

Polymer Engineering

Tailored materials
in new applications



Pultrusion profile.

*Pultrusion profiles with
thermoplastic matrix
made of polyamide 6.*

The best of three worlds: materials, processes, and product design

Are you looking for innovative, high-performance polymer-based materials with a sustainable life cycle? With our many years of experience in material and process development, we can help you find tailor-made solutions for your products – from the initial idea through to concept development and prototype production. We integrate the recycling perspective and environmental assessment right from the start, to make your products future-proof and resource-efficient.

Sustainable materials and processes to meet your requirements

We provide you with comprehensive support in the development of modern polymer-based materials – from material development and compounding through to innovative foaming technologies, injection molding, extrusion, and lightweight structural solutions. Our portfolio also includes microwave and plasma technologies, as energy-efficient methods for process optimization.

Our comprehensive expertise in material characterization and damage analysis provides you with reliable data and in-depth insights into material behavior. On this basis, we collaborate with you to develop robust material concepts that are precisely tailored to your requirements. One focus is on the development of sustainable components: from the start of the development process we select materials and concepts for an optimal product design that enables recycling and reuse. Whether you require monomaterial solutions for single-material recycling or innovative material systems, we pave the way for resource efficiency and improved recyclability.

In the field of recycling technologies, we develop efficient processes for material recovery that can be seamlessly integrated into your recycling value chain. Our environmental simulation and product qualification team furthermore evaluates environmental impacts on your materials and components and their reliability under realistic conditions of use. We can therefore support you in designing sustainable products with a long service life.

Solutions for multiple industries

Our solutions are used in numerous industrial sectors – from automotive engineering, aerospace and construction through to the packaging, toy, and leisure industries. We support you in individual tasks along your value chain and also with complex, cross-industry challenges, such as sustainable mobility, the circular economy, lightweight construction and the digitalization of industrial processes. Through precise life cycle assessments (LCAs) we identify concrete potential for product and process optimization.

Working together for optimal results

Whether through pre-competitive research in joint projects or tailor-made solutions, our efficient, flexible and application-driven approach will support you in achieving your goals.

Access to strong international networks

Our application-oriented research benefits from a broad network within the Fraunhofer-Gesellschaft, including international Fraunhofer Innovation Platforms for Composite Research in Canada and South Korea, as well as close partnerships with the Karlsruhe Institute of Technology (KIT). We have already completed complex, interdisciplinary projects within these partnerships, and can respond quickly to specific market requirements.



Five ways we're making the future possible

Innovation

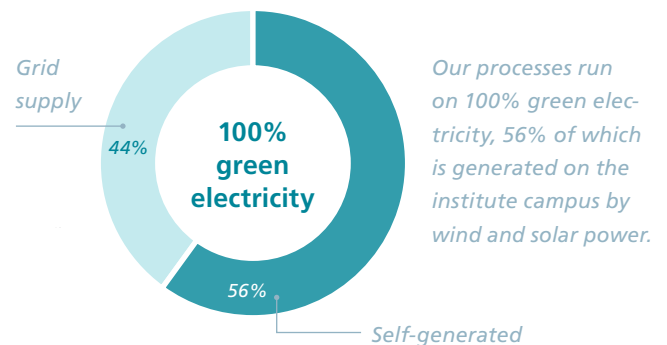
Modern materials must meet both structural and functional requirements. We investigate the electrical and thermal conductivity of polymers, their acoustic properties, scratch resistance, and antibacterial effects. Programmable materials also enable customizable responses to changing environmental conditions.

Lightweight

Lightweight construction conserves resources, saves energy, and actively contributes to climate protection. Industry-specific construction methods and designs for lightweight elements determine the choice of materials and manufacturing processes. We develop polymer-based fiber composites and optimize process chains for their efficient production.

Digitalization

Digital technologies support our research and development in process design and optimization. Current research focuses on machine learning, simulations, digital twins of materials and machines, and their interlinking to establish virtual production.



Flexibility

Customized products require a high degree of flexibility in industrial manufacturing. Short development and production times, agile production and the efficient use of resources form the basis for economical implementation. We develop modular, variable manufacturing technologies and process chains.

Sustainability

Efficient recycling and optimized, closed material cycles are key aspects of sustainable development. At Fraunhofer ICT, we improve material formulations for secondary raw materials, bio-based and recyclable material systems, energy-efficient processing methods, and self-reinforced composites.

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Material development and compounding technologies

Optimized materials and innovative processing

Customized compounds for your application

We develop thermoplastic compounds precisely tailored to your requirements. This involves a careful selection of the right formula, additives and functional fillers. We process a wide range of raw materials, powders, fibers, and media of any viscosity – even in a supercritical state.

Our materials are tailored to the subsequent shaping and further processing steps.

Customized extrusion ensures reliable processes

By optimizing screw geometries and extruder configurations to specific applications, and the use of precise dosing and granulation strategies, we can achieve precise process control. In addition to classic compounding processes, we also use reactive and extractive extrusion.

Our flexibly scalable technical center with various extruder sizes and alternative energy sources such as microwaves and ultrasound expands the range of available processes which is ideal for the processing of complex material systems.

From the idea to the market-ready material

Whether you're developing new products, improving existing materials, or introducing sustainable alternatives, we accompany you from the initial material idea through to industrial implementation. Application-oriented test series, reliable material data and rapid scaling options provide you with solutions that are convincing in the laboratory and proven in series production.



Around 30% of our industrial projects involve the use of non-petroleum raw materials, or recycled materials only.



Our offer

- **Wide range of services** – from standard to specialty compounds, including biopolymers and natural-fiber-reinforced plastics
- **Robust processes** for the preparation, formulation and quality assurance of recycled materials
- **Purification, odor and emission reduction** of plastics and compounds
- **Material development for additive manufacturing** and other high-tech applications
- **Halogen-free flame retardants** and flame retardant formulations
- **Polymerization and polymer modification** using reactive extrusion
- **High process and product safety** through online process control
- **Safe handling** of reactive substances and nanomaterials

Sensory evaluation of odorous granules



Poly lactide granules – the starting material for producing monomaterial systems.

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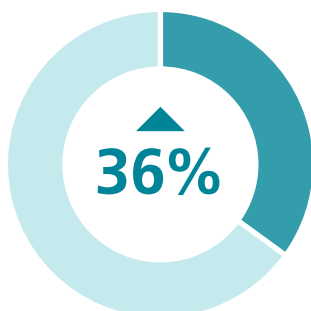
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Production of a PLA helmet in an automatic molding machine.

"The helmet can be produced with 36 percent lower CO₂ emissions than a conventional helmet."

Janne-Constantin Albrecht,
Fraunhofer ICT



Our offer

- **Thermoplastic foams** with customized properties
- **Functional additives** for thermoplastic foams with improved mechanical, thermal, and flame-resistant properties
- **Foamable compounds based on renewable raw materials**, including environmentally friendly flame retardants
- **Development of extruded foam semi-finished products**, sheets, and films
- **Complete process chain** for particle foam technology
- **Laboratory analyses and testing methods** for rapid evaluation of new material and component properties
- **Comprehensive foam characterization**, including microstructure, thermal conductivity, flame retardancy, rheology, hydrostatic pressure, thermal and chemical properties

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Foam technologies

*Sandwich structures
with core foams
made of renewable
raw materials.*

The right foam for every application

Are you looking for lightweight, functional foams for transport packaging, thermal insulation, vehicle interiors, or completely different applications?

We develop thermoplastic foams and tailor their properties precisely to the requirements of your product. We focus in particular on lightweight construction, high mechanical performance, temperature resistance, and recyclability.

Material development for thermoplastic foams

Our focus is foam-processable polymers made from renewable or recycled raw materials. Functional additives are used to optimize the mechanical and thermal properties of these foams for specific applications. Our offer also includes environmentally friendly flame retardants and high-performance foams made from technical polymers.

In addition, we develop hybrid foams that can be incorporated into sandwich structures, for example, to improve the functionality of your products and increase the efficiency and sustainability of the manufacturing process.

Extruded foams – the interplay of materials and processes

In our laboratory facilities, which are equipped with single- and twin-screw extruders, we test new material and blowing agent formulations using an efficient approach involving minimal quantities of materials. We thus support you in the development of process-reliable semi-finished foam products with customized properties.

Development and control from the granule to the molded part

We support you from material development to processing in automatic molding machines – including the production of granules containing blowing agents, structure control in the pre-foamer, and processing with steam or high-frequency technology.

At Fraunhofer ICT, we use our own laboratories to test and qualify the results, and can thus provide reliable data on insulation properties, strength, flame resistance, and recyclability.

Benefit from our many years of expertise and experience in foam technologies – and feel free to present us with new challenges! We will find a suitable solution for your requirements.

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Injection and compression molding

Efficient molding for high-performance components

High-performance components, efficient processes

We support you in the large-scale molding of flowable materials, from proven injection and compression molding through to resource-saving direct processes with local continuous-fiber reinforcement.

Customized injection molding processes for special requirements

We use cutting-edge technology to process thermoplastic and thermoset materials, such as high-performance plastics and hybrid systems. We work with you to develop customized processes – for example to produce foamed components or replacement products for light metal components that can withstand high loads.

Lightweight construction with sheet molding compounds – meeting the most stringent demands

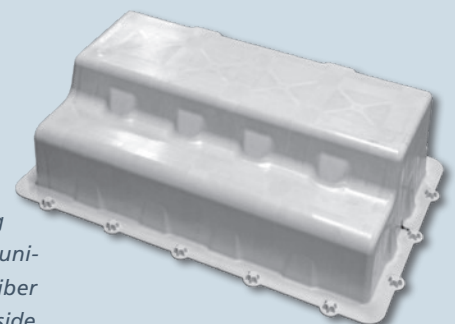
We offer innovative thermoset and thermoplastic SMC formulations as well as optimized process control. Our focus is the automotive and commercial vehicle industry; however, other sectors with high quality standards can also benefit from these processes and our experience and expertise.

Flexible direct processes with in-line compounding

Combine molding with compounding to incorporate fibers efficiently, save material and energy, and increase component performance – even with recycled fibers.

Lightest-weight construction

Locally applied unidirectional fibers improve the mechanical properties of products. 3DSW and UD preregs enable fiber-reinforced solutions suitable for large-scale production.



Traction battery housing made of SMC with local unidirectional continuous-fiber reinforcement on the inside.



Seat shell made of carbon-fiber-reinforced SMC for commercial aircraft.

**"In Germany,
almost € 360 billion
worth of goods and
services involving
lightweight design
were produced
in 2019."**

Source:

Anna Kleissner, Econmove

*»Der Leichtbau – ein ökonomisches
Schwergewicht«.*

Our offer

- **Thermoplastic and thermoset injection molding processes** using cutting-edge, large-scale production equipment
- **Sheet molding compound (SMC)** for lightweight construction applications with stringent mechanical, chemical, or thermal requirements
- **Long-fiber-reinforced thermoplastics** produced using direct LFT-D
- **Extrusion process** on hydraulic presses with up to 36,000 kN pressing force
- **Robot-based 3D fiber winding process** for the fully automated production of continuous-fiber-reinforced skeleton structures
- **Component sampling** of large-area structures such as underbody panels or battery housing

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Our offer

- **Optimization of manufacturing concepts** and process chains for continuous-fiber-reinforced plastics
- **Industry-oriented sampling** – in HP-RTM and wet compression molding, on test molds and customer molds
- **Analysis of forming behavior** on instrumented test stands
- **Automated preforming processes** for cutting, handling, draping, and trimming
- **Reactive thermoset and thermoplastic processing** with injection pressures of up to 200 bar
- **Pultrusion with thermoplastic and thermoset systems**, also with injection chambers
- **Tape-laying for large-scale production** up to 50 kg/h
- **Process data acquisition and evaluation** for the documentation and validation of simulations
- **Consulting and sampling** for material and process selection

Wet compression molding of Proxima™(DCPD) and flax fibers.

Advanced light-weight design: fiber-reinforced materials with up to 73% fiber volume content.



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Structural composites

High-strength, lightweight, and durable structural components

We develop fiber-reinforced materials and processes that combine maximum performance with minimum weight. This results in decisive advantages for lightweight construction applications in the automotive, aerospace and construction industries. Our range of processes extends from automated tape laying and forming processes through to pultrusion and infiltration processes.

From material selection to process validation

Drawing on comprehensive expertise, we support you in selecting customized material systems, developing functionalized components, and implementing efficient manufacturing processes suitable for series production – from the automation of individual steps through to complete process validation.

Structural components for the automotive and aerospace industries

New process variants in resin transfer molding (RTM) and wet compression molding enable hybridization with metal inserts and the integration of foam cores in sandwich structures. These processes can be applied using both thermoset and reactive thermoplastic matrix systems. Using the automated tape laying

process, we create customized local reinforcements for stamp forming processes.

Continuous-fiber profiles for the construction industry

We use pultrusion to produce corrosion-resistant continuous-fiber-reinforced profiles with high dimensional accuracy. In our project REcyBAR, for example, we are developing thermoplastic profiles for the construction industry as a durable, low-maintenance alternative to classic steel reinforcements.

Fiber composites made from a single material

For thermoplastic systems such as PLA, PET, PA, or PP, mono-material sandwich systems can be produced, consisting of self-reinforced top layers combined with foam cores based on the same polymer.

Increased specific strength, higher specific energy absorption

With our materials and processes, we achieve up to 6 times higher specific strength and 3 to 5 times higher specific energy absorption than traditional material systems. Your applications can also benefit from our expertise.

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Recycling technologies

Separation, processing, recycling

Effective material recycling conserves resources

The efficient use of resources is an indicator of responsible planning and action. One part of this is the recycling of materials. Whether this involves mechanical, solvent-based or chemical recycling, waste must be shredded and sorted.

Innovative processes for sustainable material cycles

Together with industrial companies, we research and develop recycling technologies – from material preparation and recycling through to downstream processes with the corresponding plant technology. The aims are to close material cycles, design sustainable production and achieve a positive life-cycle assessment.

From material analysis through to industrial application

Material flows are characterized with a view to achieving the highest possible recyclability. Methods for processing and treating the materials are developed, tested, optimized and demonstrated on a pilot scale for specific applications.

Our technical equipment enables reliable feasibility studies and the transfer of the test setups to industrial applications in an operational environment (TRL5). The wide range of technical possibilities available in the pilot plant on the Fraunhofer ICT campus in Pfinztal enable research on almost every aspect of material cycles and life-cycle analysis.

We draw on our own expertise, experience and proven methods, as well as knowledge gained through cooperation with additional partners, to provide customers with ready-to-use processes on an industrial scale.



PLA products (cups, spoons, straws), ground material, granules and recycled products made from biopolymers.



Shredding of post-consumer plastics using a cutting mill.

Our offer

- **Characterization of material flows**
- **Mechanical processing** of plastics, multilayer films, electronic waste, GRP, CFRP
- **Extraction of critical contaminants** such as flame retardants and plasticizers using sCO₂
- **Solvent-based recycling processes** to recover thermoplastic waste
- **Solvolysis** to recover monomers from thermoplastic and thermosetting polymers
- **Pyrolysis** of solvolysis residues
- **Liquid-liquid extraction**
- **Rectification** in continuous operation at 350 °C and an operating pressure of up to 1 mbar
- **Membrane filtration**, reverse osmosis, nanofiltration, ultrafiltration, microfiltration, in continuous and batch processes

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Dissolving polymers in solvents in order to recover them in a targeted process.



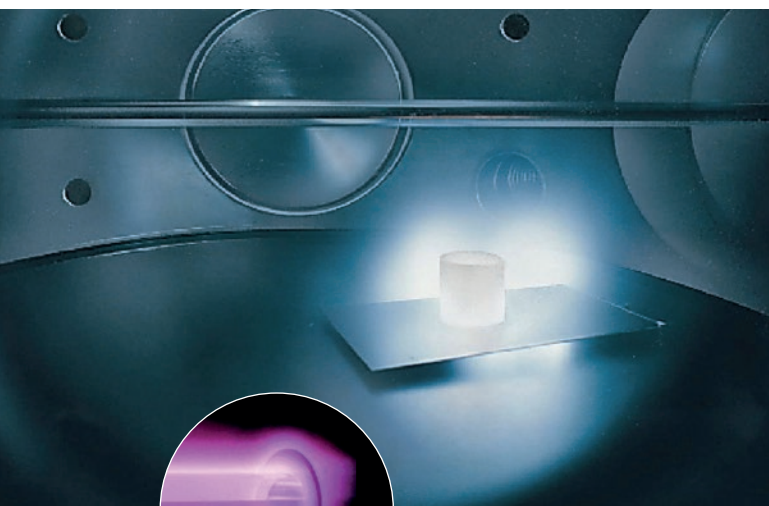
E.g. shredding, sorting and remelting plastics.



Splitting polymers into their basic building blocks (monomers) through chemical processes.



Apparatus to measure the permittivity of materials.



Plasma line with magnet, and microwave-excited plasma.

Our offer

- **Development of equipment and measurement techniques** for microwave and plasma technology
- **Numerical simulation** of electromagnetic fields
- **Construction of demonstrators** for plasma-enhanced chemical vapor deposition (PECVD)
- **Modification and coating** of surfaces using the PECVD process
- **Development of microwave equipment** for thermal processes
- **Electromagnetic field simulation** of microwave applicators
- **Measurement of dielectric function** as a function of temperature and frequency
- **Microwave-based sensor and measurement technology** for process monitoring

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Microwave and plasma technology

Efficient processes, functional surfaces

Are you looking for innovative solutions for energy-efficient heating processes or functional coatings? We support you with customized microwave and plasma technology – from process development through to industrial implementation.

Fast and gentle heating with microwaves

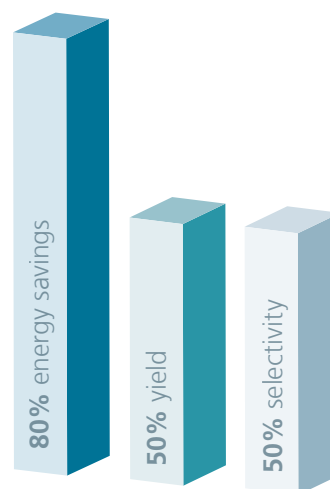
Microwaves enable fast, contactless, and gentle heating of plastics, glass and natural substances, directly inside the workpiece. We work with you to develop processes, plant technology and material formulations for applications such as microwave-assisted chemistry, debonding, pultrusion, and RTM.

Experiments and simulations for optimal processes

We combine our experimental expertise with powerful simulations for the targeted design of new processes. Using commercial software and our own numerical models, we analyze electromagnetic fields, measure dielectric functions as a function of temperature and frequency, and investigate plasma formation. This creates a solid foundation for the development of efficient systems and processes.

Innovative plasma processes for functional coatings

We are also equipped to support you in plasma process development, whether you are working with scratch-resistant coatings on polycarbonate, corrosion protection for metals, or bonding agents for hybrid components. We use microwaves to generate powerful low-temperature plasmas under vacuum or atmospheric pressure, and work with you to put new processes into practice



The use of microwaves saves up to 80% energy when replacing steam processes. We achieve a yield of up to 50% and increase selectivity by the same value.

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Material characterization and failure analysis

Reliable data for development and quality assurance

Whether for your development projects, quality assurance, or damage investigation, we test and analyze polymer materials along the entire process chain - from raw materials through to finished components. We provide you with reliable material data as a basis for informed decisions. This gives you confidence in your products, saves development time, and reduces costs in the long term.

Diverse testing methods and standard-compliant sample preparation

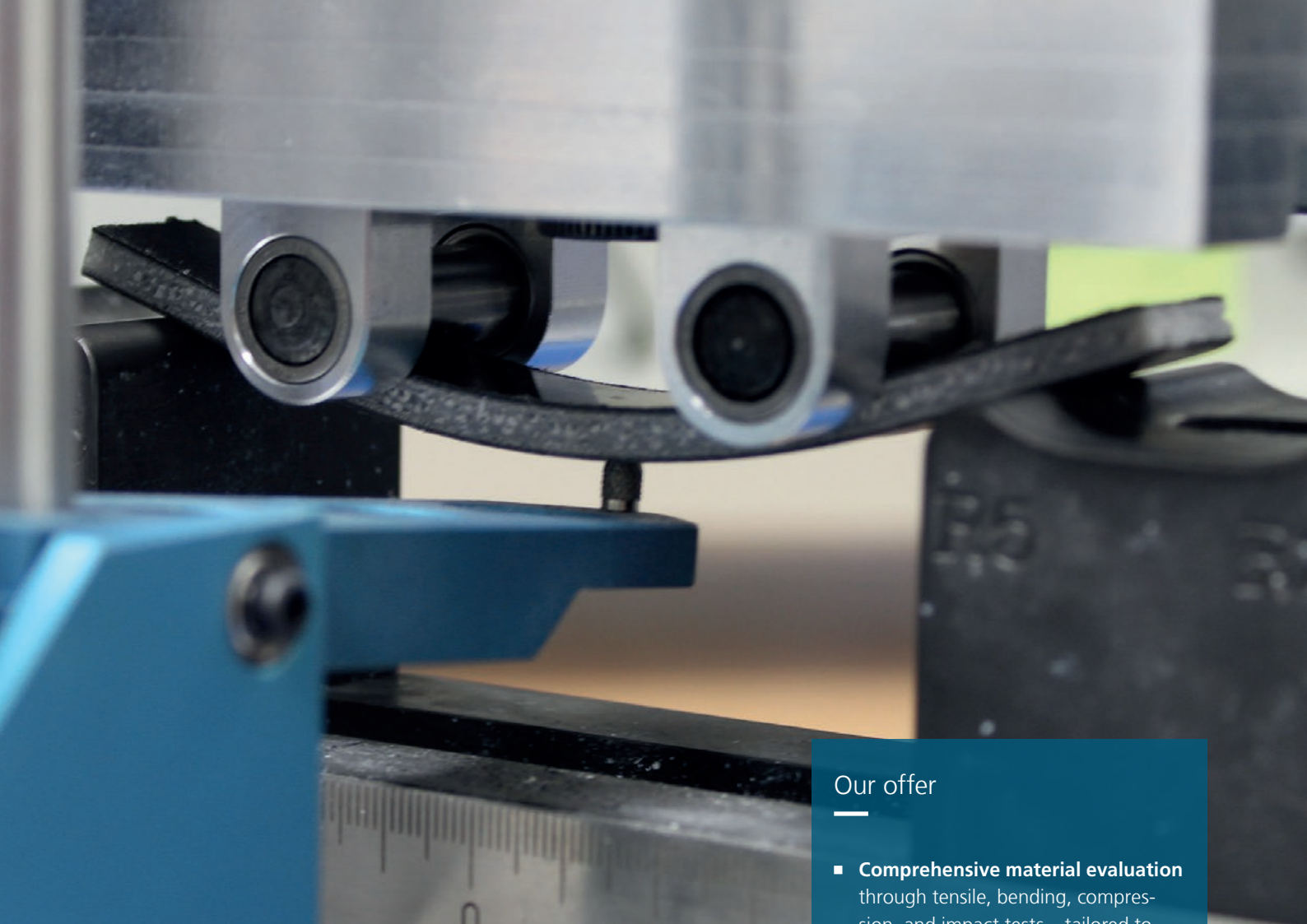
Our experienced team offers mechanical testing (tensile, bending, impact, composite), thermal analyses and flame retardancy tests, rheological measurements, and detailed microscopic examinations (light and scanning electron microscopy). We prepare the samples in our own technical center, in accordance with industry standards, using a variety of methods including injection and compression molding and conditioning.

Targeted damage analysis for practical solutions

In the event of damage, we support you with structured analyses to identify causes and identify practical solutions. You benefit from clear, directly implementable recommendations for a quick and sustainable solution to the problem.

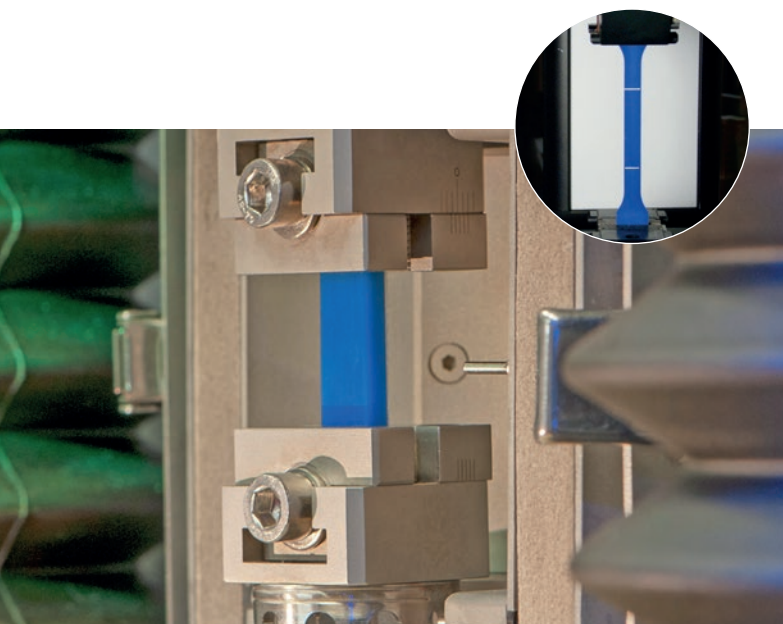
“Within three working days, you will receive an individual offer tailored to your request.”

**Dipl.-Ing. (FH)
Susanne Lüssenheide**
Fraunhofer ICT



4-point bending test of a foam sandwich component.

Dynamic mechanical analysis of polymer materials – tensile test according to ISO 527-1/2.



Our offer

- **Comprehensive material evaluation** through tensile, bending, compression, and impact tests – tailored to your application
- **Reliable strength analysis** of composite materials and foams, including shear strength and composite adhesion
- **Reliable data on temperature and aging resistance** through tests under hot and cold conditions
- **Realistic stress tests** using dynamic mechanical analysis and the simulation of complex stresses
- **Thorough material characterization** using rheological investigations for optimal processing and quality
- **Deep insights into microstructures** through high-resolution microscopy, damage and particle analyses
- **Comprehensive testing expertise** – from test specimen production through to detailed damage diagnosis

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Our offer

- **Accredited testing laboratory** for environmental simulation and product qualification
- **Evaluation of product service life** using corrosion tests with corrosive gases, salt spray, and ozone
- **Chemical resistance** of materials and products to various common liquids
- **Climate, temperature, and temperature shock** to qualify materials for different climate zones
- **Dust or water resistance and housing tightness** of products
- **Vibration and shock tests** for transport simulation, packaging optimization, and measurement of strength and resistance
- **Accelerated aging** using simulation systems with artificial irradiation and **outdoor weathering**

RSI FLCPLUS1000 corrosion test chamber with climate control unit



Natural irradiation and weathering of materials, e.g. sun and UV simulation.

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Environmental simulation and product qualification

Our testing programs ensure that your products are fit for practical use

Realistic environmental simulations for maximum product reliability

Technical products must function reliably even under demanding environmental conditions – despite heat, humidity, vibration, corrosion and UV radiation. In our testing laboratory, we simulate such stresses realistically in order to evaluate the quality, service life and usability of products under practical conditions.

Depending on the application and the related test requirements, we test both plastic components and products made from other materials. For plastic-based products, for example, we offer an evaluation of thermal and chemical resistance, aging, and resistance to mechanical stress.

Testing according to standards and individual specifications

Our technical equipment enables us to perform tests in accordance with legal standards as well as application-specific test series – from climate chambers and harmful gas systems through to vibration tests and IP protection class testing. We work with you to define test programs for the targeted qualification of your products, which produce reliable data concerning service life, inspection and service intervals.

“We carry out 250 industrial projects each year for customers from all over Europe, and are accredited according to DIN EN ISO 17025.”

**Dipl.-Ing. (FH)
Marco Markert-Kolompar**
Fraunhofer ICT

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Sustainability and life cycle assessment

Waste management concepts for your products, processes, and materials

Sustainability assessment

We support you in assessing the potential environmental impact of your products throughout their life cycle. Using comparative life cycle assessments, we demonstrate the consequences of different solutions from the product development stage onward. To ensure that your products remain affordable, we evaluate the costs of defined product systems, taking into account the entire life cycle.

Responsible use of resources

The market- and product-specific development of concepts for material recycling is the cornerstone of sustainable business practices. We support you in selecting and implementing the appropriate recycling processes, and in evaluating them from an economic and ecological perspective.

Service life is the key

To better evaluate the service life, we measure the change in material properties due to environmental influences, and thus predict the service life of your products in a given application.

Sustainability reporting

Would you like to find out more about the life cycle assessment process, or about how to evaluate your materials, products, and processes according to Scope 3, and thus fulfill your obligations for sustainability reporting? We provide you with the necessary background information on the four phases of life cycle assessment, the evaluation methods, and the latest software and database solutions. Our customized training courses comply with the framework specified by the ISO 14040 series of standards, the EU Product Environmental Footprint (PEF), and the EU Corporate Sustainability Reporting Directive (CSRD).



Shredded rotor blades as a starting material for high-quality fiber composite recycling.



Packaging waste and regrind from PET fraction

“The key is to see materials for what they actually are: valuable. When things are too cheap, they are quickly discarded. That has to change”

**Dipl.-Ing.
Torsten Müller**
Fraunhofer ICT

Our offer

- **Collection of primary data** and creation of our own LCI data sets
- **Life cycle assessment (LCA)** in accordance with ISO 14040/14044 and life cycle cost analyses (LCC)
- **Life cycle assessments to accompany developments, and comparative LCAs** for decision-making in product development and benchmarking
- **Assessment of the use phase** through life cycle assessment of environmental simulation data
- **Recycling concepts and closing the material cycle** of your products
- **Environmentally friendly design and resource efficiency strategies** for components and assemblies
- **Development of recycling concepts** for products, processes and materials in the plastics industry
- **Training on how to prepare your life cycle assessment** and fulfill your sustainability reporting obligations

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Our specialist teams provide reliable, expert advice.

Contact us – we will support you with tailor-made solutions.



Are you interested in the equipment in our laboratories and technical centers?

Scan the QR code to find out more.

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