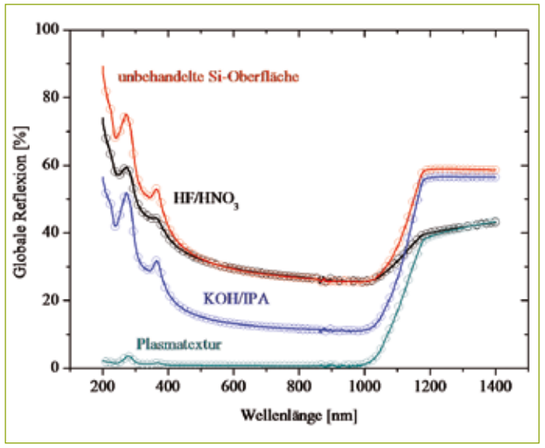
Project manager Dr. Sylke Meyer and employee Sahar Jafari (front) work in the clean room on the new technology.

However, this solution has a natural limit due to the geometric optics: Because the width of the structures created by the surface treatment is larger than the light wavelength, only a moderate reduction in reflection can be achieved. In a joint project with the Anhalt University of Applied Sciences, a team from Fraunhofer CSP wants to develop another idea by the end of March 2020: the so-called maskless plasma texturing of silicon ("black silicon method"). Instead of using wet chemical processes, the silicon is treated with fluorine- and oxygen-containing plasmas. Nanostructures that are smaller than the light wavelength are created on the surface of the solar cells. This makes almost »light-absorbing« surfaces possible.

But this method also has several disadvantages, especially for the industrial production of silicon solar cells. The plasma treatment deteriorates the electrical properties and thus the efficiency of the cells, among other things because the silicon surface is exposed to ion bombardment from the plasma, which reduces the lifespan of the charge carriers and is also contaminated during the plasma process. Last but not least, the process can hardly be integrated into the already extremely mature production processes in the solar industry, since numerous process parameters would have to be adjusted in order to be able to use plasma-textured wafers.

The approach of the project is therefore not to texture the silicon itself, but to treat an overlying layer of silicon nitride with the plasma. In this way, the excellent optical properties of the plasma texture should be preserved without the electrical properties deteriorating. This solution could also be used for industrial solar cell production without any problems, because this step can also be carried out afterwards with a finished solar cell without having to retrofit the systems used for it.

The project team submitted a patent application for the idea of texturing a SiN layer deposited on the silicon using a gas mixture containing fluorine, hydrogen, carbon and oxygen ("black silicon nitride method"). All problems associated with the black silicon method (enlargement of the silicon surface, ion bombardment, contamination) can be dealt with. The SiN layer also serves for surface passivation and can even be used to optimize the cell's efficiency in addition to other properties of the cell, such as stability against defects such as potential-induced or light-induced degradation.



Comparison of the global reflection between an untreated silicon surface (red), acidic wet chemical HF/HNO_3 (black), alkaline KOH/IPA (blue) and a Si plasma texture (green).

There are already a number of approaches to compensating for the disadvantages of plasma texturing of silicon in the laboratory. However, these are too complex and expensive to implement in the industrial production of solar cells. The project team wants to take up some of these ideas and use them for the black silicon nitride method.

With a feasibility study, the researchers have already demonstrated that a SiN layer can be deposited on the silicon surface using a PECVD (plasma-enhanced chemical vapor deposition) process, and that this can then be textured using a mask-free plasma etching step without causing damage to the underlying silicon by the plasma. The current project aims to further develop the process for the production of 6" wafers with a homogeneous texturing over the entire surface. For this purpose, the results are analyzed, for example, using scanning electron images of the surface morphology of the plasma-textured silicon nitride.

This allows conclusions to be drawn about the etching chemistry, physical components and the reaction kinetics. From this, optimized settings, for example for pressure, gas flows and temperature, can be derived during texturing. In addition, the researchers are investigating the optical and electrical properties. The result of the project should be a device concept for a prototype for industrial use, which takes process stability, throughput and the possibility of integration into an existing solar cell production into account.

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OPTIMIZATION OF POWER OUTPUT OF SOLAR MODULES WITH ANTI-SOILING COATINGS

The use of photovoltaic modules in sun-blessed regions, above all in desert regions such as Morocco, Saudi Arabia or Dubai is increasing. New solar parks are springing up because the solar radiation in the earth's »sunbelt« as these regions are referred to is usually twice as high as in our more moderate climes. However, the use of solar modules in the desert is affected by the accumulation of layers of sand and dust particles on the module surfaces, known as soiling. In a new project a team from the Fraunhofer CSP is collaborating with partners to find solutions to this problem.

Abundant sunlight, ample terrain unsuitable for residential use or for agriculture: the use of photovoltaic modules in desert regions offers many tempting possibilities and nowadays, more and more, also represents an attractive option for the generation of hydrogen and other liquid fuels. However, solar plants built in such zones have to satisfy special requirements. Fluctuations and differences in temperature and the impact of UV radiation are especially intense. This is compounded by the »soiling« of the solar modules caused by sand and dust being whipped up, which are deposited on the surfaces of the panels and solidify due to the action of dew. Soiling leads to a reduction in the amount of sunlight reaching the solar cells, so less electricity is generated and the solar module's yield falls.

Soiled photovoltaic plants are nowadays generally cleaned mechanically, i.e. by wiping or brushing the modules with cleaning apparatus or by using cleaning robots. Staff at the Fraunhofer CSP are currently working with partners from industry on a more efficient solution as part of the research project »PV-Foil«.

The aim of the research partnership is to develop and characterize new surfaces with anti-soiling properties for use in photovoltaic modules. If the research partnership achieves this goal, it will represent a major contribution to the deployment of photovoltaic technology in the sunbelt and to protecting the climate.

The soiling of solar modules with sand and dust reduces output in desert regions.

The optimized surfaces should ensure that less dust and desert sand adhere to the modules, thus rendering natural cleaning

> *»Soiling leads to a reduction in the amount of sunlight reaching the solar cells, so less electricity is generated… «*

mechanisms such as the action of the wind more efficient. The investigations will hopefully increase the power output of solar panels in sunny regions and the ability of operators to plan with certainty based on the expected output as well as reducing operating costs associated with cleaning and maintenance.

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ULTRA-HIGH PURITY PENTACHLORODISILANE FOR THE NEXT GENERATION OF MICROELECTRONICS

The coating of modern microelectronic components requires the lowest possible process temperatures. PSC GmbH would like to offer pentachlorodisilane (PCDS) as an efficient, innovative starting material for this demanding process. At the Fraunhofer Center for Silicon Photovoltaics CSP, new methods of ultratrace analysis are being developed in parallel to ensure that the manufacturing processes meet the highest quality requirements.

The process of chemical deposition is particularly attractive for the coating of microelectronic components. This process allows even complex surfaces to be coated well and uniformly, which is exactly what modern chips need because they have very filigree, three-dimensional architectures within a very confined space. The principle of chemical deposition is that gaseous starting materials (precursors) are guided over a substrate and thereby chemically decomposed (for example by heating or excitation with light or a plasma), resulting in a new layer being deposited as a solid on the substrate surface.

The precursors required for this are the main product of PSC GmbH in Bitterfeld-Wolfen. Together with the Fraunhofer CSP, PSC GmbH would like to develop new precursors that enable even lower deposition temperatures than the previously common starting materials, for which disilanes such as hexachlorodisilane (Si_2Cl_6, HCDS) are often used. This is the only way to achieve the necessary, particularly low process temperatures that are essential for highly integrated chips: In such components, individual layers are often only a few nanometers wide, which is why they cannot withstand high temperatures during the manufacturing process.

Avoiding contamination of the samples during the analysis process is a particular challenge of the project.

The company has already identified pentachlorodisilane (HSi_2Cl_5, PCDS) as a promising material. Together with the Fraunhofer team, a possibility is to be found to produce high-purity PCDS in large quantities. In addition to the actual manufacturing process, which is being developed by PSC GmbH, new analysis methods are also required, which are to be developed at Fraunhofer CSP.

In order for new microelectronic materials to be stable during manufacture and reliable later in use, ultra-high-purity qualities are required. This means that only contaminations in the lower single-digit parts-per-billion range are allowed. Otherwise, for example, metallic elements can damage the circuits. In order to prevent this, suitable, reliable and routine methods of ultra-trace analysis are being developed in the project. The Fraunhofer CSP contributes its great expertise in the ultra-trace analysis of silicon. In addition, excellent equipment for sensitive element analysis is available for the project.

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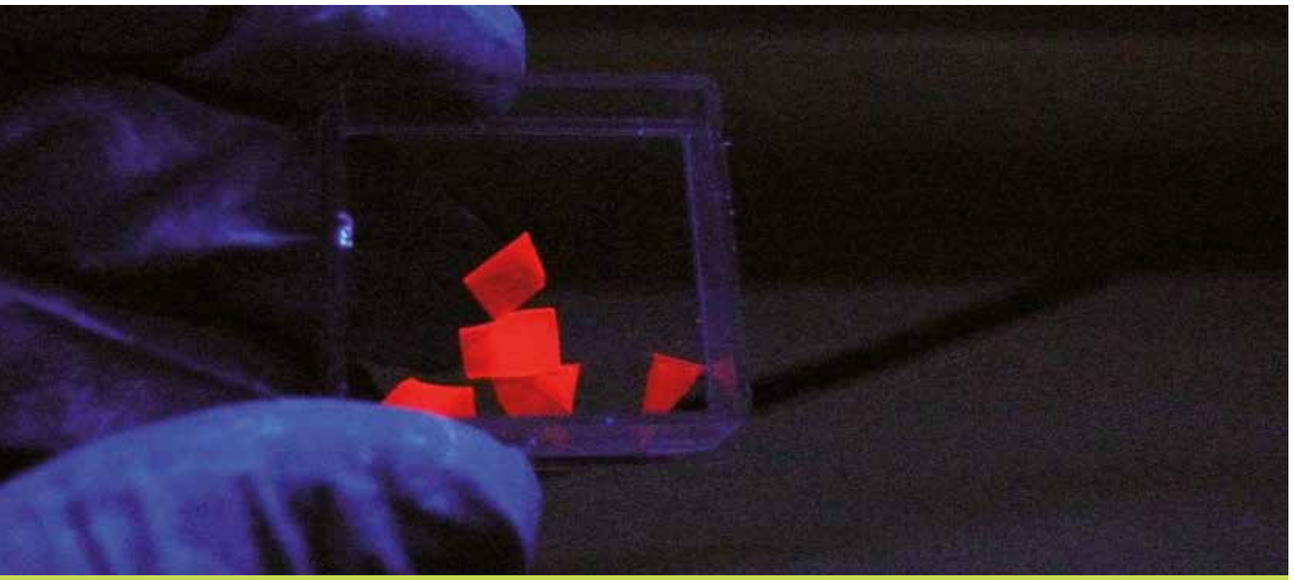
A SELECTION OF RESEARCH SUCCESS STORIES



20 | Fluorescent markings enable glass to be marked for product traceability

21 | The nucleation processes observed during the synthesis of glass ceramics, used for example in ceramic cooktops, were studied at the nano level

»THE NEWLY EQUIPPED WING WILL ENABLE US TO ENHANCE OUR ABILITY TO STAND OUT FROM THE CROWD AS A CENTER OF EXCELLENCE«

Interview with Head of business unit Prof. Thomas Höche

2019 was a year that saw myriad changes at the Fraunhofer IMWS. With reference to your business unit, what stands out most in your mind?
Without a doubt the inauguration of our new wing. After setting up the business unit Optical Materials and Technologies in 2018 we quickly realized that it was a structure capable of offering excellent research facilities. The structures within the business unit itself have also continued to take shape. Our visibility vis-à-vis our clients has continued to grow, thanks in no small measure to the workshops and symposia organized by us in Halle. Our new extension houses Europe's first scanning transmission electron microscope HF5000 made by Hitachi. During one of the inaugural workshops we were able to present the new potential avenues for investigation that the microscope opens up in the field of nano and surface analytics to an international public made up of specialists. This new instrument will go a long way to consolidating our reputation as a unique center of excellence.

Which markets are you focused on and what advantages can companies gain by working together with the Fraunhofer IMWS?
Our clients include companies from the optics industry, the paint industry, and the special engineering sector. We are specialists in the application of microstructure diagnostic and analytical methods in the context of optical materials. We use our know-how in diagnostics as a basis to develop new materials more quickly. At the same time we improve processes involving laser-based material processing by also drawing on our in-depth understanding of microstructures.

What are the typical application fields for this type of expertise?
We play a supporting role in the development of glass and glass-ceramics and use our expertise to gain an understanding of microstructure-property relationships. Other areas include effect paints, e.g. those used for car lacquer, as well as optical coatings in lithography, laser technology or the ophthalmic industry. A good example of an application is the award-winning, low-expansion glass-ceramic product called LEAZit™ developed by us. This new material can for example be used in high-tech products such as laser mirrors or as an expansion-adaptive filler. We are currently holding talks with partners from industry who have expressed an interest in bringing this innovation onto the market.

What is in the pipeline for 2020?
We will work on marketing LEAZit™. There will also be new features for the microPREP™ developed by us in collaboration with 3D Micromac AG and which has already successfully established itself worldwide in the field of laser preparation. And we also have some great ideas at a preliminary development stage, which we intend to implement together with existing and new partners.

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FLUORESCENT MARKINGS FOR HIGH-TECH GLASS

How can we mark a glass object so that it can be clearly identified within a large batch or used to trace a product? In order to answer this question boraident GmbH and the Fraunhofer Institute for Microstructure of Materials and Systems IMWS in Halle (Saale), in a joint project, have turned their attention to laser-based, fluorescent markings and developed a process.

Laser markings are one of the main products in the portfolio of boraident GmbH in Halle (Saale), which specializes in the development of products for application on glass and other transparent mediums in accordance with customers' needs. These markings already play a major role in manufacturing: by referring to different identifying characteristics it is possible to recognize a glass product and its current location or the stage of production it has reached. Here, printing is generally unsuitable for this purpose because glass is very smooth and ink is not absorbed.

Together with the Fraunhofer IMWS, a new technique enabling glass surfaces to be marked was developed in the 3-year project. The project consortium set out to create fluorescent markings on glass surfaces which were largely invisible and durable in the visible spectrum in daylight but capable of fluorescing in the visible light spectrum when stimulated by UV light, so as to render them (machine-)readable. Such markings, which can be applied using a laser process on or in the glass, offer the additional advantage that the glass is not damaged by the markings, something, for example, that can occur in other methods such as glass printing.

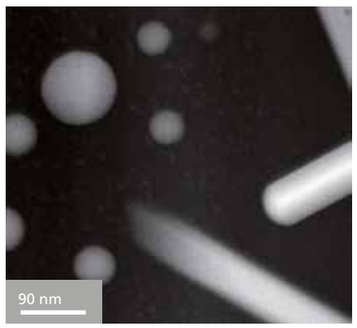

Image of the nanostructure of a $Eu(NO_3)_3$ / $BA_2TiSi_2O_8$: Tb^{3+}-solution-laden macroporous glass following thermal collapse

»Both parties have benefitted enormously from the collaboration. Our industry partner boraident was able to expand its process know-how in the laser inscription of glass and were able to input our innovation strengths in materials science, including the development of fluorescent materials and microstructure diagnostics used to speed up the process of developing materials and processes«, says Prof. Thomas Höche, Head of business unit »Optical Materials and Technologies« at the Fraunhofer IMWS while explaining the approach adopted. In his words, a few extremely promising possible applications include product reliability and protection against falsification, both of which are acquiring ever increasing importance in the manufacture of high-tech glass products such as those found in medicine, the chemical industry or telecommunications. Using the method developed by the Fraunhofer IMWS, glass, for example, can be marked with information about its manufacturer – and this can be done over the entire lifecycle of the glass and individualized so that the marking is rendered difficult to copy.

During the project a number of different approaches were pursued ranging from fluorescent nanopowders, fluorescence-particle-laden or aqueous rare-earth-laden macroporous glass, which were caused to collapse under the influence of heat, right down to saline solutions implanted in the glass surface by means of laser irradiation. The result of the project is a practically realizable and resilient solution to the problem posed.

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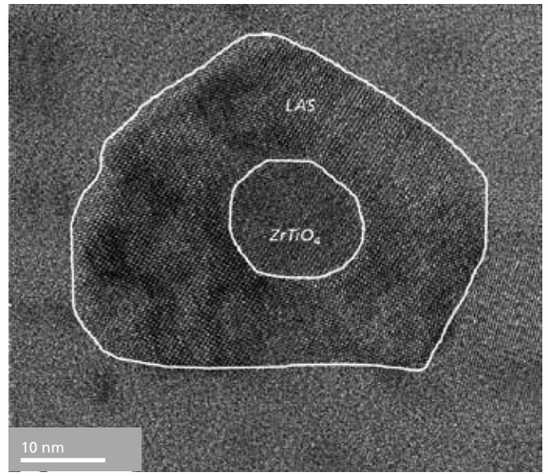
NANOSTRUCTURE-BASED DEVELOPMENT OF GLASS-CERAMICS

The complex nucleation processes at nano scale involved in the synthesis of zero-expansion glass-ceramics are being studied in a joint project with the Otto Schott Institute of Materials Research, Jena University.

Lithium aluminum silicate (LAS) glass-ceramics are widely used as zero-expansion materials in applications where the expansions accompanying sharp fluctuations in temperature must be avoided. Glass-ceramic cooktops are an outstanding example of such applications. The low expansion coefficient is made possible by a finely adjusted interaction of special crystalline secretions in the material with the glass surrounding it. LAS crystals may display the unusual property of negative thermal expansion. If they are created in a glass with positive thermal expansion, the resulting overall expansion of the composite material may be negligible even in the presence of significant temperature fluctuations. Nevertheless, the complex crystallization processes arising during the manufacture of such materials are as yet not fully understood. The usual glass compositions may in some cases have more than 15 interacting components. At the same time, the small size and the sensitivity of the crystalline secretions to electron irradiation, typically ranging between 3 and 30 nm, represent a considerable challenge when it comes to analyzing these processes.



High resolution nanostructure of a LAS glass ceramic: Growing a LAS crystal on a $ZrTiO_4$ seed crystal.

The project funded by Deutsche Forschungsgemeinschaft (DFG) in collaboration with the University of Jena has set itself the goal of gaining a broader understanding of the processes at nano scale, with a view to accelerating the development of glass-ceramics in the future and improving their properties. Particular attention is dedicated to the role of nucleating agents – tiny crystals, mostly ZrO_2 or TiO_2 or a mixture of both. They are required to trigger the desired LAS phase with adjustable size distribution.

Another focus of the project is the reduction of the composition of glass to as few components as possible, so as to gain a better understanding of the crystallization processes these model glass samples undergo. In this way, it was shown that the desired LAS phases can be formed from a simplified base glass with just six components and a nucleating agent. For the first time it was possible to obtain an image with using an electron microscope with sufficient resolution to enable the orientation relationship between nucleating agent and LAS crystal to be evaluated.

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A SELECTION OF RESEARCH SUCCESS STORIES

24 | The Fraunhofer branch specializing in carbon cycle technologies began operating in Freiberg.

25 | In the future, large-scale water electrolysis at the Leuna Chemical Complex will provide sustainable support to the chemical industry.

»SUSTAINABLE SOLUTIONS IN THE CHEMICAL INDUSTRY ARE IN HIGH DEMAND«

Interview with Head of business unit Prof. Bernd Meyer

Looking back at 2019 in your business unit what stands out most vividly in your mind?
The immense dynamism of our particular field of expertise was symbolized by the opening of the Fraunhofer branch specializing in carbon cycle technologies in Freiberg: in the future, this is where research will be conducted on the efficient, resource-saving and climate-neutral use of carbon carriers. Our network NK2 is a platform for the carbon circular economy in which partners from the economy, the scientific and political worlds and civil society will be able to engage in an exchange straddling different sectors. The success of the real-world laboratory Green-HydroChem is another highlight. This project sets out to create the world's largest electrolysis plant in Central Germany to generate green hydrogen.

Which markets are you focused on and how can companies benefit by collaborating?
Any company interested in contributing to the implementation of a sustainable and efficient carbon circular economy for processes involving the intensive use of carbon will find that we are a competent, creative and innovative partner. Such companies include those from the chemical industry, manufacturing, mechanical engineering and plant construction without forgetting the energy and waste recycling industry. The greatest demand currently comes from the chemical industry, because this is where there is a need to expand the basis of raw materials now mainly relying on fossil fuels and embark upon the development of the large-scale chemical recycling of plastic waste. We can also offer first-class processing expertise, extensive technological know-how, test plants on a quasi-industrial scale and an extremely good network.

The activities at the Fraunhofer IMWS in the field of carbon and hydrogen technologies could eventually be transferred to a new, self-standing Fraunhofer institute. Could you explain more?
Such an institute could provide a myriad of impulses to companies, especially those in the chemical industry and other energy-intensive branches in Central Germany, in the transition to a sustainable industrial society. This could result in the creation of a first-class pole of attraction in the region for technologies of the future in high demand worldwide.

What is in the pipeline for 2020?
The commencement of work on the construction of our electrolysis platform in Leuna will send an important signal that we are finally making progress on implementing our large-scale projects and on achieving our goal of establishing Central Germany as a pilot region for Chemistry 4.0. We are also working on the development of the module platform GreenCarbonChem in Leuna. Our plan is to develop and set up new gasification systems in different stages for the chemical recycling of carbon-rich waste.

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A BRANCH SPECIALIZING IN CARBON CYCLE TECHNOLOGIES

In the future, research will be conducted at the TU Bergakademie Freiberg on the resource-friendly and climate-neutral use of carbon carriers. In June 2019 Dr. Eva-Maria Stange, the Minister of State at Saxony's Ministry of Science and the Arts, approved the start-up funding for a research group on carbon cycle technologies. The new research unit is a branch of the Fraunhofer Institute Microstructure of Materials and Systems IMWS in Halle (Saale).

Carbon is a central building block of the economy and can be found in numerous products used in our daily lives. Industry's demand for carbon is mainly satisfied through primary sources of carbon such as crude oil, natural gas or coal. In the future, researchers at the Institute of Energy Process Engineering and Chemical Engineering (IEC) at the TU Bergakademie and the Fraunhofer IMWS intend to employ new processes and technologies on a large scale to enable the efficient and resource-friendly utilization of other carbon sources as low as possible in CO_2 emissions. These will include plastic and biomass waste, but also renewable energies such as wind and solar power and green hydrogen.

The institute is leading in Europe for research and development in the field of the thermal-chemical conversion of primary and secondary sources of carbon, in particular coal, natural gas and carbon waste. In this way, the IEC can develop economically viable and sustainable solutions to urgent issues affecting society. Apart from the benefits in terms of protecting the climate, it also solves the problem of plastic waste. Instead of contaminating the landscape and the seas, plastic could become a source of materials for the carbon cycling economy. There is great potential: currently in Germany alone, around 47 million metric tons of carbon waste are recycled in thermal waste treatment and combustion plants.

Within the next 10 to 15 years, the processes and technologies will be developed on a large scale, enabling use with lower emissions of CO_2 of the primary and secondary sources of carbon combusted up to now. These solutions will close the carbon

Prof. Dr. Klaus-Dieter Barbknecht, Rector of the TU Bergakademie Freiberg, PD Dr. Christian Growitsch, Deputy Head of the Fraunhofer Institute IMWS, Dr. Eva-Maria Stange, Minister of State for Science and Arts of the Free State of Saxony and Prof. Dr. Bernd Meyer, Director of the Institute of Energy Process Engineering and Chemical Engineering (IEC) at the TU Bergakademie Freiberg and Head of the business division »Chemical Conversion Process« at the Fraunhofer Institute IMWS (from the left) opened the new research institute.

cycle through the reintroduction of all sources of carbon into the process chains (chemical recycling). At the same time, the economically competitive manufacturing of mass-market products (e.g. basic chemicals, plastics) and high-priced specialist products (e.g. carbon fibers, extraction materials) using domestic carbon carriers will be enabled, including the use of residual materials with as wide a quality spectrum as possible.

During the four-year development phase just approved, investments in equipment for the analysis of carbon carriers and their conversion products and in pilot test plants are also envisaged. The various input materials will be tested there under industrial conditions in accordance with different conversion concepts.

One of the pilot plants for the conversion of carbon carriers into

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LARGE ELECTROLYZER LEUNA WINNER IN THE IDEAS COMPETITION REAL-WORLD LABORATORIES OF THE ENERGY REVOLUTION

Federal Minister of Economics Peter Altmaier selected »GreenHydroChem Central Germany« as one of the winners in the »Real-world Laboratories of the Energy Revolution« ideas competition of the Federal Ministry for Economic Affairs and Energy (BMWi). With over 100 megawatts, the world's largest electrolysis plant project for the production of green hydrogen was planned by partners Siemens AG, Linde AG and the Fraunhofer Institute for Microstructure of Materials and Systems IMWS and is now entering the concretization phase.

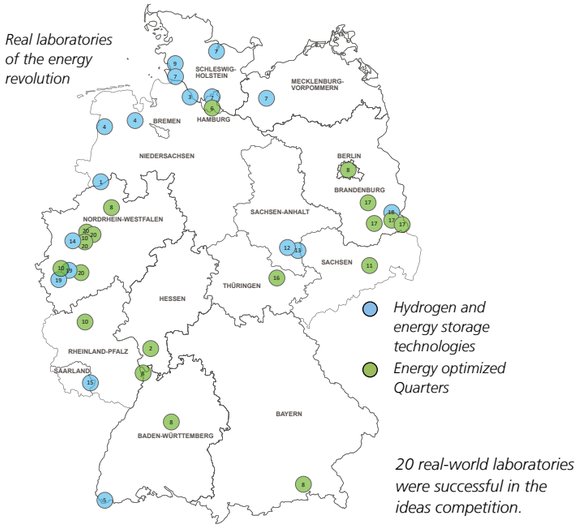
»Together with our partners, we will demonstrate the generation and storage of green hydrogen as well as its application in various utilization paths within the framework of sector coupling,» explains Florian Bergen, project manager at Siemens and overall coordinator of the GreenHydroChem real-world laboratory. »This will be the first industrial-scale supply of green hydrogen to the »Middle German Chemical Triangle« region.« The use of renewable energies from the wind and sun to produce environmentally friendly hydrogen or to refine it into CO_2-neutral chemical raw materials or fuels (e-fuels) will make a significant contribution to the reduction of CO_2 in the mobility and chemical sector.

Green hydrogen reduces greenhouse gas emissions by up to 91%. The GreenHydroChem real-world laboratory will thus make an important contribution to the transformation of energy systems in the industrial value chains and to the further development of the Central German economic region. GreenHydroChem Central Germany will be implemented in Leuna by 2024.

»With this step, we are bringing an innovative technology from Germany to the industrial scale, which is already of great interest to regions with high installed wind and photovoltaic capacities,« explains Armin Schnettler, Head of Corporate Energy Research at Siemens Corporate Technology. »This way, Germany can not only position itself as a global pioneer in the energy revolution, but also give new impetus to our country's reputation as a leading export nation.«

Siemens AG and the Fraunhofer-Gesellschaft, together with the Free State of Saxony, decided in July to build a hydrogen innovation center in Görlitz. »The knowledge gained there will flow directly into the real-world laboratory. This will make it even clearer what outstanding potential hydrogen and power-to-X have for implementing sector coupling and mastering the shaping of structural change with innovative technologies,« says Ralf B. Wehrspohn, then Head of the Fraunhofer IMWS and now board member of the Fraunhofer-Gesellschaft for Technology Marketing and Business Models.

Real laboratories of the energy revolution



20 real-world laboratories were successful in the ideas competition.

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POLYMER APPLICATIONS

A SELECTION OF RESEARCH SUCCESS STORIES

30 | A new method enables standardized testing of highly resilient sandwich materials.

31 | The potential of biopolymers for lightweight structural applications are demonstrated with the aid of a child seat demonstrator.

28 | Biomimetic synthetic rubber (BISYKA) enables the creation of tires with less wear.

»WE ARE EXPERIENCING A WELCOME RENAISSANCE IN LIGHTWEIGHT CONSTRUCTION«

Interview with Head of business unit Prof. Peter Michel

Looking back at 2019 in your business unit what stands out most vividly in your mind?
A highlight is the start of »digitalTPC«. In this joint project together with three other Fraunhofer institutes, we are developing a digital twin for thermoplastic composites. From our point of view, this is a new, exciting field – not necessarily falling within the realms of materials science or engineering but driven by data, IT and AI. By digitally representing an entire value chain without losing sight of materials and material changes, we take a step closer to a completely new interpretation of the term »digital twin«. The project's industry advisory board sees great potential in this pioneering idea.

Which markets are you focused on and how can companies benefit by collaborating with the Fraunhofer IMWS?
We are currently experiencing a renaissance in lightweight construction – e.g. through the lightweight construction initiative of the Federal Ministry for Economic Affairs and Energy extremely welcome from our perspective, because thermoplastic-based lightweight solutions are an important pillar of our core business. We support clients from the automobile industry in reducing the weight of vehicles and increasing their range. Another important mobility-related topic is the tire market. Here we are researching and developing a rubber composite designed to optimize rolling resistance and abrasion behavior. Other applications for our innovations can be found in sports equipment or the fields of urban infrastructure / construction.

Since the advent of the catchwords »microplastics« and »ocean waste« plastic has acquired an image problem. What is your response?
Our response is sustainability, above all energy and material efficiency. Lightweight thermoplastic materials are a good example of how plastic can help in this respect, because they reduce CO_2 emissions and give rise to components and assets with a long lifespan. For several years we have been active in the field of biopolymers and are developing new fields of application for such plastics based on renewable materials. Our BISYKA tires made from biomimetic synthetic rubber make a direct contribution to the reduction of microplastics in the environment, since a large proportion of such microplastics originate from tires. This type of tire has up to 30 percent less abrasion.

What is in the pipeline for 2020?
For the first time, together with Thermhex Waben GmbH, we will organize the international fiber composite sandwich conference. We will also once again be involved in the organization of the Central Germany Plastics Conference, which will be held together with the Biopolymer Congress for the first time. Naturally, we are all eagerly awaiting the completion of the new wing to our pilot plant center in Schkopau. The new facilities will allow us to deve-

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SYNTHETIC RUBBER OUTPERFORMS NATURAL RUBBER

Natural rubber from rubber trees is a raw material with a limited supply. Synthetically produced rubber, on the other hand, has not yet been able to match the abrasion behavior of the natural product, rendering it unsuitable for truck tires. But now, for the first time, a new type of synthetic rubber has been developed that achieves 30 to 50 percent less abrasion than natural rubber.

Truck tires have to put up with a lot: As a result of the heavy loads they carry and the long distances they travel every day, they are subject to heavy wear and tear. Consequently, the treads of the tires are manufactured primarily from natural rubber that comes from rubber trees and to date has demonstrated the best abrasion characteristics. Before now, artificially manufactured rubber has been unable to match the performance of natural rubber, at least in this respect. The problem with natural rubber is that the security of supply for this important raw material is endangered. In Brazil, the original home of the rubber tree, the fungus Microcyclus ulei is laying waste to whole plantations. If the fungus crosses over to Asia, where major cultivation areas are located today, the global production of rubber will be threatened.

Biomimetic synthetic rubber with optimized abrasion behavior (BISYKA)

In view of this threat, researchers at the Fraunhofer Institutes for Applied Polymer Research IAP, for Microstructure of Materials and Systems IMWS, for Molecular Biology and Applied Ecology IME, for Mechanics of Materials IWM and for Silicate Research ISC have now optimized the characteristics of synthetic rubber. »Our synthetic rubber BISYKA – that's a German abbreviation for »biomimetic synthetic rubber« – actually has superior characteristics to natural rubber,« says Dr. Ulrich Wendler, who heads up the project at the Fraunhofer Pilot Plant Center for Polymer Synthesis and Processing PAZ in the German municipality of Schkopau. Fraunhofer PAZ is a joint initiative between Fraunhofer IAP and Fraunhofer IMWS. »Tires made of the synthetic rubber lose 30 percent less mass than equivalent tires made of natural rubber. On top of that, the synthetic tires have only half the tread loss. Furthermore, the synthetic rubber can be produced on an industrial scale using existing plants and equipment. This means that the synthetic rubber offers an excellent alternative to natural rubber – including the domain of high-performance truck tires.«

Targeted analysis of dandelion rubber

But how did the researchers achieve this higher performance? At Fraunhofer IME, scientists investigated rubber from dandelions. Like the rubber from rubber trees, 95 percent of dandelion rubber consists of polyisoprene, while the remaining percentage is made up of organic components such as proteins or lipids. The advantage of dandelion rubber over tree rubber: the former has a generation succession of just three months as opposed to seven years for the latter. That makes rubber made from dandelions an ideal starting point for investigating the influence of organic components on the rubber characteristics. To this end, the Fraunhofer researchers eliminated the key organic components involved in a targeted manner.

After they had identified the organic components that were important for abrasion behavior, the researchers at Fraunhofer IAP synthesized the BISYKA rubber out of functionalized polyisoprene with high microstructural purity and the respective biomolecules. Their colleagues at Fraunhofer IWM and IMWS then investigated the characteristics of the rubber variants thereby obtained. To do this, they used extensional crystallization: If you stretch natural rubber to three times its length, crystalline regions form – the rubber hardens. "The extensional crystallization of BISYKA rubber equals that of natural rubber," explains Wendler. When making truck tires, the rubber is usually mixed with carbon black – which is where the black color comes from. Increasingly, however, manufacturers are adding silicates to the mixture instead of carbon black.

Initial testing of tires made from the nature-identical, biomimetic synthetic rubber BISYKA shows that they achieve around 30 to 50 percent less abrasion compared to natural rubber tires.

This is where the expertise of Fraunhofer ISC comes in: At the institute, scientists investigate how new kinds of silica fillers can lead to optimum alternatives to natural rubber in the automotive industry.

Synthetic rubber yields impressive results in practical tests

After the development of the BISYKA rubber, it was tested: Would it do what its extensional crystallization promised? The researchers handed over this question to an external and thus independent partner to investigate: Prüflabor Nord. For this purpose, four car tires were manufactured with a tread made from BISYKA and they were then compared with tires with a tread made from natural rubber. The tests were carried out directly on a car that drove 700 circuits in one direction and then 700 circuits in the other direction. And the result? While the natural rubber tire was 850 grams lighter after the test and lost 0.94 millimeters of tread, the BISYKA tire lost merely 600 grams and 0.47 millimeters of tread. The rolling resistance of the synthetic rubber was also better: While the natural rubber achieved a score of C on the traffic light labelling of the rolling resistance, BISYKA achieved the higher score of B. »So far, we have only carried out initial tests with the BISYKA tire blend, but they are extremely promising. As the next step, we want to further optimize the BISYKA rubber. This concerns above all the proportion and the composition of the organic components. At the same time, we will adapt the formula of the tread compound for truck tires to the new rubber,« says Wendler. Currently the researcher and his team are looking for cooperation partners who will bring the product to the market.

On April 4, 2019, the researchers presented their results at a transfer workshop at the annual conference of the German Rubber Society, East (Deutsche Kautschuk-Gesellschaft Ost) in Merseburg, Germany.

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STANDARDIZED TEST PROCEDURE FOR QUALITY CONTROLS ON SANDWICH COMPONENTS SUBJECT TO HIGH LOADS

Sandwich structures enabling lightweight construction, such as those used in the aircraft industry, in rotor blades at wind power plants or lightweight vehicles, consist of fixed top layers which are separated by an extremely light-weight core material. Mechanically they are very resilient and at the same time extremely light. However, if the rigid connection between the top layer and the core is damaged by improper loading, in extreme cases this can lead to the failure of the component. The Fraunhofer Institute for the Microstructure of Materials and Systems IMWS has developed a standardized test procedure based on its findings about the microstructure of such components using in-situ X-ray tomography to examine fracture toughness, so as to reliably predict the load limits of such sandwich structures and prevent damage.

Experimental setup of a single cantilever beam test (SCB) for a sandwich sample with a honeycomb core

The load-bearing top layer may separate from the supporting core following impact stresses, overloading or as a result of errors during manufacturing or repair work; this is known as »disbond« damage. If the damage initially remains undiscovered due to the limited extent of the damage or because it is not directly visible, it may continue to spread during continued use of the component, reduce the load-bearing capacity of the sandwich structure and in some cases lead to the complete loss of the component's integrity.

In a research project promoted by the Federal Ministry for Economic Affairs and Energy and conducted together with the Institute of Aerospace Engineering TU Dresden, the Fraunhofer IMWS developed a standard test method enabling fracture toughness, as a way of quantifying the resistance of sandwich materials against the spreading of disbond damage – i.e. the local separation of the top layer from the core – to be analyzed and hence reliably predicted.

Based on the results a specification for carrying out the test procedure on lightweight honeycomb sandwich materials with very thin top layers was drawn up and incorporated into an international initiative for the standardization of the test. The data and results collected will flow directly into a new standard at the international standards organization ASTM and will be included in the CMH-17 Composite Materials Handbook – a handbook made up of several volumes recognized by international certification bodies and aviation regulatory bodies and used to interpret composite structures.

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CHILD'S SEAT MADE OF NATURAL-FIBER-REINFORCED BIOPOLYMERS

In the project, the forces acting on the child seat made of biopolymer are measured and simulated.

Using a child seat demonstrator for vehicles, the Fraunhofer IMWS demonstrates the potential of fiber plastic composites based on biopolymer matrices and endless natural fiber reinforcement for lightweight applications. The project partners are Evonik Nutrition & Care GmbH, SachsenLeinen GmbH, TU Chemnitz and EDAG Engineering GmbH as well as GK Concept GmbH, Britax Römer Kindersicherheit GmbH, Knoten Weimar GmbH and ID Berlin.

The aim of the joint project is to develop a sustainable and fully bio-based hybrid component with high standards in terms of structure and safety. Once developed, the new materials, technologies and construction methods will be validated using a hybrid injection-molded demonstrator in the form of child seat shell.

Starting out from a bio-based polyamide, wood fiber-reinforced injection molding compounds and flax-fiber-reinforced UD tapes are developed as an endless fiber-reinforced high-performance compound for use as local reinforcement components in the child seat shell. A new method to manufacture the tape involving tow fibers – a cheap and widely available secondary product generated during the treatment of long bast fibers – has been designed and implemented.

Apart from the task in terms of process engineering consisting of optimizing the structural alignment in the fiber composite semi-finished product, other materials-related issues concerning the fiber-matrix interaction in the materials systems developed in this way are also studied. Different additives with in places potentially crosslinked characteristics obtained using ionizing radiation are tested with regard to their ability to improve the mechanical (tensile strength, expansion behavior, impact resistance) and physical (H_2O absorption, heat distortion temperature) material properties depending on the intensity of the radiation. Then tailored reinforcement inlays (laminates) are pressed from the flax-fiber-based UD tapes.

The fiber alignments in the reinforcement inlays are adjusted to the later load cases applied to the child seat shell and built up with minimum wastage using a near-net-shape technique. The biopolymer demonstrator created in the hybrid injection molding will furnish useful information about the process-structure-property relationships and the load limits of bio-based natural fiber reinforced composites, eventually arriving at the objective of combining an enhanced lightweight construction with a competitive and sustainable production method.

Apart from the creation of a demonstrator through the application of process engineering principles, the project will also furnish information about its potential in terms of recycling, including examination of recycling concepts for bio-based lightweight structures.

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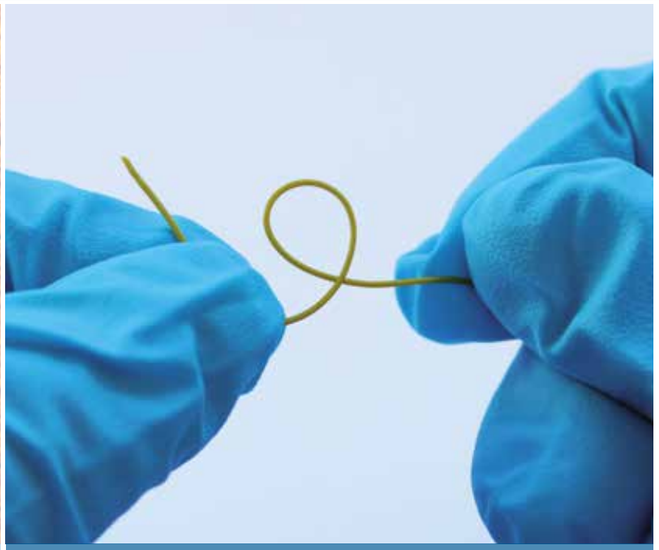
BIOLOGICAL AND MACROMOLECULAR MATERIALS

A SELECTION OF RESEARCH SUCCESS STORIES

34 | New anti-fouling technologies were developed for membrane filters used to obtain drinking water.



36 | Rods instead of pills: A new method promises improvements in the treatment of periodontal disease.

37 | Elastin and collagen offer promising ways of using materials to treat wounds.

»OUR PASSION IS THE DEVELOPMENT OF INNOVATIVE MATERIALS FOR HEALTH AND QUALITY OF LIFE«

Interview with Head of business unit Dr. Christian Schmelzer

2019 was a year of many changes at the Fraunhofer IMWS. Looking back at your business unit what stands out most vividly in your mind?
Last year we achieved both our scientific and our economic goals, so we can draw a positive balance. Apart from successfully completing a few exciting projects with our industrial and research partners, 2019 was also marked by reinforcements in terms of personnel and equipment, allowing us to acquire important new skills. One particular highlight was the positive interim evaluation of the ATTRACT Project »SkinNext« at the end of the year. At a specialist colloquium attended by colleagues from the Martin Luther University, the Fraunhofer central office and the institute's management, the course for the next project phase was set.

Which markets are you focused on and how can companies benefit by collaborating with the Fraunhofer IMWS?
Our passion is the development of innovative solutions capable of improving people's quality of life. This is why we research and improve materials for dental, personal care and health products side by side with our industry partners from the fields of medicine, healthcare and the environment. As well as supporting companies during research, development and quality control with our specific know-how we can also use our research results to support the development of a claim to position a product. We carry out valuable basic research within the context of publicly sponsored projects and internal projects in order to bolster our portfolio with the very latest scientific findings.

Biological transformation is something of a megatrend, even in the field of materials. What contribution can your business unit make in this respect?
As the name of our business unit suggests, this megatrend is an important subject for us. An example of the research we conduct is the biological transformation of implant surfaces so that they can interact with the body's own cells, thus reducing the possibility of rejection. In 2019 we also embarked on the joint project »NewChi« in which together with German and French partners we will develop new sources for the production of the biopolymer chitosan, of great importance especially in medicine, cosmetics and water treatment.

What is in the pipeline for 2020?
We will continue the process, which has already gotten off to a successful start, of developing our new strategic reorientation. From now on this will be led by an advisory board of leading economic specialists. During the year we will also make important investments to renew and expand our range of instruments for microstructural analysis and the development of biomaterials, thus enabling us to meet the demands of our partners and clients now and in the future.

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DEVELOPMENT OF ANTIFOULING - OPTIMISED SURFACES FOR REVERSE OSMOSIS MODULES RESULT IN BETTER PERFORMANCE

Clean drinking water is a valuable commodity, which unfortunately is not in sufficient supply in all countries of the world because of the lack of fresh water springs. An energy efficient method to extract usable drinking water from salt or brackish water is the so-called membrane filtration in a reverse osmosis process.

The filtration performance of the membrane modules used in this process (Figure 1) is reduced during use due to the deposition of soluble suspended solids, salt crystals and microorganisms. This biofouling takes place both on the RO membranes and on the spacers between the membranes, the so-called feed spacers, and significantly impairs the filtration process.

In the collaborative project »Innovative Membrane Spacers«, in cooperation with the IAB Ion Exchanger Bitterfeld GmbH (LANXESS AG), biofouling on the feed spacer networks was investigated. Functional polymer coatings have been developed to prevent biofouling.

The mesh-like geometry and the curved surface of the feed spacers represent a particular challenge for the coating and for its material science characterization. For this reason, additional coatings were also carried out on model foils, which were extruded from the feed spacer granulate, a polypropylene (PP) and high-density polyethylene (HDPE) mixture.

Several coating technologies were combined to create effective and long-term stable anti-fouling coatings. First, the surface of the feed spacer (polyethylene/polypropylene blend) was activated by a plasma treatment and functional groups were generated. Zwitterionic polymers (sulfobetaines) bind to these functional groups and form a hydrogel-like barrier layer through hydration of the head groups (Figure 2). The feed spacers coated with zwitterionic sulfobetaine methacrylate show an increase in hydrophilicity, a reduced surface roughness and a significant reduction in biofilm formation (Figure 3). Due to the suppression of various physico-chemical interactions, both macromolecules and microorganisms can adhere more difficultly and there is an antifouling effect.

The developed technology for antifouling equipment of feed spacers can be transferred to the industrial scale. This could increase the lifespan of reverse osmosis modules for fresh water production, reduce energy consumption and ultimately improve the sustainability of sea water desalination.

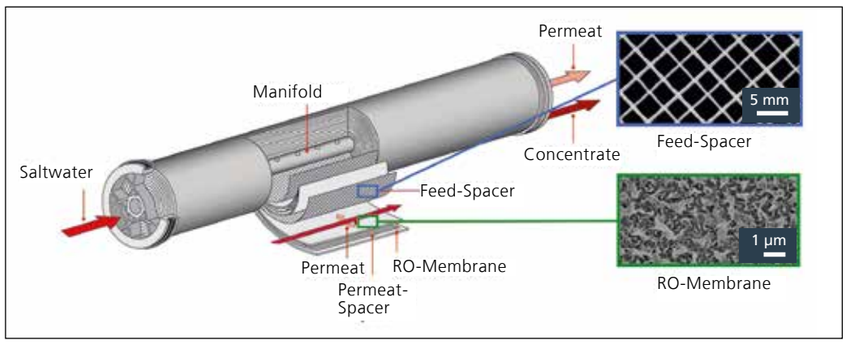

Figure 1. Structure of a Winding module for the Reverse osmosis.

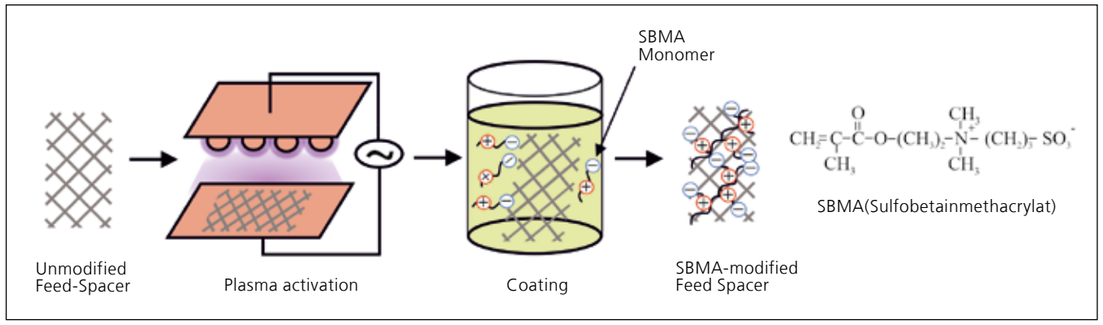

Figure 2. Schematic representation of a two-stage antifouling coating

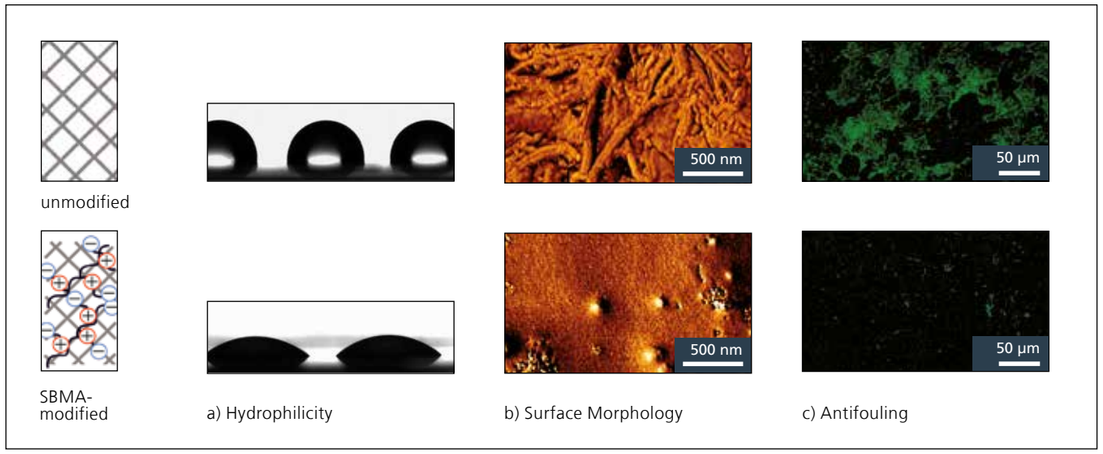

Figure 3. The surface properties of unmodified (top) and zwitterionically modified (SBMA coating) feed spacer materials:
a) water contact angle; b) surface morphology (AFM phase image); c) Antifouling effect - different adhesion of the bacteria Pseudomonas fluorescens

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NEW TREATMENT METHOD FOR PERIODONTOSIS

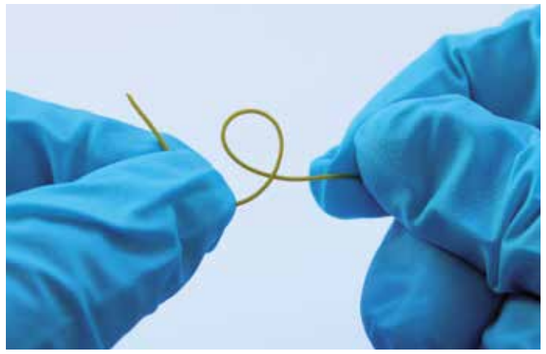
New biodegradable rods promise to provide better treatment for periodontal disease. Researchers from the Institute of Pharmacy at Martin Luther University Halle-Wittenberg (MLU) have re-combined an already approved active ingredient and filed for a patent for their invention together with two Fraunhofer Institutes from Halle. The innovation would spare patients from having many side effects. Their findings were published in the »International Journal of Pharmaceutics«.

Periodontal disease is widespread and usually caused by bacteria, which leads to an inflammation of the gums - the periodontitis. More than 50 % of adults in Germany develop periodontal disease in the course of their lives, mostly in old age. The inflammation affects the entire body and is often the cause of other diseases such as heart attacks or pneumonia. Therefore, mechanical cleaning procedures are often followed by antibiotics. These are usually administered in pill form, which puts a strain on the entire body. Common side effects are diarrhoea, abdominal pain and nausea as well as skin reactions such as redness and itching.

Ideally, the antibiotic would only act locally in the mouth rather than throughout the entire body. The research group of the MLU has therefore combined a proven antibiotic (minocycline) with an equally proven pharmaceutical excipient (magnesium stearate). The complex is just as effective, but more stable. It slowly releases the antibiotic on the spot. For simple application, the research team uses flexible, biodegradable polymer sticks that contain the antibiotic complex. The small rods can be easily inserted into the gingival pocket.

The team at the Fraunhofer IMWS used various test models to examine the adhesion, wetting and rheological properties of the developed formulations, for example with regard to how they interact with the hard and soft tissue in the oral cavity.

At the Hugo Junkers Prize, the innovation prize of the State of Saxony-Anhalt, the joint development, which could be ready for the market in just a few years, was awarded the third prize in the »Most Innovative Projects in Applied Research« category. The project was financially supported by the State of Saxony-Anhalt with funds from the European Regional Development Fund (ERDF) as part of the »Transfer and High-Performance Centre Chemical and Biosystems Technology«.



Flexible, biodegradable rods containing antibiotics for pariodontitis treatment. © Martin Luther University Halle-Wittenberg/Faculty Marketing NF1

MARTIN-LUTHER-UNIVERSITÄT
HALLE-WITTENBERG

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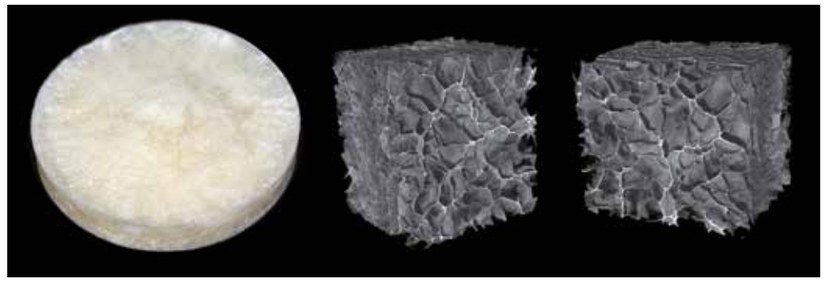
BIOMIMETIC MATERIALS FOR RAPID WOUND HEALING

The skin is not only the largest, but also one of the most versatile human organs. Above all, it has a protective function by creating a barrier to the environment for the internal organs.

However, external environmental influences, intrinsic aging processes and injuries damage the skin tissue and lead to a partially irreversible loss of function. Poorly healing and chronic wounds are particularly problematic since there are often no products available for adequate wound care and the treatment is therefore often lengthy. Research successes of the past years on aging and healing processes at the molecular level, as well as the (further) development and improvement of innovative manufacturing processes enable the production of novel, resorbable biomaterials, which can be used to minimize loss of function, shorten treatment times and improve the chances of recovery.

Since 2016, Fraunhofer IMWS employees have been researching and developing novel biomaterials for dermal use as part of the »SkinNext« project, funded by the Fraunhofer-Gesellschaft »Attract«-program. The researchers are particularly focusing on the fiber proteins elastin and collagen, which are found in the connective tissue and are responsible for the elasticity, stretch and tensile strength of the skin and other organs. Starting with proteins that are isolated from animal tissues, hydrogels are created that are further processed in the process of freeze-drying to open-pore, extremely porous sponges. These are characterized by a high swelling capacity and can absorb wound fluid, maintain a moist environment necessary for wound healing and at the same time bind excess enzymes in the wound that are disadvantageous for wound healing as a »sacrificial substrate«.

The team is also developing protein-based nonwovens using electrospinning technology, which uses an electric field to create nanofibers from viscous protein solutions. In their composition and microstructure, these imitate the fibers of the connective tissue and are therefore an optimal basic structure for cell colonization. The Fraunhofer IMWS team is currently focusing on transforming research and development into marketable products and is striving for their certification.



left: macroscopic image of a round elastin / gelatin sponge (semi-finished product for a wound dressing) with a diameter of 4 cm. Right next to it: (2 cubes) micrographs of this sponge can be seen, showing the porous structure of this sponge. The edge length of the cube is 5 mm.

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»WE HAVE ESTABLISHED A REPUTATION AS AN IMPORTANT PARTNER FOR THE LIGHTING AND ILLUMINATION INDUSTRY«

Interview with Head of business unit Prof. Stefan Schweizer

2019 was a year of many changes at the Fraunhofer IMWS. Looking back at your business unit what stands out most vividly in your mind?
In the future, the Fraunhofer Application Center for Inorganic Phosphors will play a role in enhancing the sustainability and competitiveness of the lighting and illumination industry. This is the result of the assessment at the end of the initial five-year phase of our research center founded in 2013. The evaluators from the Ministry of Culture and Science of the federal state of North Rhine-Westphalia and the Fraunhofer-Gesellschaft were extremely satisfied with its evolution, as was the Application Center's industry advisory board. We are happy that our work over the past few years has garnered so much recognition. The praise from our partners from industry in particular shows that our research activities are on a good strategic footing and that we are on the right path.

Which markets are you focused on and how can companies benefit by collaborating with the Fraunhofer IMWS?
Our service and research competencies are primarily directed at regional industries. But we also want to be a partner for research topics centering on lighting and illumination and related fields throughout Germany. Wide-ranging optical and spectroscopic analysis, thermal measurement methods and performance measurements for the evaluation and development of phosphors and phosphor systems and materials lie at the heart of our laboratory expertise. We have excellent technical facilities and work with our industry partners with a focus on the provision of services.

What is in the pipeline for 2020?
A major area of interest will be the development of our activities in the field of infrared thermography. Here, an important aspect concerns gaining a better understanding of measurement limits when determining transient temperature behavior. Last year we filed an invention on the subject matter »thermal structural function« with the German Patent Office. The method developed by us will help obtain a more precise understanding of the thermal behavior of materials and systems. In close cooperation with the university of applied sciences we will expand our range of measurement techniques in the field of surface characterization. We intend to acquire a device used to determine the bidirectional scattering distribution function (BSDF), enabling a precise description of the scatter behavior of light hitting surfaces.

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IMAGING TECHNIQUE FOR INVESTIGATING HEAT PATHS

In many technological applications, adequate cooling of heat-sensitive components is absolutely essential. An imaging technique for investigating and quantifying heat paths will help detect and evaluate weak spots.

Over the last few years the light-emitting diode (LED) has become a universal method for providing an artificial source of light. They are far superior to conventional phosphors, both in terms of efficiency and durability. However, in phosphor-based white LEDs the conversion from blue to white light causes the phosphor and hence the LED to heat up considerably. In total, around 25 percent of the electrical energy reaching the LED chip is converted into heat. The high temperatures accelerate ageing processes; as a result, the lifespan of the LED and hence of the luminaire is reduced. So heat management is an important aspect in the development of a luminaire. Whereas the inner structure of an LED with reference to heat transfer is optimized by its manufacturer, the other components of the heat path are the responsibility of the luminaire manufacturer.

Infrared thermography is a contact-free method for efficiently measuring surface temperatures. It can be used to measure the temperature of an extensive surface. Although static temperature readings enable the excessively hot points of a test specimen to be located, this method does not furnish any detailed information concerning which components of the heat path lie at the origin of the weak spot. With this challenge in mind, an imaging technique was developed at the Fraunhofer Application Center for Inorganic Phosphors in collaboration with the South Westphalia University of Applied Sciences capable of detecting and evaluating these weak spots. In order to achieve this, an algorithm designed to evaluate time-resolved temperature measurements was developed, enabling an image to be obtained of the thermal properties of each individual component of a heat path (see illustration). In this way, poor thermal contact points found, for example, in the welded section between the LED and the printed board assembly can be detected.

> *»The technique will render visible and quantify the individual thermal components of a heat path.«*

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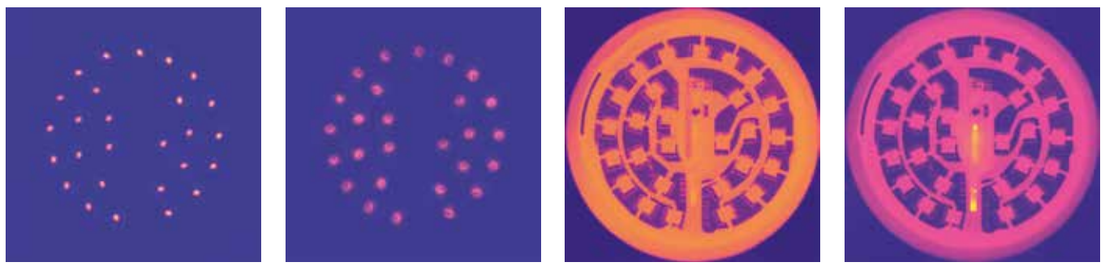
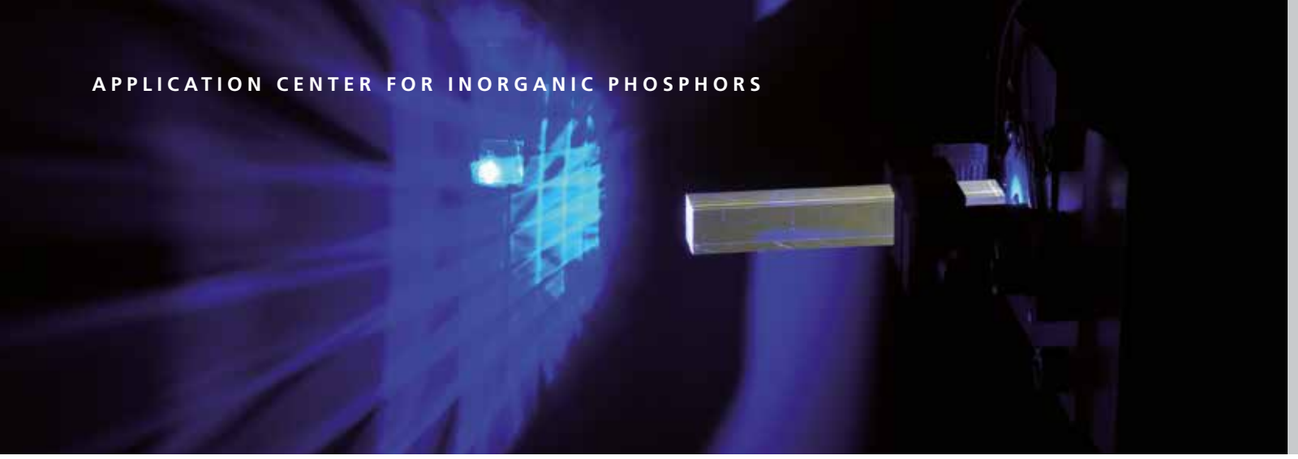


Different thermal behavior of individual components of a retrofit LED luminaire.



Dysprosium-doped glass rod glowing white under blue light excitation

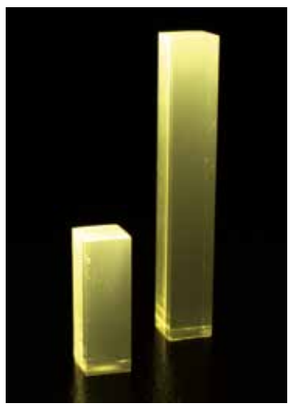
LUMINESCENT GLASS AS A LIGHT CONVERTER

Intelligent light control and advanced lighting concepts such as Human Centric Lighting (HCL) pose more stringent requirements on lighting environments. This can be addressed by further developing LED technology. Phosphors based on luminescent glass are one solution.

A typical white light LED consists of a blue LED chip covered with a phosphor polymer composite. The phosphor converts part of the blue light into yellow light. The development of heat inside this composite can give rise to changes over time in the color impression of the LED. The Fraunhofer Application Center for Inorganic Phosphors is involved in the development of alternative phosphor systems. Glass doped with metal ions from the rare earth elements opens up the possibility of a color impression stable over a long time and which could therefore significantly increase the lifespan of white light LEDs. These glass-based phosphors are characterized by their outstanding material properties and can be shaped at will. This opens the door to a variety of designs and also enables their use as luminescent optical components.

One approach involves glass based on lithium aluminum borate (LiALB), optically activated with the rare earth dysprosium (Dy^{3+}). The amount of luminescence obtained depends to a large extent on the mixing ratio of the two basic components lithium and boric oxide and the concentration of dysprosium. The resulting color impression shifts towards yellow as the amount of lithium oxide increases, whereas a shift towards green is observed with higher concentrations of Dy^{3+}.

In order to evaluate the glass system in detail, various geometric shapes are tried out. An interesting approach for new lighting concepts is provided by glass rods, because they can be used both as light conductors and light converters. The luminescence behavior of such light rods can be adjusted both via their length and the degree of dysprosium activation. In the case of ultraviolet and/or blue excitation the light rods display angle-dependent light intensity and color distribution, which can be predicted by conducting optimal simulations.



A glass rod made of dysprosium-doped borate.

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»WE HAVE DEVELOPED PIONEERING CONCEPTS«

Interview with the director, Dr. Christian Growitsch

2019 was a year of many changes at the Fraunhofer IMWS. Looking back at the Center for Economics of Materials CEM what stands out most vividly in your mind?
2019 was essentially a year of structural change at the CEM. Change concerning our close collaboration with the federal state government and our industrial partners. Here we were able to develop interesting and from my point of view pioneering concepts: in support of the sustainable progress of the region and its enterprises. But also concerning the CEM itself: in spring we set up the branch in Halle dedicated to structural change for the entire Fraunhofer Gesellschaft.

Which markets are you focused on and how can companies benefit by collaborating with the Fraunhofer CEM?
The CEM assesses the consequences of innovation, technology and regulation. Our partners come mainly from industry and politics, but also from industry associations and foundations. We analyze the economic viability of new, sustainable technologies on behalf of our industrial clients, but we also take the perspective of an economist and examine the repercussions of such technologies on society. In a number of analyses we were able to show that, at present, useful macroeconomic investments are not being made, because they are not profitable on a microeconomic level. Such examples of market failure necessitate actions by politicians, e.g. to properly regulate CO_2 emissions or damage to the environment. In this respect, last year also saw structural change facilitated by new laws, and so we were able to calculate the best moments to invest on behalf of our clients. These analyses are also useful for the colleagues in the other business units, because they provide a basis for new business models tailored to the technological innovations at the Fraunhofer IMWS.

What is in the pipeline for 2020?
For the colleagues at the CEM and myself, the changes in 2020 will be much more far-reaching than those in 2019: following its extremely satisfying evolution, the CEM will move into its new home at the Fraunhofer IMW. In the future, the branch will be under the auspices of the institute's new deputy director Sylvia Schattauer. I will personally be moving to the Munich headquarters of the Fraunhofer Gesellschaft to concentrate on the development of economic forecasting in the Executive Board Division Technology Marketing and Business Models. Although the think tank Structural Change will also move in a formal sense, it will actually remain in Halle (Saale); the structural change of coal regions can only be credibly supported in a coal-mining district. In so doing, we will bundle all the Fraunhofer competencies in Central Germany.

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INNOVATION IS THE KEY FOR SUCCESSFUL STRUCTURAL CHANGE

After the successful completion of the work in the Commission »Growth, Structural Change and Employment« at the beginning of 2019, Fraunhofer IMWS continued to support the technology-oriented structural change with a variety of activities. The work of the commission has given many trendsetting impulses. We were active with the conviction that innovation is the key to successfully shaping structural change!

Among other things, an electrolysis test and test platform will be created in the Leuna Chemical Park. Fraunhofer is helping to establish a model region for the sustainable chemical industry in Central Germany.

This perspective was given intensive consideration in the Commission's final report, for example through recommendations for sustainable, cross-sectoral technology developments, the creation of suitable regulatory freedom as well as a research and transfer offensive with the establishment of real world laboratories as a new instrument. We would like to use this tailwind to develop, implement and continuously explore transformation paths towards a sustainable industrial society together with our partners from industry and politics. Innovative, sustainable technologies and new business models are the prerequisite for good new jobs, in the former lignite fields and beyond.

At the Center for Economics of Materials CEM, the corresponding projects were coordinated as part of the management of the Fraunhofer structural change office. The CEM contributed its expertise in the economic evaluation of the consequences of innovation, technology and regulation as well as in sustainable value creation systems. This profile and the presence in the region - primarily through the activities of the service and transfer center for chemical and biosystem technology - enable us as a key player to actively support the structural change process in the previous coalfields and in German industry as a whole.

»Structural change« has long since meant more than just phasing out coal-fired power generation. Ultimately, it is important to design industrial processes that are resource-efficient and climate-neutral, while maintaining social peace and the competitiveness of companies and creating the necessary investment security. Our conviction that we can be successful in this process arises from the idea that the development of a largely CO_2-neutral energy supply and the emergence of circular economic processes should not be seen as a climate-driven gimmick, but as a motor for new value creation potential.

This perspective should also take a future-oriented structural policy into account. The example of Central Germany shows that the strengthening of dynamic cities is just as important as that of established industrial locations in rural areas, from whose economic performance many other industries benefit. In the interplay of urban development and industrial change, a break-free design of structural change is possible without social hardship and de-industrialization.

The duality of hydrogen and carbon plays a central role in this. Green hydrogen, produced by means of electrolysis using electricity from renewable energies, can replace fossil raw materials in the production of numerous products in the chemical industry. Renewable raw materials, residues and carbon-containing waste provide carbon that can be recycled instead of polluting the climate in the form of CO_2 at the end of the product's life. Together, these two approaches enable a climate-neutral industry and also open up enormous potential for the mobility sector, for example with hydrogen and battery-electric drives or synthetic fuels. They provide the basis for new, sustainable industrial symbioses.

Central Germany has significant advantages in terms of location for the use of green hydrogen, sustainable carbon carriers and the establishment of a circular economy: lignite and chemistry have shaped the region, in the corresponding branches of industry skills in process engineering and the organization of complex value creation systems have grown over generations. This is accompanied by an unusually high level of industry acceptance and a pronounced openness to technology. Last but not least, the experience of structural change after the end of the GDR created awareness: only courage, creativity and innovative strength can contribute to preserving the industrial heritage and mastering the transition to a sustainable industrial society.

In order to bundle the competences of the Fraunhofer Gesellschaft in the areas of techno and socio-economic research, the CEM was transferred to the technically tailored Fraunhofer IMW at the turn of 2019/2020. With the affiliation, Fraunhofer also takes into account the special social importance of structural change. In this way, Central Germany can become an innovation laboratory for a sustainable energy and industrial region, which can both secure a competitive advantage and be a role model for other regions in Europe.

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USE OF SCRAP REDUCES CO_2 EMISSIONS FROM STEEL PRODUCTION

The use of high-value steel scrap ensures the economic and ecological sustainability of steel production.

Scrap metal is a fundamental raw material in steel production and makes a significant contribution to reducing emissions. This is the result of the study »Scrap bonus. External costs and fairer competition in steel production global value chains«, compiled by the Center for Economics of Materials CEM on behalf of the Federal Association of German Steel Recycling and Disposal Companies BDSV. According to the report, the use of steel scrap in Europe could reduce the costs of climate change by up to 20 billion euros a year.

The use of scrap steel instead of iron ore to manufacture steel reduces CO_2 emissions. Other environmental damage such as the acidification of water bodies, summer smog or eutrophication are reduced through the use of scrap. In order to illustrate these savings the indicator »scrap bonus« was introduced for the study. It indicates the climate and environmental costs that can be avoided through the use of one tonne of scrap in steel production.

The scientists came to the conclusion that by using one tonne of recycled stainless steel scrap the steel industry could save 4.3 tonnes of CO_2 when producing steel. In the case of carbon steel and assuming the use of one tonne of steel scrap, the savings attained average 1.67 tonnes of CO_2. This means that if one tonne of carbon steel scrap is used as an input material rather than iron ore, the amount of CO_2 saved is equivalent to the amount of carbon dioxide emitted by an average car with a gasoline engine during a journey of around 9000 km. According to the research team, the »scrap bonus« lies between 79 and 213 euros per tonne of carbon steel scrap, rising to as much as 158 – 502 euros per tonne in the case of stainless steel scrap.

The avoidable emissions were calculated in the study on the basis of lifecycle analyses, which examine the generation of emissions during the production of steel right along the value creation chain. This involves performing a rigorous assessment of the lifecycle of the materials used from the extraction, manufacture and use of the raw materials, the use of energy sources right down to the utilization of residual materials.

The study makes a major contribution to raising the awareness of the importance of scrap as a raw material for steel production. Steel recycling is an integral part of a circular economy. This means that the use of high-value scrap represents an example of economically and ecologically sustainable steel production. This in turn has an important leverage effect with regard to the efficient use of materials and raw materials by the clients the CEM advise.

» Steel recycling is an integral part of a circular economy.«

»The results of the study underline the importance of steel recycling and show how it can be quantitatively and qualitatively strengthened, above all through research and development, with a focus on medium-sized enterprises. Additional support and political measures in this area can make an efficient contribution to climate protection while at the same time improving the competitiveness of the steel and steel recycling industries. For us »scrap bonus« is a bonus for scrap«, said BDSV President Andreas Schwenter coinciding with the study's publication.

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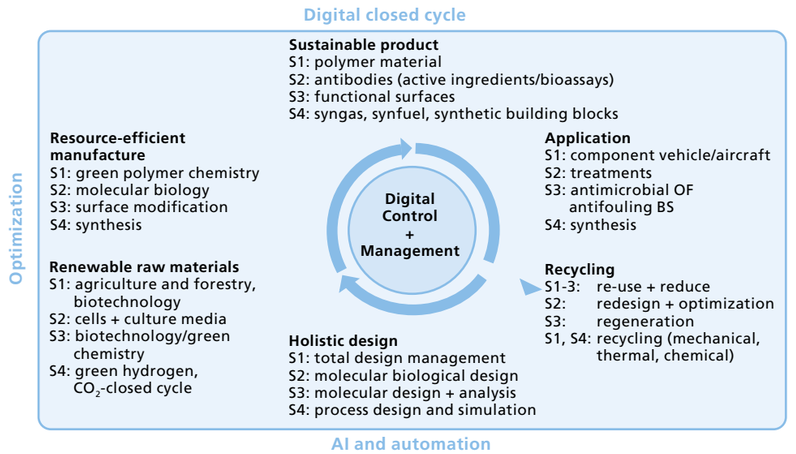
THE CENTER OF EXCELLENCE AND TECHNOLOGY TRANSFER CHEMICAL AND BIOSYSTEMS TECHNOLOGY CENTRAL GERMANY (LTZ CBS)

The Center of Excellence and Technology Transfer Chemical and Biosystems Technology Central Germany (LTZ CBS) is the main port of call for networking science and the economy and has a supra-regional presence, allowing it to act as a catalyst facilitating the interaction of research, the regional economy and politics with a view to accelerating the transfer of technology and know-how.

The activities of the LTZ CBS are especially focused on small- and medium-sized enterprises. In collaboration with research centers, innovative transfer services are provided and promoted in a targeted fashion. The connection between non-university research institutes, universities/institutes of higher education and industry creates synergies and new possibilities for the sustainable continuing development of entire sectors and branches of industry. The LTZ CBS has four different priorities, linked to one another: S1 Polymer- and biopolymer-based materials systems, S2: Holistic materials systems, S3: Sustainable interface chemistry and physics and S4: CO_2-neutral carbon and hydrogen conversion. When selecting a project, priority is given to the potential for innovation and the possibility of exploitation for products further down the line, so as to achieve holistic sustainability in accordance with the UN Sustainable Development Goals.

In many cases, the greatest possible creation of value, a circular economy and the maximization of raw materials and energy efficiency are synonymous with climate neutrality, eco-friendliness and social harmony and stability. The emphasis on a closed cycle enables the amount of by-products and consumption of energy to be reduced and through digitalization, connectivity and the application of artificial intelligence clears the way for holistic process optimization. Creativity and know-how, even deriving from the flow of information, must increasingly be regarded as equally important or even predominant resources, and this includes education, research, qualifications and further training as transfer.

Diagram: Holistic sustainability – Chemical and Biosystems Technology 4.0 – based on interdisciplinary research and development



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HEADS 2019

The first hydrogen filling station was opened in May 2019 in Halle (Saale). ***Joachim Heider*** *(Linde AG),* ***Lorenz Jung*** *(H2 Mobility),* ***Volker Ciesiolka*** *(PS Union),* ***Dr. Reiner Haseloff*** *(Minister-President of the federal state Saxony-Anhalt) and the former director of the institute* ***Prof. Ralf B. Wehrspohn*** *(from the left) enthuse about the new possibilities in sustainable mobility.*

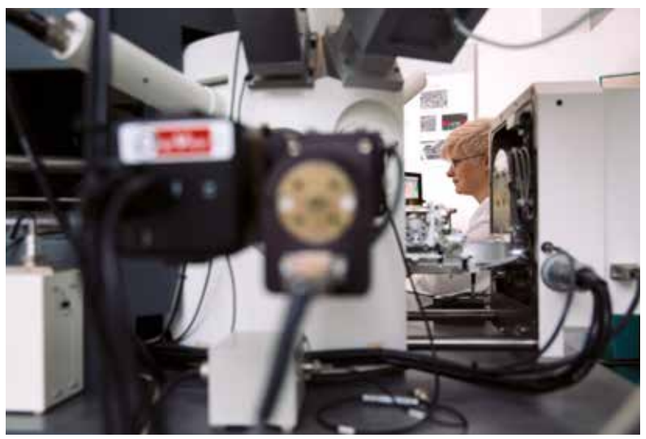
Dr. Sylvia Schattauer *has been a director at the Fraunhofer IMSWS since 2019. She mainly coordinates hydrogen- and carbon-related activities.*

Prof. Bernd Meyer*, Director of the business unit »Chemical Conversion Processes « is one of the initiators of the National Network for a Circular Carbon Economy NK2. Many leading companies from the fields of energy, chemistry, waste management and plant construction have joined the network, which among other forums exchanges ideas in workshops.*

Patrick Diehle *works on the new Hitachi HF 5000. The scanning transmission electron microscope enables even more precise information to be obtained about nanostructures.*

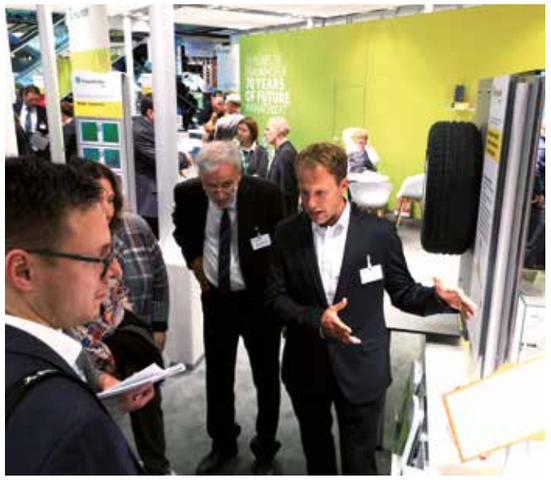
Fingerprints and greasy smears and marks on stainless steel and metal surfaces often require laborious polishing. A sol-gel nanolack designed to prevent such irritating marks is evaluated by ***Dr. Jessica Klehm*** *in a development project with partners set to conclude in 2020.*

Sandy Klengel's *work in the laboratory includes the improvement of materials for electronic system integration. She is one of around 260 staff members fortunate to have an excellent employer: the Fraunhofer IMWS was singled out by the statistics portal Statista as one of the ten best employers in Halle (Saale). The research institute's commitment to the city and to the region received an especially positive mention.*



Benedikt Gröger *(left) and* ***David Krack*** *were two of the participants in the Talent School 2019. During the 3-day workshop a total of 13 students learned about the scientific work carried out at the Fraunhofer IMWS.*

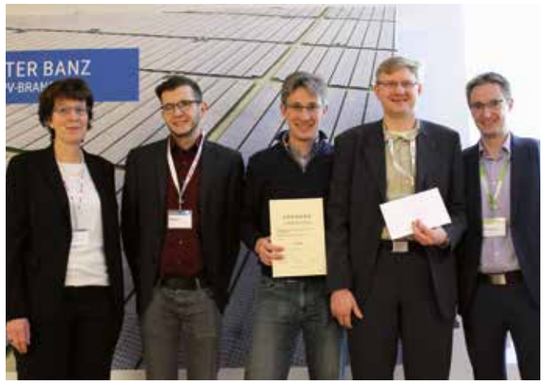
In a film, Virtual Joseph guides us enthusiastically through the Leuna Electrolysis Complex. Up to now the pilot plant only existed as a Lego model where Joseph lives, but in the future a full-scale industrial version will show us how green hydrogen can be efficiently produced and used. In an animation film, ***Luisa Mehl*** *and* ***Lisa Ossowski*** *have shown what the pilot plant will be capable of doing in the future.*



Thomas Glässer, *a staff member in the business unit Polymer Applications at the Fraunhofer IMWS presented organosandwich technology at the plastics trade show K in Dusseldorf.*

PRIZES AND HONORS

Research prize awarded by the VDI District Association Leipzig
Manuel Meusel
»Analysis of the behavior of different types of LED in a commercial LED-based sun simulator with regard to temperature dependence in the spectrum and switch-on and switch-off procedures«



01.09.2019, Leipzig/Germany

Second prize at the Best Poster Award at the 34th PV Symposium
Matthias Pander, Bengt Jäckel, David Daßler und Matthias Ebert
»Forecast of the potential power/yield loss by LeTID-prone modules«,
03.20.2019, Kloster Banz/Germany

Best Session Paper at the Electronic Components Technology Conference (ECTC)
Bianca Böttge, Falk Naumann, Sandy Klengel und Matthias Petzold
»Material characterization of advanced cement-based encapsulation systems for efficient power electronics with increased power density«,
05.28.2019, Las Vegas/USA

Outstanding Interactive Presentation Paper at the Electronic Components Technology Conference (ECTC)
Sebastian Brand, Bianca Böttge, Michael Kögel, Falk Naumann und Frank Altmann
»Non-destructive Assessment of the Porosity in Silver (Ag) Sinter Joints Using Acoustic Waves«,
05.28.2019, Las Vegas/USA

Julius Rubers (left) received the materials prize awarded by Schott AG. Maria Gaudig and Dr. Stephan Krause received recognition awards.

Materials Prize awarded by Schott AG
Julius Rubers
»Modification of PEEK materials through application of electrospun protein fibers for biomedical applications«,
06.13.2019, Halle (Saale)

Poster Prize at the 120th Annual Meeting of the German Applied Optics Society
Franziska Steudel
»Simulation luminescent optics«,
06.14.2019, Darmstadt

Best Poster Award of the 46th IEEE PVSC
Klemens Ilse
»Quantification of abrasion-induced arc transmission losses from reflection spectroscopy«,
06.21.2019, Chicago/USA

Overall Student Award of the 36th EU PVSEC
Klemens Ilse
»Physics of soiling and dust adhesion – Lessons learnt from laboratory soling tests«,
09.13.2019, Marseille/France

Outstanding Paper of the 22nd Microelectronics and Packaging Conference (EMPC) & Exhibition
Sandy Klengel, Jan Schischka, Tino Stephan, Robert Klengel, Matthias Petzold
»Influence of copper wire material to corrosion resistant packages and systems for high temperature applications«,
09.19.2019, Pisa/Italy

Best Attendee Award of the ISTFA
Michael Kögel, Sebastian Brand, Frank Altmann
»Machine learning assisted signal analysis in Acoustic Microscopy for non-destructive defect identification«,
11.14.2019, Portland/USA

Hugo-Junkers Prize awarded by the federal state Saxony-Anhalt, 3rd place in the category »Most Innovative Projects in Applied Research«
Andreas Kiesow, Sandra Sarembe
»PARODEX – Extrudates for treatment of periodontal disease«,
12.04.2019, Dessau-Rosslau

Young Talent Prize awarded by the Heinz-Bethge Foundation for applied electron microscopy
Klemens Ilse
»Microstructural investigation and simulation of natural processes on PV modules«,
11.22.2019, Halle (Saale)

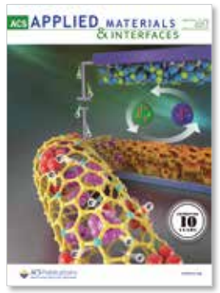
Best Student Oral Award of the International Conference on Sustainable Energy-Water-Environment IC-SEWEN 19
Hamed Hanifi
»Optimum PV Module interconnection layout and mounting orientation to reduce inhomogeneous soiling losses in desert environment«,
12.05.2019, Qatar

PUBLICATIONS

Highlight papers

Patzig, C.; Reißaus, S.; Krause, M.; Berthold, L.; Höche, T.
$Sr[Li_2Al_2O_2N_2]:Eu^{2+}$ — A high performance red phosphor to brighten the future

Nature Communications 10 (2019)



Esmaeilzadeh, P.; Menzel, M.; Groth, T.
Cyclic Redox-Mediated Switching of Surface Properties of Thiolated Polysaccharide Multilayers and Its Effect on Fibroblast Adhesion

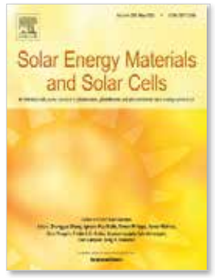
ACS Applied Materials & Interfaces 10, 37 (2018)

Romier, B.; Ivaldi, C.; Sartelet, H.; Heinz, A.; Schmelzer, C. E. H.; et. al.
Production of Elastin-Derived Peptides Contributes to the Development of Nonalcoholic Steatohepatitis

Diabetes 2018 Aug; 67(8), 1604-1615

Niepel, S. M.; Ekambaram, B. K.; Schmelzer, C. E. H.; Groth, T.
Polyelectrolyte multilayers of poly (L-lysine) and hyaluronic acid on nanostructured surfaces affect stem cell response

Nanoscale 11 (2019)



Ilse, K.; Zahid Khan, M.; Voicu, N.; Naumann, V.; Hagendorf, C.; Bagdahn, J.
Advanced performance testing of anti-soiling coatings – Part II: Particlesize dependent analysis for physical understanding of dust removal processes and determination of adhesion forces

Solar Energy Materials and Solar Cells, Volume 202 (2019)

Danke, V.; Beiner, M.; Saalwächter, K.; Schäfer, M.
Structure and Dynamics in a Polymorphic Nanophase-Separated 2 Stiff Comblike Polymer

Macromolecules 2019, 52, 18, 6943-6952

Patents awarded 2019

Busch, Michael / Werrlich, Stefan / Nagel, Frank / Jahn, Ivonne
Device and method for introducing fibers in an extruder
Patent no. EP 3 013 552 B1

Henning, Sven / Heilmann, Andreas / Füting, Manfred / Rosonsky, André / Probst, Jörn / Dembski, Sofia / Maas-Diegeler, Gabriele
Device for sample analysis for an atmospheric or variable pressure scanning electron microscope, microscopy system and microscopy procedure
Patent no. DE 10 2018 132 770.6

Kaufmann, Kai / Meier, Rico / Ackermann, Thomas / Schönfelder, Stephan / Hagendorf, Christian
Procedure and arrangements for monitoring cracking process for cracks in components with a scribing tool
Patent no. DE 10 2016 221 626 B4

Krause, Michael / Höche, Thomas
Procedure for preparing a sample for microstructural analysis and sample for microstructural analysis
Patent no. DE 10 2015 219 298 B4

Thieme, Christian / Rüssel, Christian
Ceramics and glass ceramies exhibiting low or negative thermal expansion
US 10,501,367 B2

Turek, Marko / Hagendorf, Christian / Luka, Tabea
Method and device for testing solar cells or solar modules for resistance to ageing
Patent no. 3 182 582 B1

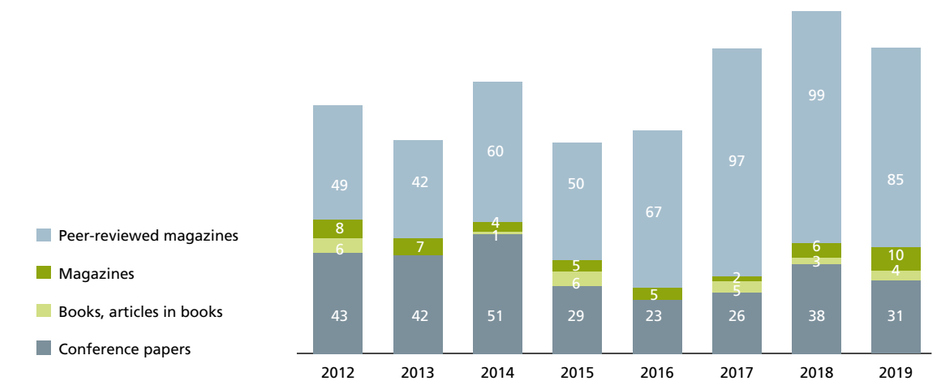
Turek, Marko / Hagendorf, Christian / Probst, Leonhard
Measurement device and method for measuring the intensity distribution of incident rays of light
Patent no. EP 3 407 035 B1

Turek, Marko / Hagendorf, Christian / Sporleder, Kai
Equipment and method for quick, extensive and spectral-sensitive reflectance measurement with high local resolution
Patent no. EP 3 460 999 B1

Dissertations

Dipl. Phys. Johannes Ziegler
Martin Luther University Halle-Wittenberg
Metal oxides as alternative emitter coatings on structured silicon

Publications overall



NETWORKING

The Fraunhofer IMWS works in numerous networks with partners from industry, science and civil society.

NETWORKING WITHIN THE FRAUNHOFER-GESELLSCHAFT

- Fraunhofer Group for Materials and Components – MATERIALS
- Fraunhofer Microelectronics Group (guest membership)
- Fraunhofer Nanotechnology Alliance
- Fraunhofer Building Innovation Alliance
- Fraunhofer Energy Alliance
- Fraunhofer Lightweight Design Alliance
- Fraunhofer Textile Alliance
- Fraunhofer Lighthouse Project eHarsh
- Fraunhofer Lighthouse Project Manitu

The following projects began in 2019 within the context of the Fraunhofer program providing funding for medium-sized enterprises:

OffEIA

Offshore demonstrator for electrochemical antifouling
Contact person: andreas.krombholz@imws.fraunhofer.de

AlgenComposite

Biologization of technical compounds through the use of algae fibers
Contact person: stefanie.meyer@imws.fraunhofer.de

The following projects began in 2019 within the context of Fraunhofer market-oriented preliminary research (MAVO) program:

MESIC

In the project »Multilayer Ceramic Embedment of SiC Semiconductor Elements«, the Fraunhofer Institute IISB (coordinator) works together with IKTS, IMWS and IWM. In combination with the competencies of Electronics and Materials Science, it is jointly researching and developing a thermally extremely stable (> 400°C) and highly compact module concept for SiC components, a first worldwide.
Contact person: frank.altmann@imws.fraunhofer.de

digitalTPC

A digital twin for thermoplastic composites will be developed within the scope of the cooperation with the Fraunhofer SCAI, IZPF and ICT. Hybrid injection molding technology currently in the process of establishing a foothold in the market and suitable for mass production will be employed, in which endless fiber-reinforced thermoplastic composite semi-finished products are reshaped and back-injection molded. It will be coordinated by the Fraunhofer IMWS.
Contact person: peter.michel@imws.fraunhofer.de

NETWORKING WITH EXTERNAL PARTNERS

- Center of Excellence and Technology Transfer Chemical and Biosystems Technology
  www.chemie-bio-systemtechnik.de
- Max Planck Institute for Microstructure Physics – Fraunhofer IMWS cooperation project HEUSLER
  http://s.fhg.de/heusler
- German Research Foundation (DFG) special research area polymers under multiple constraints
  www.natfak2.uni-halle.de/sfbtrr102
- Federal Ministry of Education and Research (BMBF) BioEconomy top cluster
  www.bioeconomy.de
- Federal Ministry of Education and Research (BMBF) SolarValley Central Germany top cluster
  www.solarvalley.org
- Federal Ministry of Education and Research (BMBF) Zwanzig20 project HYPOS
  www.hypos-eastgermany.de
- NanoMicro Network Saxony-Anhalt
  www.nanomikro.com

TECHNICAL EQUIPMENT

NEW EQUIPMENT

The Fraunhofer IMWS makes available a unique and comprehensive range of facilities to its clients for failure analysis and materials characterization. This includes technical equipment of the highest quality – within the Fraunhofer Gesellschaft the Fraunhofer IMWS possesses the most extensive range of instruments and equipment for analyzing microstructures in which more than 35 million euros have been invested since 1992. Its technical facilities are continually expanded and modernized so as to offer its clients high-tech and a first-class service. Here is a selection of the apparatus added in 2019.

- high-resolution scanning transmission electron microscope, 220-keV, probe-corrected [fig. 2]
- time-of-flight secondary ion mass spectrometer for surface analysis
- scanning electron microscope for nanoprobing, combinable with focused ion beam technology
- comprehensive gas chromatograph with time-of-flight mass spectrometer (GCxGC-TOF-MS) for comprehensive analysis of complex mixtures of organic compounds
- laser spectroscopy system for quick and precise multi-element analysis, including 3D surface measurement, sample sizes up to 600 x 400 x 140 mm [fig. 1]
- scanning hyper-spectral camera system in the SWIR and VNIR region
- gas chromatograph and mass spectrometer (GC/MS) with multiple sample injection possibilities, usable in a multitude of ways for the analysis of organic compounds and mixtures

Left figure 2, below figure 1

EVENTS

Scientific events (co-)organized by the Fraunhofer IMWS

Foundation event of the National Network for a Circular Carbon Economy NK2
01.22.2019, Espenhain

Annual Meeting of the DKG Ost – German Rubber Conference
04.04.2019, Merseburg

Technology Day: Simulation for the Lighting and Illumination Industry
04.09.2019, Soest

Elite User Workshop
04.09.2019, Halle (Saale)

8th CAM Workshop »Innovation in Failure Analysis and Material Diagnostics of Electronics Components«
04.10 – 04.11.2019, Halle (Saale)

Workshop »Innovative Chemical Utilization of Carbon and Renewable Resources for a Circular Carbon Economy«
04.15.2019, Berlin

7th TEM Preparators Conference
05.07.2019, Halle (Saale)

Seminar Quality Assurance in Generative Manufacturing
05.24.2019, Halle (Saale)

Meeting Working Group Microstructure Characterization in Scanning Electron Microscopy
05.27-05.28.2019

36th ITG Discussion Forum »Error mechanisms in small geometries«
05.28-05.29.2019, Grainau

HYPOS Dialogue »Innovative hydrogen sensor technology (Verbund HyProS)«
06.19.2019, Halle (Saale)

Inauguration Event Hitachi HF5000
06.27-06.27.2019, Halle (Saale)

Pyrolysis Conference
09.18.2019, Freiberg

The quality assurance of 3D-printed components was at the center of a workshop held in May 2019 at the Fraunhofer IMWS.

Workshop of the National Network for a Circular Carbon Economy NK2
09.19.2019, Chemnitz

»The Role of Social Norms and Preferences in Overcoming Undersupply of Public Goods: New Developments in Empirical and Theoretical Research«
09.09-09.10.2019, Freiberg

Marie Skłodowska Curie Workshop »Innovative Training Networks«
10.21.-10.22.2019, Halle (Saale)

PV Days
10.22-10.24.2019, Halle (Saale)

Global Value Chains Workshop
11.04.2019, Halle (Saale)

Rathenau Forum – Idea Workshop »Carbon as a Tool for Innovations between Tradition and the Future«
11.15.2019, Zschornewitz

International Conference on Wafer Bonding – WaferBond'19
12.02-12.04.2019, Halle (Saale)

During the »Long Night of the Sciences« guests could find out about topics such as the future of lighting.

At the Hannover Messe the Fraunhofer IMWS presented its hydrogen activities.

Further public events

Open Doors of the City of Halle (Saale)
01.12.2019, Halle (Saale)

15 years Weinberg Campus e.V.
02.05.2019, Halle (Saale)

Day of Professions
03.06.2019, Halle (Saale)

Future Days for Girls and Boys
03.28.2019, Halle (Saale)

Foundation event of the business unit »Optical Materials and Technologies«
05.23.2019, Halle (Saale)

Long Night of the Sciences
07.05.2019, Halle (Saale)

Inauguration of the new wing of the Fraunhofer CAM
09.18.2019, Halle (Saale)

Fall festival of the Fraunhofer IMWS for cooperating universities
10.23.2019, Halle (Saale)

Talent School
10.25-10.27.2019, Halle (Saale)

Trade fairs attended by the Fraunhofer IMWS

JEC World 2019
03.12-03.14.2019, Paris, France

Hannover Messe 2019
04.01-04.05.2019, Hanover

SMTconnect
05.07-05.09.2019, Nuremberg

Biopolymer
05.21-05.22.2019, Halle (Saale)

Electronic Components and Technology Conference
05.28-05.31.2019, Las Vegas/USA

Intersolar Europe
06.15-06.17.2019, Munich

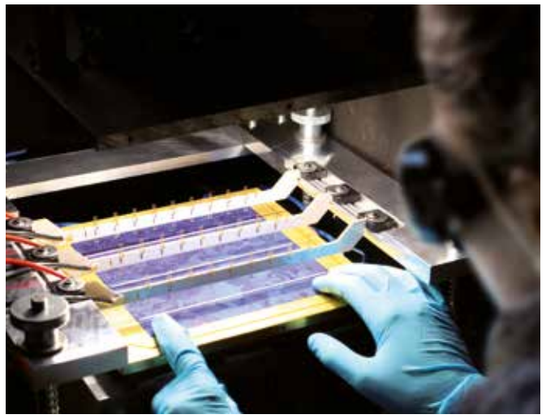
K-Messe
10.15-10.24.2019, Dusseldorf

VDI Congress Electronics in Vehicles
10.16-10.17.2019, Bonn

OUR MISSION

Our expertise in developing equipment can be seen in the device microPREP™, which enables samples for materials diagnostics to be prepared more quickly and reliably.

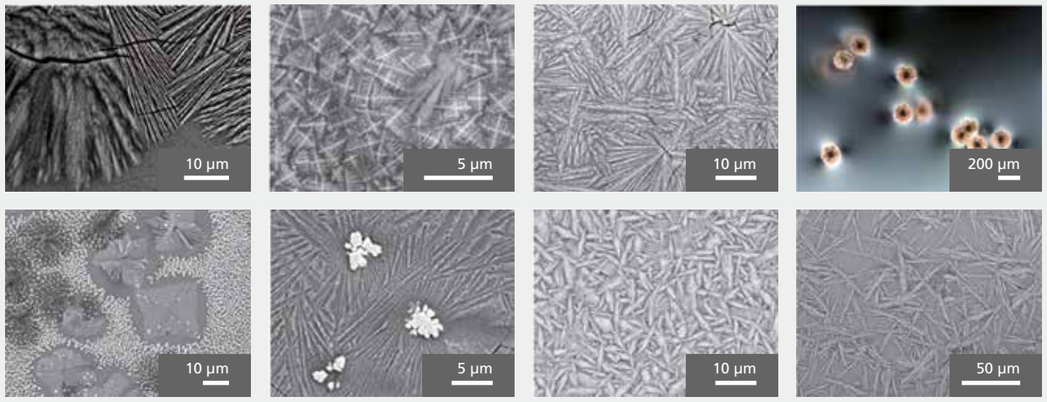
Microstructure-based technology development and diagnostics for efficient and reliable materials, components and systems



Our core competence »microstructure diagnostics«: A solar cell is tested in a solar simulator. This allows defects to be recognized and information to be gathered about degradation behavior.

The main challenge facing humanity in the 21st century is ensuring the sustainability of every aspect of life, especially through the efficient management of limited resources. The Fraunhofer Institute for Microstructure of Materials and Systems IMWS carries out applied research in the area of material efficiency and is a driving force, innovator and problem-solver for industry and public-sector clients when it comes to ensuring the reliability, safety, lifespan and functionality of materials used in components and systems.

Our core competencies lie in characterizing materials down to the atomic scale and in the microstructure-based design of materials.

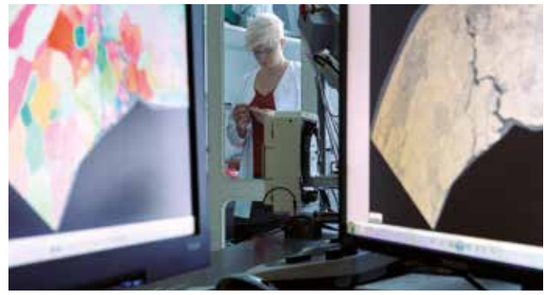


Our core competence »microstructure design«: the novel, low-expansion ceramic LEAZit™ was developed by facilitating homogeneous volume nucleation.

CORE COMPETENCIES

Microstructure diagnostics – discovered by the Fraunhofer IMWS

The Fraunhofer IMWS possesses outstanding know-how, and within the Fraunhofer-Gesellschaft it is able to offer the most comprehensive range of equipment for microstructure diagnostics. This allows us to determine the microstructural characteristics of materials and components down to the atomic level together with the resulting properties for applications. We use the microstructure, above all the microstructure of semiconductors, polymers and biological materials, in correlation to local properties so as to harness performance reservoirs.



Using ultramodern technology we can obtain deep insights into materials and their behavior in practical use.

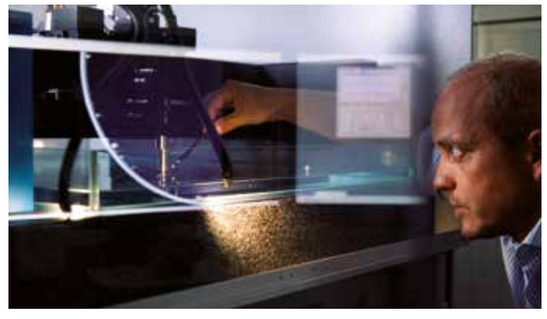
Microstructure design – designed by the Fraunhofer IMWS

Our understanding and control of microstructure allow us to intervene in fundamental material characteristics. Using microstructure design, we are able to provide our material know-how even during the development phase, and we can support our clients at the start of the value chain with materials that are perfectly designed for each application. In doing so, the Fraunhofer IMWS makes an important contribution to resource efficiency and competitive strength of its clients; allowing for more high-performance materials and opening up new application fields.

UD tapes made from fiber-reinforced plastics are processed to obtain exceptionally lightweight and robust components.

Developing testing equipment – engineered by the Fraunhofer IMWS

Successful microstructure analytics that meet our clients' needs is only possible through high-quality instrumentation. The complex questions posed in research and development, along with new methods and materials, require perfectly tailored equipment. And so – based on our many years of experience with existing technologies – we are increasingly working on the development of new devices. Our long-term collaborations with our industrial partners are an essential part of this.



An acoustic microscope enables the tiniest cracks in materials to be detected without destroying samples.

BOARD OF TRUSTEES

Tasks of the Board of Trustees

The Board of Trustees of the Fraunhofer Institute for Microstructure of Materials and Systems IMWS includes personalities from politics, business and science who are close to the institute in terms of their technical area of interest. The board of Trustees meets once a year.

Together with the Fraunhofer Board, the members of the Board of Trustees advise the institute with their expertise in strategic issues, setting the course at the institute and developing future perspectives. They are appointed by the Fraunhofer Board in consultation with the institute's management and work on a voluntary basis.

Members

- Prof. Dr. Jörg Bagdahn, Anhalt University of Applied Sciences
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»DIGITALIZATION IS THE KEY TO SHAPING THE FUTURE«

Interview with Dr. Dominik Lausch, CEO of DENKweit GmbH

At the Fraunhofer Institute for Microstructure of Materials and Systems IMWS in Halle (Saale), Dr. Dominik Lausch and his team have developed an innovative technology combining modern sensor technology and neural networks. Based on this know-how and together with colleagues, he founded DENKweit GmbH. In an interview he explains the idea behind the innovation – which is disarmingly simple.

You are the CEO of DENKweit GmbH, a spinoff from the Fraunhofer IMWS. What does your work for the Fraunhofer Gesellschaft mean to you today?
Working at the Fraunhofer IMWS has many facets. Fraunhofer offers attractive programs and hence unique opportunities: I applied for the Fraunhofer INNOVATOR program. A spinoff was my declared aim. By focusing on clear answers and simple application, we have gotten off to a flying start at DENKweit!

This was borne out in 2019 when your company won the IQ Innovation Prize Central Germany.
Our technology already enables the highly efficient quality control of battery cells for electric vehicles during production. They can be examined in real time for irregularities, contactlessly and in a non-destructive manner.

How does that work?
The flow of electricity in a battery creates a magnetic field and hence a magnetic fingerprint. Electrical defects alter this magnetic field. Using our measurement data we can infer the existence of these alterations, i.e. the defects. Given that we can also examine individual battery cells, we also manage to address a problem currently affecting e-mobility. Up to now, if a defect was suspected, the entire module had to be dismantled and analyzed in the lab. However, our method can be applied to other electronic components, e.g. solar modules.

Your promise: revolutionary technologies and enhanced cost-effectiveness in future markets. And that includes photovoltaics. As a scientist and company founder, what is your vision of the future?
Photovoltaic technology is an important element of how we will cover our energy needs in the future. We need alternative energy suppliers. However, I believe that politicians in Europe have been too slow in setting the right strategic priorities; many people do not understand the future. In this respect, realization that digitalization is the key is absolutely essential.

Dr. rer. nat. Dominik Lausch was the team manager at the Fraunhofer Institute for Microstructure of Materials and Systems IMWS in Halle (Saale) and is now CEO of DENKweit GmbH. The Fraunhofer spinoff offers efficient quality control during the manufacture of battery cells, solar modules or power electronics. This technology has been honored with the Hugo Junkers Prize and the IQ Innovation Prize Central Germany among others.

ORGANIZATION CHART

Director: Matthias Petzold*, Christian Growitsch (Deputy Director), Thomas Höche (Deputy Director), Sylvia Schattauer (Deputy Director), Thomas Merkel (Head of Administration)

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*acting

SUSTAINABILITY REPORT

In 2019, sustainability once again played an important role at the Fraunhofer IMWS. Operating costs are budgeted and assessed on an annual basis, so as to ensure that any potential for energy savings and process optimization at the Institute is exploited to the maximum.

In May the new wing of the building in Heideallee was inaugurated. The additional equipment and premises have increased energy consumption at the Fraunhofer IMWS by around 25 percent. However, consumption before the inauguration as compared to the previous year remained stable.

It was possible to reduce the savings attained the previous year at Walter-Hülse Strasse with the equipment in the technical center by a further 10 percent. The above-average load demands of the TCT refrigeration plant will, however, lead to an overall increase in consumption of 10 percent. The continued optimization of the ventilation system and the electronic room heat control system led to a further reduction in the costs of district heating.

The high load demands of the scientific facilities at Otto-Eissfeldt Strasse also resulted in an overall increase of 10 percent in energy consumption. Major factors in this respect are the supply of compressed air and cold air. In contrast, the photovoltaic system installed in 2018 has had a positive effect. Among other things, it autonomously generates electricity for the Fraunhofer CSP. This meant that peak loads could be avoided and cost savings achieved.

Social commitment

The contribution of the Fraunhofer IMWS to sustainability includes its social activities. In numerous projects the Institute supports civic commitment, citizen science or similar initiatives in Halle (Saale) and the region. An example of this was the Institute's participation in the events organized by OpenLabNet. The aim of this project is to make the science location Halle (Saale) accessible to all citizens, so as to stimulate cooperation in science, education, technology and design.

Among the Institute's contributions was a 3D printing method and shared know-how on methodology and equipment technology for environmental sensor solutions, above all for fine dust measuring applications. A format initiated by OpenLabNet and supported by the Fraunhofer IMWS is the »nAchtschicht«. Here, professionals from the creative sectors work through the night free of charge for projects based on voluntary initiatives. »Our Institute is more than happy to support these activities, for two reasons. First, Halle offers many exciting initiatives sparked by us and with which we want to network. Second, creativity, commitment and inspiration do not arise at specific times of the day – the nAchtschicht is the best proof of that«, comments Institute Director Prof. Matthias Petzold.

As part of the competition »Future City halle.neu.stadt 2050«, the Fraunhofer IMWS played a decisive role in the development of the »Flying Classroom« in which a fully-equipped laboratory is set up at various locations enabling the practice of science. At the end of November 2019 three new modules were supplied to the campus of the Christian-Wolff secondary school in Halle. They will offer places for projects in the four major fields of mathematics, IT, science and technology both inside and outside the school.

The project was also presented as part of the event organized by the competence center Social Innovation – Saxony-Anhalt. Under this format, the Fraunhofer IMWS, together with partners, sets out to successfully shape social change in Saxony-Anhalt, e.g. through social entrepreneurship. The aim of the competence center funded by the federal state of Saxony-Anhalt is to bring together the dynamic forces of the two major strands of innovation, i.e. socially effective measures and initiatives on the one hand and technological innovations on the other hand, with a view to unlocking, preparing and driving the ongoing development of innovative ideas and practices and hence support and sustainably shape social change.

OUTLOOK

Staff, projects, buildings and equipment – the four words at the beginning of the preface to this year's annual report will without a doubt also be synonymous with dynamism at the Fraunhofer IMWS in 2020.

The framework for this goal is provided by the further refinement of the Institute's strategy, on which we intend to work intensively in 2020. We are supported in our endeavors by our Board of Trustees and by the industry advisory boards for each of the business units. The aim is to identify market and technology trends and, based on this information, to refine the services we offer so as to meet the requirements of our clients even better in the future. A precondition for this to occur is the continued development of internal processes with the aim of rendering them as efficient and client-oriented as possible. Dr. Roland Langfeld, former director of central research at Schott AG and the Chair of our Trustee Board up to the end of 2019, will advise the Institute's directors with this in mind. This includes the further development of our digitalization activities, including the MAVO »digitalTPC«, the use of artificial intelligence in signal analysis or AI-based status monitoring of solar plants.

An important element of our strategic development concerns the startup of our carbon and hydrogen activities. They are currently subsumed within the business unit »Chemical Conversion Processes«. The crucial importance of these technologies, especially in shaping structural change, means that these research fields will continue to grow. In order to create ideal framework conditions, we will examine whether these activities can be transferred in the near future to their very own institute, the Fraunhofer Institute for Hydrogen and Carbon Process Technology IWKP. Dr. Sylvia Schattauer, Deputy Director at the Fraunhofer IMWS since October 1, 2019 and previously part of the Fraunhofer executive board staff is coordinating this process, in respect of which we intend to make considerable progress in 2020.

A tangible manifestation of these plans will be commencement of work on the Electrolysis Testing Platform ELP and the Scale-Up Platform Hy2Chem in Leuna. Together with our partners, we want to prepare this location for the industrial implementation of a method for producing green hydrogen. Its presence in the chemical plant and hence in the vicinity of our clients, the future users of this technology, will not only be a decisive factor for the success of the pilot plant but is also strongly symbolic of our closeness to industry. The same can be said of the pilot plant center for polymer synthesis and processing PAZ in Value Park Schkopau, whose expansion will also continue unabated in 2020.

Last but not least, the person who takes up the post of Institute Director will be another important task. The aim is to ensure a successful and smooth transition so that the Institute's new directors can carry on their work with the Institute on a strong footing. For this to occur, scientific excellence and satisfied clients constitute the most important basis. The ability to be creative, flexible and effective in our core business, project work in collaboration with industry – that is our main focus of attention in 2020.

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