Fraunhofer
ICT

FRAUNHOFER INSTITUTE FOR CHEMICAL TECHNOLOGY ICT

ANNUAL REPORT 2019/2020


Fraunhofer
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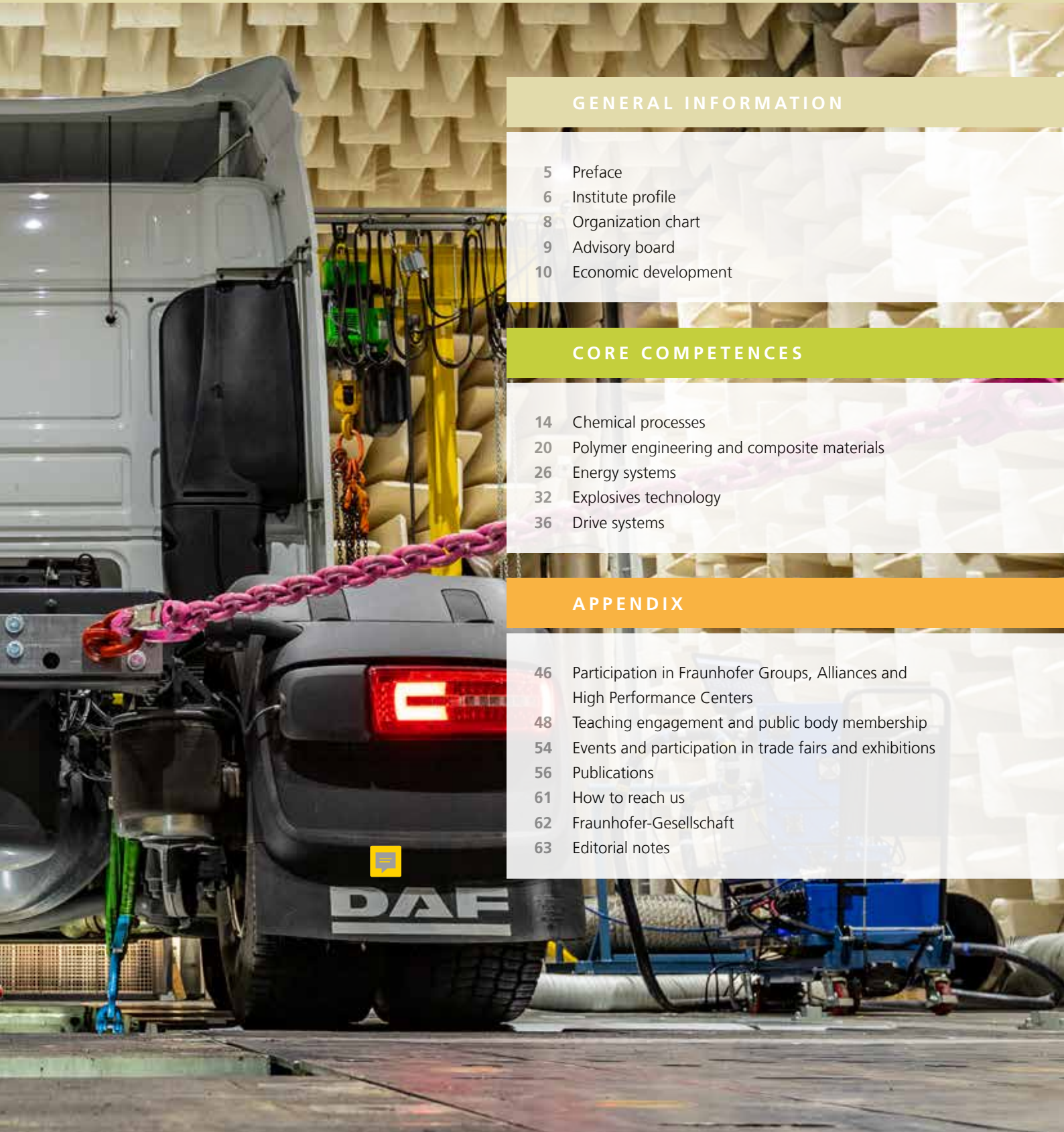

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GENERAL INFORMATION

COMMUNICATING RESEARCH

As an institute of the Fraunhofer-Gesellschaft, applied research and development is our core task. Our strengths lie in the development of materials and processes, and in defence and security research. We continually aim to sharpen the focus on our research topics and develop an in-depth knowledge of our five core competences. In addition to technical expertise, however, the communication of our research is becoming increasingly important.

We have an excellent network within the scientific community. In this community, people speak the same language and understand each other without any difficulty. Accordingly, we are experienced in writing scientific publications and presenting articles in scientific journals and at conferences. A good overview of our numerous scientific contributions in 2019 can be found at the end of the electronic annual report. A far greater challenge is to communicate our research topics to the general public. Research must be understandable. It is important to convey complex content in such a way that it is quickly understood and yet scientifically correct. This is a skill that we are trying to acquire.

About three times a year since 2019 we have organized our in-house event "Talk with..." on selected future-oriented topics such as security, energy or mobility. At this event, the institute director, the heads of the respective departments and interested employees can discuss topics reflecting the orientation of the institute, in a relaxed atmosphere and without the usual PowerPoint slides. For the institute's sixtieth anniversary, which we celebrated in July 2019 together with our families and alumni, the only presentation was given by an experienced science communicator, who made us aware of the importance of presenting content in an interesting, comprehensible and concise way. For some time now we have been using additional channels such as Twitter, Facebook and LinkedIn for this purpose.

At this anniversary celebration we tried out the new format of "pitching". Six of our researchers presented their topics to a broad audience in three minutes. The only resources the presenters were allowed was one PowerPoint slide in the background and anything they could carry single-handedly onto the stage. The very positive response to this event has encouraged us to repeat it once a year, as part of our summer festival.

Our open day was also very well received by just over 1500 guests. According to the newspaper report, we came across as "friendly, interesting and in touch with the general public". We presented our topics with a mixture of entertainment and science. Using a high-speed camera, for example, we showed pictures of airbags opening, hydrogen explosions and bursting water-filled balloons. With computer tomography we showed our guests the inner structures of a smartphone, a snail shell or a walnut. Guests tasted honey from beehives on the institute's site, on spoons made of biopolymers. The apprentice workshop produced shashlik skewers and bottle openers as giveaways for visitors. A total of 20 stations were presented in a similar way.

Our annual report describes our cutting-edge research. We would also like to test our ability to present relevant topics in an interesting and accessible way, by entering into dialog with you. Our goal is to conduct and communicate top-level research.

With best wishes, Peter Elsner

INSTITUTE PROFILE

Fraunhofer Institute for Chemical Technology

In our research we focus on the scalability of processes, and on the transfer of research results from laboratory to pilot plant scale and in some cases to pre-series application.

In 2019, around 580 people were employed at Fraunhofer ICT. Our main campus, with over 100 laboratories, multiple technical centers and 3 test centers on 21 hectares of land, is located on the Hummelberg in Pfinztal, near Karlsruhe. The New Drive Systems Department is located on the East Campus of the Karlsruhe Institute of Technology (KIT).

Our customers and project partners are chemical and process engineering companies, automotive manufacturers and their suppliers, the plastics processing industry, material manufacturers, recycling companies, companies in the field of energy and environment, customers concerned with safety-related issues, the construction industry and the aviation sector.
We are also the only explosives research institute in Germany to offer the entire spectrum from laboratory testing and technical processing through to fully developed systems.

Our core competences

The core competence **"chemical processes"** comprises the ability to design and implement innovative, resource-saving chemical and technical processes from the laboratory through to the technical scale.

It covers the entire process chain from raw material processing, chemical synthesis, purification and separation technologies through to subsequent process steps such as product refinement (e.g. crystallization and particle technology) and shaping (e.g. formulation and compounding).

Since 1994 Fraunhofer ICT has been researching technical plastics for practical use within its core competence of **"polymer engineering and composite materials"**. Our work ranges from polymer synthesis, materials technology, plastics processing, component development and production through to recycling.

Sustainable and affordable energy supply and efficient energy management are the focus of current research policy. Within the core competence **"energy systems"** we work on electrical energy storage devices for mobile and stationary systems, and on fuel cells and electrolysis as well as heat and material energy storage systems and their applications. We have accumulated more than 30 years of electrochemical and chemical know-how, laying the foundations for the development of efficient and cost-effective storage devices and converters.

"Explosives technology" is the longest-established core competence of Fraunhofer ICT. Based on decades of experience, we are the only German research institute that covers the entire development chain from the raw product to the prototype in the development of propellants and explosives. The Institute supports the German Federal Ministry of Defence, the public sector and industrial customers in investigating current challenges concerning national and international security.

Our core competence **"drive systems"** comprises solutions for electric drive trains and internal combustion engines. The systems are designed, constructed, simulated and validated through testing at Fraunhofer ICT. In addition, we validate mobile and stationary energy and thermal storage devices. In the field of internal combustion engines we are investigating synthetic fuels and additives in our research engines.

HOMEPAGE
www.ict.fraunhofer.de

ORGANIZATION CHART

Director

Prof. Dr.-Ing. Peter Elsner
Phone +49 721 4640-401
peter.elsner@ict.fraunhofer.de

Deputy Directors

Dipl.-Phys. Wilhelm Eckl
Head of Energetic Systems Department

Prof. Dr.-Ing. Frank Henning
Head of Polymer Engineering Department

Administration

Dr. Bernd Hefer
Phone +49 721 4640-125
bernd.hefer@ict.fraunhofer.de

General Management

Dr.-Ing. Stefan Tröster
Phone +49 721 4640-392
stefan.troester@ict.fraunhofer.de

Energetic Materials

Dr. Stefan Löbbecke
Phone +49 721 4640-230
stefan.loebbecke@ict.fraunhofer.de

Energetic Systems

Dipl.-Phys. Wilhelm Eckl
Phone +49 721 4640-355
wilhelm.eckl@ict.fraunhofer.de

Applied Electrochemistry

Prof. Dr. Jens Tübke
Phone +49 721 4640-343
jens.tuebke@ict.fraunhofer.de

Environmental Engineering

Dipl.-Chem. Rainer Schweppe
Phone +49 721 4640-173
rainer.schweppe@ict.fraunhofer.de

Polymer Engineering

Prof. Dr.-Ing. Frank Henning
Phone +49 721 4640-420
frank.henning@ict.fraunhofer.de

New Drive Systems

Dr.-Ing. Hans-Peter Kollmeier
Phone +49 721 9150-3811
hans-peter.kollmeier@ict.fraunhofer.de

ADVISORY BOARD

- Dr.-Ing. Thomas Czirwitzky
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ECONOMIC DEVELOPMENT

Both our revenues and our expenses increased in the past year. Our revenues were approximately 43.5 million € and expenses were just under 42 million €. Our successful financial management in 2019 therefore led to a surplus through unused institutional funding. This result is based on several factors:

At 10.4 million €, revenues from industry exceeded 10 million € for the first time.

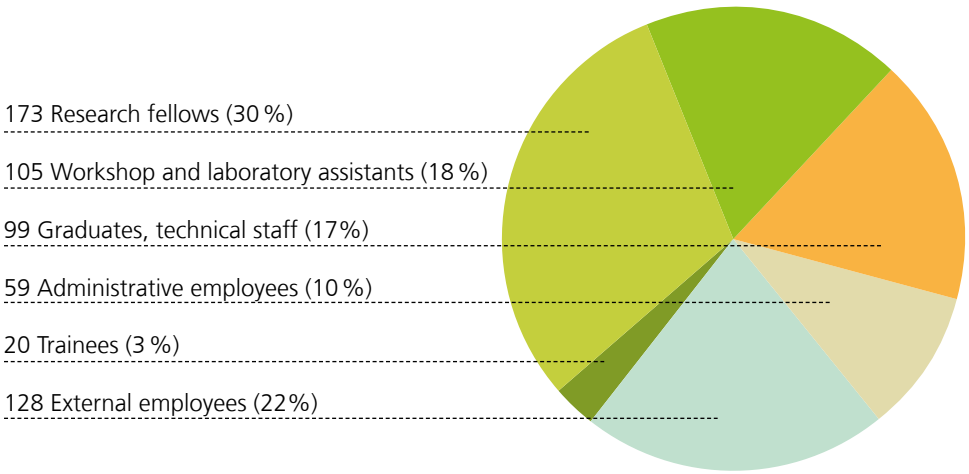
Revenues from the public sector, i.e. collaborative projects between research and industrial partners funded by the federal government, the state of Baden-Württemberg or the EU, also increased again to an all-time high of 11.4 million €. We have multiple ongoing projects with a good financing mix across different project types.

At the end of 2019, our headcount was 584, including 128 "external" employees such as student assistants, interns and graduating students. Just under a third of our workforce is made up of academic staff, 61 of whom are currently completing a PhD.

We currently employ about 100 technicians and 100 laboratory assistants, corresponding to 17 – 18% of the workforce. 59 employees, i.e. 10% of our staff, work in our administrative departments. We continue to rely on a strong training program for our future employees. We regularly run three-year training courses for cohorts of 20 apprentices, training them as chemical laboratory assistants, industrial mechanics, process mechanics in polymer technology or material testers.

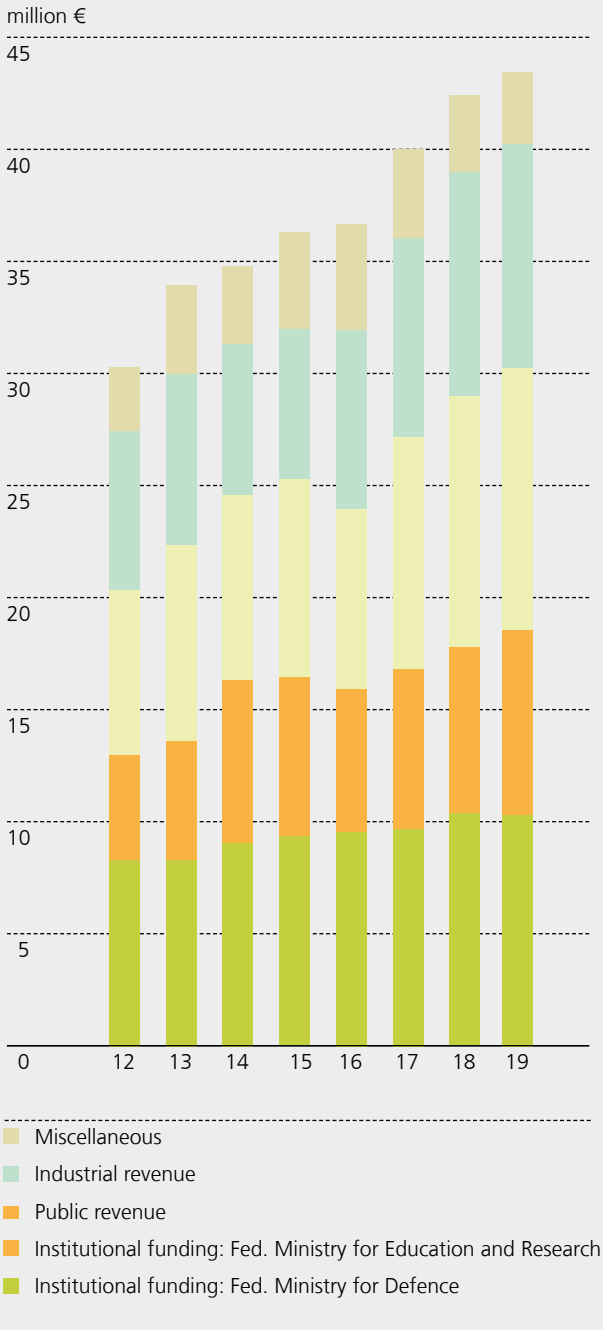
As a result of the COVID-19 outbreak we have adjusted our prediction for the coming year. For the economic year 2020 we expect a negative balance. As a non-profit organisation we cannot compensate for the currently limited operation of our laboratories and pilot plants, or for the cancellation of some of our industrial contracts. However, as we have demonstrated economic success over the past 20 years, we are optimistic that we will weather the crisis.

Workforce structure of Fraunhofer ICT: Status on December 31st, 2019

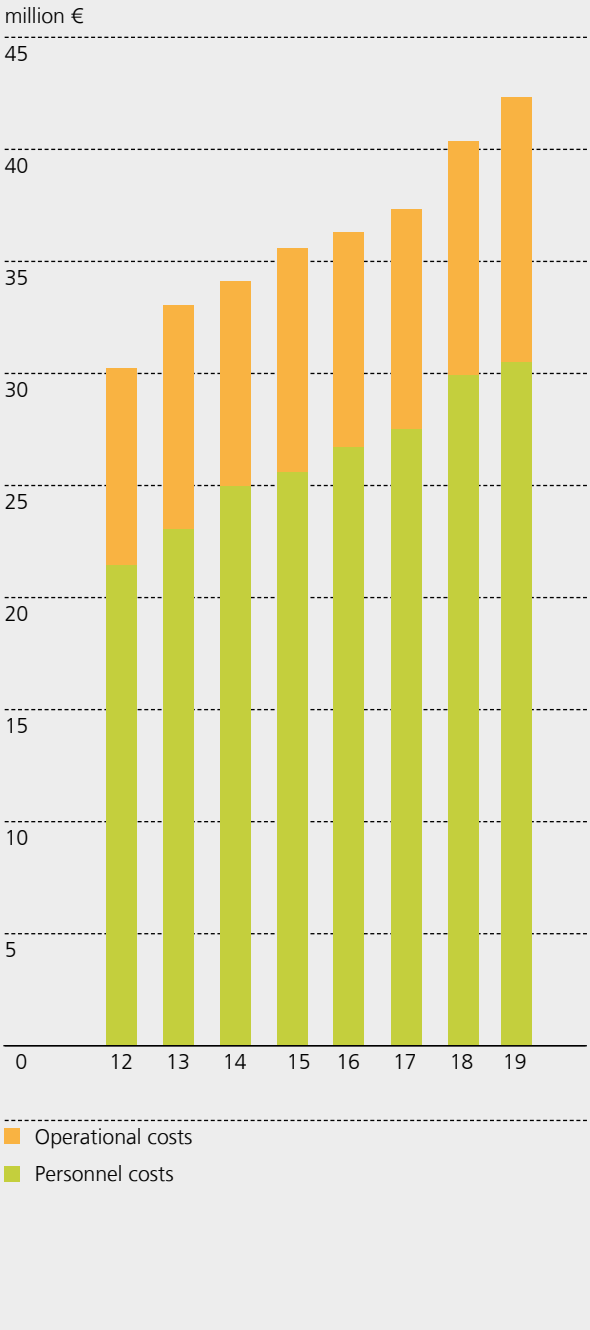


Financial development of Fraunhofer ICT, 2012 to 2019.

Revenue



Expenses



CORE COMPETENCES

CORE COMPETENCE
CHEMICAL PROCESSES

The core competence "chemical processes" comprises the ability to design and implement innovative, resource-saving chemical and technical processes from the laboratory through to the technical scale. It covers the entire process chain from raw material processing, chemical synthesis, purification and separation technologies through to subsequent process steps such as product refinement (e.g. crystallization and particle technology) and shaping (e.g. formulation and compounding).

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

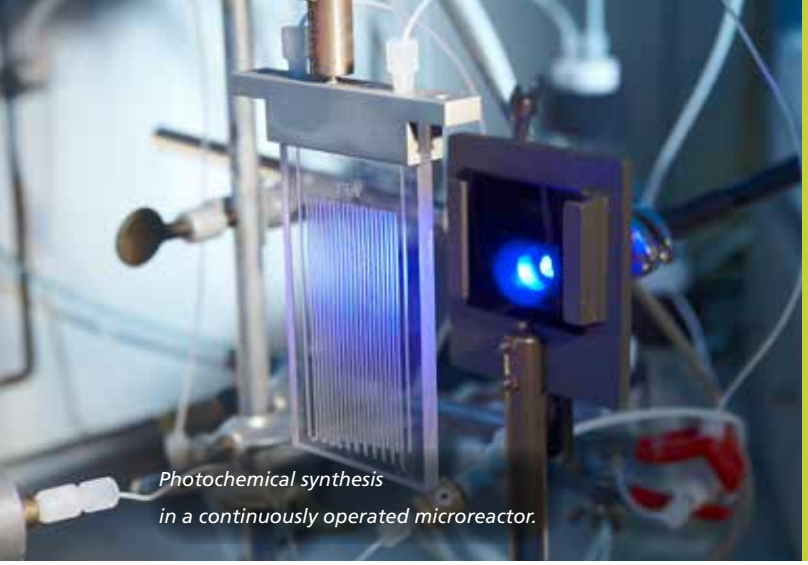
In the search for a cost-effective process, energy-efficient and resource-saving technologies are key topics of research. However, sustainability also requires the minimization of waste streams, the reuse of material fractions and the application of renewable raw material sources.

At Fraunhofer ICT we meet all these requirements through the development of modern process technologies. A considerable part of our work is exclusive, commissioned by industrial customers. A successful approach often involves a paradigm shift from discontinuous to continuous processing. For example, continuous processing involving micro-structured equipment is a key element in process design and intensification. It enables safe processing in new processing windows (for example high temperatures, high pressures, high concentrations, short reaction times) that are difficult or impossible to achieve using classical methods, and in which chemical reaction processes can be optimized from a technical and economic perspective. These are often synthesis steps used in the production of precursors or products in the field of fine and specialty chemistry.

In addition, we are systematically extending continuous processes to further unit operations and new application fields. These include in particular the intensification of downstream processing (extractive purification under different pressure regimes, reactive separation, emulsion splitting), the size-controlled production of nanoparticles and microcapsules, the development of environmentally-friendly catalytic processes (also phase transfer catalysis) and electrochemical syntheses, 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 are making significant progress in the development and adaptation of fast spectroscopic and calorimetric process analysis, which can be used to monitor the dynamics of chemical processes with a high temporal and spatial resolution. The techniques often yield kinetic, mechanistic and safety-related data for optimized process design. The rapid availability of comprehensive process analytical data not only enables process development times to be drastically shortened, but also allows the increasing application of these data in the digitalization of chemical reaction processes.

New spray drying process for particle shaping.



Photochemical synthesis in a continuously operated microreactor.

Our comprehensive know-how in the field of explosive technology means that we also have advanced competences in the safety-related design and operation of hazardous (explosive or toxic) processes. In the development of high-pressure processes we also benefit from our long-standing experience in the processing of supercritical fluids. In terms of process safety and stability, 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.

Renewable raw materials

For several years now, Fraunhofer ICT has been using renewable raw materials in process engineering. Our biorefinery processes have been specifically developed and extended from a bioeconomic perspective, to overcome obstacles in their industrial adaptation through targeted component developments. This includes in particular continuous reactor systems along the process chain up to the finished product. These processes utilize the feed materials wood, fats and oils, carbohydrates and other biomass materials which do not compete with food production.

The catalytically supported activation of CO_2 (from the air) to generate short-chain alcohols within ongoing PTL (power-to-liquid) processes is one recent development in the field of continuous process control.

We also investigate the industrial use of lignins, especially those which are a waste product of the paper industry. Industrial applications are already emerging in the field of adhesives and the substitution of bitumen in road construction, which show high economic potential. Some biopolymers are hard to degrade, so recycling processes are attracting increasing attention in this field. They enable biopolymers to be reused within closed material loops. To this end, Fraunhofer ICT has developed processes for the mechanical and chemical recycling of PLA (polylactic acid) plastics.

All process developments are evaluated in economic terms, in particular downstream processes to purify the end products. Life-cycle analyses (LCA) are carried out, which take account of both cost effectiveness and resource consumption.

CONTACT

Dr. Stefan Löbbecke

Phone +49 721 4640-230 | stefan.loebbecke@ict.fraunhofer.de

Rainer Schweppe

Phone +49 721 4640-173 | rainer.schweppe@ict.fraunhofer.de

Polylactic acid pellet: starting material for the production of lactate esters.

Depolymerization reactor.

GREEN SOLVENT DEVELOPED FROM USED BIO-BASED PLASTICS

While circular economies increase resource efficiency by reintroducing recycled materials into the value chain, the bio-economy replaces fossil carbon with renewable carbon. Both these processes create a more sustainable and resource-efficient world. Fraunhofer ICT aims to bridge the gap between the circular economy and bio-economy through the chemical recycling of bio-based plastics. The synthesis of a green solvent (alkyl lactate) from post-consumer PLA waste (polylactic acid) is one example, demonstrating the transition toward a circular bio-economy.

PLA is one of the most promising and frequently used polyesters, synthesized from renewable raw materials. Some of the most important applications of PLA include 3D printing (for which it serves as a feedstock), medical implants, packaging, compost bags, foils and textiles. However, despite significant market growth, there is still no infrastructure in place for the upcycling of waste PLA. PLA degrades relatively slowly, only under well-defined conditions, and contributes to the greenhouse effect (due to the release of CO_2). It must also be selectively processed, i.e. separately from other types of plastics to avoid the disruption of state-of-the-art recycling strategies. The energy recovered from the combustion of PLA (with the release of CO_2) is only a quarter of the energy required for its production (19.5 GJ/t versus 82.5 GJ/t). The recycling process developed at Fraunhofer ICT is therefore based on the synthesis of alkyl lactates from post-consumer PLA waste while retaining their stereochemistry.

These entities can be used for the synthesis of new, virgin PLA as well as solvents and coatings in other chemical processes. The price of these lactate esters is currently twice as high as that of virgin PLA. A further advantage of the process is its relatively simple downstreaming (purification of the product by simple distillation).

The principle of depolymerization is similar to transesterification. However, the choice of the solvent is crucial. It should be selected very carefully, keeping in mind the subsequent application.

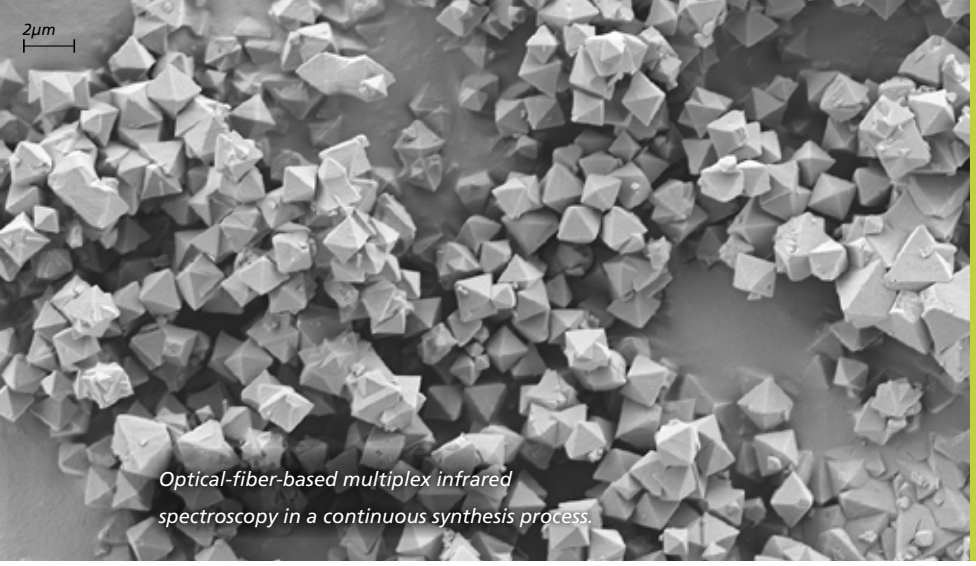
CONTACT

Dr. Davide Pico

Phone +49 721 4640-867 | davide.pico@ict.fraunhofer.de

Rainer Schweppe

Phone +49 721 4640-173 | rainer.schweppe@ict.fraunhofer.de



Optical-fiber-based multiplex infrared spectroscopy in a continuous synthesis process.

Adaptation of a pushbroom imager to a microstructured reactor.

NEW ADSORBER MATERIALS FOR RESPIRATORY PROTECTION AND PERSONAL PROTECTIVE CLOTHING

Chemical accidents, hazardous substance spills or even a terrorist attacks can result in the release of volatile or airborne hazardous substances, especially toxic industrial chemicals (so-called TICs), which pose a significant challenge to the emergency services on site. In such scenarios it is all the more important to ensure the safety of emergency responders, by providing the best possible protective equipment and technical support.

Many of the released chemicals are absorbed via the skin or respiratory tract due to their volatility. Both protective clothing and respiratory protection filters are used to protect against this hazard. In both cases, adsorption materials are used to bind the hazardous substances before they reach the body. However, these materials exhibit so-called adsorption gaps for a number of toxic industrial chemicals, including ammonia (NH_3), hydrocyanic acid (HCN), carbon monoxide (CO) and nitrogen oxides (NOx). As a result, protective clothing or respiratory protection must be frequently changed if these substances are present. A breakthrough, i.e. the exhaustion of the adsorption capacity of an adsorbent material for a hazardous substance, means that the entire protective article must be changed, even if it still protects against the majority of other hazardous substances present. If these adsorption gaps can be closed, significantly longer breakthrough times and thus longer use of the protective equipment can be achieved. This brings both operational and practical advantages, such as longer working times, and economic benefits.

In the joint project "MOFSchutz" (funding code 13N14195), funded by the Federal Ministry of Education and Research, manufacturers of protective equipment have joined forces with Fraunhofer institutes and the German Federal Office for Civil Protection and Disaster Assistance (BBK) to develop new adsorber materials that can close the existing adsorption gaps of conventional materials, most of which are based on activated carbon.

Fraunhofer ICT has synthesized novel, highly porous metal-organic frameworks (MOFs). Due to their variable structural composition in terms of pore size and pore shape, inner surface, hydrophobicity, mechanical strength and thermal stability, MOFs can be developed and synthesized according to user needs. For the adsorption of toxic industrial gases, a highly productive continuous synthesis process has been developed for the production of zirconium-based MOFs. At the same time, a novel breakthrough measuring system has been developed, which enables the characterization of MOFs and other sorption materials with regard to their retention of toxic pollutant gases. Using this measuring system, suitable MOF compounds were identified for all the tested pollutant gases, and show a better performance than the activated carbons currently used.

In addition, a database consisting of more than 600 data sets allows a quick selection of MOFs with correspondingly good retention efficiency for selected pollutant gases. The measuring system and the database are currently being expanded to include MOF composite materials - for example based on textiles, ceramics or plastics - in order to open up further applications in the field of personal protective equipment and air filters (mobile and stationary) in the future.

CONTACT

Dr. Angelos Polyzoidis
Phone +49 721 4640-875 |
angelos.polyzoidis@ict.fraunhofer.de

FACILITIES AND EQUIPMENT

- Various synthesis techniques for chemical and mechanical processing
- Pilot plant for synthesis upscaling into the 50 kg or 50 l range
- Safety boxes for the remote control of reactions in hazardous processes
- Flow chemistry test stands and synthesis units
- Facilities for the parallel screening of synthesis routes (including high-pressure processes)
- Numerous reaction calorimeters (batch and continuous)
- Cutting-edge process spectrometers for inline, online or atline process monitoring (UV/Vis, NIR, IR, Raman) in one or multiple dimensions
- Continuous and discontinuous high-pressure plants for hydrothermolysis, oxidation, hydrogenation, and reactions in subcritical and supercritical water
- High-pressure extraction units using supercritical carbon dioxide
- Pilot plants for crystallization from solutions via supercritical fluids
- Systems to determine solubility and phase equilibria at high pressures
- 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
- Mobile equipment for reverse osmosis, nano- and ultrafiltration
- Equipment for solution and melt polymerization
- Coating processes
- Spray and melt crystallization processes
- Comminution technology
- Particle size and crystal structure analyses
- Extensively equipped chemical, spectroscopic, thermal and mechanical analysis laboratories
- Units for surface analysis, volumetric and gravimetric sorption measurements
- Computer tomography

CORE COMPETENCE
POLYMER ENGINEERING AND COMPOSITE MATERIALS

Since 1994, Fraunhofer ICT has been researching technical plastics for practical use within its core competence of "polymer engineering and composite materials". Our work ranges from polymer synthesis, materials technology, plastics processing, component development and production through to recycling.

We see polymer synthesis as a basis for the further development of so-called classic polymers such as polyurethanes, polyesters and polyamides, in order to improve their functionalities (e.g. heat resistance), thus opening new application fields. Sustainability developments, such as plastics made of biobased raw materials or the fully comprehensive recycling of used plastics, are another core research topic. Further development topics are the synthesis of additives, such as flame retardants or compatibilizers for new plastic compounds. In modern flame retardant systems no halogen-containing components are used. The latest developments aim to combine thermoplastic and thermosetting functionalities in next-generation functional polymers.

The research group for material development and compounding technologies develops new compounding processes and material recipes. Particularly important topics include extractive compounding processes to reduce emissions, the removal of impurities during recycling and innovative reactive extrusion for polymer synthesis or polymer modification in twin-screw extruders. Innovative materials are produced on modern plant technology, for example in the field of biobased or nano-functionalized polymer compounds for high-quality injection molding materials and for generative manufacturing processes.

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 addition to the optimization of conventional materials, we are concerned with the foaming of biobased polymers and technical raw materials, most of which are resistant to increased temperatures. The combination of plastic foams with phase change materials enables the manufacturing of hybrid lightweight construction materials with high insulation values and additional room temperature control options. New technologies, such as radio frequency technology for particle foam processing, open up completely new areas of application for particle foams.

The research group for injection and compression molding focuses on standard and specialized processes in the injection molding and flow compression molding of thermoplastic and thermoset (fiber composite) materials. The integration of local, load-path-compatible wound or tape-laid fiber composite structures into injection molded components significantly improves the mechanical properties between load application points.

Key elements of research in the field of structural composites include the further development and industrialization of process chains for the production of highly durable, continuous-fiber-reinforced lightweight structures with thermoset and thermoplastic matrices. The core technologies are resin transfer molding (RTM) and wet compression molding (WCM) as well as thermoplastic tape laying (ATL). The placement of textile and pre-impregnated semi-finished products to produce preforms, and their handling, combination with polymer foams and metallic structures and subsequent resin infusion or stamp forming are important process steps within the processing chains.

In the research group for microwave and plasma technology we develop testing units and measurement technology. Applications include the microwave-based heating of polymers, the accelerated curing of adhesives and resin systems, and coating or modification of surfaces in the plasma-enhanced chemical vapor deposition process. A particular focus is on corrosion-resistant layers and nanoporous adhesive layers.

Colored PET bottles are shredded, depolymerized and purified to produce clean, white PET pre-products, then re-polymerized and reprocessed into PET preforms.

CORE COMPETENCE

POLYMER ENGINEERING AND COMPOSITE MATERIALS

In our testing laboratory, we carry out comprehensive examinations of polymer materials along the entire processing chain, from the raw material through to the component. In the event of damage or failure, we offer systematic analysis of the causes of the damage and the influences leading to failure, using analytical and technological measurement methods. In addition to the standardized testing of standard materials, we also offer the testing of fiber composites and polymer rigid foams, and can characterize polymer compounds with regard to their acoustic damping behavior.

In the field of online process monitoring, spectral and microwave-based measurement methods are developed for plant-integrated process and material monitoring and for process control. Projects in the context of Industry 4.0 build on our significant experience in the field of probe technology, the process integration of sensors and process-specific know-how in the evaluation of the raw data obtained. The application and integration of big data and KI algorithms enable "learning/immature processes".

In the area of recycling and waste management, processes and technologies for the material recycling of polymers are developed, aiming for a complete reintroduction into high-quality applications. The focus is on technologies for the recycling of composites and composite materials (GRP, CFRP) after the fibers have been extracted (e.g. by solvolysis or microwave-assisted pyrolysis processes), and the separation of PET multilayer composites in the packaging sector. Some consumer thermoplastics have to be subjected to an extraction process before they can be reused, for example to remove flame retardants or colorants. This involves the use of conventional solvents as well as supercritical fluids such as carbon dioxide. Starting with materials from old aircraft seats, a process of depolymerization, purification and new synthesis gives rise to materials which could be used in demonstrators of new aircraft seats. An accompanying life cycle assessment calculation shows that these seats are not only lighter but also more sustainable.

Fraunhofer Innovation Platforms (FPCs), Karlsruhe Research Factory and Alliances

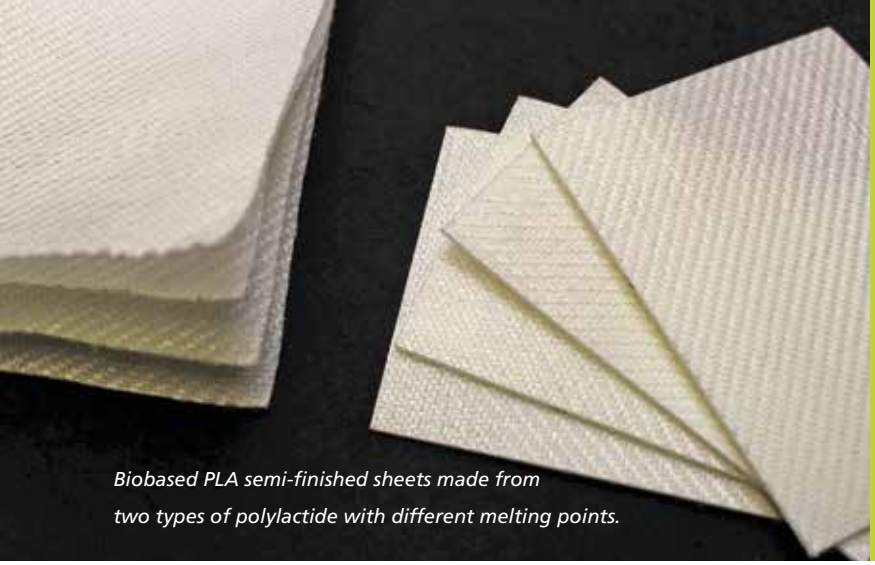
The partnership between the FPC@WESTERN in London, Ontario, Canada and Western University optimally combines the competences of Fraunhofer ICT in the field of fiber composites with the know-how in material and surface research of the Canadian university. The large-scale plant technology enables commissioned research to be carried out on an industrial scale. The research focus of the FPC@UNIST in Ulsan, South Korea, is on manufacturing processes for fiber composites, new material solutions and the transfer of lightweight construction into mass production.

The "Karlsruher Forschungsfabrik®" is an initiative of the Fraunhofer-Gesellschaft with its institutes ICT and IOSB as well as the Karlsruhe Institute of Technology (KIT-wbk) on the East Campus of the Karlsruhe Institute of Technology (KIT). Together with industrial partners, the aim is to quickly bring new, still immature production processes to series production scale. The project will make an important contribution to the "Artificial Intelligence Strategy" of the German Federal Government. In 2019, the foundation stone was officially laid by representatives of the state, KIT, and the Fraunhofer-Gesellschaft. The factory is currently under construction, scheduled for completion in early 2021.

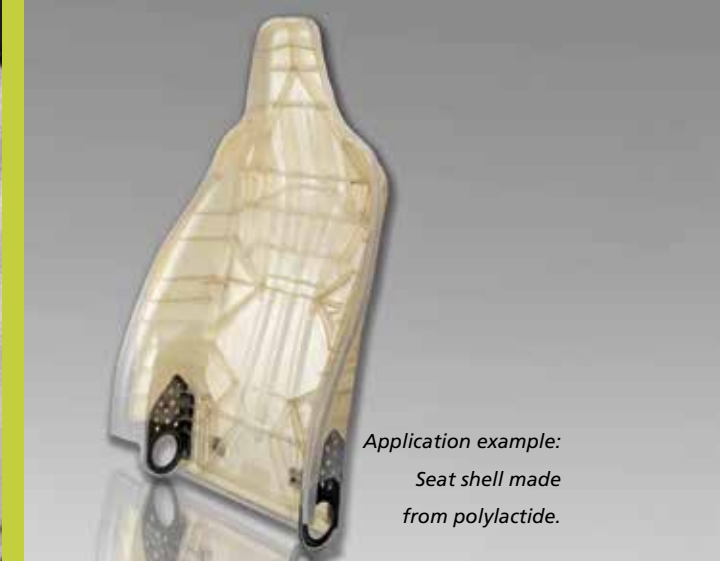
The close thematic networking with other Fraunhofer institutes within the Fraunhofer Alliances "Building Innovation" and "Lightweight Construction" enables us to offer system solutions from a single source.

CONTACT

Prof. Dr. Frank Henning
Phone +49 721 4640-420 | frank.henning@ict.fraunhofer.de
Rainer Schweppe
Phone +49 721 4640-173 | rainer.schweppe@ict.fraunhofer.de
Wilhelm Eckl
Phone +49 721 4640-355 | wilhelm.eckl@ict.fraunhofer.de



Biobased PLA semi-finished sheets made from two types of polylactide with different melting points.



Application example: Seat shell made from polylactide.

BIO4SELF – SELF-REINFORCED PLA SELF-REINFORCED FIBER COMPOSITE

Although the polymer polylactide (PLA) is not a new material, the application developed within the EU Horizon 2020 project Bio4Self is a milestone.

In this project, two different PLA types with different melting temperatures were combined to form a self-reinforced PLA composite (PLA SRPC), in such a way that the PLA with a higher melting point was embedded in the matrix of the PLA with a lower melting point to serve as a reinforcing fiber. The resulting material stiffness can compete with that of commercially-available self-reinforced polypropylene (PP) compound materials. This biobased mono-material fiber composite system can be used to produce mechanically demanding, biobased components for the automotive and domestic appliance sectors.

In general, PLA is based on renewable resources - so-called lactic acids - which are obtained from renewable raw materials such as sugar cane. Although the composite materials developed in this process have a high mechanical strength and stiffness as well as high temperature and hydrolysis stability, like pure PLA they are fully biobased, can easily be recycled and processed, and are even industrially biodegradable. These composite materials developed in the Bio4self project, which can be produced on an industrial scale, represent a milestone in the development of functionalized, high-strength, biobased material systems. In addition, the development makes a significant contribution to the sustainability of future polymer applications.

The main tasks of Fraunhofer ICT were the selection and formulation of materials for fiber and matrix systems, and process development to consolidate PLA fabrics into semi-finished sheets. Fraunhofer ICT was also responsible for the production of demonstrator components. At the composites trade fair "JEC 2019", the consortium presented the developments achieved in the project to the public using a modular seat structure as a demonstrator.
The consortium won three awards in 2019 for the material and process developments achieved in the Bio4Self project:

- JEC Award in the "sustainability" category (Europe's largest trade fair for composite materials, in Paris)
- Techtextil Innovation Award, also in the "sustainability" category (leading international trade fair for technical textiles and nonwovens, in Frankfurt)
- Global Bioplastics Award (leading international trade fair for bioplastics and biocomposites, in Berlin

Participants in the "Bio4Self" project, which was funded by the EU's Horizon 2020 research framework program (Grant Agreement no. 745762), include Fraunhofer ICT, the Technical University of Denmark, the Belgian textile research institute CENTEXBEL, and the company Comfil from Denmark.

Further information on the project and consortium can be found at: www.bio4self.eu/project.html

CONTACT
Kevin Moser
Phone +49 721 4640-533 | kevin.moser@ict.fraunhofer.de

Collection of domestic bulky waste.

Glycolysis product with recycled polyol (upper phase).

URBANREC – CONVERSION OF BULKY WASTE INTO RECYCLED PRODUCTS WITH HIGH ADDED VALUE

Bulky waste includes mattresses, upholstery, garden and outdoor furniture. In 2016, EU citizens generated 19 million tonnes of this waste, 60 per cent of which was landfilled. Every year, up to 30 million mattresses alone reach the end of their service life in the EU and are either landfilled (60 percent) or incinerated (40 percent). In 7 European countries there are now precise regulations on which materials can be landfilled.

At least 85 percent of a mattress can be recycled simply by stripping it down. Various technological solutions are available. In addition to mechanical recycling, in the project "Urbanrec" Fraunhofer ICT investigated the chemical recycling of post-consumer mattresses, with the aim of recovering the main component – polyol – from the flexible polyurethane foams used for the mattresses. The polyol obtained was then tested in three applications: Mattress foam, adhesives and insulation material. This process showed clear advantages in terms of the CO_2 footprint compared to incineration. Economically, a good logistics concept is the key factor.

In addition, Fraunhofer ICT is researching the holistic recycling of polyurethane, including the recovery of the isocyanate component. Industrially, the amines produced from the isocyanate are functionalized and remain as reactive additives in the recycling polyol. Among other things, this leads to a quality reduction compared to new goods. Through targeted removal and selective conversion, new isocyanate-free basic chemicals can be produced via phosgene-free synthesis routes for the chemical industry, which can be used in the coatings and adhesives sector.

Chemical recycling helps to reduce the dependence of the chemical industry on petrochemically manufactured products by recovering polymer monomers and producing basic chemicals. In addition, the reduction of landfill areas allows more sustainable land use.

This project received funding from the European Union's Horizon 2020 research and innovation program under the Grant Agreement no. 690103.

More information about this project can be found at: www.urbanrec-project.eu

CONTACT

Ronny Hanich

Phone +49 721 4640-586 | ronny.hanich@ict.fraunhofer.de

Rainer Schweppe

Phone +49 721 4640-173 | rainer.schweppe@ict.fraunhofer.de

FACILITIES AND EQUIPMENT

- Twin screw extruders with 18 to 32 mm screw diameter
- Dosing systems for liquid and highly viscous media and gravimetric dosing systems for pellets, powder, fibers, etc.
- Laboratory for reactive extrusion, equipped with safety devices for working with hazardous substances
- Parallel-running hydraulic compression molding machines for the processing of plastics with 6,300 and 36,000 kN clamping force
- Direct LFT unit
- 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, expansion foaming, thermoset injection molding
- Injection molding compounder with 40 mm twin-screw extruder and 7,000 kN clamping force
- Automated thermoplastic tape-laying process for nonwovens with a diameter of 2 m
- Plant technology for radiation-induced vacuum consolidation for thermoplastic nonwovens up to 0.94 x 1.74 m²
- Automated winding technology to produce complex loop structures
- 3D printing technologies for processing functionalized polymers - filament-based and AKF technology
- Particle foam technology with twin-screw extruder, underwater pelletizing, prefoamer, and a (radio frequency) molding machine
- Tandem foam extrusion plant for foamed semi-finished products
- SMC production line and BMC kneader
- Polyurethane processing PU-RIM and PU fiber spraying technology
- Thermoplastic RIM/RTM processing
- RIM/RTM technologies for processing thermoset and thermoplastic materials in high-pressure injection and high-pressure compression RTM processes
- Microwave generators with an output of 60 kW at 915 MHz, 12 kW to 60 kW at 2.45 GHz, 0.8 kW at 5.8 GHz and 0.8 kW at variable frequency from 5.8 GHz to 7.0 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 unit with 8 gas channels, ECR plasma and 1000 mm plasma length
- Universal testing machines with fixtures for bending, tensile, peel and compression tests
- Impact pendulum and falling dart test
- HDT/Vicat device
- Dynamic mechanical analysis (DMA)
- High-pressure capillary viscometer with pVT measurement technology and Rheotens® device for extensional viscosity measurement, and plate-plate viscometer
- Contact angle measurement device
- Differential scanning calorimetry (DSC)
- TG-MS, pyrolysis GC-MS
- Gel permeation chromatography (GPC)
- Light microscopy (incident light and transmitted light), polarization
- Scanning electron microscope with element analysis (SEM-EDX)
- FTIR, UV-VIS, and NIR spectroscopy
- Flame retardant test stands
- Thermal conductivity measurement device
- Hydrostatic compression testing facility for the characterization of polymer foams

CORE COMPETENCE
ENERGY SYSTEMS

Sustainable and affordable energy supply and efficient energy management are the focus of current research policy. Within the core competence "energy systems", Fraunhofer ICT works on electrical energy storage devices for mobile and stationary systems, on fuel cells and electrolysis, and on heat and chemical energy storage devices and their potential applications. Our 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.

Electrocatalysts for fuel cells and next-generation electrolyzers are a focus in the area of converters. The main emphasis is on the development of alkaline direct-alcohol fuel cells, for example palladium non-noble metal alloy catalysts for alcohol oxidation or ionomers with high stability in alkaline alcohol solutions. We are developing anode catalysts for medium-temperature fuel cells that have a high tolerance for impurities (especially sulfurous compounds), for operation with logistic fuels available for military use. We also have a high level of competence in the online analysis of electrochemical processes, which can also be applied to investigate degradation processes in vehicle PEMFCs. A further competence is the design of systems for use in unusual environments, for example under water.

One way to use electric energy efficiently is the generation of chemical products. We are working on the development of electrochemical reactors, including electrocatalysts and electrodes, their integration into a complete process, and coupling to subsequent process steps. A current example is the electrochemical extraction of hydrogen peroxide by the partial reduction of atmospheric oxygen, combined with use in a selective oxidation.

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 and sorption cooling systems, heat reservoirs based on phase-change materials, and hybrid components combining thermal mass and insulation, are strongly market-oriented and complement our fundamental research activities.

In the field of chemical storage, Fraunhofer ICT is concerned with hydrogen as an energetic material and platform chemical. A particular area of expertise is safety assessment and the design of systems, pilot plants and processes. Important research areas are the handling and especially the storage and transport of hydrogen, the development and performance of specific safety tests and the evaluation, concept and design of hydrogen storage systems. The equipment available at our Application Center for Stationary Energy Storage Devices enables the characterization and development of a wide spectrum of materials, through to the behavior of a storage device in an electric grid with renewable energy sources.

Mobile 15 kWI 30 kWh redox-flow battery container solution for an energy-autonomous field camp.

Networks and alliances

Fraunhofer ICT pools its competence with other institutes of the Fraunhofer-Gesellschaft through Fraunhofer networks and alliances. The spokesperson of the Fraunhofer Battery Alliance, Prof. Dr. Jens Tübke, is an employee of Fraunhofer ICT. Fraunhofer ICT is also active in the alliances "Energy", "Space" and "Building Innovation" 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 electric converters, aimed at different applications in the civil and military sectors. The design and development of fuel cell systems for stationary applications and for vehicles include the following focal points:

- complete characterization of PEMFC, HT-PEMFC and DMFC fuel cell stacks
- environmental simulation tests on stacks and systems, such as climate tests, effects of shock etc.
- development of operating strategies, optimization of the interaction between the fuel cell and the battery
- safety evaluations

We also develop electrocatalysts suitable for use with various fuels (hydrogen, alcohols) in acidic or alkaline fuel cells.
We have various test cells and self-developed measuring cells for the evaluation of battery materials such as electrodes, separators, electrolytes and charge eliminators.

- 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 specific cells
- Research on next-generation systems (e.g. Li-S, air cathodes, Na-systems, solid ion conductors)

CONTACT
Prof. Dr. Jens Tübke
Phone +49 721 4640-343 | jens.tuebke@ict.fraunhofer.de
Wilhelm Eckl
Phone +49 721 4640-355 | wilhelm.eckl@ict.fraunhofer.de
Prof. Dr. Karsten Pinkwart
Phone +49 721 4640-322 | karsten.pinkwart@ict.fraunhofer.de

Group photo of the early-stage researchers who are jointly investigating redox-flow batteries in the FlowCamp project.

"FLOWCAMP" – YOUNG RESEARCHERS ARE DEVELOPING ENERGY STORAGE TECHNOLOGIES

Fraunhofer ICT is the coordinator of the Marie Skłodowska-Curie "Innovative Training Network" FlowCamp, which is funded by the European Union. In this project, 15 PhD students based in 8 countries are researching novel redox-flow technologies. The goal is to achieve higher energy and power densities, and resource-saving electrolyte systems that can be used for the storage of renewable energies. The distinctive feature of this project is its training concept, which provides the young scientists with the tools they need to establish themselves in the research landscape.

The European Union's "New Green Deal", with its focus on environmental policy, is comparable in dimension and impact to the Apollo Project, which landed the first humans on the Moon. The project will impact the whole of Europe and, above all, will lead to a substantial and lasting change in the production, transport and use of energy.

The most important resource in this decision-making process is talented young researchers who bring new and fresh ideas to the table and are not intimidated by established modes of thought. With its research campus for redox-flow batteries ("FlowCamp" for short), Fraunhofer ICT coordinates a network of young European researchers in the field of stationary energy storage. In the Marie Skłodowska-Curie network FlowCamp, which is funded by the EU, these researchers are working on three flow battery systems, each with a different focus:

- Zinc-slurry-air batteries have potentially very high energy densities.
- H_2/Br_2 redox-flow batteries, on the other hand, have very high power densities in addition to relatively high energy densities.
- Aqueous organic flow batteries are not dependent on resources such as metal compounds, and operate with pH-neutral saline solutions as the electrolyte medium.

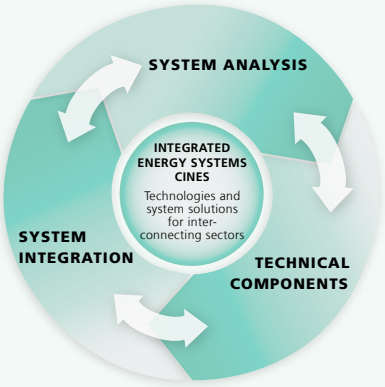
The project has already made some advances. In addition to new ion-conducting membranes, which outperform conventional ones in terms of power density and selectivity, new cell concepts have been implemented and new redox systems tested as energy storage systems.

However, the main advantage of this network is its interdisciplinarity. Various scientists and engineers from different backgrounds are working together on storage technologies. Organic chemists, physical chemists, mechanical engineers and chemical engineers are combining their expertise to advance their system and perhaps contribute, in the near future, to Europe's "Apollo" project of energy transition.

The FlowCamp project has received funding from the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie Grant Agreement no. 765289 .

More information about this project can be found at:
www.flowcamp-project.eu

Contact
Dr. Peter Fischer
Phone +49 721 4640-891 | peter.fischer@ict.fraunhofer.de



Dimensions and interactions in the CINES cluster.

Individual test stand with gas analysis for the detection of transient changes in gas composition.

FRAUNHOFER CLUSTER OF EXCELLENCE – INTEGRATED ENERGY SYSTEMS "CINES"

Fraunhofer ICT is a partner in the Fraunhofer Cluster of Excellence for Integrated Energy Systems "CINES". Fraunhofer Clusters of Excellence promote the cooperative development and processing of system-relevant topics within a research structure spanning multiple institutes. In organizational terms, these research clusters make up a "virtual institute" spread over several locations. The research clusters do not just aim to complete individual projects, but rather follow a roadmap for the long-term development of a complex technology trend. In the case of CINES, this trend is the management of large amounts of energy from fluctuating renewable energy sources. This trend has three dimensions: the cross-sectoral system analysis of the energy system, the development of digital models for system integration and operational management, and the further development of the necessary technical components, especially electrolysis.

As a partner in the cluster, Fraunhofer ICT supports the further development of water electrolysis based on polymer electrolyte membrane electrolyzers (PEMEL). The aim of this activity within CINES is the development of low-cost alternatives for large-scale use. Developments include a simplified stack design that will save costs in the manufacture of stack components like bipolar plates and porous transport layers and in stack assembly, the development of platinum-metal-free catalysts for hydrogen evolution and the optimization of oxygen-generating electrodes. This last aspect is the focus of activities at Fraunhofer ICT. Based on experience from previous projects, we are developing support materials for oxygen-evolution catalysts, which can reduce the use of rare iridium. These are transition metal oxides or carbides which are doped to increase their performance.

We also work on printing techniques for the cost-effective and large-scale manufacture of electrode structures. Finally, we research the application of thinner polymer electrolyte membranes, such as those already used in PEM fuel cells for automotive applications. These thinner membranes reduce the internal resistance of the cell - especially in larger cells - and thus enable higher current densities and higher hydrogen production rates. A disadvantage is the fact that more substances are able to pass through. Since the accumulation of hydrogen in oxygen on the anode side in particular would compromise the operational safety of the electrolyzers, recombination layers, which promote the reaction of both substances to form water, are an important prerequisite for the use of thin membranes. Fraunhofer ICT is investigating approaches that enable cost-effective but efficient implementation. To test the effectiveness of the layers, we rely on our many years of expertise in the field of mass spectrometric online analysis.

More information about the project can be found here:
www.fraunhofer.de/de/institute/institute-einrichtungen-deutschland/cluster-of-excellence/integrated-energy-systems.html

CONTACT
Dr. Carsten Cremers
Phone +49 721 4640-665 | carsten.cremers@ict.fraunhofer.de

FACILITIES AND EQUIPMENT

- Battery charging and discharging stations incl. climatic chambers for characterization of battery cells and modules
- Argon glove boxes
- In-operando layer thickness measurements at electrode and cell level during electrochemical tests
- 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 5000 in two- or three-dimensional image
- Scanning electron microscope (SEM) / spatially resolved elemental analysis using energy dispersive X-ray spectroscopy (EDS)
- RAMAN and infrared (IR) spectroscopy
- Analysis of surface size and porosity using BET gas adsorption
- Confocal microscope for surface characterization
- Ion analysis by capillary electrophoresis (CE), free-flow electrophoresis (FFE) and ion chromatography
- Thermal analysis to record physical transformations and chemical reactions with heat flow DSC
- Gas analysis using GC, MS, GC/MS and gas FTIR
- Thermal, mechanical and electrical safety testing facilities for battery cells and modules up to 2 kWh and fuel cell modules
- Synthesis options for supported electrocatalysts up to gram scale
- Test systems for electrochemical catalyst characterization and aging tests on membrane electrode assemblies
- Differential electrochemical mass spectrometry (DEMS) to investigate reaction and corrosion products
- Medium-temperature cell (120 °C – 200 °C) with online mass spectrometry (HT-DEMS)
- Equipment for the production of membrane electrode assemblies by inkjet, hot spray and electrospinning
- Several single cell test benches for the characterization of membrane-electrode units for hydrogen PEMFC, PEM, AEM and HT-PEMC based direct alcohol fuel cells, HT-PEMFCs operated on reformate, PEM electrolysis
- Test system for time-resolved online mass spectrometric measurements to investigate transient processes in automotive PEMFCs such as corrosion during switching operations or gas exchange of inert gases
- Test benches for the investigation of short stacks (PEMFC, DAFC and HT-PEMFC) up to 500 W
- Test benches for stack characterization of PEMFC and HAT-PEMFC stacks up to 5 kW with hydrogen, surrogate reformate for operating pressures up to 5 bar and with pure oxygen
- System development and investigation of components through hardware-in-the-loop method
- Environmental simulation, especially 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 equipment for coating with metals
- Various high temperature furnaces with the possibility to simulate H_2-, CO-, CO_2- or SO_2- containing atmospheres up to 800 °C, at pressures up to 50 bar
- Measuring stand for redox flow battery stacks up to 60 kW
- Test benches for redox flow battery stacks in a large-scale environment up to 250 kW
- Testing of materials for VRFBs (cell test, durability test, electrolyte tests)

CORE COMPETENCE
EXPLOSIVES TECHNOLOGY

Based on decades of experience, Fraunhofer ICT is the only German research institute that covers the entire development chain from the raw product to the prototype in the development of propellants and high explosives. The institute supports the German Federal Ministry of Defence, the public sector and industrial customers in carrying out investigations into current challenges concerning national and international security.

The institute draws on the competence of its employees in the research and development of improved energetic materials and systems for the German army, and thus helps to ensure the strong analysis and decision-making capability of the German Federal Ministry of Defence (BMVg). In addition, current issues in the thematic fields of defence and security are addressed. Research is focused on the development, synthesis, characterization, formulation and production techniques of components for rocket propellants, gun propellants, high explosives, pyrotechnics and new ignition and initiation systems. Fraunhofer ICT is the only German research institution to cover the entire development chain from the raw product through to the system prototype. Further topics in its portfolio include safety and security systems based on gas generators, flame retardant coatings, filter materials 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 groups for interior ballistics, detonics, rocket propellants and pyrotechnics then characterize the reaction behavior, sensitivity and performance data of the energetic materials in the laboratory, detonation chamber or on open-air testing ranges, up to the kilogram scale. In addition, modern simulation software is available, which can be used to analyze and evaluate the performance and safety of new energetic materials all the way to the system. Current research topics include environmentally-friendly, low-signature high-performance rocket propellants for military and civil applications, nitrocellulose-free gun propellants, insensitive high-performance explosives, gel propellants for rockets enabling controllable thrust phases, sensors in rocket engines that enable non-destructive monitoring of the aging of the propellant, and investigations into the compatibility and stability of energetic substances as well as the prediction of their aging behavior.

A further competence is the detection of explosives even in trace amounts using special sensor concepts, for example on the basis of molecular adsorbers. At Fraunhofer ICT, so-called "home made" explosives are fabricated, evaluated with regard to their handling properties and detectability, and made available to the security authorities for testing purposes. Activities extend to the development of concepts to detect illegal explosives laboratories, the design of civil or military security areas and checkpoints, and the standardized evaluation of detection systems on an international level, such as those used for security checks at airports. The development of protection systems against terrorist actions is the focus of complementary activities.

Synthesis of energetic materials.

Networks and alliances

In the field of defence 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 - an association of 15 Fraunhofer institutes that conduct applied research in the field of space technology.

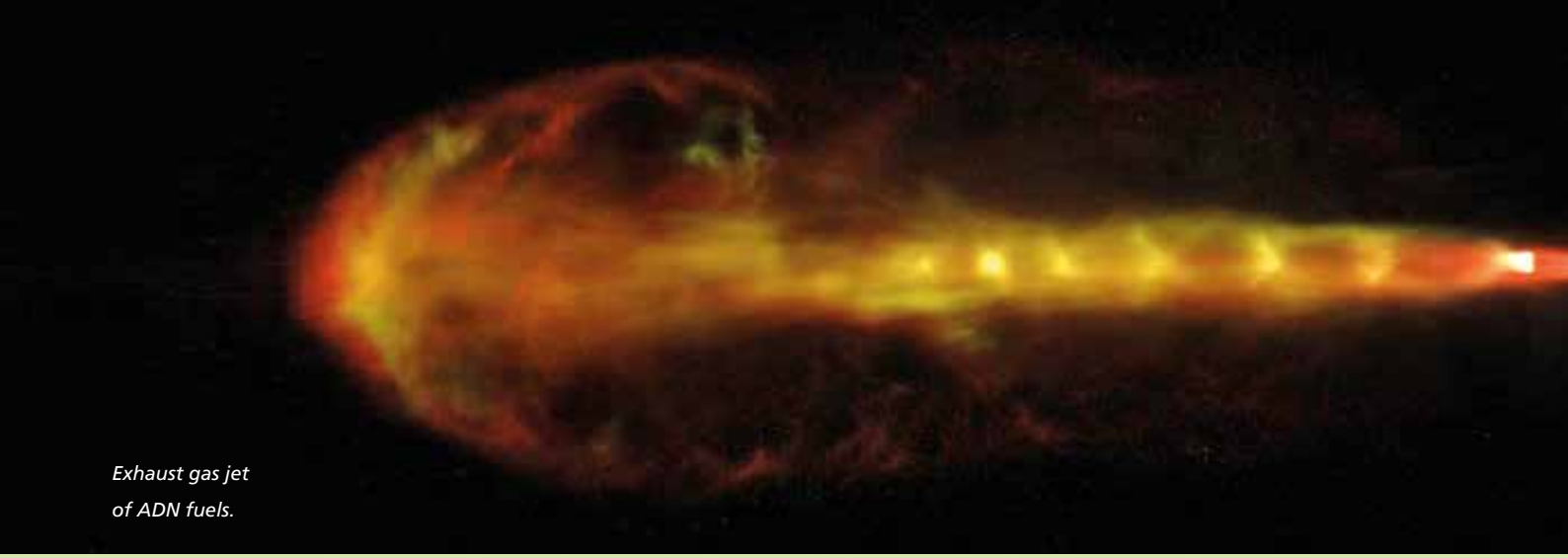
With its competence in explosives, the institute is also actively involved in numerous national and international projects (BMVg, EDA, NATO, EU, BMBF, BMI, BMWi). It also works with the BMVg in the context of bilateral research agreements. Operating as Test Center for Explosives Detection Systems on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

Research and technology

We offer research in all areas of explosives technology for the German Federal Ministry of Defence and other public authorities, the defence and security industry, and the automotive and aerospace sectors. We focus on the development, design and evaluation of energetic materials and systems, drawing on our chemical and physical know-how and safety facilities and equipment. We develop tailor-made process technologies for the safe manufacture of explosive components, support the search for REACh-compliant substances and provide demonstrators to test new energetic products.

Software-assisted analysis and design tools, developed and used at ICT, enable the screening of new propellant and explosive formulations, for example based on their performance, safety, erosivity and environmental compatibility. In the case of gun propellants and ballistics, this also includes the consideration of system aspects of weapons and ammunition. We are also able to provide support and evaluation in all development steps of pyrotechnic gas generators for safety equipment (e.g. airbags) according to application and 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 optimize their systems. Furthermore, in cooperation with the German Federal Police, the institute tests and certifies such systems for use in European airports.

CONTACT
Wilhelm Eckl
Phone +49 721 4640-355 | wilhelm.eckl@ict.fraunhofer.de
Dr. Stefan Löbbecke
Phone +49 721 4640-230 | stefan.loebbecke@ict.fraunhofer.de



Exhaust gas jet of ADN fuels.

FACILITIES AND EQUIPMENT

PILOT PLANTS AND TEST STANDS

- Chemical pilot plants and synthesis laboratories for explosives
- Pilot plants for the manufacture and processing of explosive products
- Safety boxes and testing site for explosion and safety/ security investigations
- Test Center for Explosives Detection
- Detonation chamber (up to 2 kg TNT)
- Detonation tank (up to 100g TNT)
- Test gun systems for 5.56 mm to 12.7 mm and 20 mm
- 100 m shooting range
- Test stand for rocket engines and flares
- Flow test stand for investigation of pyrotechnic systems

EQUIPMENT

- Pilot plants for the production of explosive particles
- Flow chemistry processes and synthesis units
- Fluidized-bed coater
- Spray crystallization unit
- High-pressure plant for isostatic compression molding
- Special kneaders, mixers, pelletizers and presses with explosion protection

SOFTWARE TOOLS

- Thermochemical codes for the thermodynamic evaluation of gun and rocket propellants, high explosives and pyrotechnics, e.g. ICT Thermodynamic Code, EKVI code, Cheetah 2.0., EXPLO5
- ICT thermodynamics database with over 14,000 substances
- Computational fluid dynamic (CFD) codes, such as SPEED, Ansys Fluent, Ansys Autodyn, Ansys Mechanical
- Interior ballistic codes e.g. SimIB-0D, FNGun-1D, ballistic analysis and evaluation tool BAA (ICT), software tool to simulate the combustion behavior of arbitrary shaped gun propellants (ICT), software tool for 3D form function for arbitrary shaped propellants (ICT)
- ICT-BAM for spectroscopic temperature measurement

ANALYTICAL EQUIPMENT AND LABORATORIES

- Atomic force microscope, field emission scanning electron microscope (FESEM) with variable pressure and energy-dispersive X-ray and elemental analytics (EDX)
- Micro- and nano-computed tomography scanners
- Thermoanalytical laboratory, micro- and reaction calorimeter, test stands for aging behavior
- Laboratory for mechanical testing and rheology
- Laboratory for X-ray diffractometry
- Laboratory for chromatographic and spectroscopic analysis (IR and RAMAN microscopy)
- Online spectroscopy (UV/VIS/NIR/RAMAN)
- High-speed camera and spectrometer systems
- Ballistic bombs for all gun propellant types including burn rate measurement software
- Optical and Crawford bomb for solid rocket propellants
- Blast measurement technology, QSP and temperature for detonation chamber and detonation tank
- Manganin pressure probes for measurements up to 400 kbar
- 4-channel photonic doppler velocimeter for transient velocity measurement up to 5 km/s
- Detonation velocity measurement
- Various safety test setups, e.g. Koenen test, 21 mm and 50 mm GAP test

CORE COMPETENCE
DRIVE SYSTEMS

Our core competence is the development of new powertrain systems, and comprises the development of solutions for both electric drive trains and internal combustion engines. The systems are designed, simulated and validated through testing at Fraunhofer ICT. In the field of internal combustion engines we are investigating the effect of synthetic fuels and additives in our research engines. In system development we draw on our expertise in polymer technology to produce components for casing, media flow or for elementary structures within powertrain components.

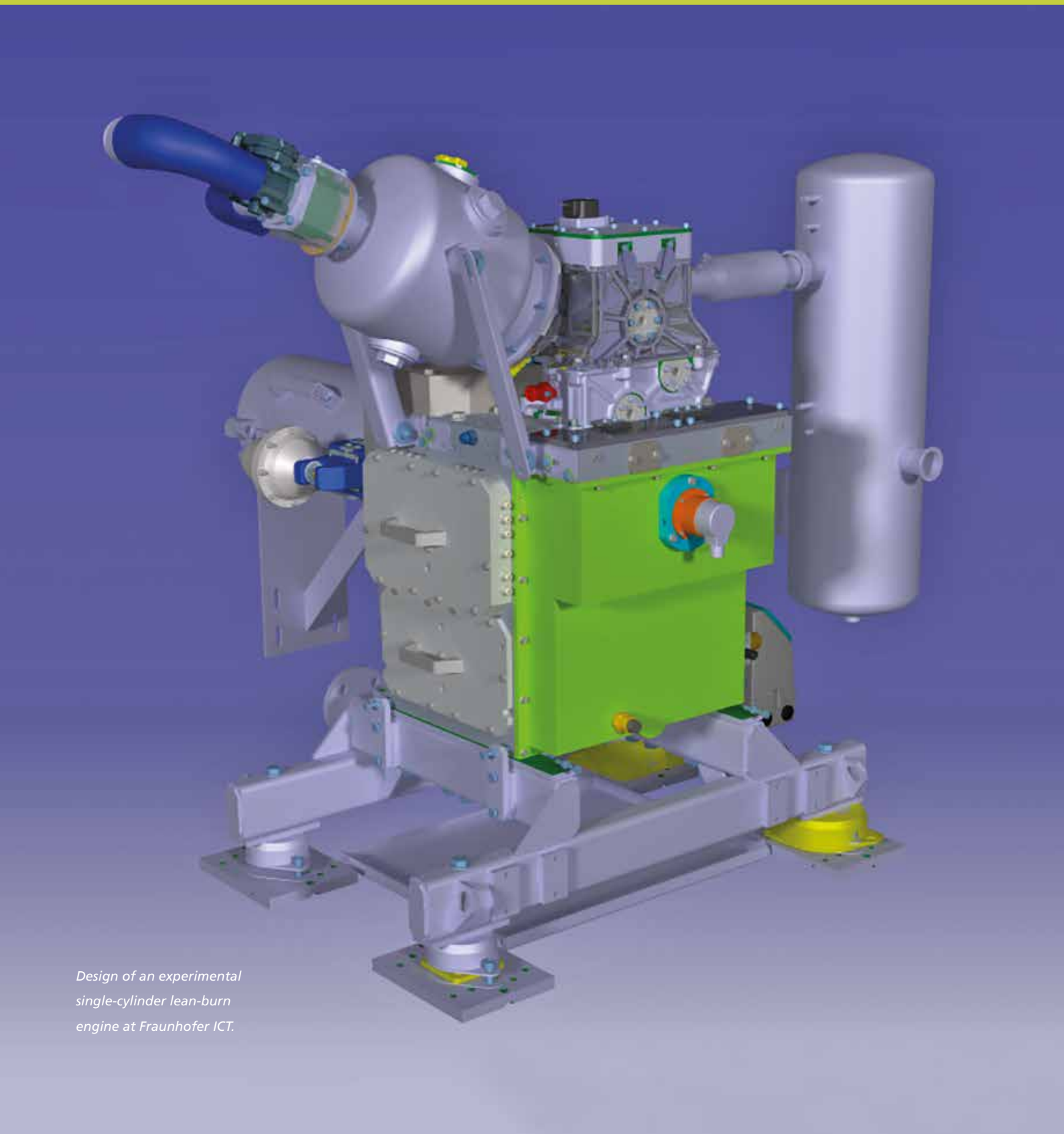
Electric powertrain concepts

In the field of electromobility, we research and develop various types of electric powertrain components. An essential part of this work is the development of electric motors and transmission systems for future battery-powered electric vehicles. We focus on the development of solutions with a high weight-specific power density and high efficiency. For this purpose we investigate alternative cooling concepts and winding types, as well as manufacturing technologies for potential use in efficient, large-scale production processes.

In the field of high voltage traction battery system developments, our research focuses on safe, lightweight solutions with integrated functions, which meet the demands for high energy and power densities while fulfilling all safety requirements during fast charging and discharging.
An essential part of these developments is the conception, design and simulation of efficient thermal management systems, which are necessary for the heating and cooling of the battery systems during operation.

Internal combustion engine concepts

Due to their very good overall efficiency (well-to-wheel) and the high gravimetric and volumetric energy density of the fuels used, combustion engines will continue to be a dominant drive concept in transport and individual mobility in the coming years. In the field of combustion engine concepts, we aim to develop technical solutions in the entire drive train for mobile applications. We research and develop combustion engines both as the sole drive unit and in combination with an electric engine, as a hybrid drive system. The objective of all our developments in this field is to reduce fuel consumption and emissions from internal combustion engines and to make the overall system safer, more flexible, more readily available and, above all, compatible with affordable mobility. For this purpose we work with highly efficient combustion processes, alternative engine concepts, improved engine mechanics and the use of residual energy. With our comprehensive research expertise and the cutting-edge equipment in our pilot plants, we are setting new trends in exhaust-gas cleanup, synthetic fuels and construction materials. Our researchers use various simulation and optimization tools, as well as modern laboratory equipment and automated test stands.



Design of an experimental single-cylinder lean-burn engine at Fraunhofer ICT.

Design competence

Drawing on our design competence, we carry out new developments of complex systems for our industrial and project partners. For example, we design and produce prototypes to validate new operating principles or layout concepts for traction batteries and electric engines, up to complete systems such as combustion engines and turbines. Our competence starts in the idea and concept phase. We develop drafts and create detailed designs and drawings with a view to production. As a standard we use CATIA V5 in connection with a CAD data management system and an extensive material database in our commissioned projects. To ensure the best possible collaboration with our industrial partners, we apply a top-down design method. This generates a clear and uniform component structure.

Simulation competence

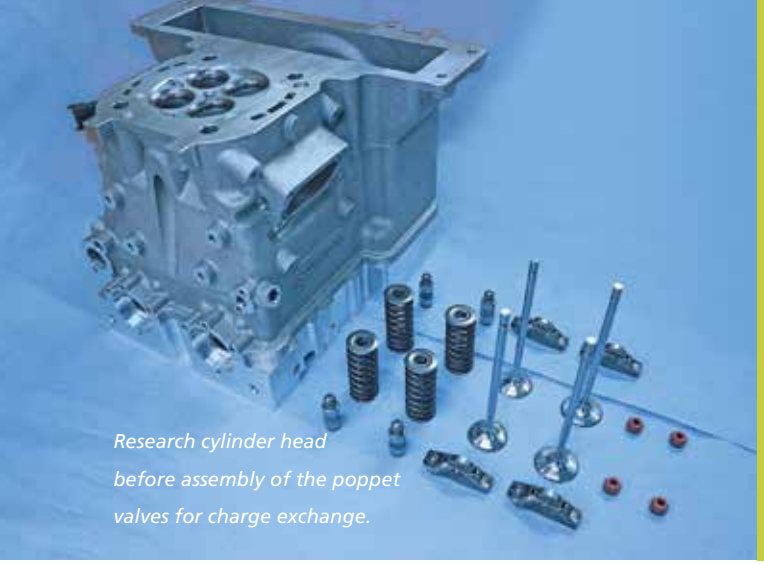
To verify and model new designs, we analyze complex components and systems, starting in the concept phase. To assess the behavior of individual components in the system, we use simulation tools for the transfer of heat, material and information, for example "Dymola" or "GT-Suite". The components are modeled physically or in a map-based system. In the field of internal combustion and electric engines, novel cooling concepts are designed and simulated using CFD and CHT modeling. The tool "IPG-CarMaker", which simulates the entire vehicle, enables vehicles to be split into different modular components, the efficiency of which can be assessed during driving. This makes it possible to calculate potential energy consumption advantages of the technologies in driving cycles. For flow, multi-body and structure simulation we also use professional tools according to current industrial standards, e.g. Ansys Fluent, Ansys Mechanical, and SimPack.

Testing competence

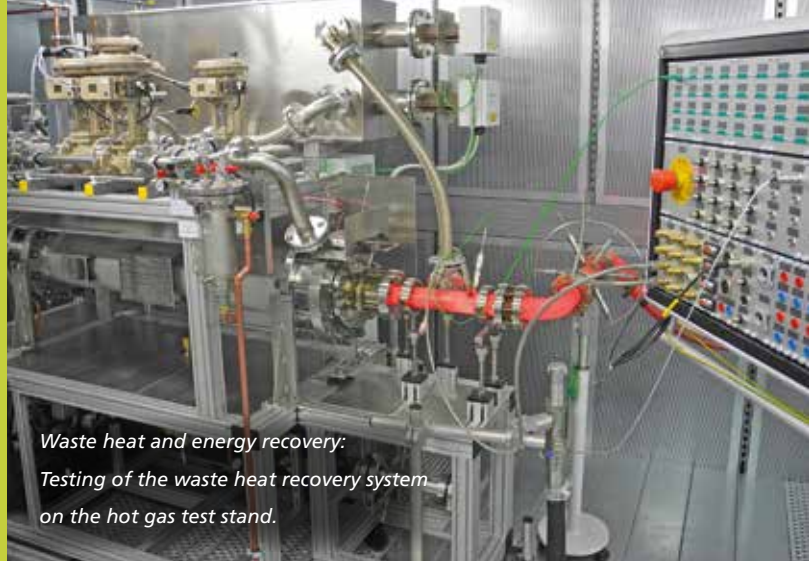
We operate cutting-edge testing facilities that complement our expertise in the simulation, design, development and manufacture of components and systems in an extensive test field. Complete measurements of multi-cylinder engines (smaller passenger car size) and single-cylinder test engines can be performed on our engine test stand.

On our hybrid test stand the entire electrical system within the drive train is investigated. The drive train comprises a DC-to-DC converter, an inverter and an electrical machine, which can be used, for example, to display changes in the battery voltage according to the state of charge. The hot gas test stand is used to investigate waste heat recovery systems, thermoelectric generators, heat exchangers, turbo generators, exhaust-gas turbochargers and exhaust systems. An extension of this test stand developed at Fraunhofer ICT enables us to investigate the damage behavior of components, or to superimpose high cycle fatigue (HCF) onto thermo-mechanical fatigue (TMF) over time. For this purpose, the hot gas test stand is combined with a high-frequency pulsator, which generates the mechanical load. Our portable exhaust gas measurement system (PEMS) and our data logger make it possible to record real driving data on emissions as well as operating and environmental conditions.

CONTACT
Hans-Peter Kollmeier
Phone +49 721 9150-3811 |
hans-peter.kollmeier@ict.fraunhofer.de



Research cylinder head before assembly of the poppet valves for charge exchange.



Waste heat and energy recovery: Testing of the waste heat recovery system on the hot gas test stand.

LIGHTHOUSE PROJECT "COMBUSTION ENGINE FOR FUTURE MOBILITY"

Motivation and objectives

Due to its high thermal efficiency and the excellent energy density of the fuels used, the combustion engine will continue to play a dominant role in mobility in the foreseeable future, especially in heavy duty applications like long haul, shipping and air traffic, but also in the field of individual transport. In the area of mobility, electric drive trains will increasingly be used alongside combustion engines, but they will not fully replace them. The further development of powertrains, while remaining open to all types of technology, is a prerequisite for successful climate policy in an affluent society. With our lighthouse projects, we tackle ongoing challenges and set strategic priorities in the development of concrete solutions for use in Germany. The goal is to quickly transform original scientific ideas into marketable products. The participating Fraunhofer institutes pool their expertise and involve industrial partners in the projects at an early stage.

Solutions

The internal combustion engine offers numerous possibilities to save fuel and reduce emissions. In addition to CO_2-neutral and locally emission-free vehicles powered by renewable fuels, the focus is on technological pathways toward the development and research of novel combustion process concepts and waste heat recovery systems. In the first phase of the lighthouse project, two scientific sub-projects were carried out at Fraunhofer ICT.

The primary research and development objective of the first sub-project, "lean-burn combustion", was to develop a concept for a highly efficient combustion process for internal combustion engines. This process is based on the combustion of a homogeneous, strongly overstoichiometric air-fuel ratio. The design of an internal combustion engine for such operation therefore allows higher, thermodynamically favorable compression ratios and the undercutting of the nitrogen oxide formation boundary, while also ensuring fast conversion rates in combustion. To ensure reliable ignition and rapid combustion of the mixture, a passive prechamber spark plug – as the ignition source – and a steel piston with an integrated combustion chamber were developed for the combustion process.

One promising measure to increase efficiency in a vehicle is the use of a Rankine process to convert the waste heat emitted by the internal combustion and use it in the vehicle's drive train. In the sub-project "Waste heat and energy recovery", a novel approach to heat storage technology in the Rankine cycle, based on the Ruths storage system, was investigated.

The circular-process components of the Rankine process with a Ruths storage system were modeled in a simulation environment and experimentally validated on the hot gas test stand. Using the components developed in the project, a waste heat recovery system was set up in the hot gas test stand for this purpose, and measured thermodynamically. The validation of the simulation models was carried out based on representative stationary operating points from the experimental investigation of the Rankine cycle process. The recuperation potential of the validated Rankine model with the Ruths storage system was evaluated based on real driving data.

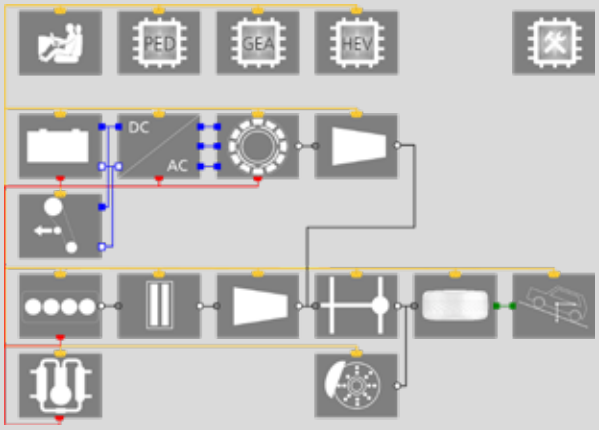
CONTACT

Ivica Kraljevic

Phone +49 721 9150-3818 |

ivica.kraljevic@ict.fraunhofer.de

VW e-Golf on the acoustic all-wheel drive dynamometer of KIT-FAST.



Model library for multi-domain simulation of the entire vehicle drive train.

LIGHTHOUSE PROJECT "MOBILITY SYSTEMS IN KARLSRUHE – HYBRID DRIVE TRAINS"

Motivation and objectives

A holistic approach to conventional and electric drive trains has the potential to optimize energy demand and emissions. Particularly where thermal management systems are concerned, there are significant differences between conventional, hybrid and electric drive trains. The core of the project is to identify the relevant components of the drive train, to simulate them and to optimize their interconnection. This holistic investigation can increase the electric range and reduce CO_2 emissions through more efficient drive systems. This is the task of the New Drive Systems Department at Fraunhofer ICT, together with the Institute of Product Engineering (IPEK) and the Institute of Electrical Engineering (ETI) of the Karlsruhe Institute of Technology (KIT).

Solutions

The object-oriented simulation approach allows any drive train topology to be mapped and evaluated. Thus, in addition to purely combustion-engine or electric drive concepts, parallel hybrids or range extenders can also be investigated. The simulation model created during the initialization phase of the regional network was extended by thermal models of the individual components. For the thermal modeling of the combustion engine, the main paths (air, cooling water, oil, etc.) as well as components (intercooler, thermostat, turbocharger, etc.) were determined. Using literature and measurement data, a simulation model of a lithium-ion battery cell was developed which simulates the electro-thermal state of the cell and calculates the heat generated when a current load and starting and ambient conditions are specified.

The most important thermal paths were determined for the thermal model of the power electronics and the electrical machine. Thermal equivalent circuits were also developed and parametrized. To evaluate possible applications, a heat recovery system based on different models of a Rankine cycle process was constructed. The design of the recovery system depends on the interconnection of the individual drive components and their performance category.

The result is a model library for multi-domain simulation of the entire drive train of the vehicle. As the degree of hybridization increases, the performance of the electric traction component improves and that of the combustion engine is generally reduced, so that the overall performance of the drive train remains constant. By this means, the optimum drive train configuration, consisting of a combustion engine and electric traction machine, can be determined for a defined route and for any vehicle. Especially for recurring journeys, such as commuting, the customer can be given a recommendation for a drive train. The results can easily be transferred to passenger transport or the transportation of goods.

CONTACT
Andreas Dollinger
Phone +49 721 9150-3819 |
andreas.dollinger@ict.fraunhofer.de

FACILITIES AND EQUIPMENT

ENGINE TEST STANDS

- Loading unit: Asynchronous machine (4-quadrant operation)
- 480 Nm, 250 kW, 10,000 1/min
- 250 Nm, 120 kW, 12,000 1/min
- Single cylinder tests
- Testing of synthetic fuels
- Hydrogen combustion

EMISSION MEASUREMENT TECHNOLOGY

- AVL M.O.V.E Gas & Particle Counter
  - $NO/NO_2CO/CO_2$, O_2
  - Opt. FID module (THC, CH_4)
  - Exhaust gas volume flow
  - OBD logging
  - Heated pipes
  - Power supply: Battery
- AVL Particle Counter APC 489
- TSI EEPS Particle spectrometer
- Cambustion fast gas analyser (NOX,HC, CO)

HOT GAS TEST STAND

- UTF natural gas burner
- Max. temperature 1200 °C
- Performance up to 400 kW
- Hot gas mass flow up to 1800 kg/h
- Temperature gradient up to 100 K/s

HIGH-FREQUENCY PULSATOR

- Electromagnetic drive
- Dynamic and static testing machine
- Test forces of up to 100 kN
- Test frequencies of up to 285 Hz

TEST METHODOLOGY AND VEHICLE SIMULATION

- Virtual testing
- IPG CarMaker
- AVL InMotion
- Derivation of load spectra

DATA LOGGER

- Individually configurable
- OBD, GPS, temperatures
- Humidity, pressure, vibration

CLUSTERS OF EXCELLENCE

The Fraunhofer Clusters of Excellence promote the joint definition and development of system-relevant topics within a cross-institutional research structure. In organizational terms, these research clusters correspond to a "virtual institute" spread over multiple locations. The research clusters do not just aim to implement individual projects, but rather to pursue a roadmap for the long-term development of a complex technology trend.

FRAUNHOFER CLUSTER OF EXCELLENCE "PROGRAMMABLE MATERIALS"

The development of programmable materials can profoundly change their use and replace complete systems of sensors, controllers and actuators. The goal of the Fraunhofer Cluster of Excellence "Programmable Materials" is to reduce the complexity of systems and reduce resource use by integrating functions into the material.

The Fraunhofer Cluster develops materials or material systems with an internal structure designed and manufactured to enable the material properties in the component to be specifically adjusted or even reversibly changed. This allows the integration of new complex and locally varied functions. The vision of the cluster is to further develop the possibility to locally tailor materials and their properties for component development.

The following topics are covered:

- programmable transportation properties (material and heat transport)
- mechanically programmable materials (mechanical and tribo properties)
- Manufacturing and upscaling
- Product development

Contact:
Elisa Seiler
Phone +49 721 4640-354 | elisa.seiler@ict.fraunhofer.de

FRAUNHOFER CLUSTER OF EXCELLENCE "CIRCULAR PLASTICS ECONOMY"

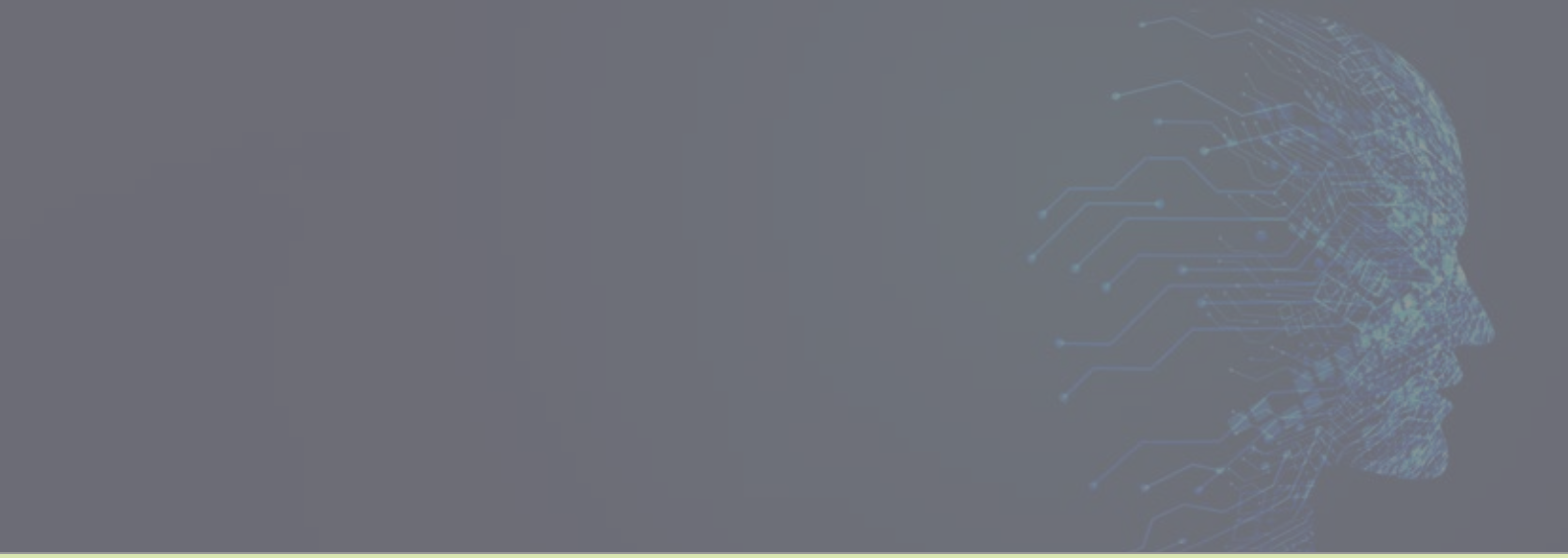
Taking plastics as an example, the participating Fraunhofer institutes show how the energy and material flows in a value chain can be transformed into a circular economy. To this end, special system services are being developed with and for the plastics industry, including its associated consumer goods and retail companies and the circular economy.

The basic idea behind the transformation from a linear to a circular economy is simple: Reduce extraction of fossil resources, avoid end-of-life losses and simultaneously facilitate a genuine closed-loop recycling of plastics. The implementation is complex: A circular economy is about more than just increasing efficiency and recycling. It addresses not only closed-loop economies, but also circular product systems throughout the entire life cycle.

The following topics are covered:

- Polymers and additives suitable for a circular economy
- Material and raw material recycling
- Digital monitoring of products and processes for real-time evaluation
- Circular product design and new business models

Contact:
Elisa Seiler
Phone +49 721 4640-354 | elisa.seiler@ict.fraunhofer.de



FRAUNHOFER CLUSTER OF EXCELLENCE "INTEGRATED ENERGY SYSTEMS INES"

The central technological and economic challenge in the next phase of the global energy transition is the system and market integration of high proportions of variable renewable energies into the energy system.

The Fraunhofer Cluster "Integrated Energy Systems" therefore works on the large-scale integration of renewable energies into the German and European energy system. A thorough, model-based energy system analysis supports the technically and economically optimized development of an energy system in which heat, electricity and transport are connected.

The following topics are covered:

- Comprehensive, cross-sectoral system analysis
- System technology for infrastructure management
- Electrolysis as the basic technology for system-relevant, large-scale storage

Contact:
Prof. Dr. Karsten Pinkwart
Phone +49 721 4640-322 | karsten.pinkwart@ict.fraunhofer.de

APPENDIX

HIGH-PERFORMANCE CENTERS, NETWORKS AND ALLIANCES

The institutes of the Fraunhofer-Gesellschaft work together, collaborating in networks 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. Fraunhofer ICT participates in the networks, alliances and high-performance centers listed below.

HIGH-PERFORMANCE CENTERS

High-performance centers organize the collaboration between university and non-university research and industry, and are characterized by binding, consistent roadmaps for the partners involved in terms of research and teaching, the promotion of young researchers, infrastructure, innovation, and transfer.

HIGH-PERFORMANCE CENTER FOR MOBILITY RESEARCH IN KARLSRUHE

The four Fraunhofer institutes ICT (including the New Drive Systems Department), IOSB, ISI and IWM, the Karlsruhe Institute of Technology, the Karlsruhe University of Applied Sciences and the FZI Research Center for Information Technology are conducting joint research on future mobility in the "Profilregion" high-performance center for mobility research in Karlsruhe. Seven initialization projects cover the key challenges of efficient, intelligent and integrated mobility across a wide range of topics. The projects generate a network of important players from science, applied research and industry.

Contact:
Dr.-Ing. Lars-Fredrik Berg
Phone +49 721 9150-3814 | lars-fredrik.berg@ict.fraunhofer.de
Ivica Kraljevic
Phone +49 721 9150-3818 | ivica.kraljevic@ict.fraunhofer.de

FRAUNHOFER GROUPS

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

FRAUNHOFER GROUP FOR DEFENSE AND SECURITY (VVS)

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

Contact:
Prof. Dr.-Ing. Peter Elsner
Phone +49 721 4640-401 | peter.elsner@ict.fraunhofer.de

FRAUNHOFER GROUP FOR MATERIALS AND COMPONENTS

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

Contact:
Prof. Dr.-Ing. Peter Elsner
Phone +49 721 4640-401 | peter.elsner@ict.fraunhofer.de

ALLIANCES

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

FRAUNHOFER BATTERY ALLIANCE

- Material and cell: Synthesis of electrode materials, current collector and particle modifications, development of electrolytes and separators, separation processes
- Cell production: Electrode production, cell assembly, cell characterization, digitized battery production, industry 4.0
- System & integration: Packaging and cell design, module development, battery management systems, prototype battery production, vehicle integration
- Testing and evaluation: Electrical and mechanical characterization, functional tests, transport and storage tests, safety and abuse tests
- Simulation: Accompanying simulations over all stages of the value chain, from quantum chemical through to structural-mechanical simulations.

Contact:
Prof. Dr. rer. nat. Jens Tübke
Phone +49 721 4640-343 | jens.tuebke@ict.fraunhofer.de

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

Contact:
Prof. Dr.-Ing. Axel Kauffmann
Phone +49 721 4640-425 | axel.kauffmann@ict.fraunhofer.de

FRAUNHOFER LIGHTWEIGHT CONSTRUCTION ALLIANCE

- New materials and material composites
- Joining and manufacturing processes for lightweight construction
- Integration of functions
- Design and configuration
- Non-destructive and destructive test methods

Contact:
Prof. Dr.-Ing. Frank Henning
Phone +49 721 4640-420 | frank.henning@ict.fraunhofer.de

FRAUNHOFER ENERGY ALLIANCE

- Renewable energy sources: Solar energy, biomass, wind energy
- Energy-efficient technologies: Combined heat and power generation (CHP) 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, transfer and use of energy data
- Energy storage and micro-energy systems: lithium technology for batteries, fuel cell systems

Contact:
Prof. Dr. rer. nat. Jens Tübke
Phone +49 721 4640-343 | jens.tuebke@ict.fraunhofer.de

FRAUNHOFER SPACE ALLIANCE

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

Contact:
Dr. Uwe Schaller
Phone +49 721 4640-676 | uwe.schaller@ict.fraunhofer.de
Volker Weiser
Phone +49 721 4640-156 | volker.weiser@ict.fraunhofer.de

TEACHING ENGAGEMENT AND PUBLIC BODY MEMBERSHIP

Teaching activities and public body membership are important tasks of a research institution. In 2019, 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 2019, we also participated in numerous working groups and public bodies, to help shape the future of our research fields.

TEACHING ENGAGEMENT

KARLSRUHE INSTITUTE FOR 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)

Weidenmann, Kay André
- Material processing technology (3 units per week, WT)
- Internship material processing technology (1 units per week, WT)
- Seminar material processing technology (2 units per week, ST)
- Materials for lightweight design (2 units per week, ST)

Institute for Vehicle Systems Technology FAST

Henning, Frank
- Lightweight vehicle construction– strategies, concepts, materials (2 units per week, WT)
- Fiber-reinforced plastics – polymers, fibers, semi-finished products, processing (2 units per week, ST)

Institute for Mechanical Process Engineering and Mechanics

Tübke, Jens
- Materials and methods for electrochemical storage devices and converters (2 units per week, WT + ST)

KARLSRUHE UNIVERSITY OF APPLIED SCIENCES – TECHNOLOGY AND ECONOMICS

Department for Electronic and Information Technology

Graf, Matthias
- Sensor laboratory 1 (2 units per week, WT + ST)

Pinkwart, Karsten
- Biochemical sensors 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
- Computer-aided lab (4 units per week, WT)
- Electronics 3 for sensor system technicians (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 (4 units per week, WT + ST)
- Material sciences: plastics (2 units per week, WT)
- Plastics processing (2 units per week, ST)
- Laboratory for plastics processing and measurement technology (2 units per week, WT + ST)

Kronis, Gunnar
- Design theory (WS, SS)

Reinhard, Stefan
- Material sciences plastics (2 units per week, WT)
- Laboratory for plastics processing (2 units per week, ST)

Mechatronics Course

Bader, Bernd

– New materials (2 × 33 units / year)

Safety Engineering Course

Gräbe, Gudrun

– Basics of environmental technology (3 units per week, WT)

Ditmar Schulz

– Emissions (3 x 8 units/year)

Industrial Engineering Course

Gräbe, Gudrun

– Environmental engineering and recycling (2 x 3 units per week, ST)

BADEN-WÜRTTEMBERG COOPERATIVE STATE UNIVERSITY (DHBW), MANNHEIM

Mechanical Engineering Course

Bader, Bernd

– Processing of plastics and elastomers (55 units / year)

– Construction with plastics (33 units / year, WT)

BADEN-WÜRTTEMBERG COOPERATIVE STATE UNIVERSITY, MOSBACH

Mechatronics Course

Peter Eyerer

– Polymer engineering (2 units per week, WT)

TECHNICAL UNIVERSITY NUREMBERG

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)

ULM UNIVERSITY

Teipel, Ulrich

– Mechanical process engineering (4 units per week, WT + ST)

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

Faculty of Electrical Engineering

Pinkwart, Karsten

– Electrochemical energy storage devices and converters (2 units per week, WT)

Mechanical Engineering Department

Cremers, Carsten

– Electrochemical power sources (2 units per week, WT)

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)

UNIVERSITY OF WEST BOHEMIA IN PILSEN, CZECH REPUBLIC

Mechanical Engineering Department

Kolarik, Vladislav

– X-ray diffractometry as an in-situ method (guest lecture, one 2-hour session, WT)

PUBLIC BODY MEMBERSHIP

Böhnlein-Mauß, Jutta
- 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)
- Visiting fellow of NATO AC326/SG1-CNG
- Member of the German Society for Thermal Analysis (GEFTA)
- Member of the International Steering Committee of the International Pyrotechnics Seminar USA (IPS-USA Seminars)
- Organizing committee member of KISHEM, Korea (South)
- Scientific committee member of the NTREM, Pardubice, Czech Republic
- Member of the Committee of the HFCS-EM (Heat Flow Calorimetry Symposium on Energetic Materials)
- Member of the "Committee of the International NC Symposium"
- Member of the International Advisory Board of the Polymer Degradation Discussion Group (PDDG)

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" of the Air Quality Control Commission (AQCC)
- Member of the Society for Environmental Simulation (GUS e.V.)
- Deputy Director of the Working Group on "Particles – Properties and Effects" within the Society for Environmental Simulation (GUS)
- Various Working Groups of the Society for Environmental Simulation (GUS)
- DAkkS Consulting Expert on Environmental Simulation

Cremers, Carsten
- 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 NATO Army Armaments Group (NAAG) Land Capability Group Dismounted Soldier System (LCGDSS) Power Team of Experts
- Member NATO Science & Technology Organization Panel SET-270 "Overcoming the Technical Barriers that Inhibit the Use of Fuel Cells for Dismounted Soldier Application"
- 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)

Elsner, Peter
- Chair of the University Advisory Board of the Karlsruhe University of Applied Sciences-Technology and Economics
- Member of the Central Committee of the Scientific and Technical Council of the Fraunhofer-Gesellschaft
- Deputy spokesman of the Fraunhofer Building Innovation Alliance
- Member of the National Academy of Science and Engineering, acatech
- Spokesperson of the Fraunhofer Sustainability Network

Eyerer, Peter
- Member of Jury VIP+ Funding Program of the Federal Ministry of Education and Research, Berlin; Project Executive Agency VDI/VDE-IT
- Consulting Expert at KMU-NETC, Funding Program of the Federal Ministry of Education and Research, Berlin; Project Executive Agency VDI/VDE-IT, Berlin
- 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 Working Group "External Ballistics" of the Bundeswehr Technical Center for Weapons and Ammunition
- Member of the Task Force "Interior Ballistics Simulation"

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

Griesbaum, Patrick
- Member of the AVK Working Group SMC/BMC

Henning, Frank
- Director of SAMPE Deutschland e.V.
- Member of the Federation of Reinforced Plastics (AVK)
- SPE Composites Division
- Adjunct Research Professor in the Department of Mechanical & 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)

Hettmanczyk, Lara
- Member of the German Chemical Society (GDCh) (including membership of the technical groups Analytical Chemistry, Chemists in Civil Service and the Association for Chemistry and Economics)

Hübner, Christof
- Elected member of the Scientific and Technical Council of Fraunhofer-Gesellschaft

Joppich, Tobias
- Representative of Fraunhofer ICT in the Lightweight Construction Center in Baden-Württemberg (LBZ-BW e.V.); assistance to the managing board
- Representative of Fraunhofer ICT in the Lightweight Construction Agency Baden-Württemberg
- Representative of Fraunhofer ICT in the VDMA Working Group on Hybrid Lightweight Technologies
- Member and spokesperson of the Working Group "EATC – European Alliance for Thermoplastic Composites" of the Federation of Reinforced Plastics (AVK)

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
- Member of the DGM Technical Committee Cellular Materials

Knapp, Sebastian
- Member of the International Pyrotechnic Society
- Member of the German Physical Society (Deutsche Physikalische Gemeinschaft)

Keßler, Armin
- Member of the International Association for Hydrogen Safety, IA-HySafe
- Member of the Intercontinental Association of Experts for Industrial Explosion Protection, INDEX e.V.
- Member of the CSE-Society - Society for the Promotion of Process and Plant Safety

Kolarik, Vladislav
- Member of the International Advisory Body of the Research, Development and Innovation Council of the Government of the Czech Republic
- Member of the German Society for Corrosion Protection (GfKORR)
- Member, Research Group on Corrosion Protection at High Temperatures, within the GfKORR
- Symposium Chairman on "Coatings for Use at High Temperatures", International Conference on Metallurgical Coatings and Thin Films, San Diego, USA

Lautenschläger, Miriam
- Member of the AVK Working Group "Natural-Fiber-Reinforced Plastics"

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

Noack, Jens
- Member of ProcessNet, including Technical Groups for Microprocessing Technology, Reaction Technology, Process Analytics, Zeolites, Working Committee on Reaction Technology for Processes with Complex Safety Issues
- Member of the German Chemical Society (GDCh), including Working Group "Process Analysis"
- Member of the German Catalysis Society (GECatS)

Parrisius, Martina
- Board member of "Lernort Labor" (learning in the laboratory), Bundesverband für Schülerlabore e.V.
- Member of "Initiativkreis Unternehmergeist in die Schulen" (entrepreneurship at school), Federal Ministry for Economic Affairs and Energy, 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)

Rabenecker, Peter
- Member of the Scientific Board of the HybridSensorNet Symposium

Reichert, Thomas
- Managing Director of the Society for Environmental Simulation (GUS) e.V.
- Former president of the European Federation of Clean Air and Environmental Protection Associations (EFCA)
- Former president of the Confederation of European Environmental Engineering Societies CEEES
- 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)
- 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 Standardization)
- 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)
- Member of the EDS Hold Baggage Explosive Study Group (ECAC)
- Member of the Quality Working Group (ECAC)

Schnürer, Frank
- Member of the Advisory Board of the Civil Security Coordination Office (KoSi)

Schweppe, Rainer
- Chairman of the CleanSky Platform "Eco Design Transversal Activity", Joint Undertaking
- Member of the International Association for Sustainable Aviation (IASA)
- Member of INNONET Netzwerk; Head of the Working Group "Recycling"
- Member of the Working Group "Bioeconomy" of the Ministry of Rural Affairs and Consumer Protection of Baden-Württemberg

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)
- Consulting expert of the Federal Ministry for Education and Research and DFG (German Research Foundation)
- Member of the Editorial Board of the journal "Chemical Engineering & Technology"
- Guest editor of the journal "Chemical Engineering and 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 Scientific Committee of the "PARTEC 2019"
- Appointed member of the ProcessNet Technical Group "Raw Materials"
- Appointed member of the Council of Science and Humanities

Tübke, Jens
- Spokesman of the Fraunhofer Battery Alliance
- Spokesman of the R&D Advisory Board of the Bundesverband Energiespeicher (BVES) (German Energy Storage Association)
- Member of the Executive Board of fokus.energie e.V.
- Chair of the MEET Scientific Advisory Board – Münster Electrochemical Energy Technology
- Member of the Advisory Board of "Battery Research Germany" of the Federal Ministry for Education and Research (BMBF)
- Member of the Technical Group for Applied Electrochemistry of the German Chemical Society (GDCh)

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 the International Pyrotechnic Society
- Representative of Fraunhofer ICT in the Fraunhofer Space Alliance

Weidenmann Kay
- Member of the Selection Committee of the German Academic Scholarship Foundation (Studienstiftung des deutschen Volkes e.V.)
- Consulting Expert of the German Research Foundation (Deutsche Forschungsgemeinschaft)
- Member of the DGM Technical Committee "Hybrid Materials"
- Member of the Scientific Committee of the International Conference on Composite Structures (2017, 2018)
- Member of the Scientific Committee of the 4th Conference on Hybrid Materials and Structures (2020)
- Member of the Executive Board of the Application Center for Material and Environmental Research, Augsburg

Wittek, Michael
- Member of the Explosive Vapor Detection (EVD) Study Group of the ECAC

Wurster, Sebastian
- Member of the Working Group for Interior Ballistics
- Member of the Working Group "External Ballistics" of the Bundeswehr Technical Center for Weapons and Ammunition
- Member of the Task Force "Interior Ballistics Simulation"
- Member of the International Ballistics Society (IBS) and member of the IBS Education Committee

EVENTS AND PARTICIPATION IN TRADE FAIRS AND EXHIBITIONS

EVENTS

March 20-21, 2019
DVM working group "Structural components made of polymer composites"
Fraunhofer ICT, Pfinztal, Germany

March 27-29, 2019
48th Annual conference of the German Society for Environmental Engineering (GUS)
"Identifying, simulating and evaluating environmental influences"
Festhalle, Stutensee-Blankenloch, Germany

March 28, 2019
Girls' Day
Fraunhofer ICT, Pfinztal, Germany

April 2-4, 2019
Interior & Exterior Ballistics Workshop
Fraunhofer ICT, Pfinztal, Germany

April 9, 2019
Working group "Plastics in the Pfalz region"
Fraunhofer ICT, Pfinztal, Germany

May 9-10, 2019
5th Symposium on Raw Material Efficiency and Raw Material Innovations
Fraunhofer ICT, Pfinztal, Germany

June 25, 2019
Wehrtechnisches Seminar
Fraunhofer ICT, Pfinztal, Germany

June 25-28, 2019
50th International Annual Conference of Fraunhofer ICT: "Energetic materials - past, present and future"
Kongresszentrum, Karlsruhe, Germany

October 8-9, 2019
Meeting of the Advisory Board of Fraunhofer ICT
Fraunhofer ICT, Pfinztal

October 22-23, 2019
Workshop: "Alternative energy supply for stationary and mobile applications in operation"
Fraunhofer ICT, Pfinztal, Germany

October 28-31, 2019
Talent School ICT and ISI Fraunhofer ICT
Fraunhofer ICT, Pfinztal

November 26-27, 2019
Workshop: "Propellants and explosives"
Fraunhofer ICT, Pfinztal, Germany

PARTICIPATION IN TRADE FAIRS AND EXHIBITIONS

January 14-19, 2019
BAU – World's Leading Trade Fair for Architecture, Materials and Systems
Munich

February 27 - March 1, 2019
FC Expo
Tokyo, Japan

February 27 - March 1, 2019
Battery Japan
Tokyo, Japan

March 12-14, 2019
Energy Storage Europe
Düsseldorf

March 12-14, 2019
JEC - World 2019
Paris, France

March 14-15, 2019
Future Security
Berlin, Germany

April 2-3, 2019
Smart Energy Conference & Exhibition
Sydney, Australia

April 2-4, 2019
Battery Conference
Aachen

April 3-4, 2019
PIAE Europe
Mannheim

April 10-12, 2019
Battery Experts Forum
Frankfurt

May 7-9, 2019
Battery Show Europe
Stuttgart

June 17-23, 2019
SIAE - Paris Air Show
Paris, France

June 25-27, 2019
Sensor + Test
Nuremberg, Germany

September 10-12, 2019
FOAM Expo
Stuttgart

September 18-20, 2019
Materials week ("WW")
Dresden

October 16-23, 2019
K trade fair
Düsseldorf

PUBLICATIONS

Albrecht F., Rosenberg P., Heilos K., Hoffmann M., Henning F.
vliesRTM - Reuse of carbon fiber waste in composite structures.
SAMPE Europe Conference 2019 Nantes - France

Albrecht F., Zimmerling C., Poppe C., Kärger L., Henning, F.
Evaluierung der Umformung infiltrierter Gewebe innerhalb einer Double Dome Geometrie.
Verbundwerkstoffe; 22. Symposium Verbundwerkstoffe und Werkstoffverbunde; 26.-28. Juni 2019; Kaiserslautern

Baumann, N.; Blankenship, A.; Dorn, M.; Cremers, C.
Belmer, F.; Bensman, B.; Brandt, T.; Cremers, C.; Derflinger, M.; Hanke.
Rauschenbach, R.; Grube, T.; Heinzel, A.; Horenkamp, W.; Jungmann,
T.; Kaimer, S.; Karzel, P.; Kleimaier, M.; Lettenmeier, P.; Pokojski, M.;
Sandstede, G.; Suermann, M.; v. Unwerth, T.; Wolf, E.
Evaluating Current Distribution and Influence of Defect Sites for Graphitic Compound Bipolar Plate Materials.
Fuel Cells, https://doi.org/10.1002/fuce.201900138

Beck B., Haas J., Tawfik H.
Dreidimensionale Faserskelette.
Kunststoffe (2019) 09, S.171 - 173

Beck B., Haas J., Tawfik H.
Three-Dimensional Fiber Skeleton.
Kunststoffe International (2019) 09, S. 114 - 116

Bermejo J., Yurrita P.
Modelling of the heat transfer coefficient in a nozzle bomb for gun propellants erosivity studies.
In: Proceedings of the 50th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Past, Present and Future", June 25-28, 2019, Karlsruhe, Germany, pp. 111-1 to 111-7, ISSN 2194-4903

Bošković D.
Reaktoren für spezielle technisch-chemische Prozesse: Mikrostrukturreaktoren.
In: Reschetilowski W. (eds) Handbuch Chemische Reaktoren. Springer Reference Naturwissenschaften. Springer Spektrum, Berlin, Heidelberg

Bohn M.A.
Kinetic study on some cases of the curing reaction behaviour of a-b systems with a and b as isocyanate and polyol or amine and epoxide.
In: Proceedings of the 50th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Past, Present and Future", June 25-28, 2019, Karlsruhe, Germany, pp. 102-1 to 102-14, ISSN 2194-4903

Bohn M.A.; Ferrapontoff Lemos M.; Mussbach G.
Modified and normal arrhenius equation to characterize glass-rubber transition shifts in filled htpb-ipdi formulations.
In: Proceedings of the 50th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Past, Present and Future", June 25-28, 2019, Karlsruhe, Germany, pp. 118-1 to 118-15, ISSN 2194-4903

Cäsar J.
Gemeinsame Studie des VDI-Gesellschaft Energie und Umwelt (VDI-GEU), VDI-Gesellschaft Fahrzeugtechnik (VDI-FVT) und der Energietechnischen Gesellschaft im VDE (VDE/ETG). Gesellschaft für Umweltsimulation -GUS-
48. Jahrestagung der GUS, Karlsruhe, 27.-29. März 2019, ISBN: 978-3-9818507-3-4, S. 27-30

Cremers, C.; Jurzinsky, T.; Baumann, N.
Hochleistungsfähige und alterungsstabile HT-PEMFC Membranelektrodeneinheiten durch neue Anbindungskonzepte Katalysator/Träger/Protonenleiter (HT-Linked) : Teilvorhaben Membran-Elektrodeneinheiten und Testung.
Pfinztal : Fraunhofer ICT, 2019, 46 S.

Dieterle M.,Viere T.; Biedermann H., Vorbach S., Posch W. (Hrsg.)
Die Integration von Fragestellungen der Circular Economy in die Ökobilanzierung.
Anwendung der Life Cycle Gap Analyse mittels industriellem Fallbeispiel in:
Industrial Life Cycle Management, Seite 99 - 110
Innovation durch Lebenszyklusdenken.
1. Auflage 2019, ISBN print: 978-3-95710-245-4, ISBN online: 978-3-95710-345-1, https://doi.org/10.5771/9783957103451-99

Eberhardt A., Bošković D., Loebbecke S., Slobodan P., Winter Y.
Customized Design of Scalable Microfluidic Droplet Generators Using Step-Emulsification Methods.
Is part of: Chemical Engineering & Technology,
October 2019, Vol.42(10), pp.2195-2201
ISSN: 0930-7516, E-ISSN: 1521-4125
DOI: 10.1002/ceat.201900143

Eberhardt M., Wendel R., Geinitz S., Henning F., Drechsler K.
Simultaneous multi-frequency dielectric analysis of the polymerization process of anionic polyamide.
ICCM Conference, Melbourne, 2019

Eisner L.; Wilhelm I.; Flachenecker G.; Hürttlen J.; Schade W.
Molecularly Imprinted Sol-Gel for TNT Detection with Optical Micro-Ring Resonator Sensor Chips.
Sensors 2019, Volume 19, Issue 18, 3909
doi:10.3390/s19183909

Elsner, P.; Eckl, W.; Löbbecke, S.
60 Years of Fraunhofer ICT: 60 Years of Applied Research and Development in Energetic Materials and Systems : Editorial.
In: Propellants, explosives, pyrotechnics 44 (2019), Nr.6, S.667
DOI: 10.1002/prep.201980631
Fraunhofer-Institut für Chemische Technologie -ICT-, Pfinztal:

Fischer C., Mittag S., Kuhlen K.-G., Schweizer C., Seifert T., Dittrich R., Kollmeier H.-P.
Simulation of Damage Characteristics.
Frankfurt a.M. : FVV, 2019, 35 S.

Ferrapontoff Lemos M., Mendes L.C., Bohn M.
HTPB modified with octyl-1-azide: structural and rheological characterization.
In: Proceedings of the 50th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Past, Present and Future", June 25-28, 2019, Karlsruhe, Germany, pp. 1-1,
ISSN 2194-4903

Eyerer P.
Labore-experimentieren, entdecken, erfassen.
Chapter
Nov 2019
ISBN: (Print) 2512-9813; (online) 2625-0594; 978-3-98119673-2-6

Gerber, T.; Fischer, P.; Pinkwart, K.; Tübke, J.
Segmented Printed Circuit Board Electrode for Locally-Resolved Current Density Measurements in All-Vanadium Redox Flow Batteries.
Batteries 2019, 5, 38.

Gerber P., Happ A.
Processing of plastic bonded explosives with new mixing technologies.
In: Proceedings of the 50th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Past, Present and Future", June 25-28, 2019, Karlsruhe, Germany, pp. 114-1
ISSN 2194-4903

Gettwert V., Weiser V., Tagliabue C., Hafner S., Fischer S.
Umwelteinflüsse erfassen, simulieren, bewerten.
Int.J.Energetic Materials Chem.Prop. Vol. 18, Nr. 1, pp 31-49, 2019.
DOI: 10.1615/IntJEnergeticMaterialsChemProp.2019027826

Graf M.
Grundlagen und Verfahren zur profilierten Erwärmung von PET-Preforms mit Mikrowellen.
Fraunhofer-Verlag; Stuttgart; 2019

Griesbaum P., Ilinzeer S., Laux M., Maertens R.
Funktionsintegrierte Duromere Faserverbundwerkstoffe für neue Anwendungen.
Jahresmagazin Kunststofftechnik 2019, S. 30–34

Heil M., Müller C., Hickmann J.
Comparison of different methods for thermal decomposition of gun propellants.
In: Proceedings of the 50th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Past, Present and Future", June 25-28, 2019, Karlsruhe, Germany, pp. 23-1,
ISSN 2194-4903

Heintz, T., Herrmann, M.:
Properties and Structure of ADN-Prills.
Propellants, explosives, pyrotechnics 44 (2019), Nr.6, S.679-686,
Wiley-VCH Verlag, Weinheim, Germany, DOI: 10.1002/prep.201800328

Heintz T., Herrmann M.
Particle properties and crystalline structure of adn-prills.
In: Proceedings of the 50th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Past, Present and Future", June 25-28, 2019, Karlsruhe, Germany, pp. 98-1 to 98-6,
ISSN 2194-4903

Henning F., Joppich T., Rosenberg P., Link T., Behnisch F., Dörr D., Hohberg M., Seuffert J.
Hybrid composites for automotive applications – development and manufacture of a system-integrated lightweight floor structure in multi-material design.
SPE ACCE 2019; SPE; Novi; 2019

Henning F., Link T.
The latest research advancements in mulit-material lightweight design.
Global Automotive Lightweight Materials - GALM; LBCG; München; 2019

Henning F.
Recent Developments and Trends in Composites.
The 25th China International Composites Industrial Technical Expo, China Composites Expo 2019, Shanghai, September 3rd-5th, 2019, China

Henning F.
Automated manufacturing of composite parts enable new class of materials for large scale vehicle production.
Second edition of the African Advanced Manufacturing Show in Nelson Mandela Bay, South Africa, November 27th + 28th, Africa

Henning F., Joppich T.
Modular and Flexible Manufacturing for Tailor-made Composite Hybrid Parts.
11th Canadian – International Conference on Composites, Kelowna, BC, CANCOM 2019, July 22-25, 2019

Herrmann M., Weyrauch H.
HMX crystal topography investigated by means of atomic force microscopy and confocal microscopy.
In: Proceedings of the 50th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Past, Present and Future", June 25-28, 2019, Karlsruhe, Germany, pp. 40-1 to 40-14,
ISSN 2194-4903

Herrmann M., Förter-Barth U.
Structure and thermal behavior of TKX-50.
In: Proceedings of the 50th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Past, Present and Future", June 25-28, 2019, Karlsruhe, Germany, pp. 41-1 to 41-10,
ISSN 2194-4903

Herrmann, M.; Bohn, M.A.; Borne, L.:
Aging of RDX crystal qualities investigated by means of X-ray diffraction rocking curves.
Proc. 16th International Detonation Symposium, Cambridge Maryland, USA, July 15–20, 2018, Office of Naval Research,
ONR-43-5762-19, 2019, 1350-1355

Herrmannsdörfer D., Herrmann M., Heintz T., Gerber P.
The way towards a CL-20/HMX cocrystal scale-up
In: Proceedings of the 50th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Past, Present and Future", June 25-28, 2019, Karlsruhe, Germany, pp. 36-1 to 36-2, ISSN 2194-4903

Herrmannsdörfer D., Gerber P., Heintz T., Herrmann M. J., Klapötke T. M.
Investigation Of Crystallisation Conditions to Produce CL-20/HMX Cocrystal for Polymer-bonded Explosives.
Propellants Explos. Pyrotech. 2019, 44, 668–678
DOI: 10.1002/prep.201800332

Hohe J., Beckmann C., Böhme W., Weise J., Reinfried M., Luthardt F., Rapp F., Diemert J.
An experimental and numerical survey into the potential of hybrid foams.
Mechanics of Materials 136 (2019) 103063
https://doi.org/10.1016/j.mechmat.2019.103063

Höhne C.-C., Posern C., Böhme U., Eichler F., Kroke E.
Dithiocyanurates and thiocyamelurates: Thermal thiyl radical generators as flame retardants in polypropylene.
Polym. Degrad. Stab. 2019, 166, 17.

Höhne C.-C., Posern C., Böhme U., Kroke E.
Sulfides and Disulfides of s-Triazine and s-Heptazine: Flame Retardancy.
FRPM19, 2019 Turku, Finnland Posterbeitrag.

Hübner C., Weiss, P., Morais M., Seidel C., Baumann S.
Processing of electrically conductive thermoplastic composites regarding additive manufacturing method.
NanoCarbon Annual Conference 2019; Network NanoCarbon; Würzburg Germany; 26.-27. February 201

Ilinzeer S., Lipowsky L., Henning F.
Material and process development of polyurethane based sheet moulding compound.
SAMPE Europe Conference 2019; SAMPE Europe; Nantes - France; 2019

Imiolek A., Becker W., Weiser V., Bieroth D.
Pressure and temperature dependency of adn-based solid rocket propellants.
In: Proceedings of the 50th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Past, Present and Future", June 25-28, 2019, Karlsruhe, Germany, pp. 107-1 to 107-10, ISSN 2194-4903

Joppich Tobias D.
Beitrag zum Umformverhalten von PA6/CF Gelegelaminaten im nicht-isothermen Stempelumformprozess.
Tag der mündlichen Prüfung: 5. Juli 2019
Hauptreferent: Prof. Dr.-Ing. Frank Henning
Korreferent: Prof. Dr.-Ing. Peter Mitschang

Jurzinsky, T.; Gomez-Villa, E.D.; Kübler, M.; Bruns, M.; Elsässer, P.; Melke, J.; Scheiba, F.; Cremers, C.
Functionalization of multi-walled carbon nanotubes with indazole.
Electrochimica Acta 298, 2019, pp 885 – 892

Kaiser M.; Schweikert W., Boskovic D.
Distribution of nitroglycerine in different ball propellants – chemometric evaluation.
WTD 91, Meppen
In: Proceedings of the 50th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Past, Present and Future", June 25-28, 2019, Karlsruhe, Germany, pp. 121-1 to 121-7, ISSN 2194-4903

Kempa P.B., Fietzek H., Herrmann M., Heintz T.
Investigation of the microstructure of ADN-prills using 2D-X-RAY diffraction.
In: Proceedings of the 50th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Past, Present and Future", June 25-28, 2019, Karlsruhe, Germany, pp. 42-1 to 42-9, ISSN 2194-4903

Knapp S., Kelzenberg S., Becker W., Lity A., Roth E., Wacker K., Weiser V.
Effects on progression rate of thermite pellets.
In: Proceedings of the 50th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Past, Present and Future", June 25-28, 2019, Karlsruhe, Germany, pp. 106-1 to 106-3, ISSN 2194-4903

Koch E.-C.; Lutradyn, Kaiserslautern; Knapp S.
High Performance Modification Of Infrared Decoy Flares.
In: Proceedings of the 50th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Past, Present and Future", June 25-28, 2019, Karlsruhe, Germany, pp. 14-1 to 14-7, ISSN 2194-4903

Kuchenreuther-Hummel V.
Oxidation kinetic studies of tic-particles using x-ray diffraction.
In: Proceedings of the 50th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Past, Present and Future", June 25-28, 2019, Karlsruhe, Germany, pp. 122-1 to 122-8, ISSN 2194-4903

Kunkel, R.; Baumann, N.; Jurzinsky, T.; Cremers, C.
PEM-Fuel Cell Catalyst Behavior between Room Temperature and Freezing Point
Fuel Cells, https://doi.org/10.1002/fuce.201900067

Lautenschläger M. I.
Kombination von Sheet und Bulk Molding Compound in Jutefaserverbunden.
Fraunhofer Verlag; Stuttgart; 2019

Link T.
UD-Tape basierte Bauteile in kurzer Zykluszeit.
Plastverarbeiter 70 (2019) 3. S. 60-63

Märtens R., Kärger L., Henning F., Wittemann F.
Injection molding simulation of short fiber reinforced thermosets with anisotropic and non-Newtonian flow behavior Composites.
Part A, Applied science and manufacturing 124 (2019), Art. 105476
ISSN: 1359-835X
DOI: 10.1016/j.compositesa.2019.105476

Märtens R., Griesbaum P., Ilinzeer S., Laux M.
Funktionsintegrierte Duromere Faserverbundwerkstoffe für neue Anwendungen.
In: Jahresmagazin Kunststofftechnik (2019), S.30-34
ISSN: 1618-8357
http://publica.fraunhofer.de/dokumente/N-568440.html

Mendl A., Panic S., Klahn T., Boskovic D.
Detection of unstable process conditions during continuous nitrate ester production.
In: Proceedings of the 50th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Past, Present and Future", June 25-28, 2019, Karlsruhe, Germany, pp. 113-1 to 113-3, ISSN 2194-4903

Mitro D., Böhnlein-Mauß J., Pfatteicher A.
Interaction parameters in plasticizer-plasticizer-mixtures.
In: Proceedings of the 50th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Past, Present and Future", June 25-28, 2019, Karlsruhe, Germany, pp. 116-1 to 116-9, ISSN 2194-4903

Morais M., Reidel R., Weiss P., Baumann S., Hübner C., Henning F.
Integration of electronic components in thermoplastic processing chain: possibilities through additive manufacturin.
NanoCarbon Annual Conference 2019; Network NanoCarbon; Würzburg Germany; 26.-27. February 201

Morais M.V.C., Oliva-Avilés A.I., Matos M.A.S., Tagarielli V.L., Pinho S.T., Hübner C., and Henning F.
On the effect of electric field application during the curing process on the electrical conductivity of single-walled carbon nanotubes-epoxy composites.
Carbon 150 (2019), S. 153-167

Noack J., Roznyatovskaya N.,Menictas C., Skyllas-Kazacos M.
Redox flow batteries for renewable energy storage.
PV-Tech Power, 21, 106-112

Nosal H., Warzała, M., Moser K., Kazimierczak J., Kopania E., Stańczyk D.
Modified fatty raw materials as plasticizers of PHBV and PHBV composites with cellulose nanofiber.
17th Euro Fed Lipid Congress And Expo, Seville, 20-23.10.2019

Nosal H., Warzała M., Moser K., Kopania E., Stańczyk D.
Modified fatty raw materials as PHBV plasticizer.
10th Workshop on Fats and Oils as Renewable Feedstock for the Chemical Industry, Karlsruhe, 17-19.03.2019

Posern C., Höhne C.-C., Böhme U., Vogt C., Kroke E.
Synthesis of Thiocyameluric Acid C6N7S3H3, its Reaction to Alkali Metal Thiocyamelurates and Organic Tris(dithio)cyamelurates.
Chem. Eur. J. 2019, 25, 15555-15564.

Piscopo C. G., Voellinger L., Schwarzer M., Polyzoidis A., Bošković D., Loebbecke S.
Continuous Flow Desulfurization of a Model Fuel Catalysed by Titanium Functionalized UiO-66.
ChemistrySelect
Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, 2019, Band: 4
S.: 2806-2809

Radulescu L., Eberhardt A., Boskovic D.
Continuous microfluidic process for formation of adnprills.
In: Proceedings of the 50th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Past, Present and Future", June 25-28, 2019, Karlsruhe, Germany, pp. 117-1 to 117-5, ISSN 2194-4903

Reichert T. , Leisner T., Saathoff H.
Scientific output from 7th EFCA Symposium on Ultrafine Particles-Air Quality and Climate.
Side-Event on Ultrafine Particles organized by EFCA at IUAPPA's 18th World Clean Air Congress (WCAC), Istanbul, 23 September 2019, http:\\www.efca.net
Society for Environmental Engineering, Pfinztal, Germany

Reichert T., Leisner T., Saathoff H.
Results of the 7th EFCA Symposium on Ultrafine Particles- Air Quality and Climate.
Eleventh Croatian Scientific and Professional Assembly, Air Protection 2019, Bol, 15-19 October 2019, ISSN 1848-185X, p.109
Society for Environmental Engineering, Pfinztal, Germany

Reichert T.
Natural and Artificial Ageing of Polymers.
9th European Weathering Symposium EWS, Basel, 18-20 September 2019, ISBN 978-3-9818507-5-8, 407 pages
Fraunhofer Institut für Chemische Technologie, Pfinztal, Germany
Gesellschaft für Umweltsimulation GUS, Pfinztal, Germany

Reichert T.
Corrosion Research at GUS 2019.
CEEES Conference, Basel, 17 September 2019, www.ceees.org
Fraunhofer Institut für Chemische Technologie, Pfinztal, Germany
Gesellschaft für Umweltsimulation GUS, Pfinztal, Germany

Schaller U., Mitro v, Böhnlein-Mauß J., Keicher T.
Investigation of etpe formulations for additive manufacturing.
In: Proceedings of the 50th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Past, Present and Future", June 25-28, 2019, Karlsruhe, Germany, pp. 115-1 to 115-5, ISSN 2194-4903

Schaller U., Keicher T., Weiser V., Hürttlen J.
4-Amino-1-Butyl-1,2,4-Triazolium Nitrate – Synthesis and Characterization.
Propellants Explos. Pyrotech. 2019, 44, 1119–1128
DOI: 10.1002/prep.201900233

Schartel B., Humphrey J. K., Gibson A. G., Hörold A., Trappe V., Gettwert V.
Assessing the Structural Integrity of Carbon-fibre Sandwich Panels in Fire: Bench-scale Approach.
Composites Part B: Engineering, Vol. 164, 82-89, 2019

Schnürer F., Ulrich C., Chirico R., Di Frischia S., Moon R., Hung K.,
Standardized characterization of inkjet-printed explosive trace samples, Proc. SPIE 11166, Counterterrorism, Crime.
Fighting, Forensics, and Surveillance Technologies III,
111660W (7 October 2019);
doi: 10.1117/12.2533029

Schweikert W., Schnürer F., Mendl A., Müller S.,
Trace level detection of explosives by surface-enhanced Raman spectroscopy.
(SERS) for defence applications: best practice," Proc. SPIE 11166, Counterterrorism, Crime Fighting, Forensics, and Surveillance Technologies III, 111660V (7 October 2019);
doi: 10.1117/12.2532780

Teipel, U.; Schweppe, R.
5. Symposium Rohstoffinnovationen und Rohstoffeffizienz 2019: 9./10. Mai 2019, Fraunhofer ICT, Pfinztal.
Stuttgart: Fraunhofer Verlag, 2019, 216 S.
ISBN 978-3-8396-1466-2

Östmark H., Eldsäter C.Van der Heijden A.E.D.M., De Klerk W.P.C.
Weiser V., Herrmann M.
Half a century of eu research on energetic materials.
In: Proceedings of the 50th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Past, Present and Future", June 25-28, 2019, Karlsruhe, Germany, pp. 0-1 to 0-5,
ISSN 2194-4903

Wehner H., Teicht C.
Phasenwechselmaterialien (PCM= Phase Change Materials) und ihre Anwendungsmöglichkeiten im Infrarot-Signaturmanagement.
Wehrwissenschaftliche Forschung Jahresbericht 2018
Bundesministerium der Verteidigung, Bonn, Juni 2019, S.: 90 -91

Weiser V., Roth E., Knapp S., Lity A.
Ignition of flare propellants using al/ni-nanofoils at subatmospheric pressure.
In: Proceedings of the 50th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Past, Present and Future", June 25-28, 2019, Karlsruhe, Germany, pp. 108-1 to 108-11,
ISSN 2194-4903

Wendel R., Eberhardt M., Geinitz S., Henning F., Drechsler K.
Investigation of a new characterization technique for anionic polyamide 6 in T-RTM processe.
Sampe Europe Conference; Nantes; 2019

Wittemann F., Maertens R., Kärger L., Henning F.
Injection molding simulation of short fiber reinforced thermosets with anisotropic and non-Newtonian flow behavior.
Composites Part A: Applied Science and Manufacturing 124 (2019)

Yurrita P., Kuchenreuther-Hummel V., Pietsch E., Bermejo J.
Lifetime of airbag inflators: perspectives for a better understanding and prediction of aging mechanisms.
In: Proceedings of the 50th International Annual Conference of the Fraunhofer ICT "Energetic Materials – Past, Present and Future", June 25-28, 2019, Karlsruhe, Germany, pp. 110-1 to 110-10,
ISSN 2194-4903

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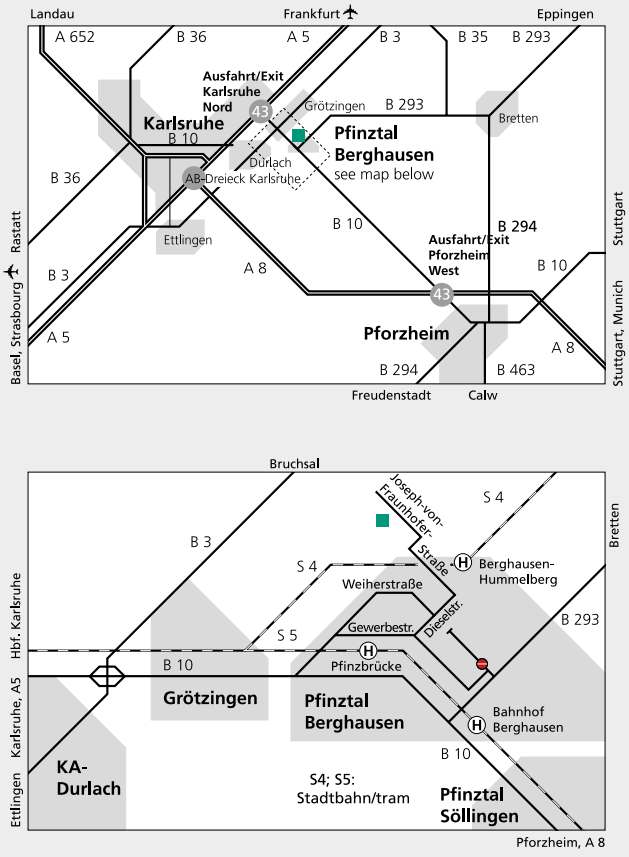
BY CAR

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 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 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 Berghausen-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)

CONTACT

Fraunhofer-Institut für Chemische Technologie ICT
Joseph-von-Fraunhofer-Str. 7
76327 Pfinztal
Germany

Please put Joseph-von-Fraunhofer Str. 5 or 11 into your navigation system!

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Dr.-Ing. Stefan Tröster
Simone Köppel, Yvonne Hofmann, Alexandra Linder

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Contact
Fraunhofer Institute for Chemical Technology ICT
Joseph-von-Fraunhofer-Strasse 7
76327 Pfinztal

Phone +49 721 4640 -0
Fax +49 721 4640-111
info@ict.fraunhofer.de

www.ict.fraunhofer.de