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FRAUNHOFER INSTITUTE FOR SILICATE RESEARCH ISC

ANNUAL REPORT
2016|17

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complete with Annex listing publications | teaching activities | patents etc.

For further information on presented projects, please follow the links next to the reports.

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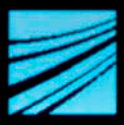
HIGHLIGHTS
2016|17
ANNUAL REPORT



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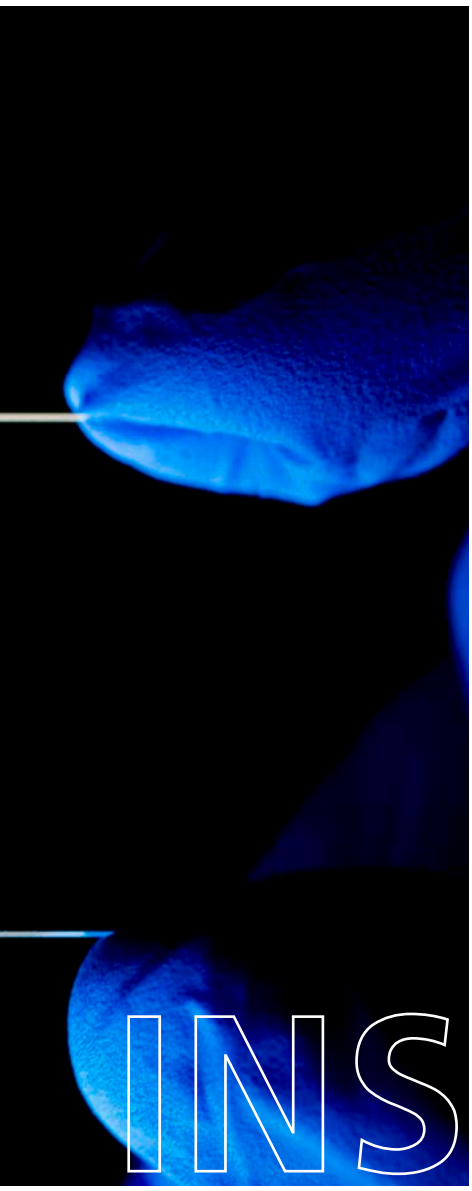

INSIGHTS ...

As a true 3D lithography technology Two-Photon Polymerization (2PP) allows to fabricate arbitrarily shaped microstructures especially suited for innovative optical applications. The picture shows a structure of 10 000 individual microprisms made by 2PP technology. With incident light, the logo of the Fraunhofer ISC will be revealed. The realization of such structures at industrial scale still poses a number of challenges tackled by current research performed by the Fraunhofer ISC. Read more about other intriguing projects presented in this annual report.

PREFACE

Dear Friends and Partners of Fraunhofer ISC,
Dear Ladies and Gentlemen,

In 2016, the Institute for Silicate Research was able to look back on 90 years full of successful research and development. The roots of our Institute today reach down to 1926 and into the Kaiser Wilhelm Gesellschaft. During the 1960s, the Insitute was part of the Max-Planck Gesellschaft before it joined the Fraunhofer Gesellschaft in 1971. Innovative materials and processing solutions have always been the mission of our R&D activities. To make sure that this impetus continues to be as strong and keen as ever, a new strategy process was initiated in 2017.

2016 also saw the Federal Government approval of the draft plannings for the two expansion buildings to accomodate the growing project group IWKS in both Bavaria and Hesssen. Respective implementation planning started out immediately so that construction can begin in 2017. The additional 5000 square meters of laboratory, office and pilot plant space are urgently needed in view of the very pleasing, but demanding growth of the project group IWKS. The solution to rent space is beginnging to be cumbersome vis-à-vis the multitude of new project tasks.

2016 also brought good news for the Fraunhofer Center for High Temperature Materials and Design HTL. A new building will be home to a one-of-a-kind European pilot plant for ceramic fiber production. The Free State of Bavaria granted further funding for the intended upscaling of the spinning process hitherto located at Würzburg from 1 kg to multi-ton scale. The project is also supported by well-known companies such as the BJS Ceramics GmbH Gersthofen, a spin-off of the SGL Carbon SE.

Special thanks are given to the Bavarian State Ministry for Economic Affairs and Media, Energy and Technology and the Hessen State Ministry for Higher Education, Research and the Arts as well as to the Fraunhofer Gesellschaft, the Federal Government and the European Uniton for their generous finanical support which enabled the expansion of the Bayreuth, Alzenau and Hanau sites.

Another highlight towards the end of the year was the winning of the Bavarian Environmental Price which went to the Project Group IWKS for the development and application of an electrohydraulical fragmentaton system to recycle photovoltaic panels in a smart and resource efficient way. Dr. Andreas Bittner, in the position as head of the business unit Energy Materials, received the price on behalf of his team.

I seize this opportunity to express my gratitude to all staff members of the Fraunhofer ISC – at the parent Institute, in the project group IWKS, and in the Center HTL – and to the staff at the Würzburg University Faculty of Chemical Technology of Material Synthesis and all our project partners for their highly committed, creative, and competent work. Last but not least I am happy to accounce that Dr. Friedrich Raether, director of the Center HTL, was appointed deputy director of the Fraunhofer ISC by the executive board of the Fraunhofer Gesellschaft in mid-2016.

The present annual report will introduce you to a number of intriguing R&D projects and I truly hope you will enjoy the reading.

Prof. Dr. Gerhard Sextl

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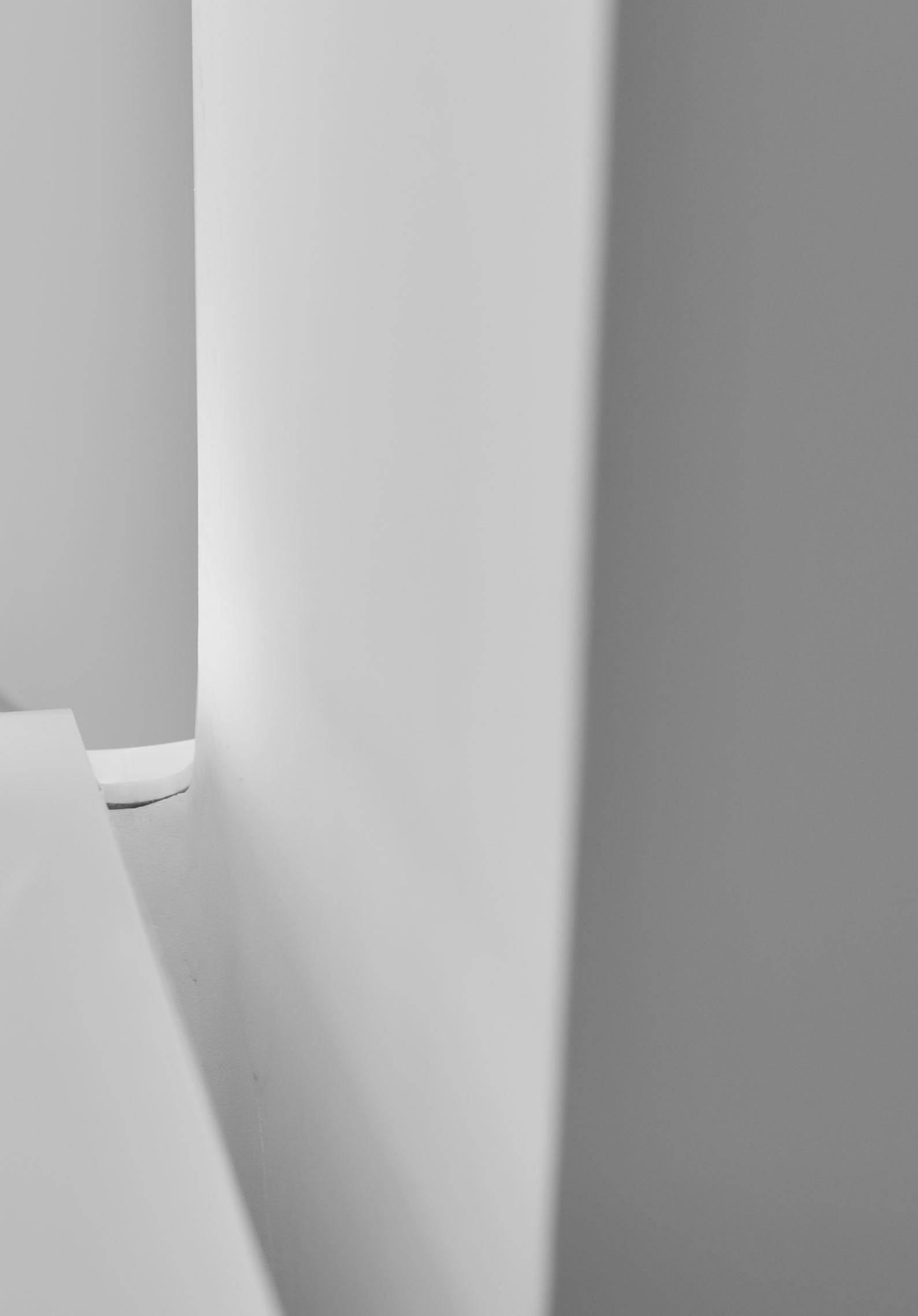
... further information and a comprehensive Annex with project overview, scientific publications and lists of events and more is available at https://www.isc.fraunhofer.de/en/publications/annual-reports.html

Selected Projects

INSTITUTE OVERVIEW



THE FRAUNHOFER ISC

AN OVERVIEW

Fraunhofer Institute for Silicate Research ISC

The Fraunhofer ISC has become one of the leading R&D centers on energy and resource efficiency in Bavaria. With a workforce of about 400 scientists and technicians at all locations combined – the Würzburg parent institute, the Bronnbach branch, the Center HTL in Bayreuth and the Project Group IWKS in Alzenau and Hanau – it works to develop innovative materials for today's and tomorrow's products.

The focus of the Clusters Materials Chemistry and Application Technology is on the optimization of materials and on efficient manufacturing techniques and processes, in line with industry requirements. The range of services offered by the Center for Applied Analytics includes materials analysis, testing, and characterization and is complemented by the Center of Device Development CeDeD with on demand measuring systems and tools. Safe high performance energy storage materials are a key topic for the Fraunhofer R&D Center Electromobility Bavaria, while the Center Smart Materials CeSMa develops electrically or magnetically switchable "smart" materials for applications in automation, mechatronics, and sensor technology. The Fraunhofer ATTRACT Group "3DNano-Cell" researches biotechnology solutions and tissue engineering.

With its particular interest in resource and energy efficiency, the Fraunhofer ISC is putting great emphasis on sustainability in its development work and seeks to use renewable, ecofriendly raw materials and designs suitable for recycling in order to pave the road for closed-loop material flows.

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❸ **Fraunhofer Center for High-Temperature Materials and Design HTL**
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95448 Bayreuth, Germany

❹ **Fraunhofer Project Group Materials Recycling and Resource Strategies IWKS**
Brentanostraße 2a
63755 Alzenau, Germany

❺ **Fraunhofer Project Group Materials Recycling and Resource Strategies IWKS**
Industriepark Hanau-Wolfgang
Rodenbacher Chaussee 4
63457 Hanau, Germany

Fraunhofer Center for High Temperature Materials and Design HTL

Founded in 2012, the Fraunhofer Center HTL now has a permanentstaff of 90. 2600 m² of high-quality laboratory and pilot plant space with state-of-the-art equipment are available for R&D projects and services. In addition, the HTL has an Application Center for Textile Fiber Ceramics in Münchberg that emerged from a cooperation between Fraunhofer and the Hof University of Applied Sciences.

The center HTL is organized in four working groups – Composite Material Technology, Polymer Ceramics, High Temperature Design and Metal Ceramic Composites – which team up to develop materials and components or to devise measuring and simulation systems for high-temperature applications. The working groups are complemented by the Simulation and Materials Testing teams. Major R&D topics concern energy, drive-line and heat technology with a focus on improving quality as well as material and energy efficiency of industrial heating processes.

In Germany, more than 10 percent of primary energy is currently used for industrial heat treatments. There is significant room for improvement in terms of saving costs and energy or improving quality. Thermo-optical measuring (TOM) devices are developed at the Fraunhofer Center HTL for the testing of high temperature materials and the optimization of manufacturing processes. They are used, for example, to optimize debinding and sintering processes.

Application Center for Texile Fiber Ceramics TFK

The Application Center for Textile Fiber Ceramics TFK in Münchberg is a joint venture of the Fraunhofer Gesellschaft and the Hof University of Applied Science. Unique in its kind in Europe, the Center provides a single point of contact for all steps along the process chain from fiber development to the finished CMC-part and creates a link between textile and ceramics industries. The Center addresses national and international companies from all sectors, in material production and application alike.

Jointly, the Centers TFK and HTL set out to optimize and produce ceramic fibers and to design textile preforms for ceramic matrix composites (CMC). The TFK's main focus is on the textile processing of ceramic fibers which are still expensive to make and hard to process owing to their fragile nature.

The Center TFK was founded in June 2014 to assist customers in all issues relating to inorganic fibers and their textile processing. Until 2018, the Bavarian Ministry of Economy and Media, Engery and Technology will be providing a total of 2.5 million euros funding to help establish this regional competence center in Upper Franconia.

Fraunhofer Project Group Materials Recycling and Resource Strategies IWKS

The Fraunhofer Project Group Materials Recycling and Resource Strategies IWKS was founded in 2011/2012 with financial support from the Free State of Bavaria and the State of Hessen. By 2016, the permanent staff at the Alzenau and Hanau sites-combined had grown to 80. A total of 850 m² laboratory and pilot plant space is currently available. Two new buildings will offer another 4900 m² lab space by 2019. In 2012, the Application Center Resource Efficiency was created in cooperation with the Aschaffenburg University of Applied Sciences.

Against the background of increasingly scarce and expensive raw materials, the Fraunhofer Project Group IWKS works to secure the long-term reliable supply of raw materials to German industry so it can maintain its current leading position in advanced technology markets. For this purpose, innovative separation, sorting and processing procedures are being researched in cooperation with industry partners, and strategies are being developed for a sustainable use of precious resources or for substitution options. The project group is organized in business units to pool core competencies, including Biogenic Systems, Urban Mining, Resource Strategies and Networks, Analysis, Energy Materials and Lightweight Construction, Magnetic Materials, Separation and Sorting Technology.

The current R&D focus is on the development of regional, global as well as customized management solutions for material flows, resource efficiency and the handling of waste. Processes and technologies are systematically analyzed to design or optimize concepts for a more intelligent and sustainable use of resources.

Application Center for Ressource Efficiency ARess

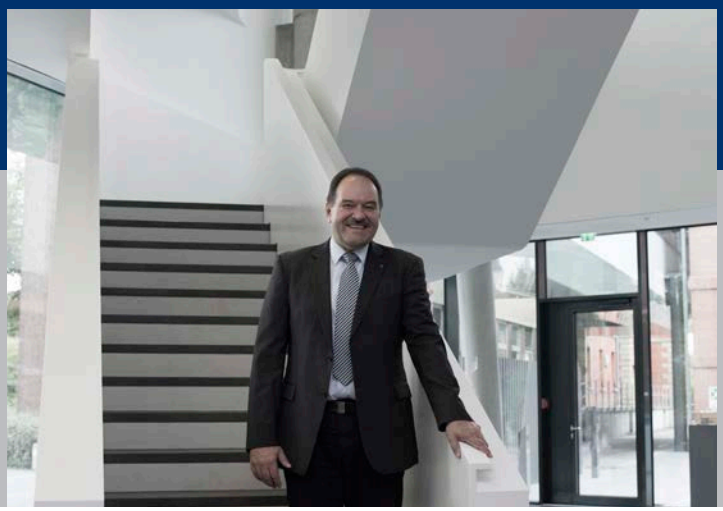
The Application Center for Resource Efficiency ARess is a joint venture of the Aschaffenburg University of Applied Sciences and the Fraunhofer ISC with its Project Group Materials Recycling and Strategies IWKS in Alzenau and Hanau. The Center researches the resource efficient design of functional elements, processes and products. By way of nanotechnological and electrochemical methods, it seeks to improve the recource efficiency of production processes and to implement efficient design for recycling.

R&D at the Fraunhofer Application Center ARess excellently complements the work of the Fraunhofer Project Group IWKS and the Aschaffenburg University of Applied Sciences. Other R&D priorities include novel methods for material separation, laser technology for recource-efficient process design and the substitution of critical materials and use of recycling-friendly manufacturing processes in electronics.

The Center has been granted funding by the Free State of Bavaria (Regional Government for for a period of five years and totalling 2.5 million euros. Professor Gesa Beck was appointed scientific director in 2015. She also holds an endowed chair at the Aschaffenburg University of Applied Sciences sponsored by the municipality of Alzenau.

Innovative material concepts for electrochemical energy storage

ORGANIZATION



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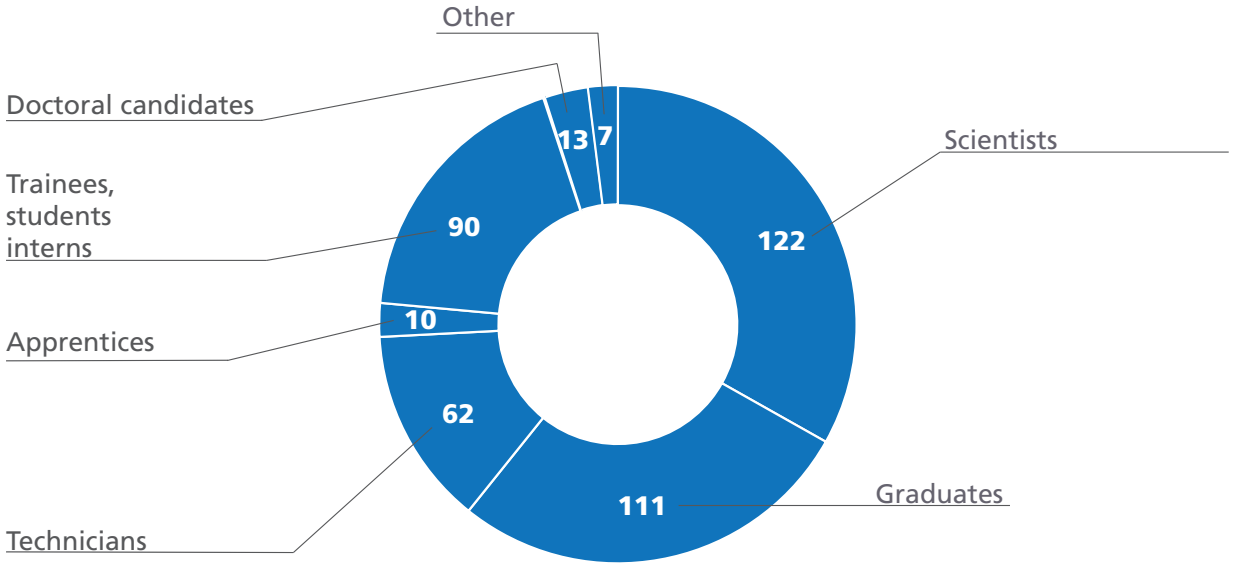
FACTS AND FIGURES

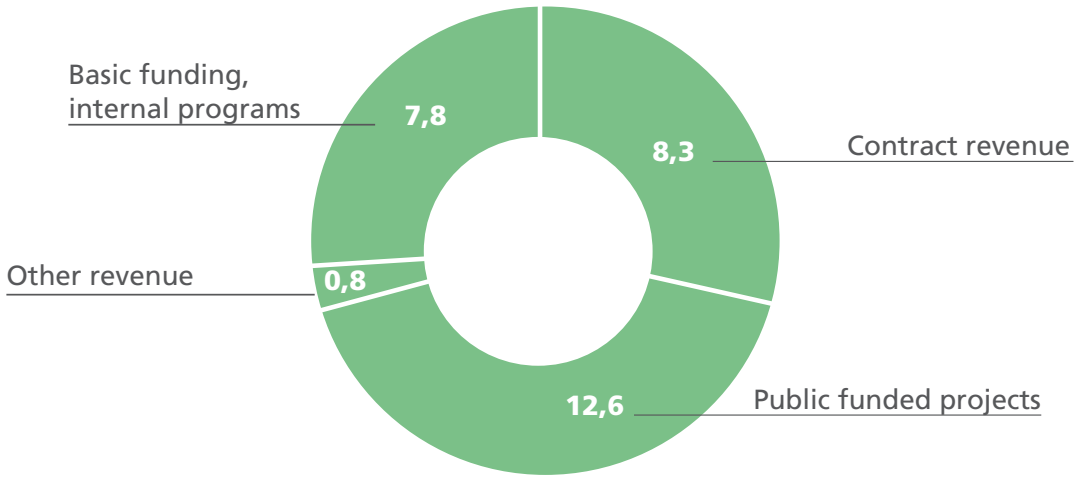
Workforce 2016	ISC	HTL	IWKS	Total
Permanent staff	173	55	67	295
Scientists	57	22	43	122
Graduates	74	22	15	111
Technicians	42	11	9	62
Other staff members	59	40	21	120
Apprentices	9	0	1	10
Trainees, students, interns	39	39	12	90
Doctoral candidates (*)	7	0	6	13
Other	4	1	2	7

(*) in addition to doctoral candidates at the associate Universities Würzburg, Augsburg, Darmstadt, Gießen

Personnel (head count)	**415**

Financing 2016	ISC	HTL	IWKS	ECS	Group
Operating budget expenditure	16.6	5.5	7.4	0.4	29.9
Personnel expenses	11.5	3.1	4.1	0.2	18.9
Non-personnel expenses	5.0	2.4	3.3	0.2	11
Operating budget revenue	15.8	5.7	7.6	0.4	29.5
Contract revenue	5.6	1.4	1.3		8.3
Publicly funded projects, EU projects	4.9	3.3	3.9	0.4	12.6
Other revenue	0.4	0.2	0.2		0.8
Basic funding, internal programs	4.9	0.7	2.2		7.8
Investments	**0.8**	**0.5**	**4.0**	**0**	**5.3**
Operating budget total expenditures (in Mio €)	**17.4**	**6**	**11.4**	**0.4**	**35.2**


Other
Doctoral candidates
Trainees,
students
interns
Apprentices
Technicians
Scientists
Graduates
13
7
90
122
10
62
111


Basic funding,
internal programs
Other revenue
Contract revenue
Public funded projects
7,8
8,3
0,8
12,6

Subsidy confirmation handed over to the Fraunhofer R&D Center Electromobility Bavaria (FZEB)

4 March 2016
Fraunhofer Center HTL: Subsidy confirmation presented to Fraunhofer Application Center TFK in Münchberg

The Center TFK was founded in June 2014 to assist mainly regional customers in all issues relating to inorganic fibers and their textile processing. The Bavarian Ministry of Economy and Media, Engery and Technology provided 2.5 million euros funding to help establish this regional competence center and to strenghten Bavaria's business position in the future-oriented field of "New Materials". On 4 March 2016, Bavarian State Minister Ilse Aigner personally presented the subsidy confirmation.

Innovative production procedures like the processing of textile fibers to 2D or 3D structures are being investigated in terms of their transferability to the processing of ceramic or carbon fibers. Ceramic and carbon fiber reinforced composites are of great importance in a number of key industries such as lightweigt construction, aerospace, automotive and energy technology.

The Application Center for Textile Fiber Ceramics TFK in Münchberg is a joint venture of the Fraunhofer Institute for Silicate Research ISC and the Hof University of Applied Sciences and forms part of the Center for High Temperature Materials and Design HTL at Bayreuth.

It is the long-term goal to turn the Application Center TFK into a permanent Fraunhofer Project Group.

11 March 2016
The path is clear for the new Fraunhofer R&D Center Electromobility Bavaria

Following the positive evaluation of the Bavarian Research and Development Center Electromobility FZEB, the Bavarian State Government granted funding for the next development stage. It involves the merger of the hitherto two sites – one at Würzburg, the other at Garching near Munich – with different activities around battery R&D. The remaining site in charge of future R&D will be the one at Würzburg, formerly known as the Center for Applied Electrochemistry which had been founded in 2011.

On 11 March 2016, Bavarian State Minister Ilse Aigner personally handed over the official 6 million euros subsidy confirmation during a little ceremony at the Fraunhofer ISC. The FZEB agrees to make good use of the grant in application-oriented reserarch to the benefit of industry and economy and commits itself to generate another 2.8 million euros contract or other revenue so that the total budget for the second stage will be 8.8 Mio euros.

External auditors had come to the conclusion that the Center for Applied Electrochemistry did an outstanding job in establishing itself as a new center. Their concepts for lithium based battery systems, hybrid storage devices and new battery materials as well as the optimization of proven lead acid batteries were found to be convincing and the technical infrastructure was rated to be as excellent as the Center's overall competency.

Workshop "From Material to System – Totally Smart"

Conference on "Magnetic Materials and Rare Earths"

24 May 2016
Center Smart Material CeSMa: Workshop "From Material to System – Totally Smart"

On 24 May 2016, the Center Smart Materials CeSMa welcomed some 50 participants from industry and research for the 8th CeSMa Workshop at the Fraunhofer ISC organized in cooperation with the Bavarian Clusters "Mechatronik & Automation" and "Neue Werkstoffe". The 2016 motto was "From Material to System – Totally Smart". After seven years of successful R&D in the Center Smart Materials project at the Fraunhofer ISC, the CeSMa team provided a comprehensive overview of the many application areas of smart materials, their progress into next generation materials and their enormous innovation potential for markets to come.

A major topic was the product-related union of smart materials with mechatronic features in such areas as automotive, engineering, medical technology or the sports and leisure industries.

Over the years, CeSMa has worked on a wide variety of applications, ranging from pressure-monitoring stockings for diabetes patients or the pressure-monitoring of leg protheses over sensor-based gesture control systems in driver seats or stepless device controls to elastomer pads for the stimulation of damaged nerves or elastomer foils with enhanced conductivity for vehicle seat heating systems.

Now that the funding phase for the CeSMa project has come to end in June 2016, the Center Smart Materials looks forward to further promote the use of electrically or magnetically controllable materials in innovative industry applications.

29 /30 June 2016
Fraunhofer Project Group IWKS: Conference on "Magnetic Materials and Rare Earths"

On 29 and 30 June, the Fraunhofer Project Group Materials Recycling and Resource Strategies IWKS held the second conference on "Magnetic Materials and Rare Earths" in the Congress Park of Hanau. The agenda covered topics like resource criticality and price development, magnetic materials and systems and "green" magnets through recycling and sustainable production.

Modern magnetic materials play a key role in the energy and drive technology, in automation or electronics. Their range of application starts with electric actuator motors and covers traction motors and enery storage devices as well as wind turbines. They have turned into an important element in many future-oriented technologies and have some bearing on the successful turnaround in the energy policy. The demand will rise for magnetic materials in the upcoming years. This is the reason why related R&D is as crucial for German industry as their reliable availability.

The expert conference aimed at informing the participants from research and industry about current developments in the magnetic materials area, including recycling and system optimization, and offered an outlook into the future. Special attention was paid to the speakers of the Fraunhofer Lighthouse Project "Critical Rare Earths" who presented latest results.

Workshop "The Nanoparticle Kitchen – Particles and Functions à la carte"

5 July 2016
Visit of Bavarian State Minister Ulrike Scharf to Fraunhofer Project Group IWKS

Ulrike Scharf, Bavarian State Minister for the Environment and Consumer Protection, came to visit the Fraunhofer Project Group IWKS in Alzenau on 5 July 2016 to emphasize the ecologic and economic need for an efficient strategy regarding critical resources. During her visit, the State Minister underlined the urgency of making fundamental changes in the exploit of natural resources. Germany, as a country lacking in natural raw materials, is called to implement a resource shift which can only work out if all players involved make wise use of available tools and begin to put an end to the steady rise in raw materials consumption. The solution has to be economically feasible and realistic, and the Fraunhofer Project Group IWKS will certainly contribute to finding it.

7 July 2016
Fraunhofer Project Group IWKS: Launch of "Ressourcen-Cluster Rhein-Main"

The future development of industry in the German Rhein Main area is highly dependent on the availability of raw materials. In this context, it is absolutely vital for decision makers from research, economy and politics to come together and find innovative solutions for a more sustainable use of raw materials. For this reason, the Fraunhofer Project Group Materials Recycling and Resource Strategies IWKS initiated the "Resource Cluster Rhein-Main". The Cluster is meant to be a central point of contact for all matters regarding resource efficiency and to act as an intermediary between industry, science, associations and politics.

On 7 Juy 2016, the Cluster was officially launched in the historic Deutsche Goldschmiedehaus in Hanau. The Project Group IWKS had joined forces with the Chamber of Industry and Commerce of Hanau-Gelnhausen-Schlüchtern to address potential partners from industry, research as well as political leaders. After the presentations of the keynote speakers, participants were invited to join round table talks on the potential of the Rhein-Main area in terms of resource efficiency and why resource effiency is crucial in the first place.

7 July 2016
Workshop "The Nanoparticle Kitchen – Particles and Functions à la carte"

An open easy access to world-class infrastructure for the reliable fabrication of functionalized nanoparticles and nanocomposites in small batches for test purposes would ease the way of companies in the chemical or pharmaceutical sector towards nanobased products. For this reason, the European Union has granted funding to the "Co-Pilot" project aiming to establish a number of pilot plants in order to provide just such an open-access infrastructure at suitable sites. Four different model systems were selected to form the base for the pilot-scale production, modification and compounding of particles in batches of up to 100 kg.

On 7 July 2016, the 13 European consortium partners from research and industry held a workshop at the Fraunhofer ISC to present details on the open access pilot line located on the Würzburg premises. About 50 participants seized the opportunity to learn more about the line and nanoparticle synthesis in general. The partners shared first results gained with the four model systems – double layered hydroxide nanoparticle polymer composites for flame inhibiting fillers, titanium dioxide nanoparticles for high refractive index composites, magnetic particles for innovative catalysts and hollow silica composites for anti-glare coatings. The CoPilot project receives EU funding within the framework of the Horizon 2020 program. Further pilot lines will be set up at nanotechnology specialist TNO in Eindhoven (NL) and at the Süddeutsche Kunststoffzentrum SKZ in Selb.

Bavarian State Minister Ulrike Scharf came to visit


Launch of Resource Cluster Rhein-Main

15 July 2016
Fraunhofer ISC and Hydro-Québec: Looking for the next generation solid state battery

The Fraunhofer Institute for Silicate Research ISC and Hydro-Québec are teaming up to conduct research and development into next-generation lithium-ion and lithium-air battery materials to be used in transportation electrification.

The joint Memorandum of Understanding was sigend on the occasion of Québec's official visit to Bavaria on 15 July 2016.

The partnership will focus on inorganic solid electrolytes and in particular on glass-ceramic electrolytes. In addition to having excellent ionic conductivity, these materials are highly advantageous in terms of safety, thanks to their non-flammable nature.

28 September 2016
Fraunhofer Center HTL: En Route to the First European Fiber Pilot Plant

Global demand is strong for high-temperature resistant materials with a high tolerance to strain and damage for they bear the potential to improve the energy efficiency of high temperature processes. Only ceramic composites (Ceramic Matrix Composites = CMC) can withstand temperatures beyond 1100 °C. CMC components are the material of choice in aerospace industry, in power generation and thermal processing technologies.

The Fraunhofer Center HTL is the first European research institution to develop CMC at all stages along the production chain, from fiber development to fiber processing, from ceramic matrix structuring to the joining method of the semi-fished CMC. Existing fiber spinning plants allow to produce a few kilograms of ceramic reinforcement fibers per year. The next challenge to be mastered is the upscaling to pre-industrial scale, i. e. a large-scale fiber production by the ton.

To create space to accomplish this task, an additional building is under construction on the site of the Technologiepark Bayreuth-Wolfsbach: The new pilot plant for the production of ceramic reinforcement fibers will be one of a kind in Europe and will offer 1350 square meters of lab space. Commissioning is planned for early 2019. At the heart of the building will be two production lines: one for oxide and one for non-oxide reinforcement fibers.

The overall cost for the new building will amount to 20 million euros, 3.75 million of which will be borne by the Fraunhofer-Gesellschaft. The remaining cost will be covered by Federal and Bavarian funding at equal shares.

21 October 2016
Fraunhofer Project Group IWKS: Bavarian State Minister Ulrike Scharf Launches Bavarian Center of Resource Efficiency

With a ceremony in the presence of Bavarian State Minister for the Environment and Consumer Protection Ulrike Scharf the Center of Resource Efficiency Bavaria (REZ) was launched on 21 October 2016. The new Center will be based at the Bavarian Office for the Environment in Augsburg and at the Chambers of Industry and Commerce in Nürnberg and Munich.

The REZ will address Bavarian enterprises and other interested parties and serve as point of information to foster networking and exchange with the goal to promote resource efficiency. The intent is to motivate companies to take action and to offer them a platform where they can find out how.

Launch of Bavarian Center of Resource Efficiency

The work of the new REZ is funded by the Augsburg region, represented by the Regio Augsburg Wirtschaft GmbH, and by the Lower Main region, represented by the Fraunhofer Project Group for Material Recycling and Resource Strategies IWKS in Alzenau.

The partnering Lower Main region will continuously contribute to the all-Bavarian REZ newsletter on resource efficiency and will also host events (workshops, training sessions, qualification courses) to keep informed on latest R&D trends and general progress in resource efficiency.

30 November 2016
Workshop on "Particle-Based Materials"

About 30 young aspiring scientists from Germany, Belgium, Switzerland and the Netherlands came together in Würzburg on 30 November 2016 for the first workshop on particle-based materials with the idea to establish a platform of exchange. The initiative to create such a platform, which had been lacking on a European level, was taken by this group of scientists: Prof. Dr. Tobias Kraus, Leibniz-Institute for New Materials, Saarbrücken, Dr. Karl Mandel, Fraunhofer ISC, Würzburg, Dr. Alexander Kühne, Leibniz-Institute for Interactive Materials, Aachen, and Prof. Dr. Robin N. Klupp Taylor, Nanostructured Particles Research Group, Erlangen.

The workshop covered an ambitious scope of topics, from binary protein crystals, aerogels, colloidal self-organization to plasmonic grids and offered a total of 29 short presentations. In eight hours, the participants gained insight into current R&D, from particle synthesis to particle-based materials and their properties. The Würzburg workshop was rated extremely helpful and informative and so another even bigger event is scheduled for November 2017.

6 December 2016
Workshop "Biodegradable Films in Packaging and Medicine"

The Fraunhofer ISC workshop "Together for a clean environment and trendsetting products" addressed interested parties from the industry to learn more about biodegradable functional coating materials. The new materials class of biobased and compostable hybrid polymers exhibits outstanding barrier properties against water vapour, flavors and oxygen. Bioplastic packaging with such a finishing holds the potential to equal conventional plastic packaging. Biodegradable barrier coatings will open up new pathways in packaging and tackle urgent environmental problems in a most promising way.

Best of all, the potential of these biopolymers does not stop at eco-friendly packaging. Applicaton concepts extend to novel solutions in the automotive or railway sectors and even include innovative ideas for high-quality products in mass markets. Fraunhofer ISC presented some examples of use in medicine and pharmaceuticals – areas that require good biocompatibility and antimicrobial properties.

6 December 2016
Fraunhofer Project Group IWKS receives Environmental Award

During a ceremony held on 6 December 2016, Bavarian State Minister for Finance, Regional Development and Home Affairs Dr. Markus Söder presented the winners of the 2016 Bavarian Environmental Award. To equal shares, the 10,000 euro price money went to the Fraunhofer Project Group IWKS, the Trägergemeinschaft Bernrieder Vorsprung and Die Umweltakademie e.V.. The award is granted by the Bavarian National Foundation to honor practical or scientific first rate contribituions to safeguard the environment.

The Fraunhofer Project Group IWKS had teamed up with the ImpulsTec GmbH to develop an innovative materials separation method for the highly efficient and environmentally friendly recycling of solar cells. What's more, it will also be suitable to recycle batteries, electronic devices or fiber composite materials.

The new method is based on the principle of electrohydraulic fragmentation. The material combinations which need to be separated are placed in water where shock waves are used to disintegrate the batch into the targeted materials. Once the water is drained, material fractions and components can simply be sieved out and sorted accordingly. The process is most efficient and the recovered material classes are of first quality. The process is environmentally more friendly than conventional methods since no chemicals are involved to separate the materials and harmful substances that might arise during the process (like dust) are instantly passivated by the water. It is possible to retrieve smallest amounts of materials or even functional components which are still intact and suitable for reuse in new products.

The first pilot plant has already been put into operation on the Alzenau site of the Fraunhofer Project Group IWKS, another plant will be set up at a medium-sized recycling company.


PROJECTS

Nanoporous glass with tunable sorption properties can improve indoor climates

WEIGHT OPTIMIZED KILN FURNITURE
WITH REDUCED MASS

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In a collaborative project, the Fraunhofer Center for High Temperature Materials and Design HTL and the Rauschert Steinbach GmbH developed a new kind of kiln furniture to significantly reduce the energy consumption of firing processes. The product now enters series production.

Kiln furniture serves to position the goods in a kiln during technical heating processes and may currently consume up to 80 percent of kiln space. All this mass needs to be heated just like the actual product to be made and so naturally adds to energy consumption and CO_2 output. Less furniture mass means less energy consumption. The desirable mass reduction can be achieved by using thinner kiln furniture and/or by increasing the porosity of the employed materials.

Within the framework of the joint project it was possible to optimize the mechanical and thermo-mechanical properties of kiln furniture materials just by improving the design in such a way that significantly less mass is required for equal performance. Two types of materials were developed for different ranges of temperature and application: "Rakor" (corundum) for temperatures of up to 1600 °C and "Ramul" (mullite) for temperatures of up to 1700 °C. Both materials achieve very good results in terms of creep resistance and thermal shock resistance. The Rakor material also exhibits an outstanding chemical resistance. With Rakor, it was possible to reduce the weight by 25 percent, when using Ramul the weight reduction even reached 30 percent.

The project was funded by the Bavarian State Ministry for Economic Affairs and Media, Energy and Technology within the framework of the "Neue Werkstoffe in Bayern" (New Materials in Bavaria) program with a grant of 0.5 million euros.

Further information at www.htl.fraunhofer.de

Kiln furniture by Rauschert Steinbach GmbH

MATERIALS AND COMPONENT TESTING –
ANALYSIS AND INTERPRETATION

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The clear advantage of non-destructive test methods is that test samples or components remain unchanged and therefore fit for later use. The Fraunhofer Center for High Temperature Materials and Design HTL specializes in non-destructive test methods using different types of imaging to identify cracks, pores, shrink holes, delamination or other signs of inhomogeneity within a component. Also, quantitative structural features like phase fractions, interface relationships, fiber orientation or density variations can be determined. A number of computer programs were developed to master these tasks and can be adapted to customer specific requirements, if necessary.

The detection of any imperfection is important in quality control and helps optimize manufacturing processes. Also, dimensional measuring can be useful for monitoring purposes in quality control or to compile CAD data for FE analyses, 3D printing and the like. In some cases, special equipment needs to be developed such as furnaces that allow investigations at high temperatures, or load-applying mechanisms to measure component deformation. Another example are transport systems required to enable the scanning of complete components with complex geometries.

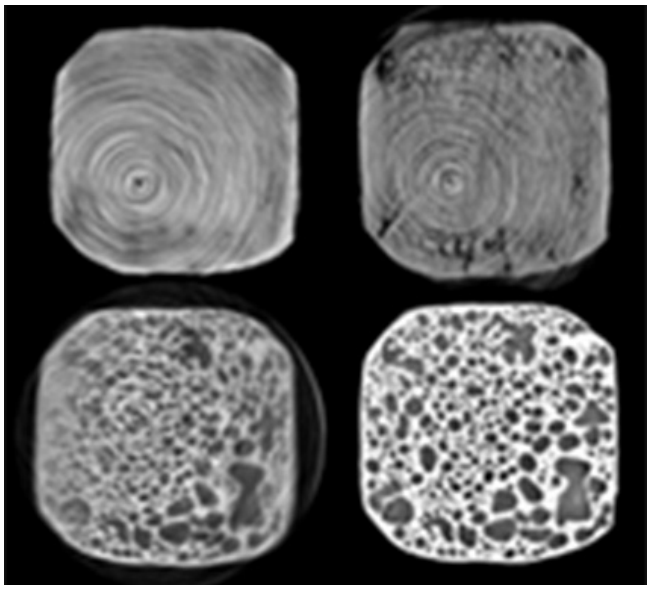
Test methods differ in experimental set-up requirements, in their limitations in terms of sample size and verifiable results or in other general restrictions. Among the available test methods are X-ray tomography, water or air coupled ultrasonic inspection, thermography, terahertz technology as well as radioscopy so that the Center HTL is well equipped to test nearly all materials and composites. Some of the test units are mobile and can be set up on site. All in all, the Center HTL's range of services covers almost each and every aspect of non-destructive materials or components testing.

Special evaluation software and algorithms are used to interpret the data collected during testing. This way, it is not only possible to determine the actual scope of damage in a component but to provide quantitative information, e. g., on individual pore sizes. Holes and geometries can precisely be measured as can temporal changes in material structures owing to chemical or thermal processes.

Further information at www.htl.fraunhofer.de

Materials testing by computed tomography (CT)

Crystallization behavior of a solder during heating. Clockwise: at room temperature, 400 °C, 1100 °C and upon crystallization



THERMAL PROCESSES –
OPTIMIZED DEBINDING

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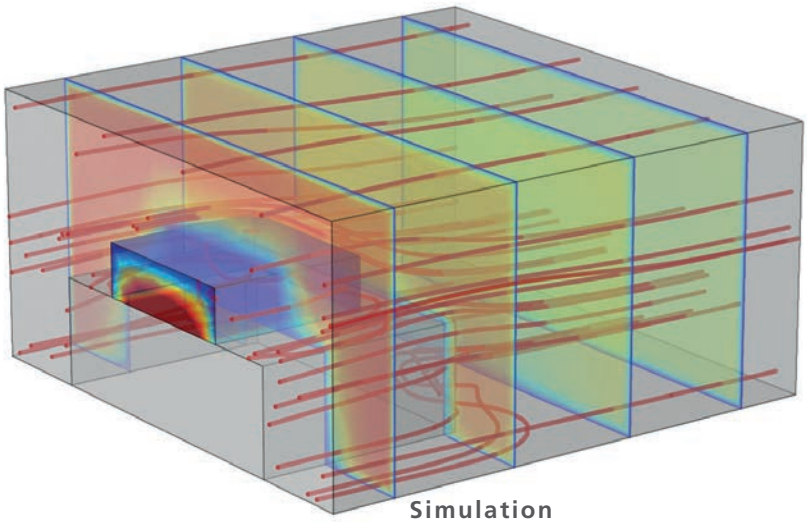
Most forming and shaping processes of ceramic components involve the use of organic binders. These must be burned out before sintering or further processing somewhere along the way from green body to finished product. Thermal debinding releases combustion or pyrolysis gases which can lead to pressure gradients. Also, chemical reactions may cause additional pressure gradients in a component. In order not to damage the ceramics, which are still in a very fragile state at that moment, debinding usually takes place at slow empirically chosen heating rates which naturally lead to long processing times.

The Fraunhofer Center for High Temperature Materials and Design HTL has developed a specific method to optimize industrial debinding processes in terms of energy efficiency, duration and product quality. The method is based on accurate in-situ measurements taken during the debinding of green bodies by means of the thermooptical "TOM" measuring device and other thermoanalysis tools available at the Center HTL. Measurements in TOM devices are carried out in the same kiln atmospheres as prevailing in actual production kilns which is a prerequisite for a subsequent transfer of the findings to the production process. For a thorough process characterization, many variables have to be measured relative to the temperature and this in best quality, including mass loss of the sample, its thermal conductivity, gas permeability and endo- or exothermal pyrolysis or debinding effects. Based on the acquired data on mass loss, a robust numerical method serves to calculate a kinetic model which enables some first optimization ideas. For validation, the maximum permissible heating rate has to be determined. This is done experimentally through meticulous acoustic detection of crack formation in the green body. To obtain full information on the optimization potential, all data are fed into a coupled Finite Element (FE) model developed at the Fraunhofer HTL just for this purpose. The model allows to predict damage to the component due to mechanical stress arising from gas pressure or temperature gradients at any given point in time during the debinding process and so helps define the optimum debinding conditions for targeted components at the computer. The method proved to be successful in a number of projects where it was possible to shorten debinding cycles by up to 40 percent compared to those which would have been empirically chosen.

Further information at www.htl.fraunhofer.de

Thermooptical measuring tools are used to optimize debinding procedures



Simulation

RESTORATION CONCEPT

FOR A PUBLIC INDOOR SWIMMING POOL AT STUTTGART-FEUERBACH

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The combination of humidity, chlorinated air and worn insulations will take its toll on any indoor-swimming pool. But if it happens to be an object of cultural heritage, a smart restoration concept is of need which does not interfere with the remaining part of the building. In order to prevent further damage to the artistically valuable façade of the public indoor swimming pool at Stuttgart Feuerbach, the authorities in charge (Hochbauamt Stuttgart) commissioned the Fraunhofer ISC to design a suitable restoration and conservation concept. The façade features a double glazing which displays obvious signs of corrosion. Of particular concern are the colored glass elements painted by the artist HAP Grieshaber between 1959 and 1964.

To find the best suited long-term concept for cleaning, restoring, and conserving the glass paintings, the team of scientists from the International Center for Cultural Heritage Preservation IZKK located at the Bronnbach Branch of the Fraunhofer ISC first analyzed sample panes of the façade glazing. An unpainted sample glass pane was used to determine the composition of the glass and to analyze the glass surface, the composition of the paint was analyzed from a painted glass pane.The investigation revealed crystalline deposits of calcium and sodium silicate compounds which fogged the pane like a white veil and so not only impaired the view but also covered the color paintings. The leaching took form in massive glass corrosion between the double glazing. In some areas the corrosion depth reached 20 micrometers. The edge seal of the insulating glass had given way and so made room for condensation between the panes of the double glazing. Glass components began to leach out and corrosion products to accumulate, until the surface of the glass was partly dissolved.

Based on these results, a concept was designed to carefully clean the façade without affecting the color paintings. The IZKK team then went on to develop a special protection coating which they tested on self-made glass samples matching the façade elements. These measures are meant to preserve the transparency of the façade and to improve the "readability" of the glass paintings. In order to prevent further corrosion, the façade panes are to be reincorporated into double glazings using latest standards and techniques.

Further information at www.izkk.de

Artistically valuable façade painting of the public indoor swimming pool at Stuttgart-Feuerbach

Testing how to clean the glass paintings

"NEW-BAT" – SUSTAINABLE REUSE OF LITHIUM ION BATTERIES

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The widespread use of lithium ion batteries, even furthered by a rising number of electric vehicles, will come along with large quantities of spent batteries. Today, only energy-intensive metallurgical methods are in place to recycle used batteries and even these are limited to the recovery of elementary metals. It would be more sustainable and make good economic sense to recover the actual battery materials – like e. g. high-grade lithium metal oxides or hitherto non-recyclable carbon compounds which could be immediately reused in new batteries. In the NEW-BAT project, with the Fraunhofer Project Group IWKS as coordinator, partnering scientists and engineers from research institutions and industry, among them the Lars Walch GmbH & Co. KG, GRS Service GmbH and ImpulsTec GmbH, join forces to develop a new system to completely recover and process valuable battery materials for direct re-use.

The most distinctive feature of the new recycling process is the electrohydraulic materials fragmentation by shock waves which dispenses with any high temperature processes. Instead, the material is fed into water or some other liquid. The shock waves are generated by an electrical discharge, and the water or other liquid serves to uniformly impart them onto the infeed material. This method enables composites and building blocks to come apart at the interfaces of different materials in a practically non-contact manner and so to separate materials in a gentle way. The material mix thus derived from the many battery components can then be sorted out efficiently in a next step. In order to obtain the purest recyclates possible, separation methods account for physical properties such as grain size and density as well as for the varied chemical compositions.

It is the electrode materials that age the most during a battery's life. Recycled materials therefore must be carefully tested and treated to restore their original quality. Project partner Fraunhofer ISC is in the position to offer special low temperature procedures suitable for lithium-ion battery materials to remove undesirable degradation products from surfaces and to repair crystal structure defects. This treatment can be combined with the application of a finishing core-shell coating which significantly improves the life and the charge and discharge properties of the recycled materials.

Further information at
www.iwks.fraunhofer.de
www.fzeb.fraunhofer.de

Recycled battery materials after electrohydraulic fragmentation

"NEW-BAT – Neue energieeffiziente Wiederverwertung von Batteriematerialien" has been granted 1.6 million euros funding within the framework of the "r4" research initiative (Innovative technologies for resource efficiency – Research for the supply of raw materials of strategic economic importance) of the German Federal Ministry of Education and Research (BMBF).

Electrohydraulic fragmentation unit
© ImpulsTec GmbH

"SuPaPhos" – LARGE-SCALE FISHING FOR PHOSPHATE IN SEWAGE

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Over the past years, an excellent laboratory infrastructure has been established at the Fraunhofer ISC for the fabrication and functionalization of nano- and microscale particles. Tailored particles with reliably reproducible properties can now be provided up to kilogram scale.

For the recovery of phosphate from sewage, the team of researchers around Dr. Carsten Gellermann (Fraunhofer Project Group IWKS) and Dr. Karl Mandel (Particle Technology at Fraunhofer ISC) developed magnetic particles with a very specific surface functionalization. The production of these particles was transferred to pilot scale within the framework of the joint research project "SuPaPhos" (Recovery of Phosphate from Sewage and Process Water with the Help of Magnetically Separable Ion Exchangers on the Large Scale). The new separation method works with superparamagnetic nanoparticle clusters embedded in a silica shell. The resulting magnetism of these micrometer-sized composite particles can be controlled by application of a magnetic field. The particle shell was chemically functionalized to bind phosphate. This way, these cluster particles can be used to fish for (meaning adsorb) phosphate in wastewater. When no magnetic field is applied, the particles are readily dispersible and so are added to the wastewater in powderform. Owing to their large and very specific surface, they bind phosphate most efficiently. Depending on the type of surface modification, 1 gram of adsorber powder can bind up to 50 milligrams of pure phosphate phosphorus within an hour at ph neutral. Upon application of an external magnetic field, the adsorber particles can be magnetically separated from the wastewater.

The phosphate assembled this way can be washed off the particles in an aqueous sodium hydroxide solution to be available for re-use in concentrated form e. g. in fertilizer production. The washed adsorber particles themselves are good for re-use in further cleaning cycles which renders the new recovery technique for phosphate from sewage even more efficient. Another benefit: The amount of chemicals required is significantly less compared to conventional processes and the phosphorus recovery rate is high with up to 70 percent relative to the entire amount of phosphorus ending up in a municipal sewage plant. The new method has already been field tested in an experimental sewage plant of the Stuttgart University which treats the entire university sewage plus the sewage of one of Stuttgart's city districts, in total the equivalent of sewage from about 10,000 inhabitants. The plant performs standard urban wastewater treatment while also offering the modular test environment for the field test.

Further information at
www.partikel.fraunhofer.de

The new adsorber powder can bind up to 50 milligrams of pure phosphate-phosphorus per hour © Universität Stuttgart

The project "SuPaPhos – Recovery of Phosphate from Sewage and Process Water with the Help of Magnetically Separable Ion Exchangers on the Large Scale" is funded by the Baden-Württemberg-Stiftung gGmbH.

Project coordinator: University of Stuttgart, Institut für Siedlungswasserbau, Wassergüte- und Abfallwirtschaft ISWA

Project partners: Institute of Functional Interfaces and Competence Center for Material Moisture of Karlsruhe Institute for Technology; University of Stuttgart, Institut für Arbeitswissenschaft und Technologiemanagement

"KLIMATOM" – NEW METHODS
TO INSPECT PLASTIC COMPONENTS

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The Center of Device Development CeDeD presents the next generation of thermooptical measuring devices for a non-contact, non-destructive examination and optimization of complex plastic components. It was especially designed to analyze the behavior of plastic compounds and composites. Experience has shown that reliable information on plastic parts produced by injection moulding or 3D printing is hard to obtain. A characterization method to detect changes in the material when exposed to humidity or extreme temperatures had been lacking up to now.

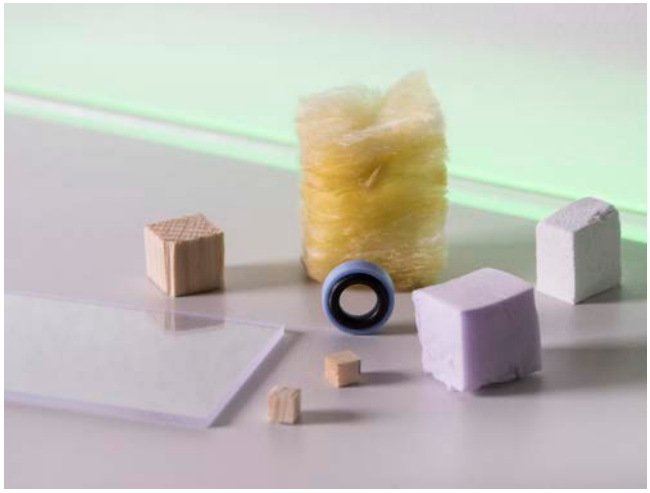
What happens to the component at high humidity or extreme ambient temperatures? How do different types of polymers or other material fractions contained in a composite respond? What effect do surfaces exhibit due to condensation or formation of ice? Fast and reliable answers can be provided by the new thermooptical measuring device KLIMATOM offered by the Fraunhofer ISC for the examination of plastic components.

The non-contact, non-destructive measuring method is good to detect even the smallest change in dimension of complex components exposed to defined temperature and humidity conditions (from -40 to 160 °C at 30 to 95 percent r. h.). The method is suitable to examine composites containing plastics with different expansion coefficients. The high-resolution CMOS technology allows to record dimensional changes in the 0.3 µm range – results that are hitherto unmatched in the inspection of polymer components.

Other application examples include the determination of the swelling and bending behavior or of the flexural strength. The device can also be used to characterize surfaces to test the functionality of applied coatings.

Further information at www.ceded.de

KLIMATOM performs measuring tasks in a non-contact, non-destructive manner



"FLEX 25" – FLEXIBLE PROTECTION FOR ACTIVE BUILDING COMPONENTS AND FACADES

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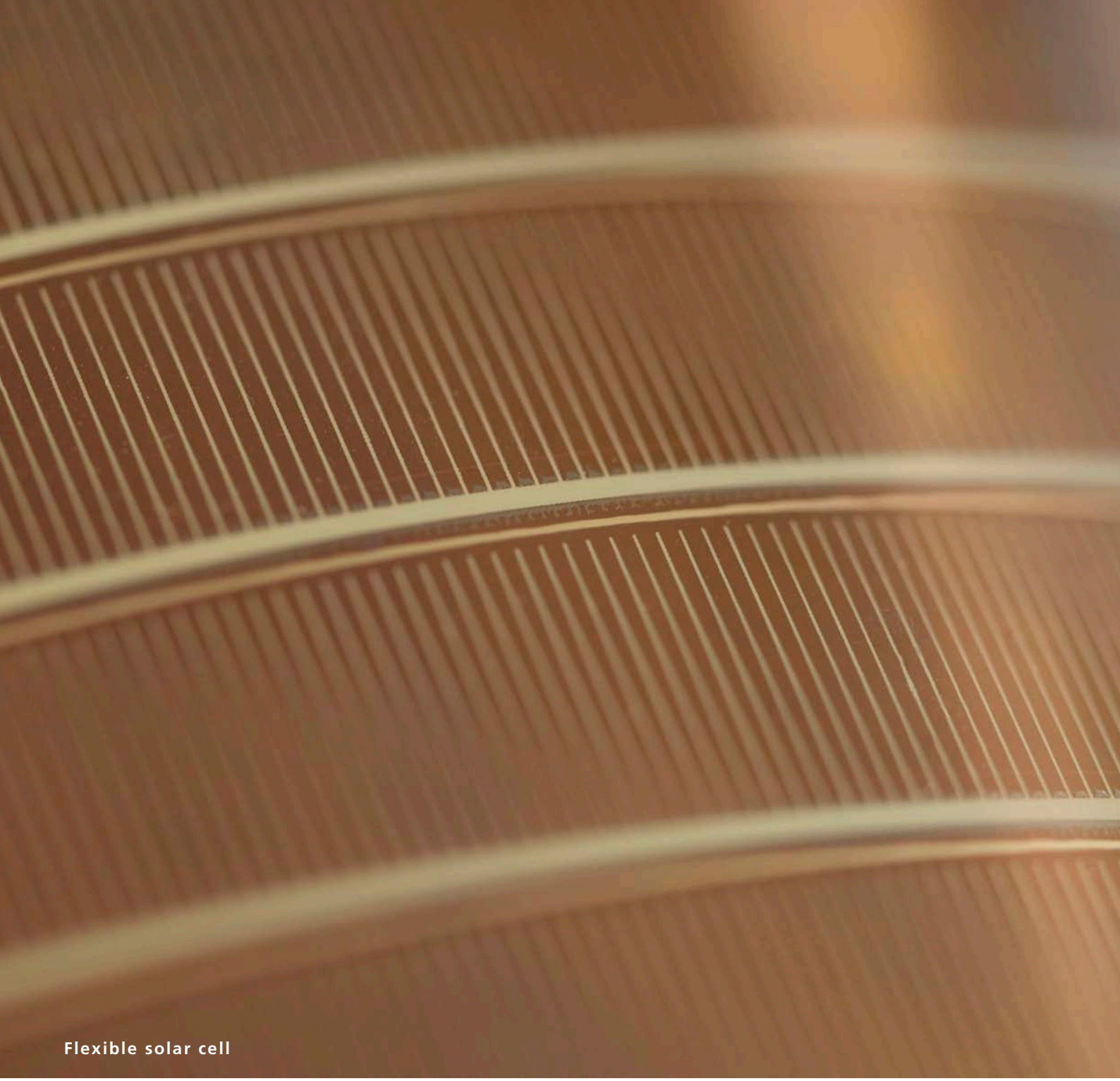
The trend in architecture and facility management is towards "smart" buildings which, by means of integrated flexible electronics, automatically respond to changing ambient conditions or offer other comfortable features like solar cell modules integrated into façades or electrochromic windows which change tint from clear to dark in strong sunshine. The "flex 25" project team now made key progress in the development of low-cost coating procedures for weatherproof fluorpolymer films required to encapsulate such flexible electronic components for their integration in building envelopes. The researchers from the Fraunhofer Institutes FEP, ISC and IVV started out with the adaptation of the ultra-barrier concept of "POLO®-High Barrier". The new functional film is finished in a roll-to-roll process with multiple layers of specific hybrid polymers developed by the Fraunhofer ISC and including at least one metal oxide layer. The side exposed to the weather is provided with a longterm stable antireflection surface. The hybrid polymers serve to even out surface and coating defects, have good gas barrier functions and embed UV absorbers to protect underlying layers and the encapsulated component from UV radiation.

The metal oxide layers were applied at the Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technology FEP. In combination with hybrid polymer layers, they provide an ideal barrier against the diffusion of water vapour and oxygen to the encapsulated components. Many fluoropolymers have a low elastic modulus which will lead to higher elongation when exposed to the mechanical strain of a roll-to-roll process. This may result in damage to pre-applied layers. At the Fraunhofer Institute for Process Engineering and Packaging IVV, the experts in handling all kinds of packaging materials mastered the challenge to adapt the existing roll-to-roll coating process for fluoropolymer films to withstand both the involved mechanical stress and the required drying temperature of 120 °C.

In their collaborative project, the three Fraunhofer Institutes accomplished to develop a robust manufacturing process in pilot scale to apply barrier coatings of consistent quality to fluoropolymer films as substrate. The water vapour permeability of 0.002 g/(m^2d) at 38 °C with 90 percent humidity meets the protection demands for the long-term use and consistent performance of sensitive electronic components.

Further information at www.barrier.fraunhofer.com



Flexible solar cell

The "flex25" project received public funding within the framework of the "Validation of the innovation potential of public research" program of the German Federal Ministry of Education and Research (BMBF).

"PRiL" – FROM SECONDARY RAW MATERIAL TO SMART FERTILIZER

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Phosphorus is an elementary building block of life: All organisms – human, animal or plant – require phosphorus to form their DNA. About 90 percent of current phosphate mining or extraction go to fertilizer production to increase agricultural yields. But geographical dependence begins to be a problem as 75 percent of phosphate reserves are concentrated in Morocco and the Western Sahara region. Also, a growing contamination of phosphate ore with heavy metals (cadmium and uranium) renders the recovery of phosphate and its reintroduction into the resource cycle even more useful.

Against this backdrop, the team of researchers partnering in the "PRiL" project and coordinated by the Fraunhofer Project Group for Materials Recycling and Resource Strategies IWKS works to develop a sustainable fertilizer using phosphate that has been recycled from incineration ashes left over from the thermal utilization of sewage sludge. The recycling takes place with the P-Bac method of Fritzmeier Umwelttechnik GmbH. The sewage sludge ashes are provided by the city of Munich from their wastewater management.

The P-Bac method generates a phosphorus recyclate via microbiological leaching from the ashes. It is the sulphor-oxidizing bacteria from the genus acidithiobacillus that produce the sulphorous acid required for the leaching. Employment of these bacteria helps reduce the amount of chemicals in the recycling phase to a minimum. After the bioleaching process, a second step is required to retrieve the phosphate from the resulting solution.

In a third step, an agriculturally efficient and widely marketable fertilizer is produced at ICL Fertilizers Deutschland GmbH using an optimized physiochemical method. The fertilizing effect of this recycling product has already been proven in previous tests. At this stage, the fertilizer production is being transferred to industrial scale.

Further information at www.iwks.fraunhofer.de

Phosphat mine © shutterstock

The project "PRiL – Recycling of Phosphorus - from secondary raw material to a smart fertilizer" receives funding from the Federal Ministry of Food and Agriculture within the BMEL program to promote innovation.

"IRETA" – RAISING THE RECYCLING RATE OF TANTALUM FROM WASTE ELECTRICAL EQUIPMENT

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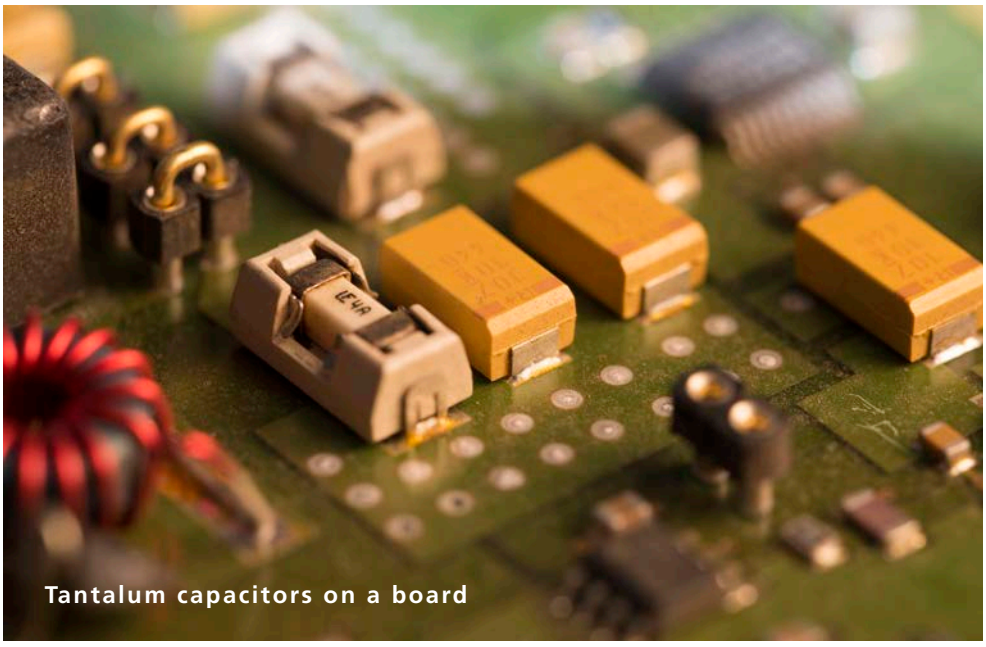
Corrosion resistance and a very high melting point of approx. 3000 °C make tantalum a popular material for electronic applications. Owing to its special electric properties, this transition metal enables the construction of small-volume but high-performance capacitors which boosts the miniturization of electric appliances. Mining for tantalum, however, involves a lot of problems so that an efficient recyling is called for. Current recycling methods fail to provide the required efficiency so that today's recycling rate is still below one percent.

The goal of the collaborative "IRETA" project is to establish secondary production to reduce the need to import tantalum. The intended new recycling route starts out with having tantalum containing capacitors identified on the circuit boards of waste electric applicances by means of a detection software. Once identified, they are fully automatically removed and mechanically processed into a powder. There are three different ways to recover pure tantalum from this powder: chemical transport, electrochemical separation or by functionalized nanoparticles. To decide which one of the three approaches is best to form the base for a pilot plant, a comparative investigation will be carried out. Among the criteria to be investigated are ecological and economic aspects.

Project coordinator is the Fraunhofer Application Center for Resource Efficiency in Aschaffenburg and Alzenau. It will be responsible for the mechanical processing and electrochemical separation route. The Fraunhofer Project Group for Materials Recycling and Resource Strategies IWKS in Alzenau is investigating the recycling by nanoparticles and by chemical transport. The optical detection and automated removal of the capacitors will be developed at the University of Applied Sciences in Aschaffenburg. The bifa Umweltinstitut GmbH located in Augsburg will carry out the environmental accounting of the three approaches. Project partners Mairec Edelmetallgesellschaft mbH, also located at Alzenau, Iolitec GmbH located at Heilbronn and Tantec GmbH located at Gelnhausen provide their experstise in recycling technologies, processing technologies and chemical synthesis. These companies will also assist the researchers in an advisory role throughout the project.

Further information at
www.iwks.fraunhofer.de
www.aress.fraunhofer.de

Tantalum capacitors



Tantalum capacitors on a board

The project "IRETA – innovative recycling methods for tantalum" has been granted funding of about 700,000 euros within the framework of the "KMU-Innovationsoffensive Ressourcen- und Energieeffizienz" by the Federal Ministry of Education and Research (BMBF)

SMART ELASTOMERS

TRAIN MUSCLES AND STIMULATE NERVES

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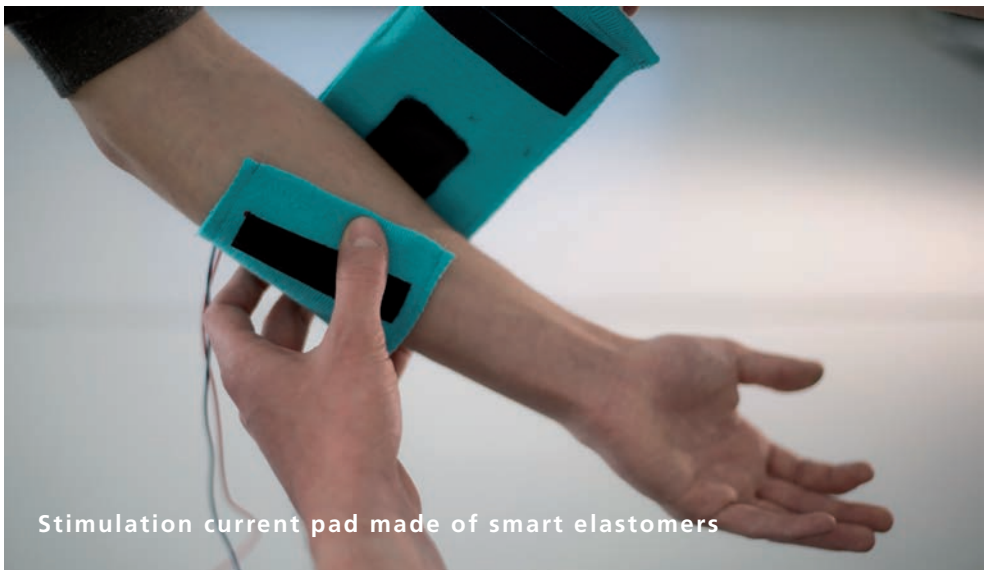
Intelligent clothing with integrated functions like the monitoring of movement sequences or detection of appearing compression or the actuator or electrically induced triggering of some kind of signal or other response are of interest in a wide variety of very different applications. In the health, sports and fitness sectors, they allow to professionally check body positions or the fitting of shoes and insoles for correctness. Games and sports applicances benefit from such monitoring options and bedridden patients could undergo self-guided muscle training programs. It is also feasible to have such functions support pain relief efforts or the regeneration of damaged nerves. Smart conductive elastomer composites as developed by the Center Smart Materials CeSMa of the Fraunhofer ISC offer intriguing opportunities to equip textiles with all kinds of functions. As of today, the smart elastomers developed by the CeSMa are mostly used in technical areas – e. g. as energy converters in self-dependent power generation from renewable sources like water-power or as sensitive but robust pressure sensors. Their special material properties, however, have a much bigger application potential.

As the material can convert mechanical stretching into an electric signal, it is principally suited to measure body signals. Arranged in the correct order and equipped with suitable electronics, smart CeSMa composites could very well serve to monitor breathing, muscle contraction and the like. This could be beneficial in patient or elderly care or whenever controlled mobilization or training is required. Another advantage of the CeSMa composites is that they can also act as signal provider in a physical way. This enables their use for the stimulation of muscles or nerves. Highly elastic and washable stimulation current pads could be made from smart elastomers. No more gluing onto skin, no more wetting to make pads stick - the material adapts to any body form and ensures very good signal transfer just by closely fitting to the skin. Elastomer pads could be integrated into textiles that remain comfortable to wear and continue to be washable. What's more, such pads would always stay in place to perform their targeted monitoring or stimulation task. This could make things a lot easier for both patient and caregiver.

Further information at www.cesma.de

Smart elastomers – flexible and stretchable



Stimulation current pad made of smart elastomers

"SEALS" – HIGH-PERFORMANCE

GLASS SEALS FOR FUEL CELLS

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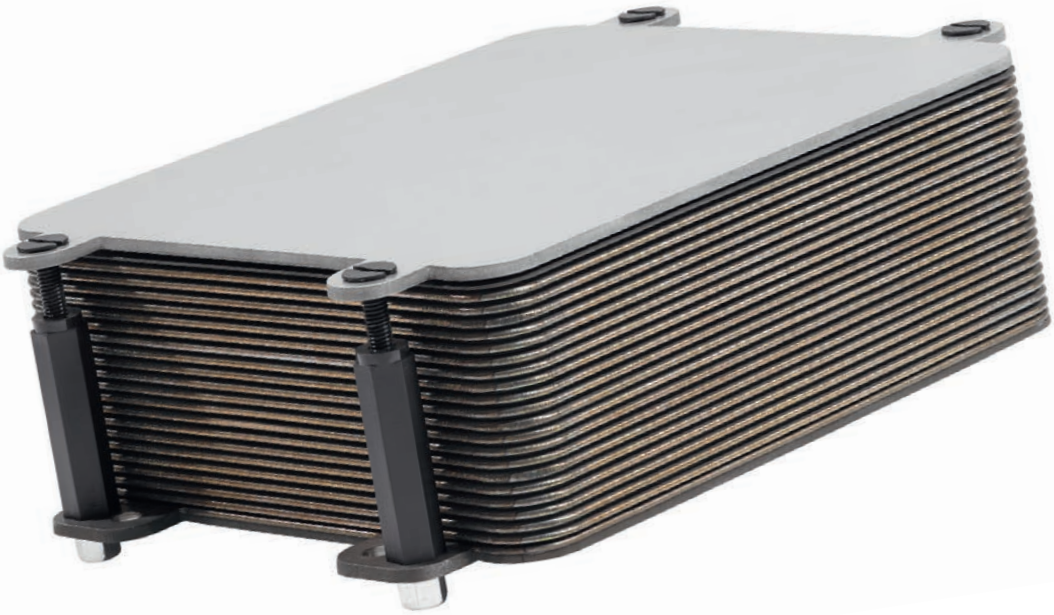
Materials used in the prodcution of solid oxide fuel cells (SOFC) must fulfill very high standards. These must still be met when it comes to joining the individual fuel cell components made of a variety of different materials from special steel to circonium oxide in a gastight and electrically insulating manner. Sealing materials must be able to withstand temperature changes from 750 °C to 900 °C and tolerate chemically agressive conditions. Conventional materials cannot cope with the given harsh conditions. In the collaborative project "Sealing Stacks – SealS", which is funded by the Federal Ministry for Economic Affairs and Energy and coordinated by the Elring-Klinger AG at Dettingen, the competence unit Glass and Mineral Materials of the Fraunhofer ISC set out to develop new sealing materials for the SOFCs. Years of experience in the development of glass seals and in-house access to thermooptical analysis tools for high-temperature processes make the Fraunhofer ISC perfect for this task.

The team of researchers around Dr. Bernhard Durschang chose a material system of alkali-free glass ceramics as a starting point. Systematically varying batch components and characterization methods, a number of different glass ceramics was produced. The goal was to find glass ceramics with just the right coefficient of thermal expansion to match the materials to be joined – in this case high-temperature resistant specialty steels – in order to achieve a mechanically stress-free sealing. To predict the actual behavior during processing and determine the required parameters for gastight sealing, the best matching glass ceramics were ground into pastes for a screen printing process. Among the facts that must be known is the temperature-dependant wetting behavior, which is registered on line, and the outgassing from the glass melt which can be determined with a thermooptical measuring device developed by the Fraunhofer ISC. Analysis of the acquired data helped optimize process-relevant material properties. Also, with the thermooptical measuring device it was possible to monitor the behavior of the glass ceramic seals under near-operating conditions which allowed to identify the best suitable batch. Demonstrators sealed with the newly developed glass ceramic seals were tested to withstand even 2000 hours of harsh operating conditions without any fault. The novel seals will also be of interest in the jointing of other materials subjected to high operating temperatures or fast temperature changes, e. g. in turbines, gas burners or other fuel cell technologies.

Further information at www.glasdienstleistungen.de

The new glass-ceramics sealing material of the Fraunhofer ISC as screen printable paste



High-temperature fuel cell from ElringKlinger AG, Dettingen ©

The project "SealS – Sealing Stacks – Glass-based sealing systems for high temperature fuel cells" is funded by the Federal Ministry for Economic Affairs and Energy (BMWI). Project partners are ElringKlinger AG, Dettingen and the Institute for Applied Materials – Ceramic Materials and Technologies at KIT Karlsruhe.

"SEEDS" – SMART BATTERIES
WITH CELL-INTEGRATED SENSORS

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A sustainable energy supply relies on best possible performance in terms of efficiency, economy, and reliability. In the collaborative project "SEEDs", the Fraunhofer Institutes for Integrated Circuits IIS and for Silicate Research ISC are setting up a one of a kind platform for research and demonstration activities in local energy management with the goal to combine existing approaches and technologies for all forms of energy – electricity, heat, cold and hydrogen - into one optimized overall system. Main focus is on renewable energy. The R&D areas covered by the project also include DC networks and energy storage, power grid simulation, cooling systems, and gas-to-power coupling.

The task of the Fraunhofer ISC is to investigate how pressure, temperature or a (possibly inhomogenous) interacting tension affect the life and performance of batteries. To this effect, the researchers use "intelligent" cells able to take spatially resolved measurements of these influencing factors within the battery during operation. The sensors are integrated in the pouchcell to measure the entire cell system's behavior while charging and aging. They have a low construction height that allows easy integration into cells and respond to deformation to take measurements.

The smart cells are produced in a semi-automated process under defined climate conditions. Electrodes are coated in an in-house cleanroom by a roll-to-roll process. The acquired data will serve to better understand influencing factors and to determine the effects of e. g. additional cooling elements, changes in cell chemistry or geometry onto the cell. The goal is to optimize the design of future cells.

Further information at www.fzeb.fraunhofer.de

Roll-to-roll coating in a cleanroom forms part of the electrode production

Coating device in a cleanroom of the Fraunhofer ISC

The "SEEDs" project (Wachstumskeime für ein energieautarkes Bayern – Energy seeds for an energy self-sufficient Bavaria) is funded by the Bavarian State Ministry for Economic Affairs and Media, Energy and Technology.

FRAUNHOFER-GESELLSCHAFT

Research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. Founded in 1949, the research organization undertakes applied research that drives economic development and serves the wider benefit of society. Its services are solicited by customers and contractual partners in industry, the service sector and public administration.

At present, the Fraunhofer-Gesellschaft maintains 69 institutes and research units. The majority of the 24,500 staff are qualified scientists and engineers, who work with an annual research budget of 2.1 billion euros. Of this sum, 1.9 billion euros is generated through contract research. More than 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Almost 30 percent is contributed by the German federal and state governments in the form of base funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society until five or ten years from now.

International collaborations with excellent research partners and innovative companies around the world ensure direct access to regions of the greatest importance to present and future scientific progress and economic development.

With its clearly defined mission of application-oriented research and its focus on key technologies of relevance to the future, the Fraunhofer-Gesellschaft plays a prominent role in the German and European innovation process. Applied research has a knock-on effect that extends beyond the direct benefits perceived by the customer: Through their research and development work, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their local region, and throughout Germany and Europe. They do so by promoting innovation, strengthening the technological base, improving the acceptance of new technologies, and helping to train the urgently needed future generation of scientists and engineers.

As an employer, the Fraunhofer-Gesellschaft offers its staff the opportunity to develop the professional and personal skills that will allow them to take up positions of responsibility within their institute, at universities, in industry and in society. Students who choose to work on projects at the Fraunhofer Institutes have excellent prospects of starting and developing a career in industry by virtue of the practical training and experience they have acquired.

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

FRAUNHOFER-VERBUND MATERIALS

For 20 years now the Fraunhofer Materials and Components Group – MATERIALS – has been integrating the expertise of the Fraunhofer Institutes working in the field of materials science. With more than 2,500 scientists and a total annual budget of around € 500 million in the area of contract research, it constitutes the largest group within the Fraunhofer Gesellschaft. Materials research and materials technology at Fraunhofer cover the entire value chain, from the development of new and the improvement of existing materials, through manufacturing technology on a quasi-industrial scale, up to the characterization of properties and assessment of service behavior.

The same research scope applies to the components made from these materials and the way they function in systems. In all these fields, experimental studies in laboratories, technical institutes and pilot facilities are complemented by equally important numerical simulation and modelling techniques - across all scales, from individual molecules and components up to complex systems and simulation of complete processes. As far as materials are concerned, the Fraunhofer MATERIALS group covers the full spectrum of metals, inorganic non-metals, polymers, and materials made from renewable resources, as well as semiconductor materials. Over the last few years, hybrid materials have gained significantly in importance. With strategic forecasts the Group supports the development of future-oriented technologies and materials. The scientists working in the Group's institutes deploy their knowhow and expertise on behalf of their customers specifically in the fields of energy & environment, mobility, healthcare, machine & plant construction, building construction & living, microsystems technology and safety. They are part of strong national and international networks and contribute towards material-related innovations and innovative processes in a wide range of working fields.

With the initiative Materials Data Space© (MDS) founded in 2015, the Group is presenting a roadmap towards Industry 4.0 enabled materials. Digitalization of materials along their entire value creation chain is viewed by the Group as a key requirement for the lasting success of Industry 4.0. The rationale behind the Materials Data Space© concept is to provide a new platform offering digital information about materials and material properties across multiple corporations along the entire value creation chain.

Members of the Fraunhofer Materials Group are the Fraunhofer Institutes for

- Angewandte Polymerforschung IAP
- Bauphysik IBP
- Betriebsfestigkeit und Systemzuverlässigkeit LBF
- Chemische Technologie ICT
- Fertigungstechnik und Angewandte Materialforschung IFAM
- Holzforschung, Wilhelm-Klauditz-Institut WKI
- Keramische Technologien und Systeme IKTS
- Kurzzeitdynamik, Ernst-Mach-Institut EMI
- Silicatforschung ISC
- Mikrostruktur von Werkstoffen und Systemen IMWS
- Solare Energiesysteme ISE
- System- und Innovationsforschung ISI
- Werkstoffmechanik IWM
- Zerstörungsfreie Prüfverfahren IZFP
- Windenergie und Energiesystemtechnik IWES

Associated institutes:

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- Grenzflächen- und Bioverfahrenstechnik IGB
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