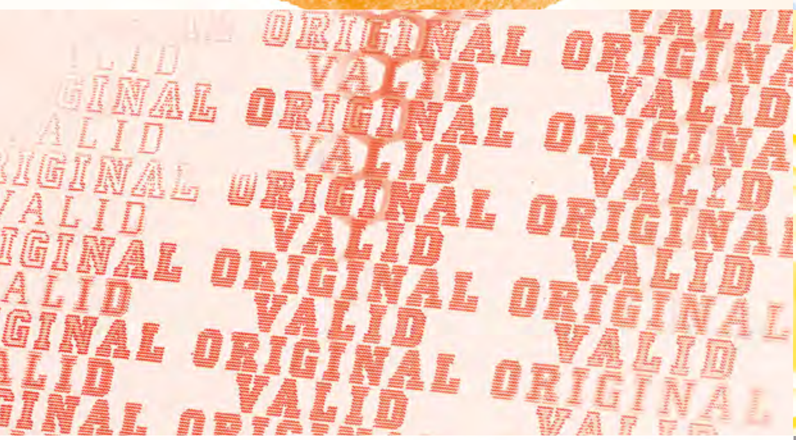
Fraunhofer

IFAM

FRAUNHOFER INSTITUTE FOR MANUFACTURING TECHNOLOGY AND ADVANCED MATERIALS IFAM



ANNUAL REPORT 2013/2014

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2013/2014

FOREWORD

Dear Reader,

once again, Fraunhofer IFAM had a strong business year in 2013. As in previous years, we were among the top institutes of Fraunhofer-Gesellschaft in terms of revenue. For years, we have seen a stable growth, which has continued over the last year. In future, growth at any price will not be our objective, but a sustainable development. Competition for internal and external resources has become noticeably more intense. To remain successful, we are therefore further strengthening and focusing our seven scientific-technological core competencies.

In 2013 the institute continued to expand by another increase in personnel. At our branches in Bremen, Dresden, Stade, and Oldenburg we now have a combined staff of almost 600. The integration of the Bremer Energie Institut (BEI) into Fraunhofer IFAM was another exemplary step in our growth development. The BEI expertise in the analysis of energy systems perfectly rounds off our Energy and Environment business segment.

In the Aviation business segment, the Fraunhofer Project Group Joining and Assembly FFM in Stade received recognition for its excellent work in 2013 after a five year pilot period. An evaluation by high-level experts confirmed the project group's direction. Its promising solutions for automated assembly and processing of carbon fiber reinforced structures were praised. Following the positive recognition by both Fraunhofer-Gesellschaft and political bodies, the group based at CFK NORD has now become a fully integrated part of Fraunhofer IFAM.

Electromobility continues to be a major topic in the Automotive business segment. Fraunhofer IFAM is coordinating the work of a number of institutes in the second phase of the flagship Fraunhofer project entitled "Fraunhofer System Research for Electromobility". In addition, we control the

1 *The institute directors of Fraunhofer IFAM: Prof. Dr.-Ing. Matthias Busse (left) and Prof. Dr. Bernd Mayer (right).*

activties of the Electromobility model region Bremen/Oldenburg. Funding for this by the Federal Ministry of Transport and Digital Infrastructure (BMVI) has once again been extended. The institute has built up a reputation as a major center of scientific research in this area. Work groups in Dresden and Oldenburg, with their research projects on energy storage, are a key element in this.

The Medical Technology and Life Sciences business segment has seen positive developments in the past year. One key area concerns dental implants with a special antimicrobial surface to prevent infection around the implant. Cases of such infection in Germany alone total about 150,000 each year and incur millions of euros in costs for patients and health insurers. These coated dental implants are currently being tested in studies at the University Medical Center Hamburg-Eppendorf. This business segment is further assisted by new techniques for functional printing, allowing additional functions to be integrated into medical devices and components.

We have also extended our activities regarding personnel training courses. In conjunction with TÜV Rheinland, Fraunhofer IFAM has started offering the "Certified Electromobility Specialist" training course. Likewise, the training course program on fiber reinforced plastics has also been extended. The Plastics Competence Center has moved into new facilities, offering a state-of-the-art laboratory for the practical sessions.

Particular gratitude also goes to our staff for their hard work and dedication. It is particularly pleasing when this successful work is recognized by awards, as was once again the case in 2013. We are also proud that our expertise is playing an important role in the universities and universities of applied sciences in the federal states where we operate sites. Many Fraunhofer IFAM scientists are contributing to the curriculum as professors and lecturers. In 2013, deputy institute director Prof. Dr.-Ing. Frank Petzoldt was appointed honorary professor in medical technology at Bremerhaven University of Applied Sciences.

We have streamlined our annual report and given it a new look as new media have changed reading habits. Trend and project reports are now focusing on key points only. For those interested in more detail, information is readily available via links leading to our correspondingly updated website.

We hope you enjoy reading about our work.

Matthias Busse

Bernd Mayer

CONTENTS

1 *Fraunhofer IFAM, Bremen.*

BRIEF PORTRAIT AND ORGANIGRAM

The Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM was founded in 1968 as a work group in applied materials research. It was incorporated into the Fraunhofer-Gesellschaft as an institute in 1974. The institute collaborates closely with the University of Bremen as a contract research institute with new focal points and systematic expansions. The current institute directors are professors in the Production Technology department at the University of Bremen. The institute has major sites in Bremen and Dresden, plus Fraunhofer Project Groups in Oldenburg and Stade.

Prof. Dr.-Ing. Matthias Busse has acted as executive institute director since 2003, leading the Shaping and Functional Materials division. Prof. Dr. Bernd Mayer has been an institute director since 2010 and heads the Adhesive Bonding Technology and Surfaces division. In both its divisions, Fraunhofer IFAM as a neutral and independent body counts among the largest R&D establishments in Europe. In 2013, Fraunhofer IFAM employed 583 staff and had an overall budget of 46.1 million euros.

Powder Technology

Casting Technology and Component Development

Functional Structures

Energy Systems Analysis

Electrical Systems

Technical Training in Electromobility

Materialography and Analytics

Adhesive Bonding Technology

Adhesives and Polymer Chemistry

Materials Science and Mechanical Engineering

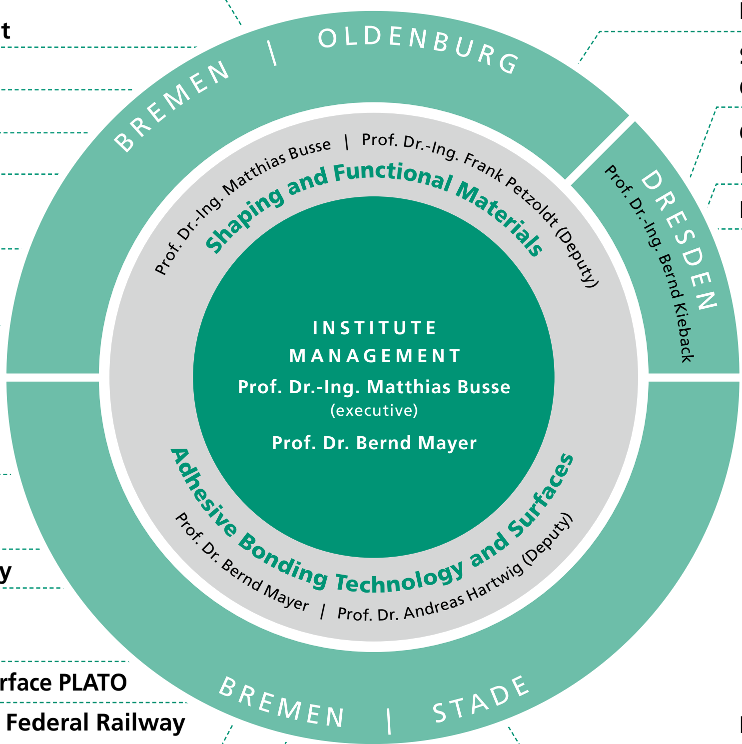
Paint/Lacquer Technology

Adhesion and Interface Research

Plasma Technology and Surface PLATO

Certification Body of the Federal Railway Authority in accordance with DIN 6701

Workforce Training and Technology Transfer



Fraunhofer Project Group Electrical Energy Storage

Sintered and Composite Materials

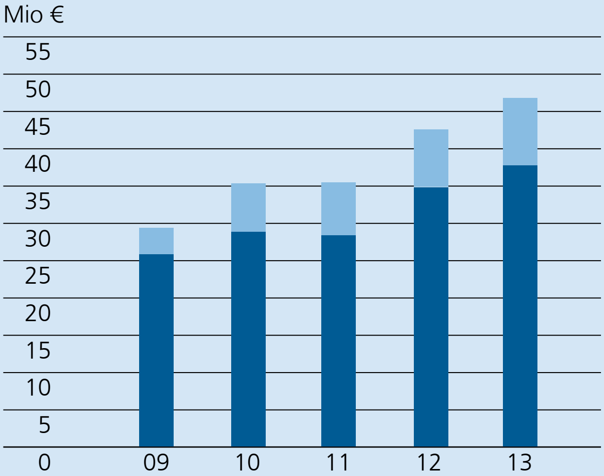
Cellular Metallic Materials

Hydrogen Technology

Fraunhofer Project Group Joining and Assembly FFM

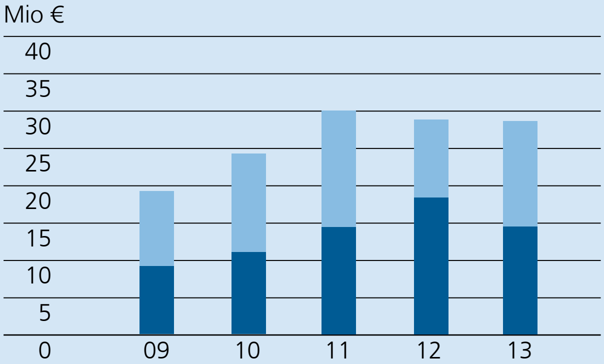
(since January 1, 2014: Automation and Production Technology)

Operating and investment budget 2009–2013



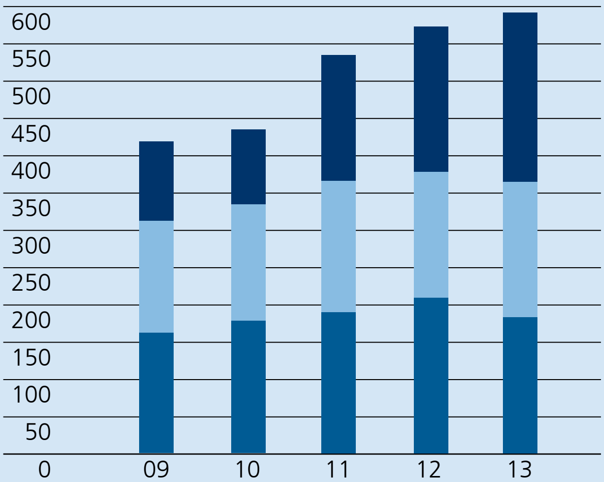
■	Operating budget	37,2 Mio €
■	Investment budget	8,9 Mio €

Project revenues 2009–2013



■	Industry	14,3 Mio €
■	Federal/state/EU/other	13,9 Mio €

Personnel development 2009–2013



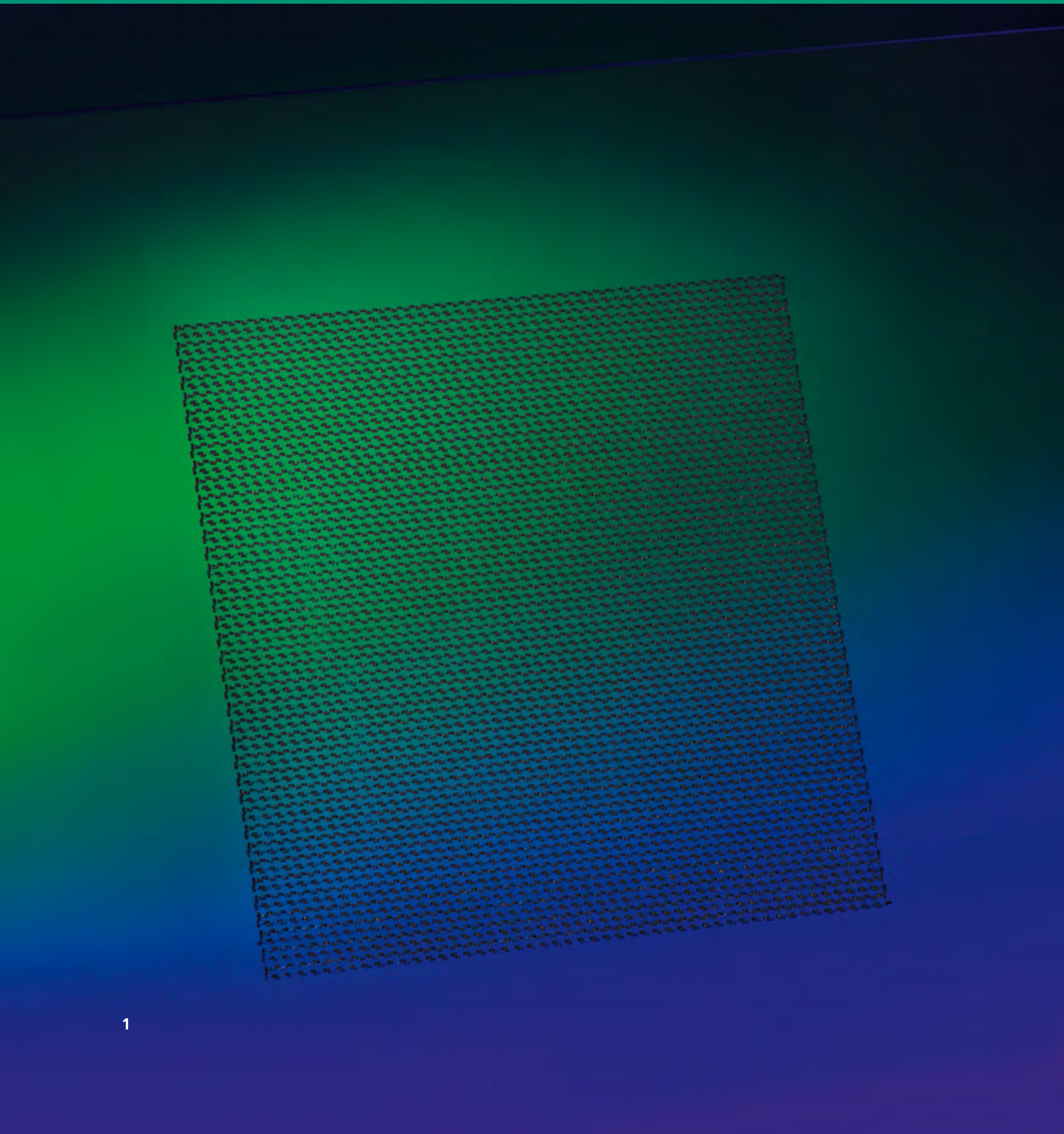
Personnel structure 2013

On December 31, 2013 a total of 583 staff were employed by Fraunhofer IFAM in Bremen, Dresden, Oldenburg, and Stade. Compared to the previous year, the number of permanent employees grew by 2,5 percent.

Scientists	224
Technical staff/administration/apprentices	179
Ph. D. students/trainees/assistants	180
Total	583

■	Ph. D. students, trainees, assistants
■	Technical staff, administration, apprentices
■	Scientists

PROFILE OF FRAUNHOFER IFAM



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SHAPING AND FUNCTIONAL MATERIALS

In developing complex system solutions, networks between industry and research organizations play a pivotal role. Technological expertise and in-depth specialist knowledge are essential here, especially at the interfaces between different disciplines. The competencies of the Fraunhofer IFAM staff, in conjunction with a broad network of partners from industry and science, guarantees the development of innovative business solutions.

Transferring basic application-oriented research into actual production solutions or component developments is a task that requires the constant advancement of know-how and technical expertise. This is why high priority is put on continually expanding competencies and know-how of the Shaping and Functional Materials division at the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM.

Our portfolio in research and development work stretches from basic application-oriented research right through to actual new products and support in production launch.

Multifunctional components with integrated sensor functions put specific requirements on the relevant materials being used. The properties can be precisely customized by combining various materials within a component, for example metal-metal, metal-ceramic, and combinations with CFRPs.

The core competence "Powder technology" covers production processes, such as injection molding, which nowadays are used to shape geometrically complex components from a range of metal alloys and ceramic materials. It has now become possible to utilize the different properties of materials within different parts of components. This allows, for instance, hard-soft or dense-porous property combinations, or even materials with sensory properties, to be custom-integrated into components. Such developments are of particular interest in micro-component production, where such integrated production solutions mean that micro-assembly work can be omitted.

Functional ink and paste formulations, and the relevant experience in applying them to components, have also been developed, especially for the "INKtelligent printing®" process. This makes it possible to equip components with sensors to record, for example, operating or ambient conditions.

A robot-based production line is now available at Fraunhofer IFAM for the functionalization of components and surfaces. This is a key step towards the implementation and introduction of sensors into automated industrial production using printing techniques.

1 *Prudent combination of thermoelectric and metallic materials allows structures to be printed as thermoelectric generators.*

2 *System for testing and characterizing materials for electrical energy storage systems.*

With its advanced casting and analytical equipment and indepth know-how of high pressure die casting processes for aluminum and magnesium alloys, Fraunhofer IFAM commands a strong market position. In addition to the optimization of casting processes with permanent molds as well as in lost-foam casting, we are constantly upgrading our core competence "Casting technology". A process engineering approach is being pursued with the development of CAST$^{\text{tronics®}}$ technology which provides casting shops with the ability to integrate functional components directly into their casting process.

We have considerable know-how regarding the conversion of cellular metallic materials into products. This allows us to develop special solutions for markets such as diesel particulate filters and also to continuously expand our knowledge. Our portfolio of methods is continuously matched to market requirements, resulting in new technological challenges. Product innovation under strict economic constraints plays an important role here as does the contribution of our research to improving the quality of life and to sustainable developments in the area of transport, energy, medicine, and the environment.

A significant success factor in all our product innovation continues to be the materials and their processing. This is particularly relevant for primary forming methods, as both material properties and component geometry can be influenced during the production process. The resulting market is growing due to the increasing complexity of these products.

Material properties and technologies for structural and functional applications are being customized and characterized. High performance materials, composite materials, gradient materials, and smart materials are all being developed for this purpose, along with production technologies for integrating the properties into components.

Our in-depth knowledge of special functional materials such as magnets, thermal management materials, thermoelectric and magnetocaloric materials, and nanocomposites is opening up new product development opportunities for our customers and completes our competence "Sintered, composite, and cellular metallic materials".

Electromobility continues to be a highly dynamic work area, particularly with regard to energy storage systems, drive technology, and system testing. These are key elements of the relatively new core competence "Electrical components and systems". This work is focusing on the development, construction, and testing of components for electric vehicles and their integration into systems. An example of this is the Fraunhofer wheel hub motor, which was largely developed by Fraunhofer IFAM. An evaluation center has already been set up for testing the complete electrical drive train. Its services include the specific investigation and evaluation of electric motors, power converters, control systems, and traction batteries. This also includes battery aging tests and characterization of the continuous operation of electrical drive systems based on standardized and real driving cycles.

The new Energy Systems Analysis department at Fraunhofer IFAM, arising from the incorporation of the Bremer Energie Institut, also addresses topics such as renewable energies, combined heat and power systems, energy-efficient buildings, as well as heating networks and electricity grids. A new technical training course for industrial users aims to pass on the latest research results and practical knowledge about electromobility.

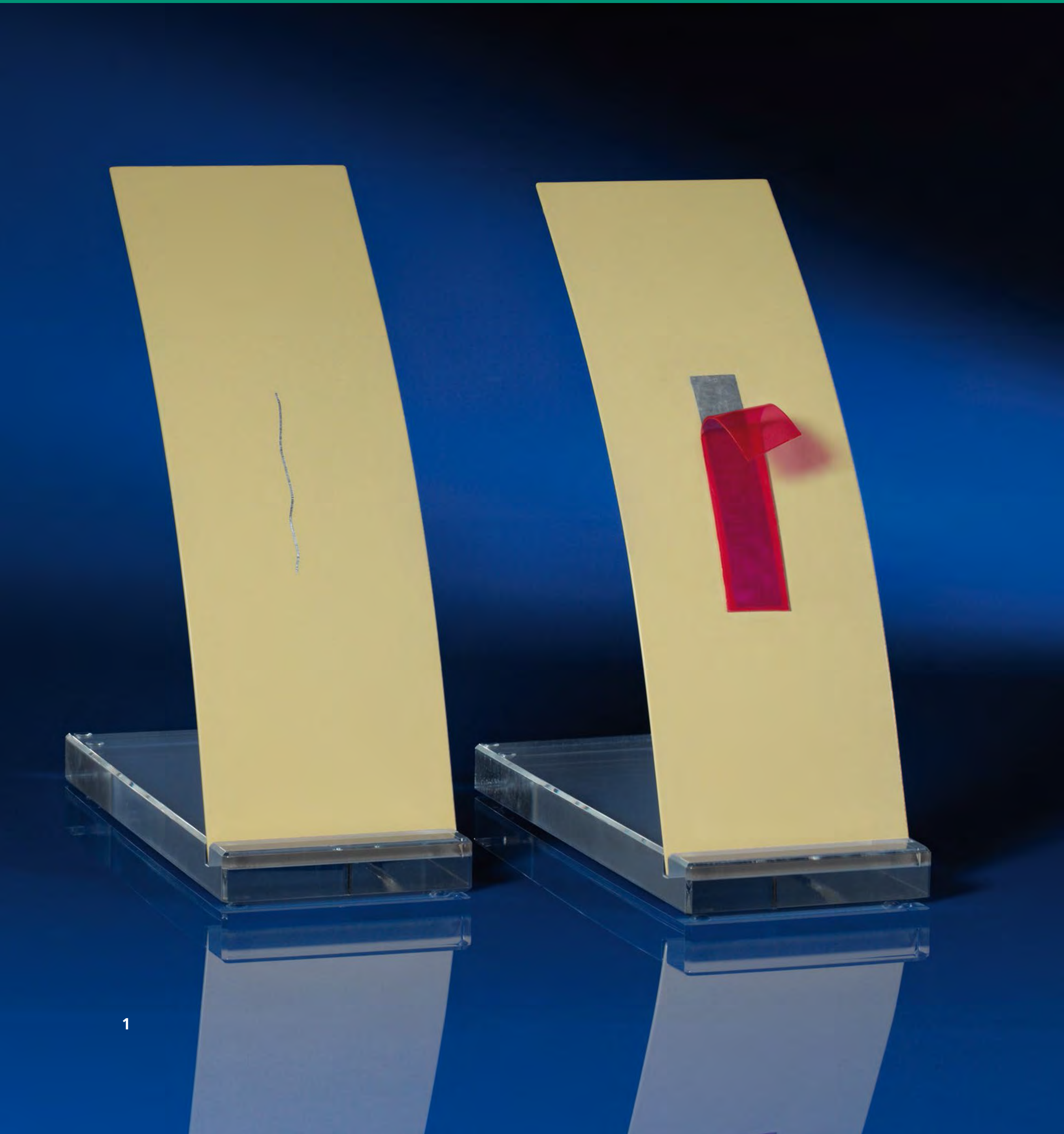
Perspectives

The further development of complex drive systems such as wheel hub motors will continue to be an interesting area of work at the Shaping and Functional Materials division of Fraunhofer IFAM. The actual drive development with the implementation of a prototype and practical testing will utilize Fraunhofer IFAM's manufacturing and testing expertise. Another interesting area is the construction and inclusion of complete vehicle models in the studies on batteries and drive motors in the form of hardware in the loop simulations on the Fraunhofer IFAM drive train test stand.

The installation of a production line for the functionalization of components and surfaces is the next step for the implementation and introduction of sensors into existing industrial production lines using printing techniques. The development of new technical options for the favorable-cost manufacture of components for electric vehicle drive trains is very attractive commercially and represents a new challenge.

Key areas of work

- Development and modification of materials: metallic materials, structural materials, functional materials, composite materials, cellular materials, thermal management, thermoelectric systems
- Powder metallurgy technologies: Special sintering processes, metal injection molding, generative processes, nanostructuring and microstructuring
- Casting technologies: Die casting, investment casting, lost-foam casting
- Functionalization of components: Sensors, actuators, nanostructuring and microstructuring
- Material analysis and materialography
- Development and construction of electrical components and integration of these into systems, testing of components for the drive train of electric motors
- Material and process development for novel energy storage systems: nanostructured electrodes, production of cell components, battery testing technology, electrochemical analysis
- Hydrogen technology
- Testing of charging infrastructures for electromobility, analysis of fleet tests, technical training courses – national and international
- Renewable energies, energy supply, and climate protection
- Energy-efficient buildings, heating networks, and electricity grids
- Combined heat and power systems



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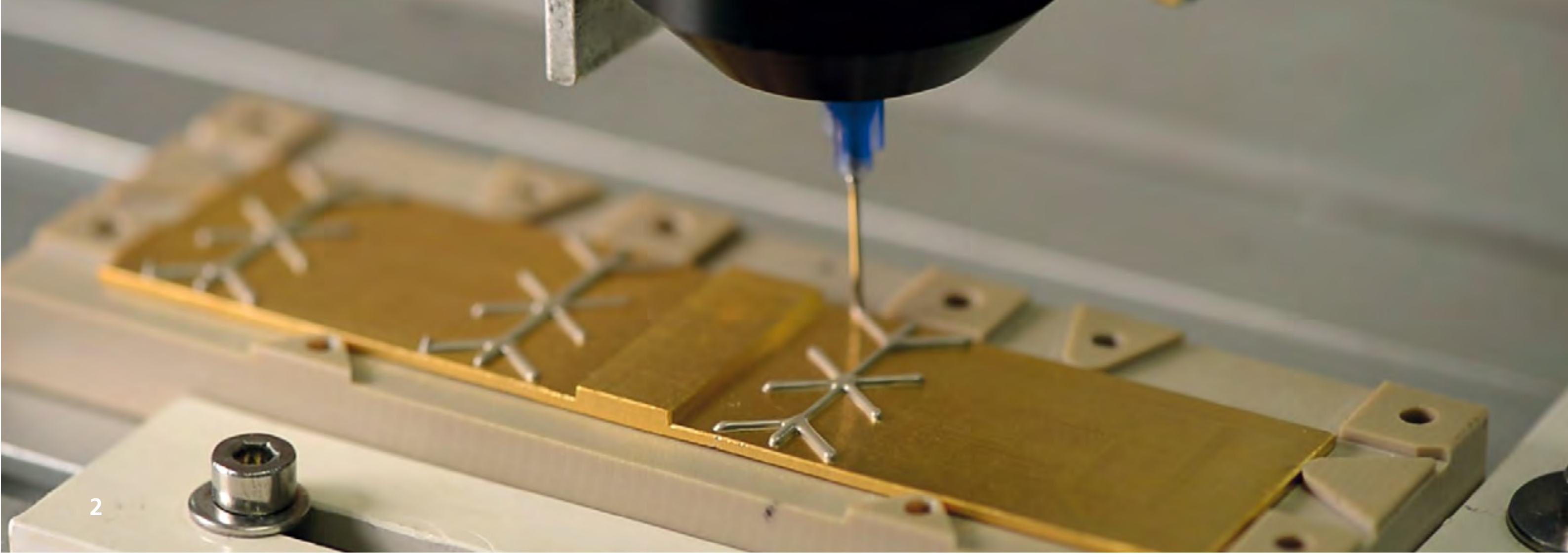
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ADHESIVE BONDING TECHNOLOGY AND SURFACES

The Adhesive Bonding Technology and Surfaces division at the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM has more than 300 employees and is the largest independent research institution in Europe working in the area of industrial adhesive bonding technology. The R&D activities focus on adhesive bonding technology, surface technology, and fiber composite technology. The objective is to supply industry with application-oriented system solutions.

Multifunctional products, lightweight design, and miniaturization – achieved via the intelligent combination of materials and joining techniques – are opening up new opportunities which are being exploited by the Adhesive Bonding Technology and Surfaces division. The activities range from fundamental research through to production right up to the market introduction of new products with partners. Industrial applications are mainly found in the transport sector – manufacturers of aircraft, cars, rail vehicles, ships – and their suppliers, energy technology, the construction industry, the packaging sector, textile industry, electronics industry, microsystem engineering, and medical technology.

"Adhesive bonding technology", a core competence, involves the development and characterization of adhesives, the design and simulation of bonded and hybrid joints, as well as the characterization, testing, and qualification of such joints. The planning and automation of industrial production as well as process reviews and certifying training courses in adhesive bonding technology and fiber composite technology are additional provided services.

The core competence "surface technology" covers plasma technology, paint/lacquer technology, as well as adhesion and interface research. Customized surface modification – for example surface pre-treatment and functional coatings – considerably expand the industrial uses of many materials and in some cases are vital for the use of those materials. The focus here is on the optimization of the long-term stability of bonded joints and coatings, including early detection of degradation and corrosion phenomena, the validation of aging tests, and inline surface monitoring. The research results in the area of aging and surface pre-treatment provide important fundamental knowledge for both adhesive bonding and coating technology, thus contributing to the safety and reliability of bonded joints and coatings.

The Fraunhofer Project Group Joining and Assembly FFM at Forschungszentrum CFK NORD (Research Center CFRP NORTH) in Stade, which is a part of Fraunhofer IFAM, is carrying out forward-looking work on large fiber reinforced plastic structures. The Fraunhofer FFM is able to join, assemble, process, repair, and carry out non-destructive tests on large 1:1 scale structures. The "fiber composite technology" core competence thus closes the gap between the laboratory/small pilot-plant scale and industrial scale FRP applications. The aspects mentioned above concerning adhesive bonding tech-

1 *Use of adhesive pickling tape to repair damage to a coating.*
2 *Special dispensing pattern for electrical contacts for lithium ion cells (project: eProduction).*

nology, plasma technology, paint/lacquer technology, as well as adhesion and interface research are also key aspects of this core competence. This is complemented by further know-how about matrix resin development, fiber-matrix adhesion, up to the sizing of joints.

The entire Adhesive Bonding Technology and Surfaces division is certified according to DIN EN ISO 9001. The laboratories for material testing, corrosion testing, and paint/lacquer technology are further accredited in accordance with DIN EN ISO/IEC 17025. The Center for Adhesive Bonding Technology has an international reputation for its training courses in adhesive bonding technology and is accredited via DVS-PersZert® in accordance with DIN EN ISO/IEC 17024. It is accredited in accordance with the German regulation for employment promotion, AZAV. The Plastics Competence Center is also accredited in accordance with AZAV and meets the quality requirements of DIN EN ISO/IEC 17024. The "Certification Body" for the Manufacture of Adhesive Bonds on Rail Vehicles and Parts of Rail Vehicles is accredited by the Federal Railway Authority (FRA, Eisenbahn-Bundesamt) in accordance with DIN 6701-2 and following DIN EN ISO/IEC 17021.

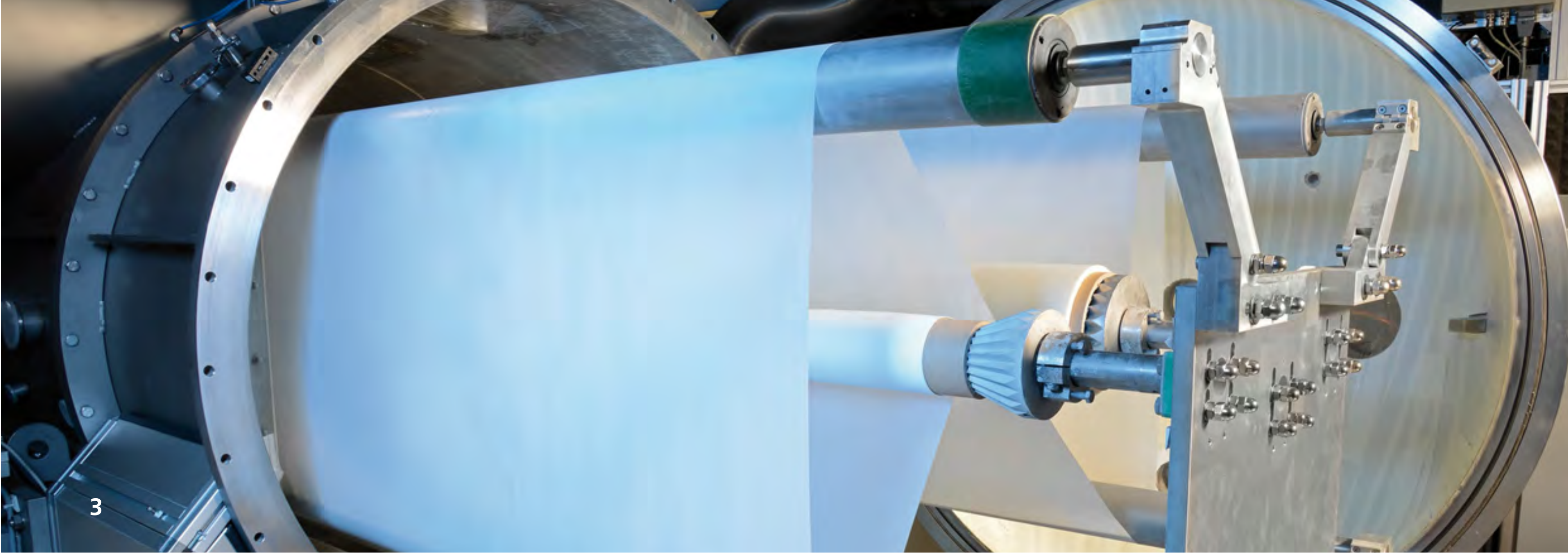
Perspectives

Industry puts high demands on process reliability when introducing new technologies and modifying existing technologies. These demands are the benchmark for the R&D activities in the Adhesive Bonding Technology and Surfaces division. Working with customers, Fraunhofer IFAM develops innovative products which are later successfully introduced into the marketplace by the companies. Manufacturing technologies are playing an ever more important role here, because high product quality and the reproducibility of production processes are key requirements for success in the marketplace.

Adhesive bonding technology has been used in vehicle construction for a long time, yet its potential has not nearly been fully utilized. Lightweight construction for vehicles as a means of saving resources, adhesive bonding in medicine and medical technology, as well as the use of nanoscale materials in the development and modification of adhesives are just a few examples of the broad activities of the institute. In order to interest more sectors of industry in adhesive bonding technology, the motto for all the activities is: Make the bonding process and the bonded product even safer! This objective can only be achieved if all the steps in the bonding process chain are considered as an integral whole.

In all areas, Fraunhofer IFAM is making increasing use of computer-aided methodologies. For example: the numerical description of flow processes in dosing pumps/valves, multiscale simulation of the molecular dynamics at a molecular level, and macroscopic finite element methods for the numerical description of materials and components.

A variety of spectroscopic, microscopic, and electrochemical methods are used in order to give insight into the processes involved in the degradation and corrosion of composite materials. Using these "instrumental methods" and the accompanying simulations, Fraunhofer IFAM acquires information which empirical test methods based on standardized aging and corrosion procedures cannot provide. Industries with very stringent requirements on surface technology make use of the in-depth expertise and technological know-how of Fraunhofer IFAM. Notable customers include leading companies – particularly in the aircraft and car manufacturing sectors.



Key activities

- Synthesis, formulation, and testing of new polymers for adhesives, laminating/casting resins
- Development of additives (nanofillers, initiators, etc.) for adhesives and coatings
- Development and qualification of adhesive bonding production processes; computer-aided production planning
- Application of adhesives/sealants, casting compounds (mixing, dosing, application)
- Development of innovative joining concepts (bonding, hybrid joints)
- Design of bonded structures (simulation of the mechanical behavior of bonded joints and components using finite element methods, prototype construction)
- Parameter determination, fatigue strength and alternating fatigue strength of bonded and hybrid joints; material models for adhesives and polymers
- Development of environmentally compatible pre-treatment methods and corrosion protection systems for long-term stable bonding and coating of plastics and metals
- Functional coatings using plasma and combined methods as well as functional coating systems
- Development of special test methods (e. g. formation and adhesion of ice on surfaces, resistance to aging)
- Evaluation of aging and degradation processes in composite materials; electrochemical analysis
- Computer-aided material development using quantum-mechanical and molecular-mechanical methods
- Automation and parallelization of processes in FRP technology
- Processing of FRP materials
- Quality assurance concepts for adhesive and lacquer/paint applications via in-line analysis of component surfaces
- National and international training courses for
  European Adhesive Bonder – EAB,
  European Adhesive Specialist – EAS, and
  European Adhesive Engineer – EAE
- Training courses for
  Fiber Reinforced Plastic Fabricator,
  Fiber Reinforced Plastic Specialist, and
  Fiber Reinforced Plastic Remanufacturer

3 *Applying a functional coating to a film via low pressure plasma polymerization.*

FIELDS OF ACTIVITY AND CONTACTS

INSTITUTE DIRECTORS

- **Prof. Dr.-Ing. Matthias Busse** (executive)
- **Prof. Dr. Bernd Mayer**

SHAPING AND FUNCTIONAL MATERIALS DIVISION

- **Prof. Dr.-Ing. Matthias Busse**
  Phone +49 421 2246-100
  matthias.busse@ifam.fraunhofer.de

DRESDEN BRANCH

- **Prof. Dr.-Ing. Bernd Kieback**
  Phone +49 351 2537-300
  bernd.kieback@ifam-dd.fraunhofer.de

ADHESIVE BONDING TECHNOLOGY AND SURFACES DIVISION

- **Prof. Dr. Bernd Mayer**
  Phone +49 421 2246-419
  bernd.mayer@ifam.fraunhofer.de

ADHESION AND INTERFACE RESEARCH

Dr. Stefan Dieckhoff
Phone +49 421 2246-469
stefan.dieckhoff@ifam.fraunhofer.de

→ www.ifam.fraunhofer.de/interface

- Surface and nanostructure analysis
- Corrosion protection and electrochemistry
- Numerical simulation of materials
- Quality assurance – monitoring surface properties
- Wet chemical pre-treatment
- Analysis of damage/failure

CERTIFCATION BODY OF THE FEDERAL RAILWAY AUTHORITY IN ACCORDANCE WITH DIN 6701-2

Dipl.-Ing. (FH) Frank Stein
Phone +49 421 2246-655
frank.stein@ifam.fraunhofer.de

→ www.ifam.fraunhofer.de/en/DIN6701

- Consultancy on matters relating to DIN 6701 (“Manufacture of adhesive bonds on rail vehicles and parts of rail vehicles”)
- Company audits and certifications in accordance with DIN 6701
- Member of the work group on adhesive bonding in accordance with DIN 6701

AUTOMATION AND PRODUCTION TECHNOLOGY

(up to December 31, 2013: Fraunhofer Project Group Joining and Assembly FFM)

Dr. Dirk Niermann
Phone +49 4141 78707-101
dirk.niermann@ifam.fraunhofer.de

→ www.ifam.fraunhofer.de/en/Stade

- Automated assembly of large structures up to a 1:1 scale
- Joining techniques (adhesives, shims, sealants)
- Processing technologies (milling, drilling, waterjet cutting)
- Automated component handling
- Shape and positional correction for large components
- Sensor-controlled robots with high positioning accuracy
- Release agent free manufacture of fiber composite components
- Manufacture of prototype components and structures
- Development of plants and components

BUSINESS DEVELOPMENT

Prof. Dr. Bernd Mayer
Phone +49 421 2246-419
bernd.mayer@ifam.fraunhofer.de

- Contact for European research projects, including project conception and applications
- Participation in regional, national, and international industry networks
- Coordination of major projects
- Focal point for large companies

ELECTRICAL ENERGY STORAGE SYSTEMS

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- Cell chemistry
- Metal-air batteries
- Paste development and electrode manufacture
- Cell assembly
- Electrocatalysis
- Battery testing stands
- In-situ analytics
- Service life and aging mechanisms

ELECTRICAL SYSTEMS

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→ www.ifam.fraunhofer.de/en/elsys

- Electromobility
- E-vehicle fleet
- Charging infrastructure
- Charging technologies (inductive, conductive)
- Test facility for e-motors (up to 120 kW)
- Test stand for traction batteries (up to 50 kWh)
- Driving cycle analysis
- Vehicle monitoring
- Simulation of the operating state of all components of the electric motor drive train

ENERGY AND THERMAL MANAGEMENT

Prof. Dr.-Ing. Jens Meinert
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jens.meinert@ifam-dd.fraunhofer.de

→ www.ifam.fraunhofer.de/en/etmt

- Efficient storage of heat and cold
- Development of high-performance latent heat storage systems
- Optimization of heat transport processes
- Cellular metals in compact heat exchangers
- Structuring of evaporator surfaces
- Thermal management of heat-generating components
- Mathematical modeling of heat transport
- Simulation of melting and solidification processes
- Measurement of thermal material and transport parameters
- Testing of technical energy-related components

ENERGY SYSTEM ANALYSIS

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→ www.ifam.fraunhofer.de/en/esa

Analyses, potential studies, and consultation of:
- Energy supply and climate protection
- Energy-efficient buildings and districts
- Combined heat and power systems
- Integrated heat and power provision
- Network-based heat supply
- Energy efficiency for material/process technology
- Economic/political boundary conditions for energy
- Residential housing and electromobility
- Integration of stationary/mobile energy storage systems

FUNCTIONAL STRUCTURES

Dr. Volker Zöllmer
Phone +49 421 2246-114
volker.zoellmer@ifam.fraunhofer.de

→ www.ifam.fraunhofer.de/en/fs

- Printed electronics
- Assembly and joining technology
- Sensor integration
- Printable inks and pastes
- (Nano) composites and functional materials
- Energy harvesting
- Catalytic layers
- Integration of functionalities
- Digital manufacturing
- Semi-automated production

CASTING TECHNOLOGY AND COMPONENT DEVELOPMENT

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→ www.ifam.fraunhofer.de/ct

- Hot-chamber and cold-chamber die casting (aluminum, magnesium, zinc)
- Lost foam casting
- Lost cores, complex geometries
- Investment casting
- Low pressure casting
- Function integration (CAST$^{TRONICS®}$)
- Development of casting technology
- Electric drive technology: Design, simulation, production, testing, and integration of components and machines

ADHESIVES AND POLYMER CHEMISTRY

Prof. Dr. Andreas Hartwig
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→ www.ifam.fraunhofer.de/adhesives

- Formulation of adhesives
- Matrix resins for fiber reinforced plastics
- Characterization of adhesives/bonded joints
- Novel additives, polymers, and other raw materials
- Morphology of adhesives and other duromers, e.g. nanocomposites
- Biofunctional surfaces and bioanalysis
- Adhesives for medicine and medical technology
- Improved reliability and productivity of bonding processes
- Market advice for adhesives and raw materials

ADHESIVE BONDING TECHNOLOGY

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→ www.ifam.fraunhofer.de/abt

- Selection and characterization of adhesives and sealants
- Long-term stability of bonded joints and seals
- Mixing, dosing, and application systems
- Adhesive application on flat substrates
- Production of bonded prototypes
- Production planning, process design, automation
- Process reviews and damage/failure analysis
- Electrically/optically conductive contacts
- Adaptive microsystems and dosing ultra small quantities
- Concepts for micro-production

PAINT/LACQUER TECHNOLOGY

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→ www.ifam.fraunhofer.de/paint

- Processing and application technologies for paints and coatings
- Qualification of materials and processes
- Functional paints and coatings (e.g. anti-icing, anti-fouling, self-healing, and dirt-repelling coatings, electrically insulating layers)
- Analysis of raw materials for coatings
- Coating formulation
- Test methods
- Analysis of damage/failure
- Training seminars

MATERIALOGRAPHY AND ANALYSIS

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→ www.ifam.fraunhofer.de/analytics

- Analysis of damage/failure
- Thermal analyses: melting point, phase changes
- Powder analysis: BET, specific surface area
- Metallography: microsections, hardness measurements, image analysis
- Scanning electron microscopy
- Focused ion beam
- Trace analysis
- X-ray phase analysis
- Training course for material tester

PLASMA TECHNOLOGY AND SURFACES PLATO

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- Low pressure plasma technology
- Atmospheric pressure plasma technology
- VUV excimer technology
- Plant technology and construction
- New surface technologies
- CVD processes
- Tribology
- Functional coatings
- Web materials/film technologies
- Pre-treatment, cleaning, and activation

SINTERED AND COMPOSITE MATERIALS

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- Additive manufacturing (electron beam melting, dispensing technology)
- Composite materials, multimaterial composites
- Light metals
- Materials for tribological applications
- Materials for energy conversion (thermoelectric materials) and storage (supercaps)
- High temperature materials
- Sputter targets

POWDER TECHNOLOGY

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→ www.ifam.fraunhofer.de/en/pt

- Powder injection molding
- Pressing and sintering
- Additive manufacturing
- Magnetic materials
- Composite materials
- Metal foams

TECHNICAL TRAINING IN ELECTROMOBILITY

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- Workforce training in electromobility in Germany and China
- Electromobility intensive
- Electromobility specialist
- Electromobility in the future
- Technology didactics

HYDROGEN TECHNOLOGY

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- Electrode materials for water electrolysis
- Electrochemical characterization of metals
- Development and testing of electrolysis cells
- Metal hydrides for reversible H_2 storage
- Techniques for the production of metal hydrides
- Development and testing of hydride reactors
- Integration of hydride reactors in H_2 energy systems
- Hydrolysis reactions for H_2 generation
- Hydrogen embrittlement for powder manufacture
- Comprehensive analysis of H_2-solid reactions

WORKFORCE TRAINING AND TECHNOLOGY TRANSFER

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andreas.gross@ifam.fraunhofer.de
→ www.bremen-bonding.com
→ www.bremen-plastics.com

- Training courses in adhesive bonding technology
- Training courses in fiber reinforced plastics
- Quality assurance for adhesive bonding technology
- Quality assurance for fiber reinforced plastic technology
- Promotion of young scientists and engineers (MINT)

MATERIALS SCIENCE AND MECHANICAL ENGINEERING

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→ www.ifam.fraunhofer.de/materialscience

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- Qualification of bonded structures
- Bonded and riveted joints: design, sizing, crash/fatigue behavior
- Combination and optimization of mechanical joining processes
- Qualification of mechanical fasteners
- Fiber composite components, lightweight and hybrid constructions
- Accredited Material Testing Laboratory

CELLULAR METALLIC MATERIALS

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→ www.ifam.fraunhofer.de/cmm

- Cellular metals from variant special materials
- Additive manufacturing via 3D screen printing
- Open-celled fiber structures and sponges
- Hollow sphere structures and precision hollow spheres
- Reinforcement of cast components with 3D wire structures
- High-performance vibration damping
- High-performance heat storage systems
- Degradable metallic implant materials
- Jewelry and design
- Catalysis and filtration

PROFILE OF FRAUNHOFER IFAM

ADVISORY BOARD

Members

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Chair of the advisory board
Airbus Deutschland GmbH
Bremen

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Henkel AG & Co. KGaA
Düsseldorf
(since May 2013)

Dr. Annerose Beck
Saxon State Ministry for
Science and the Arts
Dresden

Prof. Dr. Rolf Drechsler
University of Bremen
Bremen
(up to February 2013)

Michael Grau
Mankiewicz Gebr. & Co.
Hamburg

Dr. Stefan Kienzle
Daimler AG
Sindelfingen

Prof. Dr. Jürgen Klenner
Airbus Deutschland GmbH
Bremen

Gerd-Rüdiger Kück
Senator for Education and
Science of the Free
Hanseatic City of Bremen
Bremen

Dr. Johannes Kurth
KUKA Roboter GmbH
Augsburg

Dr. Andreas Meier
tesa SE
Hamburg
(since June 2013)

Carsten Meyer-Rackwitz
tesa SE
Hamburg
(up to February 2013)

Dr. Matthias Müller
Robert Bosch GmbH
Stuttgart
(up to February 2013)

Dr. Georg Oenbrink
Evonik Industries AG
Essen

Dr. Ralf-Jürgen Peters
TÜV Rheinland
Consulting GmbH
Cologne

Dr. Rainer Schönfeld
Henkel AG & Co. KGaA
Düsseldorf
(since June 2013)

Jan Tengzelius M. Sc.
Höganäs AB
Höganäs, Sweden

Christoph Weiss
BEGO Bremer Goldschlägerei
Wilh. Herbst GmbH & Co. KG
Bremen

Guests

Prof. Dr.-Ing. Kurosch Rezwan
University of Bremen
Bremen

Johann Wolf
BMW AG
Landshut

1 *Fraunhofer IFAM, Dresden.*

THE FRAUNHOFER-GESELLSCHAFT

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

At present, the Fraunhofer-Gesellschaft maintains 67 institutes and research units. The majority of the more than 23,000 staff are qualified scientists and engineers, who work with an annual research budget of 2 billion euros. Of this sum, more than 1.7 billion euros is generated through contract research. More than 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Almost 30 percent is contributed by the German federal and Länder governments in the form of base funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society until five or ten years from now.

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

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

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

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

→ **www.fraunhofer.de/en.html**

Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM

1
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- 28359 Bremen, Germany

2
- Fraunhofer IFAM
- Branch Dresden
- Winterbergstrasse 28
- 01277 Dresden, Germany

3
- Fraunhofer Project Group
- Electrical Energy Storage
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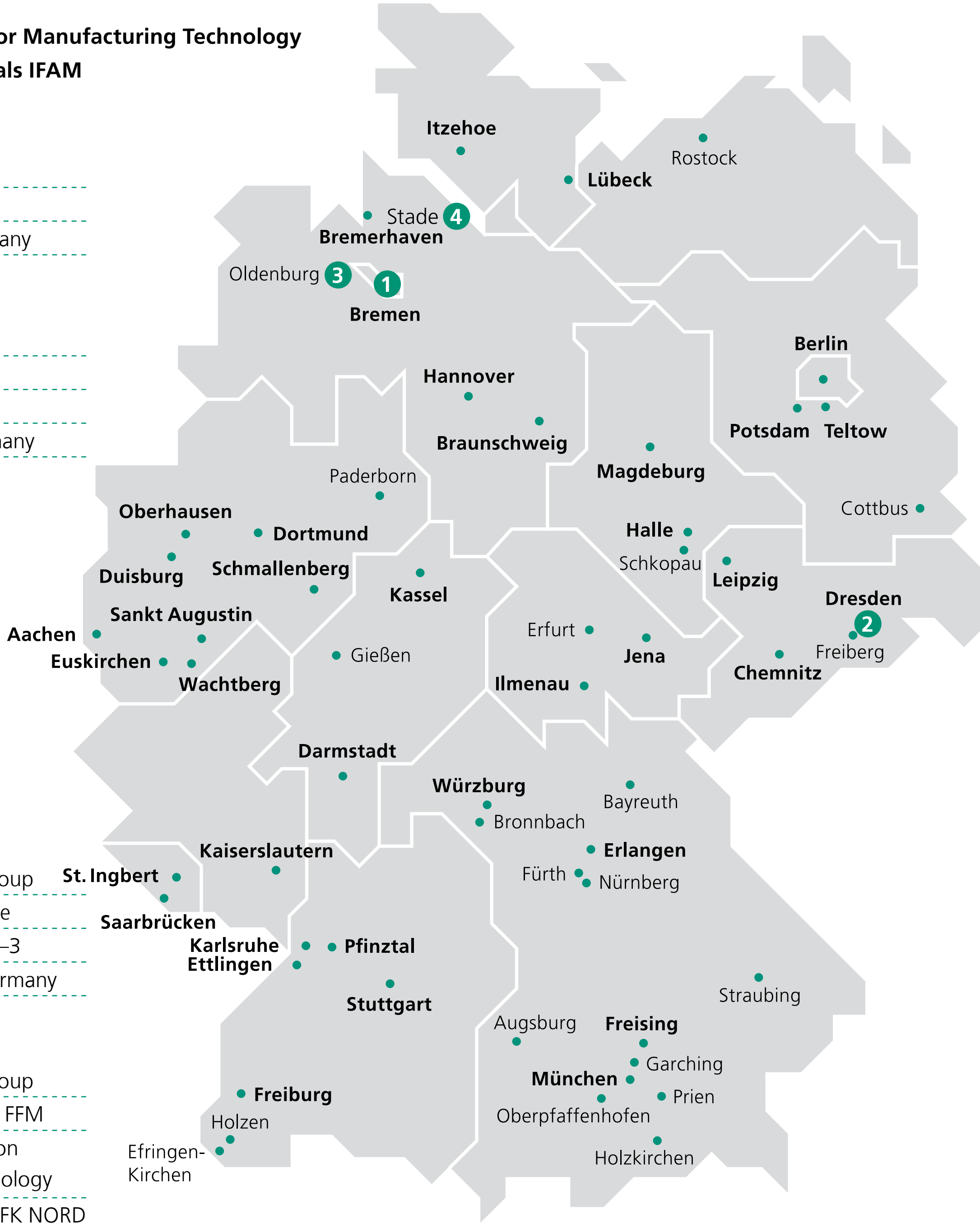
- 26129 Oldenburg, Germany

4
- Fraunhofer Project Group Joining and Assembly FFM since 2014: Automation and Production Technology
- Forschungszentrum CFK NORD
- Ottenbecker Damm 12
- 21684 Stade, Germany



Fraunhofer Institutes and facilities
Other sites

GROUPS | ALLIANCES | ACADEMY

NETWORKS AT FRAUNHOFER

FRAUNHOFER GROUP FOR MATERIALS AND COMPONENTS – MATERIALS

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

The Fraunhofer Group for Materials and Components – MATERIALS pools the expertise of the Fraunhofer Institutes that work in the field of materials science.

Materials science research within the Fraunhofer-Gesellschaft covers the entire value-creation chain from the development of new materials and improvement of existing materials through to manufacturing technology on an industry scale, characterization of properties, and evaluation of applications. The same applies for components and systems made from these materials. In addition to experimental studies in laboratories and pilot plants, numerical simulation and modeling methods are also employed. The Fraunhofer Group for Materials and Components – MATERIALS covers metals, inorganics/non-metals, polymers, renewable raw materials, and semiconductors.

The Group applies its expertise within a range of business areas including energy and environment, mobility, health, machine and plant engineering, construction and housing, microsystem engineering, and safety.

Key work areas of the Group include:

- Improving safety/comfort and reducing resource usage in transport technology as well as machine and plant engineering
- Increasing the efficiency of systems for energy generation, energy conversion, and energy storage
- Improving biocompatibility and the functionality of materials used in medicine and biotechnology
- Enhancing integration density and usage properties of components in microelectronics and microsystem engineering
- Improved usage of raw materials and improved product quality

→ **www.materials.fraunhofer.de/fhg/vwb_en/index.jsp**

Chairman of the Group
Prof. Dr.-Ing. Peter Elsner

Deputy Chairman of the Group
Prof. Dr. Peter Gumbsch

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Prof. Dr. Bernd Mayer
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1 *Network (Image: © Gerhard Bergmann).*

FRAUNHOFER ALLIANCES

Fraunhofer Institutes or divisions of institutes having differing expertise collaborate in Fraunhofer Alliances in order to jointly develop and market a specific field of business.

FRAUNHOFER ADAPTRONICS ALLIANCE

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Spokesperson for the Alliance | Contact at Fraunhofer IFAM

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FRAUNHOFER ACADEMY

Fraunhofer Academy is the umbrella organization for training courses that are offered by the Fraunhofer-Gesellschaft.

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www.ifam.fraunhofer.de/fachkraft-emobility

→ **www.academy.fraunhofer.de/en.html**

PROFILE OF FRAUNHOFER IFAM

QUALITY MANAGEMENT

Certified in accordance with DIN EN ISO 9001

Fraunhofer IFAM has been certified in accordance with DIN EN ISO 9001 since 1995. Certified areas at Bremen and Stade include:

- Product-oriented development of materials, mechanical engineering, processes and production technologies for adhesive bonding technology, surface technology, and paint/lacquer technology
- Characterization and simulation of materials and technologies
- Adhesive development
- Training courses in adhesive bonding technology, fiber reinforced plastics, and electromobility
- Casting technologies and component development
- Metallography, thermal analysis, powder measurement technology, and trace analysis
- Methods for manufacturing and processing nanodispersions
- Computer modeling and simulation

Certification in accordance with DIN EN ISO/IEC 17025

The laboratories in Bremen for materials testing, corrosion testing, paint/lacquer technology, and materialography and analysis have also been certified in accordance with DIN EN ISO/IEC 17025 since 1996.

The Fraunhofer IFAM's Dresden branch is certified in accordance with DIN EN ISO/IEC 17025 for powder metallurgy, special tests for characterizing inorganic powders and sintered materials, and for material tests on metallic materials.

Certification in accordance with DIN EN ISO/IEC 17024 and accreditation in accordance with AZAV

The Center for Adhesive Bonding Technology has an international reputation for its training courses and has been accredited via DVS-PersZert® in accordance with DIN EN ISO/IEC 17024 since 1998. Since 2009 it has been accredited in accordance with the German education quality management standard, AZAV.

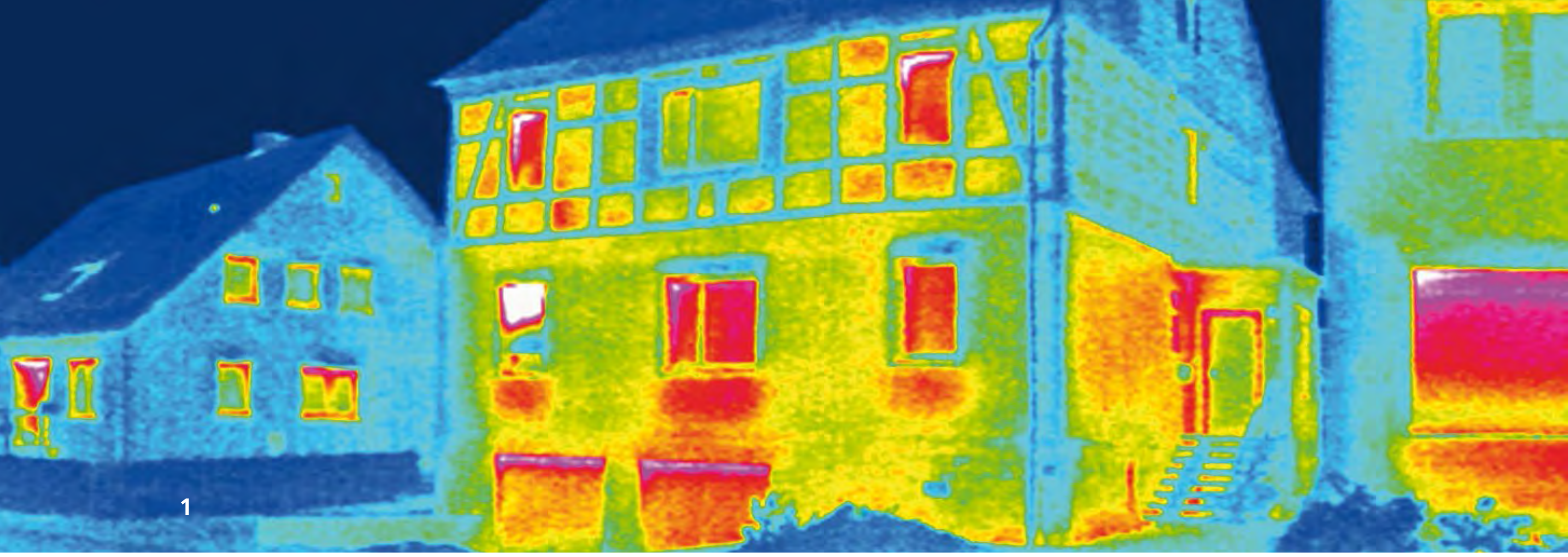
Accreditation in accordance with AZAV

The Plastics Competence Center of Fraunhofer IFAM has been accredited in accordance with the German education quality management standard AZAV since 2007 and meets the quality requirements of DIN EN ISO/IEC 17024.

Certification in accordance with DIN 6701-2 and DIN EN ISO/IEC 17021

The Certification Body for the Manufacture of Adhesive Bonds on Rail Vehicles and Parts of Rail Vehicles has been accredited by the Federal Railway Authority (Eisenbahn-Bundesamt) in accordance with DIN 6701-2 and following DIN EN ISO/IEC 17021 since 2006.

→ **www.ifam.fraunhofer.de/en/qm**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BREMER ENERGIE INSTITUT BECOMES PART OF FRAUNHOFER IFAM: "THINKING TODAY ABOUT SOLUTIONS FOR TOMORROW"

On September 1, 2013 the Bremer Energie Institut (BEI), with the support of the State of Bremen, was integrated into Fraunhofer IFAM. The team of ten multidisciplinary scientists will in particular strengthen the Energy and Environment business segment and thus complete the R&D portfolio of the already existing technology fields at Fraunhofer IFAM.

More than 20 years of expertise on energy matters

The Bremer Energie Institut was founded in 1990 as an initiative of the Bremen Energy Advisory Council of the Free Hanseatic City of Bremen. Until 2013 it had a formal contractual association with the University of Bremen and Jacobs University Bremen. It has acquired an excellent reputation for its knowledge of the energy industry and energy politics and makes important contributions to economically viable, resource-friendly energy provision by carrying out studies, writing expert reports, and developing plans for climate protection. Its customers include various ministries (federal/state), municipal and local authorities, industrial associations, energy suppliers, and housing associations.

The former BEI is now integrated into Fraunhofer IFAM as Energy System Analysis department and has special expertise in evaluation of the utilisation of combined heat and power (CHP), CHP plants in integrated energy supply concepts, and district and heating systems. The Energy System Analysis also plays a key role in the design of energy-efficient restoration and new building projects and provides technical supervision during realization (e. g. the Effizienzhaus-PLUS project). Even prior to the incorporation into Fraunhofer IFAM there has been successful collaboration regarding the electromobility model region Bremen/Oldenburg.

Research and consultancy in the context of electricity generation from renewables

The political decision to switch to electricity generation from renewables results in enormous challenges: the transformation of the existing energy systems at a local, regional, and national level. The move away from fossil fuels and the introduction of electricity generation from renewables require new technological solutions and regulations. This extremely complex and dynamic area requires a holistic appraisal of energy systems in order to guarantee supply reliability and economic viability at all times during the course of this transformation.

Energy systems analysis at Fraunhofer IFAM

The incorporation of the Bremer Energie Institut into Fraunhofer IFAM resulted in the creation of the Energy Systems Analysis group to foster the aforementioned research activities. The focus of the research group's project work will still be on district heating, combined heat and power systems, improvement of the energy balance for new housing, and the effects of the regulatory framework for energy concepts at a local and regional level.

An important aspect of regional energy concepts in connection with mobile and stationary energy storage systems is the charging infrastructure for electromobility, particularly in rural regions. This is a topic that has already been studied by Fraunhofer IFAM for several years. The potential synergy here is enormous because the efficient use of electrical, thermal, and mechanical energy from renewable sources is also very relevant for many materials and processes being developed at Fraunhofer IFAM. This concerns, for example, materials for storing and converting thermal energy in a wide range of technological fields. By analyzing and evaluating the entire energy system, economic advantages can be determined which go far beyond the mere development of prototypes. For example, the waste heat in systems with small temperature differences can be utilized, whereby adsorption storage units, phase change materials, and heat exchangers can be suitably combined, leading to significantly improved energy efficiency in combination with heat pumps.

With the competence of the new Energy Systems Analysis department at Fraunhofer IFAM, technical projects in the Energy and Environment business segment can be evaluated more thoroughly by taking into account the social, economic, and regulatory framework which can significantly influence the respective energy system. This holistic consideration of the energy systems enables potential efficiencies to be identified more easily and economic advantages can be better quantified.

Current focus of project work:

- Development of concepts for the use of centralized and decentralized combined heat and power systems
- Analysis of the storage options for fluctuating energy from renewable sources in combined energy networks (gas, heat, electricity)
- Determination of the potential utilization of district heating in suburbs and districts
- Life cycle analysis for improving the material and energy efficiency of production processes
- Design and evaluation of heat insulation and heating systems in buildings

→ **www.ifam.fraunhofer.de/en/esa**

1 *Source: © Ingo Bartussek – Fotolia.com.*

2 *Source: © Thorsten Schier – Fotolia.com.*

INTERNATIONAL COLLABORATION

More Brazilian partners

Fraunhofer IFAM researchers have collaborated with Brazilian partners for more than a decade. In the early years, the focus was on university research, whereas now there is ever greater emphasis on applied research and industrial applications. Comprehensive networks of partners now cover these three pillars of competence. These networks are effective and are the starting point for business relationships between partners whose resources and expertise excellently complement one another.

Active promotion of exchange visits for young scientists

An initiative of the German Foreign Office is currently promoting German-Brazilian collaboration in the areas of education, science, and business under the motto "Bringing ideas together" as part of the "Germany–Brazil 2013/2014" program. For example, the Brazilian government is funding the "Science without borders" (Ciência Sem Fronteiras) program up to 2015 which involves exchange visits by 101,000 students and young scientists, some of whom will visit German universities and research establishments. At the end of 2013 some 16 beneficiaries of the Brazilian program were working at Fraunhofer IFAM, including three doctoral students from the University of Bremen. In a program of "Deutsche Welle" on Brazilian TV the young students and Prof. Dr. Mayer and Dr. Leite Cavalcanti talked about their experiences.

The nationwide reporting of these activities also led to an invitation to Dr. Leite Cavalcanti from the Brazilian Ambassador to Germany, Maria Luiza Viotti, in August 2013 to attend a symposium at the Federal Institute for Materials Research and Testing (BAM) in Berlin for 200 beneficiaries of the "Science without borders" program and report about the research work at Fraunhofer IFAM.

Successful collaboration with universities and industry

There is already excellent collaboration with parties in Brazil: A visit was made by two Fraunhofer IFAM researchers to the University of Ponta Grossa (UEPG) on invitation of the university rector and president of the Brazilian Association of Federal and Local Universities (ABRUEM), Prof. João Carlos Gomes, to discuss several ongoing research projects with Brazilian universities and the first multi-year bilateral collaboration with a Brazilian industrial partner.

1 *Prof. Dr. Bernd Mayer (right), Dr. Welchy Leite Cavalcanti (left), and Marcela Martins Melo (7th from left) of Fraunhofer IFAM with beneficiaries of the Brazilian "Science without borders" program.*

Research and training in electromobility in China

Fraunhofer was one of the organizations visited by the Chinese Minister for Research, Prof. Dr.-Ing. Wan Gang, on his visit to Germany at the end of May 2013. The meeting with Fraunhofer President Prof. Dr.-Ing. Reimund Neugebauer was also attended by Prof. Dr. Jochem Heizmann, responsible for VW China since September 2012, and Prof. Dr.-Ing. Matthias Busse. Opportunities for collaborative projects in the area of energy and the environment were discussed at the meeting. The focus, however, was on electromobility: VW and Fraunhofer plan to work closely in the provinces with VW production sites.

Fraunhofer IFAM is a member of a consortium of four Fraunhofer Institutes which together with Volkswagen Group China started a project early in 2013 on the topic of charging infrastructure. Studies will be carried out, for example, on the effect of the charging infrastructure on local electricity grids and the use of electrical cars in typical suburban residential areas. This involves not only Fraunhofer IFAM but also Fraunhofer IWU (responsible for coordination) and Fraunhofer IOSB (Ilmenau).

Fraunhofer IFAM will also provide technical training in electromobility in China. A range of seminars have been developed to address topics such as electrical energy storage systems, electrical drive trains, and new vehicle concepts.

→ **www.ifam.fraunhofer.de/diandongche**

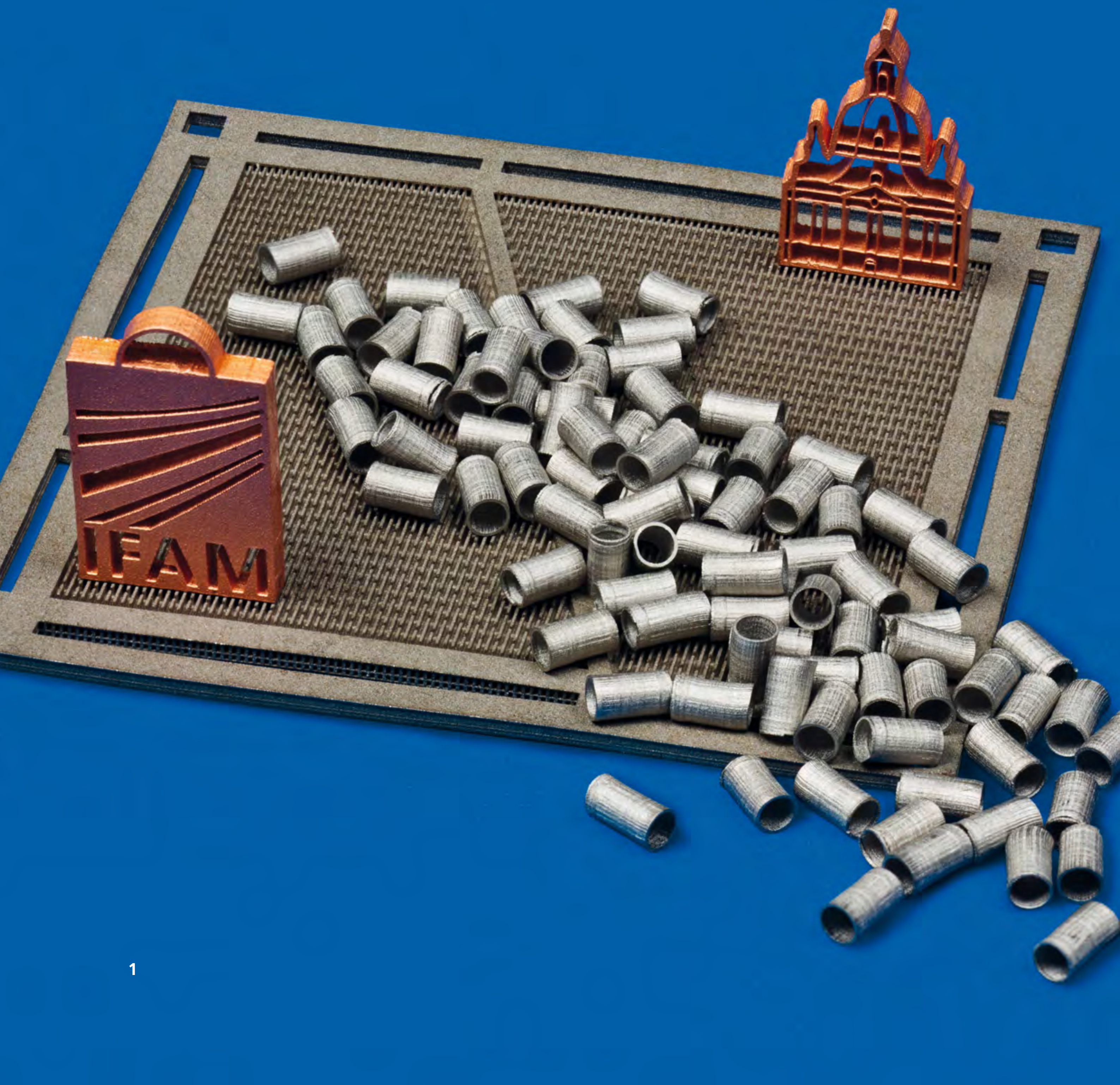
European research collaboration with Japan

The JEDI ACE project (Japanese-European De-Icing Aircraft Collaborative Exploration) started in November 2012. This is a collaborative project involving three Japanese and three European partners, funded by the Japanese Ministry of Economy, Trade, and Industry (METI) and the European Commission. The aim is to develop an integrated anti-icing system for new generations of aircraft. These new aircraft contain an ever greater quantity of CFRP materials. The anti-icing system will comprise three synergistic components: Active de-icing technology, functional coatings, which assist the de-icing function, and sensor technology, which not only monitors the icing but also the de-icing in real-time.

For Fraunhofer IFAM, this multilateral project is the starting point for closer collaboration with Japanese partners. In 2013, there were three visits to/from Japan which allowed many useful contacts to be made. Opportunities for joint projects and other collaboration were discussed with representatives from the worlds of R&D, industry, and politics. Three presentations outlined the current status of manufacturing and processing CFRP components. The existing Memorandum of Understanding between the National Composite Center of the University of Nagoya and Fraunhofer ICT will be extended to include Fraunhofer IFAM in 2014.

The excellent collaboration of Fraunhofer IFAM and Fraunhofer ICT enables a wider R&D portfolio to be offered and enhances networking and project acquisition.

2 *Prof. Dr.-Ing. Wan Gang (2nd from left) with Prof. Dr.-Ing. Reimund Neugebauer, Prof. Dr. Jochem Heizmann, and Prof. Dr.-Ing. Matthias Busse.*



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CORE COMPETENCE SINTERED, COMPOSITE, AND CELLULAR METALLIC MATERIALS

The development of materials with customized properties and combinations of properties and efficient manufacturing technologies are key activities of Fraunhofer IFAM. The utilization and tailored development of sintering and shaping processes create numerous opportunities for the manufacture and optimization of innovative metallic materials with unusual property profiles, in particular by combining properties in novel composite materials or by creating highly porous or cellular structures.

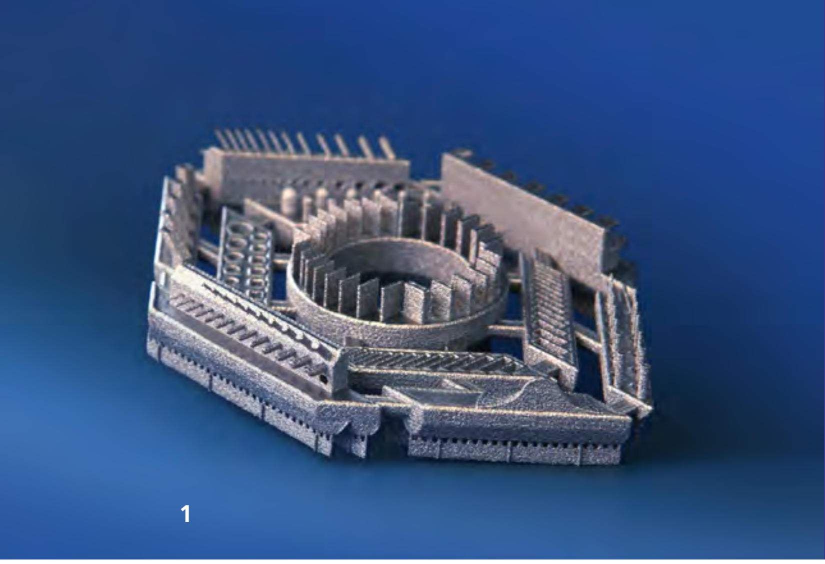
In the area of metallic and intermetallic sintered and composite materials for functional and structural applications, Fraunhofer IFAM possesses in-depth understanding of structure-property relationships and how to optimize these for specific applications. The complete powder-metallurgical technology chain from powder preparation and characterization through to various shaping and thermal treatment methods is covered. This is now being further expanded by methods such as rapid solidification of metallic melts (melt spinning and extraction) and special sintering processes (e. g. spark plasma sintering) as well as innovative oven analysis.

Fraunhofer IFAM has comprehensive knowledge of alloys and processes for manufacturing light metal components, in particular made of aluminum, for weight reduction in car manufacture. Regarding metallic composites, the focus is on materials development for thermal management of electronics, friction materials and sliding materials for high tribological loads, and special materials for mechanical and corrosive stresses at high temperature (> 800°C). The manufacture and testing of functional materials for energy storage and conversion is of growing importance. Key areas here are new and, in particular, nano-structured materials for hydrogen generation and storage, for heat storage, for efficient thermoelectric generators, and for supercapacitors.

Cellular metallic materials are another key development area. Prudent selection of materials and a wide range of customizable cell and pore structures allow a wide spectrum of application-specific properties and material savings to be realized. For example, highly porous metallic materials such as fiber-metallurgical materials, hollow sphere structures, open-cell metallic foams, 3D screen-printed structures, 3D wire structures, and porous metal papers can be used for applications such as noise absorption, heat insulation, energy absorption, mechanical damping, and material and energy transport, as well as for achieving catalytic effects.

→ **www.ifam.fraunhofer.de/metallicmaterials**

1 *Prototype components for additive manufacturing using three-dimensional screen printing.*



FRAUNHOFER IFAM EXTENDS ITS TECHNOLOGY PORTFOLIO

Customer-specific products, greater variation of design, shorter innovation cycles, and breaching the gap between small batch sizes and mass production are modern day challenges of manufacturing companies. One promising approach is additive manufacturing. This allows considerable improvement in the manufacturing economics due to the concomitant reduction in material and plant costs, shorter production time, and enhanced component design.

Technologies at the Dresden branch

Electron beam melting (EBM) is a powder bed based method whereby components are generated layer by layer by melting a powder with an electron beam. Besides the beam source, the process differs from other additive manufacturing methods in the following ways:

- The powder bed is held at elevated temperature during the layer formation process. The sintering of the powder particles provides a supporting effect in the powder bed and prevents the formation of powder dust by the electron beam.
- The process operates under high vacuum. The level of contamination in the process is hence very low, meaning very reactive materials can be processed.

In 3D screen printing the component is built up by a paste which contains metal powder via a screen printing process. Special features of the technology are as follows:

- The use of a paste means that all materials that are available as a powder can be employed.
- The use of fine powders enables high-quality surfaces and fine structures to be realized.
- The use of the industrially established screen printing process enables problem-free mass production of components.

Opportunities, market potential, perspectives

Additive manufacturing methods can potentially lead to completely new production chains and products. For metallic components, powder based methods allow much greater freedom of design and the use of a very wide range of materials. Fraunhofer IFAM has state-of-the-art equipment and longstanding know-how of materials and powder metallurgy. This expertise in technology and materials provides an excellent basis for Fraunhofer IFAM to assist with implementation in industrial production.

→ **www.ifam.fraunhofer.de/en/additive**

1 *Design prototype for EBM made of Ti-6Al-4V (CAD template: University of Duisburg-Essen, Department of Production Technology).*

2 *3D screen printed structure (prototype).*

RECYCLING OF RARE EARTH MAGNETS AND PRODUCTION WASTE

The imposition of export duties by China in 2010 and 2011 for certain raw materials made lowering the need for rare earth imports a key economic goal of the German government. The three main ways of achieving this goal are exploiting own primary deposits, reducing or substituting the use of certain rare earth elements, and recovering rare earths via recycling.

Although neodymium, praseodymium, and dysprosium are the most industrially important rare earths due to their use for the manufacture of high-performance NdFeB magnets, there has been insufficient emphasis up until now on recycling these elements. Indeed, there are very few approaches for processing old magnets and magnetic waste that allow effective separation of the rare earth elements and removal of contaminants (e.g. oxides, organic compounds).

Fraunhofer IFAM in Dresden has developed a hydrometallurgical recycling process for the effective recovery of neodymium, praseodymium, and dysprosium from material mixtures. By exploiting physical relationships and having optimum process control, the principle is to have such a high overall selectivity that there is no need for complex and costly fine separation of rare earths using ion exchangers or liquid-liquid extraction plants. In order to produce new high-quality NdFeB magnets it is, however, essential that samarium, which is present in mixtures of magnetic materials, is removed as well as oxides and organic compounds.

Project work has demonstrated that the required selectivity for recycling magnetic materials on a laboratory scale can be achieved by ensuring suitable physical pre-treatment and pre-separation, plus controlled hydrometallurgical digestion. This recycling method is in the process of being patented.

→ **www.ifam.fraunhofer.de/en/recycling**

1 *End-of-life magnetic material.*

POWDER TECHNOLOGY

1

CORE COMPETENCE POWDER TECHNOLOGY

Powder technology has long been successfully used by industry. Component manufacture using powder technology is unique in allowing the simultaneous customization of material properties and geometry. Powder technology is a core competence of Fraunhofer IFAM. Our expertise here extends from the powder to the product on all matters concerning the materials, shaping, tolerances, process safety, and special requirements.

The basis for powder technology solutions are the starting materials. Required property profiles can be achieved by the mixing of powders. For example, properties such as hardness, toughness, Youngs modulus, wear properties, and thermal expansion can be adapted to requirements. New soft magnetic materials and hard magnetic materials are gaining increasing importance.

A key aspect is knowledge of various shaping and production processes. Shaping and sintering are key processes for component manufacture.

Metal injection molding (MIM) is an example of an established and important shaping process. The experts at Fraunhofer IFAM possess an in-depth understanding of the whole process chain, from the starting powder to feedstock systems and injection molding through to the sintered product. Our range of services includes component development, the production of pilot series, knowledge transfer, and training of production personnel. Also covered are shaping processes for special products such as micro MIM, two component MIM, and extrusion.

Fraunhofer IFAM also has comprehensive expertise in additive manufacturing, where products are made from metal powders without molds being required and are manufactured in virtually any desired shape from 3D CAD data. This method is now not only being used for rapid product development but increasingly also for the production of high-quality, individualized products for end-users.

Functional printing is used to add functions to components. Various powder-based printing technologies therefore also form part of our expertise in powder technology. The methods are being transferred to an industrial scale using a specially designed production line.

Supporting technologies are also important. These include the simulation of shaping processes, as for topology optimization, as well as analytical technologies for powder characterization and rheology.

→ **www.ifam.fraunhofer.de/powdertechnology**

1 *Calibration tool produced by additive manufacturing (SLM) with internal vacuum and cooling channels.*

PRODUCTION LINE FOR PRINTED FUNCTIONAL COMPONENTS READY FOR USE

In autumn 2013, Fraunhofer IFAM in Bremen commissioned a robot-based production line with various printing technologies. The excellent design brings together screen printing, ink jet, aerosol jet, and dispensing modules in a single production unit. This allows 2D and 3D surfaces to be simultaneously functionalized to meet a very wide range of requirements.

From a production perspective, the integration of complex functional structures into a component via multilayer formation using an existing process chain is very important. The printed structures here have functionalities such as sensors, passive and active electrical components, as well as energy generators and energy storage systems. The new production line with a central robot unit and surrounding component feed, heat treatment oven, and processing and production modules enables flat and 3D components to be functionalized with multilayered printed electronics, simulating series production. The robot system automatically feeds the individual units with the components to be functionalized. The various printing technologies mean that a wide range of materials and processes can be combined in order to meet customer requirements.

The production line allows not only technological aspects but also production-related issues such as reproducibility and economic viability to be evaluated. The production line thus supports the work of Fraunhofer IFAM in application-oriented powder technology and surface technology.

→ **www.ifam.fraunhofer.de/en/fs**

DEGRADABLE, LOAD-BEARING IMPLANTS – NEW MATERIALS FOR PEOPLE

Better implants improve the quality of people's lives. In order to avoid the need for operations to remove implants after the healing process is complete, which are an ordeal for patients and costly for the health system, there is a growing interest in degradable implants.

Against this background, the Fraunhofer funded "DegraLast" project builds a material and technology platform for manufacturing innovative load-bearing bone implants. Materials with customized mechanical properties and degradation behavior are being developed for use in orthopedics and traumatology. The main challenge here is to ensure the mechanical stability of the total system of implant and bone during the whole period of implant degradation and bone healing. To meet this challenge, the project group is developing innovative composite materials based on biodegradable metals and bioceramics.

Modern additive manufacturing and molding methods are being used to manufacture the implants. In order to ensure that the new materials can be used for implants, biological tests are simultaneously being carried out to measure the osseointegration and the degradation of the implant material at cell level in physiological media. In addition, monitoring systems based on optoacoustic imaging are being developed for later clinical use in order to follow the degradation of the implant and healing of the bone.

→ **www.ifam.fraunhofer.de/compositematerials**

1 *Production line at Fraunhofer IFAM integrates screen printing, ink jet, and dispensing technologies.*

2 *Porous disc and dense trauma implant made of biodegradable iron-TCP composite.*

ADDITIVE MANUFACTURING ON THE RISE – FRAUNHOFER IFAM PROVIDES UNBIASED ADVICE AND CUSTOMIZED TRAINING

Additive manufacturing (AM), rapid prototyping, 3D printing, solid freeform fabrication, rapid manufacturing, and fabbing – these terms describe a group of mold-free manufacturing methods in which the work piece is generated layer by layer from a three-dimensional digital model by adding or solidifying the material. There is industry-wide interest in these technologies because they allow highly customized components to be manufactured.

Fraunhofer IFAM has in-depth experience with additive manufacturing methods. Customer-specific training seminars are offered which give an overview of production methods, latest technologies, and current research work.

The seminars highlight the uses of additive manufacturing with the help of practical examples, they describe process limits with regard to the materials – metals, plastics, and ceramics –, building volumes, and surfaces, they provide information about guidelines and standards and offer unbiased advice about equipment suppliers. Depending on customer requirements, the seminars can, for example, cover the integration of AM into existing process chains, the combination of AM with other established production methods, designing for AM, and the quality assurance of powders for metal-based methods. The suitability of components for AM can be evaluated in special workshops. The training seminars and workshops are tailored to customer needs with regards to their scope, content, number of participants, and venue.

→ **www.ifam.fraunhofer.de/additive**

MERGING OPPOSING PROPERTIES: ABRASION RESISTANT YET WELDABLE

A great number of components in machines, cars, and aircrafts must be able to be welded and must also be abrasion resistant. Weldable metal alloys such as stainless steel 316L have a relatively low surface hardness with poor abrasion resistance. In collaboration with Schunk Sintermetalltechnik GmbH, Fraunhofer IFAM has used 2-component metal injection molding – so-called 2C-MIM – to combine these two very opposing material properties in a component.

This enables, for example, components to be manufactured with a local abrasion-resistant side, corner, or surface of either a CoCr alloy or tungsten carbide containing composite material. The materials are joined during the shaping, meaning that additional costly joining or coating steps can be avoided. The adhesion strength of the composite was demonstrated in tensile tests to be similar to the strength of stainless steel. The technical challenge is to modify the powder materials such that both shrink equally and without cracking in the subsequent oven process. Further case studies have already shown that powder materials with various opposing properties can be joined, for example non-magnetic/soft magnetic, ductile/brittle, and high thermal conductivity/low thermal conductivity. The process can be highly automated, so allowing series production of functional components.

→ **www.ifam.fraunhofer.de/mim**

3 *Airfoil designed at Fraunhofer IFAM and produced by additive manufacturing.*

4 *Tensile bars made of CoCr and stainless steel 316L.*

1

CORE COMPETENCE CASTING TECHNOLOGY

Casting technology has many established applications in a range of industries. Fraunhofer IFAM supports industrial customers in the area of casting technology, from the initial idea to the final product. A variety of casting processes and materials are used for different applications.

Fraunhofer IFAM has built up in-depth know-how and has an extensive range of facilities for die casting, investment casting, and lost foam casting, the three most important casting methods.

Die casting is the most productive of the three methods and today still has enormous potential for enhancing value creation. Key current research areas include lost (salt) cores, cast structural components, and hybrid joining of FRPs with casting materials, in particular CFRP and aluminum.

Investment casting is useful for complex and delicate structures with fine surfaces. Here, a wax model of desired geometry is prepared, embedded in molding material, and then heated. The resulting hollow space is then filled with melt in the investment casting plant.

Lost foam technology is used for casting large and small parts of high complexity directly as near net shaped parts. The method allows uniquely complex components to be manufactured with any design of channels and undercuts – without demolding grooves or burrs. Fraunhofer IFAM is a leader in lost foam technology and works closely with industry via the group of Lost Foam Council e. V..

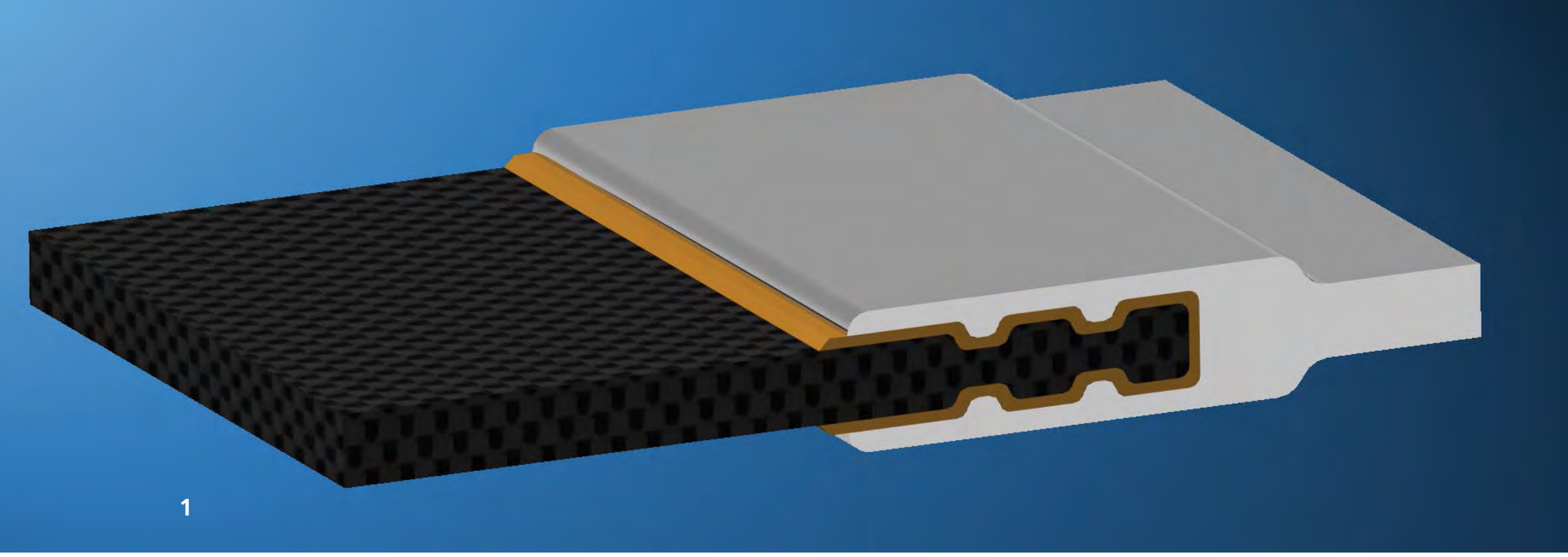
The casting materials used include aluminum, magnesium, zinc, copper, steel, and customer-specific special alloys. In addition, special materials such as metal-matrix composites are developed and improved, opening up new applications for casting and cast components.

The function-integrated cast components being developed at Fraunhofer IFAM are a growing area of work. The integration of electronic components involves function-integration during the casting process. CASTTRONICS® technology allows advanced electronic, sensor, and actuator functionalization of cast components, for example RFID component identification and sensors for load detection. Numerical simulation of casting processes and extensive analytical facilities are also available at Fraunhofer IFAM.

Furthermore, there is the unique opportunity for customers to also benefit from the expertise of other related research groups at Fraunhofer IFAM, for example in the area of corrosion protection, surface coatings, and adhesive bonding.

→ **www.ifam.fraunhofer.de/castingtechnology**

1 *Foamed polystyrene model in cross-section and cast salt core with inner channels and undercuts, manufactured using lost foam casting.*



"CARBONAL" – JOINING CFRP AND ALUMINUM USING CASTING TECHNOLOGY FOR LIGHTWEIGHT STRUCTURES

In a project funded by the German Research Foundation (DFG) entitled "CFRP-aluminum transition structures for lightweight construction", a novel joining technology is being developed for joining CFRP and aluminum using casting technology. The aim is to develop a series production process, whilst simultaneously preventing electrochemical corrosion between the CFRP and aluminum.

Lightweight design of structures increasingly requires the use of combinations of materials

Lightweight design has advantages. Fiber composites come into their own wherever low weight and load-bearing functionality are required. However, metals are also sometimes required. One method that unites the best properties of different materials is the so-called hybrid construction which allows, for example, the properties of CFRP and aluminum to be combined.

New technological approach

The novel CARBONAL process enables metallic transition members to be cast to conventional CFRP elements. These transition members enable easy joining with other metal components. Fraunhofer IFAM is currently developing new approaches for creating different joints via die casting. The transition member between the aluminum and CFRP has lower weight and requires less space than conventional joining techniques.

The transition member leads to electrochemical decoupling of the materials and so prevents corrosion of the aluminum-CFRP composite. The special benefit of these transition members, which are made of heat-resistant glass or ceramic fibers or protective polymer layers, is a facile and direct integration into the aluminum components using casting technology.

This novel hybrid casting-joining technology is termed CARBONAL and is being developed by the Casting Technology competence field at Fraunhofer IFAM. This work is being assisted by the Plasma Technology and Surfaces PLATO department at Fraunhofer IFAM. This group is studying surface modification of the transition members to improve the mechanical and anti-corrosion properties of the joints.

Potential applications

This technology has potential applications in the car manufacturing industry and for recreational products and robotics, to name just a few areas. The novel CARBONAL process enables metallic transition members to be cast to conventional CFRP elements. These transition members in turn enable easy joining with other metal components. Problematic bonding or mechanical joining processes between the metal and FRP are hence no longer an issue. If there is damage to the FRP component, the metallic joints can be easily detached and the FRP component easily replaced.

1 *Infiltration of CFRP with aluminum melt.*

CASTTRONICS® – CONTACTLESS AND ROBUST CASTING IDENTIFICATION

Established RFID technology enables electronic, contactless, and smart identification of products and components (RFID = Radio Frequency Identification) and is the logical advancement of previous identification methods. The RFID transponder has a globally unique serial number and can be supplemented with a customer-specific code in order to guarantee unambiguous identification. RFID works by radio, requires no visible contact, is reliable, and hence offers advantages for industrial applications:

- Electronic coding without optical markings
- Simultaneous identification of several cast components possible
- Resistant to rough industrial environments, contamination, and damage to the cast component surface
- Greater reliability of data integrity and reading rate
- Encryption of data possible
- Protection for cast components against plagiarism
- VDA-compliant code

The RFID transponder can be applied to already produced cast components on their surface or can be mechanically integrated into these. The patented CASTTRONICS® technology also offers the option of casting the RFID transponder directly into the component during the casting process. For the latter, the transponder is protected by a special high-temperature resistant capsule from damage by the aluminum melt.

Total traceability of cast components

The cast component is uniquely labeled from the moment it is removed from the mold. Counterfeiting is also no longer possible. If there is damage, loss, or manipulation – the code of the casting stays protected with CASTTRONICS® technology. In contrast to visual identification methods, components with integrated transponders can still be unambiguously identified even after a surface treatment, e. g. because of varnishing, shot blasting or contamination.

VDA recommendation for RFID identification of components

The foundations for the future are already being put down today. The VDA recommends RFID for the identification of components and products, including for the traceability of car parts and identification of their technical design (VDA 5005), for monitoring components in car development processes (VDA 5509), and for monitoring components and assemblies in the car industry (VDA 5510). In addition to standardization in accordance with the VDA, the electronic product code EPC is an international key and code system under GS1 for unique global identification of products.

Fraunhofer IFAM is supporting the casting industry with its forward-looking, timely work on RFID technology. If just a few centimeters of reading range suffice, the system frequency of 125 kHz (LF) that has prevailed up until now for metals is used. The use of 868 MHz (UHF) represents the next technological step. This increases the reading range to up to a meter for cast components with integrated RFID transponders.

2 *Stationary RFID reading system for identification of cast components in a fully automatic production and assembly line.*

1

CORE COMPETENCE ADHESIVE BONDING TECHNOLOGY

Adhesive bonding refers to a manufacturing method, belonging to the group of joint processes, that involves the joining of substrates using an adhesive to form a material-fit joint. Over recent decades, adhesive bonding has become ever more widely used by a host of industries. The Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM realized the potential of adhesive bonding technology at an early stage and developed this as a core competence. Fraunhofer IFAM is internationally recognized in this field and is the largest independent research organization in Europe working in this area.

The core competence adhesive bonding technology at Fraunhofer IFAM involves development and characterization of materials, development and usage of various application techniques, design and validation of structures, as well as in-depth quality assurance.

The institute has a wealth of experience regarding the modification of polymer systems as well as the development of adhesives and sealants. Challenges such as adhesion promotion and protection against aging form part of the portfolio as do the development and use of biomimetic adhesives. For characterizing adhesives and bonded joints a wide spectrum of chemical, physical, and mechanical test methods is utilized. The aging behavior and service life of bonded joints are often key aspects.

The integration of adhesive bonding technology into industrial production requires an application method adapted to the specific utilization. To achieve high-quality bonded joints it is often necessary to pre-treat the substrate surfaces. The substrates are cleaned and activated or modified to enable the adhesives to adhere to the substrates with good long-term stability. Process automation, including tolerance-specific production methods, is important in many industries. Also important are the design of bonded joints and the dimensioning of bonded structures. This is based on experimental parameters for materials, joints, and components determined in an accredited test laboratory, taking into account the specific boundary conditions of the application.

The institute provides consultancy on all matters relating to adhesive bonding technology. Optical methods, in-line analyses, and a wide variety of destructive and non-destructive test methods are used for quality assurance purposes. An established and comprehensive portfolio of training courses in adhesive bonding technology is also offered. The certificates of the courses which are given worldwide are accredited and recognized in all of Europe. These courses are a further key aspect of the quality assurance concept for adhesive bonding technology.

Fraunhofer IFAM also acts as a Certification Body of the Federal Railway Authority for auditing and approving companies that carry out or subcontract adhesive bonding work, sell bonded products, or offer services regarding the designing and dimensioning of bonded components for rail vehicle construction.

→ **www.ifam.fraunhofer.de/adhesivebonding**

1 *Differential scanning calorimetry (DSC) for measuring polymer properties such as the glass transition temperature and heat capacity.*


1


2

ADHESIVE BONDING FOR STEEL STRUCTURES

Hollow sections are widely used to build steel structures due to their constructional and design advantages. The individual components are generally welded to each other. Under dynamic stress, the inner root regions of welded joints that are difficult to observe are, however, the starting point for fatigue cracks. A research project is investigating if bonded joints are a viable alternative to welds.

In many industries, adhesive bonding is replacing traditional, mostly mechanical joining methods, such as rivets, bolts, and welds. Adhesive bonding is already well established in the car and aircraft manufacturing industries. Bonded joints transfer forces across the entire bonding area, meaning lower stress peaks compared to point-form or line-form joints. The stiffness of the substrates and mechanical properties of the adhesive determine how the stress varies across the bonded joint.

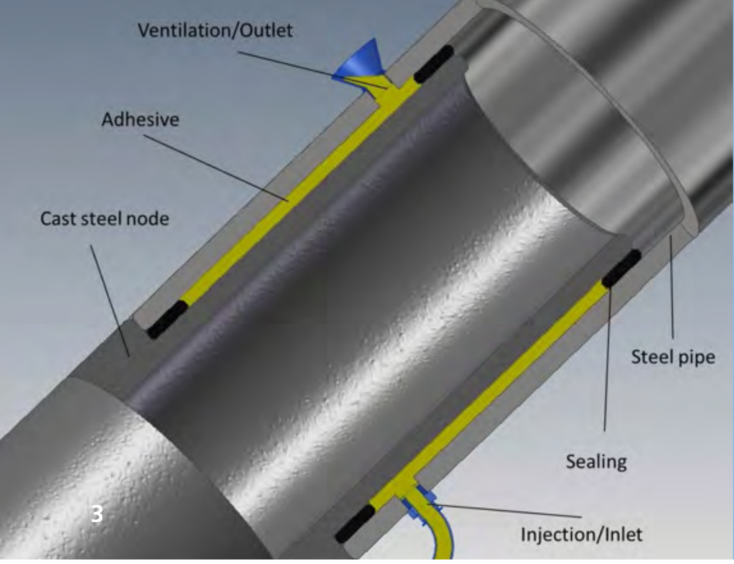
Hollow sections and tubular elements are used as load-bearing structures for bridges, high-rise buildings, cranes, and wind turbines. Under fatigue stress, the welded nodes of hollow sections develop fatigue cracks due to the notch effect of the weld seam. Even for cast steel nodes, where the weld seams are outside the highly stressed fusion areas, tests show that fatigue cracks start from the weld root. The cracks are first seen after penetration through the wall thickness.

The use of adhesive bonding for major steelwork structures has up until now not been standard practice. The first question that needs answering is whether the high forces in major steelwork structures can be borne by bonded joints. Whereas welding involves welding the pipe ends, the bonded joints between the steel pipes and cast steel nodes are realized as lap joints in the length direction. Studies show that the typical shear stresses encountered for selected and analyzed applications for steel structures can be borne by a suitable adhesive for a long period of time provided there is sufficient overlap of the substrates. The overlap lengths here are of the order of magnitude of the pipe diameter. Although this provides a technical starting point for using adhesives to join high-duty steelwork structures, other challenges must still be overcome.

The permissible size variation of the steel pipe and cast steel node prescribed by standards means that, depending on the pipe size, the gap thickness can vary by several millimeters. Hence it must be assumed that the gap is large – which for stiff, force-transmitting bonded joints is unusual.

Surface pre-treatment of the substrates is essential prior to adhesive bonding. A number of studies using XPS and other techniques have tested the suitability of cast steel surfaces for adhesive bonding. This is ensured after grit blasting with corundum. Furthermore, the long-term stability of the bonded joints must be guaranteed by applying a corrosion protection coating. It must be ensured that the coating is an element of the force transfer chain. Tests have shown that epoxy-based powder coatings meet the strength and resistance requirements.

Selecting a suitable adhesive is a complex matter because many factors have to be considered. The structural design requirements mean that the adhesive must have a certain minimum stiffness. Standards specify adhesives having a high glass transition temperature, ideally above 80 °C. The adhesive must be injected into the cylindrical gap between the cast steel node and steel pipe. Low viscosity adhesives are required for this.



After inlet into the gap at room temperature, the adhesive must have sufficient strength, after a day, for further assembly to be possible. Curing of the adhesive at high temperature would not be desirable and for this reason a 2-component adhesive is required. In order to minimize intrinsic stress during the curing, the shrinkage of the adhesive on curing must be as low as possible. Continuous stress on the bonded joints must lead to minimum deformation due to creep, so low-creep adhesives are required. Following preselection, the different adhesives had to be tested and evaluated as pure adhesive specimens, lap shear specimens, pipe specimens, etc.. This enabled two adhesives to be identified that met all the requirements.

Taking account of the boundary conditions for high-duty steel structures, a production concept was drawn up and implemented for a specimen structure and adhesive. The joining device allows semi-automatic centering of the pipes and secure holding. The adhesive is injected into the cylindrical gap that forms on assembly. Unusual for a structural bonded joint is that almost a liter of adhesive had to be injected due to the wide gap. The production concept comprises eight steps: Assembly of the joining device at the node, cleaning of the bonding area on the node, application of sealing tape, positioning the pipe using the centering device, adhesive preparation and mixing, inserting the adhesive container and closing the pressure vessel, adhesive inlet, closing the inflow.

Outlook

The objective of the project is to develop bonded joints suitable for connecting hollow sections on cranes, bridges and wind turbines. The use of adhesives considerably expands the range of design options. Intelligently designed multifunctional components have the potential to radically change joining technology in the construction industry. In addition, the facile joining of different materials using adhesives and the resulting innovative design opportunities should also benefit architects.

Funding

Federal Ministry of Economics and Technology (BMWi) under the program for funding joint industrial R&D

Partners

- Forschungsvereinigung Stahlanwendung e. V. (FOSTA)
- Karlsruhe Institute of Technology
- Munich University of Applied Sciences

→ **www.ifam.fraunhofer.de/abt**

1 *Joint between a steel pipe and cast steel node in building construction: Terminal building at Stuttgart Airport.*
2 *Detailed view of a welded joint between a steel pipe and cast steel node.*
3 *Production concept for bonding pipes.*
4 *Positioning the device to create the bonded joint.*

SURFACE TECHNOLOGY

CORE COMPETENCE SURFACE TECHNOLOGY

New materials often drive innovation and end up in key technologies of everyday life. The industrial range of uses of many materials can be considerably expanded by customized modification of their surfaces. The Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM has long-standing and in-depth expertise in surface technology, acquired in projects with partners from a range of industries and involving many innovative products and processes.

In general, materials are designed to meet predefined property requirements, such as strength, elasticity, and heat resistance, or to meet the requirements of a production process. If components have to suit certain additional needs, this is often only possible using special surface technologies. Intelligent surface technologies such as pre-treatments and coatings are able to improve the properties of materials and components or provide them with additional functions.

The expertise of Fraunhofer IFAM covers the whole process chain of surface technology from materials' development to the characterization and evaluation of surfaces, their functionalization and modification, and on to various application methods. The development of processes – such as dry and wet chemical pre-treatment, coating processes, printing processes, as well as thin/thick film technologies – and also quality assurance are key areas of the work. The characterization and evaluation of surfaces using chemical, electrochemical, and structural analysis is an important aspect of the institute's work, as is the application of various simulation methods.

The experts at Fraunhofer IFAM have comprehensive knowledge of customized surface modification and functionalization. This includes the cleaning as well as the activation of surfaces and suitable pre-treatment prior to coating or bonding. The functional attributes of surfaces are very varied and depend on the respective application. Surfaces can be customized with low-drag, anti-icing, dirt-repellent, anti-fouling, antibacterial, and biocompatible properties. Specific tribological or optical requirements as well as sensor functions can also be provided. In addition, a very wide spectrum of application methods can be used, ranging from the laboratory scale to pilot plants as far as upscaling for (large) series production.

Quality assurance is an important aspect of surface technology. In-line quality assurance concepts and test methods, which allow constant process monitoring, are developed at Fraunhofer IFAM. The institute possesses accredited test facilities, which are also utilized for failure analysis. Finally, special training courses are given and there is a regular transfer of surface technologies to industrial practice.

→ **www.ifam.fraunhofer.de/surfaces**

1 *The nanostructuring of the coating, visible as a hologram, is used for product and brand protection.*

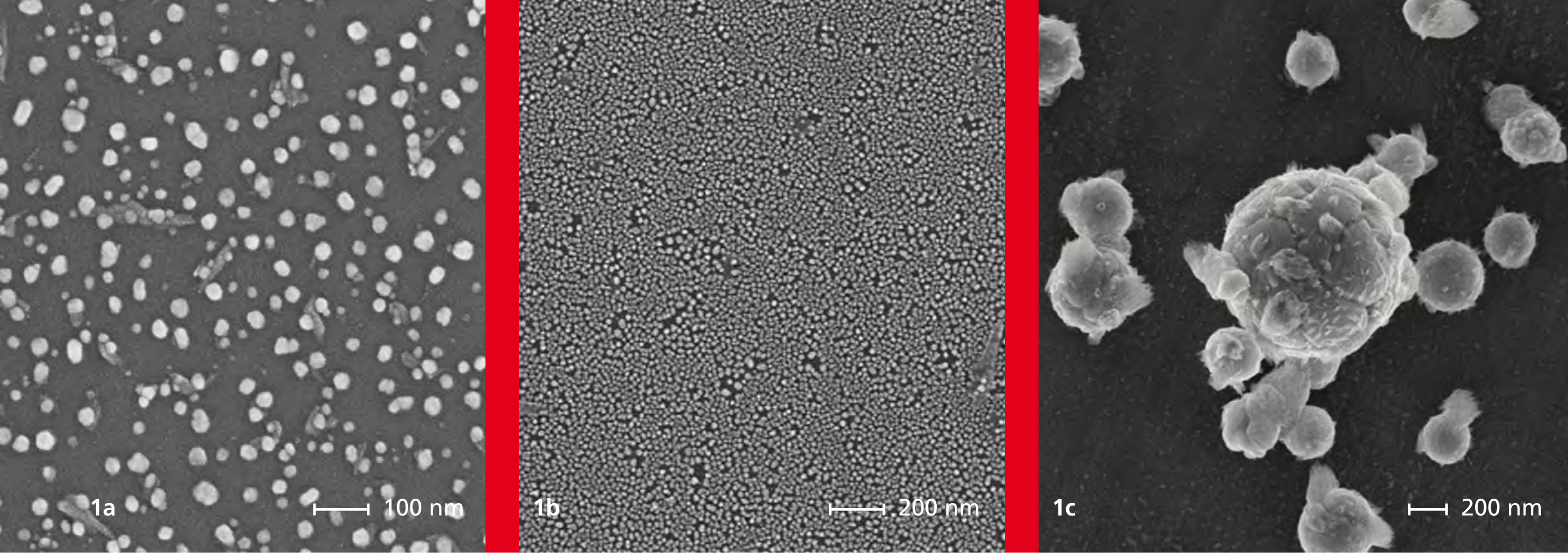
AP PLASMA OFFERS INNOVATIVE METHODS FOR APPLYING THIN NANOCOMPOSITE LAYERS

The Plasma Technology and Surfaces PLATO department at the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM has developed a new, innovative method for the generation and functionalization of metallic nanoparticles and for the deposition of thin, functional nanocomposite layers using atmospheric pressure plasma (AP plasma). This work has been ongoing since mid 2011 in a close collaboration with Plasmatreat GmbH as part of a joint project funded by the Federal Ministry of Education and Research (BMBF).

Despite their small size, nanoparticles are currently playing an ever more important role in modern life. They are widely used, for example, in paints and polymer technology in the cosmetics and medical technology sectors. Besides the use of nanoparticles as additives, they can also be incorporated into polymer matrices and be deposited as nanocomposite layers. This allows a variety of surfaces to be given innovative functional features such as anti-bacterial or anti-fouling properties.

However, the manufacture, processing, and modification of nanoparticles are technologically challenging. Thus, wet chemical methods are often applied to produce metallic nanoparticles by chemical precipitation. These processes generally consist of several steps and involve a high consumption of hazardous media. Disposal of these media is as a rule complex and costly. Otherwise, metallic nanoparticles can also be produced using low pressure plasma processes. Here, the particles are generated by either a physical vapor deposition (PVD) or chemical vapor deposition (CVD) and can subsequently be deposited on substrates as thin layers. Since these processes operate at low pressures, there are relatively high costs for generating the vacuum in the process chamber. Also, the cycle times in production are relatively long. Furthermore, there are limitations regarding the size and geometry of the treated components, which restricts the industrial use of these processes significantly.

The collaborative APASI project "Development of atmospheric pressure plasma technology to deposit functional nanocomposite layers" was being carried out to address these shortcomings. It aimed to determine the suitability of pulsed, arc-like discharges at atmospheric pressure (Openair® plasma systems) for generating metallic nanoparticles, their simultaneous coating in the gas phase, and the possible deposition of thin metal-polymer nanocomposite layers. For this purpose, a special nozzle head system was designed and manufactured, which allows a controlled feeding of metallic wire electrodes (e.g. made of silver, gold, or copper) directly into the plasma volume. The pulsed arc-like discharge channels induced in the plasma are directly drawn at the electrode surface and initiate particle-forming sputter processes. The project team has succeeded in producing almost spherical metallic particles of nanoscale diameter (Fig. 1a + b). Furthermore, it was found that the size of the particles is highly dependent on the power density of the pulsed discharge channels on the metal electrodes. Hence, a customized variation of the process parame-



ters allows also submicron range particles to be produced (Fig. 1c).

Feeding a film-forming precursor into the plasma enables a direct functionalization of the nanoparticles after their generation. This was the basis for the development of a coating process in which the metal nanoparticles were incorporated into an organosilicon, plasma-polymer matrix and successfully deposited as nanocomposite layers.

The composition, morphology, and functional properties of the resulting layers were characterized in detail. For example, the inductive heating of the deposited nanocomposite layers was demonstrated. Here, the incorporated metal nanoparticles absorb the microwave energy leading to heating of the substrate surface.

The anti-bacterial properties of the nanocomposite layers were also evaluated. It was shown that the layers are effective not only against Escherichia coli bacteria, which are typically used for such tests, but also against much more resistant strains of bacteria such as Methylobacterium extorquens and Pseudomonas fluorescens. This makes the developed nanocomposite coatings highly promising for heat-exchangers and ventilation as well as air-conditioning systems.

Summary

The innovative method to produce metallic nanoparticles, developed and studied in the frame of the APASI project, is a favorable-cost and technologically simple alternative to existing wet chemical and vacuum based CVD/PVD techniques. The advantages of atmospheric pressure plasma technology, such as low space requirements, low process costs, easy integration into existing process chains, in-line capability, and localized as-needed coating, open up an array of opportunities for surface functionalization.

Acknowledgment

The aforementioned work was undertaken within the framework of the APASI project "Development of atmospheric pressure plasma technology to deposit functional nanocomposite layers". This was funded by the Federal Ministry of Education and Research (Funding program: KMU-innovativ: Nanotechnologie (NanoChance); Project term: April 1, 2011 to July 31, 2013).

Project partner

- Plasmatreat GmbH, Dr. Alexander Knospe

Industrial partners

- MAHLE Behr GmbH & Co. KG, Dr. Oliver Mamber
- Siemens AG, Dr. Florian Eder

→ **www.ifam.fraunhofer.de/en/adplasma**

1a–c *Scanning electron micrographs of nanoparticles generated using atmospheric pressure plasma: (a) silver, (b) gold, (c) silver.*

FIBER REINFORCED COMPOSITES

1

CORE COMPETENCE FIBER REINFORCED COMPOSITES

Fiber reinforced plastics (FRPs) refer to materials that consist of a matrix with embedded fibers. Thermosets are used as matrix materials at the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM. The advantages of FRPs are their high stiffness in the direction of the fibers combined with the ability of the matrix to be shaped. These advantages, along with their low specific weight, mean FRPs are ideal for lightweight components such as those used for aircraft and car manufacture.

In all areas of transport – cars, rail vehicles, ships, and aircraft – new materials and lightweight design are resulting in lower fuel consumption, reduced CO_2 emissions, and hence resource friendly and environmentally friendly mobility. In the area of renewable energy, and in particular wind energy, FRPs are opening up energy-efficient construction methods and are improving the profitability of wind turbines. Lightweight design at Fraunhofer IFAM is particulary concerned with fiber reinforced plastics containing glass, carbon, and natural fibers. The expertise ranges from resin development, design, component manufacture, and surface modification to automated assembly as well as joining technologies.

The first task is the selection or development of suitable resin systems to meet the specific requirements of the manufacturing process such as low curing shrinkage and rapid curing. Challenges such as electrical conductivity, lightening protection, and impact resistance are also addressed. Only by customization of the interfacial properties between the fibers and matrix resin can an optimal material system be used. This is achieved using a range of surface techniques, including plasma treatment of fiber surfaces. Surface modification is also vital for the manufacture and further processing of the components. Techniques worthy of mention at this juncture are cleaning, activation, coating, and the application of functional layers.

The growing industrial use of FRPs necessitates increased automation of assembly and joining technologies – this is a further field of expertise of Fraunhofer IFAM. With the help of optical measurement techniques, shape and positional adjustments can be made to both small and large components to enable precision machining using robots.

Quality assurance is an absolute must in all phases – namely during the manufacture, assembly, and repair of FRP components. This is aided by Fraunhofer IFAM's comprehensive range of training courses. The training courses are a means of technology transfer, whereby technological findings and methods are passed on to industry.

→ **www.ifam.fraunhofer.de/frp**

1 *CFRP-AFMO development platform.*

1

BUILDING A STRONG FUTURE – IMPROVED FRP TRAINING COURSES AT OUR NEW PREMISES

New premises bring many advantages

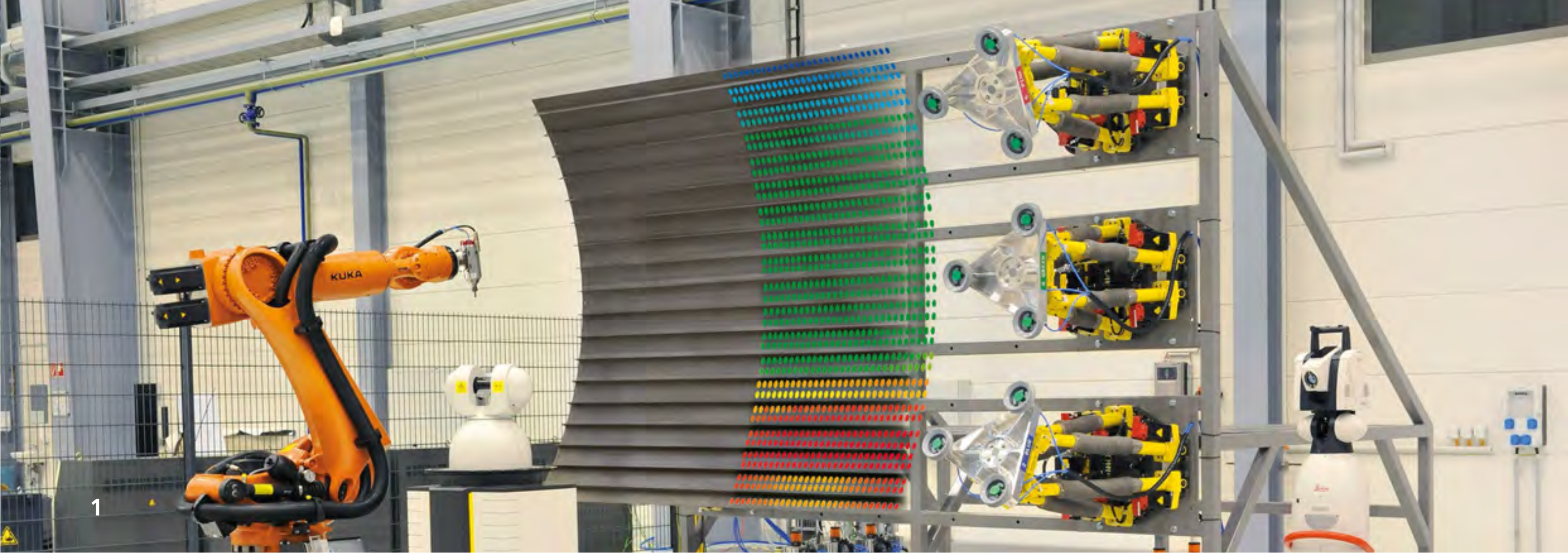
The Plastics Competence Center of Fraunhofer IFAM moved to new premises in the spring of 2013. The new premises are more spacious, more centrally located, and more modern than the old facilities. The Plastics Competence Center has offered certified workforce training courses in fiber reinforced plastics since 2007. The new Plastic Competence Center is in the direct vicinity of Bremen Technology Park, near Fraunhofer IFAM. The official opening on June 17, 2013 gave representatives of companies that use fiber reinforced plastics the opportunity to see the new facilities and learn about the training courses.
With an area of over 900 square meters for the workshop, classrooms, and offices, the new building is ideal for providing training courses in fiber reinforced plastic technology. The workshop and classrooms have state-of-the-art equipment and are suitable for courses with up to 24 participants. The layout of the rooms has been specifically designed for the training courses. There are various restaurants and hotels close-by to cater for the needs of course participants.

Expanded range of training courses

The range of training courses at the Plastics Competence Center has also been expanded. The content and length of the courses are now even better adapted to the needs of the participants and requirements of lightweight construction. Fiber reinforced plastics are becoming ever more important for lightweight construction and practical know-how in this area is vital. Trained personnel are essential in order to be able to fully utilize the potential of fiber reinforced plastics. The focus of the training courses is on how to manufacture high-quality fiber reinforced plastics and how to carry out repairs. The course participants learn how the raw materials influence the resulting properties of components, learn about the different manufacturing methods, and learn about the required boundary conditions of manufacturing processes. The various courses provide information about laminate structure and component geometry and highlight the special features of these materials. Each course contains in-depth practical sessions to consolidate the theoretical knowledge. This develops a familiarity with FRPs and allows sources of defects not only to be identified at an early stage but to be avoided in advance.

→ **www.bremen-plastics.com**

1 *Manufacturing an FRP component by hand lay-up.*



SUCCESSFUL EVALUATION OF THE FRAUNHOFER PROJECT GROUP FFM

On August 29, 2013, about five years after being founded, the Fraunhofer Project Group Joining and Assembly FFM in Stade was evaluated by representatives of the Executive Board of the Fraunhofer-Gesellschaft along with partners from industry and research organizations and representatives of the State of Lower Saxony. The objective was to evaluate the results achieved since its founding, appraise the strategic perspectives and so come to a decision about furthering the activities in Stade.

The chairman of the evaluation committee was Dr. Georg Rosenfeld, Head of the Research P2 department at the Fraunhofer-Gesellschaft. The minutes were taken by the Fraunhofer IFAM representative, Dr. Helmut Schmidt. Industry was represented by Jens Gralfs, responsible for R&T Overall Physical Design at Airbus Operations GmbH, Dr. Stefan Kienzle, Director of Group Research & Sustainability at Daimler AG, Norbert Schulz, Head of Quality Management at Mercedes Works in Bremen, and Ludwig Schleicher, owner of Ludwig Schleicher Anlagenbau GmbH & Co. KG. Prof. Gerhard Ziegmann of the Institute for Polymer Materials and Plastics Technology at TU Clausthal gave the scientific insight. Present at the evaluation for the State of Lower Saxony, the main funder, were Thomas Kroemer, Section Head: Coordinator of the Maritime Industry and Aviation and Aerospace Industries at the Lower Saxony Ministry for Economic Affairs, Employment, and Transport and Dr. Hans Schröder, Head of Science and Commerce at the Lower Saxony Ministry for Science and Culture.

Following the presentations, discussions, and tour of the site, there was unanimity: The Executive Board of the Fraunhofer-Gesellschaft was recommended, as of January 1, 2014, to make the Fraunhofer Project Group Joining and Assembly FFM a department of Fraunhofer IFAM based in Stade, with future joint funding by the federal and state governments.

It was emphasized that the group offers the complete assembly process, thus distinguishing themselves from their competitors. The expertise comprises joining, processing, and automation technologies, so providing comprehensive R&D services for customers ranging from covering processes and production equipment right through to software. A particular strength of the Fraunhofer Project Group Joining and Assembly FFM is the close collaboration with Fraunhofer IFAM in Bremen and TU Hamburg-Harburg. Innovative bonding processes are developed in collaboration with Fraunhofer IFAM while the expertise in processing technology of Prof. Wolfgang Hintze of the Institute of Production Management and Technology (IPMT) and that of Dr. habil. Jörg Wollnack in robotics and optical measuring technology are utilized in joint projects. This combined know-how has enabled FFM to successfully secure major projects at an early stage and to provide own finance. The evaluators encouraged the project group to continue along the same path in order to identify the common technological needs of the aircraft and car manufacturing industries and to develop generally applicable solutions.

Following the recommendation of the Evaluation Committee, the Executive Board of the Fraunhofer-Gesellschaft made a decision on November 29, 2013 to continue the Fraunhofer Project Group FFM as the Automation and Production Technology department of Fraunhofer IFAM in Stade.

→ **www.ifam.fraunhofer.de/en/Stade**

1 *CFRP-AFMO development platform.*

ELECTRICAL COMPONENTS AND SYSTEMS

CORE COMPETENCE ELECTRICAL COMPONENTS AND SYSTEMS

The core competence "Electrical components and systems" is a relatively new area for Fraunhofer IFAM. Our expertise in this area has significantly expanded over recent years and we collaborate closely with other areas of expertise at the institute.

Fraunhofer IFAM adopts a system research approach in this area, whereby individual technologies and components are always considered and developed in relation to the whole system, for example an electric car.

At a component level, the scientists are developing novel metal-air batteries for, in particular, the synthesis and processing of new active materials. In addition, thermochemical energy storage systems are being developed based on innovative hydrogenatable metal alloys. Electrical drive technology is focusing on the development, control, assembly, and testing of electrical machines, in particular for drive applications. Adhesive bonding technology, surface technology, and coatings extend the expertise for matters such as the joining, contacting, insulation, and protection of electrically conducing materials.

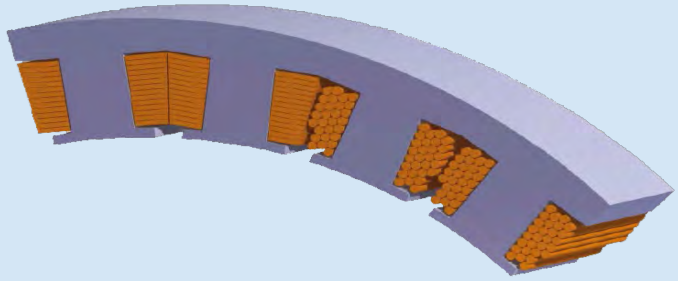
As many electrical components are being developed for cars, an understanding of systems for electric cars and electromobility is vital. Our know-how in this area includes the design, efficient control, assembly, and testing of vehicles, concept vehicles, and their components, especially electric and hybrid drive systems. In order to improve operating reliability, individual components such as the electric drive train are being qualified by "hardware in the loop" simulation of operating performance on a test stand. Here, experience is utilized from the fleet of electric vehicles being operated in the Electromobility model region Bremen/Oldenburg. We pass on our know-how by giving training courses in electromobility. These courses specifically target customers in Germany and China.
An example of the multidisciplinary approach at Fraunhofer IFAM is the cast coil. This innovative product, which was originally developed at Fraunhofer IFAM, involves expertise in casting technology and electric drive technology plus the development of special insulating coatings.

The incorporation of the former Bremer Energie Institut into Fraunhofer IFAM as the new Energy Systems Analysis department represents a logical expansion of the Electrical Components and Systems core competence. The matter of charging infrastructure for electromobility shows, by way of example, that not only technical challenges but also economic and regulatory boundary conditions must be taken into account.

→ **www.ifam.fraunhofer.de/ecs**

1 *Prototypes comparing a wound coil, a rapid prototyping model, and three cast coils.*

1



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AIR-COOLED WHEEL HUB MOTOR WITH HIGH TORQUE DENSITY IS THE OBJECTIVE OF THE FRAUNHOFER SYSTEM RESEARCH FOR ELECTROMOBILITY II PROJECT

Since the start of 2013, sixteen Fraunhofer Institutes, coordinated by Fraunhofer IFAM, have been involved in the "Fraunhofer System Research for Electromobility II – FSEM II" project carrying out innovative research on electromobility. This builds on and expands the expertise and networks of the Fraunhofer Institutes developed during the FSEM I project which started back in 2009.

One aim of the project is to develop innovative technologies and components for hybrid and electric vehicles. This involves three subprojects: "Drive train/Chassis", "Battery and range extender", and "Design and infrastructure".

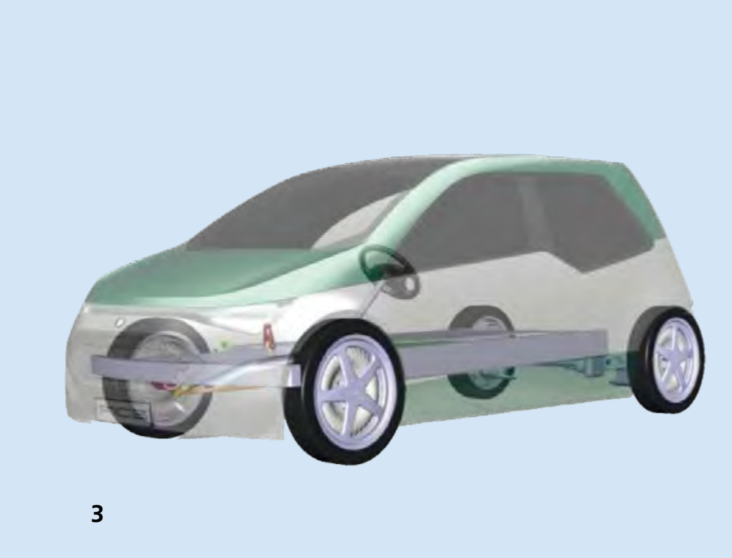
The "Drive train/Chassis" projects involve the development, production, and testing of a robust air-cooled wheel hub motor with high torque density which can be used as a direct drive on all four wheels of a light urban prototype vehicle.

Challenge of air-cooled direct drives

Wheel hub motors offer the opportunity to reduce the cost and energy consumption of electric vehicles by obviating the need for a classical mechanical drive train. This simultaneously increases the space in the vehicle and allows the realization of active driving safety systems via independent torque adjustment on each driven wheel.

Fraunhofer IFAM is hence developing an air-cooled wheel hub motor using innovative manufacturing technology and an alternative electrical drive topology to guarantee both the required high torques and optimal functional safety.

In the case of an air-cooled system, a particular challenge is to comply with the maximum temperatures that are set by the materials and joining technologies that are used. The thermal resistance during the entire transport between the heat source and contact surface with the cold air must be minimized. This is achieved via transient 3D simulation of the local temperature distribution accompanied by experimental determination of selected material and transport parameters.



3

4

Cast winding

By using cast coils, the conductor cross-section can be precisely adapted to the available space. This is therefore maximized and there is optimal thermal connection of the conductor for cooling. This allows considerably better heat dissipation than conventional wire coils. Despite the slightly higher specific resistance of aluminum compared to copper, current densities can be achieved in the air-cooled electrical motors that are comparable with conventional water-cooled motors. This lowers the weight and costs, with simultaneous increase in the torque and power data.

A particular challenge is to develop the insulation coating. Fraunhofer IFAM is developing coatings that are electrically insulating at elevated operating temperatures. At the same time the layer must be as thin and uniform as possible. Wet chemical methods, low pressure plasma processes, and Light$^{PLAS®}$ technology are being used for this.

Safety of the whole system

An innovative electrical drive topology with an inverter based upon H-bridges minimizes the effects of failure due to component failure or a short circuit. In combination with the motor control unit while taking into account functional safety requirements, this provides a drive system which can be reconfigured in the event of failure, meaning this redundancy can compensate any braking torque in the event of failure and so enable further travel, for example to a garage workshop.

Technical data for the motor	
Max. torque	500 Nm
Max. power	20 kW
External radius	220 mm
Length of laminations	40 mm
Mass of active part	14.5 kg

→ **www.elektromobilitaet.fraunhofer.de/en.html**

1 *Air-cooled wheel hub motor with running gear and rim in cross-section.*
2 *Comparison of cast coils and wound coils.*
3 *Concept vehicle with four wheel hub motors.*
4 *Cast coil with insulating coating.*

INDUSTRY-SPECIFIC SOLUTIONS

The R&D work of Fraunhofer IFAM aims to bring innovation to as many industrial sectors as possible. The focus is on the drivers of innovation in the respective industries. The most important industries are defined as individual business segments.

Automotive

The automotive business segment covers manufacturers of road vehicles and their suppliers. Challenges of the automotive sector are high cost pressure, the need for clear product differentiation, and in particular constant improvement of the eco-friendliness of their products. The manufacture and running of road vehicles puts high demands on energy and resource efficiency. Strategies to meet these criteria are lightweight structures and hybrid structures using new materials. Robust, rapid, and eco-friendly processes are vital. In recent years, the electrification and hybridization of the drive train has been a key area.

Aviation

The aviation business segment targets manufacturers of aircraft and helicopters, their suppliers, and their service providers, particularly in Europe. The aircraft industry faces the challenge to further reduce fuel consumption and the emission of harmful substances and noise. Potential solutions are more efficient engines, the use of lightweight structures, and new materials. Continuing cost pressure is also forcing manufacturers to search for solutions to further automate their own manufacturing processes.

Energy and environment

The energy and environment business segment focuses on energy suppliers and manufacturers of environmental technologies (for example solar energy systems and wind turbines) and their components. The generation of energy in the future and its storage and transport are major challenges here. Increasing urbanization raises the matter of centralized versus decentralized energy provision. Improving the efficiency or effectiveness to offset increasing energy costs goes hand in hand with the need to reduce emissions, in particular via increased usage of renewable energy sources. A further key area is energy provision for electromobility.

Life sciences and medical technology

The medical technology area targets manufacturers of implants, instruments, medical adhesives, and wound dressings as well as coating companies. The focus in the life sciences area is on biological surface functionalization and biosensors. The cleaning properties, long-term stability, reliability, and mechanical properties of products are usually subject to strict quality requirements. Comprehensive norms and standards, restrictions for approval, and cost pressure are additional factors. Biocompatibility and biointegration are becoming increasingly important.

PEOPLE AND MOMENTS

DR.-ING. FRANK PETZOLDT APPOINTED HONORARY PROFESSOR AT UNIVERSITY OF APPLIED SCIENCES BREMERHAVEN

The University of Applied Sciences Bremerhaven appointed Dr.-Ing. Frank Petzoldt as an honorary professor on March 21, 2013. The deputy institute director of Fraunhofer IFAM and head of the Powder Technology department is responsible for the "Production-oriented medical technology process chains" teaching module for the Medical Technology course.

Even before his appointment as honorary professor, Frank Petzoldt had helped to shape the medical technology course. His appointment is in recognition of his scientific knowledge and teaching skills as well as his merits of many years.

Beyond his previous lectures on materials technology, Frank Petzoldt will now expand his teaching, in close collaboration with Fraunhofer IFAM, to include detailed practical and theoretical modules for the master's course in Medical Technology, allowing production technologies like additive manufacturing and metal injection molding to be placed in the context of medical applications.

The students will benefit from the strong practical focus and the inclusion of recent developments and new technologies in the course material. They will learn that medical technology products must meet the very highest requirements with regards to their physical and mechanical properties and surface quality. The teaching role of Frank Petzoldt will not only benefit the students, but also Fraunhofer IFAM. This is because an interest in materials research and manufacturing technology will be kindled in the students at an early stage, helping to ensure Fraunhofer IFAM of a stream of young scientific talent.

1 *Prof. Dr. Josef Stockemer presents Dr.-Ing. Frank Petzoldt with his honorary professorship.*

FEDERAL MINISTER JOHANNA WANKA AND BUNDESTAG CANDIDATE OLIVER GRUNDMANN LEARN ABOUT R&D AT CFRP NORTH IN STADE

On September 12, 2013 Prof. Dr. Johanna Wanka, Federal Minister of Education and Research, and Oliver Grundmann, the Stade Bundestag candidate, visited the research center CFRP NORTH. Dr. Dirk Niermann, Head of the Fraunhofer Project Group Joining and Assembly FFM, informed the guests about the already completed and ongoing R&D work and also gave them an insight into future projects on large CFRP structures.

Three major projects were initially undertaken to develop the necessary processes and components and to undertake initial qualification for industrial production: The joint ParAMont/One Step Assembly project developed and constructed a large plant for automated processing of CFRP shells for aircraft fuselages. The ProsihP project developed a research plant for the high-precision milling and drilling of large CFRP components up to 13 m in length using three industrial robots from different manufacturers. The CFRP-AFMO project resulted in a versatile handling system for large, flexible CFRP components which adapts to different geometries. The system uses laser technology to make the components available for automated assembly processes in a highly precise way with force control and optimum shape and position. These projects were funded by the State of Lower Saxony. The One Step Assembly project was also supported under the aviation industry research program of the Federal Ministry of Economics and Technology.

The priority now in Stade is to transfer the technologies that have been developed to the aircraft manufacturing industry. The results will also be transferred to other industries where large FRP structures are used. The issues of weight-saving and low resource usage will in the future be the focus of the R&D work at CFRP NORTH and hence also the Fraunhofer FFM: The Fraunhofer Project Group develops assembly and machining processes for the aircraft manufacturing industry and also the large plants that are required, for example, for the automated series production of XXL structures made of FRPs.

1 *From left to right: Federal Minister Prof. Dr. Johanna Wanka and Bundestag candidate Oliver Grundmann with Dr. Gregor Graßl (Fraunhofer Project Group FFM), Prof. Dr. Axel Herrmann (Chairman of CFK-Valley Stade e.V.), and Dr. Dirk Niermann (Head of Fraunhofer Project Group FFM).*

FARBE UND LACK AWARD 2013 TO ANDREAS STAKE FOR A UV CURED COATING WITH MULTIFUNCTIONAL SURFACE

Andreas Stake won the FARBE UND LACK Award 2013 for his publication entitled "Scratch-resistant UV cured coating with intelligent finish". Dr. Michael Hilt, chairman of the paint chemistry group at the Gesellschaft Deutscher Chemiker e.V. (GDCh), and Dr. Sonja Schulte, chief editor for science and technology for FARBE UND LACK, presented the award on November 7, 2013 at the annual meeting of the Verband der Ingenieure des Lack- und Farbenfaches e.V. (VILF) in Neu-Isenburg. The award is presented for the best publication of the last 12 months by an author younger than 40 years of age. A jury of eight experts from industry and R&D establishments, along with the readership of FARBE UND LACK, decided on the winner.

Working together with researchers in the Paint/Lacquer Technology department, the Plasma Technology and Surfaces PLATO department, and the Leibniz Institute of Polymer Research Dresden e.V., Andreas Stake developed a multifunctional, scratch-resistant, UV cured coating. The unique feature of the layer system is the integration of several and in some cases opposing functions. The development of high-performance coating systems is a prerequisite for increasing the turnover of raw material and coating manufacturers, specialty chemical manufacturers, plant constructors, etc. by opening up new applications. The work was carried out under the program for funding joint industrial research (project 350 ZGB: New functional surfaces for industrial applications by combining switchable polymer brushes and scratch-resistant clearcoats).

The aim of the project was to manufacture switchable coatings for technical surfaces which can, amongst other things, switch between opposing surface properties. For example, switch between hydrophobic/oleophobic and hydrophilic and hence be able to adapt to changing ambient conditions.

These intelligent coatings based on adaptive, functional polymer brush systems respectively fluoro-surfactants bring together the advantages of stability and switchability. The polymer brushes are responsible for adjusting and switching the wetting properties of the surface whilst the clearcoat provides stability for the polymer brushes which are coupled to nanoparticles.

1 *Andreas Stake (center) receives the FARBE UND LACK Award 2013 from Dr. Michael Hilt, chairman of the paint chemistry group at GDCh, and Dr. Sonja Schulte, chief editor for science and technology at FARBE UND LACK.*

1

DR.-ING. GREGOR GRASSL AND DR. MATTHIAS OTT WIN THE COMPOSITE INNOVATIONS AWARD

Dr.-Ing. Gregor Graßl – Fraunhofer Project Group Joining and Assembly FFM – and Dr. Matthias Ott – Plasma Technology and Surfaces PLATO – received the Composite Innovations Award on June 11, 2013 at the CFK-Valley Convention in Stade for an innovative deep-drawable release film which allows efficient release agent free demolding of components. The award was donated by CFK-Valley e.V., the Hanseatic Town of Stade, and the Private University of Applied Sciences in Göttingen.

The Flex$^{PLAS®}$ film that was developed at Fraunhofer IFAM for release agent free manufacture of FRP components has a number of advantages. The film can be easily stretched and can withstand being stretched up to 300 percent without functional impairment. Curved and structured FRP components of XXL size can be readily manufactured with the film. Many sectors of industry welcome this technology because the molding process was up until now very complex due to the fact that residues of conventional release agents were left behind on components and the molds. The cleaning of component surfaces risked causing damage and lengthy and expensive delays to manufacturing processes. The use of Flex$^{PLAS®}$ release film can be readily integrated into production processes, making the manufacture of FRP components much faster and cheaper. Flex$^{PLAS®}$ paves the way for the economical manufacture of plastic and FRP components with ready-to-paint surface properties.

Following their manufacture, the components can be immediately coated without further pre-treatment. The new technology also allows the in-mold coating of fiber composite components: This process is relatively simple and involves applying a gel coat to the Flex$^{PLAS®}$ release film in the mold. The production of the FRP component then takes place on the coating. The in-mold coating and FRP component are cured together and the coated component with the release film is then removed from the mold.

1 *Composite Innovations Award 2013.*

DR. MARCUS TEGEL AND DR. LARS RÖNTZSCH WIN THE F-CELL AWARD 2013

On October 7, 2013 Dr. Marcus Tegel and Dr. Lars Röntzsch of Fraunhofer IFAM in Dresden were presented with the f-cell award 2013 – first place, science category – at the f-cell forum in Stuttgart.

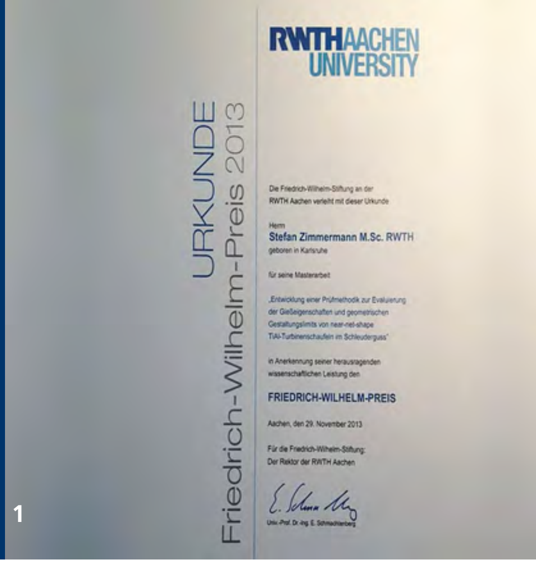
The researchers won the award for their work on "Hydrolysis-based ultra-high energy storage materials". Their work addressed a topical issue: Our ever increasing mobility and increased usage of mobile devices such as smart phones, cameras, and GPS units mean that there is a constant need for energy in whatever situation. Whilst access to electricity is not a given everywhere, water is almost always available.

Researchers in Dresden have found that energy storage systems based on certain metal hydrides are particularly suitable for meeting mobile energy needs. When these metal hydrides come into contact with water there is a so-called hydrolysis reaction which directly produces gaseous hydrogen. This is then converted into electricity by a fuel cell.

Special features of the novel energy storage materials are the rapid release of energy, their easy handling, and their low weight. A simple reaction vessel, a fuel cell, and water from any natural source allow systems to be realized from these materials which can store far more energy than conventional alkaline magnesium batteries and modern high-performance lithium thionyl chloride batteries. Also, they undergo no self-discharge and cost much less than special batteries.

This promising technology of Fraunhofer IFAM in Dresden is suitable for many mobile applications, for example for emergency power supply systems, portable electronic devices, charging devices, camping/recreational equipment, and buoys.

1 *Award winner Dr. Marcus Tegel (right) with Holger Haas of Stuttgart Region Economic Development Corporation (Source: © Peter Sauber Agentur).*



STEFAN ZIMMERMANN RECEIVES FRIEDRICH-WILHELM PRIZE 2013

Stefan Zimmermann was awarded the Friedrich-Wilhelm Prize 2013 at a ceremony at RWTH Aachen on November 29, 2013. The prize is awarded annually to students and young researchers of RWTH Aachen for the excellence of their work.

Stefan Zimmermann received the prize for his master's thesis entitled "Development of a test method for evaluating the casting properties and geometric design limits of near-net-shape TiAl turbine blades using centrifugal casting".

The Friedrich-Wilhelm prize is awarded by the foundation of the same name. The main aim is to promote research and teaching at RWTH Aachen and support the students and young researchers.

The foundation is named after the Prussian Crown Prince who was to become King Friedrich Wilhelm III. In 1858 he received a donation of 5000 thaler from the Aachener und Münchener Feuerversicherungsgesellschaft to found a polytechnic institute in the Rhine Province. This donation became the basis for the Friedrich-Wilhelm Foundation, which in turn became the basis for RWTH Aachen.

This year 10 bachelor dissertations/master theses, 13 doctoral theses, and 4 habilitation (academic) theses from RWTH Aachen received prizes.

1 *Certificate from RWTH Aachen.*

NAMES | DATES | EVENTS

1

The R&D activities of Fraunhofer IFAM focus on materials and manufacturing technologies. There is a strong emphasis on practical applications with much of the work involving collaborative projects with partners from a wide range of industries. Scientific excellence in core competencies provide the basis for this.

Collaboration with universities and technical colleges

Close collaboration and networking with universities and technical colleges are important for Fraunhofer IFAM. We have particularly close links with the University of Bremen and TU Dresden.

During the 2013 summer semester and 2013/2014 winter semester, researchers at Fraunhofer IFAM gave over 40 teaching courses at the University of Bremen, TU Dresden, University of Applied Sciences Bremen, University of Applied Sciences Bremerhaven, and the International University Dresden.

Scientific publications and presentations

Approximately 100 publications during the year documented the R&D work of Fraunhofer IFAM, so also confirming its strong position in the academic community. This is further emphasized by awards and prizes bestowed on employees.

In 2013 Fraunhofer IFAM scientists participated in many conferences, trade fairs, and seminars. Almost 200 presentations (in the form of talks or posters) were given through the year. The ever greater international networking of the institute is indicated by the fact that more than a quarter of these presentations was at events in foreign countries. The institute also regularly organized its own events. In 2013 more than 30 events (conference/seminar/workshop) were either organized or hosted by Fraunhofer IFAM.

Patents

Patents document the ability of an organization to innovate. Fraunhofer IFAM was granted 14 patents in 2013, surpassing the high number of previous years.

Detailed information about:
- conferences, seminars, and workshops
- scientific publications (Ph.D. theses, publications, presentations, and posters)
- patents and
- awards and prizes

can be found on the Internet at:

→ **www.ifam.fraunhofer.de/nde**

1 *Fraunhofer IFAM, Stade.*

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