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FRAUNHOFER-INSTITUE FOR SILICATE RESEARCH ISC

The online version of the Annual Report can be found under:

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

More information on each of the projects mentioned can be found under the link indicated by the Project Report.

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Youtube:	**Fraunhofer-Institut für Silicatforschung ISC**

HIGHLIGHTS

2018|19

ANNUAL REPORT

FOREWORD

It's just the tip of the iceberg...

...plastic waste in the oceans has become an everyday topical issue and the images of plastic at the beach and in the water are in our heads. Plastic is getting into in the food-chain, it's indestructible and ultimately it lands on **our own** plates.

But that's just a small part of the problem which we have brought about with our lifestyle up to now. Climate change, which we are driving forward with our hunger for energy, mobility, consumption and global networking, will primarily do harm to ourselves and our coming generations. It's not about "protecting nature", it's about protecting people, where there's a need to change our way of thinking.

Not **using up** resources, but **using** them with care. Promoting environmentally compatible products and sustainable production, ensuring affordable health insurance, paving the way for resource-conserving energy supply and mobility – we need to measure our work against the scale of these challenges and we, at Fraunhofer ISC, want to make significant contributions to their resolution.

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

First and foremost, let me tell you about a current new change: at the beginning of April, the Board of Management of the Fraunhofer-Gesellschaft decided to release IWKS, the project group for Materials Recycling and Resources Management which was founded in 2011 under the umbrella of Fraunhofer ISC, into autonomy. The brief of managing the Fraunhofer IWKS as an independent facility was assigned by the Board of Management to Prof. Dr. Anke Weidenkaff, the newly appointed Executive Director. The Senate of the Fraunhofer-Gesellschaft will address the formal transition of the Fraunhofer-IWKS into autonomy on January 1, 2020 in its meeting next November.

Both of the ongoing large building projects for the IWKS are progressing well, operationalization is anticipated at the end of 2019. This will mean that the Fraunhofer ISC will successfully conclude eight years of development works in Alzenau and Hanau. The ISC wishes our colleagues in the IWKS lots of luck and every success!

A third large building project - the Fraunhofer Center HTL building for a fiber pilot plant which is unique in all of Europe already had its grand opening April 12, 2019 in Bayreuth. Meanwhile, plans are forging ahead for the Fraunhofer Translational Center Regenerative Therapies TLC-RT and the Fraunhofer Project Center for Stem Cell Prozess Engineering building project. The integration of the TLZ-RT into the Fraunhofer ISC is an outstanding success. As a result of the transition of Prof Heike Walles, whom I would like to thank at this juncture for her excellent work and further professional advice, to the Universität Magdeburg, the management of the TLZ-RT was rearranged in autumn 2018 and entrusted to Dr. Marco Metzger and his deputy Dr. Oliver Pullig.

Link to the ISC video on YouTube

The strategy process carried out in 2018 for the Fraunhofer ISC was audited by a review panel in September. The strategic thematic areas **"Materials meet… Biomedicine, Energy, Adaptive Systems, Clean Environment, Resources"** received strong backing from the auditors. A video was made to outline the Fraunhofer ISC 's new self-image as a significant contributor to the solutions of the world's great challenges and it was presented for the first time on the occasion of the audit. The video is also available on our channel using the QR code below.

Among the highlights of the past and current year are the two notable prizes which were awarded to employees of the Fraunhofer ISC. In January 2018, Dr. Sabine Amberg-Schwab was awarded the New Plastics Innovation Prize by the renowned Ellen MacArthur Foundation and in May 2019, Dr. Jörn Probst and Dr. Bernhard Durschang received the Fraunhofer-Prize "Human-Centered Technology" which is only awarded biennially – congratulations to those honored.

The Fraunhofer ISC is in a good position – and this is the achievement of all the employees together. With this in mind, I would like to thank my dedicated colleagues in the Fraunhofer ISC as well as the associated professorial chairs at the Universität Würzburg for their creative and competent work and especially our project partners, the funding bodies and ministries for their constructive collaboration.

Yours

Gerhard Sextl

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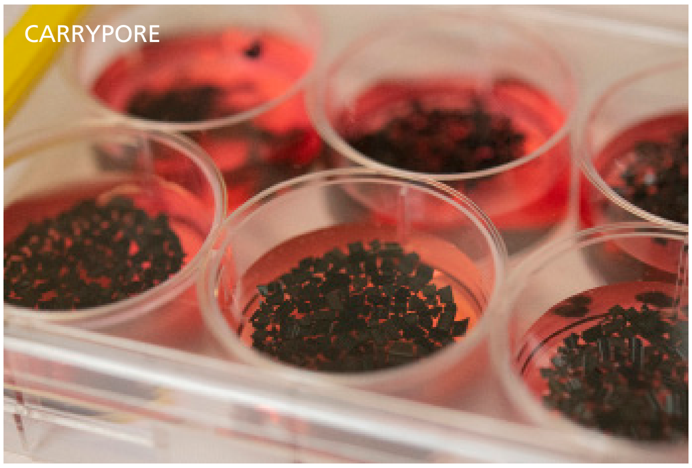
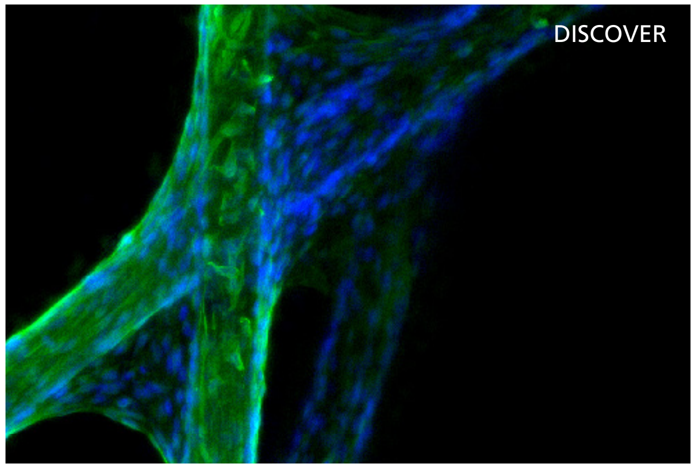
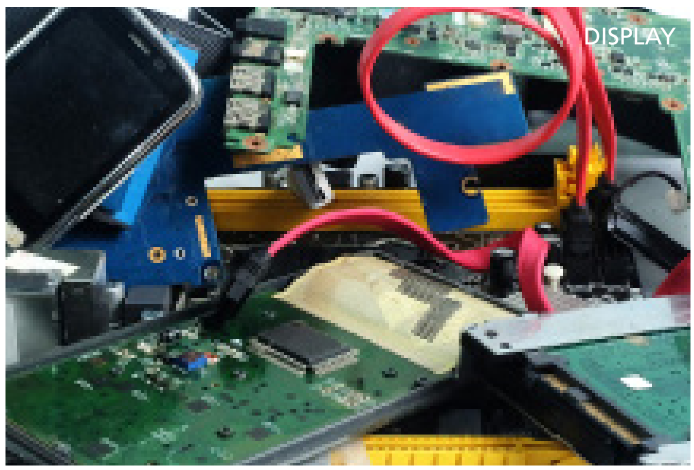






PROJECT REPORTS 2018

FRAUNHOFER ISC | WÜRZBURG AND BRONNBACH

FRAUNHOFER TRANSLATIONAL CENTER REGENERATIVE THERAPIES TLC-RT | WÜRZBURG

FRAUNHOFER-CENTER HTL | BAYREUTH

PROJECT GROUP IWKS | ALZENAU AND HANAU

AN OVERVIEW OF THE INSTITUTE

Fraunhofer Institute for Silicate Research ISC

The Fraunhofer Institute for Silicate Research ISC is one of the most important Bavarian centers for materials-based research and development in the fields of energy and resource efficiency. In 2017, the Fraunhofer Translational Center Regenerative Therapies TLC-RT in Würzburg was integrated into the Fraunhofer ISC. This also strengthens medicine and biotechnology, the Institute's strategically important third research area. In 2018, some 500 scientists, technicians and engineers were researching and working at the five branch sites of the Institute.

The Materials Chemistry and Application Technology clusters focus on optimization of materials and efficient production procedures and processes as well as their adaptation to the needs of industry. The comprehensive services of the **Center for Applied Analytics ZAA** in materials analysis, testing, and characterization and the development of scientific equipment in the Center of Device Development CeDeD complement the services offered. Powerful and safe energy storage systems are the main research focus of the Fraunhofer R&D Center for Electromobility Bavaria FZEB.

The Center Smart Materials CeSMa develops "smart" electrically or magnetically switchable materials for applications in automation, mechatronics, and sensor technology.

The Fraunhofer TLC-RT and the "3DNanoCell" group of the Project Center SPT are developing solutions in the areas of tissue engineering and regenerative medicine. With a view to resource efficiency, energy efficiency, and sustainability, the Fraunhofer ISC bases its developments on the use of regenerative and environment-friendly raw materials as well as recycling technologies to pave the way for closed materials cycles.

Fraunhofer Translational Center Regenerative Therapies TLC-RT

Since October 2018, the "Fraunhofer Translational Center Regenerative Therapies ", TLC-RT, has been directed by PD Dr. Marco Metzger and his deputy Dr. Oliver Pullig. The work of the TLC-RT is oriented to combining new materials with tissue engineering and its rapid application in new forms of therapy. Innovative applications in material development are thus rapidly made available to regenerative medicine. The thematic emphases include implants and cell therapies, e.g. for cartilage and bone replacement or after cancers, especially diseases which cannot be treated with the standard present-day therapies.

In this context, the major aspects include the biological compatibility as well as the surface structuring of the substrate material and a three-dimensional framework which allows for the directed growth of and scar-free wound closure by the tissue cells.

Another important point of contact between materials research and biomedicine is the synthesis of biologically and biochemically functionalized particles that can be used for individualized diagnostics and therapy as well as regenerative therapeutic approaches in dental medicine. The University Hospital Würzburg is the partner in this field. Their collaborative work now aims at promoting the cell and cell tissue-based development of new therapies for the treatment of diseases and functional disorders of the human body. Important focuses of the Fraunhofer ISC, in addition to new therapeutic approaches, are also the development of human 3D in-vitro test systems and bioreactor systems for reliable and rapid assessment of new agents as well as medical products and therapies. Laboratory automation and new procedures for GMP production also play an essential role.

Project Center for Stem Cell Process Engineering

By pooling the complementary expertise of the core institutes, Fraunhofer IBMT and Fraunhofer ISC, the "Project Center for Stem Cell Process Engineering" at the Würzburg site forms a nationally and internationally prominent competence center, utilizing innovative materials. Its objective is to convert stem cell processes to an industrial scale using automation solutions and to improve them with the aid of innovative materials in the areas of cell expansion and differentiation and cryopreservation.

Fraunhofer-Center for High Temperature Materials and Design HTL

Since its inception in 2012, the Fraunhofer Center HTL, directed by Dr. Friedrich Raether, has grown to a total of 90 staff members. After the recent opening of the newly-built concourse for a pilot plant for producing reinforcement fibers, the latest instrumentation and resources are now available for development projects and R&D services on an area of around 4000 m² in Bayreuth. The portfolio is supplemented by know-how in innovative and efficient fiber processing in the Application Center for Textile Fiber Ceramics TFC, directed by Prof. Frank Ficker.

The staff members of the six research groups; Simulation, Precursor Ceramics, Composite Materials Technology, Ceramics, Ceramics Fibers, and Thermal Processing Plants develop materials and components as well as measuring and simulation procedures for high temperature applications. Important applications are in the fields of energy, propulsion and heat technology.

The research at the Fraunhofer Center HTL focuses on improvement in the quality, materials efficiency and energy efficiency of high-temperature processes. Since more than ten percent of the final energy in Germany is ultimately consumed in industrial high-temperature processes, there is a significant potential for improvement in terms of cost and energy savings. The Fraunhofer Center HTL develops and utilizes thermo-optical measuring processes (TOM) for testing high temperature materials and for optimizing their production processes.

Application Center for Textile Fiber Ceramics

The "Application Center for Textile Fiber Ceramics" (TFC) in Münchberg is based on cooperation between the Fraunhofer Gesellschaft and the Hof University of Applied Sciences. This facility is unique in Europe and covers the entire development chain of ceramic composite materials from fiber to processing to final product. As such, this research topic creates a connection between the textile and the ceramics industries. This comprehensive process chain is intended to appeal to companies both from materials production and from product development.

The TFC and the Fraunhofer Center HTL collaborate on the production of ceramic fibers and on the load-specific design and further processing of textile preforms into Ceramic Matrix Composites (CMC). The specific focus of the TFC is on the intermediate step, namely the textile processing of ceramic fibers, which are still very expensive and difficult to process at this time. The establishment of the TFC in June 2014 has provided companies in Upper Franconia and supra-regional enterprises from the materials production and application industries with a powerful partner for textile processing of inorganic fibers. By 2018, the Bavarian Ministry of Economic Affairs, Regional Development and Energy had provided funds of € 2.5 million in order to establish this competence in the region and to expand it further.

Fraunhofer Research Institution for Materials Recycling and Resource Strategies IWKS

The Fraunhofer Research Institution for Materials Recycling and Resource Strategies IWKS was established as project group in 2011 based on the support of the two German states of Bavaria and Hesse. Approximately 90 staff members were employed at the premises in Alzenau and Hanau in 2018. Since April 1, 2019, the project group has been operated as an independent Fraunhofer facility with the mandate of the Fraunhofer-Gesellschaft. Currently, the facility has a total laboratory and technical department floor area of 850 m² – and two new buildings with a total of 5,000 m^2 working area are expected to be completed by the end of 2019. The Fraunhofer Applied Research Center for Resource Efficiency ARess is attached to this facility.

In light of the fact that raw materials are becoming scarcer and more expensive, the Fraunhofer IWKS works with the premise of ensuring raw material supply in the long term. For this purpose, the project group and its industrial partners investigate innovative separation, sorting, reprocessing and substitution options and develop strategies for the sustainable handling of valuable resources. The Fraunhofer IWKS pools these core competences in the areas of Biogenic Systems, Urban Mining, Resources Strategies and Scientific Networks, Analytics, Energy Materials and Lightweight Construction, Magnetic Materials, Materials Technology as well as Separation and Sorting technology.

The focus is on the development of regional, global and company-specific concepts for material flows, waste products and resource management. Processes and technologies are systematically analyzed, sustainable resource approaches are prepared and resource efficiency is optimized.

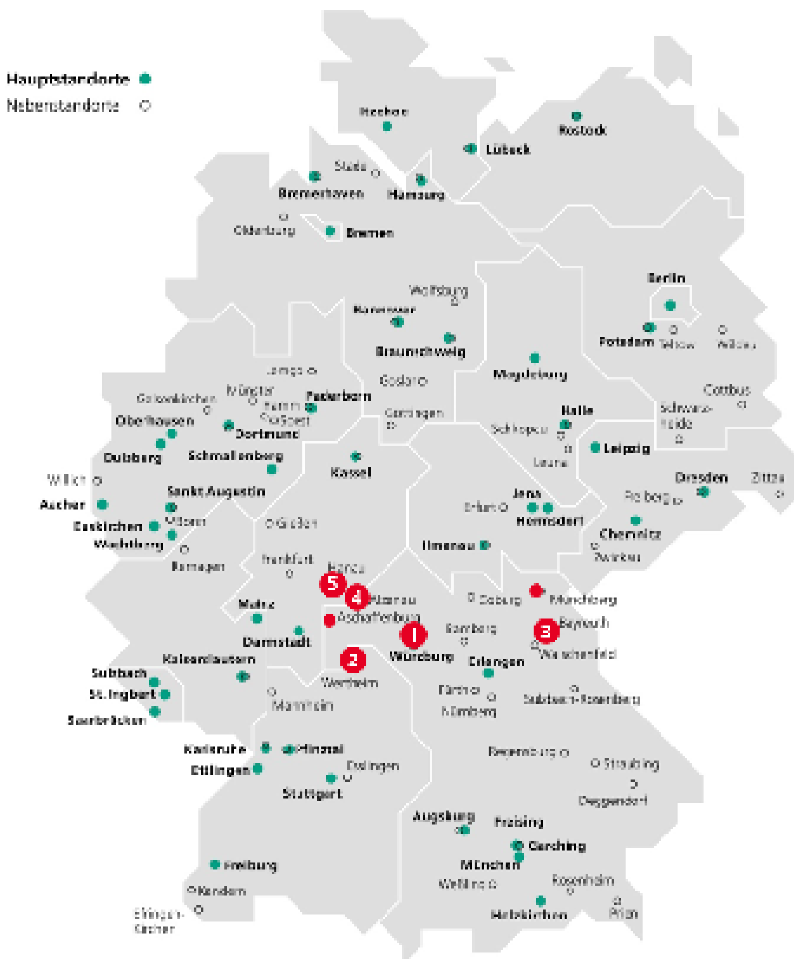
Fraunhofer Applied Research Center for Resource Efficiency ARess

The Fraunhofer Application Center for Resource Efficiency was established in 2015 within the framework of a collaboration between the Aschaffenburg University of Applied Sciences and the Fraunhofer ISC with its project group for Materials Recycling and Resource Strategies IWKS in Alzenau and Hanau.

The Application Center focuses on the resource efficient design of functional elements, processes, and products. This primarily uses laser- and nanotechnological as well as electrochemical methods for resource efficient production technology and for a resource efficient and reccling friendly design.

The main research topics of the ARess complement the work of the Fraunhofer Project Group IWKS and the Hochschule Aschaffenburg. They focus on the fields of nanotechnological and electrochemical pathways for resource efficient processes and products, novel procedures for the separation of materials, laser technologies for resource efficient process design as well as the substitution of critical substances and the use of recycling friendly production processes in electronics.

The center received 2.5 million Euros in funding from the State of Bavaria (Regierung von Unterfranken) over a period of five years. The city of Alzenau established an endowed chair at the Hochschule Aschaffenburg for its scientific direction, which has been held by Prof. Gesa Beck since September 1, 2015.



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MATERIALS MEET ...

At intervals of five years, Fraunhofer ISC subjects its strategic orientation to an intensive, critical internal review and then faces an external review panel, made up of representatives from research and industry, with the newly adjusted planning. The most recent audit took place in September 2018.

In its Strategic planning for the years 2018 – 2023, which was decidedly positively evaluated by the auditors, Fraunhofer ISC focused on making significant material, process and product-based contributions to the solution of the greater (global) challenges.

Hence, the guiding principle of the research agenda is to address the effects of climate change and population growth, rising energy consumption, environmental pollution and excessive use of resources with the tools of materials research also.

Under the motto "Materials meet...", the research activities of the Fraunhofer ISC are oriented to five strategic application fields - to simplify orientation, the projects in the present Annual Report are also organized accordingly:

Materials meet Energy

The principal activities in the energy sector are carried out in the Fraunhofer Center for High Temperature Materials and Design in Bayreuth and in the "Fraunhofer R&D Center for Electromobility Bavaria FZEB" and "Center Smart Materials (CeSMa)" centers. In addition to energy-efficient methods for synthesizing functional materials, the R&D activities include

- improving the energy efficiency of thermal processes using suitable material and process development,
- developing components for Li-ion, solid-state Li-ion and lead-acid batteries as well as magnetic materials,
- constructing and utilizing thermo-optical measurement equipment for the energetic optimization of thermal processes, and
- developing Energy Harvesting Systems (on the basis of adaptive materials).

Materials meet Biomedicine

To be able to respond to the increasing significance of the Health Sector in the Fraunhofer ISC and the demand for innovative functional materials in the TLZ-RT and the SPT, materials and processing development will in future be more intensely focused on functional biohybrid materials which can be produced in automated, digitized processes, conforming to GMP. In particular, there is a need for the development or further development of

- (stem) cell-seeded (biocompatible) substrate materials as implants for regenerative therapies,
- proliferation of induced pluripotent stem cells using a standardized procedure on a pilot scale,
- complex in-vitro 3D disease and barrier models for testing and developing new formulations and therapeutic agents,
- automated production processes for patient-individualized implants and
- non-invasive characterization methods for human tissues, also for quality control of GMP processes.

Materials meet Clean Environment

As the core competence of the Institute is chemical material synthesis, one of the most important tasks at the parent institute is the transformation of the existing palette of multifunctional non-metallic and hybrid materials (ORMOCER®e) into bio-based, biocompatible and biodegradable functional materials with properties optimized to the application (bioORMOCER®), which can be produced in an environmentally friendly and cost-efficient manner. In detail

- new bio-based raw material sources for functional material syntheses will be developed (in cooperation with the IWKS) and
- will counteract the increasing accumulation of non-degradable plastic waste in the environment by means of biocompatible and/or biodegradable multifunctional materials.

Materials meet Adaptive Systems

To work more intensively with the future issues related to increasing digitization, such as the "Internet of Things", robotics, autonomous driving, laboratory automation and switchable systems, the Adaptive System field of strategy is being redefined for the parent Institute. The R&D activities in this area include the concentration of work which has already been carried out in the past by various groups. Other adaptive production processes are being established which are also of paramount importance for the field of Biomedicine. Specifically, the works include the development of

- new sensor and actuator concepts based on magneto rheological elastomers and printable piezo-polymers,
- electro and magnetochromic systems for switchable facade elements, smart textiles or hybrid components,
- electro and magnetorheological liquids, gels and/or elastomers for mechatronic functions and
- hybrids, inorganic and organic functional materials for light direction, beam formation, data transfer and for packaging applications as well as display technologies.

Materials meet Resources

The issues of recycling, substitution and resource strategies are concretized in the strategy fields of the Fraunhofer Research Institution for Materials Recycling and Resource Strategies IWKS. Focused on the guiding principle of a unified approach to the recycling of reusable materials, their resource strategical orientation includes the development of

- economically viable and environmentally sound recovery processes for critical materials and valuable raw materials with minimal deployment of resources,
- sustainable substitute materials for critical or environmentally harmful materials and
- strategies for the sustainable use of critical raw materials.

Using these measures, the Fraunhofer ISC is creating the basis for stable and future-orientated institute development in the 2018-2023 planning period.

Institute management

Prof. Dr. Gerhard Sextl

ext. -100

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MATERIALS CHEMISTRY
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- BARRIER COATINGS – Dr. Sabine Amberg-Schwab -620
- FUNCTIONAL COATINGS – Dr. Klaus Rose -626
- PARTICLE TECHNOLOGY – Dr. Karl-Sebastian Mandel -402

R&D CENTER ELECTROMOBILITY
Dr. Henning Lorrmann
-519

- LITHIUM-ION-TECHNOLOGY – Dr. Guinevere Giffin -959
- LEAD ACID TECHNOLOGIES – Jochen Settelein -916
- ELECTROCHROMIC SYSTEMS – Dr. Marco Schott -556
- ANALYTICS/ SERVICES – Dr. Sarah Hartmann -244
- PROCESS DEVELOPMENT – Andreas Flegler -565

APPLICATION TECHNOLOGY
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-551

- GLASS – Dr. Gerhard Schottner -627
- OPTICS AND ELECTRONICS – Gerhard Domann -551
- DENTAL AND MICROMEDICINE – Dr. Herbert Wolter -510

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- APPLICATION TECHNOLOGY – Dr. Bernhard Brunner -416

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BOARD OF TRUSTEES

NUMBERS | FACTS | FIGURES

466 EMPLOYEES

21 assistants | interns

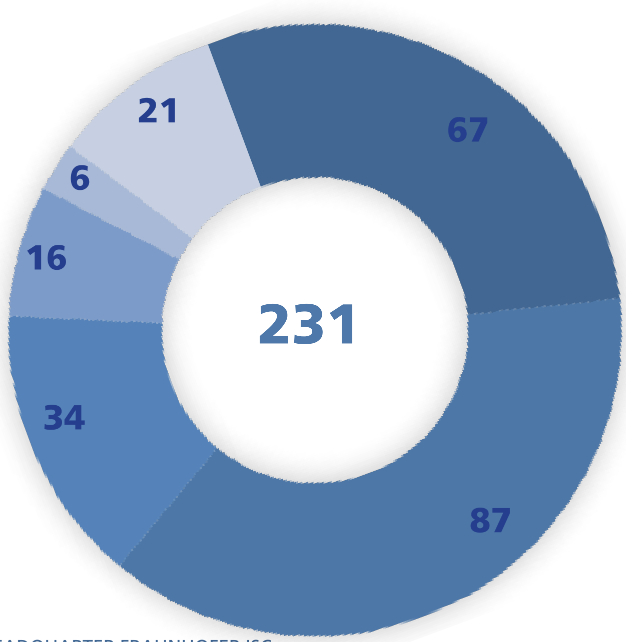
6 apprentices

16 postgraduate students

34 technical staff

87 graduate staff

67 scientific staff



HEADQUARTER FRAUNHOFER ISC

231 staff in the Fraunhofer ISC | main building

+ 100 staff in the Fraunhofer-Zentrum HTL in Bayreuth

+ 48 staff in the Translationszentrum für Regenerative Therapien TLZ-RT

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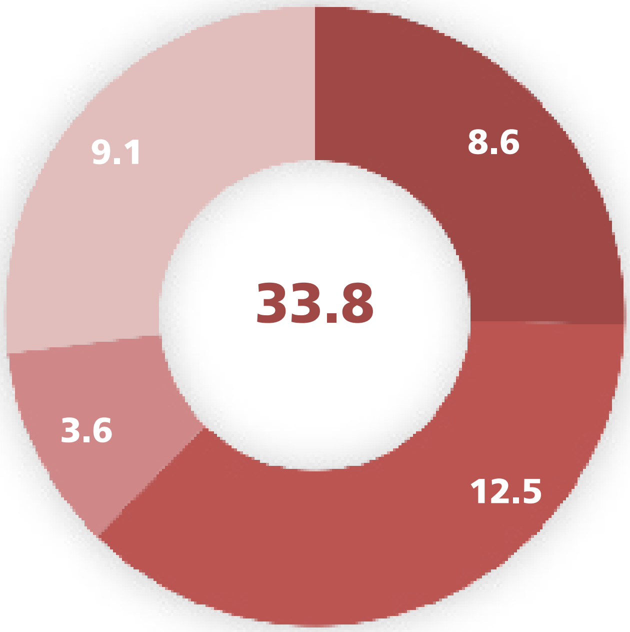
+ 34 staff in the Projektgruppe IWKS Hanau

+ 53 staff in the Projektgruppe IWKS Alzenau

Version 4/1/2019

TOTAL BUDGET €33.8 MILLION



€ 9.1 million institutional funding

€ 3.6 million EU | Other

€ 12.5 million public revenues

€ 8.6 million commercial revenues

€ 16.8 million in the Fraunhofer ISC | main building

€ 6.5 million in the Fraunhofer-Zentrum HTL

€ 3 million in the Translationszentrum für Regenerative Therapien TLZ-RT

....

€ 3.4 million in the Projektgruppe IWKS Hanau

€ 4.1 million in the Projektgruppe IWKS Alzenau

Version 12/31/2018

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FRAUNHOFER PREIS

“The new DNA of high-strength glass ceramics”, this is how Dentsply, the largest dental company in the world with

annual revenue of around 3 billion euros, promotes the result of a just under four-year-long material, process and product development at the Fraunhofer ISC which was achieved in collaboration with the German affiliate DeguDent GmbH, Hanau and the VITA Zahnfabrik GmbH, Bad Säckingen. This breakthrough in the field of restoration materials was possible at the Fraunhofer ISC due to bringing together scientific excellence in the field of new glass material development and engineering innovation in the construction of a glass-melting plant to produce dental glass ceramic blocks. CAD/CAM processed materials for dental “chair-side” applications form the backbone for future dental replacement materials (inlays, onlays, veneers, crowns, bridges etc).

Rethinking glass ceramics - the key to success

Up to now, glass ceramics have been selected on the basis of the crystalline components since these have a great influence on the mechanical and thermal (e.g. coefficient of thermal expansion) properties. The glass matrix was practically taken for granted. The team headed by Dr. Bernhard Durschang and Dr. Jörn Probst pursued a different approach to the solution and varied the glass matrix (also called the residual glassy phase). The positive properties of the existing tried and tested crystalline portions were carried over into the new composition at the same time. In this way, both the optical and the mechanical properties could be considerably improved.

In preliminary tests, it was seen that up to 15 % zirconium oxide remained amorphous in the glassy phase of known lithium silicate glass ceramics. That opened up the possibility of pushing forward in new dimensions in relation to mechanical, chemical and optical properties. These glass ceramics feature a higher glass matrix ratio than do glass ceramics which are ZrO_2-free or have low ZrO_2 and hence they exhibit outstanding optical properties. Despite the higher glassy phase ratio, the newly developed glass ceramics show at least equal chemical resistance whereas the mechanical properties are significantly superior to previous available products mechanical properties. The standardized 3-point flexural strength is given as the characteristic value for mechanical stability in dental applications.

Lithium silicate glass ceramics which are reinforced with zirconium oxide (ZLS) exhibit flexural strengths of up to 450 – 500 MPa which are hence not only considerably higher than competitive products on the market, they also open up the market in molar bridges (i.e. in the molar region, with the highest strength requirements) for the aesthetically superior dental material glass ceramic for the first time.

What’s more, the common two-step crystallization process is no longer necessary with these glass ceramics. The CAD/CAM materials previously available can only be processed to a flexural strength of up to 200 MPa and require thermal treatment at about 800 °C and higher for more than 30 minutes to increase their flexural strength (sintering in ceramics, crystallization in glass ceramics). Due to the very fine microstructure and the high glass matrix ratio of these new glass ceramics, the final crystallized product can be processed with conventional CAM units at a flexural strength of approx. 500 MPa. This means that the high-strength glass ceramics can be used in both the common two-step and the shortened one-step process. This is an enormous advantage for efficient dental treatment.

Awarded the Fraunhofer Prize “Human-Centered Technology” 2019

The Fraunhofer-Prize, “Human-Centered Technology”, which is conferred every two years and endowed with € 50,000, was awarded to Dr. Jörn Probst and Dr. Bernhard Durschang for developing the high-strength glass ceramic for modern chair-side care, their innovative approach as well as for its industrial production implementation. The jury based its decision on the multi-criteria development pursued, involving both medical parameters and efficient production technology, among other factors.

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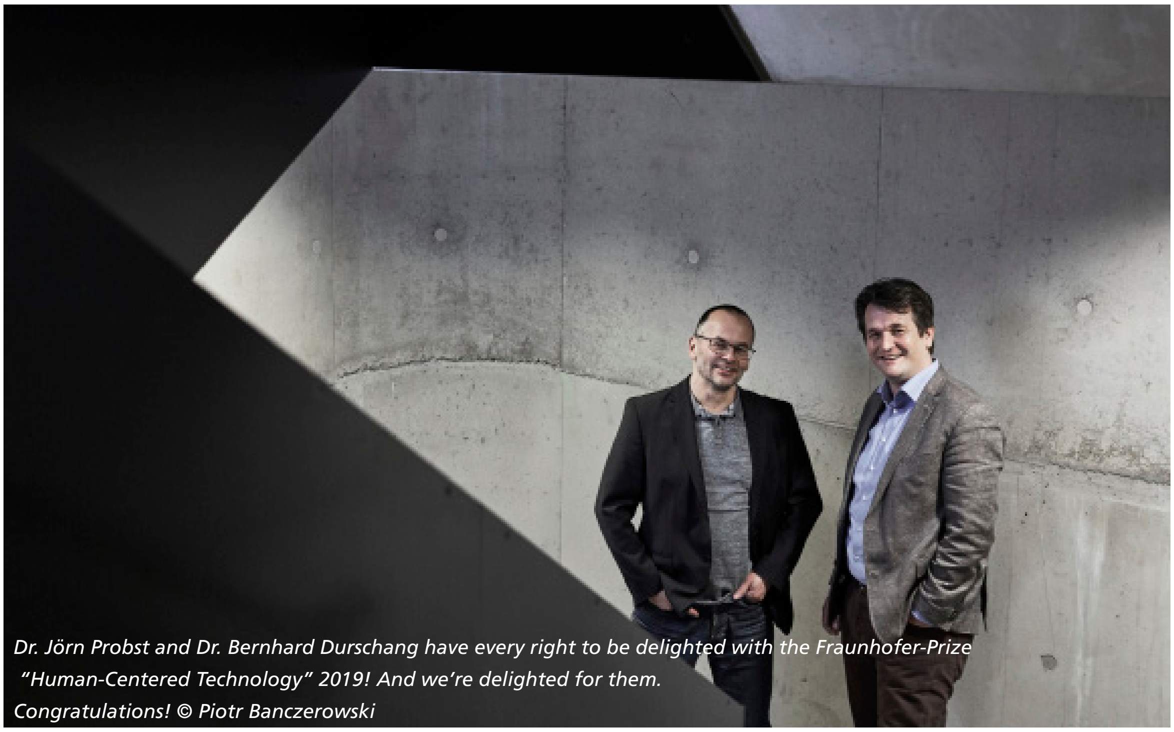

Dr. Jörn Probst and Dr. Bernhard Durschang have every right to be delighted with the Fraunhofer-Prize "Human-Centered Technology" 2019! And we're delighted for them. Congratulations! © Piotr Banczerowski

See the video about dental glass ceramics

At the award ceremony, form left: Prof. Hans-Ulrich Wiese, Dr. Monika Kursawe, award winners Dr. Bernhard Durschang and Dr. Jörn Probst and President Prof. Dr. Raimund Neugebauer.

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REVIEW

New Plastics Innovation Prize

On 1/23/2018, DR. Sabine Amberg-Schwab in Davos received the New Plastics Innovation Prize of the Ellen McArthur Foundation for developing bioORMOCER®; in all, five award winners shared this year's "Circular Materials Challenge" which is endowed with 1 million dollars. The prize was presented related to the launch of the World Economic Forum Annual Meeting in Davos.

Open day at HTL

An Open Day took place at the Bayreuth site of the Fraunhofer Zentrum HTL on 4/14/2018. Visitors were able to have a look around the new HTL building and find out many interesting things.

Industry workshop "Electronic waste and plastics" at IWKS

In May 2018, guests from industry and science caught up on research activities in the fields of separating and sorting technologies at the Fraunhofer Project Group IWKS. The central theme of the workshop, which was held in cooperation with the IHK Würzburg-Schweinfurt Mainfranken, was modular sorting equipment, the new benchmark in segregating individual components in complex material flows.

Audit in analysis

On June 14 and 15 2018, the accreditation audit for the Analytic Group took place. The auditors were very satisfied and granted accreditation for the next year.

DAkkS
Deutsche
Akkreditierungsstelle
D-PL-11140-12-00

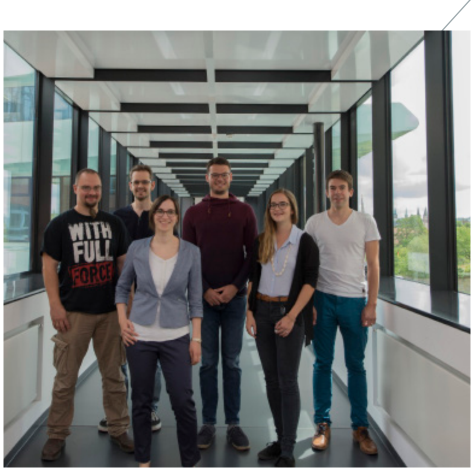
Industrial sustainability at Untermain in Alzenau

The Fraunhofer Project Gropu IWKS and the BVMW (German Association for Small and Medium sized Business) hosted "Industry Night; Sustainability in the Untermain Region" on 6/26/2018 to discuss the topic of responsible use of resources and how to practice applied conservation of the environment and nature as well as social protection.

BMBF-Project for junior groups

On 7/1/2018, in addition to taking over the management of Particle Technology at the ISC, Dr. Karl Mandel, also assumed directorship of a junior group at the University Würzburg.

The project "NANO-ID - nanoparticle-based markers with fingerprints for monitoring material and productions flows" was financed with € 1.8 million by the BMBF for five years.



Successful evaluation of "EnerTHERM" (HTL)

The evaluation of the "Sustainable Thermal Processes" (abbreviated to EnerTHERM) project took place on 7/19/2018. Over a period of more than five years, many new methods (measurement procedures, measuring devices, simulation methods and joining processes) and materials were developed at the HTL to increase the efficiency and sustainability of thermal treatments in industry. The evaluation committee praised their outstanding work.

Minister for Economic Affairs visits IWKS

On 9/6/2018, Franz-Josef Pschierer, the Bavarian Minister for Economic Affairs, was a guest of the IWKS project group in Alzenau to gain a personal insight into the status of the project group's expansion and progress on the spot. During a tour of the shell construction for the new IWKS building, he emphasized the economic significance of securing resources and recycling.

Change of management in the Translational Center

On 10/1/2018, Prof. Dr. Heike Walles left the Fraunhofer ISC to move to the University Magdeburg and establish a new professorial chair there.
The management of the Fraunhofer TLC-RT thus passed on a provisional basis to LPD Dr. Marco Metzger (pictured right), supported by Dr. Oliver Pullig as his Deputy.

Prof. Dr. Anke Weidenkaff takes over as Head of the Fraunhofer-Projektgruppe IWKS

On 10/1/2018, Prof. Dr. Anke Weidenkaff took over as Head of the Fraunhofer Project Group IWKS in Hanau and Alzenau. Previously, Prof. Weidenkaff occupied the professorial chair for Chemical Material Synthesis at the Institute for Materials Sciences of the University Stuttgart. Alongside the transfer to the project group, Prof. Weidenkaff was appointed to the Technische Universität Darmstadt. The new subject area of "Materials Chemistry/Materials Engineering and Resource Management" will be established there under her leadership.

National Academy of Science and Engineering acatec as a guest at the ISC

On 11.11.2018 the acatech was a guest at the Fraunhofer ISC with their series of public events "acatech on Tuesday". In addition to Prof. Dr. Sextl, Prof. Dr.-Ing. Dieter Spath, President of the Akademie der Technikwissenschaften acatech, Prof. Dr. Alfred Forchel, President of the University Würzburg and Dr. Eleonore Hos, Senior Teacher and Board Member of the "young researchers initiative", discussed the issue of "Nanotechnology – from research into the schools" in a panel discussion and with the audience.

ISC glass sensors honored in Belgium

The glass sensors from the Fraunhofer ISC were selected as one out of 40 prominently presented innovations from cultural heritage research for the EU Commission's "Fair of European Innovators in Cultural Heritage" in Brussels as part of the Year of Cultural Heritage. Dr. Johanna Leissner and Sigrid Arzuman were onsite in Brussels on November 15 and 16, 2018 and received a high-ranking visitor in the person of Jean-Eric Paquet (DG RTD), General Director of "Research and Innovation" for the EU.

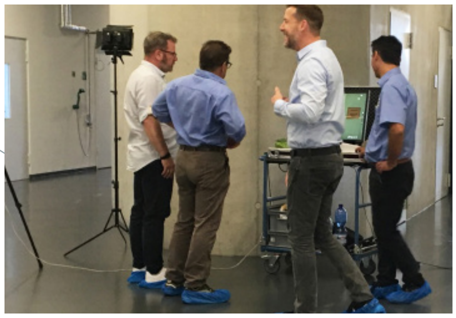
Tissue Engineering – Principles of 3D-Tissue Culture

The Fraunhofer Academy Tissue Engineering Practical Seminar took place in Bronnbach from November 14-16, 2018. During the three days of the course, the participants were given a comprehensive overview of the biological and materials science-related principles of Tissue Engineering and the work of the Fraunhofer- TLC-RT

First Place at the EPAA 3Rs Science Prize

Dr. Antje Appelt-Menzel (Fraunhofer TLC-RT) won first place at this year's EPAA 3Rs Science Prize ("The European Partnership for Alternative Approaches to Animal Testing"). The prize was presented at the EPAA-Annual Conference on 11/20/2018.

ISC-Film



This year a film was made about the activities of the Fraunhofer ISC and can be admired on YouTube.
Please follow the link www.youtube.com and visit our channel *Fraunhofer-Institut für Silicatforschung ISC* or use the nearby QR-code for a mobile device.

The Regional Council held meeting at the ISC

The most recent (2018) meeting of the Regional Council for the lower Franconian Region took place on 12/19/2018 in the Fraunhofer ISC. The guests at Neunerplatz included members of the Federal and State Parliaments for the region, District Chief Officers, (Lord) Mayors, representatives from the Chambers of Commerce, University President and University of Applied Sciences Vice President as well as the then District President Beinhofer. Prof. Sextl availed himself of the opportunity to report about the strategic expansion of the ISC.

Kick-off-Meeting with Empa

FZEB and Empa began a joint project for the solid state batteries of tomorrow on 1/16/2019. 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 together with their industrial partners took place at the Fraunhofer ISC in Würzburg.

TLC-RT successfully evaluated

On 1/30/2019, an external review commission carefully scrutinized the TLC-RT and their development activity over the last five years was put to the test with the result "Very Good Work" on a variety of counts, ranging from the relevance of the topics, to the scientific excellence, to the very positive development in commercial revenues. The team spirit, the development work carried out by Prof. Dr. Heike Walles as well as the smooth transition in the management team of the young, rapidly growing group was also singled out for praise.

The external evaluators were: Dr. Wimbauer (Bayerisches Staatsministerium für Wirtschaft, Landesentwicklung und Energie), Dr. Senkel (Fraunhofer Zentrale), Ms Simon (Universitätsklinikum Würzburg), Dr. Klug (Uni Würzburg), Prof. Windbergs (Uni Frankfurt), Prof. Kasper (Uni Wien), Prof. Büttner (Fraunhofer IVV), Herr Lothar (Regierung Unterfranken) and Ms Konrad (Regierung Unterfanken)

CarryPore – a new material basis for cell culture substrates

Targeted proliferation and efficient reproduction of living cells in-vitro is one of the key technologies of biomedicine. Procedures available today are still very cost-intensive which hinders the further development and introduction of new materials or individualized cell therapies and makes even established applications, such as the production of therapeutic antibodies, expensive.

In addition to innovative bioreactor technologies for 3D tissue culture in its Fraunhofer TLC-RT and process automation in the Project Center for Stem Cell Processing SPT, the Fraunhofer ISC also pursues material-based approaches to making the proliferation of relevant cell lines more cost-effective and more reproducible. CarryPore, the Fraunhofer internal project together with the Fraunhofer Research Institution for Marine Biotechnology EMB, looks at whether porous glass flakes with an additionally introduced magnetic moment are suitable substrate materials to make cell proliferation more efficient.

In conventional substrate systems, cell proliferation runs more or less two-dimensionally to the boundary surface between the nutrient solution and the vessel wall or substrate surface. In this way only a fraction of the available nutrients are converted and the reactor volumes are not efficiently used.

A simple three-dimensional approach was pursued in CarryPore in order to be able to use the total volume of the nutrient solution for cell proliferation. Special glasses were designed for this which can be magnetized due to iron doping. These magnetizable glasses are processed to fine glass flakes with defined porosity and rounded edges using a special process. When introduced into nutrient solution, these glass flakes can be controlled by a magnetic field keeping them floating in the solution and are thus optimally washed around. The defined porosity created a three-dimensional structure to which the cells can attach and move and replicate. Cell production can thus take place in the total volume.

As early as in preliminary experiments, it proved possible to find suitable glass compositions which facilitated or even promoted cell growth. In a Vycor® process, the glasses receive a defined porosity and its associated surface pattern. Cells which accumulate there proliferate more vigorously than on pore-free glass surfaces or on the walls of culture vessels. Experiments were carried out on particulate systems with various forms to decide on the shape and eventually the flake shape was identified as particularly suitable. On the one hand, they offer the cells an even surface and attractive accumulation conditions and on the other, they provide a favorable ratio between volume and surface to enable the cell substrate to float. A procedure developed in the Fraunhofer ISC allows for price-effective production of these optimized flakes.

The glass pieces selected in this way are doped with iron oxide to make them magnetizable and thus to control their later distribution in the nutrient solution. However, the doping must be modified to the effect that the cells do not come in direct contact with the iron to avoid a negative influence on cell growth. First approaches to iron masking with collagen or fibrin are being further pursued.

In principle, an interesting substrate for cell proliferation is now available even in the non-doped porous glass flakes. The additional possibility of magnetically controlled movement of the flakes in the nutrient medium will require even more development steps. This technological approach is seen as very promising however, since it was also possible to determine that an external magnetic field does not have a disruptive effect on the cells.

PROMISING
Magnetizable porous glass flakes as substrates for efficient cell proliferation.

Fraunhofer Research program for small and medium-sized companies

Project partner:
Fraunhofer EMB, Lübeck | Germany

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BISYKA – biomimetic synthetic rubber better than the original

Due to its high tear-resistance and good abrasion resistance, natural rubber remains unrivalled wherever extreme mechanical loads occur, such as in the truck or aircraft tire sector. Hence, natural rubber remains indispensable for tire production. However, it is becoming harder and harder to supply the market due to increasing demand on the one hand and diverse socioeconomic restrictions and biological hazards on the other.

In a joint project, five Fraunhofer-Institutes researched the reasons for the extraordinary mechanical properties of natural rubber and have successfully transferred these to synthetic rubber. From this project they developed the biomimetic synthetic rubber "BISYKA".

Natural rubber has a very highly uniform molecular architecture with a very high proportion (approx. 93 – 95 %) of cis 1,4 polyisoprene which is low in imperfections and has a low proportion (5 – 7 %) of plant-specific biocomponents. When the material is stretched, both of these characteristics bring about this special effect: from an extension of about 200 %, signs of crystalline rubber constituents can be seen. This extensional crystallization increases almost linearly with extension and prevents the spread of tears or counteracts the further extension of the material by hardening. By systematically varying the material composition from synthetic polyisoprene, bioadditives and filler materials, the project partners achieved a stepwise optimization of the extensional crystallization in the rubber system.

The task of Fraunhofer ISC was to develop the filler which was intended to further optimize the properties of "BISYKA". Up until that point, highly dispersible silica nano filler materials had not played a significant role for use in natural rubber since the interaction of rubber, bonding agent and filler did not work. The reason for this is considerable quantities of non-rubber constituents such as protein, carbohydrates and lipids which massively disrupt the dispersion and linkage of the silica filler.

In the course of the project, the Fraunhofer ISC developed an alternative approach with nanostructured microparticle powders. Their adjustable dispersion behavior can be produced starting from colloidal silica nanoparticle dispersions. Within the rubber, these have the potential to arrange themselves either in a mechanically stable aggregate or a loose agglomerate or, in the extreme, to be separated down to the output value.

In established standard processing procedures the silanizing reagent is added immediately during filler incorporation and reacted in situ. In contrast the ISC process allows to control the behavior in advance under well defined conditions. This results in a previously unachievable precision in the adjustment of the agglomeration and aggregation behavior and in the resultant reinforcement effect of the filler material. In particular, it becomes possible to better control the proteins and lipids which compete for surface space when incorporating in natural rubber.

After the successful transfer from laboratory synthesis to pilot scale, road tests were carried out where the tires made from the biomimetic rubber "BISYKA" outperformed the natural rubber-based reference tires in all three categories: the rolling resistance is lower, the wet grip and dry grip are somewhat higher and abrasion is even reduced by 30 – 50 %.

FIRST TESTS
of tires with BISYKA, the nature-identical, biomimetic synthetic rubber, show that it produces around 30 – 50 % less abrasion in comparison to natural rubber tires.
© Till Budde for Fraunhofer IAP

The "BISYKA – biomimetic synthetic rubber" project was supported over a period of three years by an internal Fraunhofer-Gesellschaft program for market-oriented preparatory research (MAVO).

Project partners
Fraunhofer IAP (Coordinator), Potsdam-Golm | Germany

Fraunhofer IME, Aachen | Germany
Fraunhofer IMWS, Halle | Germany
Fraunhofer IWM, Freiburg | Germany

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›› Materials meet ...
›› CLEAN ENVIRONMENT

ReViSEDBatt – mechanical damage hastens the end of battery service life

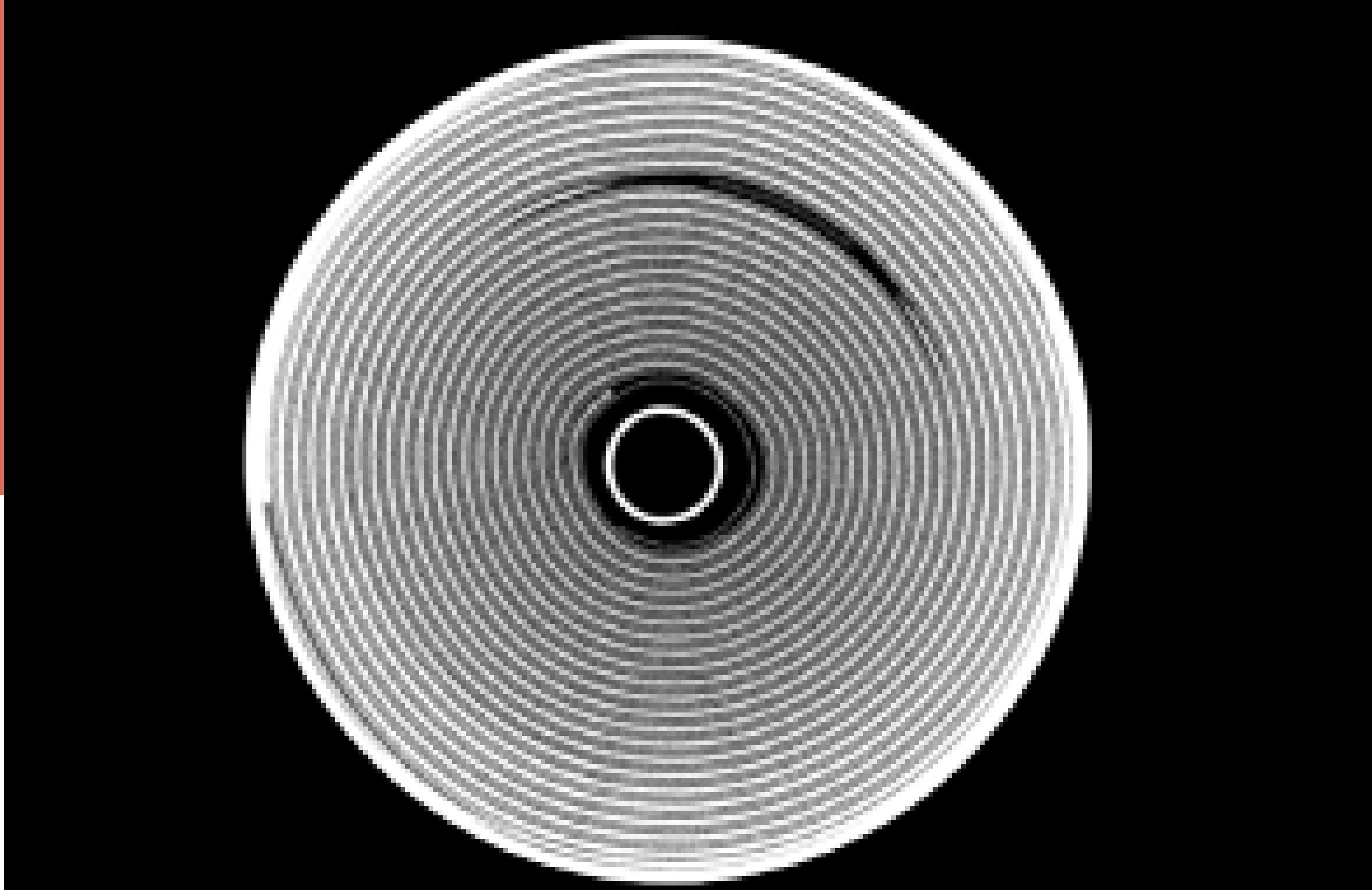
Range, service life and safety; these are the three most important quality criteria for Lithium-ion batteries. However, even during their production, e.g. during cell assembly into modules and during their further transport, batteries are subject to many mechanical stresses which can impact their useful life. More negative influence come along when they are in operation, such as vibration, impacts or shock impulses. Traction batteries are particularly subject to shock stresses when in use in forklifts or electrical cars and an obstacle such as the edge of a curb is travelled over. Portable, battery-operated devices such as cordless screwdrivers and smart phones likewise suffer from mechanical stresses, for example due to falling which can result in damages and hence to problems when charging and discharging the battery cells.

In the "ReViSEDBatt" project, partners from industry and research applied themselves to the question of how these stresses affect the safety and service life of batteries in the short or long term. The project is coordinated by the Fraunhofer R&D Center Electromobility FZEB of the Fraunhofer ISC. The mission of the center is to investigate static load scenarios which can lead to aging phenomena in lithium-ion cells. The first results show a great variation in the effects caused by mechanical stresses on the various cell types (cylindric-type, pouch-type and prismatic cells). The purpose they are to be used for decides which cell format is installed. Hence, flat cell shapes are used in smart phones whereas several cylindric-type cells are installed in cordless screwdrivers to allow for higher capacity. Prismatic and pouch-type cells, which are usually firmly installed in battery modules, are preferentially used for traction batteries. This type of assembly limits the space and thus impedes the reversible volume change ("breathing") of the cells which accompanies their charging and discharging.

As a result of reactions between electrolytes and electrodes, passive layers are formed in which lithium ions are "consumed": the battery cell becomes "fatigued" with advancing age and thus no longer delivers as much energy as at the beginning. Another effect of the formation of passive layers is the spread of the lithium ion cells over a considerable period of time. If pressure from outside is added to this, then uneven pressure distribution on the electrodes can result. Due to the high pressure, some places on the electrode become inactive which results in an amplified local accumulation of elementary lithium. This phenomenon is known as lithium plating and accelerates energy loss in the battery cells. However, lithium plating also presents a great safety risk since it can give rise to a short circuit and thus the abrupt release of the total energy available in the battery cell.

An even pressure distribution over the electrode, e.g. because of spring-loaded bracing of the cells can greatly reduce lithium plating. At the Fraunhofer Fraunhofer R&D Center Electromobility FZEB, it was possible to demonstrate this on the basis of accelerated aging experiments in which lithium ion cells were charged and discharged up to 800 times and in mechanical simulations.

Inhomogeneous pressure distribution in prismatic cells was also simulated in the course of the ReVISEDBatt project. Due to their flat coil electrodes, these cells exhibit very inhomogeneous pressure distribution which has a negative effect on the separator and the cell aging.



CT SCAN
Cross-sectional view of a cylindric-type cell-defect in electrode winding.

The joint project "ReVisedBatt" – resonances, vibrations, shocks, external mechanical forces and detection methods for lithium ion batteries" is supported by the 6th Energy Research Program of the Federal Ministry for Economic Affairs and Energy (BMWi). The Fraunhofer ISC is the project coordinator.

Partners
Technical University of Munich | Germany
Munich University of Applied Sciences | Germany
Infineon Technologies AG, Neubiberg | Germany
Hilti Entwicklungsgesellschaft mbH, Kaufering | Germany
HOPPECKE Advanced Battery Technology GmbH, Zwickau
ThyssenKrupp System Engineering GmbH, Hohenstein-Ernstthal, Germany
TÜV Süd Battery Testing GmbH, Garching | Germany

Associated partners
BMW Bayerische Motoren Werke Aktiengesellschaft, Munich | Germany

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IE4B – solid state batteries for tomorrow's electric cars

To guarantee greater safety for electric car traction batteries and to save on size and weight, it is expected that lithium ion cells in future shall only consist of solid materials and no longer contain any flammable liquid electrolytes. Furthermore, by using metallic lithium as the anode material – instead of the graphite anodes usually used today – solid-state batteries promise greater energy density and significantly shorter charging times.

As part of an international cooperation, the Swiss Federal Laboratories for Materials Science and Technology Empa in Dübendorf, Switzerland and the Fraunhofer R&D Center Electromobility FZEB at the Fraunhofer ISC develope production-ready, high-performance solid-state battery systems which allow for a stable charge and discharge cycle at room temperature and rapid discharging.

Empa is laying the basis for this new battery technology in the "IE4B" project. This includes the development of solid-state electrolytes, the production and characterization of thin layers with customized electronic properties as well as the development of nanostructured anode materials.

The Fraunhofer R&D Center Electromobility FZEB is contributing its expertise in process development and is working on lithium conducting polymers and on the development of protective layers made from sol gel materials with specific properties for batteries. They are also developing, producing and testing prototypes and small series of battery cells.

The project is divided into two phases: The first phase deals with fundamental aspects and uses battery model systems which are produced using thin-film methods at Empa and ISC. In this first phase, the aim is to clearly understand and better control the processes taking place at the interfaces between cathode, solid state electrolyte and anode. In the second phase, this knowledge will be used to manufacture a functional solid-state cell that will be produced in a small series utilizing the process engineering expertise of the Fraunhofer ISC.

This two-step approach offers significant advantages – assembly of the thin-film cells as a model system in phase 1 is easier to analyze. This enables the best matching electrode and electrolyte combination to be identified. The more complex three-dimensional assembly of larger battery cells in phase 2 will be made considerably easier due to the previously coordinated materials.

MODEL SYSTEMS
Stephan Bücheler of the EMPA produces model systems for the next generation of batteries using thin-film methods. © Empa

The "IE4B – Interface Engineering for Safe and Sustainable High-Performance Batteries" project is supported for three years as part of the Fraunhofer-" ICON – International Cooperation and Networking" program. The objective of "ICON" for the Fraunhofer-Gesellschaft is to increase the strategic cooperation of their institutes with selected international centers of excellence in various fields.

Partner
Swiss Federal Laboratories for Materials Science and Technology
Empa, Dübendorf |Switzerland

Associated partners
Heraeus Deutschland GmbH & Co. KG, Hanau | Germany
Bühler AG, Uzwil | Switzerland
Applied Materials WEB Coating GmbH, Alzenau | Germany
Varta Microbattery GmbH, Ellwangen | Germany
ABB Ltd, Zürich | Switzerland

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Batterie2030+ – new european research initiative accelerating Europe's battery revolution

A world which is changing over from fossil fuels to renewable energy carriers for its energy requirements is going to be increasingly dependent on innovative concepts for energy storage and especially on batteries. Better batteries are capable of not only reducing the CO_2 footprint of the traffic sector, but also stabilizing the power grid. "Battery 2030+", the large-scale European research initiative, brings together leading scientists and companies from all over Europe to achieve significant progress in battery science and technology.

The first subproject of "Battery 2030+" started in March 2019 and lays the basis for the ten-year, large-scale and long-term European research initiative with 17 partners in nine European countries to create the battery technology of the future.

The objective of "Battery 2030+" is the development of sustainable high-performance batteries which shall be made available as leading-edge technology to European industry. Batteries are among the key technologies to enable deep decarbonization in the European energy system, especially in the traffic sector (with electromobility) and in the electricity sector (with the storage of intermittent renewable energy sources). New generations of extremely high-performance, reliable, safe, sustainable and affordable batteries will be required in the near future. Many different concepts are being developed and discussed with this in mind.

The focus of this research initiative is on the challenges which confront the project partners in the production of high-performance batteries. The aim is to establish a platform for this which also uses machine learning and artificial intelligence to efficiently identify new battery materials.

Special attention is given to the interfaces in batteries where reactions take place which can impair the battery service life. In addition, smart functionalities are developed which are intended to be integrated on both system and cell level, with the purpose of improved sustainability also.

With its more than 25 years of experience in development and analysis, the Fraunhofer R&D Center Electromobility FZEB at the Fraunhofer ISC is part of the project consortium and is coordinating the Fraunhofer participation in this EU-wide project.

CELL MANUFACTURING LAB FZEB IN WÜRZBURG
The process chain for the production of battery cells is passed through in this laboratory.

The "Battery 2030+" project receives support as part of the European Horizon 2020 program.

Partners
Uppsala Universitet | Sweden
Politechnico Turino | Italy
Tekniske Universitet | Denmark
Vrije Universiteit Amsterdam | Netherlands
Universität von Münster | Germany
Commissariat à l'énergie atomique et aux énergies alternatives CEA | France
Karlsruher Institut für Technologie KIT | Germany
Centre national de la recherche scientifique CNRS | France
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Fundacion Cidetec, San Sebastian | Spain
Kemijski Institut (NIC) | Slovenia
Sintef | Norway
EMIRI, Brussels | Belgium
EASE, Brussels | Belgium
RECHARGE, Brussels | Belgium
Absiskey, Grenoble, France

Associated partners
The consortium receives support from official European and national bodies, among which are ALISTORE ERI, EERA, EIT InnoEnergy, EIT RawMaterials, EARPA, EUROBAT, EGVI, CLEPA, EUCAR, KLIB, RS2E, Swedish Electromobility Center, PolStorEn, ENEA, CIC energigune, IMEC and the Tyndall National Institute.

For more information
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Europäische Kommission

» Materials meet ... » ENERGY

ThermElast – textile-integrated sensors and actuators

Adding sensors to flexible materials such as textiles is not so easy as with machines, since they involve moveable or extendible materials. In the current project, ThermElast, the Fraunhofer ISC's Center Smart Material has therefore further developed its elastomer sensors for integration into textiles. Expandable sensors and actuators now can be attached to textiles using both the textile printing process and by simply ironing onto the textiles. This allows for smart, electronically controllable textiles (e-textiles) equipped with diverse sensor and actuator functionalities for a wide range of potential applications in medical technology, sport, furniture, vehicles or transport safety.

By mixing in electrically conductive components, conductive films can be produced from silica which can be employed in this form, for example as extendible heating elements. If alternate conductive and insulating silicon layers are laminated on top of each other, stretchable capacitors are created whose capacity changes when deformed and can be used for measuring extension and pressure. The design and softness of the sensors can be customized to the application. This enables the sensors to have made-to-measure sensitivity and characteristic curves according to the customer requirement for the specific application area. The silicon used is skin-friendly, washable, robust and very elastic. The sensors made from it can withstand even extreme extension without loss of properties over many million load cycles. The sensors convert mechanical extension into an electrical signal and are thus also suitable for measuring signals from the human body, e.g. breathing, movement or muscle contraction.

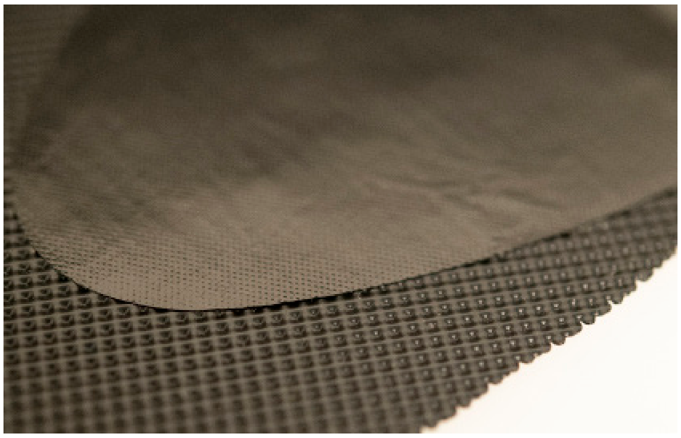
For polyester and cotton – which are the most commonly used synthetic and natural fibers in the textile sector – the sensors can be permanently bound to the fabric using a standard iron in a short period (approx 1 min) even at low temperatures of 80 °C. Since the procedure allows for individual placing of the sensor structures, it is especially suitable for smaller numbers of units. The desired structures can be separately produced as iron-on films so that theoretically any desired number of sensor patterns and different functions can be combined together. In addition, various surface structures can be generated which range from "super-smooth" to "very structured". The sensors can be ironed onto very different textiles and can thus be used not only for initially equipping but also for retrofitting textiles – even in private households.

Using the direct textile printing process, sensor structures can be printed onto the desired material in a very short time. The process can be easily integrated into the further processing of textiles, even for large unit numbers all the way to mass production. Although, in comparison to ironing-on, the printing process is more technically complicated, it is nonetheless more cost-effective due to the high unit numbers and hence especially interesting for larger manufacturers of textile goods.

Sensors for heating surfaces and pressure or extension can thus be ironed on depending on requirement and application. They can be connected to commercially available cables or even with printed elastic conducting-path structures. Sensor and actuator systems integrated into textiles are produced in this way which can be used for the generation and/or monitoring of functions (heat, current pulses, light signals and data processing).

SMART TEXTILES
Sensors can be either printed on or even ironed on.

below:
The surface structured can be varied too:
super-smooth or very structured



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100 percent precision – efficient calibration and marking of laboratory glass

Precise volume-measuring devices made of glass are used in laboratories. They retain their dimensional accuracy permanently, are resistant to many chemicals and easy to clean. High-quality laboratory glass is subject to strict test standards to ensure the measurement accuracy which is required in laboratory use. Hence, every measuring vessel – for example a volumetric flask – is individually calibrated after manufacture in a complicated process so that the marking for the nominal volumes can be affixed accurately.

In order to simplify and accelerate the calibration process, the Center for Device Development CeDeD of the Fraunhofer ISC, in collaboration with laboratory glass manufacturers has developed semi-automatic devices which work reliably, highly precisely, rapidly and without mercury, e.g. AQUAJUST®cam or AUTOJUST®cam. Just as in the manual procedure, the measuring flasks are filled with an exact amount of calibration liquid under exactly defined conditions and the meniscus of the liquid level is marked in the measuring flask. Very high precision is achieved due to the automated meniscus detection and marking attachment since no angular errors arise. The complete process is controlled and carried out semi-automatically by the devices, only the placement of the flasks to be calibrated is still manual – or can also be automated if desired.

However, the individually attached – whether by hand or machine – enamel paint markings have hitherto still needed to be fired onto the laboratory glassware in order to be permanent. In the process, the entire measuring flask is heated to the melting point of the enamel. Not only does the enameling process at the appropriate high temperature take time and energy, it can also lead to a softening of the glass flask and hence to a slight deformation. Volume changes can occur as a result so that the measurement volume calibration previously carried out is no longer exactly correct and the measuring flask needs to be excluded during the subsequent quality check.

To avoid this process-related wastage as well as to save time and energy, a new device, the Marking Firing Device (MFD*), has been developed in the CeDeD. It only heats the volumetric flasks directly at the markings and the enamel melts and is burnt onto the glass surface. A highly-intense heat source, directed precisely onto the ring marking rapidly and energy efficiently carries out the enameling. In the process, the glass flask is only heated in the region around the marking and its stability and dimensional accuracy are therefore not impaired. Thermal stresses can also be largely avoided due to the special process design so that stability and resistance to temperature change are retained as expected in later use, too.

The MFD closes a previously existing gap in the calibration of high-quality laboratory glassware and ensures precise, enduring volume markings without the risk of deformation and its associated volume changes which accompanied the hitherto necessary enameling processes. Aside from increasing process reliability, the efficient local warming saves energy and time and so makes an important contribution to sustainable production in the laboratory glassware industry.

*Marking Firing Device – a development of the Center of Device Development

MARKING FIRING DEVICE
The latest development from the Center of Device Development at the Bronnbach site

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Historical (hollow) glassware put to the test – optimal storage and cleaning

In several subprojects, the International Convention Center for Cultural Heritage Preservation IZKK, investigated valuable historical glass objects from the collection of the Rastatt Favorite Palace of the State Palaces and Gardens of Baden-Württemberg and the Veste Coburg art collection. The focus was on mouth-blown glass which shows different damage profiles, including crizzling, with fine cracks and droplet formation or extensive crystalline deposits. The research work was particularly focused on damages which can be triggered by unfavorable storage such as a damp environment or a polluted atmosphere.

The aim of the IZKK was not only to identify damage profiles and categorize them into damage classes – from "weak expression" to "severe damage" – but also to develop specific recommended actions for optimal storage conditions and cleaning methods.

The scientists made use of light microscopic, spectroscopic and scanning electron microscopic analytical methods for the exact characterization of the damage and to obtain information about the chronological sequence of the damage. To find clues for climatic influence evaluation, original glass samples with typical glass deposits as well as deliberately aged model glasses were examined for possible damage processes with the Klima-TOM (Thermo-optical Measuring Device by Fraunhofer ISC). Using defined model glass matched to the original glass objects enabled comparable and reproducible weathering experiments and even allowed for the use of destructive examination methods.

In addition to determining suitable climatic conditions for storing historical glass, the IZKK researchers also concerned themselves with the question of how cleaning cycles and methods affect both intact and damaged glass. In general, the experiments showed that cleaning had an influence on the appearance of the damage profile. Current test series are focused on restoration practice and include cleaning with distilled water or mixtures with ethanol or tensides, commercial glass cleaners and water which is specifically enriched with ions (sodium and potassium). Following these tests, the aim is to evaluate the effectiveness of the cleaning solutions and to identify potential risks such as the formation of films, accelerated damages or crack formation.

The first results show a positive effect for cleaning glass where crizzling is beginning. Short-term dipping or rinsing of glass ensures the retention of glass transparency to the greatest extent.

The results of climate simulation show that especially high air humidity and drastically fluctuating humid-dry cycles cause damage or accelerate the progression of damage. However, too dry ambient conditions of less than 38 % atmospheric humidity – a storage concept which is widespread in many museums and collections – can lead to further clouding of more severely damaged glass and to the loss of flakes. Thus, practical recommendations for conservation must consider the glass objects with their various glass recipes and pre-existing damage.

A CLOSER LOOK
Glass under the light microscope, here one can clearly see multilayered crack formation.

Financial support from the State Palaces and Gardens of Baden-Württemberg **as well as specialist cooperation with the Veste Coburg art collections**

Project partners
State Palaces and Gardens of Baden-Württemberg
Veste Coburg art collections

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EBiSC2 – cell bank expansion, focus on cost efficiency and user benefit

Since their discovery, so-called induced pluripotent stem cells (iPS) cells) have been demonstrated to have huge potential for the research field of regenerative medicine and the development of disease models. Their ability to develop into almost every cell type of an organism makes iPS cells one of the most promising model systems for answering medical research questions. However, large quantities of these cells and the differentiated cells derived from them, consistently characterized and systematically categorized, are needed for many potential applications in science and industry. In order to meet these requirements, there is a need for, on the one hand, a robust, reliable supply chain and on the other scaling-up of cell-based production processes.

Therefore, the European Bank for induced pluripotent Stem Cells EBiSC started a second project phase. The new EBiSC2 project aims to become a self-sustaining facility for high-quality iPS cells, to expand its existing cell catalog and to offer additional services based on iPS cells. EBiSC2 intends to ensure worldwide, long-term access to well-characterized, quality-controlled iPS cells for academic and commercial research and furthermore to support R&D activities such as disease modelling and drug development. Building on the clinical network established by EBiSC, EBiSC2 will also press ahead with clinical involvement in the collection and appropriate administration of disease-related patient data in order to further promote disease modeling and drug development.

The Fraunhofer IBMT is the coordinator of this IMI*-sponsored project with 16 partners from industry and research. **Fraunhofer Project Center for Stem Cell Process Engineering** (PZ-SPT) which is currently run by both affiliated institutes, Fraunhofer IBMT and ISC in the ISC premises in Würzburg is also involved.

One task being crucial for achieving sustainability within the EBiSC2 will be scaling up, using new automation platforms to provide larger quantities of cell material – both iPS cell lines and the cells derived from them. The PZ-SPT, which has tasked itself with forming a competence center for stem cell process technology using innovative materials, will play an important role here.

Automated upscaling of hiPS cell lines and of differentiated cell models should lower the operating costs considerably. Hence, in developing automated process technology, the Fraunhofer IBMT in the PZ-SPT takes on a key role in the EBiSC2. Another of the working packages for the IBMT in SPT will be "ready-to-use" provision of cell lines.

Thus, the cell lines available in the EBiSC2 bank shall not just be provided in the standard vials, but prepared in the laboratory, ready for further use.

Along with the EBiSC2 partners, SPT is developing the methods and logistic processes required for this, so that the users can later obtain, e.g. ready-to-use well-plates prepared with cell models in the desired development state and can use these immediately in their devices for the desired experiment. For users in the pharmaceutical and medicinal product industries, this would massively improve the usability both of hiPS and the differentiated cell lines and reduce the expense of their use.

*Innovative Medicines Initiative

European Bank for induced pluripotent Stem Cells

The EBiSC2 project is financed by the Joint Undertaking (JU) of the Innovative Medicines Initiative 2 as part of the Grant Agreement No. 821362. The JU is supported by Horizon 2020, the European Union Research and Innovation Program and by EFPIA.

Project partner:
Fraunhofer IBMT, Saarbrücken | Projektzentrum Stammzellprozesstechnik (Coordination) | Germany
Fraunhofer UK Research Ltd. | Great Britain
Charité Universitätsmedizin Berlin | Germany
Department of Health and Social Care, European Collection of Authenticated Cell Cultures, Great Britain
Bioneer A/S | Denmark
Katholieke Universiteit Leuven, Stemcelinstituut Leuven | Belgium
ARTTIC SAS | France
Janssen Pharmaceutica NV, Belgium
Bayer AG Leverkusen | Germany
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UCB Biopharma SPRL | Belgium
Pfizer Ltd. | Great Britain
Takeda Development Centre Europe Ltd. | Great Britain
FUJIFILM Cellular Dynamics, Inc. | USA
Institut de Recherche Servier | France

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» Materials meet ...
» BIOMEDICINE

innovative medicines initiative

European Federation of Pharmaceutical Industries and Associations

Successfully audited – the Fraunhofer Translational Center for Regenerative Therapies

The Fraunhofer Center for Regenerative Therapies TLC-RT was joined with the Fraunhofer ISC in August 2017, and has shown exceptional development since then in its fields of activity, "biomaterials", "in-vitro test systems", "clinical development", "laboratory automation" and "bioreactor technology". The development and expansion work to date at the TLC-RT was evaluated by an external review panel in January 2019. In addition to their scientific excellence, they scrutinized the organizational and commercial structure as well as the content orientation and thematic focus. Overall, in the evaluation, the TLC-RT was found to be very impressive in all areas with very good results.

The review panel attested to the very good work of the interdisciplinary team and excellent performance in scientific terms. They were particularly impressed by the good development in commercial revenues, exceptional competence and visibility as well as the great dedication to education shown by the TLC-RT employees which is reflected in their numerous teaching responsibilities and dissertations.

Despite the disruption caused by a change of management and the associated organizational adjustments in Fall 2018 – Prof. Dr. Heike Walles, the previous Director, changed over to the Universität Magdeburg and management of the institute was transferred to Dr. Marco Metzger and Dr. Oliver Pullig as his Deputy – the team was able to completely achieve the targets set in the 2017 interim evaluation. Noteworthy unique selling points had been established in previous years and in the process, an array of long-existing challenges in the area of regenerative medicine had been mastered.

The TLC-RT's exceptionally wide portfolio of human tissue models is based on various cell lines such as primary cells, adult stem cells and induced pluripotent stem cells (iPS cells). Thus, for example, they have managed to develop a cell-based skin model which is vastly superior in regard to duration of application to all full thickness skin models which are available around the world because it was possible to greatly slow down the shrinkage and change processes in the biomatrix.

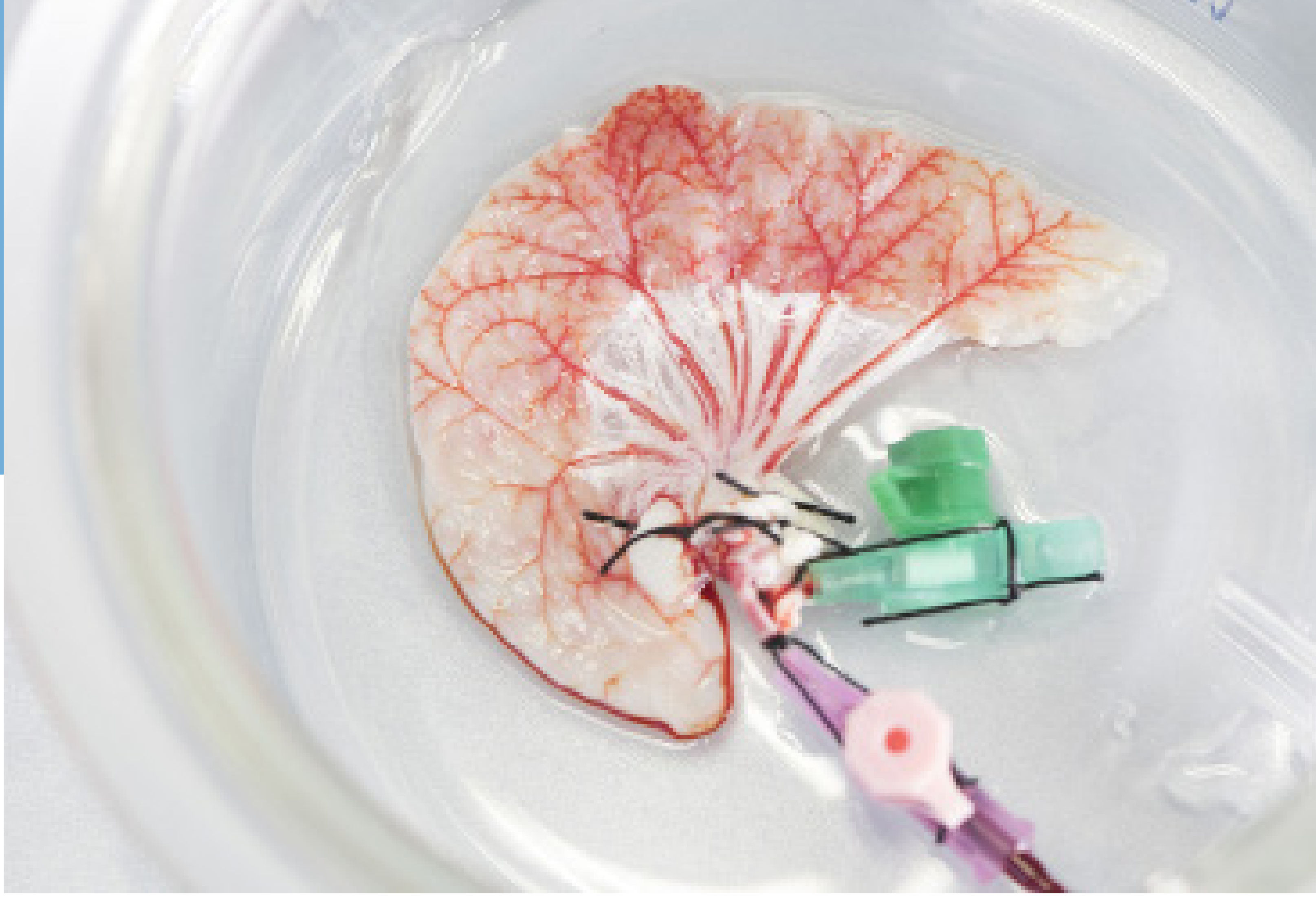
The primary-cell based intestinal model and iPS-derived blood-brain-barrier model are other highly relevant model systems with which the TLZ was able to achieve outstanding features. These tissue models are already being used for a wide range of biomedical research questions or in risk evaluation of chemicals and drugs.

In addition to sound 3D tissue models, models which imitate a pathophysiological situation are also important for the development of new active substances. In the TLC-RT, it was possible to develop complex human tumor models which demonstrably possess a basal membrane - an important factor in physiological cell anchoring. It is of great clinical importance in assessing tumor aggressiveness and invasiveness. There is no comparable tumor model with integrated basal cell membrane in the world.

New indication fields for 3D tissue modelling were also addressed in Würzburg, including the use of models for infection studies with obligate human pathogens or in-vitro risk assessment and validation of medical products such as iron oxide nanoparticles for biocompatible marking of mesenchymal stem cells to enable imaging tracking of these cells after transplantation. Production of nanoparticles which are customized to customer-specific requirement profiles is also possible.

Clinical tests are already ongoing on cartilage implants which were cultured in vitro from cartilage tissue. In the area of regenerative medicine, unique competences and technologies are available for the production, testing and qualification of the so-called ATMPs (Advanced Therapy Medicinal Products) under GMP (Good Manufacturing Practice) conditions which have been developed in the TLC-RT over the years.

Automated incubator technology, optimized for tissue production is another core competence of the Translational Center. This technology has been CE certified and outlicensed for distribution to IncuReTERM, the spinoff company in Würzburg. Non-destructive measurement methods and automation strategies were furthermore developed to enable optimal monitoring and standardizing of the cell culture process and 3D tissue formation.



BIOVASC®
Biological vascularized scaffold for colonization with living cells (red: nutrient medium) – a TLC-RT development

Fraunhofer Center for Regenerative Therapies TLC-RT
Start-up funding from 07/2014 to 06/2019.

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TheraVision – innovative viral immunotherapy increases chance of healing in cancer treatment

Alternative cancer treatment methods have become increasingly important in the last decade. With their individualized treatment methods and innovative medicinal products, they can greatly improve chances of heating. In the "TheraVision" project, five Fraunhofer-Institutes made it their aim to establish a platform technology which could be widely deployed for innovative, sustainable cancer therapy combining oncolytic viruses and immunotherapy. They work together to accomplish this in an interdisciplinary team which combines competences in molecular-biological and virological work, in the development and optimization of pharmaceutical processes for transfer to pilot scale as well as in establishing in vitro and in vivo test methods.

Viruses are able to penetrate cells, to produce both foreign and viral proteins within the cells, to multiply, and ultimately to kill the infected cells. Because of these properties, virus have great potential in cancer therapy. But there is a great considerable need for optimization in regard to their specificity and effectiveness.

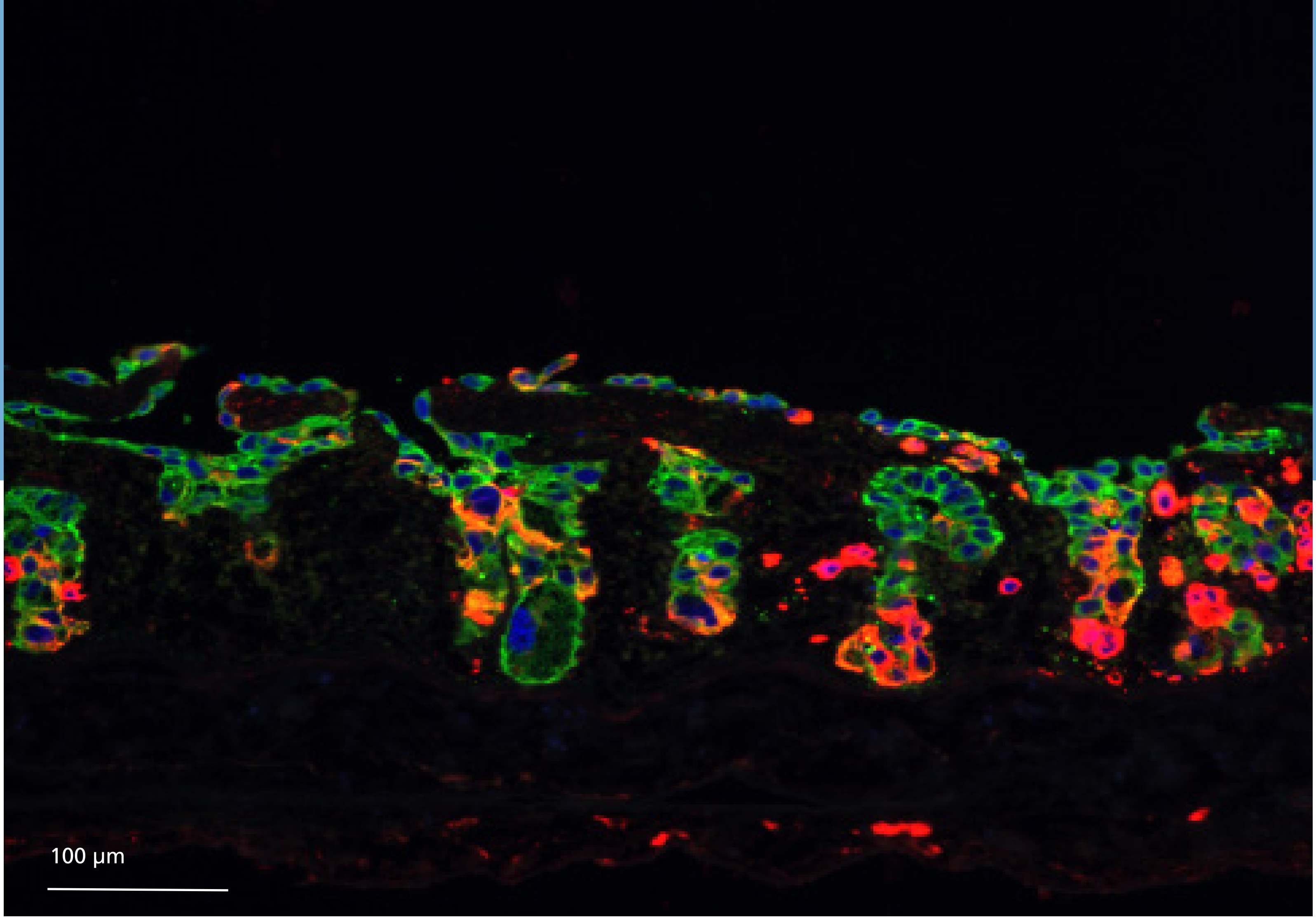
Many tumors are especially difficult to treat because they make use of the so-called immune checkpoints which protect them from being killed by the body's own immune system. Blocking these checkpoints and hence activating the immune system against the abnormal cells is a promising, innovative therapeutic approach. Transgenes are integrated in order to functionalize the therapeutic viruses. One of the transgenes should be specifically coded to recognize the cancer cells. A second transgene codes for another antibody which interacts with the immune system checkpoint and can thereby cancel the tumor-related blockage of the body's own immune cells. Activated in this way, the immune system should be able to fight against not just the primary tumor mass but also distant metastases.

In order to be able to test the success of the combined viral and immune therapy, the partners must establish new practical models which contain not only tumor cells but also functional human immune cells. Tissue Engineering offers a good basis for enabling efficient preliminary testing of this form of therapy in the laboratory before testing is carried out in the more complex humanized mouse models which are also assembled with patient material in the last step.

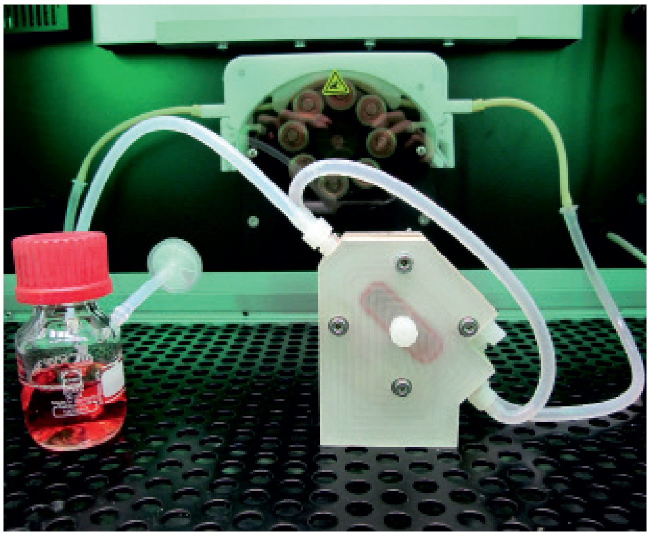
Utilizing its longstanding expertise in Tissue Engineering, the Fraunhofer Center Regenerative Therapies TLC-RT – part of the Fraunhofer ISC – analyzes the effect on the primary tumor and scattered tumor cells. The Translational Center uses 3D models for this which recreate human tissue formation. In these tissue models, the tumor environment can be replicated including other cell types (for example, immune cells) on the basis of a decellularized porcine intestinal matrix.

In comparison to the greatly simplified systems with 2D culture, results which have been gained using these 3D tumor test systems can provide more exact predictions of the actual success of a medicinal product. The novel aspect of this approach is that the effect of viral therapy on tumor cells migrating into tissue can be tested in bioreactors and over a longer period of up to three weeks. Up to this point, tests have shown that the virus successfully kills tumor cells in the 3D model.

The therapeutic effect of the newly developed virus system will first be tested on lung cancer, which has an especially high mortality rate, but is intended to be used with other tumor types also later.



3D TUMOR MODEL
Pan-cytokeratin (green), vimentin (red)- immunofluorescence staining. Tumor cells form a tumor tissue on a decellularized intestinal matrix after about 10 days. They grow on the surface and in the former crypt structure of the intestine (green cells). Due to growth factors, they change their characteristics and even migrate actively into the matrix (red cells).



The "TheraVision – platform technology for the development, production and testing of oncolytic viruses for tumor therapy" project is supported as part of the Fraunhofer "MAVO - market-initial initial research" program.

Project partners
Fraunhofer IGB, Stuttgart | Germany
Fraunhofer ITEM, Hannover | Germany
Fraunhofer IZI, Leipzig | Germany
Fraunhofer ITWM, Kaiserslautern | Germany

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DISCOVER UltraCare – release of active ingredients from biodegradable fibers

To be able to fight disease sources locally in the body and thus to support heaaling in a more targeted, dosed and hence more effective manner, that's what one wants to achieve with drug carriers. They work exactly where they are needed and release their active ingredient there. Most of the drug carriers which are already established today deliver therapeutic substances more or less continually, in any case uncontrollably, over a certain period of time. In contrast, for optimal therapeutic success, many therapies require finely regulated release of the active substance at points of time and for time periods which are different for each patient. Thus, for example, tumors or bacterial contamination on the surface of implants react especially well (or badly) to the active agent used against them at particular development stages. To enable such individualized therapies, an ideal drug carrier must release active substance in a triggerable manner and in a specific concentration (effective threshold).

As part of the Discover funding program of the Fraunhofer-Gesellschaft, the materials technology-related prospect of an inexpensive, highly-effective and widely deployable carrier system was developed which allows for controlled active substance release caused by an external stimulus. An essential additional requirement for this development was the innovation's compatibility with standard available imaging methods, allowing for subsequent monitoring such as magnetic resonance tomography (MRT).

Ultrasound-based methods are established in medical imaging and are hence widely available. In addition, ultrasound offers the great advantage that even deeper tissue levels in the human body can be reached non-invasively. Consequently, the focus of the Discover project was on ultrasound as an external stimulus for controlled active substance release. Accordingly, carrier systems needed to be found which could be influenced by ultrasound in the desired manner.

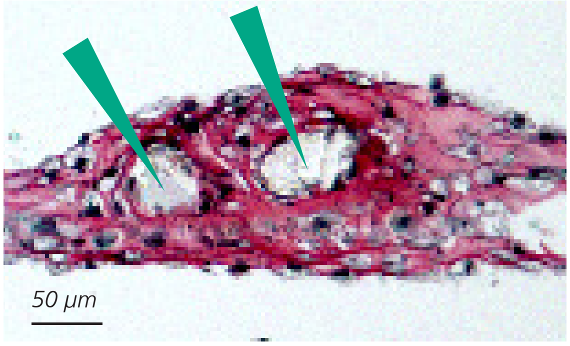
The basis for the development of the new drug carrier systems was the expertise in bioresorbable fiber materials which was available at the Fraunhofer ISC. Thus, for example, silica gel fiber fleeces for wound care were developed in the past for an industry partner. These are now CE certified. The open-mesh nature of these fibrous cell-carrier structures is in that way optimized that healthy cells from the edge of the wounds grow onto the fiber mesh. Simultaneously, the cell-carrier structure begins to degrade under physiological conditions so that, in the end, the wound is regenerated with healthy human tissue and the carrier structure has been broken down.

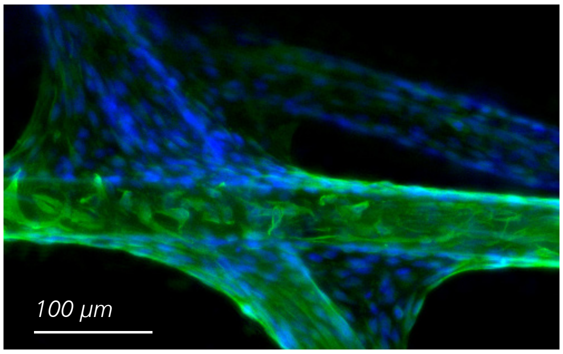
For the Discover project, drugs were integrated into these fibrous cell-carrier structure and modified in such a way as to enable release triggered by ultrasound. The spinning process was also specifically further developed for the integration of both hydrophilic and hydrophobic drugs and the practical feasibility was tested with model drugs. Loaded in this way, the carrier system was analyzed in vitro for its degradation behavior and drug release and demonstrated the desired increased release after ultrasound treatment. The biodegradable carrier system was in addition tested according to DIN ISO 10993-5 with regard to cell compatibility and was proven to be non-toxic.

In summary, in the course of the Discover project, a promising, biodegradable and biocompatible carrier system for controlled drug release was developed and evidence was provided for the release principle and its function. Fiber fleece production can be upscaled to a technical scale so that cost-effective production is also possible later. The next development steps concern transfer from model drugs to real drugs as well as testing on in-vitro disease models, among others.

FIBER FLEECE
Controlled release of drugs – even finely regulated and adjustable individually for every patient – is possible using this fleece, for example in tumors or for bacterial contamination on implants.

Center: Cartilage tissue on silica gel fiber (arrow = fiber cross section)
Below: Human dermal fibroblasts on hybrid microfibers





The “UltraCare – ultrasound-triggered release of active ingredients from biodegradable fibers” project was supported for one year as part of the internal Fraunhofer Discover Program. Unconventional, original ideas are encouraged in the Discover Program. Within this program funding, the aim is to initially examine the fundamental feasibility of unconventional ideas.

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ICCE – Integrated Computational Ceramics Engineering

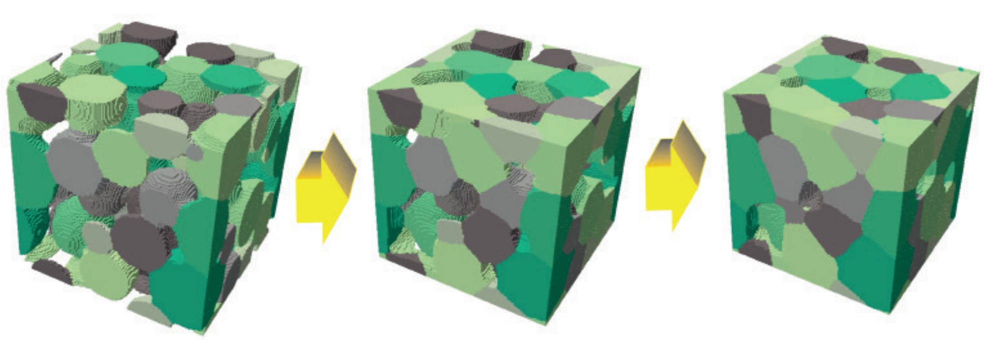
The networked use of coordinated simulation processes and experimental methods for faster, more targeted material development has become more important world-wide in recent years. This so-called Integrated Computational Materials Engineering, abbreviated to ICME is already used in various ways in the development of new mechanical materials however, in contrast, it is hardly used in the area of ceramic materials. And yet, the core points of the concept can be transferred without restriction to ceramics. The point is to use computer simulations to clarify the relationships between (1) production and structure, structure and properties and (2) properties and performance properties of the material and to use them for targeted material development.

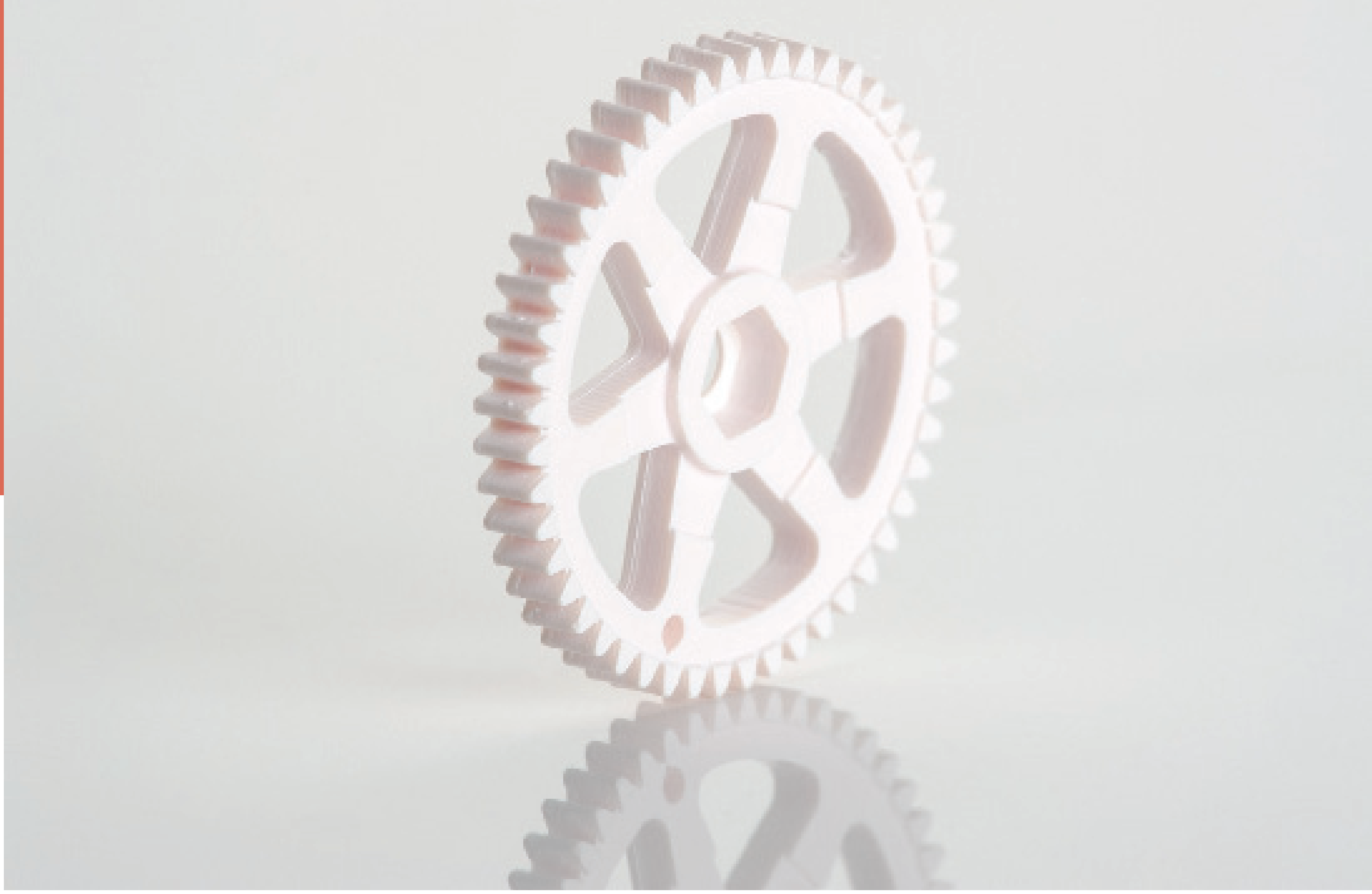
In the past years, at the Center for High Temperature Materials and Design HTL, a range of building blocks for Integrated Computational Ceramics Engineering, abbreviated to ICCE, have been created or further developed. To address the problem of how the production process influences the structure (relationship (1)), models on two different scales were developed and used successfully in projects. Now, on a micro scale, microstructure development during sintering has been simulated as a function of, for example the temperature curve and deductions made about the conditions for the greatest possible homogeneity of densely sintered ceramics. On the macro scale, there are FE models available for debinding and sintering which are strictly based on precise in-situ measurement data.

Using these models, the relevant thermal processes can be optimized on the computer so that components achieve the desired final form and density, reliably and crack-free, with minimal consumption of energy and time. The long-established microstructure property simulation is available for relationship (2). It has, in the meantime, been expanded to the prediction of the material properties of ceramic matrix composites (CMC). Regarding point (3), computer-aided evaluation of application properties are being evaluated for their effects on probability of breakage, at the HTL, for example, computer tomography measured structures of surface or volume defects with the aid of FE analysis.

In recent years, the model for relationship has primarily been advanced within the context of publicly sponsored projects such as EnerTHERM and Isi2Ker. Conversely, simulation-based thermal process optimization in particular has already been very successfully applied in various bilateral projects with industrial partners. In future projects, it is intended that there will increased use of all the ICCE methods mentioned together to actively promote digitization in ceramics development, too.

SINTER SIMULATION
Representation of three intermediate states in modeling a sintering process





3D PRINTING
Among the methods available for ceramic molding, is additive molding with 3D printing.

The" EnerTHERM - Sustainable Thermal Processes" project was supported by the Bavarian State Ministry for Economic Affairs, Regional Development and Energy from 2013-2018.

The "Isi2Ker - Inherently Safe Sintering of Ceramics" was supported by the Bavarian Research Foundation from 2016 - 2018.

Project partner:
CeramTec AG, Marktredwitz | Germany
Sembach GmbH & Co. KG, Lauf | Germany
Döbrich & Heckel Steatitwerke GmbH & Co. KG, Altdorf | Germany

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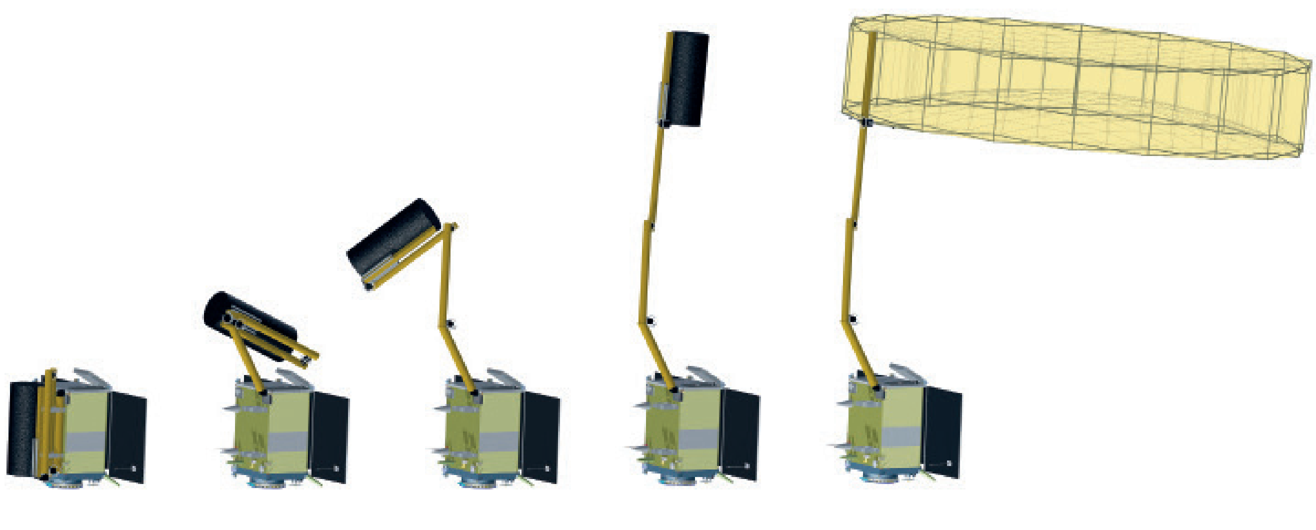
Development of a metallic mesh for use in foldable space reflectors

Earth observation and telecommunication missions need increasingly large space reflectors to transmit the required signal bandwidth. Reflector sizes of up to several meters are needed because of these requirements. However the size of such systems is limited by the available transport rockets.

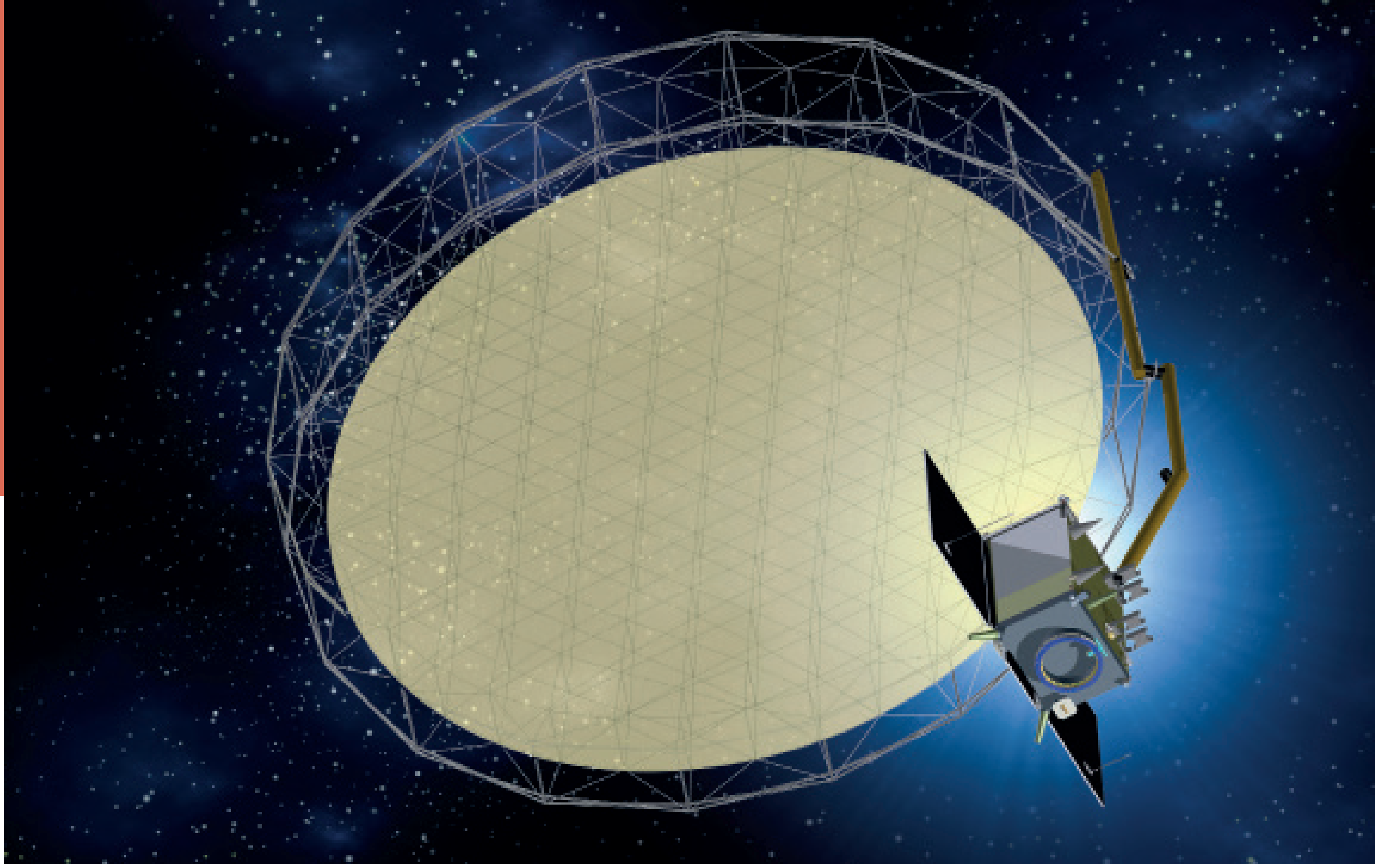
Many different, in part highly complex, ideas have been developed to enable such reflectors to be realized, but most of these could not be put into practice. The USA has been the market leader in manufacturing foldable solutions until now. Japan also has succeeded in making a marketable, foldable lightweight construction system. Two technology studies from the European Space Agency (ESA) and a Horizon 2020 activity of the European Commission (EC), have paved the way for this key technology to be realized in Europe, too.

Low reflector material weight is particularly important for fuel economy when the carrier rocket starts off. The entire construction must be stowable in the smallest space possible and hence it must be possible to fold it without damaging. After unfolding of the shield, both the durability of the textile surface in its stretched state and interference-free transmission in space must be ensured.

This requires research work in regard to suitable types of bonding and joining technology for the production of a textile surface. In order to keep the weight of the large structures small and their elasticity great, the reflector surface is made of a very fine technical knitted fabric of gilt metal wires. A prototype with a diameter of five meters was fabricated, assembled and tested as part of the ESA activities, SCALABLE and MESNET. In the follow-up project "Large European Antenna« (LEA)", supported by the European Union, a flight-ready reflector has now been developed and tested, the material of which is being tested for suitability for use in space.



SKETCH
of the unfolding process of a reflector (picture: HPS GmbH)



LARGE - LARGER - SPACE
SMERALDA satellites with large fold-out reflector (picture:HPS GmbH)

The "LEA – Large European Antenna" project is supported as part of the European Horizon 2020 program.

Project partners
High Performance Space Structure Systems GmbH, Munich | Germany
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Development and coating of ceramic reinforcement fibers

Fossil fuels are most commonly deployed in energy generation using gas turbines, irrespective of whether these are used for electricity generation or locomotion. It is essential that these processes are made more energy efficient if the energy targets of the Paris Agreement for Climate Protection are to be reached. If ceramic materials, known as Ceramic Matrix Composites (CMC), are used in the hot gas area of a gas turbine, both the weight of the machine and the required amount of cooling air can be reduced and their effectiveness can be greatly increased.

FIBER DEVELOPMENT

The HTL is active working on developing and establishing such CMC materials, in the area of ceramic reinforcement fiber development, among others. Since the '90s, the Ceramic Fiber workgroup has been working on developing ceramic reinforcement fibers in the Al-Si-O and Si-C-N-B material systems and on their production from laboratory scale all the way to extended technical scale. This covers the complete process chain from synthesis of the spinnable raw material to the completely processed continuous filament, wound onto a spool.

Based on a dry-spin process under inert gas conditions, SiC(N) fibers have been developed with a tensile strength of 2500 MPa and an Young´s Modulus of 150 GPa as part of the "New Materials in Bavaria" program of the Bavarian Ministry of Economic Affairs and the "SiC-Tec" project series, together with the SGL Carbon and subsequently with BJS Ceramics GmbH. These can be produced at the expanded technical plant at the Würzburg site with a capacity of approx. 1 kg per month.

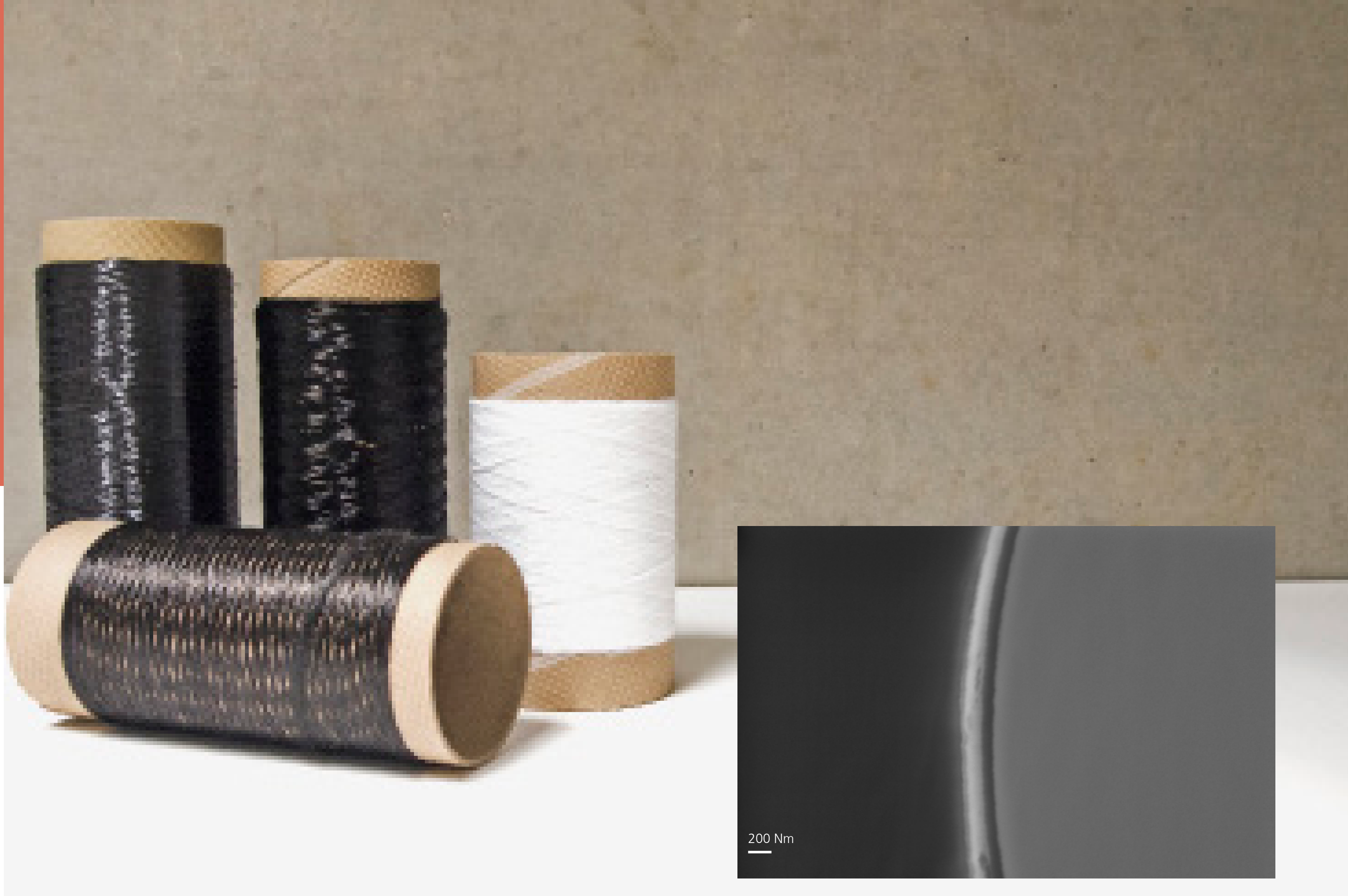
Dry spin processes for long fibers in the Al-Si-O material system are being developed in parallel with various partners. The aim is to achieve mechanical properties which are comparable with the Nextel™ 440 or NITIVY ALF™ 72/28 type ceramic continuous fibers made by 3M™.

The time-consuming thermal processes for precursor-fiber ceramization are particularly limiting for the output of both processes. A fiber pilot plant based on both development routes has been built at the Bayreuth site which, in 24-hour operation, will make possible an annual capacity of 3 tons for oxide fibers and a capacity of > 5 tons for the non-oxide reinforcement fibers in the Si-B-N-C material system. The building with its complete technical infrastructure was opened in April 2019. The first plant aggregates have already been delivered and assembled so that it will be possible for both R&D lines to go into operation in the 1st quarter of 2020. Besides the actual fiber production, there are plant sections for ceramic coating of the continuous fibers integrated into both lines.

FIBER COATING

Fiber coatings are being developed at the HTL alongside the ceramic fibers. The role of the coating is to place a fiber-matrix-interface which allows for damage-tolerant fracture behavior in ceramic composite materials. Another role is to protect the ceramic fibers from corrosive attack. A comparatively cost-effective wet chemical route is predominantly pursued when applying the fiber coating. Process speeds of up to 1000 m/h are reached using this at present. There is experience in applying coatings for non-oxide and oxide material systems as well as non-oxide - oxide hybrid systems.

Air-stable and more inexpensive coating precursors have been developed for these existing layer systems. Moreover, the processing of the existing systems has been optimized. Process parameters have been identified in coating application which enable improvement in coating quality with simultaneous increase in coating thickness. Among other developments are multi-layer coating systems. These consist of alternating boron nitride and silicon carbide layers or boron nitride and silicon nitride layers.



FIBER SPOOLS
An annual capacity of > 5 T for non-oxide reinforcement fibers is planned at the new fiber pilot plant working in 24-hour operation.

Right:
REM image of a wet-chemical double coating on an SiC fiber.

SiC FIBER DEVELOPMENT
The “SiC-Tec3” was supported over three years with a project of the Bavarian State Government in the “New materials in Bavaria” program of the PTJ.

Project partners
BJS Ceramics GmbH (Coordinator) Gersthofen | Germany

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FIBER COATING
The “WIMI CMC-SiC” project is being supported for a period of three years with a project funding of the Bavarian State Government.

The “MAVO CMC-Engine” project was supported over a period of three years by an internal Fraunhofer program for market-oriented preparatory research (MAVO).

Project partners
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Embraced – from baby diaper to raw material

Around one tonne of garbage is generated from disposable diapers during a baby's diaper phase. In fact approx. 8.5 million tons of such hygiene waste is generated every year in Europe. They contain both organic and inorganic waste material, including particularly plastics and up to now they have been difficult or impossible to recycle. The EU-sponsored "Embraced" project consists of a consortium of 13 project partners who have made baby diaper recycling their objective. As part of the program, it is intended that a complete recovered materials cycle should be drawn up and its establishment prepared for.

Up to 4 % of Europe's household waste consists of absorbent hygiene products (also known as AHP-waste). Until now, recycling has been too complex and costly for commercial implementation on an industrial scale. In the "Embraced" project, this waste flow has been carried over into a cycle with efficient recycling on a pilot scale – in the process, up to 10,000 tons of AHP waste was converted to reusable materials.

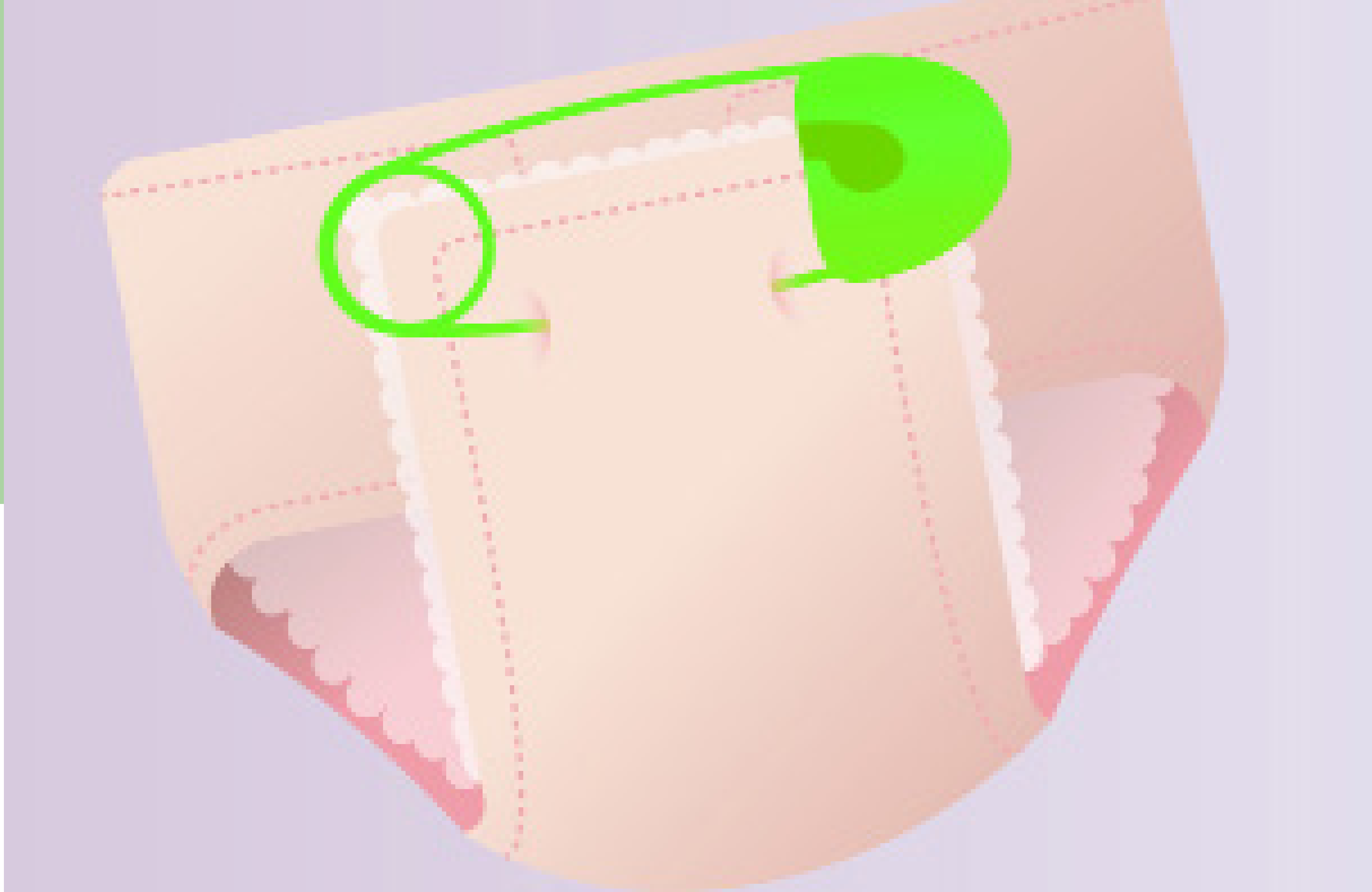
All waste fractions are considered in the project. For this purpose, materials cycles were developed for all the materials. These can be essentially divided into four fractions:

- Cellulose
- Plastic
- Highly-absorbent polymers
- Substances of biological origin / nutrients

The wastewater flows which accrue during the recycling process are also considered in the process – this is one of the project's work packages which is dealt with by the Fraunhofer Project Group for Materials Recycling and Resource Strategies IWKS. It includes the recovery of reusable materials and nutrients such as phosphate or ammonia from the process wastewater which occurs when diaper waste is processed. For example, at up to 10 gram per liter, ammonia – a sought-after raw material in the chemical industry – is present in sufficient quantities to justify commercial recovery.

The Fraunhofer Project Group IWKS examined different technologies for process water treatment and identified flat-membrane filtration using the cross-flow principle as the most efficient.

The advantage of the process in comparison to other methods is primarily the selective separation of ammonia without the use of chemicals. Furthermore, fewer intermediate and preparatory steps are required. Membrane filtration also shows advantages from an energy-related point of view when compared to standard procedures such as thermal recovery. This means that a sustainable process with greater cost-efficiency has been developed. The objective is to upscale the process to an industrial scale in a pilot plant. Aside form this project, the Project Group IWKS also applies their expertise in the area of nutrient recycling to other process waters or the production of fertilizer from sustainable raw materials.



BABY DIAPERS
During a baby's diaper phase around one ton of garbage is generated
© pixabay.de

The "Embraced" project is supported by the European Union.

Project partners
AEB Amsterdam | Netherlands
Circe Zaragoza | Spain
Contarina SPA Lovadine di Spresionao | Italy
Edizioni Ambiente Mailand | Italy
Fater Pescara | Italy
Fertinagro Ternel | Spain
Legambiente Rom | Italy
Novamont Novaras | Italy
Procter & Gamble Rom | Italy
Osijek | Croatia
TerraCycle | UK
Wittenburg Zeewolde | Netherlands

For more information
www.embraced.eu

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NeW-Bat – battery recycling reconceived

Stationary energy storage and mobile high-performance batteries have a key role to play in the course of the current revolution in energy and mobility. Consequently, the number of energy storage devices and high-performance traction batteries will continue to increase. There is already a great demand for the raw materials required for batteries such as lithium, cobalt and graphite. Not only does that push up the market prices, it also aggravates the import dependency of European industry. Efficient recycling, especially for old lithium-based batteries, would therefore make a significant contribution to securing a supply of the urgently required raw material for local industry and, then again would also conserve resources and thus protect the environment.

The existing processes for recycling traction batteries are however very energy-intensive and only permit partial recovery of the materials. As part of the"NeW-Bat" research project sponsored by the BMBF r^4 research initiative, the Fraunhofer Project Group IWKS is working together with their project partners on new methods for the efficient recovery of especially critical raw materials like cobalt, both from used batteries and from production waste. This will make old battery recycling not only more economical but also more environmentally friendly.

The scientists are adopting innovative approaches in the pilot plants of the Fraunhofer Project Group IWKS at the site in Alzenau and Hanau, by disassembling the batteries rather than melting them as a whole. The process known as electrohydraulic fragmentation (EHF) is employed for this, where a shock wave generated by an electrical discharge is directed through a medium – usually water – and the battery is processed by it. The result: the material boundaries are in such a way strained that the individual components can be easily separated from each other. When separated in this way, the purity of the recyclable substances is already very high in the active material (anode and cathode material, in most batteries consisting predominantly of graphite or nickel-manganese-cobalt compounds). It can be further processed into new battery cells immediately. This efficient separation also makes the plastics and metals such as copper and aluminum contained in the batteries available for secondary use.

Since it is the active electrode materials in the battery which age most during use, the materials recovered after separation must be carefully tested and appropriately treated to restore their original quality. Undesirable degradation products and material impurities are removed from the active materials of lithium-ion batteries using special post-treatment processes. This treatment is combined with a refinement stage where a core-shell coating is applied. This significantly improves the service life and the charge and discharge properties of the recycled materials.

The research consortium is already successfully producing batteries from production waste on a laboratory scale and the charge density and service life of these batteries corresponds to the reference cells – an important milestone on the way to revolutionizing battery technology.

ELECTROHYDRAULIC FRAGMENTATION
A shock wave is directed through a medium – normally water – by means of an electric discharge and the batteries are mechanically processed thereby.

The "NeW-Bat" project is supported by the Federal Ministry of Education and Research (BMBF) as part of the "r4- Research for the supply of raw materials of strategic economic importance" initiative.

Project partners
Lars Walch GmbH & Co. KG, Baudenbach | Germany
GRS Service GmbH, Hamburg | Germany
ImpulsTec GmbH, Radebeul | Germany

For more information
www.r4-innovation.de/de/new-bat.html

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DISPLAY – recovery of valuable materials and raw materials from displays and PCBs

Many electronic devices contain valuable raw materials. Until now, after these products have reached the end of their lifecycle, recovery of these materials has been only partially possible or not in any efficient way. What's more, aside from the lithium ion battery (approx. 25 % of weight), smartphones or tablets often consist of very complex material compounds which contain polymers (approx 30 %), glass (approx. 15 %) and metals, including critical elements like indium, gallium or germanium. These used devices are currently being laboriously manually disassembled for the urgently necessary battery removal. Glued together housing parts and components hamper the disassembly and increase the risk of damaging the battery. At present there is no mechanical or chemical process which can efficiently disassemble such used products. Present day procedures using blast furnaces concentrate on the effective recovery of metals, whereas other valuable substances such as polymers, glass and the low-concentration and hence cost-intensive elements are by and large lost.

In the "DISPLAY" project, the Fraunhofer Project Group IWKS, together with partners from research and industry conducted research into using the existing technology to develop an innovative process chain for upscaling to an industrial scale. For this, lithium ion batteries were removed from small display devices such as smartphones and tablets and also valuable materials and raw materials were recovered from these products and from printed circuit boards (PCBs).

The aim of the project is to deliver a technically and economically convincing solution for material-oriented treatment of display devices and PCBs using the combination of electrohydraulic fragmentation, spectroscopic sorting and the solvent-based CreaSolv® process.

It is intended that the individual processes, which currently have a technology readiness level (TRL) of 5 (technology validation in relevant environment), shall be connected to a process chain and raised to TRL 7 (demonstration in operational environment). In this way, the researchers are recovering high-quality flat glass, engineering plastics such as ABS or PA and metal concentrates which will be fed into downstream hydrometallurgical and pyrometallurgical recovery processes. This approach is revolutionizing material recovery as a whole and the profitability of the recycling process for electronic devices, since a much higher percentage of the raw materials contained are processed into marketable secondary raw materials and time-consuming, expensive manual process steps are no longer necessary.

Results to date show a high degree of fraction purity and practical feasibility. The consortium is currently developing concepts for upscaling the complete process for continual industrial use together with plant engineering. This will not only reduce costs and increase the efficiency of the recycling process but also conserve valuable resources.

ELECTRICAL WASTE
The "Display" project investigated the recovery of valuable materials from electronic devices. © Shutterstock

The "DISPLAY" project has received funding from the European Institute of Innovation and Technology, a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation. The Fraunhofer IWKS is coordinating the project.

Project partners
Fraunhofer IVV, Freising | Germany
SUEZ Groupe | France
CEA (Commissariat à l'énergie atomique et aux énergies alternatives) | France
ENEA (Agenzia Nazionale per le Nuove Tecnologie, l'Energia e lo Sviluppo economico sostenibile) | Italy
Orange S.A. | France

For more information
www.iwks.fraunhofer.de/de/presse-und-medien/pressemitteilungen-2017/EITRawMaterials.html

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FRAUNHOFER-GESELLSCHAFT

The central remit of the Fraunhofer-Gesellschaft is to carry out research with practical relevance. Founded in 1949, the research organization undertakes applied research that drives economic development and serves the wider benefit of society. Its contracting partners and clients come from industry, the service sector and the public sector.

At present, the Fraunhofer-Gesellschaft maintains more than 72 institutes and research facilities in Germany. More than 26,600 staff, predominantly with scientific or engineering qualifications, work with annual research volumes of 2.6 billion euros. Of this sum, more than 2.2 billion euros is generated through contract research. The Fraunhofer-Gesellschaft generates around 70 % of this research revenue through industrial contracts and publicly financed research projects. About 30 % is contributed by the German federal and Länder governments in the form of basic funding, enabling the institutes to work on problem solutions which will only become relevant to industry and society in five or ten years.

International collaborations with excellent research partners and innovative companies all over the world provide direct access to the most important current and future scientific and economic areas.

With its clear orientation to applied research and its focus on key technologies which are relevant for the future, the Fraunhofer-Gesellschaft has a central role to play in the innovation process in Germany and Europe. The impact of applied research extends beyond its direct use to the customer. The research and development work of the Fraunhofer Institutes contributes to the competitive strength of their local region, Germany and Europe. They promote innovation, strengthen technological performance capacity, improve the acceptance of modern technology and provide training and professional development for the urgently needed next generation of scientists and technologists.

The Fraunhofer-Gesellschaft offers their staff members opportunities for professional and personal development for demanding positions in their institutes, at universities, in business and society. Due their practice-oriented training and experience at the Fraunhofer Institutes, outstanding professional entry and development opportunities open up for those studying.

The name of the Fraunhofer Gesellschaft, recognized as a non-profit organization comes from the Munich scholar, Joseph von Fraunhofer (1787–1826). He was equally successful as a researcher, inventor and businessman.

Figures correct as of: January 2019

FRAUNHOFER GROUP MATERIALS

Fraunhofer MATERIALS pools the expertise of 16 material science and engineering institutes of the Fraunhofer-Gesellschaft.

The Group applies its know-how primarily in the following economically significant business areas in order to realize system innovations by means of tailored material and component development:

- Energy and Environment
- Mobility
- Health
- Machinery and Plant engineering
- Construction and Living
- Microsystems technology
- Safety

The core competencies of Fraunhofer material research cover the entire value chain:

- Materials development
- Technology development
- Evaluation of application behavior
- Materials modeling and simulation

The Group covers the entre spectrum of materials from metals, polymers and ceramics to materials made from renewables. The overall budget of Fraunhofer MATERIALS was over 473,5 million euros in 2018. The Group currently has more than 4,600 employees, about 2388 which are all scientists.

Materials research and technology at Fraunhofer encompasses the entire value chain, running the gamut from the development of new and improvement of existing materials, industrial-scale manufacturing technologies, characterization of properties to the evaluation of application characteristics. This applies to components made of these materials and their behavior within the system.

For more information about Fraunhofer Group MATERIALS:

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APPENDIX

As one of the 72 Fraunhofer institutes, the Fraunhofer-Institute for Silicate Research ISC is part of the leading network for applied research in Europe. Aside from its numerous research project, the Fraunhofer ISC meets its research and teaching commitments by means of cooperation in national and international bodies, committees and alliances, by the scientific lectures, publications and teaching activities of the staff, by organizing and participating in events and trade fairs and by mentoring final papers 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 projects in the Fraunhofer ISC which are publicly funded.
https://www.isc.fraunhofer.de/projekte

Patents

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

Scientific lectures

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

Scientific publications

www.isc.fraunhofer.de/publikationen

Conference transcripts

www.isc.fraunhofer.de/tagungsbaende

Teaching activities

www.isc.fraunhofer.de/lehrtätigkeiten

Events, trade fairs and exhibitions

The Fraunhofer ISC was represented at numerous trade fairs and events this year also.

Please find a list here:
www.isc.fraunhofer.de/de/messen-und-termine.html

Committees and bodies

www.isc.fraunhofer.de/mitgliedschaften

Alliances and networks

The 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.
www.isc.fraunhofer.de/allianzen

LEGAL NOTICES

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