Fraunhofer
ICT

FRAUNHOFER INSTITUTE FOR CHEMICAL TECHNOLOGY ICT

ANNUAL REPORT 2015/2016

EDITORIAL NOTES

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ANNUAL REPORT
2015/2016

WHICH TOPICS WILL WE BE RESEARCHING IN 2020?

The strategy of each Fraunhofer institute is audited every five years. In 2015 it was the turn of Fraunhofer ICT, and together with a group of nine external advisors, the Institute Director and Heads of Department evaluated the institute's existing competences, market position and development potential. We weren't aiming to produce a treatise, but rather a simple, practical strategy document that will guide our research and development over the next five years. In many ways our strategy is "nothing new": we took a clear decision not to be driven by the hype surrounding certain research topics, or the short-term promise of easy revenues. Rather, we chose to focus on research areas that have a broad basis, supported by many scientists, and that have been validated and measured through projects, patents, and publications. We also chose to build on competence areas in which we have a competitive advantage, and in which we see demonstrable development potential over the next five years.

A central element of our strategy was the definition of four core competences of the institute, each of which involves multiple departments. These competences are:

- Chemical and Environmental Engineering
- Polymer Engineering
- Energy Systems
- Explosives Technology

For each of these core competences, we summarized our expertise and infrastructure, and evaluated our position relative to other scientific institutions worldwide. We then reviewed our research results, patents, publications and revenues from the last three years, and developed projections. Particular attention was paid to expected changes in the methods, tools and technologies involved: our strategy document contained a technology roadmap in each area of competence, as well as an assessment of opportunities and risks. On the basis of this data, we could then formulate our research aims.

The results of the strategy audit are summarized on the coming pages. Rather than structuring our Annual Report by department as in previous years, we have structured it around the four core competences.

Only the future can show whether our plans and decisions are prescient. The only certainty is that, as a research institute, we will always be required to react flexibly to new developments. We will need to adopt new topics, and maybe reduce our activities in areas that do not meet expectations. However, you can be assured that at Fraunhofer ICT these decisions will not be taken lightly or hastily, but will have a solid basis.

We believe (and our strategy auditors have confirmed) that the institute's expertise and infrastructure place it in an excellent position for the next five years and beyond. We are also convinced that the increased internal networking within the four core competences will improve our performance as a service provider and development partner.

We look forward to your feedback on our strategic development, and hope that you enjoy reading this year's Annual Report!

With best wishes,

Peter Elsner

CONTENTS

GENERAL INFORMATION

CORE COMPETENCES

PROJECT GROUPS AND BRANCHES OF THE INSTITUTE

APPENDIX

INSTITUTE PROFILE

The Fraunhofer Institute for Chemical Technology ICT, founded in 1959, is one of the largest and longest-established institutes of the Fraunhofer-Gesellschaft, which currently has around 24,000 employees and a total turnover of 2.1 billion Euro.

Including the institute's external project groups, Fraunhofer ICT had around 800 employees in 2015. At its headquarters in Pfinztal, over 540 employees carry out research and development work in the core competence areas of chemical and environmental engineering, polymer engineering, energy systems and explosives technology.

The total area of the institute in Pfinztal is 200,000 m². This includes 25,000 m² of laboratories, offices, pilot plants, workshops, test stands and other facilities. This exceptional research infrastructure, which includes high-volume pilot plants and industrial-scale equipment, enables us to develop and implement new materials, processes and products up to near-industrial level. Well-equipped laboratories with cutting-edge safety features and energy-saving technology are available at the institute, as well as all the analysis and testing procedures needed for research in our specific fields.

Our clients and project partners are mostly from the automotive and transport sectors, as well as the fields of energy, environment, defense, security, chemistry and process engineering.

Our security research

We are the only explosives research institute in Germany to offer a full spectrum from laboratory testing and technical processing through to fully developed systems. We have many years of experience with energetic materials, for example solid rocket propellants or high explosives, and have been a research partner of the German Defense Ministry for over 55 years.

Aerial view of Fraunhofer ICT, Pfinztal (Photographer: Michael Seher, Pfinztal).

MISSION STATEMENT

"Researching where it's fun" is the motto of Fraunhofer ICT. This refers firstly to the pleasant working atmosphere that we cultivate at the institute, and secondly to the high degree of independence enjoyed by our employees. Our researchers are motivated by a "healthy" mixture of freedom to structure their work as they see fit and adopt a creative approach to problem-solving, and responsibility toward the customer for their own research results. We consider the combination of research freedom and personal responsibility as the key to scientific excellence and exceptional research results.

Our mission corresponds to the mission of the Fraunhofer-Gesellschaft. We work for and with an international network of partners and customers, carrying out applied research that drives economic developments and serves the wider benefit of society. Our system and technology innovations increase the competitiveness of the region, Germany and Europe as a whole.

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ECONOMIC DEVELOPMENT

In economic terms, 2015 was a very stable year for us. Both our expenditure and our revenues increased moderately compared to the previous year. As planned, our staff (scientific, technical and administrative personnel as well as laboratory assistants) remained constant in 2015. Following a reduction in 2014, we slightly increased the number of student assistants (classified as "external" employees) who are working at the institute. Another positive development is that we now host 20 apprentices. This number has risen steadily over the past few years.

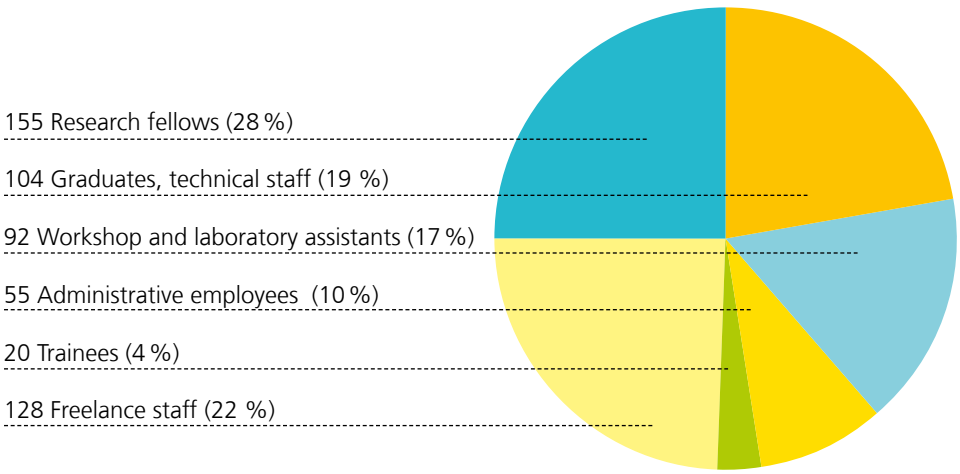
Our expenditure increase of 1.5 million € is mainly due to higher material and equipment costs. We had reduced this expenditure significantly in 2014 due to the economic situation. In the current business year this was no longer necessary, and our expenditure has returned to the 2013 level. The continuous modernization of our facilities is essential to our research work.

Our revenues also increased by 1.5 million € compared to the previous year, exceeding the 35 million € mark for the first time. These figures refer only to our headquarters in Pfinztal.

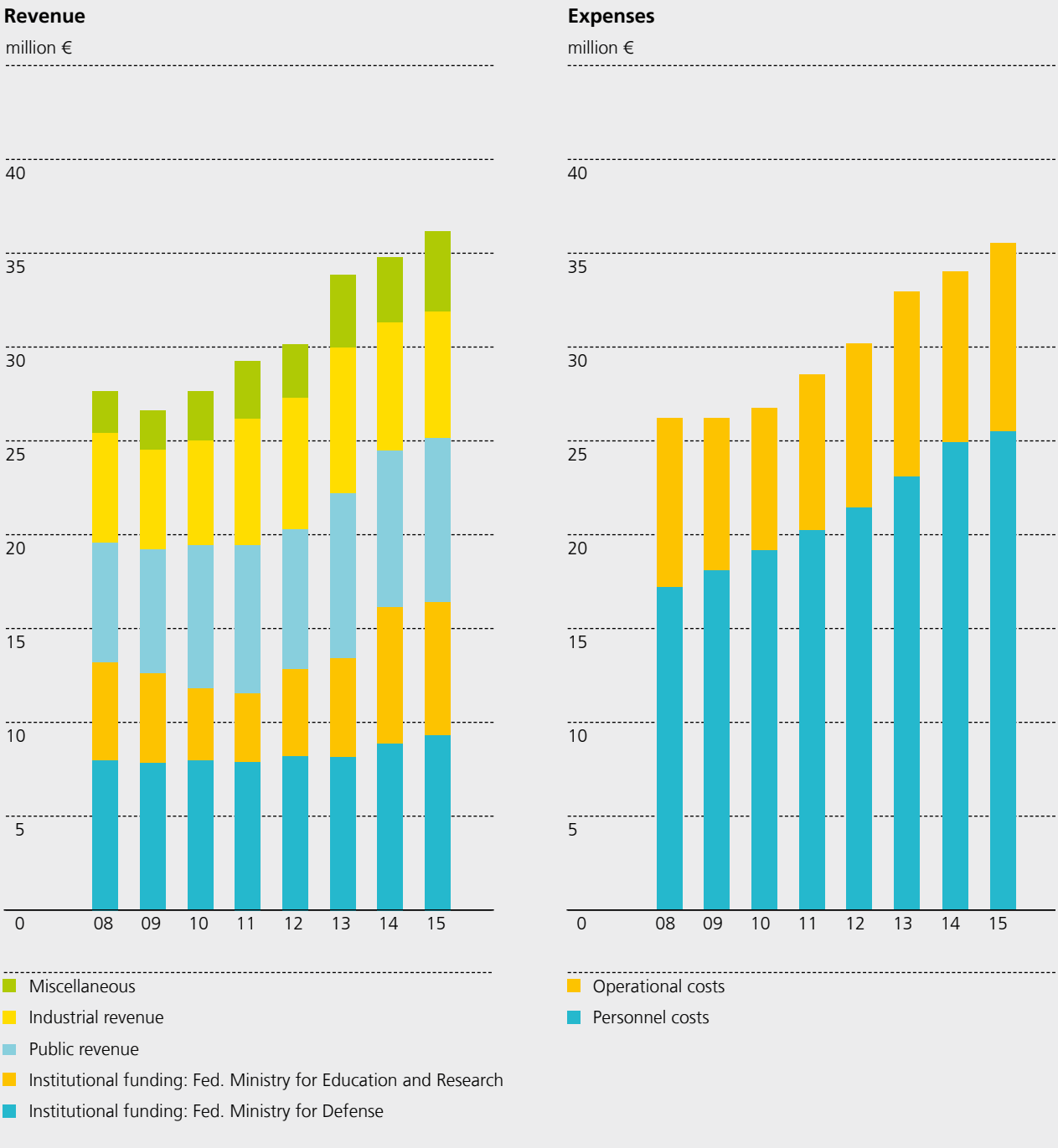
Direct revenues from industry remained constant compared to the previous year, at 6.7 million €. Due to our higher operating expenses, this means that our percentage of industrial revenue has decreased to around 30-31 percent. We still exceed the 30 percent industrial revenue that is required of each Fraunhofer institute, but will place increased emphasis on this important indicator in the coming year. Our mid-term target is to increase our percentage of industrial revenues to over 35 percent. Our revenues from national and European public funding agencies increased in 2015. This funding is provided for applied research in collaboration with industry. Our revenue mix therefore reflects our objectives, with a clear emphasis on applied research and development for and with industrial companies, and a share of around 30 percent for more fundamental and pre-commercial research.

We were consequently in a strong economic position at the end of 2015, and initial indicators at the start of 2016 are also very positive.

Workforce structure of Fraunhofer ICT: Status December 31, 2015.



Financial development of Fraunhofer ICT, 2008 to 2015.



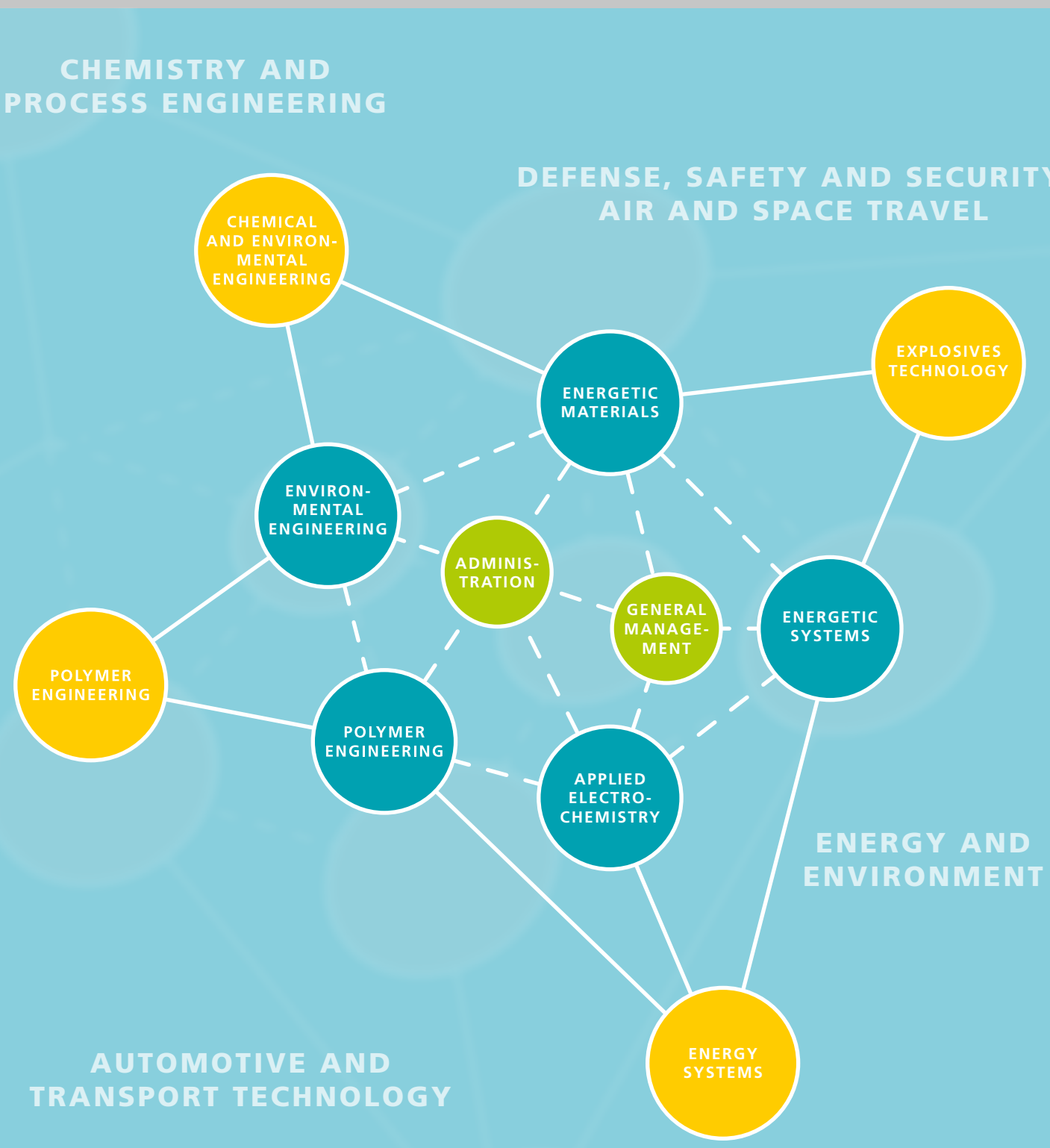
BUSINESS AREAS AND CORE COMPETENCES

The core competences of Fraunhofer ICT are most frequently applied in four market-oriented fields:

- Defense, safety, security, air and space technology
- Automotive and transport industry
- Energy and environment
- Chemistry and process technology

As these business areas overlap more and more frequently, we believe that it is neither necessary nor helpful to list the research topics or even projects that belong in each.

Rather, the business areas serve as a way to outwardly represent our core competences through the markets and market sectors of our industrial and public clients. Many of our competences span several of these business areas. A good example is our battery research and development. Li-ion batteries, for example, are relevant to all four business areas, depending on their specific application. We have consciously decided against appointing a single person to be responsible for each business area, because we value both the market-oriented and the scientific and technological focus of our research topics. These two aspects determine which primary market, which market segments and which path to market entry are selected.


CHEMISTRY AND PROCESS ENGINEERING
DEFENSE, SAFETY AND SECURITY, AIR AND SPACE TRAVEL
CHEMICAL AND ENVIRON-MENTAL ENGINEERING
ENERGETIC MATERIALS
EXPLOSIVES TECHNOLOGY
ENVIRON-MENTAL ENGINEERING
ADMINIS-TRATION
GENERAL MANAGE-MENT
ENERGETIC SYSTEMS
POLYMER ENGINEERING
POLYMER ENGINEERING
APPLIED ELECTRO-CHEMISTRY
ENERGY AND ENVIRONMENT
ENERGY SYSTEMS
AUTOMOTIVE AND TRANSPORT TECHNOLOGY

CORE COMPETENCE
CHEMICAL AND ENVIRONMENTAL ENGINEERING

The core competence "Chemical and Environmental Engineering" is concerned with the capacity to design and implement novel, resource-efficient chemical processes, from the laboratory to the technical scale. It covers the entire process chain from raw material processing, chemical engineering and downstream processing (e.g. separation technologies) through to subsequent process steps such as product refinement (e.g. particle technology) and shaping (e.g. formulation, compounding).

Target parameters of chemical process design and process optimization include performance spectrum, safety, cost-effectiveness and sustainability. Where the performance of processes of fine and specialty chemistry is concerned, high selectivities and yields must be achieved, and specific properties obtained in the target product.

In the search for a cost-effective process, energy-efficient and resource-saving technologies are key topics of research. However, sustainability also requires the minimization of waste streams, the reuse of material fractions and the application of renewable raw material sources.

At Fraunhofer ICT we meet all these requirements through the development of modern process technologies. A successful approach often involves a paradigm shift from discontinuous to continuous processing. For example, continuous processing involving micro chemical engineering is a key element in process design and intensification. It enables processing in new processing windows that cannot be achieved using classical methods, and in which chemical reaction processes can be significantly optimized from a technical and economic perspective. This approach is often used to produce precursors or products in the field of fine and specialty chemistry (e.g. polymers, agrochemicals, pharmaceutical precursors, surfactants, explosives, life science products). A large proportion of this work is carried out exclusively on behalf of industrial customers.

In addition, the application spectrum for continuous processing is being systematically extended to further unit operations and new application fields. These include in particular the intensification of downstream processing (e.g. extraction, phase separation), the size-controlled production of nanoparticles and microcapsules, the development of photochemical syntheses and environmentally-friendly catalytic processes and the intensification of multiphase reaction processes (gaseous/liquid, liquid/liquid).

An important tool in process design is cutting-edge process analysis techniques, some of which have been developed in-house. We have achieved particularly significant progress in the development and adaptation of rapid spectroscopic and calorimetric process analysis. We can use this to monitor chemical processes with a high temporal and spatial resolution. The techniques often reveal kinetic, safety-related and other relevant data for optimized process design.

Continuous multipurpose unit for synthetic processes on the kg/h scale.


UNICON-LF
UNICON-LF

Our comprehensive know-how in the field of explosive technology means that we have advanced competences in the safe design and operation of hazardous processes (explosive or toxic). In the development of high-pressure processes we also benefit from our long-standing experience in the processing of supercritical fluids like water, carbon dioxide and ammonia.

Both in terms of process safety and in achieving a reliable, robust and efficient processing, tailored process monitoring and control is a core element of our development work. Our capacity to scale up synthesis and increase throughput in multipurpose, mini plant and pilot units developed in-house means that we can prepare larger quantities of substances for testing, and examine safety and economic aspects using realistic operating parameters and scales.

To enable the use of renewable raw materials we develop biorefinery processes and evaluate them from a bioeconomic perspective. Biogas processes for energy storage complete the bioeconomic activities of the Fraunhofer ICT.

Biorefinery processes include for example the degradation of wood and other lignocelluloses or fats and oils that are not in competition with food production, in order to obtain platform chemicals (lignins, aromatic and aliphatic secondary products). Continuous processes are used to break down lignocelluloses on a mini-plant scale, and various techniques are employed for the synthesis of platform chemicals from sustainable raw materials.

The economical downstream processing of the product streams is also a frequent point of interest in the development of biorefinery processes. We are therefore currently working on the intensification and energy optimization of classic separation techniques, and the development of continuous and next-generation separation technologies ("Molecular Sorting" project).

In the field of resource efficiency and waste management, sustainability is a core concern in terms of minimizing waste streams, material recycling and the use of renewable raw materials. Additional possibilities for exploiting secondary raw materials have emerged from our expertise in the field of sustainable product design ("Eco-Design"), life cycle assessment (LCA) and the substitution of critical raw materials (for example in the Fraunhofer lighthouse project "Molecular Sorting").

Besides this, Fraunhofer ICT uses environmental simulation to predict product service life, which is an important aspect of sustainable economics. In this process, environmental influences on technical products from a wide variety of sectors – including automotive, automotive supply, electrical and electronic equipment, packaging and construction – are simulated, and the effects are measured in weak-point analyses.

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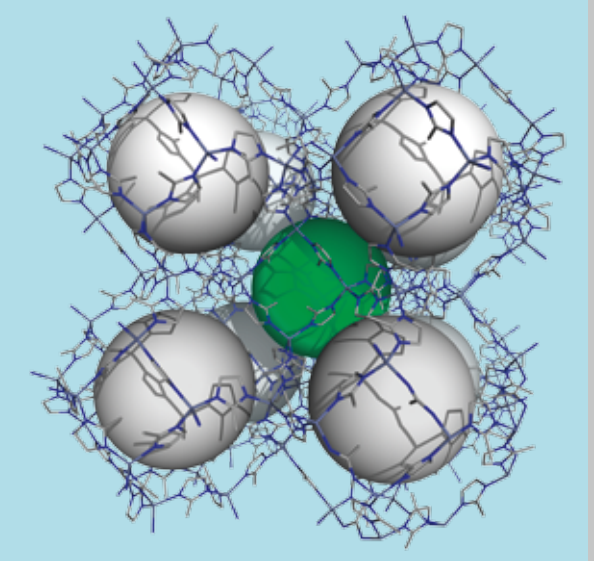

METAL-ORGANIC FRAMEWORKS

Nanoporous "all-rounders"

Metal-organic frameworks (MOFs) are in continuous high demand as a new class of highly porous materials. Their potential applications range from gas storage, gas separation and catalysis through to biomedicine, sensor technology, energy technology and microelectronics. With their large specific pore volumes of up to 3.6 cm^3/g, and their high specific surface areas of up to 7,000 m^2/g, MOFs can significantly outperform conventional porous materials such as activated carbon or zeolites. An important characteristic of MOFs is their modular construction consisting of metallic clusters (nodes) and organic linkers stretched across the framework structure. The targeted combination of organic linkers and metallic nodes allows the development of MOFs with very different material properties.

MOF applications require high-performance production processes

Fraunhofer ICT optimizes MOF syntheses in terms of the reactions and technology involved. Production strategies are developed which enable the scalable and economical fabrication of MOF substances in the kilogram range, in order to make MOFs available for initial industrial applications. For the synthesis of MOF substances like ZIF-8 (zeolitic imidazolate framework 8), which are in high demand, we are making a systematic transition from conventional discontinuous batch production to continuous processing. For this purpose, microprocessing components are used that enable a significant intensification of mass and heat transport in the reactor, as well as a precise control of the residence time. Over multiple development cycles, this has enabled significant process optimizations in terms of throughput, product quality and MOF production costs. Using continuous processing with microfluidic structures, MOF crystals can be obtained with a narrower particle size distribution. It is also possible to tailor the microscopic and macroscopic morphology of the MOF products to a particular application, through precise selection of the processing conditions. Typical synthetic capacities are currently in the range of several kilograms of product per day, in some cases with production costs of significantly less than 1 € per gram of MOF.

Together with the continuous synthesis approach, a reactor concept was selected which offers a high space/time yield and is also scalable. Increases in the throughput are achieved through parallelization of the reaction paths while maintaining the selected dimensions and thus maintaining optimized material and heat transfer conditions and an optimal residence time. By this means a classic problem of upscaling batch processes, namely the altered surface area and volume ratio, is avoided. The result is a consistent product quality, in particular regarding the crystal structure, BET surface area, sorption behavior, particle size and thermal and chemical stability. These quality parameters are recorded continuously during the synthesis and production design, so that process adjustments can be made at an early stage.

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PHOTOS *Left: Typical structure of an MOF compound (here: ZIF-8, consisting of Zn nodes and 2-methylimidazole linkers). Grey and green spheres represent the different pore sizes in the framework. Center: MOF crystals with a narrow particle size distribution (here: ZIF-8, medium particle size of 500 µm). Right: The key element of continuous MOF production: microfluidic reactor structures.*

BIOREFINERY PROCESSES

Over the past few years, Fraunhofer ICT has developed numerous biorefinery processes to break down foliage and waste wood, fats and oils, carbohydrates and residual biomass from biogas units, for the synthesis of high-value intermediate products. These products include plasticizers, lubricants, surfactants, varnishes, polymer precursors and pharmaceutical precursors. In a collaboration with Fraunhofer CBP, which was co-founded by Fraunhofer ICT as an external research group of Fraunhofer IGB, the techniques developed in this project were transferred to industrial mini-plant scale. One particularly important research project ended half a year ago: "Lignocellulose Biorefinery", coordinated by DECHEMA (Society for Chemical Engineering and Biotechnology), and funded by the Agency of Renewable Resources (FNR). The aim of this project was to reuse lignin, cellulose, hemicellulose and further components recovered by breaking down woods. As Fraunhofer ICT has been using organosolv processes (ethanol/water degradation) since 2003 to extract biomass content, it was able to optimize these processes in terms of their chemistry, technology and also cost-efficiency.

The organosolv degradation of wood using ethanol and water can yield a particularly pure, sulfur-free lignin with a relatively low molecule size (1,000-1,500 g/mole). Through specialized processing and the selection of the lignin precipitation method, it is possible to vary the properties of the material. As an aromate-rich raw material, lignin is well suited to the chemical industry. The successful use of lignin as a polymer in resins, polyurethanes and PU foams has frequently been demonstrated.

Through the catalytic breakdown of lignin we achieved high yields of oligomeric aromatic products with large quantities of valuable phenols.

We produced phenol resins, PU foams, polyurethanes and also thermoplastic lignin blends and natural fiber composites, and analyzed their properties. By this means various formulations were developed that had advantageous application-specific property spectra and were also suited to industrial production. Particular attention was paid to the economical use of C5 and C6 sugars released in the degradation of wood. Fraunhofer ICT has over 13 years of extensive experience in the synthesis of 5-HMF (hydroxymethylfurfural) and its secondary product 2,5-FDCA (furandicarboxylic acid) from sugars, which have been used to synthesize a wide variety of polyfuranoates and other polyesters.

The sugar fractions are also easily converted into different polyols for polyurethane or polyester applications. Unlike polyols based on plant oil, the products obtained are mechanically tough.

A sustainability evaluation of the entire process, particularly in the categories of climate change, acidification, eutrophication and cumulated fossil energy requirement, revealed advantages including a 50-80 percent reduction of emissions compared to conventional reference processes.

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PHOTOS *Right: Products of various pulping processes carried out on beech wood. From left to right: lignin (extraction), charcoal (pyrolysis) and oligomer phenols (high-pressure breakdown of lignin).*

FACILITIES AND EQUIPMENT

- Various synthesis techniques for mechanical and chemical processing
- Continuous and discontinuous high-pressure plants for hydrothermolysis, oxidation, hydrogenation, and reactions in subcritical and supercritical water
- High-pressure extraction units for extraction in supercritical carbon dioxide
- Systems to determine solubility and phase equilibrium at high pressures
- Equipment for solution and melt polymerization
- Mobile equipment for reverse osmosis, nano- and ultrafiltration
- Pilot plants for crystallization from solutions via supercritical fluids
- Various distillation units for the thermal separation of high-boiling/sensitive material mixtures (down-flow evaporator, high-temperature vacuum rectification)
- Units for liquid/liquid and solid/liquid extraction
- Microwave processing test stands and synthesis units
- Facilities for the parallel screening of synthetic approaches (including under high pressure)
- Numerous reaction calorimeters (batch and continuous)
- Pilot plant for upscaling into the 50 kg or 50 l range
- Safety boxes for the remote control of reactions in hazardous processes
- Cutting-edge process spectrometer for inline, online or atline process monitoring (UV/Vis, NIR, IR, Raman)
- Extensively equipped chemical, spectroscopic, thermal and mechanical analysis laboratories
- Units for surface analysis, volumetric and gravimetric sorption measurements
- Coating processes
- Spray and melt crystallization processes
- Comminution technology
- Particle size and crystal structure analyses
- Computer tomography
- Environmental simulation units (climate, vibration, destructive gases, corrosion, protection category)
- Facility for the measurement of volatile organic compound (VOC) emissions from materials and components

CORE COMPETENCE
POLYMER ENGINEERING

Since the institute's restructuring in 1994, within its core competence "Polymer Engineering" Fraunhofer ICT has successfully conducted application-related research ranging from polymer synthesis, mechanics of materials, component development and manufacture through to the recycling of polymers and their applications.

In the field of polymer and additive synthesis we mostly focus on the development of so-called conventional polymers such as polyurethanes, polyesters and polyamides. Our main objective is to achieve new properties which will broaden the possible applications of these polymers. Besides polymer synthesis, another key field of research is the synthesis of additives and flame retardants, for example for new biopolymer compounds.

These developments are gaining importance due to changes in the area of feedstocks, and due to regulatory requirements (e.g. REACh). Because of its wide-ranging thematic orientation, the core competence "Polymer Engineering" is able to meet the process requirements that arise from changing material systems.

In the area of compounding and extrusion we concentrate on process and material development. Our research on process development emphasizes extractive compounding processes for emission reduction. Researchers working on material development focus on recycled materials and biopolymers.

In the field of nanocomposites, we investigate the processing and characterization of functional composites using nanoscale additives (in particular carbon nanotubes) in order to obtain materials with improved electrical, mechanical or thermal properties. The thematic field of foam technologies is concerned with particle foam technology and the manufacture of foamed semi-finished products in the direct foam process. In this area, the key fields of research are the optimization of conventional materials – for example in regard to improving thermal insulation – and the foaming of polymers made from renewable raw materials as well as the improvement of surface quality.

Central R&D topics in the field of thermoplastic processing are adapted injection and compression molding processes, e.g. for the integration of local reinforcement elements or inlays for hybrid components, and direct process technologies for LFTs. Thermoplastic foam injection molding is also expected to gain importance, which is why we have already intensified our work in this thematic area.

The research and development focus in the field of thermoset processing is material and process development for the large-scale manufacture of long-fiber-reinforced composite parts, which are needed for structural and surface components. Our competences in this field include, for example, sheet molding compounds (SMC) and PU fiber spraying.

Examples for the application of particle foams.

The research group for high-performance fiber composites works on the further development and industrialization of resin transfer molding processes (RTM) for the large-scale manufacture of components made from thermoset and thermoplastic (T-RTM) high-performance fiber composites. An important element of our research is the production of textile preforms and their handling and subsequent resin infusion under high pressure.

Our competences in the area of microwave and plasma technology include the development of plant and measurement technology for microwaves and microwave-based plasmas as well as numerical simulations of the electromagnetic field. Possible applications include the microwave-based heating of polymers and resin systems and the generation of plasmas for the surface modification of components. Particular attention is paid to the reproducible and controlled application of microwave technology and to efficient plasma processes.

In the area of online process monitoring, spectral and microwave-based measurement methods are used for integrated process and material monitoring and for process control. Our comprehensive know-how in the field of probe technology relates in particular to microwave processes and the application of spectral methods in the UV, VIS, NIR and IR range, as well as in process RAMAN spectroscopy.

In the area of recycling and waste management we develop processes and technologies for the material recovery and reuse of polymers, focusing on concept strategies for recycling composites such as those used in the rotor blades of wind turbines.

Besides the material treatment of compounds, we also seek to improve resource efficiency through chemical treatment, and in particular through the development of solvolysis methods.

Fraunhofer Project Centre FPC for Composites Research

Through the unique cooperation between the Fraunhofer Project Centre for Composites Research (FPC) at Western University in London, Ontario, Canada and Western University itself, the competences of Fraunhofer ICT in the field of fiber composite materials are combined with the know-how of the Canadian university in the fields of material and surface research. The FPC uses cutting-edge technology for the processing of fiber composites. Commissioned research projects, in particular for the automobile industry, can therefore be carried out on an industrial scale. The close cooperation and the exchange of engineers, technicians and researchers allow the comprehensive development of materials and processes tailored to the respective market requirements.

Networks and alliances

Close thematic networking with other Fraunhofer institutes within the Fraunhofer alliances "Building Innovation", "Auto-MOBILE Production", "Lightweight Construction" and "Nano-technology" enables us to provide system solutions from a single source.

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PHOTOS *Left: Seat row on a plane (demonstrator Clean Sky). The polyurethane formulation contains about 23 percent by weight of renewable resources. Right: Microwave antennas for direct CFRP heating.*

JTI CLEAN SKY

Clean Sky is the largest research program so far for the advancement of the European aviation industry. The objective: reducing environmental pollution created by aviation. Within the scope of this project, the aim is to cut CO_2 and nitrogen oxide emissions by 50 and 80 percent respectively, while reducing noise pollution by half. Every year, about 2.2 billion people travel by plane, and the numbers are rising. Twenty years from now there will be twice as many airplanes traversing the sky. However, such a large number of planes will have a negative impact on the environment. Five hundred stakeholders from 24 countries (including 14 Fraunhofer institutes) contribute to JTI Clean Sky, aiming to make flying more environmentally friendly.

Light, lighter, lightest ...

If the aim is to make an airplane environmentally friendly, the most important aspect is its weight: the lighter the plane, the less kerosene it consumes and the lower its emissions. For this reason, manufacturers now tend to replace metal constructions by functional lightweight materials and carbon-fiber-reinforced plastics (CFRP). Researchers at Fraunhofer ICT are therefore working on upscaling manufacturing processes to mass production, for example using optimized processing technology and process control, and a laying head which the Project Group for Functional Lightweight Design FIL at Fraunhofer ICT has developed in collaboration with the company Coriolis. When attached to a commercially available industrial robot, the laying head grips the resin-coated carbon fibers and transfers them to the mold, where they are cured. The company Premium Aerotec will soon be manufacturing the first components of the Airbus A 350 using the new method.

More intelligent planes

Clean Sky also deals with other aspects of aviation. In areas around the Sahara, about 2.5 kg of sand run through an engine during take-off and landing. Above a certain temperature, the sand melts and is deposited on the turbine blades, causing damage. Researchers at Fraunhofer ICT therefore apply microparticles to the thermal insulation layer. These react with the melted sand and raise its melting point, which causes it to solidify and prevents it from binding with the surface.

Environmentally friendly recycling

The recycling of jets has not yet become common practice. However, if aviation is to become more environmentally friendly, there will be no way around it. The EcoDesign project, a Clean Sky subproject under the direction of Fraunhofer ICT, focuses on technologies for recycling airplanes. Compound materials present a great challenge because it is difficult to separate the fibers from the surrounding resin. At Fraunhofer ICT, a method has been developed that enables the separation of fiber-reinforced composites into the components "fiber" and "matrix polymer". An aircraft seat developed at the institute, made from 100 percent recycled polyurethane foam and equipped with a sustainable flame protection system, is the only prototype developed by a research institution that has reached the demonstrator stage for future planes.

On behalf of the aviation industry, and in collaboration with other institutes, Fraunhofer ICT has developed a software-based system for a holistic life-cycle assessment of aircraft interior components (ENDAMI). As early as the planning phase, this user-friendly software provides information on the environmental effects of specific materials and components.

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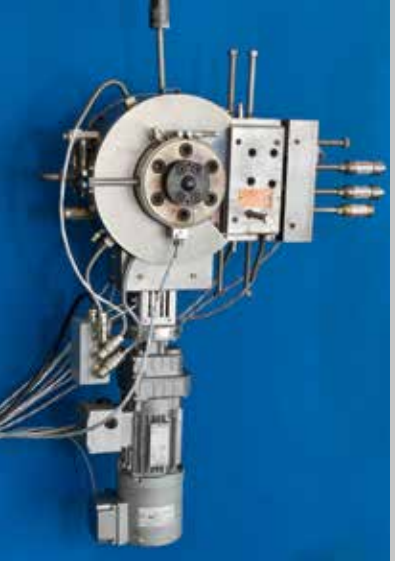

NanoOnSpect

Nanoscale particles can considerably improve the functionality of plastics without the need for large quantities of additives. However, in order to achieve the desired electrical conductivity, the amount of additives and also the particle distribution in the polymer mixture must be exactly right. Within the scope of the EU-funded project NanoOnSpect, a new online characterization tool (the so-called "^{on}BOX") has been developed.

As functionalizing nanoparticles and small product batches is often expensive, the early detection of quality fluctuations and compliance with tolerances are decisive factors in the manufacture of nanocomposites. In this field, the standard approach for the manufacture of "conventional" polymer compounds – offline analytics performed after production – can lead to significant economic losses. Due to the complex correlations between the quantity of particle additives, the dispersion quality, process parameters and the properties of the base polymer, in many cases the targeted properties of the polymer mixture can only be achieved after several testing cycles.

Within the European collaborative project NanoOnSpect, Fraunhofer ICT and its partners have developed an analysis tool that is suitable for industrial application and enables characterization of the targeted properties of polymer nanocomposites during the production process. The tool therefore saves both material costs and time. It also helps to improve the quality of the polymer compounds and to find a stable process window, as process and material optimization can be conducted more quickly and efficiently without waiting for the results of the offline analysis.

The "^{on}BOX" is installed at the end of the compounding extruder, where tailored sensors analyze the polymer mixture while it is still in the molten state. The exact composition, viscosity, conductivity and dispersion quality of a composite made from polymers and nanoparticles can be investigated using, for example, spectroscopy, ultrasound analysis and dielectric characterization.

If required, the data can be processed by the system using neural networks and expert systems, and automated process corrections can be derived.

One key research area in the project was the investigation of correlations between the properties measured in the melt and those measured in the final, solid component.

Besides their application in the characterization of nanocomposites, the online sensors and evaluation methods can also be used for conventional material mixtures.

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PHOTOS *Left: ^{on}BOX for online analysis. Right: Validation of the NanoOnSpect technology at the extrusion line at Addiplast SAS, France.*

FACILITIES AND EQUIPMENT

- Various twin-screw extruders
- Optimized compounding methods
- Gravimetric dosing systems for pellets, powders, fibers, etc.
- Dosing systems for liquid and highly viscous media
- Strand pelletizing, underwater pelletizing and hot die pelletizing
- Several dryers, vacuum pumps and melt filters
- Parallel-running hydraulic compression molding machines for the processing of plastics with 6,300 and 36,000 kN clamping force
- Direct LFT plant
- Hydraulic compression molding machine with intermediate table and 2,400 kN clamping force
- Injection molding units with clamping forces between 350 and 7,000 kN
- Advanced processing technologies for injection molding, injection embossing, multicomponent injection molding, thermoplastic foam injection molding and expansion foaming
- Injection molding compounder with 40 mm twin-screw extruder and 7,000 kN clamping force
- Automated thermoplastic tape-laying process for layups of up to 2 x 2 m^2
- Winding technology for the manufacture of complex loop structures
- Particle foam technology with twin-screw extruder, underwater pelletizing, prefoamer and steam chest molding machine
- Tandem foam extrusion plant for foamed semi-finished products
- Several gas dosing stations
- SMC production line
- Polyurethane processing PU-RIM and PU fiber spraying technology
- Thermoplastic RIM/RTM processing
- Thermoset RIM/RTM technology for high-pressure injection and high-pressure compression RTM process
- Automated preform center for the manufacture of textile preforms
- High-pressure CO_2 foam autoclaves
- Microwave generators with an output of 1.2 to 50 kW at 915 MHz, 2.45 GHz and 5.8-7 GHz
- Microwave-based sensor technology for process monitoring
- Low pressure area plasma with 500 x 1,000 mm application area and 8 x 2 kW power output
- Low-pressure-plasma system with 8 gas channels, ECR-plasma and 1,000 mm plasma length
- Universal testing machine 50 kN
- Impact pendulum and falling dart test
- HDT / Vicat device
- High-pressure capillary viscometer
- Rheotens® device for measuring extensional viscosity
- Melt index testing device
- Plate-plate viscosimeter
- Contact angle measurement device
- Tensiometer
- Differential scanning calorimetry (DSC)
- TG-MS, pyrolysis-GC-MS
- Molar mass determination by gel permeation chromatography (GPC)
- TGA and microwave ashing to determine fiber content
- Light microscopy (incident light and transmitted light), polarization
- (Cryo-)microtome, grinding and polishing machines
- White light interferometer
- Scanning electron microscope with element analysis (SEM-EDX)
- FTIR with ATR attachment, IR microscope
- UV-VIS and NIR
- Flame retardant test stands
- Thermal conductivity measurement device

CORE COMPETENCE
ENERGY SYSTEMS

Sustainable and affordable energy supply and efficient energy management are key areas in current research policy. Fraunhofer ICT's core competence "Energy Systems" concerns energy storage devices for mobile and stationary systems, comprising fuel cells, thermal storage and material energy storage. The institute's electrochemical and chemical know-how has been accumulated over more than 30 years, laying the foundations for the development of efficient and cost-effective storage devices and converters.

New storage possibilities are developed for electrical energy storage, and already known or commercially available batteries are investigated and further developed. The emphasis is on lithium-ion batteries, all-solid-state batteries, redox-flow batteries and so-called post-lithium-ion systems, such as lithium-sulfur or sodium-based batteries. Cells and battery modules are thermally and electrically characterized and simulated, and can therefore be designed for different applications and requirement profiles. Other topics of interest are safety and abuse investigations with gas analysis, post-mortem investigations on cells and battery modules, and the development and validation of safety concepts for operation, transport and storage.

Electrocatalysts for next-generation fuel cells are the focus of work in fuel cell development, and the aim is to increase the power density of liquid-powered systems and, if possible, to avoid the use of platinum as a catalyst. In the development of direct-alcohol fuel cells, emphasis is placed on the investigation of electrochemical processes in fuel cells, for example the oxidation of alcohols and further fuels, and the oxygen reduction reaction. Stacks and fuel cell systems can be designed, constructed and extensively characterized for operation with liquid fuels or hydrogen.

Our work on solid-oxide fuel cells (SOFCs) centers on characterizing their performance under different operating conditions, and on aging tests on membrane materials to investigate the aging mechanism, and the subsequent optimization of new membrane materials. In electrolysis mode the degradation of electrode and support materials can be characterized.

Thermal storage devices based on phase-change materials (PCMs) or zeolites are developed and characterized. This involves basic physical and chemical characterization, including the modeling and characterization of adsorption and desorption phenomena using thermoanalytical methods. The design, construction and testing of sorption storage systems and heat storage systems based on phase-change materials, as well as that of latent heat storage systems, are strongly market oriented and complement our fundamental research activities.

Besides thermal storage, material energy storage also makes an important contribution to the energy economy. Here Fraunhofer ICT is concerned with hydrogen as an energy carrier.

In the field of hydrogen safety, activities relate mainly to the handling and especially the safe storage and transport of hydrogen, the development and performance of specific tests and the evaluation, concept and design of hydrogen storage systems.

Redox-flow battery tanks.

Networks and alliances

Fraunhofer ICT pools its competence with other institutes of the Fraunhofer-Gesellschaft through Fraunhofer networks and alliances. Fraunhofer ICT leads the Battery Alliance (spokesman Prof. Dr. Jens Tübke) and consequently has strong networks within Fraunhofer in the core competence of energy systems. Fraunhofer ICT is also active in the alliances "Energy", "Space" and "Nanotechnolgy" in relation to this topic.

Services and technology transfer

We offer our customers a wide range of development services for electrical and thermal storage devices and electrical converters for different application fields. The design and development of (for example) range extenders or APU fuel cell systems for stationary applications and for vehicles comprises:

- The complete characterization of PEMFC, HT-PEMFC and DMFC fuel cell stacks
- Environmental simulations on stacks and systems, such as climate tests, the effects of vibration etc.
- Development of operating strategies
- Optimization of the interaction between the fuel cell and the battery
- Safety assessments using FMEA methods

We also develop electrocatalysts suitable for use with various fuels (hydrogen, alcohols) in acidic or alkaline fuel cells. To evaluate battery materials like electrodes, separators, electrolytes and conductors, a wide variety of test cells and numerous specially developed measurement cells are available. We offer our customers the following investigations and services:

- Conductivity measurements (electrolyte, membrane, separator)
- Evaluation of electrodes (e.g. NCA, NCM, graphite, Si, LCO, LTO, O_2 cathodes etc.)
- Tests on separators, and investigation of electrolytes (organic, inorganic, ionic liquid, solid ion conductive) to determine performance and stability
- Thermal simulation and cooling concepts for cells, modules and batteries, and development of module and battery concepts with customers' cells
- Research on next-generation systems (e.g. Li-S, air cathodes, Na-systems, solid ion conductors)

In our abuse test laboratories we can conduct thermal, mechanical and electrical safety tests on Li-ion cells and on modules up to 6 kWh. These tests can be planned according to customer specifications, and the gases released can be analyzed qualitatively and quantitatively.

We also conduct inorganic and organic analyses of battery electrolytes and battery electrolyte mixtures with the help of specific head space methods, gas analyses of cells after internal gas formation and post-mortem analyses of failed cells.

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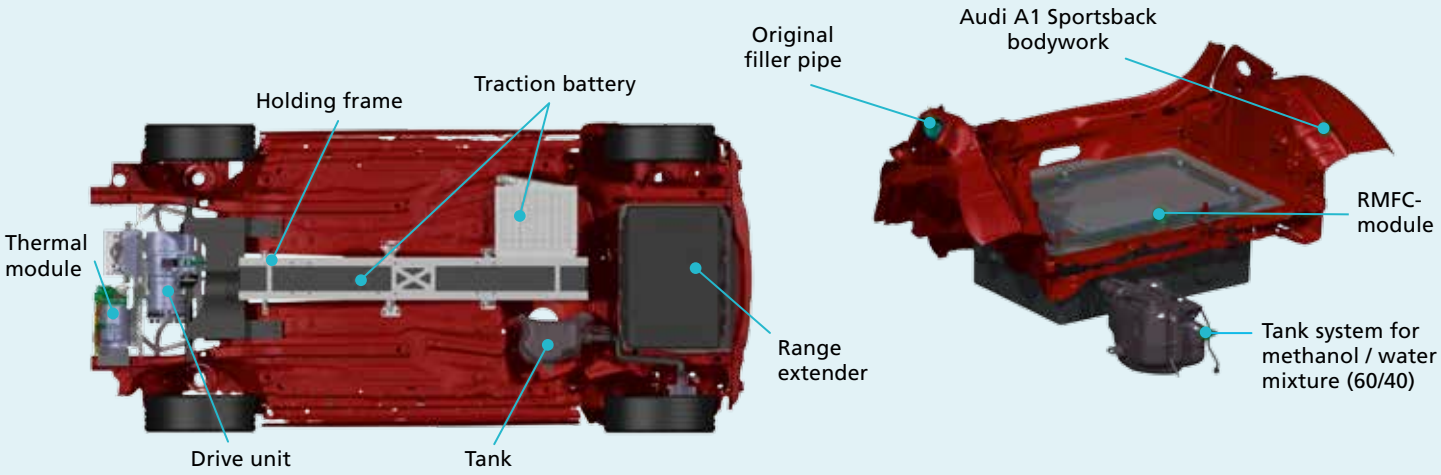

RANGE EXTENDER FUEL CELL

Battery- and fuel-cell-powered systems currently represent two competing approaches that are being developed with the aim of reducing noise and pollution in urban areas, and utilizing renewable energy sources for transport. In battery-electric vehicles the costs of the battery systems are in direct proportion to the energy content of the battery, and therefore increase along with the required vehicle range. Fuel cells, on the other hand, are energy converters, the cost of which depends on the power requirement. In a hybrid construction with a battery and a fuel cell as range extender, the two systems complement each other: the fuel cell offers the advantages of a longer range and rapid refueling.

In various projects, Fraunhofer ICT is consequently developing range extender solutions, from APU systems up to approx. 5 kW, which reduce the demand on the drive battery by supplying energy to additional consumers such as heating, lighting and air conditioning systems, and simple range extenders between 5 kW and 15 kW, which recharge the battery during operation without direct energy supply to the engine, through to larger systems of over 15 kW, which supply the engine directly and can drive the vehicle even if the battery is completely run down.

In the project "Fraunhofer System Research for Electromobility II", which was funded by the Fraunhofer-Gesellschaft, a 5 kW fuel cell module was set up as a range extender for battery electric vehicles, based on a commercially available PEM fuel cell. One aim was to improve air-air starting. In collaboration with other Fraunhofer institutes, a competence cluster was developed within the Fraunhofer-Gesellschaft to tackle this problem and additional challenges in the field of electromobility. A 5 kW range extender fuel cell module based on a HT-PEM from the company Serenergy, using a methanol-water mixture as a fuel, was integrated into a vehicle in the project "REM 2030". In this project, which was funded by the state of Baden-Württemberg and the Fraunhofer-Gesellschaft, an Audi A1 was constructed with a battery-electric drive consisting of a drive battery and a fuel cell range extender module, based on the competence of the Fraunhofer Project Group NAS. The fuel cell module, which had previously only been used for stationary applications, was investigated in terms of its potential application in vehicles and the necessary modifications. Besides the integration of the module into the vehicle and the development of a tank system, it was also possible to recover heat from the fuel cell. Using a driving cycle for regional mobility recorded during the project, a range extension of 150 km was demonstrated for 20 l of fuel. The vehicle battery was also designed and constructed at Fraunhofer ICT, and provides 12 kWh of energy.

The construction of a fuel cell module for an army UUV (unmanned underwater vehicle) was carried out in cooperation with the German Army's Technical Center WTD71 in the project STEHNIS, which aimed to test the application of a fuel cell in a UUV. The developed system provides 3 kW power and runs on hydrogen. A significant challenge in this project was the operation of the fuel cell in a sealed container. No emissions from the system could be released into the environment, as this would have affected the trim of the underwater vehicle.

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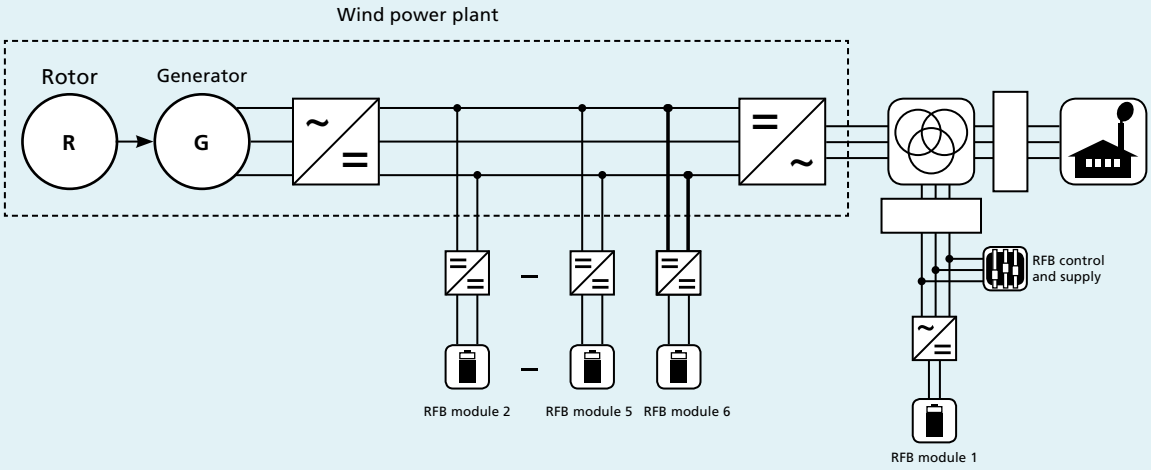
PHOTO *Installation of the range extender fuel cell with tank system, traction battery and thermal module in the Audi A1 Sportsback.*



REDOX-FLOW BATTERY

Redox-flow batteries (RFBs) store electrical energy in chemical bonds, and therefore have a basic similarity to accumulators. However, unlike in classic accumulators, the energy-storing material flows through the cell, absorbing energy (charging) or releasing it (discharging). This requires two redox pairs whose half-cell potentials show the greatest possible potential difference. During charging / discharging, ions are exchanged between the two electrolytes through a proton- or anion-conducting membrane (e.g. NAFION). Electron transfer takes place in the cell at suitable electrodes (for example graphite, C-felt). The energy-storing material is kept outside the cell in tanks, and the amount of energy stored depends only on the volume of the tank, not on the size of the cell. The size of the cell determines its power.

In the context of the "RedoxWind" project, which is funded by the state of Baden-Württemberg and the Fraunhofer-Gesellschaft, a vanadium redox-flow battery (intensively developed and investigated at Fraunhofer ICT) will be scaled up to pilot level. A large-scale redox-flow battery storage device (2 MW / 20 MWh) and a wind turbine (2 MW) will be built on the institute's site. The interaction between the wind turbine and the storage device will provide operational data, and through testing different operating strategies we will be able to determine the most economical way to work with this energy storage device.

Aside from challenges in process engineering, a further important limitation of redox-flow technology is that the materials and the stack construction used are currently too complex and therefore economically uncompetitive.

Another point of interest in the project is the connection of the battery to the energy network and the wind turbine. The battery will be connected directly to the DC circuit of the wind turbine. Unlike a grid connection, this direct connection eliminates the need for an additional conversion step in power transfer, and reduces the investment costs needed for the conversion technology.

The new building for the redox-flow battery, consisting of a battery hall, research and development laboratories and pilot plants, was completed at the end of 2015. The first components of the system, such as 18 electrolyte tanks on the ground floor with a volume of 50 m³ each, are already in place. The battery modules will be constructed from mid-2016 onwards in several development steps, starting with a so-called research module which can later be used for a variety of research projects, even when the entire system is operational.

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PHOTO *Electrical connection of the redox-flow battery to the wind power plant and the ICT electricity grid.*

FACILITIES AND EQUIPMENT

- Charging and discharging stations for battery cells and module characterization
- Argon protective gas boxes
- High-speed and infrared cameras
- Cryostats and climate chambers from -70 °C to 250 °C
- Scanning tunneling microscope (STM) / atomic force microscope (AFM) with 3D imaging in the atom / nano range
- Digital microscopy with magnification factor up to 5,000 in two- or three-dimensional image
- Scanning electron microscope (SEM) / X-ray diffractometer
- RAMAN and infrared (IR) spectroscopy
- Thermal, mechanical and electrical safety testing facility for battery cells and modules up to 6 kWh, fuel cell modules
- Synthesis options for supported electrocatalysts up to gram scale
- Measuring stations for electrochemical catalyst characterization and aging tests on membrane-electrode assemblies
- Differential electrochemical mass spectrometry (DEMS) for the investigation of reaction and corrosion products
- Medium-temperature cell (120 °C – 200 °C) with online mass spectrometry (HT-DEMS)
- Spraying devices for the production of membrane electrode units
- Multiple individual test stands to characterize membrane electrode units for hydrogen PEMFCs, PEM- and AEM-, and HT-PEMC-based direct-alcohol fuel cells, HT-PEMFCs operated on reformate, and PEM electrolysis
- Measuring stand for time-resolved online mass spectrometry measurements to investigate transient processes in automobile PEMFCs, such as corrosion during gear shifting processes or gas exchange of inert gases
- Test stand for the investigation of short stacks (PEMFC, DAFC and HT-PEMFC) up to 500 W
- Test stand for the stack characterization of hydrogen-air and hydrogen-oxygen PEMFCs with operating pressures up to 5 bar
- System development and investigation of components through hardware-in-the-loop method
- Environmental simulation, in particular mechanical tests (vibration, impact etc.) on fuel cell stacks and systems
- Online mass spectrometer with membrane flow unit for analysis of the liquid phase
- Sputtering unit for coating with metals
- Test stand for differential electrochemical mass spectrometry (DEMS)
- Various high-temperature ovens with the possibility to simulate H_2, CO, CO_2 or SO_2-containing atmospheres up to 800 °C

CORE COMPETENCE
EXPLOSIVES TECHNOLOGY

As the only German research institution covering the entire development chain for explosives, from the raw material to the prototype, Fraunhofer ICT offers its long-standing experience to the German Federal Ministry of Defense, the public sector and industrial customers, carrying out investigations into current challenges concerning national and international security.

The institute draws on the competence of its employees in the development of improved chemical energy sources and systems for the German army, and thus helps to ensure the strong decision-making capabilities of the German Federal Ministry of Defense (BMVg). Research is focused on the synthesis, development, characterization, formulation and production of components for rocket propellants, gas generators, gun propellants, explosives and new ignition systems. Further elements in the portfolio are non-lethal capabilities, safety and security systems such as airbag gas generators, munition flame retardancy coatings, and pyrotechnic flares with spectral emissions that spectrally resolving seekers cannot distinguish from those of real engines.

In the development of propellant and explosive systems, performance, sensitivity, handling safety, functionality and environmental compatibility are adjusted and optimized for individual application profiles and requirements. To this end components are synthesized and modified in Fraunhofer ICT's laboratories, new binder systems and formulations are developed and the energetic products are fabricated in the institute's pilot plants. The research group for interior ballistics and detonics then characterizes the reaction behavior, sensitivity and performance data of the products in the laboratory, detonation chamber or open-air testing ranges, up to the kilogram scale. Current research topics include innovative, high-performance rocket propellants for military and civil applications, foamed propellant structures, insensitive high-performance explosives, gel propellants for rockets enabling controllable thrust phases, sensors in rocket engines that enable non-destructive monitoring of the state-of-aging of the propellant, and the compatibility and stability of new energetic materials as well as the prediction of their aging behavior and performance.

A further research competence is the detection of explosives, even in trace amounts, using specific molecular adsorbing agents. So-called terrorist explosives are fabricated at Fraunhofer ICT, evaluated in terms of their handling safety and detectability, and made available for tests. Activities extend to the development of concepts to detect the illicit fabrication of explosives, the design of civil or military security areas and checkpoints, and the standardized evaluation of detection systems, such as those used in airport security, on an international level. A parallel field of work is the development of protective systems against terrorist activities.

Quality assessment of energetic materials – sample insertion into an X-ray diffractometer.

Networks and alliances

In the field of explosives technology and security research, Fraunhofer ICT is a member of the Fraunhofer Group for Defense and Security (VVS), in which seven Fraunhofer institutes and three guest institutes have pooled their competences and work together to coordinate and implement research activities. Fraunhofer ICT is also a member of the Fraunhofer Space Alliance, in which 15 Fraunhofer institutes cooperate to perform applied research in the field of space technology and travel.

With its competence in explosives, the institute is also actively involved in numerous national and international projects (BMVg, EDA, NATO, EU, BMBF, BMI, BMWi). It also works with the BMVg in the context of bilateral research agreements. Operating as a test center on behalf of the German Federal Police, the institute contributes its know-how to international committees aiming to improve aviation security.

Services and technologies

We carry out research in every area of explosives technology, on behalf of the Federal Ministry of Defense, the defense and security industry and the automotive and aerospace sectors. Emphasis is placed in particular on the development, design and evaluation of energetic products and systems, drawing on our chemical know-how and high-safety facilities. We can perform or evaluate every step in the development of pyrotechnic gas generators for safety equipment (for example airbags) for specific applications and according to customer requirements. In our test center for explosive detection systems, we offer the manufacturers of airport scanners and detection devices the opportunity to carry out tests with real explosives and reference substances, in order to evaluate and fine-tune their systems. Furthermore, in cooperation with the German Federal Police, the institute tests and certifies such systems for use in European airports.

We also provide assistance in identifying REACH-compatible substitutes, developing selective sensors for explosives or designing microreaction technology for hazardous processes such as the synthesis of explosive components.

Software-assisted analysis and design tools enable the screening of new propellant and explosive formulations, for example based on their performance and environmental compatibility. Where gun propellants or ballistics are concerned, the system characteristics of weapons and ammunition can be explicitly included.

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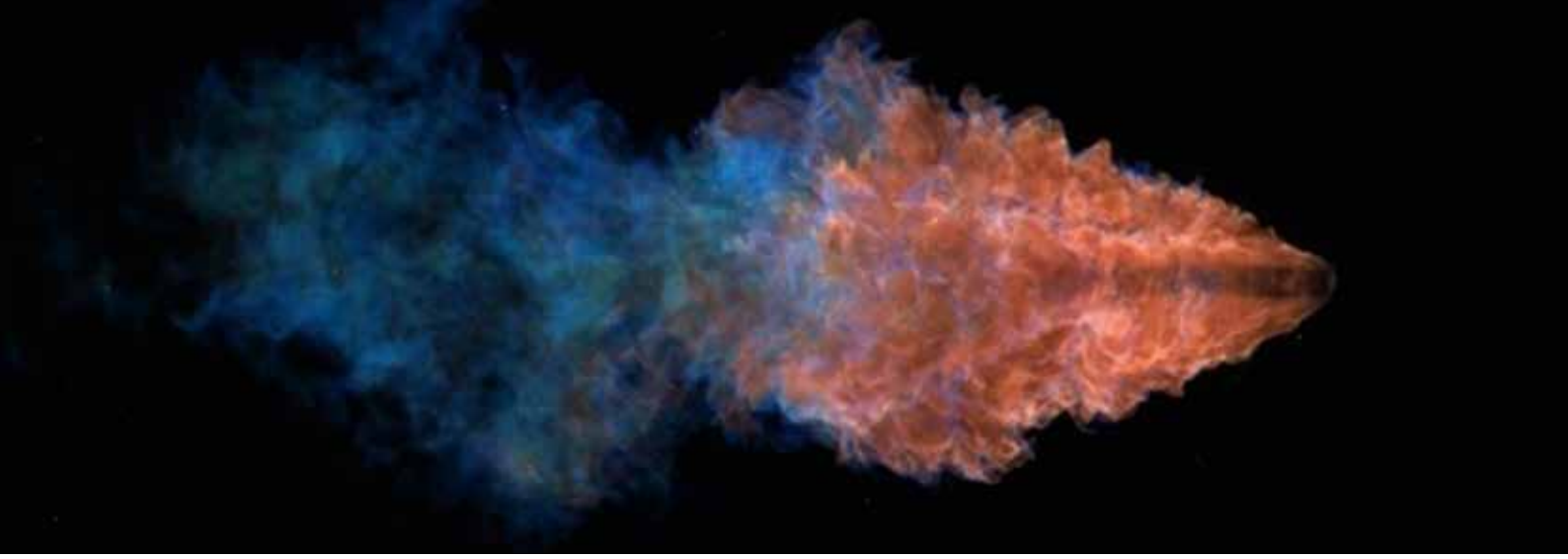

DEVELOPMENT OF PYROTECHNIC FLARES

As a defense against seeker-guided missiles, flares can be released to sidetrack the attacking missile. Pyrotechnic flares play an important role in protecting platforms against infrared-guided missiles. New, spectrally resolving sensors seek out the radiation signature of the targeted platform. To foil such attacks, new flares must be developed which have a radiation signature similar to that of the object to be protected. Current research and development therefore concentrates on spectral flares with an emission that imitates the plume signature of the platform they are protecting.

This includes a material developed by Fraunhofer ICT: pyro-organic compositions. These combine the spectral properties of suitable hydrocarbons during combustion and highly-energetic, pyrotechnic compounds, to achieve maximum radiation performance. In the development of new chemical formulations, the selection and composition of components is determined by thermodynamic calculations as input parameters for a spectral simulation model. This results in numerous chemical formulations, which are fabricated in small quantities as test samples to investigate their combustion and radiation behavior in the combustion laboratory.

The flares are characterized under various (including subatmospheric) pressure conditions, in both open and closed combustion. The evaluation of the flame patterns and the combustion speeds, combustion temperatures and spectral emissions provides design parameters and important insights into the pyrotechnic combustion behavior. This enables selection and optimization of the most promising formulations. After simulation calculations with 3D combustion models, which also determine the temporal variation of emittance, real-scale specimens are produced. Besides the combustion behavior, luminosity and the spectral signature of the substance, a defined, rapid and reliable ignition is a key characteristic of the flare.

It is therefore necessary to develop a suitable pyrotechnic primer composition which enables rapid ignition of the active substance without negatively influencing the radiation behavior of the flare. Testing the effectiveness of real-sized flares is extremely important for the development process. For this purpose Fraunhofer ICT uses a specially developed flare test facility with an adjustable directed air stream to simulate near-realistic test conditions for the new materials. The air stream can be operated according to three speed profiles: helicopter, air freighter and fighter plane. Combustion tests carried out on the flares are recorded by measuring systems with spectral resolution and imaging capability, in order to characterize ignition reliability, the temporal profile of radiation intensity, spectral distribution of radiation and total radiation.

From the chemical formulation of materials to the production of real-size prototypes and their investigation under realistic conditions, Fraunhofer ICT has expertise in every step of the development of new decoy flares.

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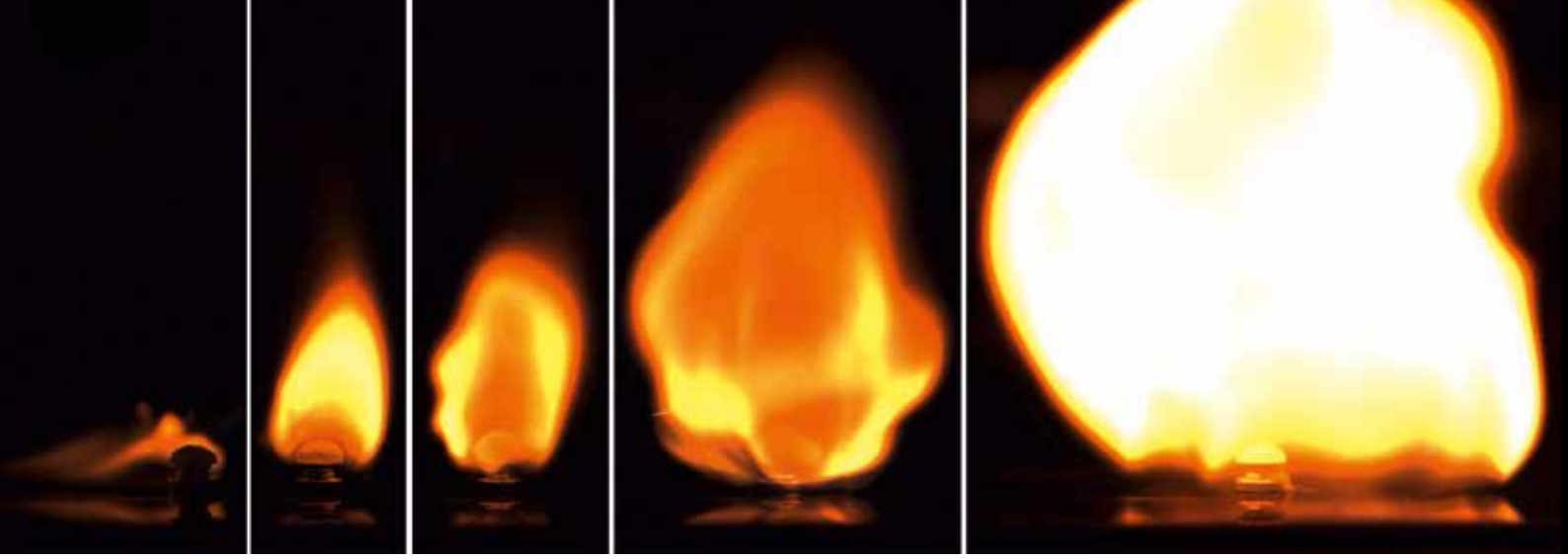
PHOTO *Burning decoy on the flow test stand.*



GEL PROPELLANTS FOR CONTROLLED PROPULSION

The chief advantage of gel-type rocket propellants is the possibility they offer to produce rocket propulsion systems with variable thrust strength and controlled thrust in discrete phases. Comparisons with solid and liquid propellants show that the advantages of each system are combined in gel propellants without their characteristic disadvantages. Unlike solid propellants, propulsion systems with gel propellants can be extinguished and reignited as required. The shear-thinning behavior means that in a state of rest the gel propellant is above its flow point, and therefore reacts flexibly to small shearing effects. The propellant only starts to flow when larger shear forces are applied. This means that the propellant cannot leak from the system, and that in the event of damage the environmental impact is less severe, as the flow of propellant into the soil is slowed significantly. Where diergolic or hypergolic propulsion systems are used, the risk of the fuel mixing with the oxidizing agent is very small even in the event of leaks. Even if the substances come into direct contact with each other, convective mixing processes are negligible, so no potentially explosive mixtures can form.

Fraunhofer ICT has been developing gel propellants since 2001, in the context of a national technology program to investigate the applicability of gel-type fuels and propellants. The products were demonstrated as early as 2009 in test flights. In the context of the "National Gel-Technology Program", suitable fuel and oxidizing gels were developed, and fundamental investigations were carried out concerning their combustion and stability.

Nitromethane, which can be gelled with inorganic gelators (e.g. carbon nanotubes (CNTs)) or organic gelators, is well-suited for use as a fuel for monergolic and diergolic systems. To increase the performance of the gel propellants, energy-providing additives (e.g. metals) can be used in the fuel gel, or the fuel gel can be used in combination with an oxidizing gel within diergolic systems. Using classic oxidizing agents such as hydrogen peroxide or nitric acid, mass-specific impulses of up to 2,600 Ns/kg can be achieved. Under certain conditions even hypergolic ignition (ignition on contact between the fuel and oxidizing agent) is possible, which makes it easier to interrupt and restart propulsion.

Energetic ionic liquids (EILs) with nitrate or dinitramide anions can be used as alternative fuels to replace nitromethane gel, or as performance-enhancing additives to existing gels. These EILs have a very good thermal stability, electrical conductivity, a higher thermal capacity and a very low vapor pressure. This means that no explosive vapor is emitted during transportation, storage or handling. The low glass transition temperatures of under -60 °C also mean that the EILs are very suitable for use as a substitute for hydrazine-based propulsion systems in aerospace applications, and also have a higher performance in terms of the volume- and mass-specific impulse. In combination with hydrogen peroxide solutions, hypergolic systems with short ignition times are also possible.

CONTACT

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PHOTO *Combustion of drops of a gel propellant.*

FACILITIES AND EQUIPMENT

PILOT PLANTS AND TEST STANDS

- Chemical plant and synthesis laboratories for explosives
- Pilot plants for manufacturing and processing of explosive products
- Safety boxes and testing site for explosion and safety investigations
- Test Center for Explosives Detection
- Detonation chamber (up to 2 kg TNT)
- Test stands for guns up to 20 mm caliber
- Combustion test stand for rocket engines and flares
- Combustion stand for investigation of pyrotechnic systems

EQUIPMENT

- Pilot plant for supercritical fabrication of ultra-fine particles
- Microprocessing test stands and synthesis units
- Fluidized bed coater
- Spray crystallization unit
- High-pressure unit for isostatic compression molding
- Detonation chamber (up to 2 kg TNT-equivalent)
- Special kneaders, mixers and presses with explosion protection

ANALYTICAL EQUIPMENT AND LABORATORIES

- Atomic force microscope, field emission scanning electron microscope (FESEM) with variable pressure and energy-dispersive X-ray analysis (EDX)
- Microcomputed X-ray tomography
- Thermoanalytical laboratory, micro- and reaction calorimeter, test stand for aging behavior
- Laboratory for mechanical testing and rheology
- Ballistic and optical facilities to determine combustion speed and measure flame temperature
- Laboratory for X-ray diffractometry
- Laboratory for chromatographic and spectroscopic analysis (IR and RAMAN microscopy)
- Online spectroscopy (UV/VIS/NIR/RAMAN)

FRAUNHOFER ICT-IMM
INSTITUTE FOR MICROTECHNOLOGY MAINZ

We have now been part of the Fraunhofer-Gesellschaft for two years. Our mission is to continually understand our customers' and partners' needs so that we can offer them application- and customer-oriented solutions to ensure their competitiveness. In doing so, we always strive for the responsible handling of new technologies, and for sustainable solutions for society and for the economy. This is reflected by the organization of our competences according to the following priorities: sustainable economy and energy, healthy living, intelligent mobility and civil security.

Our competences in the field of sustainable economy and energy include catalysis, hydrogen technology, biofuels, power-to-gas, heat and refrigeration management, energy storage, fusion energy, continuous synthesis of chemicals and nanoparticles, encapsulation of nanoparticles, photochemistry and electrochemistry. In accordance with the principles of green chemistry, we apply photochemistry as an important synthesis route for future industrial applications.

Photochemistry comprises a class of chemical reactions that are initiated by an interaction with light. They generally take place at room temperature and normal pressure. Such sustainable and environmentally friendly conditions allow access to reagents and secondary products which are difficult to achieve with thermal treatment. Photochemistry is therefore a viable alternative for performing non-thermal syntheses. Up to now it was virtually impossible to perform photochemical reactions on a large industrial scale. It was simply not feasible to irradiate a conventional "vessel" containing any kind of solution with sufficient uniformity for a reasonably controlled process to be carried out. For this reason ICT-IMM has brought its microreactor technology into play, allowing the light to completely penetrate the thin layer of solution on its way through the reactor. Moreover, the precisely defined residence time enables greater control over byproduct formation.

As regards healthy living, our scientists perform research in point-of-care diagnostics, targeted drug delivery,

active ingredient synthesis, functionalization, food safety, neurostimulation and implants. Point-of-care diagnostics is one of the most important future topics when it comes to treating patients fast and individually. However, we also work on fundamental questions of survival in a hostile environment. Long-term manned space missions, like missions to Mars, require dedicated solutions to nourish the astronauts during travel. A promising approach is to biologically convert the astronauts' urine to liquid fertilizer for growing plants (e.g. tomatoes). A system like this is currently being developed by DLR and the University Erlangen-Nürnberg, and will be tested in a satellite mission in 2017. In the framework of this project, Fraunhofer ICT-IMM developed an autonomous ion analysis module which will be used to regularly measure the concentration of various ions in the liquid fertilizer during the space mission. The ion analysis module uses a microfluidic-chip-based electrophoresis concept and is characterized by a lightweight, compact design as well as fully automated sampling and data acquisition. Besides application in space missions, the Fraunhofer ICT-IMM ion analysis module is also suited, for example, to Industry 4.0 applications (i.e. fully-automated monitoring of ionic liquids).

In the field of intelligent mobility our researchers concentrate on reformer systems, exhaust gas cleaning, fuel supply, leakage tests and sensing in a harsh environment. In some cases mobility is closely linked to convenience, for instance in aircrafts. While the aircraft itself is built for a long life, interior furnishings in the cabins are renovated many times over the lifetime, and the same applies to the galleys. Obsolete equipment is replaced by new equipment that usually requires more power – be it high-performance galley appliances or amenities like miniature TVs in each individual seat back rest. However, the power available in an airplane – generated in-flight by the turbines – is a limited resource. For this reason researchers at ICT-IMM have engineered a supplementary power unit in each galley in the shape of a movable trolley cart, in collaboration with Diehl Aerospace GmbH and the German Aerospace Center DLR. The trolley can even facilitate the approval process, since it does not require new approval every time the airplane is retrofitted. The researchers utilized fuel cell technology: fuel cells generate power efficiently and also quietly. Propylene glycol is used as a fuel, as it is a liquid substance which requires no pressurized containers, becomes non-flammable when mixed with water and is non-toxic. Moreover, it is already being used in airplanes as a coolant and de-icing agent.

Last but not least, civil security as a field of competence includes CBRN detection, water analysis and special sensor technology.

Besides these competences, we have a detailed knowledge of some fundamentals on which our 25 years of success have been built: process analytics, process control, simulation, reactor design and development, plant development, microfluidic components, sample preparation, assay development, spectral measurement methods, precision machining, surface modification, analytics and electronic engineering.

You can request the complete Annual Report of Fraunhofer ICT-IMM (German version only) at info@imm.fraunhofer.de.

CONTACT

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PROJECT GROUP FOR NEW DRIVE SYSTEMS NAS

In 2015 the Fraunhofer Project Group for New Drive Systems continued its very positive development. In July 2015 we moved into our new facilities on the East Campus of the Karlsruhe Institute of Technology. We are now based on the ground floor of Building 70.03 in Rintheimer Querallee 2 in Karlsruhe. Here we have 600 m² of office space, and therefore the necessary environment for the continued, sustainable development of our research topics and personnel over the next few years.

Research results in the group's individual competence areas

Besides the extension of our competence areas of design, simulation and testing, in 2015 we conducted several research and development projects. Two of these are described in the following paragraphs:

Drawing on our new competences in selective laser melting (SLM) in the competence group for design, we worked together with an academic research partner to produce a geometrically complex cylinder head based on a tool-less production method. The wide range of combustion engine developments mean that these cylinder heads vary significantly in form, and only small quantities of each type are required. SLM technology therefore has economic as well as technical advantages. In this research area, the project group focuses on the design of components and structures which are tailored to the individual materials and processes, to ensure full exploitation of the possibilities offered by selective laser melting. Simulation studies show that this technology can be used to create geometrically complex components and structures, which can improve the efficiency of combustion engines. For example, the cylinder head can be designed to reduce the local operating temperature at the roof of the combustion chamber.

Validation work carried out by the testing team over the next year will provide experimental proof of these advantages in our single-cylinder research engine.

Another important research topic of the past year was the development of a lightweight cylinder casing for a single-cylinder research engine. Together with an industrial partner, we demonstrated the potential of lightweight design through the application of fiber composites in highly loaded engine components. The aim of the development was the substitution of conventional cast metal alloys by high-performance fiber composites. Our joint development will enable us to produce drive train components that are far lighter than the current state of the art, without additional costs. The project required holistic component development from the design and simulation through to testing and validation. The validation of the components on our engine test stand showed that besides the weight-saving potential (up to 28 percent has been demonstrated so far) significant improvements can be achieved in the acoustic and thermal behavior compared to state-of-the-art light-metal aluminum casting technology. The results were presented in various publications, and form a strong basis for further development work for a multi-cylinder combustion engine for passenger vehicle applications.

Successful operation of a hot gas test stand

A hot gas test stand installed in 2014 enabled the project group to extend its testing competences over the past year. Besides measurements on exhaust turbochargers, the long-term behavior of exhaust gas treatment systems, or residual heat use applications, could now be tested. The test stand was used intensively for research in this thematic area, for a wide variety of testing and validation projects. In 2016 we plan to extend the hot gas test stand with hardware for carrying out thermo-mechanical investigations, which can be used in our upcoming research and development projects.

CONTACT

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AUGSBURG BRANCH FOR FUNCTIONAL LIGHTWEIGHT DESIGN FIL

Increasing environmental awareness and dwindling resources mean that lightweight construction is indisputably one of the most important future technologies in the aviation, automotive and mechanical engineering sectors. High-performance fiber composites will play a particularly important role, as they offer not only the highest lightweight potential but also a wide range of functional advantages. The most important materials in this class are carbon-fiber-reinforced plastics with continuous-fiber reinforcement adjusted to the load. These materials are up to 30 percent lighter than aluminum and up to 60 percent lighter than steel. However, hybrid construction using metal-fiber composites, which combines the advantages of the two materials, also has significant potential in numerous applications.

This significant lightweight potential can only be exploited where new concepts are developed that combine a design suited to the fibers and textiles involved, innovative construction methods, new structural and material concepts and resource-efficient large-scale manufacturing technologies with a high level of automation.

Under the direction of Professor Klaus Drechsler (Professorship for Carbon Composites at the Technical University of Munich) and Professor Frank Henning (Professorship for Lightweight Construction at the KIT Karlsruhe), the Augsburg branch for Functional Lightweight Design is working towards this objective in collaboration with research institutions and industrial partners from the Augsburg region and beyond. The aim is application-oriented research in the field of resource-efficient construction and manufacturing technologies for high-performance fiber composite structures in machinery and vehicle construction. This includes generating fundamental know-how and improving the competitiveness of industrial partners by creating products that are optimized and sustainable over their entire life cycle, and opening up new fields of application. The objectives are reflected in the core activities of the branch, which span the entire value chain.

Activities range from simulation and the calculation of key data for CFRP components, online solutions for process monitoring, material development and characterization through to automatable production processes and a recycling process following the application phase of the corresponding products. A further aspect relevant to all the development areas and subprocesses is sustainability analysis and the identification of optimization approaches in a holistic life-cycle assessment.

The Augsburg branch, which was established in February 2009, now employs 50 research staff, who are assisted in their project work by roughly 20 technicians.

The founding of the Augsburg branch, with the aim of developing it into an independent Fraunhofer Institute, results from the concerted action of numerous institutions in the region and beyond: in particular the Bavarian Ministry of Economic Affairs, the companies involved in the Carbon Composite e. V. network, the Swabian Chamber of Industry and Commerce (IHK), the Institute for Physics at the University of Augsburg and the city of Augsburg.

In 2015, in particular the research area of materials and testing was expanded, and now covers sample preparation as well as the optical, chemical and thermal analysis and the mechanical characterization of fiber composite structures.

The MAI Enviro project, initiated by the Cluster Management, Fraunhofer ICT-FIL and Fraunhofer IBP's Life Cycle Engineering Department, is concerned with the following key questions: How can CFRP components be manufactured in an energy-efficient way? What impact does processing have on the energy consumption? How do the development efforts of the excellence cluster MAI Carbon influence resource efficiency?

It was shown that the primary energy demand from non-renewable resources for the manufacture of CFRP components can be reduced by up to 70 percent through the use of renewable energy and through process optimizations, some of which have already been applied. Comprehensive documentation and further results can be found in the final report of the MAI Enviro project, which was published by Fraunhofer Verlag.

To bring forward the introduction of innovative energy- and material-efficient production and processing technologies for lightweight construction along the whole processing chain, the Federal Ministry of Education and Research (BMBF) initiated the funding program "Energy-Efficient Lightweight Con struction" within the framework "Research for the production of tomorrow". Three of the 15 planned research activities could be completed in 2015: PRESCHE, PulForm and FlexiCut.

The FIL branch is still working on establishing the use of materials according to the load path, in combination with energy- and material-efficient processing.

CONTACT

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PARTICIPATION IN FRAUNHOFER ALLIANCES AND INNOVATION CLUSTERS

The institutes of the Fraunhofer-Gesellschaft work together, collaborating in groups and alliances or pooling different skills in flexible structures as and when needed. This secures their leading position in the development of system solutions and the implementation of comprehensive innovations. The Fraunhofer ICT participates in the groups, alliances and clusters listed below.

FRAUNHOFER GROUPS

Institutes working in related subject areas cooperate in Fraunhofer Groups and foster a joint presence on the R&D market. They help to define the Fraunhofer-Gesellschaft's business policy and act to implement the organizational and funding principles of the Fraunhofer model.

Fraunhofer Group for Materials and Components

- Health
- Energy and environment
- Mobility
- Construction and living
- Machinery and plant engineering
- Microsystem technology
- Safety

Fraunhofer Group for Defense and Security Research VVS

- Security research
- Protection and deterrence
- Reconnaissance and surveillance
- Explosives and safety engineering
- Decision-making support for government and industry
- Localization and communication
- Image processing

FRAUNHOFER ALLIANCES

Institutes, or departments of institutes, with different competences collaborate in Fraunhofer Alliances, in order to carry out joint research work and market implementation in a specific business area.

Fraunhofer autoMOBILE Production Alliance

- Production research for electromobility
- Methodological competence (logistics, planning, quality assurance)
- Vehicle body
- Powertrain
- Electrical / electronic systems
- Interior
- Assembly / vehicle final assembly

Fraunhofer Battery Alliance

- Materials: development, characterization, processing
- Construction concepts: mechanical construction, electrical circuitry, thermal design, safety concepts
- Battery management: monitoring, state-of-health, charging management, functional safety
- Production: processes, plant technology, process control, sustainability
- Simulation: material level, cell, battery
- Testing: functionality, reliability, safety and wear, aging

Fraunhofer Building Innovation Alliance

- Product development
- Construction components and systems, buildings as holistic systems
- Software
- Construction sequences, construction planning, logistics, construction operations, life cycle assessments for buildings
- International projects, construction in different climate zones

Fraunhofer Energy Alliance

- Renewable energy sources: solar energy, biomass, wind energy
- Efficiency technologies: such as block heat and power technologies, preparation of gases, storage and energy conversion technologies, fuel cells
- Buildings and components: energy-saving houses, energy technology for buildings
- Digitalization of the energy economy: collection, analysis, transport and use of energy data
- Energy storage and micro-energy systems: lithium technology for batteries, fuel cell systems

Fraunhofer Lightweight Construction Alliance

- New materials and material composites
- Manufacturing and joining technologies relevant to lightweight construction
- Functional integration
- Design and configuration
- Non-destructive and destructive test methods

Fraunhofer Nanotechnology Alliance

- Nanomaterials / nanochemistry
- Nanooptics / electronics
- Nanobiotechnology
- Modeling and simulation
- Manufacturing technologies, handling

Fraunhofer Space Alliance

- Communication and navigation
- Materials and processes
- Energy and electronics
- Surfaces and optical systems
- Protection technology and reliability
- Sensor systems and analysis

INNOVATION CLUSTERS

Innovations are the lifeblood of our economy. To achieve success on the international market, a company has to be quicker and better at developing new, attractive products than its competitors. There is no shortage of good ideas in our companies, but being able to transform them swiftly into top-quality marketable products is an equally important factor in the business equation. The effectiveness of an innovation process depends decisively on efficient cooperation between development and production. For this reason, it is important for providers of research and development services to work in close collaboration with industry.

Technologies for Hybrid Lightweight Construction – "KITe hyLITE", Karlsruhe

- Development of material systems and production technologies for the implementation of functional lightweight solutions
- Implementation of new technologies in commercially-viable mass production in the automotive sector and in machine construction

Regional Eco Mobility 2030 (REM 2030) – Concepts for the urban mobility of the future

- Local emission-free driving in cities and urban areas
- Drive system technology and lightweight construction
- Driver and mobility assistant systems
- Energy-efficient use of electric vehicles as part of a broader energy-management concept
- New business models for changing mobility needs

TEACHING ENGAGEMENT AND PUBLIC BODY MEMBERSHIP

Teaching activities and public body membership are important tasks of a research institution. In 2015 our employees held numerous lectures at the KIT and various other universities and colleges. In this way we contribute to the skills of scientists and technicians and our own future researchers. In 2015 we also participated in numerous working groups and public bodies, to help shape the future of our research fields.

TEACHING ENGAGEMENT

KARLSRUHE INSTITUTE OF TECHNOLOGY KIT

Institute for Applied Materials – Material Science and Engineering (IAM-WK)
Elsner, Peter
– Polymer Engineering (2 units per week, WT + ST)
– Working techniques for mechanical engineering (2 units per week, ST)

Institute for Vehicle Systems Technology (FAST)
Henning, Frank
– An introduction to lightweight construction (2 units per week, WT)
– Composite materials for lightweight construction (2 units per week, ST)

Institute for Piston Machines (IFKM)
Kollmeier, Hans-Peter
– Drive systems and options for increasing efficiency (1 unit, WT)

Institute for Mechanical Process Engineering and Mechanics
Tübke, Jens
– Materials and methods for electrochemical storage devices and converters (2 units/week, WT + ST)

KARLSRUHE UNIVERSITY OF APPLIED SCIENCES – TECHNOLOGY AND ECONOMICS

Career Service
Fischer, Peter
– Storage of renewable energy – lecture course for international engineering students (2 units, WT + ST)

Department for Electronic and Information Technology
Graf, Matthias
– Sensor laboratory 1 (2 units per week, WT + ST)
Hefer, Bernd
– Chemistry and exercise (2 units per week, ST)
– Physical chemistry (4 units per week, ST)
Pinkwart, Karsten
– Bio-chemosensors III (2 units per week, ST)
– Batteries, fuel cells and super-capacitors (2 units per week, ST, WT)
– Renewable Electricity Generation and Storage (2 units per week, ST)
– Electrochemical Energy Storage Systems (2 units per week, WT)
Urban, Helfried
– Measurement technology for mechatronic students (4 units per week, ST)
– Electronics 3 for sensor system technicians (4 units per week, WT)

Vietnamese–German University (VGU), Ho Chi Minh City (Vietnam)
Hefer, Bernd
– Physical chemistry (4 units per week, WT)

BADEN-WÜRTTEMBERG COOPERATIVE STATE UNIVERSITY (DHBW), KARLSRUHE

Engineering Department, Mechanical Engineering Course
Becker, Wolfgang
– Waves and optics (4 units per week, WT)
Kauffmann, Axel
– Technical mechanics and mechanics of materials I (3 units per week, WT + ST)
– Technical mechanics II (3 units per week, WT + ST)
– Technical mechanics III (2 units per week, WT)
– Material sciences: plastics (2 units per week, WT)
– Plastics processing (3 units per week, ST)
– Laboratory for plastics processing (2 units per week, ST)
– Product lifecycle management (2 units per week, ST)

Mechatronics Course
Bader, Bernd
– New materials (33 units / year)

Safety Engineering Course
Gräbe, Gudrun
– Basics of environmental technology (3 units per week, WT)

Department of Commercial Engineering Studies
Gräbe, Gudrun
– Environmental engineering and recycling (3 units per week, ST)

BADEN-WÜRTTEMBERG COOPERATIVE STATE UNIVERSITY (DHBW), MANNHEIM

Mechanical Engineering Course
Bader, Bernd
– Properties and processing of elastomers (55 units / year)
– Construction with plastics (33 units / year, WT)

HECTOR SCHOOL OF ENGINEERING AND MANAGEMENT

Henning, Frank
– Automotive lightweighting and manufacturing of composites (15 units / year, WT)

TECHNICAL UNIVERSITY NUREMBERG

Applied Chemistry and Process Engineering Department
Küttinger, Michael
– Electrochemical process technology (12 units – lectures and practical work, ST)

Process Engineering Department
Teipel, Ulrich
– Mechanical process engineering (6 units per week, ST and 4 units per week, WT)
– Particle technology (4 units per week, WT)
– Particle engineering (4 units per week, ST)

HELMUT-SCHMIDT UNIVERSITY – UNIVERSITY OF THE FEDERAL ARMED FORCES HAMBURG

Electrical Engineering Department
Pinkwart, Karsten
– Electrochemical energy storage devices and convertors (2 units per week, WS)

ASSOCIATED INSTITUTE OF OSTFALIA UNIVERSITY OF APPLIED SCIENCES

Training Center Wolfenbüttel
Cremers, Carsten
– Fuel cell technology (block lecture, 6 double units, ST)
Tübke, Jens
– Battery technology (block lecture, 6 double units, ST)

UNIVERSITY OF WESTERN ONTARIO, CANADA

Faculty of Mechanical Engineering, Material Science
Henning, Frank
– Lightweight design of vehicles (2 units per week / WT)
– Composite manufacturing (2 units per week / WT)

THEOPRAX-TEAM

Accredited teaching engagement for teacher training events in the German federal states of Rheinland-Pfalz, Hessen and Nordrhein-Westfalen on behalf of the German Federal Ministry of Economics and Technology.

WT = winter term ST = summer term

PUBLIC BODY MEMBERSHIP

Armbrust, Torsten
- Member of the European Working Group on Non-Lethal Weapons (EWG-NLW)

Baumgärtner, Sebastian
- Representative of the Fraunhofer ICT on the platform "Car Body" of the Fraunhofer AutoMOBILE Production Alliance

Becker, Wolfgang
- Member of the Working Group on Process Analysis of the German Chemical Society (GDCh)
- Member of the Scientific Board of the European Materials Research Society (EMRS)

Böhnlein-Mauß, Jutta
- Member of the Working Group IPT-REACH of the Federal Office of the Bundeswehr for Equipment, Information Technology and In-Service Support Bundeswehr
- Member of the Working Group "Interior Ballistics" of the Bundeswehr Technical Center for Weapons and Ammunition

Bohn, Manfred
- Member of the German Chemical Society (GDCh)
- Member of the Bunsen Society for Physical Chemistry (DBG)
- Member of the German Society for Thermal Analysis (GEFTA)
- NATO AC326 /SG1-CNG
- Member of the International Steering Committee of the
- International Pyrotechnics Seminar USA (IPS-USA Seminars)
- Member of the Steering Committee of the International Pyrotechnics Seminar (IPS)
- Organizing committee member of KISHEM, Korea (South)
- Scientific committee member of the NTREM, Pardubice, Czech Republic
- International Confederation for Thermal Analysis and Calorimetry (ICTAC)
- European Society for Thermal Analysis and Calorimetry (ESTAC)
- Member of the Committee of the HFCS-EM (Heat Flow Calorimetry Symposium on Energetic Materials)
- Member of the Committee of International NC Symposium
- Member of the International Advisory Board of the Polymer Degradation Discussion Group (PDDG)

Boskovic, Dusan
- DIN NA 055-03-13 AA, Technical Committee for "Microprocessing Technology"

Bücheler, David
- Member of the AVK Working Group SMC/BMC

Cäsar, Joachim
- DKE 131 "Environmental Simulation"
- DKE 212 "IP Protection Categories"
- Member of the German Engineers' Union VDI e. V.
- Deputy Chair of the Working Group "Effects on Products" in the Air Quality Control Commission (AQCC)
- Member of the Society for Environmental Simulation (GUS) e. V.
- Deputy Director of the Working Group "Particles – Properties and Effects" of the Society for Environmental Simulation
- Various Working Groups of the Society for Environmental Simulation (GUS)
- DAkkS Consulting Expert on Environmental Simulation

Cremers, Carsten
- Member of the NATO STO Task Group SET-206 "Energy Generation for Manwearable/Manportable Applications and Remote Sensors"
- Appointed member of the Joint Technical Committee on Fuel Cells of the Society for Energy and Environment (GEU) of the German Engineers' Union (VDI) and the Power Engineering Society (ETG) of the Association for Electrical, Electronic & Information Technologies (VDE)
- Member of the industrial network of the Working Group "Fuel Cells" in the National Federation of Machinery and Plant Construction (VDMA)
- Member of the Technical Group "Applied Electrochemistry" of the German Chemical Society (GDCh)
- Member of the Electrochemical Society ECS

Diemert, Jan
- Founding Member and Board Member of the European Composites, Plastics & Polymer Processing Platform (ECP4)
- Member of the Polymer Processing Society (PPS)

Eckl, Wilhelm
- Deputy Chairman of the European Working Group Non-Lethal Weapons (EWG-NLW)

Elsner, Peter
- Member of the Advisory Board of the Karlsruhe University of Applied Sciences, Technology and Economy
- Member of the University Council of the Karlsruhe University of Applied Sciences, Technology and Economy
- Member of the Central Committee of the Scientific and Technical Council of the Fraunhofer-Gesellschaft
- Member of the Presidential Council of the Fraunhofer-Gesellschaft
- Chairman of the Fraunhofer Group for Materials
- Deputy spokesman of the Fraunhofer Building Innovation Alliance
- Deputy spokesman of the Scientific Working Group Plastics, WAK
- Member of the National Academy of Science and Engineering, acatech

Eyerer, Peter
- Executive Board of the TheoPrax Foundation
- Member of Jury VIP+, Funding Program of the Federal Ministry of Education and Research, Berlin; Project Executive Agency VDI/VDE-IT
- Consulting Expert for the Project Executive Agency in the German Aerospace Center e. V.
- President of the "Offene Jugendwerkstatt" (youth workshop), Karlsruhe

Fischer, Thomas
- Member of the Working Group "Interior Ballistics" of the-Bundeswehr Technical Center for Weapons and Ammunition
- Member of the Task Group "Interior Ballistics Simulation"
- Member of the Working Group IPT-REACH of the Federal Office of the Bundeswehr for Equipment, Information Technology and In-Service Support Bundeswehr

Gettwert, Volker
- Member of the Technical Group "Construction Chemistry" of the German Chemical Society (GDCh)

Gräbe, Gudrun
- Member of the Water Chemistry Society (professional group of the GDCh)

Henning, Frank
- Deputy Director of SAMPE Deutschland e. V.
- Member of the Federation of Reinforced Plastics (AVK)
- SPE Composites Division (Board of Directors, European Liaison)
- Adjunct Research Professor in the Department of Mechanical and Materials Engineering, Faculty of Engineering of the University of Western Ontario, Canada
- Deputy Chairman of the Executive Board of the Center for Lightweight Construction Baden-Württemberg (LBZ-BW)
- Member of the Advisory Board to the Federal Agency for Lightweight Construction BW

Herrmann, Michael
- Member of the German Crystallography Society (DGK)
- Member of the German Society for Thermal Analysis (GEFTA)

Hübner, Christof
- Elected member of the Scientific and Technical Council of the Fraunhofer-Gesellschaft
- Representative of the Fraunhofer ICT in the Fraunhofer Nanotechnology Alliance

Joppich, Tobias
- Representative of the Fraunhofer ICT in the Lightweight onstruction Center in Baden-Württemberg (LBZ-BW e. V.); assistance to the managing board
- Representative of the Fraunhofer ICT in the Lightweight Construction Agency Baden-Württemberg
- Deputy member of the Working Group "EATC – European Alliance for Thermoplastic Composites" of the German Federation of Reinforced Plastics (AVK e. V.)

Juez-Lorenzo, Mar
- Member of the German Society for Electron Microscopy (DGE)
- Member of the European Microscopy Society (EMS)

Kauffmann, Axel
- Member of the Fraunhofer Building Innovation Alliance

Knapp, Sebastian
- Member of the International Pyrotechnic Society

Kolarik, Vladislav
- Member of the German Society for Corrosion Protection (GfKORR)

Krause, Dörthe
- Member of the Working Group "Entrepreneurial Spirit" of the Federal Ministry of Economics and Technology, Berlin
- Executive Board Member of the Federal Association "Lernort Labor e. V."
- Executive Board Member of the TheoPrax Foundation

Löbbecke, Stefan
- ProcessNet, including Technical Groups for Microprocessing Technology, Reaction Technology, Process Analytics; Working Committee on Reaction Technology for Processes with Complex Safety Issues; Working Group for Metal-Organic Frameworks (Founding Member)
- Member of the German Chemical Society (GDCh), including Working Group "Process Analysis"
- Member of the German Catalysis Society (GECatS)

Marioth, Eric
- Co-coordinator of the Fraunhofer EU-Network and leader of the Working Group "Training"

Möller, Kai-Christian
- Deputy spokesman of the Fraunhofer Battery Alliance
- Member of the Electrochemical Society, Battery Division
- Member of the Technical Group for Applied Electrochemistry of the German Chemical Society (GDCh)
- Member of the project support committee "Working Group for Electrochemical Storage Technology" of the Research Association for Power Transmission Engineering (FVA)
- Member of the Working Board EMOBILITY.AG50 of the DKE (German Commission for Electrical, Electronic & Information Technologies)
- Member of the EU M-era.NET Strategic Expert Group (SEG)
- Study Advisory Council Showcase Electromobility – Second Life for LIBs from EVs
- Scientific Advisor National Platform Electromobility UAG 2.2

Müller, Torsten
- Member of the American Helicopter Society (AHS)

Neutz, Jochen
- Member of the Program Committee and National Contact Point of the European Symposium on Non-Lethal Weapons
- Member of the Project Team for Non-Lethal Capabilities of the European Defence Agency (EDA)
- Chair of the Program Committee AIRBAG 2000 plus
- Member of the NATO Project Group DAT-NLC

Noack, Jens
- International Electrotechnical Commission IEC 61427-2 JWG 82 "Secondary Cells and Batteries for Renewable Energy Storage and Smart Grid Structures"
- International Electrotechnical Commission IEC TC 21 / TC 105 JWG 7 "Flow Batteries"
- German Commission for Electrical, Electronic and Information Technologies (DKE), Working Group 371.0.6 "Flow Batteries"

Parrisius, Martina
- Member of the Expert Advisory Board Neue Oberstufe Berlin

Pinkwart, Karsten
- Fraunhofer Electrochemistry Network (Coordinator)
- Executive Board Member of the Association of Electrochemical Research Institutes (AGEF)
- Member of the Working Group "Energy Technology" of the German Society for Defense Technology (DWT)
- Director of the Working Group "Batteries" of the Society for Environmental Simulation (GUS)
- Member of the Working Group "Electrochemical Processes" of DECHEMA / ProcessNet
- Member of the Technical Group "Applied Electrochemistry" and "Chemistry and Energy" of the German Chemical Society (GDCh)

Reichert, Thomas
- Managing Director of the Society for Environmental Simulation (GUS) e. V.
- President of the European Federation of Clean Air and Environmental Protection Associations (EFCA)
- President of the Confederation of European Environmental Engineering Societies (CEEES)
- Member of the Technical Advisory Board of the Clean Air Commission, Board III on Environmental Quality, in the German Engineers' Union (VDI) and the DIN (German Institute for Standardisation)
- Chairman of the Working Group "Effects on Materials and Environmental Simulation" of the Clean Air Commission at the VDI and DIN
- Chairman of the European Weathering Symposia (EWS)
- Chairman of the CEEES Technical Advisory Board for "Climatic and Air Pollution Effects on Materials and Equipment"
- Chairman of the Organizing Committee for the Ultrafine Particles Symposia (UFP)
- DIN Standardization Committee on Plastics, NA 054-01-04, Resistance Against Environmental Influences

Roeseling, Dirk
- Member of the Liquid Explosive Study Group (ECAC)
- Member of the Trace Explosive Study Group (ECAC)
- Member of the EDS Cabin Baggage Explosive Study Group (ECAC) (formerly ACBS)
- Member of the Vapor Trace Explosive Study Group (ECAC)

Schmidt, Kerstin
- Vorstandsmitglied der Energieavantgarde Anhalt e. V.

Stier, Christian
- Member of the AVK Working Group for Fiber Analysis
- Working Group for Masonry Recycling (Association of research institutions and multiple industrial associations for construction material)
- Molecular Sorting Platform (Exchange and Acquisition Platform within the FhG)

Teipel, Ulrich
- Appointed member of the ProcessNet Technical Committee on Comminution and Classification
- President of the Working Group on Particles – Properties and Effects within the Society for Environmental Simulation (GUS)
- Appointed member of the ProcessNet Technical Committee on Crystallization
- Consulting Expert of the German Federation of Industrial Research Associations (AiF) and the German Research Foundation (DFG)
- Editor Board of the journal "Chemical Engineering & Technology"
- Guest editor of the journal "Chemical Engineering & Technology", thematic area of particle technology
- Director of the Working Group for the Influence on Products, in the Commission on Air Pollution Prevention of VDI and DIN (KRdL)
- Liaison lecturer of the DFG at the Technical University Nuremberg
- Member of the German-Russian Raw Materials Forum
- Member of the Working Group "Limits of development/ sustainability" of the Intern. Seminar on Planetary Emergencies at the World Federation of Scientists / Erice Member of the Scientific Committee of the "PARTEC 2016"

Thoma, Bernd
- Member of the Working Group "Euro-RTM-Group" of the Federation of Reinforced Plastics (AVK)

Tübke, Jens
- Spokesman of the Fraunhofer Battery Alliance
- Member of the Working Group "National Platform for Electromobility" (NPE)
- Member of the Technical Advisory Board of the Forum Electromobility e. V.
- Member of the Electrochemical Society, Battery Division
- Member of the Technical Group for Applied Electrochemistry of the German Chemical Society (GDCh)
- Member of the Society for Chemical Engineering and Biotechnology (DECHEMA e. V.)

Urban, Helfried
- Honorary professor at the Karlsruhe University of Applied Sciences

Weiser, Volker
- Member of the Combustion Institute
- Member of the German Fire Protection Association
- Member of International Pyrotechnic Society
- Board Member of the Workshop on Pyrotechnic Combustion Mechanisms
- Representative in the Fraunhofer Space Alliance

Wurster, Sebastian
- Member of the Working Group for Interior Ballistics
- Member of the Task Group "Interior Ballistics Simulation"

EVENTS AND PARTICIPATION IN TRADE FAIRS AND EXHIBITIONS

EVENTS

February 4-5, 2015
Closing Workshop "Technology Cluster Composites Baden-Württemberg TC²"
Fraunhofer ICT, Pfinztal, Germany

March 25-27, 2015
44th Annual conference of the German Society for Environmental Simulation GUS "Assessment, Simulation and Evaluation of Environmental Influences"
Festhalle, Stutensee-Blankenloch, Germany

April 23, 2015
Girls' Day
Fraunhofer ICT, Pfinztal, Germany

April 23-24, 2015
Product Design in Particle Technology
Fraunhofer Forum, Berlin, Germany

May 18-20, 2015
8th European Symposium on Non-Lethal Weapons
Stadthalle Ettlingen, germany

June 17-18, 2015
Urban Mobility in the Future. Symposium of the Innovation Cluster REM 2030
Konzerthaus, Karlsruhe, Germany

June 23, 2015
16th Defense Engineering Day
Fraunhofer ICT, Pfinztal, Germany

24.-25. Juni 2015
"Energy-Efficient Lightweight Design" – closing event of the projects Flame, PResche, Pulform and Sowema
Fraunhofer ICT, Institutsteil FIL, Augsburg, Germany

June 23-26, 2015
46th International Annual Conference of the Fraunhofer ICT: "Performance, Safety and System Applications"
Congress Centre, Karlsruhe, Germany

November 5, 2015
2nd Young LCA Researcher Workshop Karlsruhe "Modelling End of Life in Life Cycle Assessment"
Fraunhofer ICT, Pfinztal, Germany

PARTICIPATION IN TRADE FAIRS AND EXHIBITIONS

January 19-24, 2015
BAU
Munich, Germany

February 25-27, 2015
Fuel Cell Expo
Tokyo, Japan

March 10-12, 2015
JEC Composites Paris
Paris, France

March 18-19, 2015
VDI-Kunststoffe im Automobilbau
Mannheim, Germany

March 26-29, 2015
expoMED Eurasia
Istanbul, Turkey

April 13-17, 2015
Hannover Messe
Hannover, Germany

May 20-22, 2015
EST Energy Science Technology
Karlsruhe, Germany

June 15-19, 2015
Achema
Frankfurt, Germany

June 15-21 2015
SIAE
Le Bourget, France

September 22-24, 2015
Composite Europe
Stuttgart, Germany

October 13-17, 2015
Fakuma
Friedrichshafen, Germany

PUBLICATIONS

Antes, J.; Loebbecke, S.
Reaction calorimetry in microreactors: fast reaction screening and process design.
In: Proceedings of the 10th European Congress of Chemical Engineering (ECCE10), September 26 – October 1, 2015, Nice, France

Armbrust, T.; Krebs, H.; Neutz, J.; Scholz, P.; Thiel, K.-T., Zettl, S.
Review on ICT's research on scalable non-lethal launchers and projectiles.
In: Proceedings of the 8th European Symposium on Non-lethal Weapons, May 18-20, 2015, Ettlingen, Germany, p. 5-1

Armbrust, T.; Rozincsak, L.; Klemenz, M.; Hummel, M.; Bernewitz, J.; Neutz, J.
Inhibitors for non-lethal anti-material applications.
In: Proceedings of the 8th European Symposium on Non-lethal Weapons, May 18-20, 2015, Ettlingen, Germany, p. 28-1

Armbrust, T.; Krebs, H.; Neutz, J.; Walschburger, E.; Eisenreich, N.
Results for miniaturized directed acoustic arrays.
In: Proceedings of the 8th European Symposium on Non-lethal Weapons, May 18-20, 2015, Ettlingen, Germany, p. 29-1

Becker, W.; Inone-Kauffmann, E.; Eckl, W.; Eisenreich, N.
Near infrared spectroscopy as a tool for in-line control of process and material properties of PLA biopolymer.
Nahinfrarotspektroskopie als Werkzeug für die in-line Kontrolle von Prozess- und Materialeigenschaften von Polylaktid Biopolymeren.
In: tm – Technisches Messen 2015; 82(12): 653–662

Becker, W.; Inone-Kauffmann, E.; Eckl, W.; Eisenreich, N.
Nahinfrarotspektroskopie als Werkzeug für die in-line Kontrolle von Prozess- und Materialeigenschaften von Polylaktid Biopolymeren.
2. Internationale Konferenz zur Optischen Charakterisierung von Materialien OCM-2015, Karlsruhe, March 18-19, 2015

Böhnlein-Mauß, J.; Mitro, D.; Helfrich. M.
Influence of different plasticizers on the glass transition temperature of mixtures with energetic thermoplastic elastomers.
In: Proceedings of the 46th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Performance, Safety and System Applications", June 23-25, 2015, Karlsruhe, Germany, ISSN 2194-4903, p. 127-1 to 127-2

Bohn, M.A.
Assessment of description quality of models by information theoretical criteria based on Akalke and Schwarz-Bayes applied with stability data of energetic materials.
In: Proceedings of the 46th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Performance, Safety and System Applications", June 23-25, 2015, Karlsruhe, Germany, ISSN 2194-4903, p. 6-1 to 6-23

Bohn, M.A.
Stability and characterization of GAP bonded ADN-propellant – the problem of gas formation during curing with isocyanates.
In: Proceedings of the 46th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Performance, Safety and System Applications", June 23-25, 2015, Karlsruhe, Germany, ISSN 2194-4903, p. 116-1

Bordet, F.; Ahlbrecht, K.; Tübke, J.; Ufheil, J.; Hoes, T.; Oetken, M.; Holzapfel, M.
Anion intercalation into graphite from a sodium-containing electrolyte.
Electrochimica Acta, Band 174, August 20, 2015, S. 1317–1323, Elsevier, Philadelphia (USA).

Bošković, D.; Schweikert, W.; Panić, S., Mitrikevičiūtė, U.; Loebbecke, S.
Quantum cascade laser spectroscopy for inline monitoring of microfluidic processes.
ACHEMA 2015, June 15-19, Frankfurt am Main, Germany

Bošković, D., Schweikert, W.; Panić, S., Mitrikevičiūtė, U.; Rossmann, B.; Loebbecke, S.
In-line reaction monitoring of microreaction processes by laser spectroscopy.
In: Proceedings of the European Symposium on Chemical Reaction Engineering, ESCRE 2015, October 27-30, 2015, Fürstenfeldbruck, Germany

Bošković, D.; Mendl, A.; Panić, S.; Loebbecke, S.
Monitoring microfluidic processes with new Infrared and Raman spectroscopic tools.
In: Proceedings of the 4th Asia-Pacific Chemical and Biological Microfluidics Conferences, November 2-4, 2015, Da Nang, Vietnam

Buczkowski, T.; Noack, J.; Fischer, P.; Tübke, J.; Pinkwart, K.
A vanadium redox flow battery for uninterruptible power supply applications.
Proceedings, 6th International Flow Battery Forum, Glasgow, Scotland, 2015

Cremers, C.; Hitscherich, M.; Ries, P.; Niedergesäß, A.; Rau, M.S.; Pinkwart, K.; Tübke, J.
Fuel cells as range extender or auxiliary power unit for electric vehicles.
20th World Hydrogen Energy Conference, WHEC 2014. Vol.1, Gwangju, South Korea, June 15-20, 2014, Red Hook, NY: Curran, 2015, ISBN 978-1-63439-655-4, p. 50-55

Cremers, C.; Jurzinsky, T.; Bach Delpeuch, A.; Niether, C.; Jung, F.; Pinkwart, K.; Tübke, J.
Electrocatalysts for direct alcohol fuel cells.
ECS Transactions, Vol. 69, 2015, p. 795-807.

Deimling, L.; Billeb, G.; Klahn, T.; Schreiber, A.; Zilly, A.
Investigation of rotating pyrotechnical decoy in realistic air flow with authentic ignition.
In: Proceedings of the 46th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Performance, Safety and System Applications", June 23-25, 2015, Karlsruhe, Germany, ISSN 2194-4903, p. 110-1 to 110-4

Eberhardt, A.; Boskovic, D.; Loebbecke, S.
Continuous production of polymeric nanoparticles in microfluidic structures.
ACHEMA 2015, June 15-19, Frankfurt am Main, Germany

Eberhardt, A.; Loebbecke, S.
Applicability of CFD methods for design and optimization of multiphase microreactors.
In: Proceedings of the European Symposium on Chemical Reaction Engineering, ESCRE 2015, October 27-30, 2015, Fürstenfeldbruck, Germany

Fürst, T.; Kuppinger, J.; Huber, T.; Henning, F.
Molding tools without sealing gaskets.
KUNSTSTOFFE international 5/2015 (2015), S. 32-34

Fürst, T.; Kuppinger, J.; Huber, T.; Henning, F.
Presswerkzeuge ohne Dichtung.
KUNSTSTOFFE 5/2015 (2015), S. 62-65

Fürst, T.; Schirmaier, F.; Thoma, B.; Kärger, L.; Henning, F.
Cost-efficient Preforming as leading process step to achieve a holistic and profitable RTM product development.
1st International Composite Congress (ICC); AVK; Stuttgart 2015

Gerber, P.; Happ, A.
A new mixing technology for plastic bonded explosives.
In: Proceedings of the 46th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Performance, Safety and System Applications", June 23-25, 2015, Karlsruhe, Germany, ISSN 2194-4903, p. 133-1 to 133-2

Gettwert, V.; Fischer, S.
Small scale motor tests of ADN/GAP based propellants.
In: Proceedings of the 46th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Performance, Safety and System Applications", June 23-25, 2015, Karlsruhe, Germany, ISSN 2194-4903, p. 104-1 to 104-10

Gettwert, V.; Tagliabue, C.; Weiser, V.; Imiolek, A.
Green Advanced High Energy Propellants for Launchers (GRAIL) – First results on the Burning Behavior of AN/ADN Propellants.
eucass 2015, Kraków, Poland, June 29 – July 3, 2015

Gettwert, V.; Tagliabue, C.; Weiser, V.; Imiolek, A.
Green advanced high energy propellants for launchers (grail) – First results on the burning behavior of AN/ADN propellants.
6th European Conference for Aeronautics and Space Science (EUCASS), Krakow, Poland, June 29 – July 3, 2015, Paper 466

Gettwert, V., Bohn, M. A.; Fischer, S.; Weiser, V.
Performance of ADN/GAP propellants compared to Al/AP/HTPB.
Insensitive Munitions & Energetic Materials Technology Symposium (IMEMTS), May 18-21, 2015, Rome, Italy

Gettwert, V.; Bohn, M.A.; Schubert, H.
Propellants.
In: Ullmann's Encyclopedia of Industrial Chemistry. WileyOnlineLibrary, http://onlinelibrary.wiley.com/book/10.1002/14356007

Günthner, C.; Knapp, S.; Weiser, V.
Multi-modal dense sphere packing algorithm for the simulation of thermites.
In: Proceedings of the 46th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Performance, Safety and System Applications", June 23-25, 2015, Karlsruhe, Germany, ISSN 2194-4903, p. 122-1

Guschin, V.; Becker, W.; Mikonsaari, I.
Kombination von turbidimetrischer Methode mit Verfahren der multivariaten Datenanalyse zur Charakterisierung von Nanokompositen.
In: Tagungsband, 7. Symposium „Produktgestaltung in der Partikeltechnologie", April 23-24, 2015, Berlin, Stuttgart: Fraunhofer Verlag, 2015, 566 S., ISBN: 3-8396-0877-5, ISBN: 978-3-8396-0877-7

Guschin, V.; Marioth, E.
PROCYCLE: Analyse und toxikologische Bewertung von Stäuben aus Recycling- und Verwertungsprozessen von Nanocomposites und Strategien zur Gefährdungsminimierung.
DANA 2.0 NanoCare Clustertreffen. May 20, 2015, Dechema e. V., Frankfurt

Guschin, V.; Becker, W.; Mikonsaari, I.; Weiss, P.
Online-Charakterisierung von Nanokompositen.
11. Kolloquium Prozessanalytik; Wien, Austria; December 1-2, 2015

Guschin, V.; Knapp, S.; Wehner, H.; Haspiel, F.; Pappert, S.; Eckl, W.
Application of thermochemical sorption material to control the moisture of ammunition.
In: Proceedings of the 46th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Performance, Safety and System Applications", June 23-25, 2015, Karlsruhe, Germany, ISSN 2194-4903, p. 128-1 to 128-6

Hagen, M.; Hanselmann, D.; Maca, R.; Gerber, D.; Ahlbrecht, K.; Tübke, J.
Lithium-sulfur cells: the gap between the state-of-the-art and the requirements for high energy battery cells.
Adv. Energy Mater. (2015), 1401986, http://dx.doi.org/10.1002/aenm.201401986

Hakspiel, F.; Pappert, S.; Teipel, U.; Eckl W.
Experimental determination of heat-dynamics of a zeolite bedding.
Energy, Science and Technology 2015. The energy conference for scientists and researchers. Book of Abstracts, EST, Energy Science Technology, International Conference & Exhibition, May 20-22, 2015, Karlsruhe, Germany, URN: urn:nbn:de:swb:90-442903, EVASTAR ID: 1000044290, Verlag Karlsruhe, KIT

Hakspiel, F.; Pappert, S.; Teipel, U.; Eckl, W.
Experimental determination of heat-dynamics of a zeolite bedding in a plug flow reactor.
27. Deutsche Zeolith-Tagung mit dem Jahrestreffen Fachtagung Adsorption, February 25-27, 2015, Carl von Ossietzky Universität Oldenburg, Germany

Hangs, B.; Link,L.; Henning, F.:
Characterization of complexly warped components made from locally reinforced UD-tape laminates.
12th International Conference on the Mechanical Behavior of Materials (ICM12); KIT; Karlsruhe; 2015

Heintz, T.; Leisinger, K., Roßmann, C.
Scale-up approaches for the ADN-prilling process by emulsion crystallization.
In: Proceedings of the 46th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Performance, Safety and System Applications", June 23-25, 2015, Karlsruhe, Germany, ISSN 2194-4903, p. 105-1 to 105-2

Herr, T.
Neue Elektrolyte zur Steigerung der Energiedichte einer nicht-wässrigen Vanadium-Acetylacetonat-Redox-Flow-Batterie.
In: Wissenschaftliche Schriftenreihe des Fraunhofer ICT, Band 64, Fraunhofer Verlag, 2015, ISBN 978-3-8396-0920-0

Herrmann, M.; Förter-Barth, U.; Keicher, T.
Microstructure of energetic thermoplastic elastomers investigated by means of x-ray diffraction.
In: Proceedings of the 46th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Performance, Safety and System Applications", June 23-25, 2015, Karlsruhe, Germany, ISSN 2194-4903, p. 53-1 to 53-10

Herrmann, M.; Kempa, P.B.; Altenburg, T.; Polyzoidis, A.; Piscopo, C.G.; Löbbecke, S.
Charakterisierung von metall-organischen Gerüststrukturen (MOF) mit Hilfe der Röntgenbeugung.
In: Teipel, U. (Hrsg.), Produktgestaltung in der Partikeltechnologie, Band 7, Fraunhofer Verlag, Stuttgart, 2015, ISBN 978-3-8396-0677-7, S. 489-495

Herrmann, M.; Bohn, M.A.
Aging of explosive crystals investigated by x-ray diffraction.
Advances in X-ray Analysis, Vol. 58, Proc. 63rd Annual Conf. on Application of X-ray Analysis, 2015, ISSN 1097-0002

Herrmann, M.; Förter-Barth, U.; Bohn, M.A.; Krause, H.; Koch, M.; Arnold, W.
Microstructure of the PBX KS32 after mechanical loading.
Propellants Explos. Pyrotech. 2015, Vol. 40, p. 880–885

Herrmann, M.; Heintz, T.; Gerber, P.; Fischer, T.
Insensitive, high-performance explosives.
In: Military Science Research, Annual Report 2014, Defence research for the German Armend Forces, Federal Ministry of Defence, Bonn, Germany, August 2015

Herrmannsdörfer, D.; Herrmann, M.; Heintz, T.
New approaches to the CL-20/HMX cocrystal a less sensitive high power explosive.
In: Proceedings of the 46th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Performance, Safety and System Applications", June 23-25, 2015, Karlsruhe, Germany, ISSN 2194-4903, p. 107-1 to 107-9

Hohmann, A.; Schwab, B.; Wehner, D.; Albrecht, S.; Ilg, R.; Schüppel, D.; v. Reden, T.
MAI ENVIRO. Vorstudie zur Lebenszyklusanalyse mit ökobilanzieller Bewertung relevanter Fertigungsprozessketten für CFK-Strukturen.
Stuttgart: Fraunhofer Verlag, 2015, 116 S., ISBN 978-3-8396-0929-3, ISBN 3-8396-0929-1

Hörold, A.; Schartel, B.; Trappe, V.; Gettwert, V.; Korzen, M.
Protecting the structural integrity of composites in fire: intumescent coatings in the intermediate scale.
Journal of Reinforced Plastics and Composites, Vol. 34, Iss. 24, p. 2029-2044, 2015

Imiolek, A.; Weiser, V.; Kelzenberg, S.; Roth, E.; Lity, A.
Self-propagating combustion synthesis of nanostructured particles.
In: Proceedings of the 46th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Performance, Safety and System Applications", June 23-25, 2015, Karlsruhe, Germany, ISSN 2194-4903, p. 120-1 to 120-10

Jurzinsky, T. Cremers, C. Jung, F. Pinkwart, K. Tübke J.
Development of materials for anion-exchange membrane direct alcohol fuel cells.
International Journal of Hydrogen Energy, Vol. 40, 2015, p. 11569-11576

Jurzinsky, T.; Bär, R.; Cremers, C.; Tübke, J.; Elsner, P.
Highly active carbon supported palladium-rhodium PdXRh/C catalysts for methanol electrooxidation in alkaline media and their performance in anion exchange direct methanol fuel cells (AEM-DMFCs).
Electrochimica Acta, Vol. 176, 2015, p. 1191-1201

Karcher, M.; Henning, F.; Chaloupka, A.; Schmölzer, S.; Moukhina, E.
Bestimmung der Aushärtekinetik eines 2-stufig aushärtenden Epoxidharzes zur Herstellung von Hochleistungsfaserverbunden.
Zeitschrift Kunststofftechnik des WAK (2015), Journal of Plastics Technology

Karcher, M.; Henning, F.; Gerlitzki, M.; Thoma, B.
Evaluation of a new "inlineprepreg" process approach to established processes for the manufacturing of structural components out of carbon fibre reinforced plastics.
SPE Automotive Composites Conference & Exhibition (ACCE), September 9-11, 2015, 46100 Grand River Avenue, Novi, MI 48374

Karcher, M.; Hangs, B.; Bücheler, D.; Starke, J.; Rausch, J.; Ebli, S.; Krämer, J.; Müller, T.
MAI qfast – Assessment and direct comparison of various fiber reinforced systems based on generic structures.
1st International Composites Congress (ICC), Stuttgart, September 21-22, 2015

Keckl, C.
Verkürzung von Prozessketten am Beispiel des Direkt-SMC-Prozesses.
Leipzig, 4. Kongress Ressourceneffiziente Produktion

Kempa, P.B.; Herrmann, M.
Pair distribution function analysis of ammonium nitrate – evaluation of measuring systems for energetic materials.
In: Proceedings of the 46th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Performance, Safety and System Applications", June 23-25, 2015, Karlsruhe, Germany, ISSN 2194-4903, p. 102-1 to 102-10

Keßler, A.; Wassmer, C.; Knapp, S.; Weiser, V.; Sachsenheimer, K.; Raab, A.; Langer, G.; Eisenreich, N.
Effects of Radiation on the flame front of hydrogen air explosions.
In: International Conference on Hydrogen Safety, ICHS2015. October, 19-21 2015 – Yokohama (Japan)

Klahn, T.; Zilly, A.; Schreiber, A.; Deimling, L.
Recomat-spectrometric application.
In: Proceedings of the 46th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Performance, Safety and System Applications", June 23-25, 2015, Karlsruhe, Germany, ISSN 2194-4903, p. 109-1 to 109-6

Knapp, S.; Eisenreich, N.; Kelzenberg, S.; Weiser, V.
Hot-spot modelling of propellant regression part 2.
In: Proceedings of the 46th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Performance, Safety and System Applications", June 23-25, 2015, Karlsruhe, Germany, ISSN 2194-4903, p. 121-1 to 121-2

Knapp, S.; Weiser, V.; Kelzenberg, S.; Roth, E.; Eckl, W.
Hot-spot modelling of thermite mixtures.
Europyro 2015 – 41st International Pyrotechnics Seminar; Toulouse, Frankreich; May 4-7, 2015; 181-190

Kröber, H.; Böhnlein-Mauß, J.
Preparation and characterization of foamed propellants using supercritical fluids.
In: Proceedings of the 46th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Performance, Safety and System Applications", June 23-25, 2015, Karlsruhe, Germany, ISSN 2194-4903, p. 115-1 to 115-5

Kuchenreuther-Hummel, V.; Rozincsak, L.; Neutz, J.
Thermogravimetric study on the reaction of magnesium and aluminum in nitrogen.
In: Proceedings of the 46th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Performance, Safety and System Applications", June 23-25, 2015, Karlsruhe, Germany, ISSN 2194-4903, p. 112-1 to 112-9

Leidinger, M.; Rieger, M.; Weishaupt, D.; Sauerwald, T.; Nägele, M.; Hürttlen, J.; Schütze, A.
Trace gas VOC detection using metal-organic frameworks as pre-concentrators and semiconductor gas sensors.
Procedia Engineering, 2015, 120, 1042–1045. http://doi.org/10.1016/j.proeng.2015.08.719

Loebbecke, S.; Tuercke, T.; Mendl, A. Boskovic, D.; Antes, J.
Processing of hazardous and energetic materials in microreactor plants.
ACHEMA 2015, June 15-19, Frankfurt am Main, Germany

Loebbecke, S.; Antes, J.; Bošković, D.
Recent advances in spectroscopic and calorimetric process analysis for microfluidic processes.
In: Proceeedings of the 20th international COMS Conference, September 14-16, Krakow, Poland

Löbbecke, S.; Polyzoidis, A.; Piscopo, C.G.; Schwarzer, M.
Synthesis and manufacture of mofs: challenges and recent developments.
In: Proceeedings of the Workshop "Metal-Organic Frameworks for Industry: Up-scaling and Shaping", October 15, 2015, Dresden, Germany

Manis, F.; Wölling, J.; Drechsler, K.
Damage behaviour of fibre reinforced materials induced by high temperature oxidation for optimisation of thermal recycling routes.
In: 20th Symposium on Composites, pp. 1088-1095, 2015

Materna, M.; Keßler, A.
Characterization of sibex in 1,5m³ ICT detonation tank.
In: Proceedings of the 46th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Performance, Safety and System Applications", June 23-25, 2015, Karlsruhe, Germany, ISSN 2194-4903, p. 126-1 to 126-11

Mendl, A.; Löbbecke, S.; Köhler, J.M.
SERS analytical module for high throughput screenings in droplet-based microfluidics.
In: Proceedings of 3rd International Conference on the Implementation of Microreactor Technology in Biotechnology; May 10-13, 2015, Opatija, Croatia

Mendl, A.; Löbbecke, S.; Köhler, J.M.
SERS analytical module for high throughput screenings in droplet-based microfluidics.
In: Implementation of microreactor technology in biotechnology. 3rd international conference, CIP – Cataloguing-in-Publication National and University Library of Slovenia, Ljubljana, ISBN 978-961-6756-58-7

Mitro, D.; Böhnlein-Mauß, J.
The influence of different nitrocelluloses on the interaction in a binder-plasticizer system.
In: Proceedings of the 46th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Performance, Safety and System Applications", June 23-25, 2015, Karlsruhe, Germany, ISSN 2194-4903, p. 132-1

Moser, K., Holzer, A., Bergmann, B.
Environmentally-friendly, heat-resistant profiles – Development of materials tailored to process.
Kunststoffe international, 9 (2014); 3 S, 77-79, Carl Hanser Verlag, München

Moser, K.; Holzer, A.; Bergmann, B.; Diemert, J.
Optimized profile extrusion processes for biopolymer blends.
Polymer Processing Society Conference 2015, Polymer Processing Society, Graz, Austria, September; 2015

Moser, K.; Holzer, A.; Bergmann, B.; Diemert, J.; Elsner, P.
Optimization of PLA compounds using novel nucleating agents and plasticizers.
Polymer Processing Society Conference 2015, Polymer Processing Society, Graz, Austria, September, 2015

Mußbach G.; Bohn, M.A.
Non-destructive method to follow ageing of solid propellant in rocket motors.
In: Proceedings of the 46th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Performance, Safety and System Applications", June 23-25, 2015, Karlsruhe, Germany, ISSN 2194-4903, p. 119-1 to 119-9

Nägele, H; Pfitzer, J.; Ziegler, L; Inone-Kauffmann, E; Eisenreich, N.
Application of lignin materials and their composites (lignin applications in various industrial sectors, future trends of lignin and their composites).
In: Faruk, O.; Sain, M. (Hrsg.) Lignin in Polymer Composites, 1st Edition, Elsevier Inc., 2015, ISBN 978-0-323-35565-0, S. 233-244.

Nardai, M.M.; Bohn, M.A.
Cohesion properties in pbx and composite propellants – computational results and experimental aspects.
In: Proceedings of the 46th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Performance, Safety and System Applications", June 23-25, 2015, Karlsruhe, Germany, ISSN 2194-4903, p. 19-1 to 19-16

Nardai, M.M.; Bohn, M.A.
Cohesion properties in pbx and composite propellants – computational results.
In: Proceedings of the 46th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Performance, Safety and System Applications", June 23-25, 2015, Karlsruhe, Germany, ISSN 2194-4903, p. 113-1 to 113-12

Noack, J.; Roznyatovskaya, N.; Herr, T.; Fischer, P.
The chemistry of redox-flow batteries.
Angew. Chem. Int. Ed. 54 (34), S. 9776–9809, 2015

Noack, J.; Roznyatovskaya, N.; Herr, T.; Fischer, P.
Die Chemie der Redox-Flow-Batterien.
Angew. Chem. 127 (34), S. 9912–9947, 2015

Noack, J.; Tübke, J.; Pinkwart, K.
Dithionite / air direct ion liquid fuel cell.
Journal of Power Sources, 286, 232-238, 2015

Piscopo, C.G.; Polyzoidis, A.; Schwarzer, M.; Loebbecke, S.
Stability of UiO-66 under acidic treatment: Opportunities and limitations for post-synthetic modifications.
Microporous and Mesoporous Materials 208 (2015) 30-35, http://dx.doi.org/10.1016/j.micromeso.2015.01.032

Piscopo, C.G.; Polyzoidis, A.; Schwarzer, M.; Loebbecke, S.
Stability of uio-66 under acidic treatment: Opportunities and limitations for post-synthetic modifications.
In: Proceedings of the 2nd Euro-Asia Zeolite Conference, January 25-28, 2015, Nice, France

Piscopo, C.G.; Polyzoidis, A.; Schwarzer, M.; Löbbecke, S.
Study of UiO-66 stability under acidic treatment: synthetic and post-synthetic investigations.
In: Proceedings of the 27. Deutsche Zeolith-Tagung, February 25-27, 2015, Oldenburg, Germany

Polyzoidis, A.; Schwarzer, M.; Loebbecke, S.; Piscopo, C.G.
Metal organic frameworks (MOFs): Time for a breakthrough in material supply. Advantages and perspectives of MOF synthesis in flow.
Chimica Oggi/Chemistry Today, 05/2015, 33(3), pp. 65-68

Polyzoidis, A.; Piscopo, C.G.; Löbbecke, S.
Nanoporöse Multitalente.
Chemie&More, 04.2015, pp. 12-15

Polyzoidis, A.; Altenburg, T.; Piscopo, C.G.; Schwarzer, M.; Loebbecke, S.
Fast and continuous synthesis of UiO-66 by employing microreaction technology.
In: Proceedings of the 2nd Euro-Asia Zeolite Conference, January 25-28, 2015, Nice, France

Polyzoidis, A.; Altenburg, T.; Piscopo, C.G.; Schwarzer, M.; Loebbecke, S.
Synthesis of MOFs at technical scale applying batch and continuous processes.
In: Proceedings of the 27th "Deutsche Zeolith-Tagung", February 25-27, 2015, Oldenburg, Germany

Polyzoidis, A.; Altenburg, T.; Schwarzer, M.; Loebbecke, S.; Kaskel, S.
Continuous microreactor synthesis of ZIF-8 with high space-time-yield and tunable particle size.
Chem. Eng. J. 2016, 283, pp. 971-977

Quaresma, J.; Keicher, T.; Piñeiro, M.; Deimling, L.; Campos, J.; Krause, H.
Deflagration-detonation experiments of sensitized mixtures of ammonium or urea nitrates and an energetic thermoplastic elastomer.
In: Proceedings of the 46th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Performance, Safety and System Applications", June 23-25, 2015, Karlsruhe, Germany, ISSN 2194-4903, p. 25-1 to 25-16

Rapp, F.; Mack, C.; Elsner, P.
Geschäumte Kunststoffe – Trends und Herausforderungen.
WAK Jahresmagazin Kunststofftechnik 2015

Rapp, F.; Schneider, A.; Elsner, P.
Biopolymer Schaumpartikel effizient produziert mit flexibler Technik.
Gala Symposium 2015, Wesel, Deutschland

Richards, J.
Untersuchungen an a-C:H:Me beschichteten Substraten zur Eignung als alternatives Bipolarplattenmaterial für wässrige Vanadium Redox-Flow Batterien.
In: Wissenschaftliche Schriftenreihe des Fraunhofer ICT, Band 63, Fraunhofer Verlag, Stuttgart, 2015, ISBN 978-3-8396-0911-8

Rieger, M.; Heil, M.; Hürttlen, J.; Schnürer, F.; Bunte, G.; Krause, H.
Metal Organic Frameworks as selective preconcentrator material for gas-phase sensing.
In: Security Research Conference 10th Future Security, 2015, Vol. 10, Berlin, Fraunhofer Verlag

Rieger, M.; Wittek, M.; Weishaupt, D.; Polyzoidis, A.; Löbbecke, S.; Krause, H.
Breakthrough volumes of BTEX compounds on state of the art MOFs.
In: 1st European Conference on Metal Organic Frameworks and Porous Polymers (euroMOF), 2015, Vol. 1, p. 126, Potsdam, Germany

Rosenberg, P.; Thoma, B.; Henning, F.
Characterization of epoxy and polyurethane resin systems for manufacturing of high-performance composites in high-pressure RTM process.
15th-annual SPE Automotive Composites Conference & Exhibition; Society of Plastics Engineers; Novi, MI 48374; 2015

Roznyatovskaya, N.
The Chemistry of Redox-Flow Batteries.
In: Angewandte Chemie – International Edition 54(34):9776-9809, August 2015, DOI: 10.1002/anie.201410823

Roznyatovskaya, N.
Sieving effects in electrical double-layer capacitors based on neat [Al(hfip)4]– and [NTf2]– ionic liquids.
Article in ChemElectroChem 2(6): 829-836, June 2015, DOI: 10.1002/celc.201500024

Schaller, U.; Keicher, T.; Weiser, V.; Krause, H.
Synthesis and characterization of nitrate based energetic ionic liquids (eils).
In: Proceedings of the 46th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Performance, Safety and System Applications", June 23-25, 2015, Karlsruhe, Germany, ISSN 2194-4903, p. 114-1 to 114-6

Schneider, A.; Mack, C.; Rapp, F.
Schaum aus dem Gelben Sack. Expandierte Polyolefine aus Sekundärrohstoffen herstellen.
Kunststoffe 5/2015, p. 86-89

Schnürer, F.; Heil, M.; Rieger, M.; Eberhardt, A.; Aniol, J.; Krause, H.
Localisation of IED manufacturing facilities by detection of explosives in sewage water.
In: Beyerer, J.; Meissner, A.; Geisler, J. (Hrsg) 10th Future Security 2015. Security Research Conference. Proceedings, September 15-17, 2015, Berlin, Stuttgart: Fraunhofer Verlag, 2015, ISBN: 978-3-8396-0908-8, ISBN 3-8396-0908-9, S. 285-291

Schnürer, F.; Schweikert, W.; Almaviva, S.; Chirico, R.; Nuvoli, M.; Palucci, A.
A new eye-safe UV Raman spectrometer for the remote detection of energetic materials in fingerprint concentrations: Characterization by PCA and ROC analyzes.
In: Talanta, Volume 144, 1 November 2015, p. 420-426

Schreiber, A.; Klahn, T.; Zilly, A.; Deimling, L.
Hyperspectral imaging of pyrotechnical decoys.
In: Proceedings of the 46th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Performance, Safety and System Applications", June 23-25, 2015, Karlsruhe, Germany, ISSN 2194-4903, p. 111-1 to 111-6

Seyidoglu, T.; Bohn, M.A.
Modelling of loss factor curves obtained by torsion-dma of htpb and gap based binders manufactured with different curing agents and plasticizers.
In: Proceedings of the 46th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Performance, Safety and System Applications", June 23-25, 2015, Karlsruhe, Germany, ISSN 2194-4903, p. 118-1 to 118-26

Teipel, U. (Hrsg.)
Produktgestaltung in der Partikeltechnologie, Bd.7.
Tagungsband, 7. Symposium "Produktgestaltung in der Partikeltechnologie", April 23-24, 2015, Berlin, Stuttgart: Fraunhofer Verlag, 2015, 566 S., ISBN: 3-8396-0877-5, ISBN: 978-3-8396-0877-7

Thoma, B.
Methodische Umsetzung und Bewertung eines neuartigen Prozesses zur lokalen und automatisierten Fixiierung von textilen Preformlingen.
In: Wissenschaftliche Schriftenreihe des Fraunhofer ICT, Band 62, Fraunhofer Verlag, Stuttgart, 2015, ISBN 978-3-8396-0887-6

Tübke; J., Hagen, M.
Post Lithium-Ionen Batterien.
In: Batterien als Energiespeicher, 1st Edition (Editor: Eckard Fahlbusch), Beuth Verlag, 2015, 293 ff., ISBN 978-3-410-24478-3

Tübke, J.; Noack, J.; Wietschel, L.
Stand und Perspektiven von Redox-Flow-Batterien als stationäre Speicherlösungen.
Technikfolgenabschätzung – Theorie und Praxis 24. Jg., Heft 3, 2015

Weide, T.; Guschin, V.; Becker, W.; Kölle, S.; Maier, S.; Seidelt, S.
Analysis of pure tar substances (polycyclic aromatic hydeocarbons) in the gas stream using ultraviolet visible (UV-Vis) spectroscopy and multivariate cure resolution (MCR).
Applied spectroscopy 69 (2015), Nr.1, S.143-153, ISSN 0003-7028

Weiser, V.; Roth, E.; Raab, A.; Knapp, S.; Kelzenberg, S.; Eckl, W.
Pyroorganic flares – state of the art and progress.
Europyro 2015 – 41st International Pyrotechnics Seminar; Toulouse, Frankreich; May 4-7, 2015; p. 705-715

Weiser, V.; Hürttlen, J.; Schaller, U.
ADN and AN solutions in hydrogen peroxide as green oxidiser for hypergolic propellants.
6th European Conference for Aeronautics and Space Science (EUCASS), Krakow, Polen, 29.6 – 3.7.2015; Paper 472

Weiser, V.; Roth, E.; Kelzenberg, S.; Becker, W.; Sachsenheimer; K.
Experimental and theoretical comparison of a systematic variety of thermite compositions.
In: Proceedings of the 46th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Performance, Safety and System Applications", June 23-25, 2015, Karlsruhe, Germany, ISSN 2194-4903, p. 24-1 to 24-14

Wimmer, A.K.; Salles, A.; Müller, T.; Elsner, P.
Entwicklung eines Design for End of Life Tools für die Luftfahrtindustrie.
In: Chemie Ingenieur Technik (Zeitschrift) (2015) WILEY-VCH Verlag http://dx.doi.org/10.1002/cite.201400154

Wimmer, A.K.
Germany gets on Eco Design for aircraft end-of-life strategy.
2nd European Aircraft Recycling Symposium, S. 47-49, Stuttgart, 2015, ISBN 978-3-942319-06-5

Winkler, A.; Kahlmeyer, M.; Böhm, S.; Sims, S.; Gettwert, V.; Urban, H.
X-Bond – Entkleben unter Nutzung exothermer Reaktionen.
15. Kolloquium Gemeinsame Forschung in der Klebtechnik, Dechema, Köln, March 3-4, 2015

Zydziak, N.; Ambrosio Zanin, M.-H.; Trick, I.; Hübner, C.:
Direct generation of titanium dioxide nanoparticles dispersion under supercritical conditions for photocatalytic active thermoplastic surfaces for microbiological inactivation.
Materials Chemistry and Physics 153 (2015), S. 274-284

HOW TO REACH US

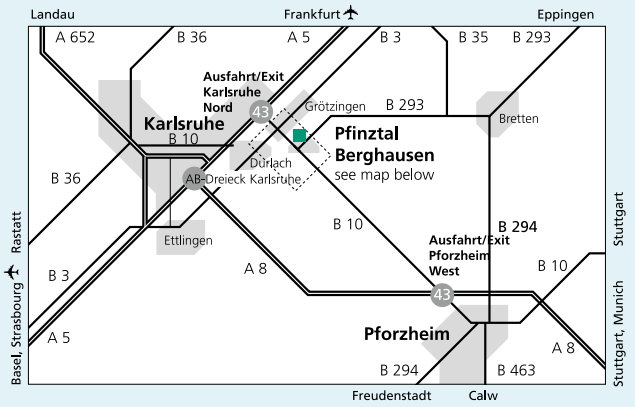
BY CAR

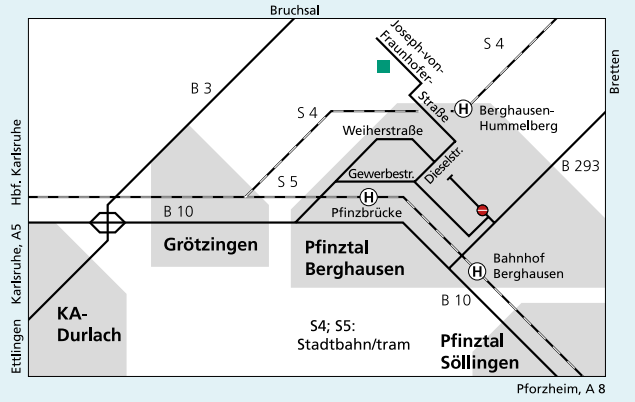
Approaching from Frankfurt/Main or Basel (CH):
Autobahn A5, exit Karlsruhe-Nord [43], follow B10 towards Pforzheim, turn left approx. 300 m after the tunnel and follow signs to the Fraunhofer ICT; follow Joseph-von-Fraunhofer-Straße approx. 1.5 km uphill to reach the institute.

Approaching from Stuttgart or Munich
Autobahn A8, exit Pforzheim-West [43], follow B10 towards Karlsruhe, drive through Pfinztal-Berghausen, turn right after the gas station at the edge of the village and then follow signs to the Fraunhofer ICT; follow Joseph-von-Fraunhofer-Straße approx. 1.5 km uphill to reach the institute.

BY TRAIN

Take the train to Karlsruhe Hauptbahnhof, change to the "Stadtbahn" (city tram) S4 which runs every 20 or 40 minutes towards Bretten/Eppingen/Heilbronn, exit at the stop Berghausen-Hummelberg. Travel time approx. 20 minutes, plus 10 minutes up the hill on foot. Please note that the S4 "Eilzug" does NOT stop at the stop "Hummelberg", and that the normal tram stops only on request (press the button near the door).





BY PLANE

- Frankfurt/Main Airport (approx. 120 km)
- Straßburg Airport (France) (approx. 100 km)
- Stuttgart Airport (approx. 80 km)
- Baden Airport Karlsruhe (approx. 40 km)

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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 67 institutes and research units. The majority of the nearly 24,000 staff are qualified scientists and engineers, who work with an annual research budget of more than 2.1 billion euros. Of this sum, more than 1.8 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 Länder 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.

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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.