Fraunhofer
ISC

FRAUNHOFER INSTITUTE FOR SILICATE RESEARCH ISC

ANNUAL REPORT 2019|20

HIGHLIGHTS

2019|2020

ANNUAL REPORT *to go*

If you would like to read more about us, you can browse through the online version of our annual report (see QR code on the bottom left). Here you will find texts and further information as well as links to audio and video files. It can all be found at www.isc.fraunhofer.de/jahresbericht.

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FOREWORD

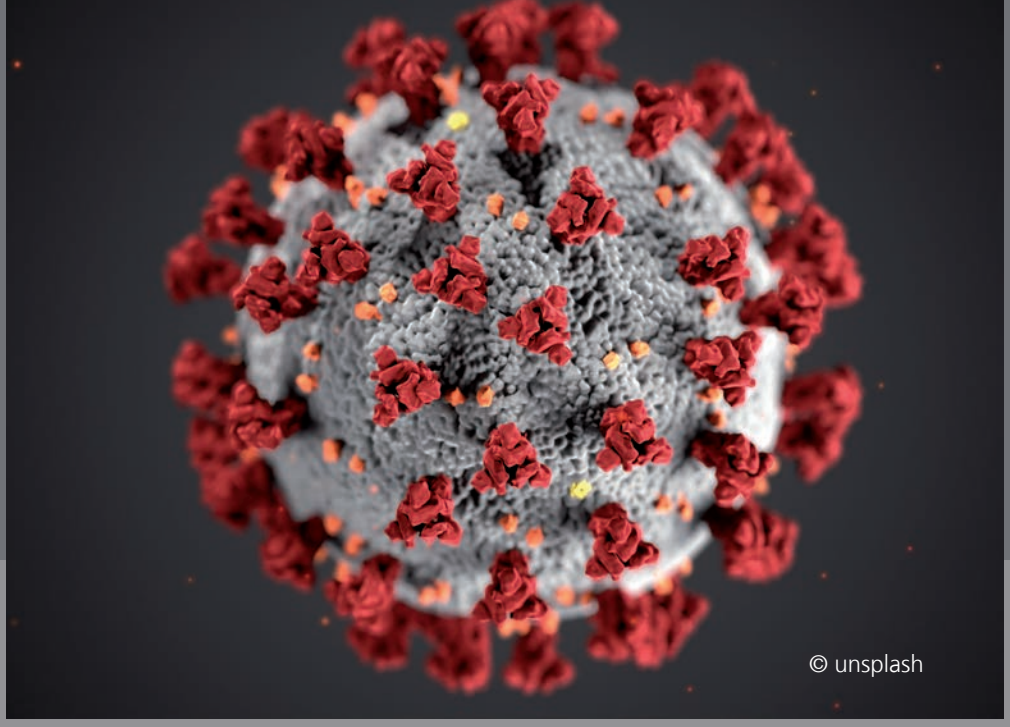
Dear friends and partners of Fraunhofer ISC,
Ladies and gentlemen,

The past year 2019 was dominated worldwide by the global challenge of climate change. This situation also provides an opportunity for Fraunhofer ISC to examine its own competencies in the field of materials research for climate protection and to focus strategically on expanding these. Some of you will have received Fraunhofer ISC's climate calendar at the beginning of 2020 and will thus already have gained some insight into our research interests in this field. The areas of focus defined in our 2018 strategic planning have been expanded to include "Materials meet ... climate" and "Materials meet ... digitization". Here the ISC is making important contributions to solving global challenges.

The topics of digitization and artificial intelligence have increasingly become the focus of materials research at the ISC. In addition to the ongoing activities in laboratory automation, the Institute will also promote the use of artificial intelligence for material development within the framework of the European Battery 2030+ initiative. This is where our expertise in the fields of sensor technology, analytics, in situ measuring methods and automated online monitoring comes into play. This knowledge creates the conditions for the acquisition and automated evaluation of digital material data, forming an indispensable interface between materials data space and the analog product and its requirements.

In addition to these virtual and strategic themes, spatial development also plays an important role in a successful future. Until the two major construction projects were completed for the Fraunhofer Research Institution IWKS facility, which became independent last year, the ISC held responsibility for these. The two new research buildings in Alzenau and Hanau, certified in accordance with the guidelines for sustainable construction, have now been handed over to their users, with state-of-the-art equipment providing an excellent environment for the further development of the former project group.

In Bayreuth, the construction of the fiber pilot plant projected together with our industrial partner BJS is proceeding according to plan. The commissioning is planned for early 2021. At that point, the production plant for SiC fibers, which is unique in Europe, will start production in Bayreuth. In Würzburg, the reconstruction of the historically protected building of the former eye clinic at Würzburg's Röntgenring, which was opened in 1901, began in early 2020 with initial construction and safety measures. The next two years will see the construction of a state-of-the-art research building for Fraunhofer ISC with laboratories for the development of regenerative therapies, 3D tissue engineering, drug screening and stem cell processing technology. We would like to take this opportunity to thank the federal and state ministries and the European Union for financing the construction and the Fraunhofer Gesellschaft for its strategic development support.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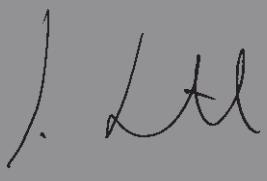
The year 2020 brought an unexpected global crisis in the form of the COVID 19 pandemic. This is a new challenge - and an opportunity - not only for the economy but also for the research landscape. In record time, the digitalization of communications was pushed forward worldwide, production was converted and research activities were steered in new directions. The Fraunhofer Gesellschaft research program, launched immediatly under the motto "Fraunhofer vs Corona", has bundled the research efforts of all Fraunhofer Institutes and thus created a development platform for application-oriented coronavirus research in a very short time. Fraunhofer ISC has also contributed ideas and expertise in this area, from rapid drug screening for antiviral substances to the development of antiviral surfaces. The projects that have now been initiated will be reported out in the coming years. To this point, the ISC has coped well with the immediate effects and dangers of the crisis. Not least due to prudent planning and implementation of measures by the local crisis management team and the responsible actions of the staff, it was possible to avoid cases of infection and a lockdown of the Institute while at the same time continuing our project work and the acquisition of new projects under these difficult conditions. I offer my sincere thanks to all staff and their families.

I wish us all luck, energy and success in overcoming the global challenges.

And stay healthy!

Yours
Gerhard Sextl



Materials meet Energy
All videos on YouTube

Under the motto "Materials meet...", Fraunhofer ISC makes important contributions to solving global challenges through its materials research and process development activities. Its research focuses on climate change, environmental pollution, excessive resource use and energy system transformation as well as material innovations with and for artificial intelligence and digitalization, aging populations in industrialized countries and growing urbanization.

Well, you gotta start somewhere.

"Climate change, which we are intensifying through our appetite for energy, mobility, consumption and global networking, will also primarily harm ourselves and our future generations... these are the challenges against which we must measure our work, and at Fraunhofer ISC, we want to make essential contributions to solving them".

This sentence was already included in last year's Fraunhofer ISC annual report. With the launch of the global "Fridays for Future" movement, climate change now also moved onto the political agenda, the EU declared a "Green Deal" and greater priority was finally given to achieving climate targets. The Fraunhofer ISC campaign **"Materials meet ... Climate"**, which was developed in 2019, was designed to place the calendar year 2020 under the mark of climate protection. Twelve topics from research and development show opportunities and possibilities for reducing CO_2 emissions through new materials and intelligent technologies. More information can be found at www.materialsmeet.fraunhofer.de and in social media under the hashtag #MaterialsmeetClimate.

The research activities grouped under **"Materials meet ... Energy"** also play an important role in this context. With its Fraunhofer Electromobility R&D Center, the Institute is currently involved in more than a dozen national and international research projects relating to the establishment of a new generation of energy storage systems and their production platforms in Europe. The declared aim of the Europe-wide activities is to create a strong competitive position for European manufacturers in the field of stationary and mobile batteries required for energy system transformation and electromobility. But Fraunhofer ISC is not only developing new materials and components for lithium-based storage technologies. With its Center for High Temperature Materials and Design HTL, Fraunhofer ISC is also making major contributions to the climate-friendly energy revolution in the areas of efficient, resource-saving energy conversion and optimized high-temperature processes. At the Bayreuth location, a fiber pilot plant will be put into operation in 2021, the only one of its kind in Europe, producing ceramic fibers for high-temperature lightweight construction on an industrial scale.

Since the beginning of 2020, however, world affairs have been dominated by the COVID-19 pandemic in a way that would not have been thought possible in our highly developed civilization. This brings to mind another research focus of Fraunhofer ISC: **"Materials meet ... Biomedicine"**. With the research conducted at its Translational Center for Regenerative Therapies, Fraunhofer ISC is also working on solutions to a global challenge. For example, human 3D tissue models of the respiratory tract can be used to investigate the interaction of coronaviruses with human body cells and the effectiveness of active substances. The additional research funds made available at short notice by the Fraunhofer Gesellschaft and the German Federal Ministry of Education and Research enable a number of important projects to be carried out here with partners from industry and research to investigate viral attacks on body cells and possible approaches for cures. The initial results are to be reported next year.

By bringing together material synthesis, cell biological systems and additive manufacturing processes under the umbrella of Fraunhofer ISC, new biomedical applications in regenerative medicine are opened up. As alternatives to animal testing, human 3D test models are available that simulate healthy or diseased body barriers and thus permit the testing of new formulations and therapeutics. In the future, the integration of automated production methods and robot-assisted systems will enable the reliable, fast and cost-effective cultivation of cell models and cell-based test systems.

... to go further into the future

#MATERIALSMEETCLIMATE

Material and process development is increasingly implementing methods of artificial intelligence, digitization and automation in an effort to find solutions faster. At the heart of **"Materials meet ... digitization"** at Fraunhofer ISC is the development of a comprehensive ontological description of the many different classes of materials and the process chains required for their processing. The architecture of a central data space is derived from this concept, which is fed throughout the course of its constant growth both by actually recorded process parameters and analysis results as well as by output data from simultaneously created simulation models. Furthermore, the development of modular "machine learning algorithms" makes it possible, on the basis of ontological description, to establish indirectly accessible correlations between variables, especially between parameters of materials and processes and the target properties of those materials. In addition, these are intended to facilitate the extraction of features from analytical data, e.g., spectral or (electron) optical and to complement human expertise in a meaningful way. From the outset, the development of data structures and data procedures is intended to be an iterative process with an agile methodology. The goal of the process is to make available a generally applicable tool for conducting research more efficiently within and between the working areas of the Institute. Accompanying developments such as the High-Throughput Screening System 4.0, the APRONA project for automated, robot-supported particle production or highly scaled material syntheses with online acquisition of synthesis-relevant material parameters create necessary interfaces between the material itself and the digital data space.

To contribute to "digital" future topics such as "Internet of Things", robotics, autonomous driving, laboratory automation and switchable systems, new demands are also made on the functions and properties of the materials used. Intrinsic condition monitoring by means of sensor functions, adaptive modification of physical properties and detection of environmental influences as well as multifunctional materials and electrical/optical/mechanical systems that are also suitable for digital manufacturing processes – e.g. high-resolution 3D printing - are some of the tasks being carried out at Fraunhofer ISC under the heading **"Materials meet ... Adaptive Systems"** .

In addition to digitization, the transformation of the economy from value creation based on fossil resources to the sustainable and resource-saving use of renewable raw materials is becoming increasingly important. This is brought together under the umbrella term "bioeconomy" as the knowledge-based production and use of biological resources, processes and principles to provide products and services in all economic sectors within the framework of a sustainable economic system. The concept of bioeconomy is closely linked to "circular economy" and is evolving into "circular bioeconomy". However, bioeconomy not only focuses on the optimization of material flows and resource management but also targets social change processes and the biologization of many branches of industry, generating entirely new products and solutions. Fraunhofer ISC is positioning itself in this area through **"Materials meet ... Clean Environment"** and **"Materials meet ... Bioeconomy"** with sustainable solutions for the refinement and efficient material use of biogenic materials. The materials portfolio will be successively expanded in the direction of biogenic functional materials and recycling capacity through the simplification of complex material composites supported by quality assurance procedures. Biobased, biocompatible and biodegradable functional materials replace environmentally harmful materials. Sustainable material solutions as well as energy- and resource-efficient methods and processes throughout the value chain are core topics.

And so, the circle closes once again since all developments at Fraunhofer ISC mesh with one another to play an active role in overcoming the major challenges of our time and ensuring a livable future for us and future generations.

»» MATERIALS MEET ... FUTURE CHALLENGES!

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Vice Director | Operational Management

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Chemical Coating Technology
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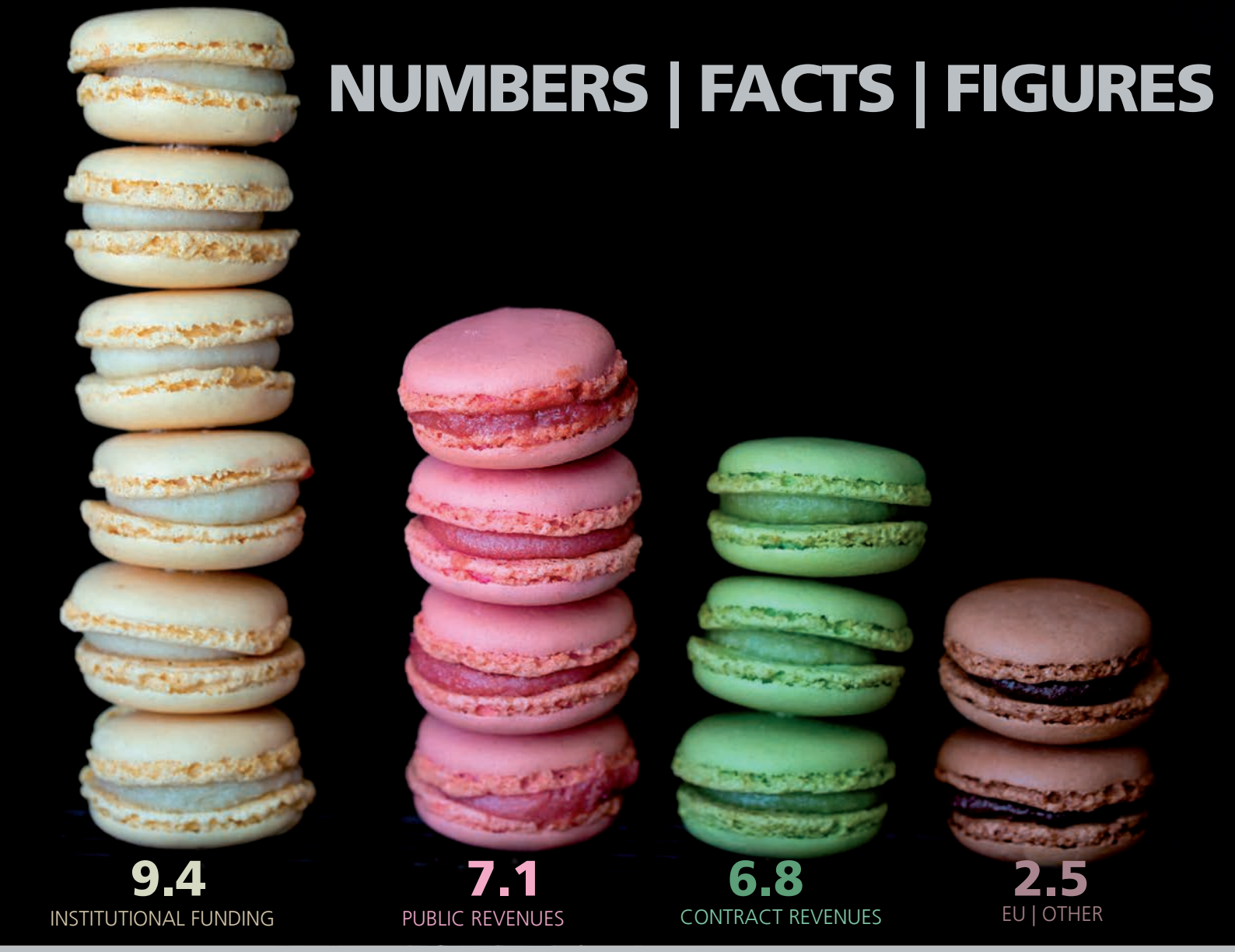
NUMBERS | FACTS | FIGURES



OPERATING BUDGET FRAUNHOFER ISC € 25.9 MILLION

€17.3 million for the	Fraunhofer ISC | main site
€5.2 million for the	Fraunhofer Center HTL
€3.4 million for the	Translational Center for Regenerative Therapies TLZ-RT

FRAUNHOFER ISC PLUS FRAUNHOFER IWKS € 33.5 MILLION

through April 2019

€3.9 million for the	IWKS Hanau Project Group
€3.8 million for the	IWKS Alzenau Project Group

111 SCIENTIFIC STAFF

121 GRADUATE STAFF

48 TECHNICAL STAFF

9 TRAINEES

18 PHD STUDENTS

56 RESEARCH ASSISTANTS AND INTERNS

	ISC	HTL	TLZ
Scientific staff	69	24	18
Graduate staff	85	26	10
Technical staff	40	4	4
Trainees	9		
PhD students	16	1	1
Research assistants	18	20	8
Interns	8	2	

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The Board of Trustees is made up of leading figures from politics, industry and science with close professional ties to Fraunhofer ISC. Together with the Executive Board of the Fraunhofer Gesellschaft, they advise and support the Institute with their expertise in strategic issues, helping to set the course for the Institute and the development of future prospects.

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OUR YOUNG SAVAGES

Editor: Ferdinand and Patrick: For a year now, you have been the "newcomers" jointly heading the Chemical Coating Technology Department at Fraunhofer ISC, which was formed from two new working groups – Barrier Coatings and Hybrid Polymer Layer Systems. How did this occur?

Ferdinand Somorowsky: I had already worked for Fraunhofer ISC during my university studies and also wrote my final thesis and dissertation there. The Institute had already offered me a position in chemical analysis during my doctorate, which I accepted after completing my thesis. That was very exciting: a position involving management responsibility for four employees and a large number of different projects from a wide range of areas with very tightly synchronized development of activities. It was fun, interesting and very instructive, but at some point I wanted to get back into material development, and I started looking for new possibilities. It was precisely at this time that the ISC made strategic plans to combine the upcoming generational shift of two department heads with an organizational realignment of the two groups for different hybrid polymer coating systems to take advantage of synergies. For this purpose, two suitable people were now being sought to take over joint management of the new division. I was very interested, and I applied.

Patrick Wenderoth: I had completed my studies and my PhD at the University of Saarbrücken with a focus on intermetallic compounds, metal hydrides and tracking of metal–hydrogen reactions. I worked in various research projects, including a project for a well–known lighting manufacturer, with a focus on the development of polysiloxanes. I found this application–oriented work very exciting. And by chance, Martin Peters, head of the Materials Chemistry Cluster, contacted my research group to inquire whether there was a suitable candidate for the scientific management of a coating technology division.

THE FACTS

Dr. Ferdinand Somorowsky
Age: 34
Single
Education: Degree in Chemistry at the University of Würzburg, thesis and doctoral dissertation in the field of glass and mineral materials on the topic "Development of nanoporous glass with controlled sorption properties to improve indoor air conditioning" at Fraunhofer ISC

Dr. Patrick Wenderoth
Age 35
Married
Education: Chemistry at Saarland University in Saarbrücken (Degree with specialization in "Chemistry for Materials Science and Technology"), thesis and doctoral dissertation in the field of intermetallic compounds and metal hydrides / metal-hydrogen reactions with the topic "Investigations on hydride formation of Zintl phases of alkaline earth metals with aluminum, gallium and silicon"

Since July 2019, joint management of the
Chemical Coating Technology Department at Fraunhofer ISC

DR. FERDINAND SOMOROWSKY AND DR. PATRICK WENDEROTH

Editor: But not closely related to your professional focus on metal hydrides?

Wenderoth: Well, I had already left metal hydrides behind me a good four and a half years earlier. During my postdoctoral period, I was able to build up some know–how and experience in polysiloxane chemistry, which has a strong affinity with the chemistry of hybrid polymers in which the ISC specializes. So it was a good fit with my expertise.

Somorowsky: From a technical point of view, Patrick was definitely impressive in the job interviews, and since we have to work very closely together, the personal side is also very important, and that was a good fit.

Wenderoth: Yes, I liked the team right away – you very quickly develop a basic impression as to whether you can work together, and the fit here was instantaneous.

Editor: Generational shift – that sounds like many aspects: Transfer of knowledge, salvaging a wealth of experience, organizational restructuring, concepts for the future. How did you approach the new task?

Somorowsky: Well, we had a lot of respect for both groups. They are working very successfully, and the two leading scientists are very well known in the community and industry. That's quite a legacy. And as the new heads of an organizational unit, we were suddenly something akin to the managing director of a small company. You have a lot of things on your plate: the finances, resources, project acquisition, employees – and you also have to advance the scientific work – we are both happy to have a sparring partner not only for the professional exchange but also for everyday questions as well as the "old–time" leaders from whom you can learn a lot and who are always there to help us with guidance and resources.

Wenderoth: We have devoted half a year to preparation and training in addition to conducting daily business. A lot of good energy went into developing our own ideas – scientifically and organizationally – and also into managing the transfer of knowledge.

Somorowsky: But we also have structural support: for example, budget planning is done at the cluster level, and controlling provides important help. At the moment, project acquisition and application take up a lot of space in our company. This year we have many project applications on the way, so there is a lot of paperwork and some things we are doing for the first time. These are time–consuming ... and sometimes also annoying.

Editor: How do you share the work? By topic? Or more by function?

Wenderoth: To promote team unity, we explicitly did not want a division of content. This means that we both take care of the various duties and share our views about them.

Somorowsky: Because we have a common office, communication is uncomplicated and smooth. We share information and notes on projects using appropriate tools. This way we always keep each other informed. Functional tasks, on the other hand, have already been divided. While Patrick is responsible for the training of young scientists and positioning in the community, I have taken over supervisory responsibility for personnel.

Editor: How has acceptance gone from within the reorganized working group?

Somorowsky: Both of us have been well received and also integrated into the group, ensuring that the cooperation in the different areas works very well and is fun.

Wenderoth: The merged group is certainly more heterogeneous now, but everyone is open to the new structure, and cooperation is working very well.

OUR YOUNG SAVAGES

Editor: After all, the passing on of knowledge and experience is a very central aspect of a generational shift – not only here but also in many companies. What kind of experience have you had with this?

Wenderoth: Our experience over the past year taught us that knowledge transfer works best ad hoc. If a certain question comes up, we exchange ideas and the two more experienced colleagues provide us with excellent support. But we are also trying to create appropriate structures. For example, a lacquer database combines the various formulations of both areas. Here we want to gather as much knowledge as possible.

Somorowsky: But you should also have no illusions. Knowledge accumulated over 30 years of work is not transferred in a few months. And, of course, neither is the experience with customers' questions and production processes. We try to create as many opportunities as possible for exchange of perspectives on specific issues in the ongoing project work. And a great deal of knowledge is also available from the technicians, especially the specific expertise for implementation. In any case, it is important to keep an eye on the timeline, but you actually have too little time in normal everyday life.

Editor: Apart from knowledge transfer, what do you see as a particular challenge?

Wenderoth: With our hybrid polymer functional layers, we are active in many different industries. It is therefore necessary to be familiar with a large number of substrates, process steps and functionalities common in the various industries across a wide variety of products – metals, plastics, paper, glass or ceramics in products such as watches, washing machines, cars, refrigerated counters or even airships. This requires a quick grasp of the situation and a high level of specialized competence.

Editor: A wide field then. What specifically attracts you?

Somorowsky: The work is unbelievably varied – you constantly learn new things. The hybrid polymers (ORMOCER®e[1]) offer a rather special material base but also constant innovation and inventiveness for new functionalities. About 130 coating formulations are currently used as established systems for different applications. And the work, which involves a variety of industrial projects, research projects, application letters and technical projects, is simply great fun. Research and application are brought under one roof, and ideally you can see how your own developments will eventually be brought to market in the products of industrial partners.

Editor: You've also been thinking about the future. Where are we going with the ORMOCER®en?

Wenderoth: We have put together a long list of ideas in terms of both application areas and functionalities. But there are also topics concerning the implementation in existing process chains – that is, concerning process capability. What we can reveal at this point is that we want to transfer the climate–, environment– and resource–relevant biological aspect – in other words, renewable raw materials and capacity for biodegrading – from barrier applications to other areas.

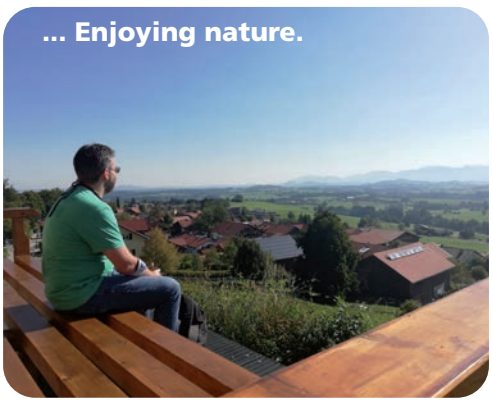
Somorowsky: For example, a new field of application is medical technology. We are already working on concepts together with the Stem Cell Process Technology Project Center and the Translational Center for Regenerative Therapies. However, we will also continue to develop proven products and combine functionalities of known formulations. The industry appreciates the ISC not only as a creative source of ideas but above all as a reliable development partner and supplier of solid, well–developed, secure systems.

1 ORMOCER®e: Brand of the Fraunhofer–Gesellschaft zur Förderung der angewandten Forschung e. V., Munich, Germany

WHAT ELSE DO YOU DO?

DR. FERDINAND SOMOROWSKY

DR. PATRICK WENDEROTH



OUR YOUNG SAVAGES

PROF. DR. KARL MANDEL

Editor: You studied in Munich, Salzburg, Ulm and Oxford. You came to Würzburg for your doctorate – what tipped the scale?

Karl Mandel: Actually a coincidence – my partner went to Würzburg for graduate study, but at first glance it appeared there was nothing suitable there for me and my fields of expertise. Fraunhofer ISC was the next address I contacted, although I was quite naive and had no great hopes. Coincidentally, a research project on the topic of wastewater treatment with particles was just starting there in the particle group of Dr. Carsten Gellermann at that time, and they were looking for a doctoral student with both nanoscientific skills and ideally with hydrological–geoscientific skills – not a very common combination. And by coincidence, I had immersed myself in precisely these topics during my studies. So: in the right place at the right time – and curious enough to get involved in the task of writing a doctoral dissertation on a Fraunhofer topic. So I submitted my application documents and was promptly invited by Prof. Sextl, head of the Institute and a faculty member – and my future doctoral supervisor – and was warmly welcomed as a doctoral candidate.

Editor: No sooner had you completed your doctorate than you were entrusted with the responsible job of group leader. How did that come about?

Almond: Actually, this was again a series of coincidences. Carsten Gellermann, the group leader who had brought me to the ISC, went to Alzenau on behalf of the Institute to assist in setting up the IWKS project group. The group was headed by an experienced colleague, Dr. Uta Helbig, but shortly afterwards, she was hired by the Technical University of Nuremberg. Prof. Sextl immediately entrusted Dr. Dembski and me with the leadership of the group; after a short time, the two groups became independent. Group management – a real challenge for me as an inexperienced newbie. In retrospect, I must say that Mr. Sextl has placed a great deal of trust in me in this respect. I have accepted the challenge. But the first two years were very tough – after all, I had to bring in projects to finance my group, take care of the strategic direction and manage the staff for whom I now suddenly had supervisory responsibility.

Editor: Were there moments when you wanted to throw everything away?

Almond: After the first 10 or so project applications had been rejected, I set myself a deadline of December 2014. If I hadn't managed to get at least one or two well–paying projects for my group by then, I actually would have left. The head of the Institute gave me more credit than I gave myself. If Mr. Sextl had not always encouraged me and discounted the many rejected project applications as "part of the job", I would have thrown in the towel earlier. And in November 2014, two major projects with a total volume of more than €1.7 million for the following three years actually came along, which was a real success – and a great relief for me.

Editor: You submitted your doctoral dissertation in the very short time of two and a half years. For your dissertation you also received the renowned German Study Prize of the Körber Foundation. Had you already toyed with the idea of post–doctoral study at that time?

Almond: Yes, that really only worked because the Institute and the group – and not least the doctoral supervisor – made it possible. A post–doctoral qualification was already something of a distant dream back then. But I had my doubts whether I was the right person for this path. That's why I wanted to go more in the direction of an applied–sciences school. But Mr Sextl convinced me – with some persistence – to take the path to the research university. There were still a few hurdles to overcome before my post–doctoral thesis with the Fraunhofer connection was also accepted at the university. In the end, it worked out well and I was able to generate 33 publications from the post–doctoral thesis.

Editor: I have to say that was well done! It also worked out with a job offer – and not just one.

Almond: Yes, actually I was lucky enough to get several offers. I chose the faculty position at the University of Erlangen because it is not only close to my group at the ISC but also gives me the opportunity to have both groups – Fraunhofer and my research group at the university – working closely together. And last but not least, this is of course also an issue for the family – geographical proximity is all the more important and welcome to me. Erlangen welcomed me with open arms, and the cooperation with Fraunhofer is seen there in a very positive light. The contacts between Erlangen and Würzburg are already excellent, and I am sure that a lot will come from these in the future.

THE FACTS

Age: 35
Married | 3 children
Primary: Secondary: Hohenschwangau
Education: BSc Geosciences at the University of Munich and Technical University of Munich (BSc work at the University of Salzburg), MSc in Materials Science at the University of Ulm (MSc work at the University of Oxford)
December 2010 - September 2013
Doctorate at Fraunhofer ISC and the University of Würzburg on "Superparamagnetic nanocomposite particles for water purification and resources recovery"

Since 2013
Head of Particle Technology at Fraunhofer ISC

November 2015 - January 2020
Post-doctoral qualification at the University of Würzburg and Fraunhofer ISC on "Functional supraparticles based on iron oxide and silica nanoparticle building blocks"

Since April 2020
Professor of Inorganic Chemistry at the University of Erlangen-Nuremberg

OUR YOUNG SAVAGES

PROF. DR. KARL MANDEL

Editor: You started in April 2020 under difficult conditions – the coronavirus lockdown. What was the effect of this?

Almond: Erlangen and the ISC are well–positioned in this respect: we were able to manage an incredible amount virtually, and the actual relocation of the laboratory and the setup in Erlangen went off without a hitch – thanks mainly to my two super teams in Würzburg and Erlangen and thanks to the flexibility of the administration.

Editor: What plans do you have for your groups now?

Almond: We want to have a very close link between the research at the university and that at the ISC – the basics in Erlangen, the application in Würzburg. The focus is on functional supraparticles – what new properties and functions become possible when nanoparticles are combined into supraparticles – for example, particles that communicate for sensor technology or as markers, additives for smart surfaces, adsorber and cleaning systems, particles for photoelectrocatalysis. The courses of study for chemistry and molecular science in Erlangen are currently being revised, which means that supraparticle chemistry can now be integrated into teaching from the outset.

Editor: What is important for you in teaching?

Almond: Of course I want to teach students the basics, but above all I want to train them to be independent and creative thinkers – that's where we're ahead of the computers. Purely mechanical knowledge accumulation and retrieval can also be done by machines.

Editor: What drives you?

Almond: Staying curious, letting myself be inspired, trusting in cooperation and teamwork, being open to other ideas – and continuing to create, recognize and take advantage of serendipitous opportunities.

WHAT ELSE DO YOU DO?

"Free time can be wild sometimes: I love to be outside, whether cycling, hiking or skiing.

I just love the mountains.

I am also up for wild races. Unfortunately, I didn't win the bobby car race, but I guess it's hard to get started there too..."

FRAUNHOFER INITIAL RESEARCH

LEAD PROJECT »»MANITU

Materials for sustainable tandem solar cells with maximum conversion efficiency

Maximum-efficiency solar cells produce electricity at low cost and use less space and material. High efficiencies are also made possible by new products such as energy-autonomous buildings or electric cars that can be charged via solar cells. However, the efficiency of silicon solar cells can no longer be increased at will. The physical limits responsible for this can be overcome with tandem solar cells. Efficiencies of over 35 % are possible with such cells. Tandem solar cells have therefore become the focus of current solar cell research.

At the same time, within the next 5–10 years, worldwide annual photovoltaic growth will increase to more than 1 TWp. These quantities also demand constant avoidance of critical materials (such as lead) in the production of solar modules. In the Fraunhofer "MaNiTU" lead project, therefore, six Fraunhofer Institutes are working together to develop sustainable, highly efficient and cost-effective tandem solar cells based on new absorber materials and specifically coordinated contact layers. The consortium consists of Fraunhofer Institutes ISC, IWM, IST, MWS, IWKS. It is coordinated by Fraunhofer ISE.

FRAUNHOFER EXECUTIVE BOARD PROJECT

Preserving cultural heritage through research and high-tech

For the first time, climate change and the protection of cultural heritage are on the agenda of the German EU Council presidency from July to December 2020. In the next Horizon Europe research framework program as well, research on the preservation of cultural heritage will be prominently represented. Because our cultural heritage is in danger, an extremely acute threat to our cultural heritage is posed by climate change, with an increase in extreme weather events, but also by the consequences of the coronavirus pandemic and man-made catastrophes such as the fire at Notre Dame Cathedral in Paris and primarily the boom in mass tourism. Research and technological development are needed to meet these challenges: sustainable conservation materials, new analytical methods, socio-economic studies and, above all, new digitization technologies. For this reason, the Executive Board project "Cultural Heritage II" addresses the effects of climate change and the opportunities of digitization. 20 Fraunhofer Institutes have pooled their expertise to work closely together. They are cooperating with partners from the Dresden State Art Collections Research Alliance; the Saxony State, Regional and University Library; and the German Mining Museum in Bochum as well as with many other partners, including the renowned University of Oxford; Saarland State Monuments Office; Potsdam University of Applied Sciences; Treasury of the Munich Residenz; University of Freiburg and other institutions.

Topics:

- Development of an ontological data and knowledge platform FALK
- Socio-economic valuation of cultural heritage in the digital age
- Digital twins and urban space
- Sustainability of materials under the influence of climate change
- Public relations, training and knowledge transfer

The project is funded at a level of € 1.95 million. "We are very grateful for the financial support. It enables Fraunhofer to develop innovative technologies at the forefront of the cultural heritage sector, thereby consolidating our technological leadership. Fraunhofer also makes an important contribution to the European Green Deal and addresses the cultural dimension of sustainability in Germany and Europe," says Dr. Johanna Leissner, coordinator and scientific representative in Brussels.

ICON »»ALL SOLID STATE

Strategic partnership between
Empa and Fraunhofer

IE4B – solid state batteries for tomorrow's electric cars

As part of a strategic, international cooperation program of the Fraunhofer Gesellschaft, Empa in Dübendorf (Switzerland) and the Fraunhofer Institute for Silicate Research ISC in Würzburg (Germany) launched a three-year joint research project at the beginning of January to create the basis for a new production-ready generation of traction batteries for electric cars. In contrast to the lithium-ion cells in common use today, these cells are to consist only of solids and will no longer contain combustible liquid electrolytes. In this project, Empa is developing the chemical-physical fundamentals for this new battery technology; Fraunhofer ISC is contributing its expertise in process development and battery cell production and is producing the first prototypes.

MAVO PROJECTS

MAVO »» BIOELEKTRON

Biodegradable electronics for active implants

Medical implants are used to compensate for many lost bodily functions, significantly improving the quality of life of those afflicted in this way. Due to demographic growth, demand for these will increase steadily. Biodegradable implants would carry out their function for a limited period of time and then dissolve completely. Surgical intervention for removal would not be necessary. Purely passive stabilizing implants, such as sutures, cardiovascular stents or bone implants, have long been the subject of medical research and in some cases have been established as products.

The development of novel active implants on the basis of biodegradable electronics represents a consistent innovative measure to be achieved by the MAVO joint project bioELEKTRON. It will become possible to produce implantable assistance systems that have an active therapeutic and/or diagnostic function with a period of use limited to the specific application. Expert reports from industry and science prove that a need exists, particularly in the fields of neural stimulation, visceral surgery and pre-surgical diagnostics, for a demonstrable additional benefit for patients concurrent with an expected reduction in costs. Further applications for biodegradable electronics in veterinary medicine, agriculture, animal husbandry, biotechnology and the food industry appear promising. In the project, the essential components of biodegradable electronics are developed and integrated into an active implant. Barrier layers, conductor paths, electrode contacts and active electronic components are manufactured as functional basic components. Special attention is paid to scalable degradation kinetics, which are tested at in vitro level, as well as to biocompatibility and functionality. The project prototype specifically addresses the application of a resorbable stimulation and conduction electronic system resting on the meninges for pre-surgical epilepsy diagnosis. The prototype will prove the basic feasibility of the concept. Medical-technological innovation enables the opening of new services and markets. A basic prerequisite for technology transfer is the observance of legal and regulatory provisions during the development process.

The consortium consists of the Fraunhofer Institutes ISC, IBMT, FEP, IWKS-ALZ, and ENAS. It is coordinated by Fraunhofer FEP.

FRAUNHOFER PRELIMINARY RESEARCH

MAVO »»CRYORET

Cryopreservation technologies for stem cell-based retinal implants

Age-related macular degeneration (AMD) is the most common cause of blindness in the Western world. Rising life expectancy will result in an increase in the number of cases of this degenerative disease. Currently, AMD cannot be cured. Only in a small proportion of patients can the progression of the disease be slowed by regular, cost-intensive injections into the eyeball (IVOM). However, novel, regenerative forms of therapy are now beginning clinical trials. These are also based on the replacement of the diseased tissue with stem cell-based flat implants. Such a regenerative treatment has the potential to cure AMD if applied in time. For the majority of patients currently without treatment options, this would be an enormous improvement in quality of life due to the elimination of peripheral costs caused by the consequences of blindness. For the health care systyem in the long term, this would be a financially competitive treatment concept that could possibly replace IVOM therapy. Since AMD is based on multifactorial genetic predisposition and lifestyle, sufficient third-party donations are needed to obtain the original cells. It takes about two months to grow the implant from these cells. However, since the window of opportunity for successful therapy closes quickly, a stockpile of implant-ready tissues is necessary if there is to be broad clinical use of the procedure. The achievement of the technical and biotechnological prerequisites for such storage through function-preserving cryopreservation will be demonstrated for the first time in the MAVO project KryoRet.

In addition:

(1) the carrier membranes supporting the implant will be designed in a way that maintains its integrity during freezing,
(2) containers and media will be developed to protect the implant from harmful concentration gradients by means of passively controlled ice growth,
(3) assays for the evaluation and screening of the developed technologies will be established. These should not have an irreversible influence on the implants and should therefore be reusable, so that the implant itself can be tested for functionality and subsequently implanted.

To date, only a few of these non-destructive test methods are available. However, these are far from sufficient to achieve a full characterization of the implant's functionality.
The expertise needed to achieve these ambitious goals in polymer science and structuring, surface functionalization, formulation of particulate systems, stem cell biotechnology and ophthalmology is being pooled by Fraunhofer Institutes ISC, IST and IBMT in this joint project. The production of the membrane and storage of the implant can be marketed directly in cooperation with the pharmaceutical industry. The industrial property rights that ensue can be exploited via licensing, especially in view of their broad applicability in regenerative medicine.

MEF PROJECTS

MEF »»THERMELAST

Thermo-activated elastomers for smart textiles

The growing market for "smart textile" applications with a wide range of functions, from sensors to actuators and even energy conversion, places high demands on the materials used and requires cost-effective production facilities. At the present time, conductor paths, electrodes,and electronic components (such as motion sensors) are electrically connected with wires or conductive threads. The integration of cables, sensors and electronics into a very wide range of textile carriers is carried out with (converted) textile processing machines (looms, knitting, embroidery, sewing machines), often in combination with bonding techniques. Although these standard processes allow great flexibility in processing, they always represent a compromise among a number of bonding and contacting methods, making production expensive. The lines themselves are not stretchable, are susceptible to corrosion and frequently cannot be washed. Based on ISC-developed silicone elastomers, two low-cost production processes (adhesive technology for semi-finished products and printing technology) are to be developed. The silicone elastomers can be used as insulation material as well as highly conductive materail, when combined with conductive particles.

This permits an unlimited combination of highly stretchable, chemically and mechanically robust conductor structures, electrodes and strain/pressure sensors to be incorporated into textiles and cover fabrics, achieving short cycle times in the

range of 10 seconds and material costs of less than 10 €/kg at low investment costs. The various functional elements are integrated as demonstrators into a fabric such as a vest or seat cover so that they can be displayed.

MEF »»RAPIDDOSIMETER

Risk assessment of corrosive environmental conditions

Materials, buildings and plants are subject to corrosive environmental influences over time. This leads every year to enormous financial burdens in the billions or even to destruction, with serious consequences as exemplified by the case of steel and concrete bridge construction. The recording and assessment of the environment ("environmental monitoring") is therefore of great economic importance, especially in times of climate change, since corrosive processes are chemical reactions that can, for example, occur twice as fast under a temperature increase of 10° C. The rapid, integrated recording of environmental influences would therefore be a useful tool for the development of environmentally compatible materials or special corrosion-protected coatings that reliably protect building and plant infrastructures from decay. Maintenance intervals can also be optimized and planned accordingly. Up to now, however, there has been no precise and integrating environmental sensor that meets industrial requirements and records all relevant parameters as simultaneously as possible. On the one hand, the response is too slow, while on the other, analysis and determination of significance are strongly error-prone. The coupons currently available are too large for recesses that are difficult to access and cannot be used.

There is an urgent need for a more rapid measuring system for environmentally influenced corrosiveness that can be assessed without error and thus provide reliable results. Depending on the environment, a response should take place within days or weeks. The dosimeter to be developed must be easy to handle, small and inexpensive.

The aim is to develop a particularly small dosimeter with a measuring area of only 1 cm^2 based on a highly corrosion-sensitive glass powder. The progress of corrosion on glass can be precisely and objectively measured spectroscopically. This enables early and reliable information concerning the corrosion influence of selected environments that can be transferred to other materials.

Areas of application:

- Packaging, containers, sea cargo;
- IT infrastructure: Electronics in automobiles, in measuring instruments;
- Structural monitoring, including multi-story parking garages, bridges, tunnels, wind power plants in the offshore area; risk to structural steelwork elements from salt water.
- Corrosion protection test: Environmental simulation for corrosion and weathering tests: artificial accelerated aging experiments; corrosion endurance test runs such as car body recesses

MEF »»SCARCARE

Bioresorbable membrane to prevent postoperative adhesions and scarring

Postoperative adhesions are one of the most common complications after a surgical intervention involving soft tissue, e.g., in the intestine or uterus. In this case, the incised tissue during the operation (OP) does not heal as desired but instead grows together with surrounding organs to form scar tissue. These adhesions not only cause the patient severe pain but are often the cause of further complications such as unwanted childlessness, chronic lower abdominal pain or a narrowing and obstruction of the bowel. A necessary follow-up operation of the fused organs not only incurs additional costs for a new operation but above all exposes the patient once again to the typical risks of an operation (e.g., contamination by hospital germs). The aim of this research project is the development of a bio-resorbable membrane that prevents postoperative adhesions as a barrier and at the same time has a regenerative effect on the organism to reduce scarring.

By the end of the project, a functional bio-resorbable membrane should be available that can be easily applied during surgery and that has the potential to avoid scarring and prevent postoperative adhesions.

FRAUNHOFER PRELIMINARY RESEARCH

RAPID SME-ORIENTED IN-HOUSE RESEARCH SME PROJECTS

SME »» HyPad

Hydroactive wound pad with wound self-cleaning capacity for individualized therapies

The demographic change in the industrialized countries is manifesting itself in a constantly growing number of people in need of care amid a concurrent decline in the number of available care workers. For the treatment of chronic and difficult-to-heal wounds, various standardized, passive and non-patient-specific products are already on the market. A breakthrough in the treatment of chronic wounds would therefore be the development of a wound pad that is precisely tailored to each patient-specific wound geometry that also enables in situ regeneration of the wound while at the same time cleaning the wound itself. Particularly with regard to shape adaptation, there are enormous deficits in products currently on the market which must be overcome in order to achieve an innovative leap forward.

The result of this development is a regenerating, absorbable and healing-promoting material that combines with a component that initially rinses the wound and sucks inflammation out of the wound fluid. Moreover, the double-layer wound pad developed can be cut to fit any wound geometry and will not leave any substances in the wound that could interfere with healing. On one hand, this combination promises accelerated wound healing. On the other, the easy shape adjustment allows enormously the flexible use while simultaneously increasing the patient's wearing comfort by avoiding painful pressure points.

DISCOVER PROJECTS

DISCOVER »» iGene

Inductible method of genome editing for biomedical and biotechnological applications

The "iGene" research project of the Fraunhofer Institutes IME and ISC aims to demonstrate the feasibility of a completely new genome editing process. Genome editing, also known as gene scissors, is a promising method of molecular genetics that enables the targeted modification of the genetic material of organisms at the level of individual genes and with the precision of a single DNA base pair. Currently, designer enzymes are mainly used as genetic scissors (e.g., the recently discovered endonuclease CRISPR-Cas9 technology) to cut DNA at a specific site, resulting in double-strand breaks. These are eliminated by the cell's own repair system, a mechanism that is, however, prone to errors: Genes can be deactivated or individual DNA building blocks can be removed or added to produce the desired DNA change.

Despite the current scientific success, these methods have problematic aspects, including mutations at undesirable sites in the genome (known as off-target effects). In addition, existing genome editing technologies are protected by a large number of patents and can only be used in industrial projects to a very limited extent.

With the "iGene" project, Fraunhofer IME and ISC are pooling core competencies in the fields of molecular biology, biophysics and materials research to develop inductible physical genome editing, which is the focus of the targeted innovation. In contrast to the biological gene scissors, the physical gene scissors can completely dispense with the enzymatic activity of designer endonucleases, with no nucleases remaining in the host cell, thus minimizing off-target effects.

DISCOVER ""3-DiNO

Three-dimensional arrangement of nanoparticles for electro-optical applications

Order is the key to extraordinary material properties that make possible a wide range of applications in everyday life. The simplest examples are crystal structures in semiconductors to enable special electronic and optical properties. In the Discover Project 3-DiNO, Fraunhofer Institutes ISC (Würzburg) and IOSB (the Ettlingen site) are pursuing innovative approaches to the precise arrangement of nanoparticles at precisely defined points in a three-dimensional macroscopically sized body to create artificial materials with special electro-optical properties. These materials hold the potential to become revolutionary optical components with new or improved properties that cannot be achieved by conventionally arranged particulate layers or nanocomposites. These can include particular elements for wavelength conversion, non-linear optical elements and components for photovoltaics as well as for sensor technology. To make possible the required three-dimensional arrangement of nanoparticles, both institutes are combining their expertise in the production of nanoparticles, the synthesis of matrix materials and high-precision 3D lithography.

OUR YEAR 2019

FRAUNHOFER IS 70 YEARS OLD

For 70 years, its employees have made the Fraunhofer Society the leading partner for applied research. That was reason enough for us to celebrate in 2019 as we look ahead.

"What's next" is at the same time the central question and our declaration. The anniversary year of the Fraunhofer Gesellschaft founding officially began on March 26, 2019 with a reception hosted by the Bavarian state government.

PROJECT WITH EMPA SOLID STATE BATTERY

On 1/16/2019, FZEB and Empa initiated a joint project to create the solid state batteries of tomorrow. They intend to promote this important key technology for electromobility in Europe together with well-known industrial companies from Switzerland and Germany. The kick-off meeting with their industrial partners took place at Fraunhofer ISC in Würzburg.

27 GERMAN MEAT CONGRESS

On 13 February 2019, the 27th German Meat Congress took place in Bonn. Participating was Dr. Victor Trapp, who took part in the panel discussion on the topic "The Duty – The Way out of the Packaging Mania? The ISC is working on biodegradable plastic packaging, a building block on the way to a cleaner environment.

PHOTONICS WEST SAN FRANCISCO

Our two colleagues Dr. Sönke Steenhusen and Andreas Räder were at Photonics West in San Francisco February 2-7, 2019 – this show has been a fixture in our trade show planning for years and marks the start of our trade show year! On display were hybrid materials for microelectronics.

GOODBYE IWKS ...

For eight years, the Fraunhofer IWKS project group has been making progress in securing raw material supplies in Germany. Founded under the umbrella of the Fraunhofer Institute for Silicate Research ISC and continuously growing since then, the research group has been prolonged as an independent Fraunhofer institution under the name Fraunhofer IWKS at its locations in Alzenau and Hanau since April 8, 2019. Good luck!

OPENING OF FIBER PILOT PLANT IN BAYREUTH

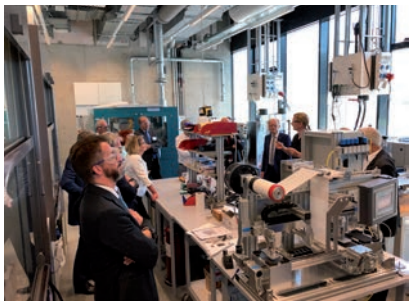
The Bayreuth location was able to expand its area in 2019: a new building for the large fiber pilot plant was formally inaugurated in April 2019. The Bavarian Minister of Economic Affairs was present for the ceremonial address along with many other guests from politics, science and business.

Thus, only a few years after the opening of the new institute building, the second major construction project for the Fraunhofer Center HTL has been completed.

VISIT BY THE PRESIDENTS OF THE STATE PARLIAMENTS

Visiting the facilities on Monday, June 4, 2019, about 70 state parliament presidents from Germany, Austria, South Tyrol and Belgium were guided through the laboratories by our employees. The visitors were very interested and asked many questions.

We were very pleased by the comment of President Aigner, the bavarian state parliament leader, as reported at the evening event: "At noon today we saw the future!"



CELEBRATION TO HONOR FRAUNHOFER PRIZE WINNERS

On July 8, 2019, colleagues Jörn Probst and Bernd Durschang were honored in a ceremony at Prof. Sextl's institute marking their receipt of the 2019 Fraunhofer "Human-centered Technology" Prize. The colleagues received the award for their work on high-strength dental glass ceramics for chairside procedures. The Dentsply Sirona employees responsible for glass-ceramic development were also present, and, together with the prize winners, they expressed their satisfaction with the outstanding joint project and discussed future topics.

OUR YEAR 2019

PROJECT COMPLETION DEGREEN

At the beginning of August 2019, the final presentation of the basic research project DEGREEN (Dielectric Elastomer Generators) of CeSMa, funded by the Bavarian Ministry of Economic Affairs, took place. After seven years, the evaluators were very satisfied with what had been achieved in the development of dielectric elastomers, and they praised the excellent work of the CeSMa team. New designs for decentralized power supply by micro hydroelectric power plants were developed and the first generators were tested on the Wern, Saale and Tauber Rivers.

FAREWELL DR. POPALL AND PROF. DR. WALLES

In 2019, we said goodbye to our long-serving colleague Dr. Popall, who built up the ISC International division through his contacts.

Prof. Walles, the initiator and head of the Translational Center for Regenerative Therapies TLZ-RT, also departed. She has accepted a position at the University of Magdeburg.

We wish both of them all the best and express our heartfelt gratitude for their excellent teamwork!

POLITICIANS VISIT FRAUNHOFER ISC

Fraunhofer ISC is highly regarded by politicians irrespective of party affiliation as a point of contact for discussions about the future. Guests were Hubert Aiwanger of the Free Voters Party, District President Dr. Eugen Ehrmann and Patrick Friedl, a member of the Bavarian Parliament and spokesman on matters of conservation and climate adaptation.

PATRICK FRIEDL, MEMBER OF THE STATE PARLIAMENT

MINISTER OF ECONOMICS HUBERT AIWANGER

Digitization State Minister Dorothee Bär visited Fraunhofer ISC in October for a background discussion on that subject.

DISTRICT PRESIDENT DR. EUGEN EHRMANN

STATE MINISTER DOROTHEE BÄR

FOUNDING OF eLi INSTITUTE

The formal launch of the virtual "European Lithium Institute (eLi)" took place at the beginning of 2020. eLi brings together partners from all across the lithium value chain. The bundling of expertise in the fields of exploration, mining, processing, manufacturing and recycling as well as predictive modeling in a European institute offers comprehensive consulting and competent development partners for the sustainable, responsible and economically viable use of lithium.

ABAA12 IN ULM

Our colleagues Mario Weller and Philip Daubinger were taken by surprise at the ABAA12 in Ulm! They suddenly found themselves standing next to Stanley Wittingham of the State University of New York at Binghamton, who, along with John Goodenough of the University of Texas at Austin and Akira Yoshino of Meijo University Nagoya in Tokyo, had been awarded the Nobel Prize in Chemistry that very day for the development of lithium-ion batteries. Of course we immediately took a picture.

FRIEDRICHSTRASSE BRANCH OFFICE RELOCATES AFTER 30 YEARS

At the end of November, the Friedrichstrasse branch office premises were handed over to the new owner and lessor. This brought activities to a close at the branch after 30 years. It had begun in 1989 with the Coatings Application Center, spinning off T_O_P Oberflächen GmbH in 2000. Quite moved by the demolition that accompanied the new owner's reconstruction work, our colleagues packed up in November and are now back at Neunerplatz.

FRAUNHOFER ACADEMY CONVENES IN BRONNBACH

On December 13, 2019, the second practical seminar on 3D tissue engineering took place, jointly organized by the Fraunhofer Academy and TLZ. The nine fee-paying participants from the industrial and research sectors were enthusiastic about the training content that Marco Metzger, Florian Groeber-Becker, Oliver Pullig, Jörn Probst, Lisa Kiesewetter and Tobias Schmitz had prepared for the seminar program and were also delighted with the outstanding ambience in Bronnbach.

WHAT WE DO

MATERIALS – 1D

As a materials research institute, Fraunhofer ISC develops innovative, functional and sustainable materials for industrial applications. Our focus is on glass, glass ceramics, ceramics, plastics – especially inorganic-organic hybrid polymers – as well as sol-gel materials, particles and smart materials. The materials are processed into particles, powders and fibers in a fully one-dimensional manner.

More on page 35

PROCESSES

In addition to traditional methods of material production and processing, automated processes are increasingly playing a role in material development. Using modern production methods, customer-specific special parts and components can be manufactured in a resource-efficient manner. The material properties are either adapted to the desired manufacturing processes or - if this is not possible - alternatives are found. Complex component shapes and design principles are possible, as is individualized but cost-effective mass production, not to mention the contribution of digitalization to material development and production.

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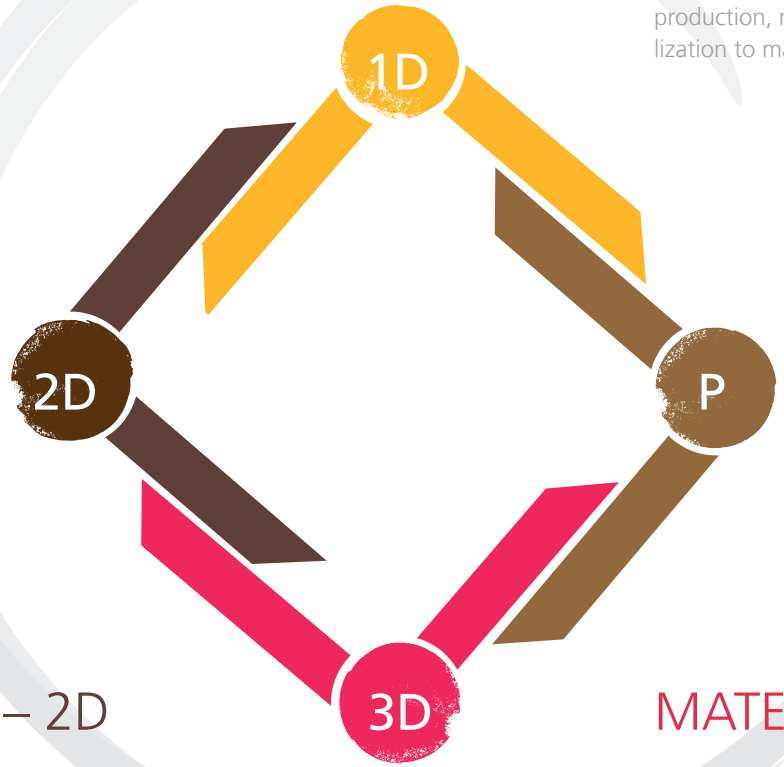

MATERIALS – 2D

Fraunhofer ISC has an exceptionally well-developed research infrastructure that includes industry-oriented processing methods, enabling it to upscale coating and paint syntheses on behalf of customers and to bring further processing of coatings up to pilot scale. The product range includes paints and (multi)functional coatings both on an inorganic basis and on a hybrid polymer basis, e.g., bio-based bioORMOCER®s. In addition to traditional protective and functional coatings, switchable and active coatings can also be produced.

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MATERIALS – 3D

With industry-oriented shaping processes, material development enters the third dimension. Composite materials, special glass, ceramics and hybrid polymers as well as "living" materials such as organoid cell cultures can be achieved.

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ANALYTICS

Precise analysis and characterization form the backbone of every material development. In this area, Fraunhofer ISC earns high marks with its experienced experts who use their materials knowledge and meticulous intuition to identify problems and/or damage. The Center for Applied Analytics is accredited under DIN EN ISO/IEC 17025:2005. In addition, it is one of the testing laboratories approved for the testing of mineral wool by the RAL and EUCEB quality review organizations.
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TESTING

The testing of material and usage properties plays an important role in industrial implementation. Equipment to test for a wide range of concerns ensures meaningful and reliable evaluations in such areas as chewing simulation, battery charging cycles and weathering tests. Another field of activity is the validation of active substances on biological test systems according to the Three Rs principle to avoid animal testing.
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MATERIALS

1D

ONE-DIMENSIONAL MATERIAL DEVELOPMENT AS STEP 1

Just as grain achieves a different effect as kitchen flour than in its original form as a grain and can thus become a component of delicious cakes, different particle sizes and fiber dimensions also influence the effects that can be achieved with one-dimensional materials. These can be used as additives and fillers or as substrate and reinforcing materials, thus having an amazing effect on the properties of the materials that contain them.

For example: particles of magnetic materials, which are very small, only exhibit magnetism in an external magnetic field. If there is no field, they are not magnetic. In this way, switchable magnets can be created - with a few additional material tricks.

This chapter discusses how industrial material loops can be closed or how iron reinforcements in concrete can be replaced by thin fiberglass bundles.

Welcome to a tour of the Fraunhofer ISC **materials "kitchen"**.

MATERIALS 1 D

More information about this project at www.isc.fraunhofer.de/Jahresbericht

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Publication: Indicator Supraparticles for Smart Gasochromic Sensor Surfaces Reacting Ultrafast and Highly Sensitive
Susanne Wintzheimer, Maximilian Oppmann, Martin Dold, Carolin Pannek, Marie-Luise Bauersfeld, Michael Henfling, Sabine Trupp, Benedikt Schug, and Karl Mandel in Particle and Particle Systems Characterization, Volume 36, Issue 10, October 2019*
https://doi.org/10.1002/ppsc.201900254

Where there's smoke – new fast CO sensors provide reliable warning

These have been mandatory for a number of years: Smoke detectors that also detect smoke in residential buildings and give residents timely warning. But flawed if the steam from the noodle pot sets off the alarm. The susceptibility to false alarms is due to the fact that inexpensive smoke detectors have so far been based only on the weakening of light by particles. For such sensors, it does not matter whether the cause is due to smoke, water vapor or dust. Unfortunately, much more reliable semiconductor-based CO detectors used for fire detection in the professional sector are too expensive and create high operating costs because they have to be heated constantly. They are thus inappropriate for the consumer sector.

Fraunhofer ISC and its two sister institutes IPM and EMFT have taken action to address this problem through an internal research project that has developed a cost-effective and reliable CO sensor. At the core of the sensor are nanoporous particles permeated with special dyes. In conjunction with the adapted particles, the dyes react very quickly, and even the smallest amounts of CO in the ambient air produce a change in color. The sophisticated sensor design prevents malfunctions caused by other environmental influences. Fraunhofer ISC contributed its expertise in particle synthesis and process engineering for particle production, infiltration and application via printing processes, while IPM and EMFT contributed the sensor architecture, control and gas-sensitive dyes. The same process and appropriately dye selection can also be used to implement additional sensors – for example, to warn of volatile hydrocarbons or other harmful gases in the ambient air. Due to their simple design, these innovative sensors can be produced very cost-effectively and are easy to read due to the rapid color change – an impressive idea that also has great potential for mass production.

MATERIALS DEVELOPMENT

More information about this project at www.isc.fraunhofer.de/Jahresbericht or www.project-oasis.eu

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EU joint project OASIS (Open Access Single entry point for scale-up of Innovative Smart lightweight composite materials and components): European technology platform for sustainable lightweight production with nanomaterials – 20 partners from research and industry, EU-wide networking of 12 pilot lines, six lighthouse projects – including lightweight construction for building and construction.

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation

International cooperation for CO_2 reduction EU OASIS project establishes pilot production lines

The building materials industry is one of the world's major CO_2 producers Material and process innovations for building and construction are therefore an important lever for reducing CO_2 emissions and achieving climate targets. Fraunhofer ISC has long supported sustainable building materials in this area – for example, in the use of energy-saving recycled aggregates in concrete production. The Institute is currently working together with European research institutes and well-known industrial companies on a technological revolution for lightweight concrete construction using nanomaterials. Under the leadership of the renowned Spanish construction and infrastructure group Acciona Construcción SA, a sustainable, climate-friendly and cost-effective process is to be developed for the replacement of iron reinforcements with stable but much lighter fiberglass rods. Previous attempts to produce fiberglass reinforcements by extrusion for load-bearing structural parts – on bridges, for example – failed due to the high costs of the complex production process. Fiber bundles are impregnated with resins, then shaped and slowly cured in large furnaces. On the whole, this step of controlled, slow and complete curing of large reinforcement components is lengthy, prone to error and expensive. With inductively heatable nanoparticles from Fraunhofer ISC in the resin matrix, the curing step in extrusion could now be simplified. The advantage of the new process is the rapid inductive heating. This allows the entire cross-section to be cured uniformly, quickly and reliably. Errors and unevenly hardened areas could be avoided. The new lightweight reinforcements are designed to save energy and weight, signifying an advancement in reducing CO_2 emissions in the field of construction and design. The inductive hardening process, which has so far been tested on a laboratory scale, is being set up as part of the EU project OASIS for a lightweight pilot production line, and the nanoparticle formulation is being further developed to meet specific requirements. To this end, the pilot line for the production of nanoparticles, which has already been established by the Particle Technology Department at Fraunhofer ISC as part of the EU project CoPilot, will be expanded from the current 5 kg/hour to 10 kg/hour to provide the required quantities.

MATERIALS 1 D

More information about this project at
www.isc.fraunhofer.de/Jahresbericht

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Project funded by the Federal Ministry of Education and Research BMBF
within the framework of the program "InnoEMat"

InnoEMat_Electrovortex (promotional reference number: 13XP5008)

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

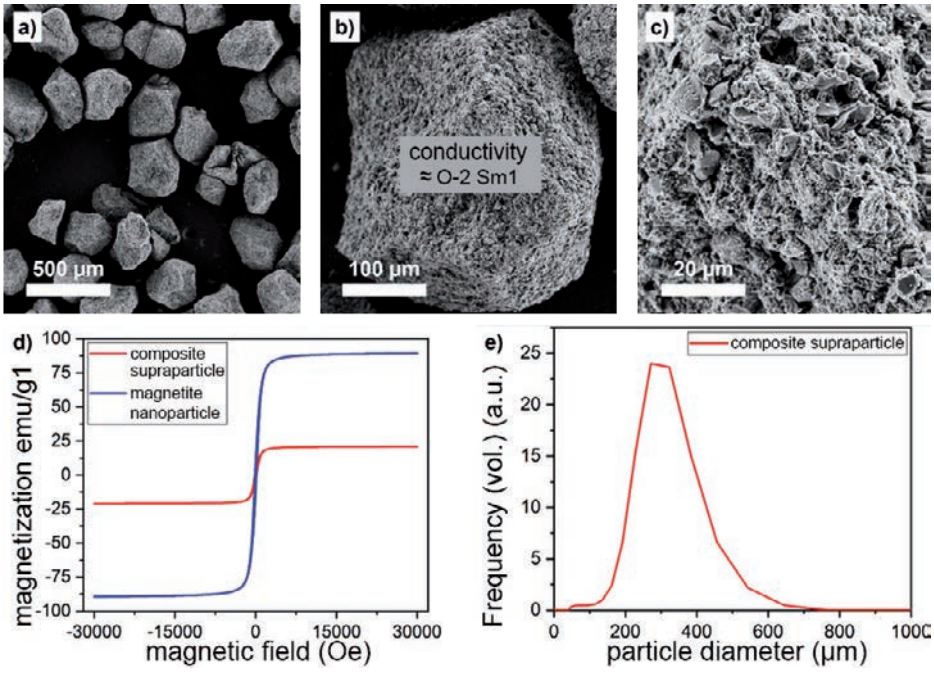
Closing industrial material loops – with new electrochemical fluidized bed reactors and functionalized particles

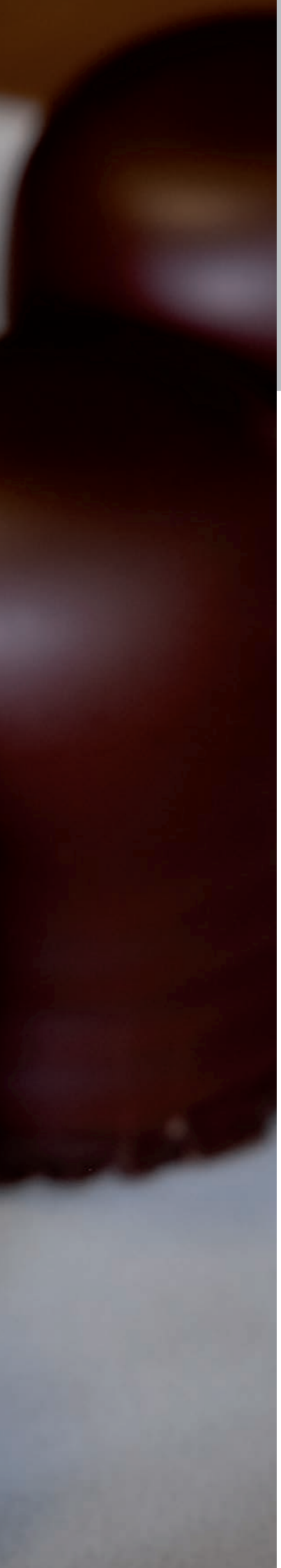
Closed sustainable production loops – water resources are increasingly coming into focus. In that matter the expanding shortage of drinking water worldwide due to the growing population and climate change, this task also has social and ecological significance. For this reason, even in comparatively water-rich countries such as Germany, research is being conducted into closing water loops in industrial production. The aim is to minimize the input of salt and residues into surface waters. Many industrial chemical syntheses produce considerable amounts of waste water. These often contain salts, but their concentrations are so low that their use as educt flows is not economically viable. In addition, the waste water often contains organic contaminants that must be separated because they would cause problems in production. Environmentally friendly disposal of this waste water is associated with high costs. In addition, saline waste water interferes with biological degradation in sewage treatment plants and can pollute surface waters. In most cases, neither purification nor concentration can be achieved economically with established processes.

In the Electrowhirl project, Fraunhofer ISC, in collaboration with the Karlsruhe Institute of Technology (KIT), Leibniz Institute for Interactive Materials DWI, DECHEMA Research Institute and the Covestro, FuMA-Tech and Evonik companies, has been researching the fundamentals of new electrochemically fluidized bed processes that in the future will allow salt-laden wastewater from the chemical industry to be more completely purified and organic trace substances to be removed. Two innovative fluidized bed electrodes were developed in the project: the flow electrode capacitive deionization or FCDI (slurry electrode) for salt concentration and the magnetic-electrochemical fluidized bed electrode for the removal of organic contaminants using functionalized magnetic and electrically conductive particles from Fraunhofer ISC.

MATERIALS DEVELOPMENT

The basic feasibility of salt concentration was demonstrated. In addition, important process parameters have already been determined. Advantages are seen above all with solids-laden waste water for which conventional membrane processes are difficult to use, as well as through the driving force of ion movement instead of the usual water movement. The focus of future projects will be on economic efficiency, regeneration of components and recycling capacity, the reduction of corrosion and abrasion in the fluidized bed reactors as well as on the particles, not to mention the upscaling of the process. The consortium sees further possible applications for the process in such areas as electro-enzymatic reactions or microbial fuel cells.





MATERIALS

2D

TWO-DIMENSIONAL - OUR MATERIALS IN PAINTS AND COATINGS

Just when everything is going well, an **unexpected flaw** destroys everything. So that this does not happen to you with your carefully manufactured products, we have been working with **coating materials and technologies**...

Functional coatings not only look attractive: they also create new functionalities and added value with little material input. Depending on the application and task, they protect against gases, moisture, light, heat, mechanical stress or contamination. They can "feel", create transitions at the interfaces of materials, promote cell growth or inhibit the development of microbes, provide adhesion, reduce friction, change color or reflective properties, store energy and, depending on your preference, have either an anti-static or static charging effect. **The spectrum of possibilities is enormous.**

Fraunhofer ISC has **decades of experience** in developing a wide range of functional coating types for industry. Many of our developments can be found in the products marketed by our customers. Material development is based on typical wet-chemical production processes that can be applied over large areas regardless of the atmosphere – e.g., dipping, spraying, scraping, R2R, printing. These inorganic – ceramic or glass-like – or inorganic-organic hybrid coating materials can be perfectly adapted to the desired characteristic profiles through chemical synthesis. Solvents, pot life and processing modalities can also be considered. Through our network, we can also arrange upon request to provide reliable partners for production or contract coating.

Coatings are also prone to errors, however. The thinner the layer, the lower the fault tolerance and the more important the material-, process- or production-related failures, from a "pinhole" to a crack or even the delamination of the layer. This is why Fraunhofer ISC's work for its clients includes **identifying and eliminating the causes of errors** . The scientists at the Center for Applied Analytics have extensive material and production expertise, and they use their detective instincts and comprehensive analytical methods to identify the sources of error.

MATERIALS 2D

More information about this project at www.isc.fraunhofer.de/Jahresbericht

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EFFICIENT USE OF SOLAR ENERGY IN ARID REGIONS

A successful cooperation with the King Abdulaziz City of Science and Technology (KACST)

The use of solar energy with photovoltaics offers an efficient way to generate electricity, especially in arid regions. However, it is precisely there that the regular precipitation needed to clean the power plants naturally and maintain full performance is lacking. Dirt-repellent surfaces can help to minimize the cleaning effort. In addition, the anti-reflective quality of these coatings increases the transmission of the radiation and thus the efficiency of the modules. Fraunhofer ISC's multifunctional particle-based coating systems, which have been continuously developed over the last 10 years, have had particular success in this area. The coatings combine anti-reflective qualities with dust-repellent surface modifications and can thus increase the efficiency of PV systems, extend cleaning intervals and drastically reduce maintenance and service costs.
As part of the development work on these multifunctional layers, a collaboration was established between 2013 and 2016 with the King Abdulaziz City for Science and Technology (KACST) in Saudi Arabia, resulting in two new patents. On the basis of this successful cooperation, a follow-up project was launched in 2017 to bring the joint patent to market maturity and to commission a pilot dip coating plant in the Solar Village near Riyadh. The focus of the joint research project is the elucidation of various contamination phenomena and adhesion mechanisms of dirt particles on glass surfaces. For this purpose, a large-scale field trial was conducted for a period of one year at eight locations in Saudi Arabia having different dirt characteristics (e.g., near urban areas with dirt particles from tire wear, household emissions, oil and sooty dirt from the vicinity of industrial plants, rural or uninhabited locations with sand and dust particles).

In addition to Fraunhofer ISC's multifunctional coating systems, coatings from leading competitors were also evaluated in the benchmark field test. Parallel to the field tests in Saudi Arabia, the coated panes were assessed in a specially developed dust test chamber at Fraunhofer CSP in Halle. Together with its sister institute, it subsequently prepared and published VDI Standard 3956-1, "Test procedures for the dust-related pollution procedure of solar energy systems".

The evaluation of all tests, both in the field and in the laboratory, revealed that the Fraunhofer ISC coating systems delivered very good results at almost all locations. On the basis of findings from the field test as well as the tests in the new dust test chamber, the multifunctional coatings produced at the ISC can be further optimized in the coming years and adapted to different climatic regions, pollution types and new applications. The pilot plant is expected to go into operation during 2021. It will initially be used to coat the front glazing of smaller PV street lighting modules and will also be used later for larger modules.

COATINGS AND LACQUERS

New material approach for mulch films – NewHyPe against microplastics in the field

On the road to more environmentally friendly cultivation methods, Fraunhofer ISC is working with research and industry partners from Germany, Finland and Norway to develop sustainable mulch films for agriculture as part of the NewHyPe joint project co-financed by the EU and the Federal Ministry of Education and Research (BMBF). Mulch films are used to extend the growing season – as in asparagus cultivation, for example – to reduce weeds and thereby minimize the use of pesticides, but also to evaporation and exert a positive effect on the soil's water balance. The use of petroleum-based plastic films predominates, ultimately contributing to the buildup of microplastics in the soil. Paper mulch films are not durable enough for most applications, and they usually contain petroleum-based binders that pollute the soil. A more environmentally friendly replacement for the films used on a large scale needs to be extremely cost-effective and capable of being mass-produced.

Fraunhofer ISC and its partners in the NewHype project focus on the further development of proven technologies and inexpensive renewable raw materials. Paper is to be produced on an inorganic-organic basis from functionalized nanocellulose and/or lignocellulose originating in the wood industry along with a biodegradable and mineral oil-free binder. On its own, this paper must be sufficiently stable to be used as mulch film. For longer cultivation periods, the project team is also working on a cost-effective biodegradable functional coating that further stabilizes the paper. The Chemical Coating Technolgy Department at Fraunhofer ISC is coordinating the joint project and contributing its many years of expertise in the functionalization of nanocellulose or lignocellulose in combination with hybrid binders and paper enhancement to resist moisture and other influences. Together with the partners and within the framework of the bio-economic initiatives of the EU and the German government, a cost-effective and sustainable replacement for current mulch films is to be created on the basis of renewable raw materials.

More information about this project at www.isc.fraunhofer.de/Jahresbericht

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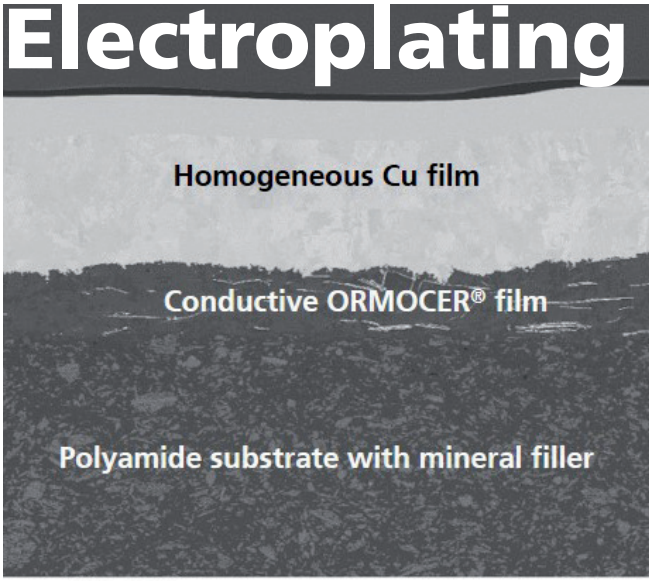
Funding code: 031B0924A
Funded by the the Federal Ministry of Education and Research (BMBF)

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

MATERIALS 2D



More information about this project at www.isc.fraunhofer.de/Jahresbericht

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Funding code: 03XP0221B - funded by the the Federal Ministry of Education and Research (BMBF)

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

Electroplating plastics in an environmentally friendly way

When it comes to the sustainable use of raw materials and supplies, many established industrial processes are vulnerable to criticism. One example is the electroplating of plastics, i.e., the refinement of plastic surfaces through the electrochemical deposition of chrome or other metals. From car door handles to cream jars, electroplated plastic products are ubiquitous, and process technology is well established and designed for cost-effective mass production. However, many chemicals, some of them toxic, are used in the conventional galvanizing process along with palladium, a precious metal in critically short supply.

Together with industrial partners from the plastics and electroplating sectors, Fraunhofer ISC is working on a wet coating process that eliminates the need for palladium as a conductive metallization and avoids the use of environmentally harmful chemicals. This is made possible by specially designed multifunctional hybrid polymers. Due to their chemistry and special structure, they create reliable adhesion between the plastic surface and the galvanic layer and, by means of a doping process, provide the conductivity necessary for the galvanic process. The basic feasibility has already been demonstrated in preliminary projects; in the current joint project, materials and process are being optimized and material synthesis is being updated. With Fraunhofer ISC's material innovation, electroplating could become much more environmentally friendly and easier through the elimination of etching processes and critical process chemicals. Beyond the environmental aspects, the expected cost reduction due to the smaller number of process steps is of great importance to the affected industries.

COATINGS AND LACQUERS

Sustainable surface treatment for container glass

Glass is a recyclable and versatile packaging material of the first order. Nevertheless, hidden behind the production of glass containers for packaging beverages, food and other goods is a complex process of glass melting, hot forming, subsequent hot finishing and cold finishing (Hot End Coating HEC or Cold End Coating CEC). HEC, for example, uses titanium dioxide or tin oxide to fill micro-cracks from the production process, preventing crack propagation in the glass and thus permanently strengthening the container and even protecting it to a certain extent from glass breakage. The microwaxes or long-chain polymers used in the CEC, on the other hand, are intended to facilitate the circulation of the glass containers through the filling lines and provide additional protection for the glass surfaces by reducing friction between the containers. While the glass melting process itself has had repeatedly successes in recent decades as a substitute for critical ingredients, HEC and CEC continue to use dubious process chemicals such as chlorobutyl titanate, tin(IV) chloride, butyl tin chloride and other organic compounds to deposit titanium oxide or tin oxide onto the glass surface.

By contrast, new inorganic-organic hybrid polymers from Fraunhofer ISC can achieve crack-healing and reinforcing effects comparable to those of conventional HECs and a reduction in friction similar to conventional CECs in a single "cold" tempering step. Not only can the HEC process step be eliminated, but a number of critical and sometimes toxic halogenated process chemicals can be replaced. Another advantage is the significantly higher scratch resistance of the hybrid polymer-based coating compared to conventional CEC coatings. This material and process development by Fraunhofer ISC can make an important contribution to sustainable and efficient glass container production. The process has already been tested on a small scale on beverage bottles.

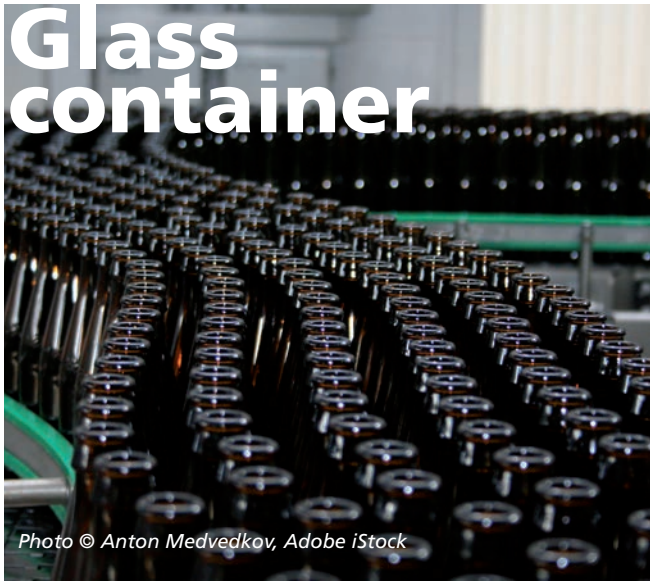

Photo © Anton Medvedkov, Adobe iStock

Bottles in the bottling plant require strong surface protection against cracking and scratching as well as low friction when circulating through the plant – the task of a new halogen-free coating from Fraunhofer ISC for container glass.

More information about this project at www.isc.fraunhofer.de/Jahresbericht

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Funding code: 03XP0221B - funded by the BMBF

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

MATERIALS 2D

More information about this project at www.isc.fraunhofer.de/Jahresbericht

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Funding code n°869929

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation

Project partner:
Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technology FEP (coordination)
Fraunhofer-Institute for Silicate Research ISC
ChromoGenics AB, Sweden
School of Mechanical Engineering, National Technical University of Athens, Greece
University of West Bohemia, Czech Republic
SIA AGL Technologies, Latvia
FASADGLAS BÄCKLIN AB, Sweden
Vasakronan AB, Sweden
"Agios Panteleimon" General State Hospital of Nikaia, Greece
VAN ROMPAEY SARA, Belgium
AMIRES s.r.o., Czech Republic

Regulate sunlight at the touch of a button

The hot summers reveal the problem: Modern glass façades may be beautiful, but they make high demands on a building's air conditioning. In an EU-funded joint project, a shading system that is fully integrated into the façade elements and windows and can be variably adjusted depending on sunlight is being developed using electrically controlled, highly transparent electrochrome coatings as a promising alternative to existing shading systems. These could be effective in reducing the amount of energy required for the air conditioning of buildings. The electrochrome materials are applied as thin layers on transparent, conductive substrates, intensifying their color at the touch of a button to create a pleasant darkening effect. When shading is no longer required, they can also be brightened at the touch of a button.

In the "Switch2Save" project launched in 2019, Fraunhofer ISC is contributing its many years of experience in the production of electrochrome layers using roll-to-roll processes (R2R) on flexible substrates and in the upscaling of processes and system development. The electrochrome layers produced by Fraunhofer ISC are based on innovative materials that exhibit high color contrast and short switching times. R2R process capability also offers great potential for future cost reduction in the production of electrochrome elements. Fraunhofer ISC is also contributing its expertise and technical infrastructure to the Switch2Save project, which is aimed at identifying optical and electrochemical properties. The aim of the EU-funded project is the large-scale production of electrochrome and thermochrome switching laminates for use in façade elements and windows.

COATINGS AND LACQUERS

More information about this project at www.isc.fraunhofer.de/Jahresbericht

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The project, coordinated by Fraunhofer IWKS and Fraunhofer ISC, was funded by BBI-JU within the framework of the European Union's Horizon 2020 research and innovation program with €4.4 million (funding no. 720736)

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation

HyperBioCoat – new bio-based packaging materials

Takeout capacity, convenience and constant availability of fresh food, long food shelf life: All this is not possible without high-tech plastic packaging. The consequences for the environment are serious. Due to improper disposal and the decomposition of plastics into microplastics that pollute our oceans, groundwater and soil, threats exist for flora and fauna and not least for human health.

Food packaging must fulfill a variety of different properties: especially as a barrier against water vapor, oxygen and flavors, it plays an important role in protecting sensitive goods. Although biodegradable packaging materials have been on the market for years, they do not possess these properties to a sufficient extent. As coating materials, the bioORMOCER®s developed at Fraunhofer ISC offer excellent barrier properties and can make new environmentally friendly packaging materials possible by applying them to biopolymer films, essentially "upgrading" them. Fraunhofer ISC was a partner in the BBI project HyperBioCoat, which was successfully concluded in August 2019. The aim of the European Union-funded project was the further development of the properties of bioORMOCER®s to find different formulations for hard and flexible substrates and extract biological molecules such as hemicellulose from biological residues. For example, fruit scraps were examined and found to be fundamentally suitable for the extraction of hemicellulose and cellulose. The successful use of organic components obtained from food scraps or waste for bioORMOCER® paint synthesis can prevent competition with food agriculture and also close an important recycling loop. Biodegradable bioORMOCER® coatings for bio-based packaging materials therefore contribute to environmental protection and can be successfully used in innovative packaging designs. The further development and product-specific adaptation of bioORMOCER®s is being advanced at Fraunhofer ISC in follow-up projects together with industrial partners.

MATERIALS 2D

More information about this project at
www.isc.fraunhofer.de/Jahresbericht

Dr. Sabine Amberg-Schwab | Phone +49 931 4100-62(

How plastic packaging becomes recyclable

Plastic is a material with many positive properties for packaging: Light, inexpensive, shatterproof, durable – and therefore widely used. However, discarded plastic packaging has become an environmental burden worldwide. Recycling is not possible for many types of packaging – e.g., foil pouches with a stand-up base – because different plastics are combined as laminates in a single packaging material to achieve stability, sealing capacity, printing capacity, moisture resistance or oxygen impermeability. The different types of plastic in the laminate usually cannot be separated, nor can they be recycled together since their chemical makeups are so different.

Fraunhofer ISC is working with three other Fraunhofer Institutes on a new manufacturing process for polyolefin-based plastic films to replace non-recyclable foil laminates. The core elements of the process are pure polyolefins or recyclates, special additives and physical and wet-chemical post-treatment. The aim is to enable the foil properties to be adapted to the respective technical requirements as precisely as laminates made of mixed plastic types. However, by restricting the use of these foils to a single type of plastic, they will be fully recyclable and can form a true material cycle, which means they will be able to serve as raw materials for new packaging. With its material expertise, the ISC ensures the required barrier effect of the new generation of foils against oxygen and moisture.

COATINGS AND LACQUERS

More information about this project at www.isc.fraunhofer.de/Jahresbericht

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Funding code: 03XP0221B - funded by the BMEL

Bundesministerium für Ernährung und Landwirtschaft

One step further: How plastic packaging can be "organic"

While the recycling capacity of polyolefin-based plastic packaging aims to achieve the lowest possible loss of fossil resources, Fraunhofer ISC's developments of biogenic plastic packaging go one step further in the direction of bioeconomy and reduction of fossil resources. Together with four partners from industry and research, Fraunhofer ISC is working on a new generation of foils based on biogenic, readily available raw materials that meet all the usual requirements for food packaging. The starting point is biogenic plastics based on lactic acid (PLA). Lactic acid is a basic material produced from substances such as milk processing residues. PLA's previous disadvantages, including moisture sensitivity, difficult processing and lack of recycling capacity, are to be eliminated by modifying the formulation and combining PLA with partially bio-based bioORMOCER®s. The biogenic films obtained by this method are intended to have technical properties comparable to those of conventional foil laminates for food packaging, which are generally non-recyclable but consume less material and can be reused. In this way, they should not only create a resource-efficient circular economy but also break the dependence on fossil raw materials. The research project is funded by the Federal Ministry of Food and Agriculture within the framework of the "Renewable Resources" funding program.

© PIXABAY

MATERIALS

Truly **appealing and appetizing**: the donut with the golden glaze and colorful sugar flakes. A donut's shaping and decoration are half the battle. But of course, the dough must also be able to do its part, to be sufficiently shapable and stable to retain its shape. And it should also be pleasantly moist and tasty. The catalog of requirements for donuts is not particularly extensive; one could also mention the origin of the raw materials – preferably organic or at least sustainably produced – or the total absence of substances harmful to the consumer.

In material development, **requirements** regarding **raw materials, structure and functionality** come into play in a similar way. To name just a few: availability, cost, low hazard potential and environmental friendliness, condition, resilience, durability –or even biocompatibility and capacity for degrading. Added to this are shapability, a capacity to take on a variety of functions, and of course the desired functionality itself.

A particular challenge is posed by materials with variable properties: **"switchable"** materials that can change their properties **"at the push of a button"**, sensory materials, materials that can repair damage and have a stabilizing effect through their slow pace of change, or materials based on living cells that can be used in new prostheses or implants, for example.

Fraunhofer ISC also offers competent partners for research and development in these areas through its expertise in **smart materials, conservation research and regenerative therapies**.

MATERIALS 3D

More information about this project at www.isc.fraunhofer.de/Jahresbericht

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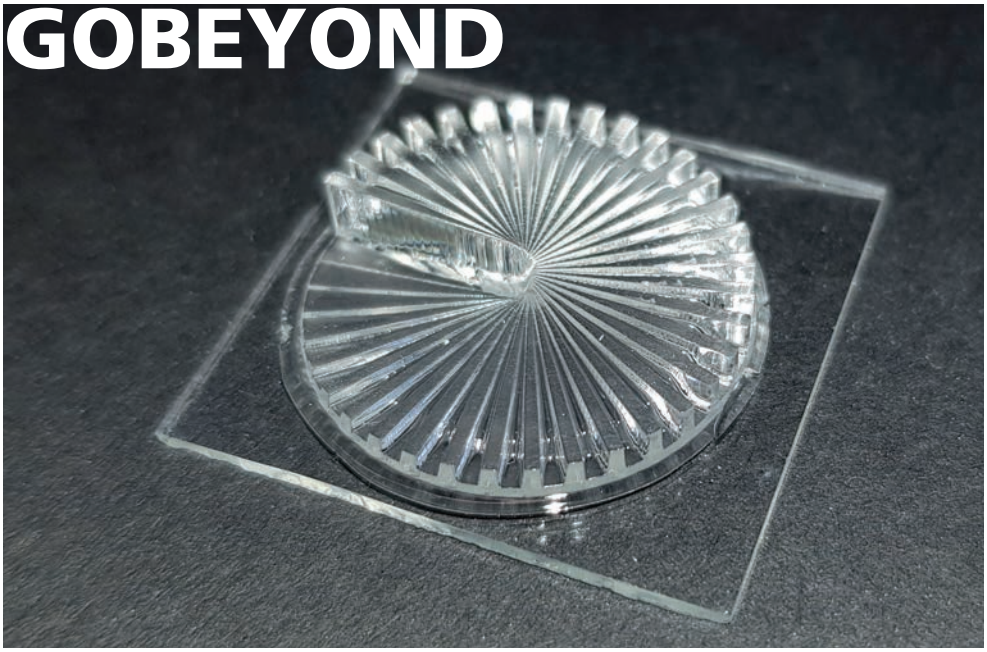
Reversible stabilization of archaeological glass

Archaeological glass finds are among the most fascinating testimonies of earlier cultures. They tell of craftsmanship and technical skills, widely ramified trade relations, luxury and status as well as social and religious rituals. And yet the fact that the glass survives is often a small miracle since the sensitive material suffers from mechanical as well as chemical "attacks" from the storage conditions. The glass is leached out, for example, by permanent moisture, which changes the glass composition and structure, 'gel layers' are formed along with pores and extremely fine crack systems known as craquelés, which can thoroughly penetrate the glass and destabilize it. Accordingly, the finds are often fragile, with their former beauty barely visible on the surface, and they pose a great challenge to both archaeologists and restorers.

With "Cloisil A18", the Cultural Heritage Protection Group at Fraunhofer ISC has developed a material that can be used to protect archaeological glass finds for salvage, transport, restoration and archiving. The low-viscosity strengthener based on hybrid silicate polymers penetrates into three-dimensional pores and cracks in damaged glass. Within a few hours, the initial strengthening effect occurs, allowing the glass to be safely handled. As laboratory tests show, it has already become possible to use the consolidator in the recovery of soil finds, including block excavations: The glass is soaked together with the adhering or surrounding soil and can thus be recovered and archived without damage. During subsequent examination, cleaning and restoration, the hardener can be dissolved and removed with water and/or ethanol. Under certain circumstances, this can also be done partially once the condition of the respective find has been checked, enabling the glass to be exposed and cleaned step by step. The setting agent is almost invisible, and it can also be used after cleaning to secure the glass for transport, exhibitions or storage in depots. The transparency of the glass is brought closer to its original state by filling in refractive cracks and pores. The material has already been used for various purposes in a number of EU conservation research projects. Recent research on glass finds from the cathedral excavation on behalf of the cathedral construction lodge in Cologne have shown Cloisil A18's particular suitability for stabilizing archaeological glass.



3D-printed optics for individualized mass production

Customized yet suitable for mass production? The Fraunhofer lead project "Go Beyond 4.0" aims to eliminate this apparent contradiction. In the subfield of illumination optics, two Fraunhofer Institutes – for Silicate Research ISC and for Optics and Precision Engineering IOF – are working together on a material-based and production engineering solution for "batch size 1".

The starting point is the relatively easily customizable 3D printing technology. However, the disadvantages of three-dimensional printing so far have been the disturbing effects on volume and on the surfaces of printed objects, such as layer formation or roughness. Even the material properties of common 3D printable plastics are usually insufficient for optical components and systems. High demands are made on optical systems in the lighting sector. The materials used should be as similar to glass as possible, must not yellow in use and require high transparency in the relevant wavelength ranges of the light passing through them. Layer boundaries in volume and less-than-smooth surfaces due to print-related structures on the micrometer scale, common occurrences in 3D printing, are not acceptable for use in optical systems.

However, with ORMOCER®s (glass-like inorganic-organic hybrid polymers) from Fraunhofer ISC and an improved printing technology from Fraunhofer IOF, a leap in quality has been achieved. Developers at Fraunhofer ISC have also used specially adapted optical ORMOCER®s in the field of optical packaging and interconnection technology.

In addition, other required functions such as apertures, conductor paths or mirrors can be integrated into the printed optical components during the manufacturing process. This strategy simplifies subsequent assembly and makes highly complex optical components possible. The combination of optical ORMOCER®s and 3D printing processes facilitates the creation of optical systems. This makes it possible to consider printed optics for special lighting tasks that were previously difficult to implement. Fraunhofer researchers are already working on parallelizing the processes for larger quantities.

More information about this project at www.isc.fraunhofer.de/Jahresbericht

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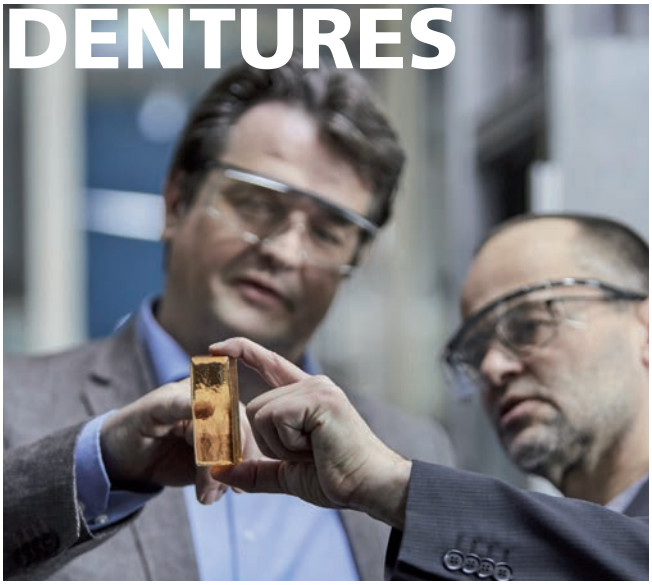
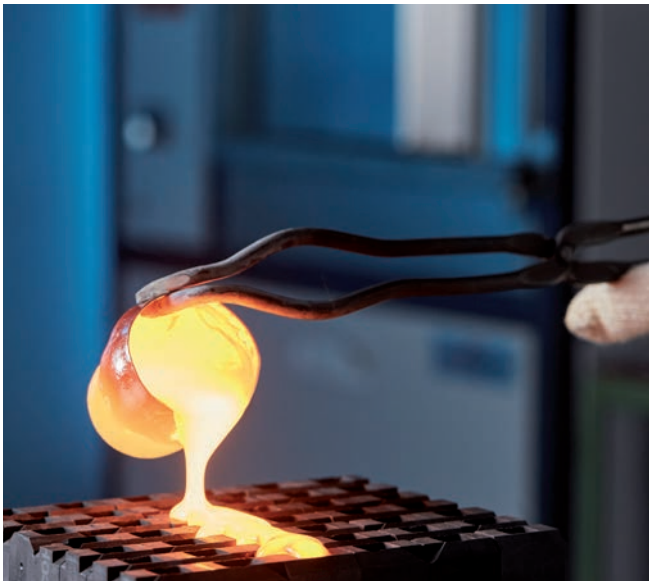
MATERIALS 3D





Photos Piotr Banczerowski for Fraunhofer

More information about this project at www.isc.fraunhofer.de/Jahresbericht

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Dr. Bernhard Durschang | Phone +49 931 4100-304

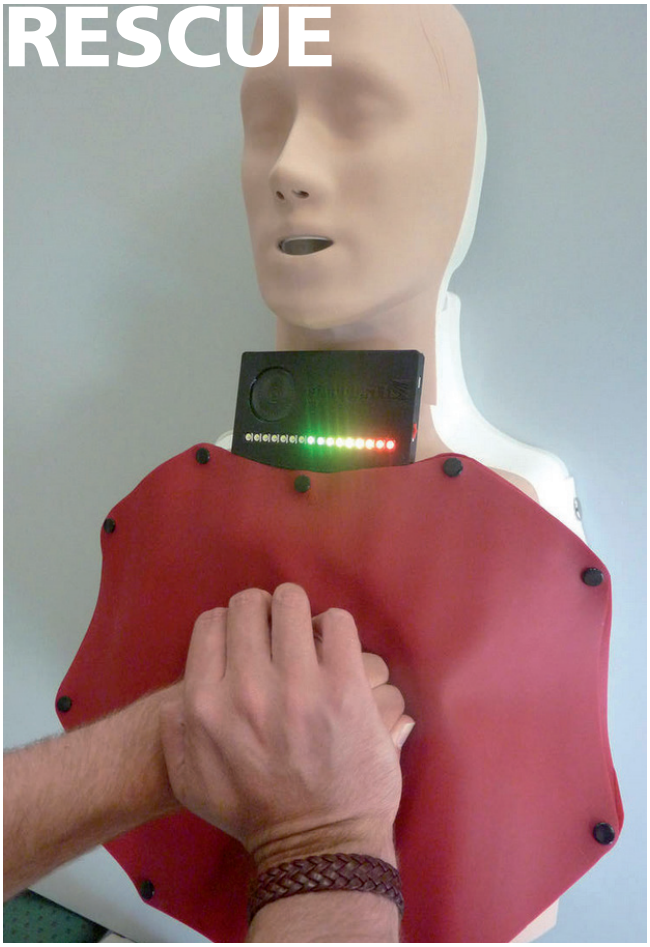
Link to the YouTube video

New teeth: high-strength and ready for immediate use

There is no harder material in our body than enamel, which is why the demands on a dental prosthesis are very high: Teeth must look natural, be able to withstand high stresses and be ready for patient use as quickly as possible. Dr. Bernhard Durschang and Dr. Jörn Probst of Fraunhofer ISC, together with their partners, have developed exactly such a dental prosthesis, receiving the Fraunhofer "Human-centered Technology" prize for it in May 2019.

Glass ceramics consist of an amorphous glass phase and a crystalline phase. Until now, researchers have tried to expand the crystalline phase as far as possible to achieve the desired strength. The two scientists at Fraunhofer ISC broke with textbook wisdom, made changes to the glass phase and added various metal oxides to the amorphous phase. In this way, they achieved the strength required for the new prosthetic material.

At 500 MPa, the new glass ceramics are significantly stronger and more robust than conventional glass ceramics, which only achieve around 350 MPa. In addition, the new material, which can be shaded to match any nuance of tooth color and exhibits an enamel-like translucency, has an excellent appearance. The dental prosthesis matches the natural look of the patient's own teeth. An additional process step during production, post-hardening in a furnace, is no longer necessary, and the glass ceramics can be finished "chairside", saving time. The two partner companies received everything from a single source: from the initial solution proposal to the CE-certified production plant. In the meantime, the innovative glass ceramic is already being used by many dentists.



More information about this project at www.isc.fraunhofer.de/Jahresbericht

Dr. Holger Böse | Phone +49 931 4100-203

Link to the YouTube video

Resuscitation mat simplifies cardiac massage

Around 10,000 people die in this country every year as a result of cardiovascular failure, even though they could be saved. In such an emergency situation, only fifteen percent of Germans find the courage to help those affected with a cardiac massage. For fear of making mistakes, many do nothing at all or perform compression too timidly. A new type of resuscitation mat is designed to make it easier for untrained first responders to revive victims in the event of cardiac arrest, thus lowering the inhibition threshold for resuscitation.

Fraunhofer ISC developed the silicone mat with integrated "Rescue Aid" sensor technology in collaboration with students from the University of Applied Sciences in Munich. The resuscitation mat, which is modeled on the human torso, is placed on the upper body. This avoids direct physical contact and reduces the fear of contact on the part of the first responder. The silicone mat was developed in the Fraunhofer design competition "Form Follows Future", which links science and design.

Silicone pressure sensors are integrated into the mat to measure the depth of pressure. They are made of a soft film and therefore cannot cause injuries – an advantage over the few products available on the market, which are rigid and cause pain in the palms of first responders' hands during resuscitation. The sensors are connected by cable to electronics and LEDs located in a box at the top edge of the mat. The LEDs indicate how much pressure is applied to the upper body or mat. If they glow green, the pressure is just right to revive the affected person. If the pressure is too weak or too strong, the LEDs turn red. The cardiac massage is supported by a tone that sets the rhythm for resuscitation.

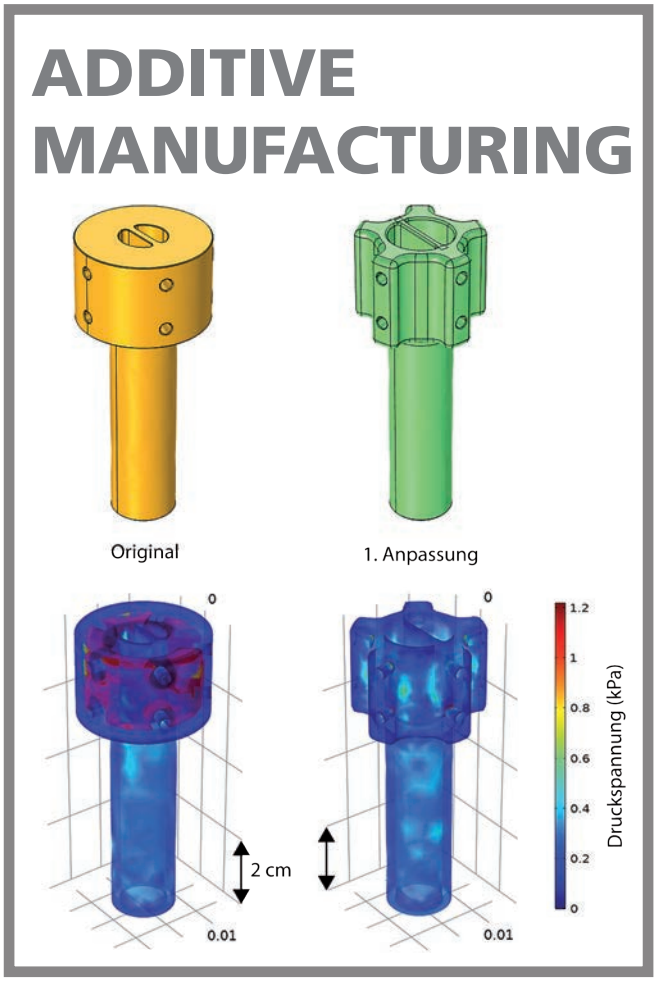
In tests with a mannequin used for resuscitation training, the Fraunhofer research team was successful in proving that Rescue Aid works. The mat reached demonstrator state and will be optimized and adapted for differently sized individuals. Due to its technological approach and simple electronics, the resuscitation mat can be manufactured at low cost.

MATERIALS 3D

Additive manufacturing on its way to series production

The last decade has been marked by a leap in the development of additive manufacturing. Conventional, mostly subtractive manufacturing has overcome its limitations to enable the production of completely new components with previously unimaginable geometries, reflecting the pioneering spirit and innovative potential in additive manufacturing. At the same time, the shift began from prototype and small series production to industrial series production. This was made possible on one hand by anchoring additive thinking increasingly in design and on the other by continuing to develop basic materials, printing processes and equipment. However, the requirements for series production are stricter than for prototyping. Economic aspects (low unit costs, high throughput) as well as quality-relevant aspects (reliability, capacity for reproduction, dimensional accuracy) take on a higher significance. In order to achieve this, methods for monitoring and optimizing the entire process chain must be developed.

The Fraunhofer-Center for High Temperature Materials and Design HTL employs two-stage additive manufacturing processes for the production of metals, ceramics and composites. In these, a low-energy additive manufacturing process for the production of a 'green' component is separated from the subsequent furnace treatment, which is usually time- and energy-intensive, for debinding and sintering or infiltration. The simultaneous firing of many components makes these processes economically very attractive. In addition to feed stocks and pressure parameters, Fraunhofer HTL develops methods of analysis for quality assurance with respect to green components. This facilitates efficient optimization along the first half of the process chain. For the design of the subsequent thermal processes, Fraunhofer determines the material properties that are critical for process kinetics. For this purpose, it uses, among other things, conventional thermal analysis as well as in situ analysis in specially developed thermo-optical measuring systems (TOM). The measured data are then used in a coupled FE simulation that takes into account the thermal, mechanical, chemical and geometric aspects of optimization.



This permits the interaction of material, component design, furnace chamber and the thermal processes to be simulated. The process forms the basis for predicting potential sources of defects, shrinkage and distortion in a component- and material-specific manner and for designing the entire process chain around safe and economical yet flexible series production.

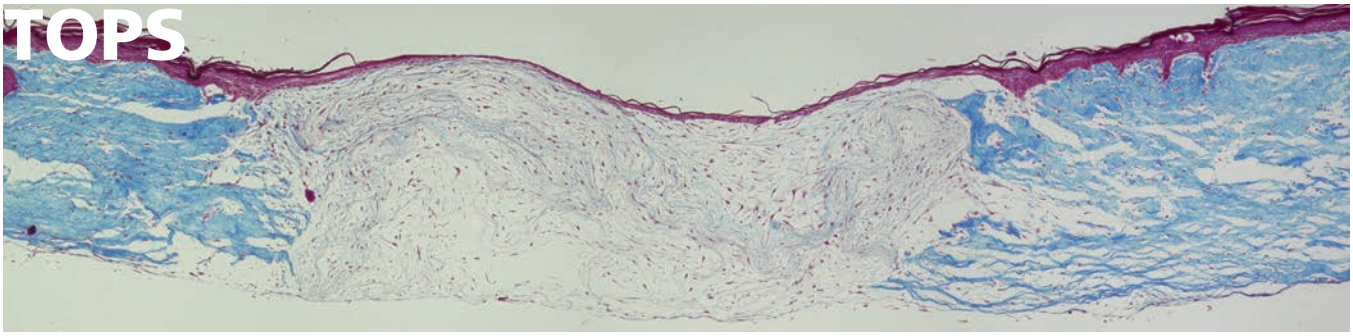
More information about this project at www.isc.fraunhofer.de/Jahresbericht

Joachim Vogt | Phone +49 921 78510-417

Connecting skin and metal –improvement of transcutaneous osseointegrated prosthesis systems

In Germany, around 25,000 people are affected by amputations of the extremities every year. After amputation, patients usually receive a fully external prosthesis. Disadvantages of this fitting include an unphysiological and loose connection between the residual limb and the prosthesis that impedes a natural sequence of movements, the development of pressure and chafing points, and secondary infections due to continuous skin moisture under the prosthesis stocking. Transcutaneous osseointegrated prosthesis systems (TOPS) can create significant improvements. In these combined endo-exo prostheses, stable metal sockets are implanted onto which the external prostheses are attached. The advantage for the patient is a firm mechanical connection with the bone. This enables natural movement sequences and avoids the problems mentioned above. There are currently three centers in Germany that offer this care, and there are an increasing number of patients who can be helped in this way. However, there is a serious disadvantage to TOPS: Since the skin cannot completely attach to the metal after the metal base has been surgically removed, an open gap remains. This "permanent wound" requires continuous attention and carries a constant risk of infection. Using modified fiber fleeces developed at Fraunhofer ISC, researchers at the Translational Center for Regenerative Therapies now see a real chance of avoiding such "permanent wounds" in the future. In cooperation with Armed Forces Hospital Berlin, one of Germany's TOPS centers, a concept was developed to create a permanent connection between skin and metal that is as natural as possible. It begins with fiber fleeces that accommodate the growth of skin cells. Proof that fiber fleeces are basically suitable for stimulating skin formation was shown earlier when they earned CE approval as a medical device for application as a wound dressing. A new type of fiber has been developed for use in TOPS that has been optimized for material, diameter and porosity to promote the permanent growth of skin cells on one hand and create a firm bond to the metal on the other. The current research project on feasibility is nearing completion since earlier tests on in vitro skin models demonstrate excellent colonization of the fiber material with skin cells and the formation of an epidermis that serves as a barrier against pathogens. Further pre-clinical tests are still ongoing, and follow-up projects are planned for the conduct of clinical tests. If these are also successful, an application can be made for approval as a medical device. This would be a decisive step forward for transcutaneous prosthetics. The concept could also be transferred to other medical areas where the aim is to minimize the risk of infection during skin penetration, such as in catheters.

The skin model shows the successful colonization of the fiber fleece and the formation of an epidermis (red) over an artificial wound. In the process, the fiber fleece bonds with the skin tissue via the newly formed biological tissue and is sealed from above against bacteria by the epidermis.
© T. Weigel, Fraunhofer- TLZ-RT



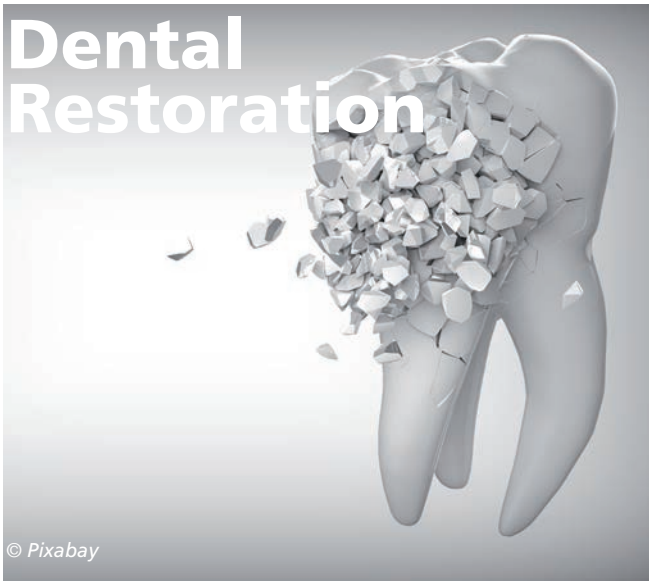
More information on this project is available at www.isc.fraunhofer.de/Jahresbericht
Dr. Tobias Weigel | Phone +49 931 4100-514

Project funding by the Federal Office for Equipment, Information Technology and Utilization of the Bundeswehr (BAAINBw)
Project partner: Armed Forces Hospital Berlin

MATERIALS 3D

Etching and bonding in one step – biocompatible materials for dental restorations

Dental health is enormously important for maintaining human well-being and overall health. The demand for cost-effective and aesthetic dental materials for small and large tooth conservation measures is great, and the pressure to innovate is high. There is also a focus on the necessary procedural steps for patient-friendly, fast and cost-effective dental treatment. In the "SODA" joint project, funded as part of the high-tech strategy of the German Federal Ministry of Education and Research, Fraunhofer ISC and its partners are developing and validating innovative self-etching adhesives that function as a combination of etching gel and bonding (self-etch technology). This shortens the usual procedure in caries treatment – removing damaged enamel, etching the cavity, applying bonding for the permanent connection of the later filling with the tooth, and finally the application and shaping of the filling material. Biocompatible materials based on ORMOCER® provide the required functionality and durability on one hand, while offering a safe system with regard to allergens on the other. The elimination of a separate etching step (total-etch technology) with a comparably high etching effect saves time and cost and reduces the susceptibility to errors during application. In addition, the formulation of the new self-etching adhesives ensures a shelf life of up to two years – an important aspect for practical applications.



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More information about this project at www.isc.fraunhofer.de/Jahresbericht

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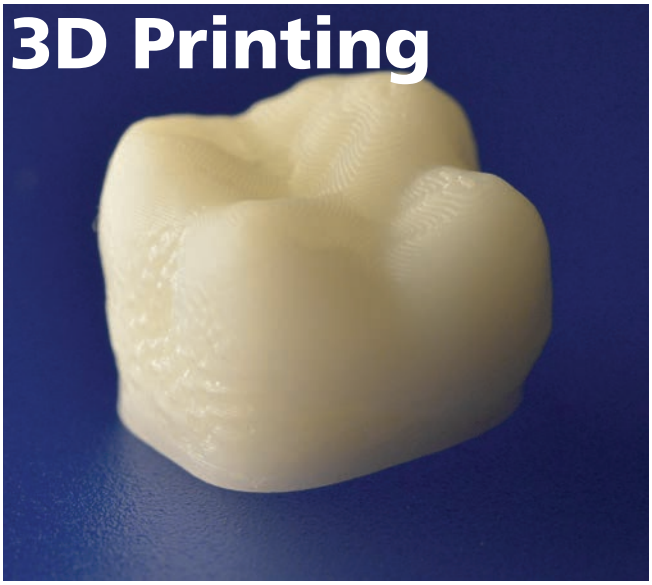
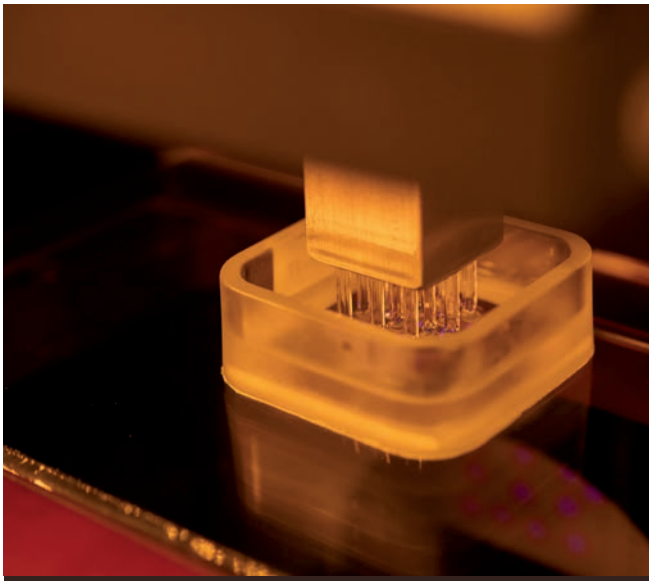
Resorbable or durable – biocompatible materials from the 3D printer for dental and micromedical applications

Ever since they became technologically established, 3D printing processes have stimulated a desire for individualized medical products such as implants or earmolds to emerge from the printer. The selection of printable materials is straightforward, and not all materials are suitable for dental and micromedical applications. With its many years of expertise in the field of biocompatible materials, Fraunhofer ISC is continuing to develop its hybrid polymers for 3D printing. The systemic composition of the material determines whether non-resorbable or resorbable products are produced. Depending on their intended use, different properties, structures and functionalities as well as a patient-specific design of the printed products for dental medicine, implantology or hearing acoustics can be created. Fraunhofer ISC is currently working on printable composites with high filler content, high translucency and a high-quality mechanical property profile for permanent use as indirect restorations – in the form of crowns, for example. Developments are also focusing on material systems with specifically adjustable flexibility, such as dental splints to correct misaligned teeth (aligner technology). Depending on the combination of components, a thermal effect can also be incorporated. In this way, the printed material can be stiff at room temperature yet soft and flexible at body temperature. This effect is particularly useful for the fitting of hearing aids to the patient.





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PROCESSES

P

METHODS AND PROCESSES UP TO THE PILOT-TESTING LEVEL

Who wants to bake a good cake? ... (from an old German nursery rhyme) No matter how many ingredients in the recipe: A cake cannot be prepared without a sequence of steps, proper kneading, stirring or beating, an oven heated to the requisite temperature and the right amount of baking time. **The entire process is important for the result**.

It is the same in industrial production. As a materials research institute, Fraunhofer ISC **does not stop at the formulation**stage but also develops **manufacturing and processing methods** in parallel in accordance with the requirements of the client.

In addition to new processes for shaping and encapsulation, the piloting of innovations such as the upscaling of nanoparticle production or the fiber pilot plant at the Fraunhofer-Center for High Temperature Materials and Design HTL, the topic of **digitization and automation of processes** also plays an important role.

Supported by robots, they can become repeatable, reliable, robust, efficient and cost-effective. In combination with online analytical methods, they can also create the interface between the digital material data space and the real material in development and application, thus forming the basis for a new type of material development.

PROCESSES

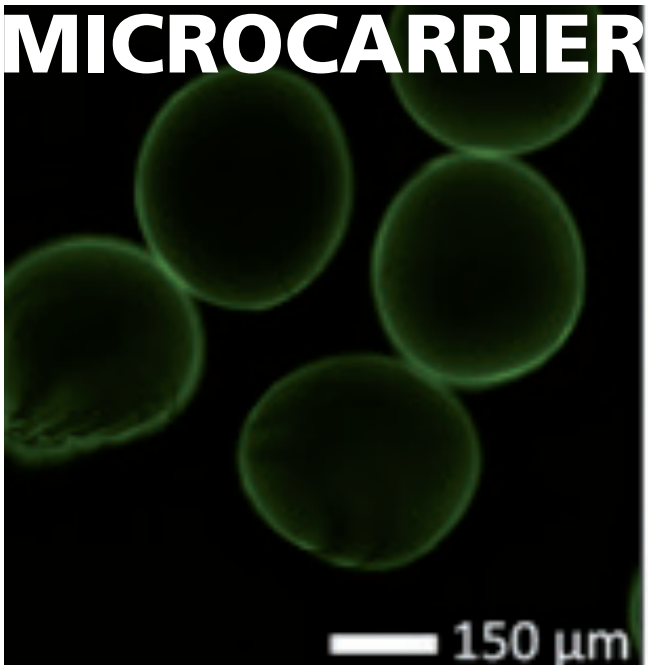
Scalable manufacturing process for microcarriers for the cultivation of iPS cells

Induced pluripotent stem cells (iPS cells) such as those used for research on cell-based implants or human organoid model tissues require special growth conditions usually generated in cell culture vessels. An innovative alternative to conventional growth vessels in which the cells are arranged two-dimensionally on a surface is offered by 'microcarriers', three-dimensional carrier structures that float freely in the cell growth vessel. The advantage of the microcarriers is the large surface on which the human iPS cells can settle and their more effective simultaneous utilization of the volume capacity of the cell culture vessel.

At the Fraunhofer Institute for Biomedical Engineering IBMT, alginates have been identified as a highly suitable material for microcarriers because these are soft and elastic and thus very good at simulating the conditions of the cell environment in the body. Until now, alginate-based microcarriers could only be produced in a non-automated process that severely limited the scale of their use in cell cultivation.

At the Fraunhofer Center for Stem Cell Process Technology/ Fraunhofer ISC, a scalable manufacturing process for spherical microcapsules has now been combined with special alginates tailored to the cell growth of iPS cells. To this end, these alginates were modified and adapted to a modern encapsulation process developed by the Particle Technology Department of Fraunhofer ISC, thus allowing large quantities of spherical structures to be produced in a short time. In previous experiments, for example, it was possible to produce alginate carriers with a diameter of 300 micrometers at a frequency of 150,000 pieces per minute. The rate of carrier area generation per minute corresponds to the growth area of more than two classical cell culture flasks, reducing by a factor of 20 the carrier culture's space requirement.

As has been demonstrated in cell growth experiments, microcarriers produced in this way are biocompatible and suitable for cell cultivation. Further material modifications to produce a certain size, wall thickness, elasticity or viscosity or to use certain hardening processes are possible. The microcarriers can also be biofunctionalized or loaded with active ingredients and thus adapted to specific requirements. This provides a highly scalable, flexible process for the customer-specific production of substantial quantities of soft cell carriers that are highly suited to simulating real growth conditions of cells in the body.



More information about this project at www.isc.fraunhofer.de/Jahresbericht

Timo Grunewald | Phone +49 931 4100-820

More information about this project at www.isc.fraunhofer.de/Jahresbericht

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Mechanical engineering and the future of glass – High-Throughput Screening 4.0

With its fully automated glass screening system, from weighing batch components to controlled cooling, Fraunhofer ISC's Glass Group, together with the Center for Device Development (CeDeD), has set up a research device for modern glass development that is unique in the world. With the High-Throughput Screening System (HTS) 4.0, Fraunhofer ISC is now developing a new generation of systems that have been further enhanced for digitization and materials data space. In cooperation with the Federal Institute for Materials Testing and the "who's who" of glass research in Germany, a concept for the real data acquisition of the digital material data space will be developed. The HTS 4.0 is equipped by CeDeD with the necessary additional modules and interfaces to permit online acquisition of the relevant data during the melting and cooling process. Fraunhofer ISC is thus bringing glass, a material steeped in tradition, into the 21st century – not least because special glass, with its potential for application in hydrogen technology and solar technology as a material base, is one of the hopes for a climate-neutral energy industry. And Fraunhofer ISC is once again laying the scientific and technical foundations for the glass of the future.

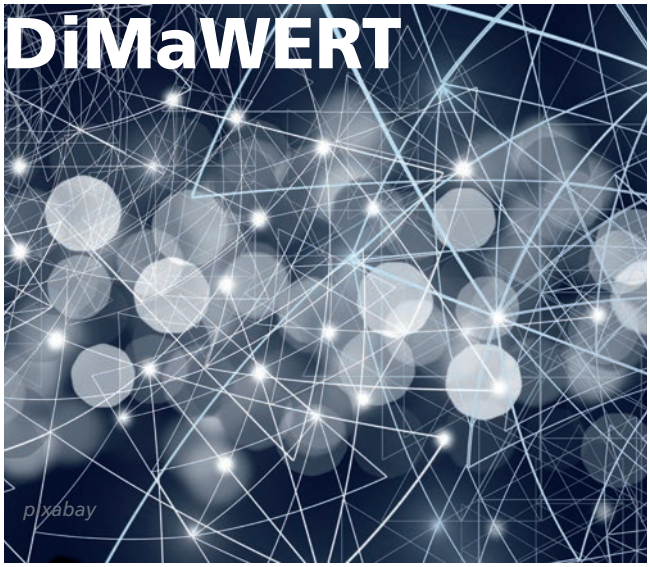
PROCESSES

DiMaWert – digitization of material development along the value chain

The aim of Industry 4.0 is to meet very special challenges in high-temperature processes in large industrial furnaces where sufficient data are frequently unavailable concerning the conditions in the furnace and the status of the firing material. The DiMaWert project, the Fraunhofer-Center for High Temperature Materials and Design HTL is developing innovative high-temperature sensor technology and digital methods as future tools for digitization even in highly energy-intensive sectors such as the ceramics, cement or steel industries to address this problem.

A technical highlight includes an autonomous sensor module that can travel through a large tunnel furnace as it continuously and wirelessly reports parameters such as temperature, flow or gas composition and produces a visual image of the furnace interior. Development of the sensor is being partly carried out at the ISC in Würzburg. The data is intended to aid in the development of digital furnace twins that either represent the actual furnace so accurately that they are suitable for the virtual development of thermal processing plants or are based on models that are so fast that they can be used for the real-time control of thermal processes. The latter will be essential if future demand-side management is to handle the increasingly fluctuating energy supply.

To achieve these goals, existing simulation methods will be linked within the project in such a way that they allow a top-down development of materials and furnace components. At all levels, artificial intelligence algorithms are tested and, if successful, are used to increase the efficiency of the digital tools.



More information about this project at www.isc.fraunhofer.de/Jahresbericht

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The DiMaWert project is funded by the Bavarian State Ministry of Economic Affairs, Regional Development and Energy.

Gefördert durch:

Bundesministerium für Wirtschaft und Energie

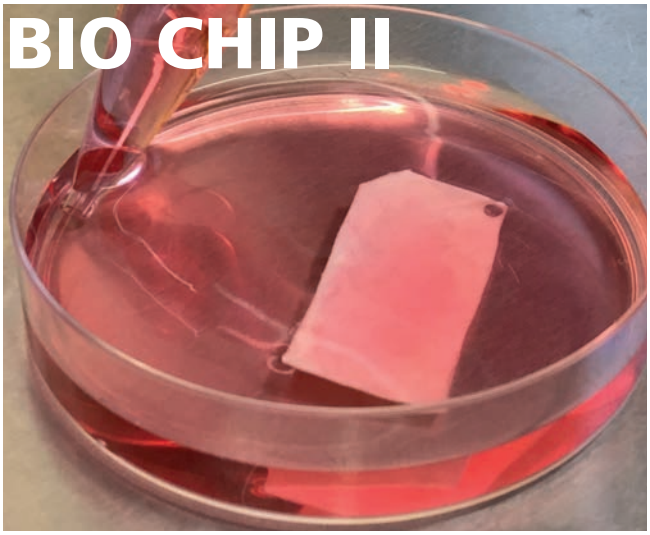
aufgrund eines Beschlusses des Deutschen Bundestages

BIO CHIP Phase 2 clinical study on new cartilage implants nearing completion

A new method of using the body's own cells to produce implants for injuries to the cartilage of the knee joint was clinically applied and evaluated in the Europe-wide BIO CHIP study with the participation of the Fraunhofer Translation Center for Regenerative Therapies TLZ-RT. To date, 95 patients have undergone successful operations at European partner clinics and another eight have been postponed due to the restrictions imposed by the COVID 19 pandemic. Nevertheless, we can already draw a very positive interim conclusion.

For the required cartilage implants, cartilage tissue was removed from the nose of the participating patients; the cartilage cells were isolated and cultivated into cartilage implants at two different stages of maturity (2.5 days and 4 weeks). Experienced surgeons at the participating clinics implanted these for the treatment of focal cartilage defects in the knee joint – these are strictly limited damages of the sort caused by sports injuries or accidents, for example. In subsequent monitoring, patients consistently reported a significant improvement in mobility and pain relief. There was no apparent difference to patients as to which of the two implants they received. For handling during implantation, however, according to the participating physicians, the more mature implants offer an advantage due to their greater stability.

The three-year study impressively confirms the effectiveness of the treatment with cartilage implants manufactured by Fraunhofer TLZ-RT using a new method and clearly indicates improvement in the patients receiving treatment. Patients and project partners are now hoping for similarly positive results in the remaining operations that have been postponed due to COVID 19. A follow-up study is also being considered by the clinical partners that would carry out a long-term evaluation of the previous study participants over a lengthier monitoring period. One of the questions that could be answered by this study is whether the difference in cell implant maturation has a long-term effect on the success of the treatment.



More information about this project at www.isc.fraunhofer.de/Jahresbericht and www.biochip-h2020.eu

Dr. Oliver Pullig | Phone +49 931 31-83748

Link to YouTube

The project is funded by the European Union in the Horizon 2020 program, Research and Innovation, under grant agreement No. 681103, BIO CHIP.

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation

PROCESSES

Improving the sustainability of high-voltage batteries – EU project ECO COM'BAT completed

Range, service life, safety or charging times – electric mobility places high demands on new high-performance batteries. The real challenge, however, is posed by the resource requirements for a growing number of lithium-based car batteries. To address this, ten partners from industry and research successfully joined forces in the ECO COM'BAT project to get a sustainable next generation of high-voltage lithium-ion batteries off the ground. All essential aspects along the value chain of batteries were considered.

The main task was to replace frequently expensive, rare or even critical conventional materials such as cobalt in the electrodes and fluorine in the electrolyte. As part of the project, ORMOCER®-coated, low-cobalt NMC 622 and a special low-fluorine high-voltage electrolyte based on the conducting salt lithium bis(fluorosulfonyl)imide (LiFSI) were adapted and optimized to meet the high battery requirements. These can be stably operated even at comparatively high voltages, leading to improved energy densities and consequent increases in resource efficiency. To achieve further improvement in energy and power density, structuring additives such as Porocarb® and Graphistrength® were used. The sustainable materials were processed in conventional pouch cells that exhibited up to 50 percent higher cycle stability (at 4.3 V) than the industrial reference samples in the comparative test.

With a few upscaling steps, the pilot stage for batch sizes of up to 20 kilograms was reached. To optimize the ECO COM'BAT materials and cells, a comprehensive simulation of battery performance and aging was conducted. In addition, an efficient recycling design was developed and tested to recover valuable materials such as nickel, cobalt, graphite and lithium not only in their elementary form but also in the form of the processed functional materials, thus achieving a high degree of sustainability.

More information about this project at www.isc.fraunhofer.de/Jahresbericht

Dr. Andreas Bittner | Phone +49 931 4100-213

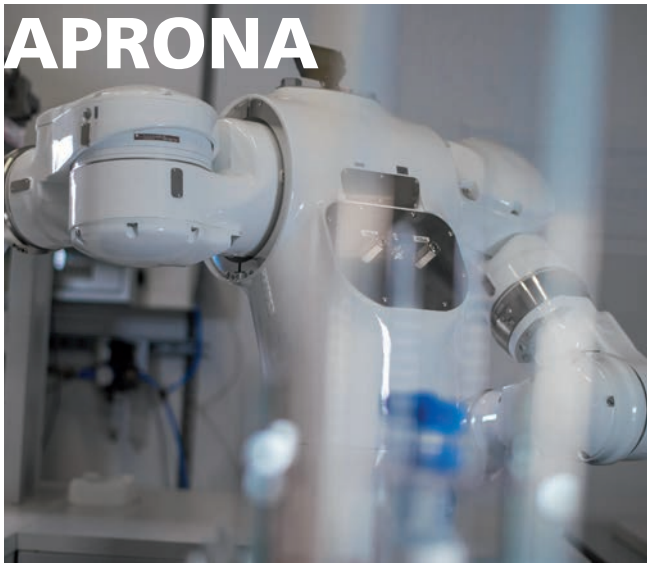
For more information www.eco-combat.com

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation

Following further research activities after the project's completion, Fraunhofer ISC, together with plant engineering companies such as ImpulsTec and CEPA, has now been able to create the possibility of selectively recovering the carbon and cathode active materials and easily separating copper and aluminum. Even upcycling is now possible. By processing the active materials, it is possible, for example, to reduce the cobalt content and utilize old, worn-out batteries for the production of modern, low-cobalt batteries. This allows a complete cycle to be established for the materials used in the battery.

APRONA – automated production of nanoparticles with a flexible robot-based platform

One of the greatest challenges in the synthesis of nanoparticles is the establishment of manufacturing processes that ensure reproducible product properties. The production of biofunctionalized nanoparticles, for example, could benefit enormously from the automation of the process in meeting the requirements of personalized medicine. With funding from the German Federal Ministry of Education and Research (BMBF), a flexible, interactive robot platform for the production of nanoparticles for diagnostic and/or therapeutic in vivo or in vitro use was established in the joint project "APRONA". The aim is to automate the production of nanoparticulate systems under GMP-compliant conditions. The process, which consists of manufacturing, reprocessing, cleaning and characterization, was designed for a two-arm robot. This acts autonomously with synthesis-relevant peripheral equipment. Internal process quality control is ensured. A regulatory assessment of the synthesis process offers the possibility of achieving basic aspects for the CE certification of the two-arm robot. With digitized nanoparticle production, patient-specific therapy solutions – e.g., individualized loading of the nanoparticles with special active ingredients or antibodies – can be flexibly produced through manufacturing contracted on site.



More information about this project at www.isc.fraunhofer.de/Jahresbericht

Dr. Sofia Dembski | Phone +49 931 4100-516

The project "APRONA - Flexible robot-based platform for the automated production of nanoparticles" started in September 2017 and was funded by the German Federal Ministry of Education and Research (BMBF) with around €1.6 million as part of the initiative to promote SME-centered, strategic R&D alliances in networks and clusters.

Project partners
Coordination: BioRegio Stern, Stuttgart
Fraunhofer Translational Center for Regenerative Therapies TLZ-RT
Goldfuss engineering GmbH, Balingen
Biametrics GmbH, Tübingen
BioTeSys GmbH, Esslingen

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

For more information
www.regenerative-therapien.fraunhofer.de

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ANALYTICS

PRECISE ANALYSIS AND CHARACTERIZATION BY SPECIALISTS

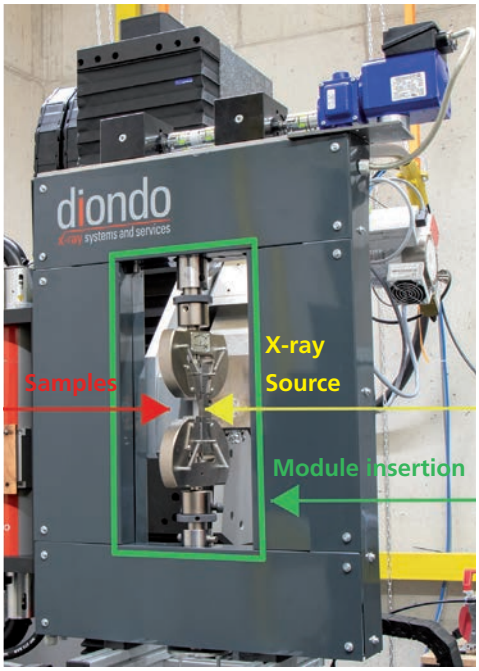
That aroma! The nose is a highly sensitive organ with complex tasks. It warns of dangers – from spoiled food, harmful chemicals or smoke. But it can also serve as a guide to food sources and special pleasures, and it plays a role in interactions with other individuals – you either can or cannot "smell" each other. Humans have about 400 different receptors for this, and dogs around 1000. These are distributed across millions of sensory cells in the nasal mucosa, responding to specific scent molecules. By simultaneously addressing several receptors, humans can distinguish **about 10,000 odors**. The nose is extremely sensitive, and even a picogram of an odor-intensive substance in one liter of air is sufficient not only to perceive the scent but even to recognize what it is. Evolution has thus provided us with an extremely compact and **powerful analytical instrument**. Where the detection of cake aroma is concerned, this is certainly without equal.

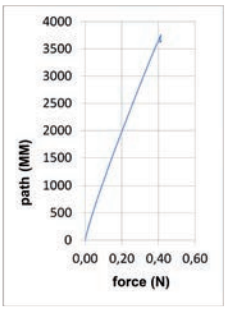
Fraunhofer ISC has a **broad portfolio of analytical methods** and sophisticated preparation techniques at its disposal for more technical tasks, including non-destructive defect detection in components, analysis of battery components, production-related analysis for quality assurance, chemical, physical and mechanical characterization, damage analysis, bioanalytical issues and the clarification of structure-property relationships in materials development and process optimization. Special methodologies and even testing and analysis equipment are developed for specific problems. In combination with **well-founded material expertise** from a wide range of areas - from inorganics to cell therapy – test results are interpreted precisely and, if desired, **customized solutions** are also offered.

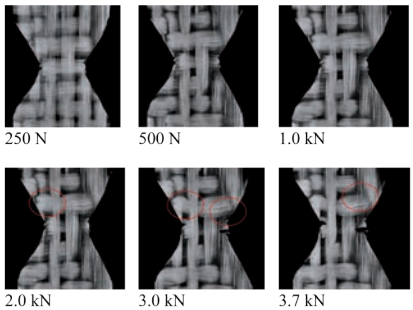
Thanks to Wikipedia for the facts about olfactory perception.

ANALYTICS

CT MEASUREMENTS







More information about this project at www.isc.fraunhofer.de/Jahresbericht

Jan-Marcel host | phone 0921 78510-250

In-situ computed tomography for spatially resolved detection of defect growth

In collaboration with diondo GmbH, the Fraunhofer Center for High Temperature Materials and Design HTL has developed a test frame for computed tomography systems that can be used for volumetric examination of components during an additional thermo-mechanical or thermo-chemical load. The system is completely modular and can be installed in any CT system, thus complementing existing systems.

A special feature of the concept is modular expansion with numerous load components. For example, a component can be simultaneously or separately subjected to a mechanical load (tensile/bending/torsion and compression testing) by integrating a climatic chamber at -40°C to +200°C or heated in a furnace up to 1450°C. Further modules permit changes in atmospheric or (wet) chemical environments. All modules can be assembled in a few easy steps and allow quick conversions without great effort.

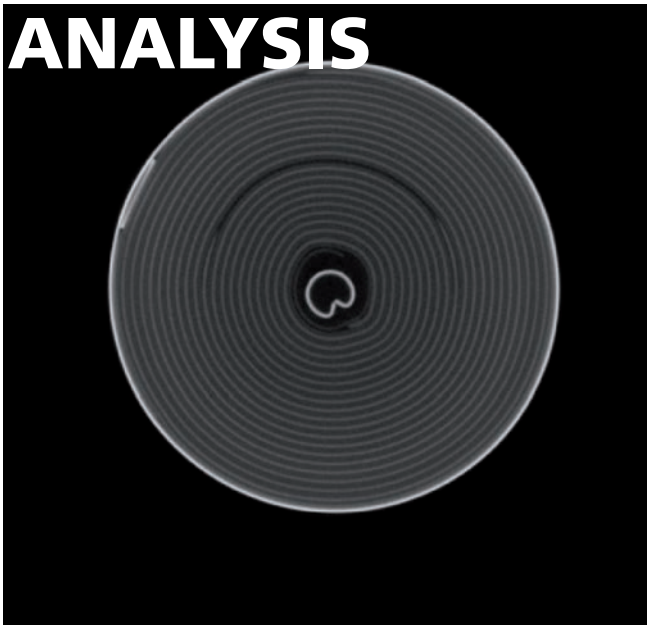
The CT measurements accommodate volumetric images with a resolution of up to 2 µm. Depending on the design, mechanical loads of up to 150 kN are possible.

Figure 1 shows a test frame mounted in an existing computer tomography system for mechanical tensile testing up to 50 kN. As an example of a simple tensile test, Figure 2 shows the measured failure curve of a fiberglass-reinforced plastic sample (GRP). Increasing the tensile force up to 2 kN causes elongation in the material, leading to a distortion of the fiber bundles in the matrix. At 3 kN tensile force, matrix failure begins, initial cracks are visible, ultimately leading to failure of individual fiberglass elements at 3.7 kN tensile force and causing the entire component to fracture.

Battery analysis– on the trail of aging
How mechanical stresses affect battery aging

Battery cells, including lithium-ion cells, alter their volume during charging and discharging. This effect is known but has been the focus of hardly any research up until now. Using new analytical methods, the Fraunhofer R&D Center Electromobility (FZEB) is investigating not only this effect but also the ways in which interactions between volume changes and charge states affect battery aging and, above all, the aging of components. Using a newly established dilatation measuring cell, the volume change and the resulting pressure build-up in the cell as well as mechanical stresses at the electrodes can be precisely correlated operando with the electrochemical processes in the cell. Previous investigations have shown a clear, cell-typical correlation between the different charge states ("stages") and pressure peaks caused by volume expansion. This method is therefore also suitable for non-destructive monitoring of the charge state of a cell type during battery cycling operando.

Another finding from the electrochemical-mechanical measurement data is the correlation between the influence of non-homogeneous pressure distributions and the deposition of lithium at the anode, known as lithium plating, which is one of the main causes of accelerated aging of battery cells. For this purpose, sample preparations with cross section polishing (CSP) were carried out at the Center for Applied Analytics and evaluated by electron microscopy. It has been demonstrated that inhomogeneous pressure distributions or pressure peaks in the battery cell reinforce lithium plating. On the other hand, a homogeneous pressure distribution or the application of homogeneous pressure to the cell system, e.g., by clamping the cells in a module, can have a positive effect on battery life. By precisely examining and correlating the measured data (operando and post mortem) on individual cell types, battery analysis at Fraunhofer ISC thus provides findings that are important for the further development of battery cells, cell stacks and battery management systems.



More information about this project at www.isc.fraunhofer.de/Jahresbericht

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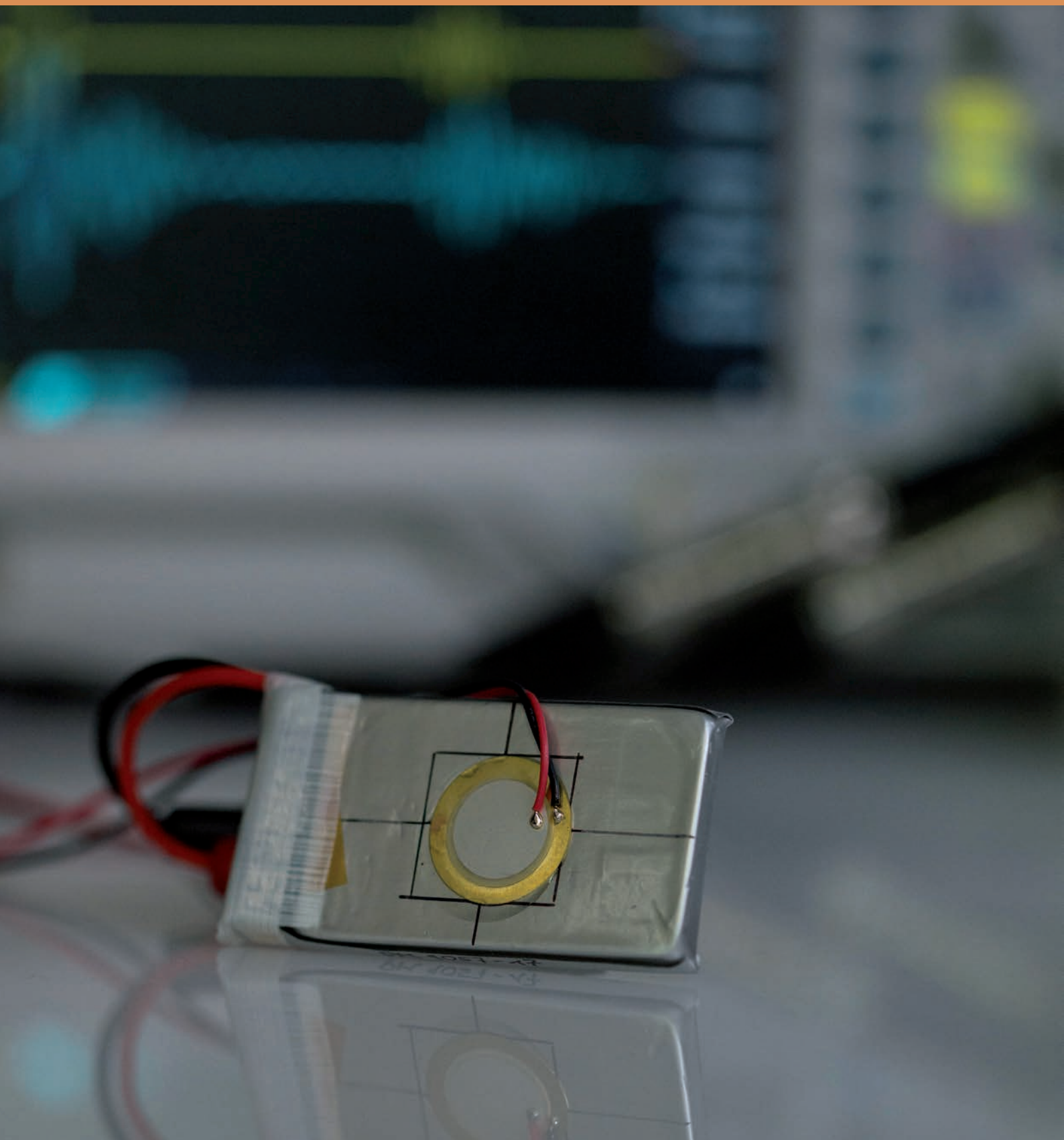
The joint project "ReVisedBatt" – resonances, vibrations, shocks, external mechanical forces and detection methods for lithium ion batteries" is supported by BMWi and runs from September 14, 2017 to March 31, 2021.

Gefördert durch:

Bundesministerium für Wirtschaft und Energie

aufgrund eines Beschlusses des Deutschen Bundestages

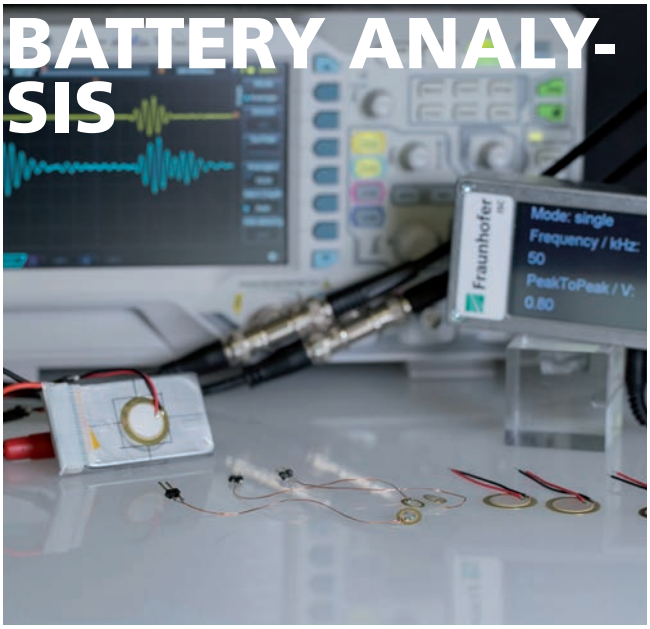
ANALYTICS



Battery analysis – optimized quality control from cell production to the end of the cell's useful life.

In the area of battery cell analysis, the Fraunhofer R&D Center for Electromobility FZEB has established itself in recent years as one of three competence centers in Germany for ultrasonic monitoring of batteries, conducting a series of research and industrial projects. Through collaborative work with the other centers at the Technical University of Munich and RWTH Aachen University as well as its sister institute, Fraunhofer IKTS, ultrasound sensor technology will be further developed to provide a database for automated analysis, digitized material development and the use of Artificial Intelligence in the field of battery development.

A great advantage of ultrasonic sensor technology is the varied interaction of ultrasonic signals with matter and its high sensitivity to material changes. Mechanical and structural changes within the battery cell can thus be detected. Thus the methodology could already provide a key to greater efficiency at the cell production stage – for example, in the online determination of the actual electrolyte filling and the reduction of waiting times – as well as in the monitoring of the charge state and the aging of the electrodes. It is conceivable that important status criteria such as the "end of life" for the different cell types could be redefined on this basis for each application and that these could be incorporated into the optimization of battery management. Whether this can extend the life of the batteries and improve "second-use" options – an important component for a smaller CO_2 footprint and the saving of resources – is to be investigated in the newly launched SPARTACUS project.



More information about this project at www.isc.fraunhofer.de/Jahresbericht

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Projects:

Cell-Fill - Process-structure-property relationship for filling and wetting processes of large-size lithium-ion batteries, 01.10.2019-30.09.2022, funded by the Federal Ministry of Education and Research (BMBF) https://www.prozell-cluster.de/projekte/cell-fill/

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

SPARTACUS - Spatially resolved acoustic, mechanical and ultrasonic sensing for smart batteries, September 1, 2020 - August 31, 2023, funded by the European Commission

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation

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TESTING

TESTING BY SPECIALISTS

If the scent is too tempting, then it only helps if you take a big bite to judge whether olfactory analysis will stand the test in practice – does it taste good or not? What is quite simple and completely subjective in the case of cake requires a **sophisticated approach** for other questions.

Fraunhofer ISC is working to ensure that in vitro cell cultures will be able to perform tasks in the future for which laboratory animals have often been used in the past. For example, organoid test systems based on human cells – for example intestinal, skin or respiratory tract models – are cultivated at the Translational Center for Regenerative Therapies to screen active substances rapidly and reliably or to test substances for their potential damage to humans.

But the classical mechanical-physical test and inspection procedures – under DIN or through procedures developed especially for specific problems – also serve to evaluate the application behavior of materials. To evaluate battery components, Fraunhofer ISC operates test rigs that cycle batteries under defined conditions. In this way, specific load scenarios can be taken into account in material development and battery optimization and, hand in hand with analysis, damage mechanisms can be detected that negatively affect battery life. This is **important knowledge not only for our own material development but also for that of our development partners**.

TESTING

In search of regenerative therapy approaches for Crohn's disease and Co. – tests on 3D tissue models

Chronic inflammatory bowel diseases such as Crohn's disease or ulcerative colitis affect around 300,000 patients in Germany. Although current therapeutic approaches achieve a relief of inflammation in the intestine, a cure is not available to afflicted patients at this time. In addition to the administration of anti-inflammatory drugs, surgical removal of the entire colon is often considered in severe cases, resulting in significant restrictions for the patients concerned.

The underlying causes of these diseases are not yet known. To achieve a better understanding of the pathophysiological processes of these diseases and thus to find innovative therapeutic approaches that, among other benefits, could also offer a genuine chance for a cure, the Fraunhofer Cluster of Excellence for Immune-Mediated Diseases (CIMD) is conducting a research project focused on the 'arylhydrocarbon receptor' (AhR). Numerous scientific studies have shown that the AhR plays a decisive role in the control of inflammatory processes regulated by the immune system. The Fraunhofer Research Cluster CIMD is therefore working on modern AhR ligands that influence the activity of the receptor by binding to it. In addition to pharmacological substances, potential AhR ligands are also found in natural nutrients, making it possible to ingest them with food, which could explain such factors as the influence of diet on the course of chronic inflammatory bowel diseases.

CIMD aims to identify and synthesize innovative AhR ligands with anti-inflammatory function. Since the end of 2019, the Fraunhofer Translational Center for Regenerative Therapies has been involved in the project. Its in vitro tissue models of healthy and chronically inflamed human intestinal mucosa provide a cell-based test system for the newly identified AhR ligands.

The complex 3D tissue models of the TLZ-RT realistically simulate the natural cell environment and allow the (patho-)physiological processes in the intestinal mucosa to be examined in vitro (in the test tube). The TLZ-RT has an extensive cell bank of different cell and disease types that it uses for the model construction. The CIMD project primarily uses cells that were isolated in TLZ-RT from intestinal mucosa biopsies of Crohn's disease patients. Based on human primary cells, the models allow virtually in vivo investigations of the effect of different AhR ligands and thus of their influence on the inflammatory status of the diseased cells. Through direct comparison of the effect of AhR ligands in models built up from "healthy" intestinal mucosa cells, it is possible to derive statements on the potential effect of the substances in chronically inflamed cells from the results obtained. Since there is an entire range of differently acting AhR ligands, the aim is to identify those having the strongest effect and thus to make a specific contribution to the regeneration of cells. If suitable AhR ligands with high efficiancy are found after completion of the ongoing in vitro studies, the next steps involving drug development and preparation for approval will follow in subsequent projects.

More information about this project at www.isc.fraunhofer.de/Jahresbericht

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ImmuTHerM – new test systems for the validation of immunological therapies

A new approach to the treatment of malignant tumors is immunotherapy using ‘immune checkpoint blockers’ (ICBs). Immune checkpoints are receptors on the membranes of T cells, the body's own defense cells. They regulate the immune response of the T cells to prevent autoimmune responses and other reactions. Tumor cells can fool this checkpoint and thus prevent the body's immune response, allowing a tumor disease to develop. If it were possible to block these checkpoints, T cells could theoretically gain the capacity to recognize and eliminate the tumor cells. In 2018, the Nobel Prize for Medicine was awarded to the US immunologist James Allison and the Japanese immunologist Tasuku Honjo for the discovery and exploitation of these biological processes for cancer therapy.

In practice, however, suitable test systems to evaluate the efficacy of ICB-based therapies are still needed. Using the example of malignant melanoma – one of the most dangerous tumors – which leads to about 3000 deaths every year in Germany, the research project ImmuTherM is setting up a new test system intended to identify a reliable validation method. To this end, a model malignant melanoma system already developed by the Translational Center for Regenerative Therapies in cooperation with the University Hospital of Würzburg will be expanded to include additional tumor cell lines and human T cells. The aim of the joint research project is to develop individual test systems in which tumor cells and T cells come from the same patient and can provide reliable information about the individual effectiveness of an ICB-based therapy. In addition, this could also reduce the number of animal experiments required in the early pre-clinical phase of drug development.

The project "ImmuTherM - In Vitro Test Methods for the Evaluation of the Efficacy of Immunological Therapies for Malignant Melanoma" started in April 2019 and is funded by the German Federal Ministry of Education and Research (BMBF) within the initiative for the promotion of alternative methods to animal testing.

More information about this project at www.isc.fraunhofer.de/Jahresbericht

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GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

TESTING

Advancing precision medicine – with FORTiTher and laboratory automation to achieve individualized tumor therapies

"Pioneering technical developments in the fields of computer technology and the biological description of tissues and single cells and their finest composition and function today permit a comprehensive analysis of individual tumor diseases. It will be possible to incorporate the processing of large amounts of data into daily care quickly and at a reasonable economic cost for each individual case, with the aim of designing an individually tailored therapeutic strategy. The differentiated diagnosis of individual tumor tissues by means of high-resolution functional imaging and genetic analysis will be supplemented by less invasive examinations of tumor cells and messenger substances based on blood and urine samples. Single-cell studies and efficient testing of crown cultures in the test tube will be developed and automated. The data obtained yield a differentiated picture of a tumor with respect to malignancy, growth, interaction with the immune system, tendency to spread and response to medication. Scientists of the interdisciplinary consortium FORTiTher have contributed to this progress in the past with various preliminary works. Together with the research community, they will unite technologies from the various fields in a research association to create the basis for the timely transfer of high-tech test systems into medical care."

This is how the Bavarian Research Foundation describes the research network launched in 2019.

The project team associated with the Fraunhofer Translational Center for Regenerative Therapies at the Department of Tissue Engineering and Regenerative Medicine TERM at the University Hospital of Würzburg is contributing its expertise and working within the framework of ForTiTHer on an automated pilot process for individualized drug testing on tumors, including those in advanced stages. In biopharmaceutical research, meaningful tissue models are required for the development of individualized therapeutic procedures through which substances can be tested for their efficiency on a patient-specific basis. There is a lack of models capable of representing tumors in an invasive, metastasized state, especially for the advanced stages of the disease, which have so far been difficult to treat.

In addition, reliable manufacturing processes are required that can reproduce these patient-specific test systems in parallel in conformity with relevant quality standards such as GMP. In contrast to previous screening systems, the present project aims to set up flexible, robot-based production of 3D tumor test systems of varying complexity using the example of colon, breast and lung tumors, which are the most common tumor types in the Western population. Automation provides support for regulatory issues due to its superior reproducibility. This is also a prerequisite for the efficient screening of predictions based on biological computation that uses individual data on biological systems in precision oncology. The TERM team can build on the laboratory automation work done at the Translational Center for Regenerative Therapies.

More information about this project at www.isc.fraunhofer.de/Jahresbericht

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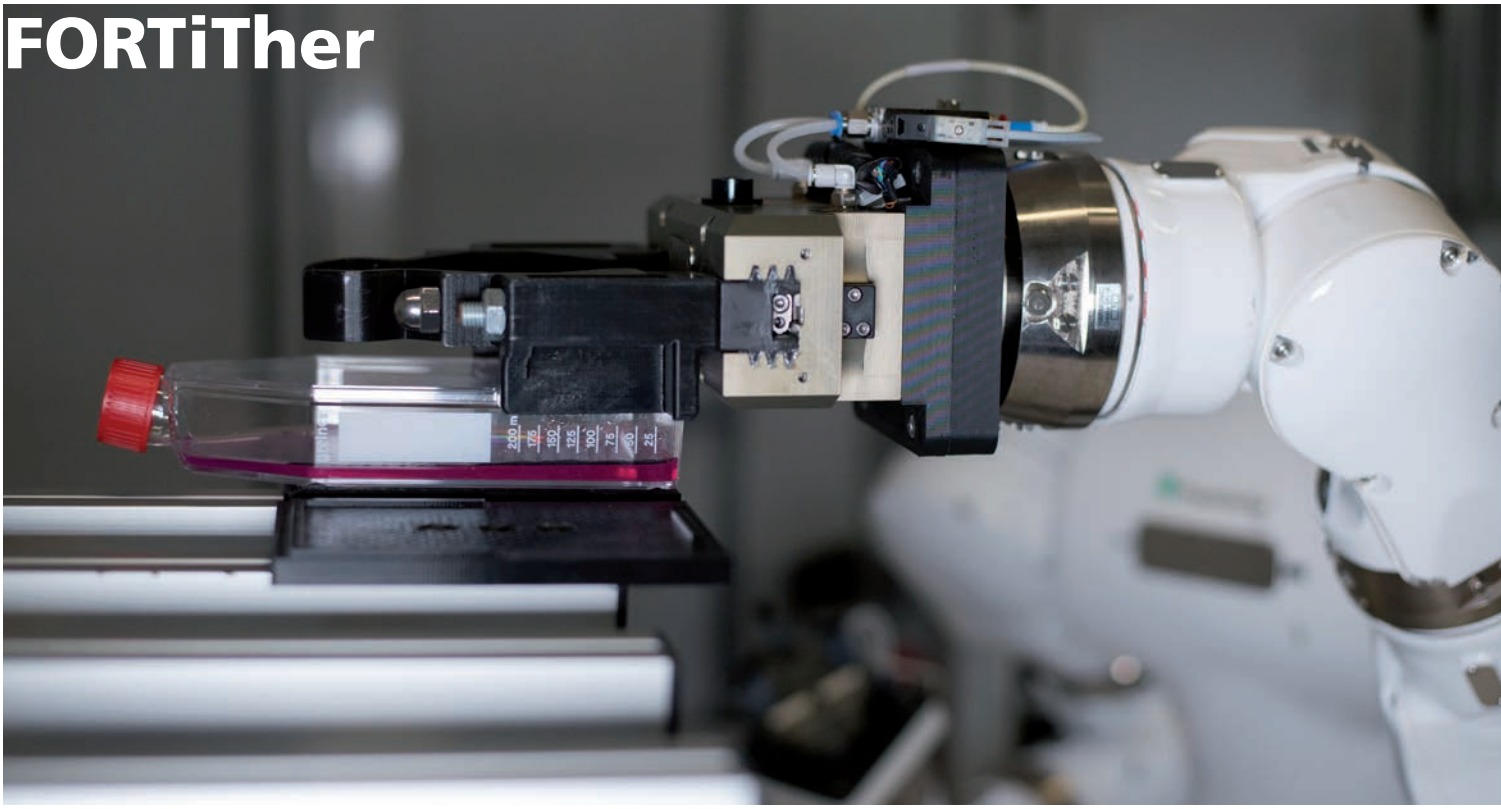
FORTiTher



FORTiTher receives funding by National Decade Against Cancer, the Federal Ministry of Education and Research wants to join forces in the fight against tumor diseases. The intent for cancer research is to be further strengthened and purposefully advanced, particularly in the areas of prevention, early detection, diagnostics and innovative therapies. Over the coming ten years, therefore, the campaign will focus on four thematic blocks: Prevention, diagnostics, therapy, and patient participation and involvement.
You can find more information under the following links:

- *https://www.bmbf.de/de/nationale-dekade-gegen-krebs-7430.html*
- *https://www.dekade-gegen-krebs.de/*
https://www.bundesgesundheitsministerium.de/themen/praevention/gesundheitsgefahren/krebs.html
- *https://www.krebsinformationsdienst.de/grundlagen/krebsentstehung.php*

Bayerische Forschungsstiftung

FORTiTher
Forschungsverbund Tumordiagnostik für individualisierte Therapie

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EDUCATION

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YOU LIVE AND LEARN!

You never stop learning – and that is actually the beauty of it! Always remain curious, always look beyond your own nose and get involved in something new, even if you are already one of the "experienced old hands". The Fraunhofer Academy, together with several Fraunhofer Institutes, offers a top-class professional development program with certified courses, conferences and practical seminars. Fraunhofer ISC developed the concept for the Academy's first continuing education program in the field of life sciences and has been offering a practical seminar on 3D tissue engineering for two years. In 2020, the range of courses will be continued and expanded to include online sessions.

And because it is also satisfying to invite the community to join in discussions of the current state of science and technology, Fraunhofer ISC is also active in organizing workshops and symposia such as the 22nd International Blood Brain Barrier Symposium, which was held in Würzburg in 2019.

We are not neglecting **promotion of our own young talent**, however. The Institute provides training in various professions and offers young scientists the opportunity to get a taste of applied research during their studies – a dream job: Inventing the future!

EDUCATION

More information about this project at www.isc.fraunhofer.de/Jahresbericht

Sabrina Rota | IZKK | Phone 0 9342 9221-710

Cooperation with the Fraunhofer Academy – Practical Seminar Tissue Engineering

In collaboration with the Fraunhofer Academy, a professional training program of the Fraunhofer Society for specialists and executives from industry, research institutions and universities, the Fraunhofer Translational Center for Regenerative Therapies TLZ-RT has established a Fraunhofer Gesellschaft training program in the field of life science/health over the last two years. The "Practical Tissue Engineering Seminar", which was held for the second time in November 2019, gave participants from the life science industry and academia a comprehensive overview of the biological and material science basics of tissue engineering over the course of three days and provided insights into practical applications ranging from personalized test systems to the development and approval of cell-based therapies. For example, tissue engineering methods can be used to produce complex implants from the body's own cells as well as biologically compatible carrier materials that minimize the body's rejection and physiologically reconstruct (regenerate) defects in the long term. In contrast to traditional implants, development of the new therapeutics takes into account the self-healing powers of the body to use cellular mechanisms and restore destroyed organ functions either partially or completely.

With the support of the International Center for the Protection of Cultural Hertitage and Conservation Research IZKK, the theoretical part of the course took place in the special, focused atmosphere of Bronnbach Monastery in the Tauber Valley. For the practice portion, the participants were invited to the laboratories of the Translational Center and the Department of Tissue Engineering and Regenerative Medicine (TERM) of the University Hospital of Würzburg. The inspiring contrast between monastic seclusion in the former Cistercian abbey of Bronnbach – today classified as a monument of special national importance – and the ultramodern biological laboratory equipment was, in addition to the scientific content, the special attraction of the event for the participants. Beginning in Fall 2020, the seminar will also be offered in English to meet the demands of an international audience.

22nd International Symposium on Signal Transduction at the Blood-Brain Barriers

From September 11 to 13, 2019 the "22nd International Symposium on Signal Transduction at the Blood-Brain Barriers" was held in Würzburg. This year's hosts were the Translational Center for Regenerative Therapies at Fraunhofer ISC and the University Hospital of Würzburg. They welcomed around 150 visiting international experts to the three-day lecture series. The symposium addressed the latest developments in the study of blood-brain barriers including new concepts in drug delivery, in vitro modeling, new approaches in technology, molecular mechanisms regulating integrity or the role of the blood-brain barrier in infections. In addition to various lectures organized around eight thematic sessions, young scientists were also provided with an significant forum through poster sessions and a poster award. The blood-brain barrier protects the brain from possible pathogens, toxins or other substances circulating in the blood and is of utmost importance for brain functions. On the other hand, it is precisely this function that makes drug treatment more difficult since many active ingredients cannot pass through the barrier. The Translational Center for Regenerative Therapies provides a highly respected 3D tissue model of the blood-brain barrier that offers exciting opportunities to analyze many problems, notably drug transport.

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More information about this project at www.isc.fraunhofer.de/Jahresbericht

Sabrina Rota | IZKK | Phone 0 9342 9221-710

Dream job: Inventing the future!

Are you interested in natural science and technology, in chemistry and materials or in how new products are created from material innovations? Would like to work in this field? The opportunities for a career at Fraunhofer are as varied as the fields of research, ranging from work in science/technology or administration, from direct entry to doctoral level. Fraunhofer ISC offers motivated and talented individuals first-class development opportunities and substantial personal responsibility right from the start. As one of the 74 Fraunhofer Institutes, the Fraunhofer-Institut for Silicate Research ISC is a part of Europe's leading network for applied research.
Top research needs highly motivated personnel with the right qualifications. Fraunhofer ISC offers a pleasant working environment. Creativity and new ideas are appreciated and performance is rewarded. In addition to student training, including internships and bachelor's, diploma-level, master's and doctoral theses, Fraunhofer ISC also offers training at its chemical and physical laboratories and electrical and precision engineering workshop as well as in administrative areas.

The Würzburg institute employs staff in the fields of physics, chemistry and materials science, mineralogy, geophysics, process engineering, plastics technology and mechanical and electrical engineering.
You can find more about our training, job and career opportunities on the internet at

https://www.isc.fraunhofer.de/de/job-und-karriere.html

APPENDIX

As one of the 74 Fraunhofer Institutes, the Fraunhofer-Institut für Silicatforschung ISC is a part of Europe's leading network for applied research. Aside from its numerous research projects, Fraunhofer ISC meets its research and teaching commitments through participation in national and international bodies, committees and alliances, through its staff's scientific lectures, publications and teaching activities, by organizing and participating in events and trade fairs and by mentoring theses and dissertations to support the young researchers of the future.

To help you stay informed about the current status of our research and teaching activities, you will find a comprehensive Fraunhofer ISC online offering here:

Ongoing projects with public funding

Please follow this link to find a list of all publicly funded projects at Fraunhofer ISC.
https://www.isc.fraunhofer.de/projekte

Patents

Patents document the capacity for innovation of an organization. You will find an overview here:
https://www.isc.fraunhofer.de/patente

Scientific lectures

The lectures of our staff reflect the variety of the research areas within Fraunhofer ISC.
https://www.isc.fraunhofer.de/vortraege

Scientific publications

https://www.isc.fraunhofer.de/publikationen

Conference transcripts

https://www.isc.fraunhofer.de/tagungsbaende

Teaching activities

https://www.isc.fraunhofer.de/lehrtaetigkeiten

Events, trade fairs and exhibitions

Fraunhofer ISC was also represented at numerous trade fairs and events this year.
Please find a list here:
https://www.isc.fraunhofer.de/de/messen-und-termine.html

Committees and bodies

https://www.isc.fraunhofer.de/mitgliedschaften

Alliances and networks

Fraunhofer ISC is an active member of numerous national and international research networks. The aim of this cooperation is to promote interdisciplinary exchange of knowledge with industry and other university and extramural research facilities, to contribute our own competences and to gain new partners.
https://www.isc.fraunhofer.de/allianzen

About the Fraunhofer Gesellschaft

https://www.fraunhofer.de

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