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IKTS

FRAUNHOFER INSTITUTE FOR CERAMIC TECHNOLOGIES AND SYSTEMS IKTS

ANNUAL REPORT 2015 2016

Cover

cerenergy® – Assembling of a ceramic high-temperature battery cell for stationary energy storage.

ANNUAL REPORT 2015/2016

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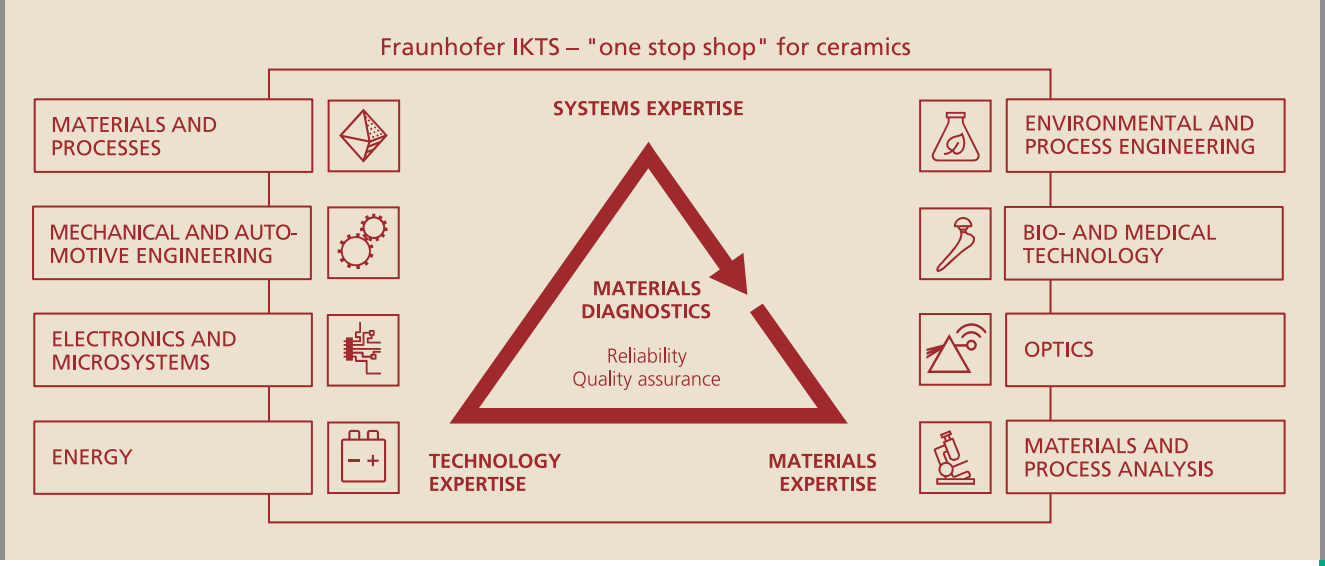
FOREWORD

Dear partners and friends of IKTS,

I am pleased to present you our new annual report. We had a successful year and completed a number of exciting projects, in many cases transferring the results to industry. In 2015, two spin-offs were established: ceragen GmbH, created to market the "eneramic®" fuel cell systems developed in a Fraunhofer foundation project, and MPower GmbH, which utilizes our fuel cell stack know-how.

Over the last reporting period we performed the standard Fraunhofer evaluations with the support of a panel of experts from industry. All in all, our strategy of covering the entire field of ceramics with technological core competencies while concentrating on the eight business divisions described in this report was clearly followed. IKTS once again proved itself to be a strong team. We are well prepared for the future and can continue to carry out our mission of conducting applied research to serve industry. Once again, I would like to invite you to make use of our expertise. We at IKTS are always available to support you in realizing your project ideas and look forward to discussing these ideas with you.



We invested overall 5 million euros of the over 54 million euros budget in new equipment to further strengthen and develop our core competencies at all of our sites. We would especially like to thank the *Länder* of Saxony and Thuringia for supporting these investments.

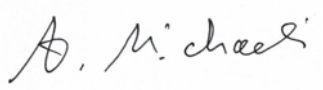
We made considerable advances in the field of medical and bioceramics. With our partner, Fraunhofer IZI, we opened the Bio-Nanotechnology Applications Lab (BNAL) in Leipzig on October 2, 2015. A new group was established to support these activities, with funding provided by the Fraunhofer Attract Program. Apart from developing new implantable materials and components and equipping them with sensor and actuator properties to make them theranostic, we will draw on our expertise in materials diagnostics to develop new diagnostic techniques at BNAL.

Our non-destructive evaluation (NDE) methods will also be coupled with our additive manufacturing (AM) activities for medical technology and other applications.

With the combination of NDE and AM, it should be possible to predict and avoid defects during the component printing process and thereby increase process reliability. By connecting our long-term experience and expertise in the development of printable ceramic materials (pastes and inks) with various AM process technologies as well as established processes, such as injection molding or functional ceramic hybrid technology (LTCC/HTCC) and integrating non-destructive test technology, we hope to establish unique capabilities in the field of additive manufacturing. Here, too, synergies are created from cooperation between our three sites and the fields of structural and functional ceramics.

Our 2015 annual report includes a compilation of highlights and trends from our various business divisions. I hope that they provide a source of inspiration for new project ideas, which we can discuss with you at any time. As always, I invite you to make use of our well-equipped facilities and our outstanding IKTS team. We look forward to working with you.

Sincerely,



Alexander Michaelis

April 2016

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FRAUNHOFER IKTS IN PROFILE

PORTRAIT

The Fraunhofer Institute for Ceramic Technologies and Systems IKTS covers the field of advanced ceramics from basic preliminary research through to the entire range of applications. Superbly equipped laboratories and technical facilities covering 30,000 m^2 of useable space have been set up for this purpose at the sites in Dresden and Hermsdorf.

Based on comprehensive materials expertise in advanced ceramic materials, the institute's development work covers the entire value creation chain, all the way to prototype production. Fraunhofer IKTS forms a triad of materials, technology and systems expertise, which is enhanced by the highest level of extensive materials diagnostics. Chemists, physicists, materials scientists and engineers work together on an interdisciplinary basis at IKTS. All tasks are supported by highly skilled technicians.

The focus is placed on manufacturers and especially existing and potential users of ceramics as project partners and customers. Fraunhofer IKTS operates in eight market-oriented divisions in order to demonstrate and qualify ceramic technologies and components for new industries, new product ideas, new markets outside the traditional areas of use. These include Mechanical and Automotive Engineering, Electronics and Microsystems, Energy, Environmental and Process Engineering, Bio- and Medical Technology, Optics, as well as both the conventional Materials and Processes and Materials and Process Analysis as overall interdisciplinary offers. The institute is therefore available as a competent consulting partner and starting point for all ceramics-related issues: a real "one stop shop" for ceramics.

Among our unique areas of expertise, we offer:

End-to-end production lines: from starting materials to prototypes

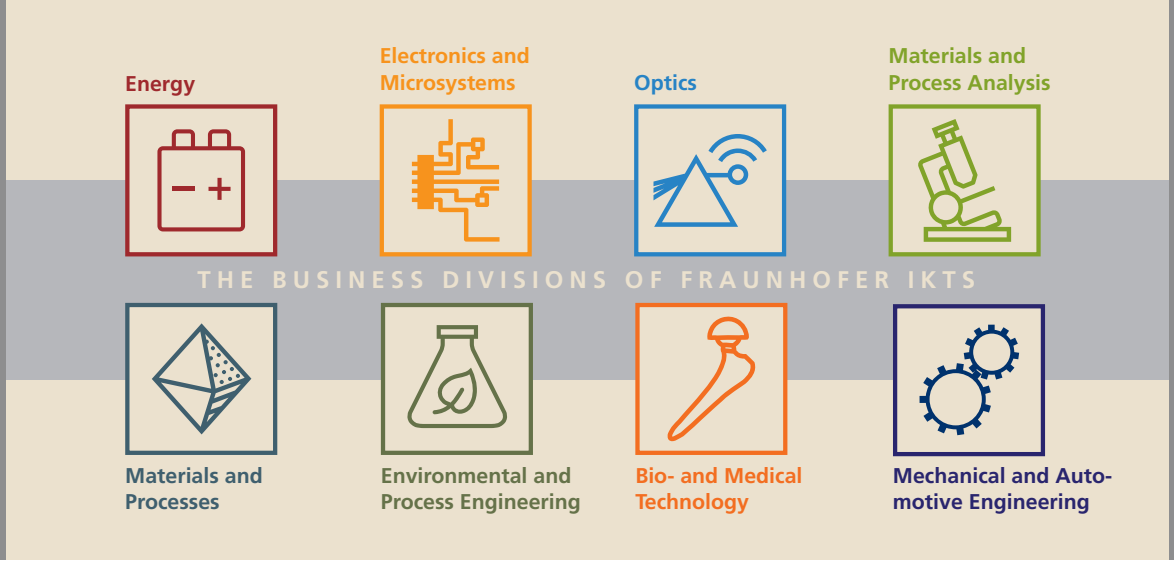
For any class of ceramic materials, we have access to all the standard processes of raw materials preparation, forming, heat treatment and finish processing. Where it makes sense, the institute can even conduct phase synthesis. In functional ceramics, we hold a particular core competency in paste and film technology. Multiple clean rooms and low-contamination production areas are kept at the ready, among other things, for multilayer ceramics and highly purified oxide ceramics lines of technology.

Multi-scale development

Fraunhofer IKTS can convert developments from the lab into the technical standard. There is industrially suited equipment and machinery of the latest designs available for all relevant lines of technology, in order for partners and customers to realize the prototypes and pilot-production series needed for market launch, to develop production processes, and to implement quality processes. Thus, residual cost risks and time to market can be minimized.

Synergies between materials and technologies

The combination of differing technology platforms, of functional and structural ceramics for example, allows for multifunctional components and systems that intelligently exploit ceramic properties. This enables the production of innovative products with markedly added value at low cost.



Competent analysis and quality assessment

High-performance analysis and quality control are a decisive factor for market acceptance of products, especially in ceramic production processes. Since we understand materials as well as ceramic production processes at a fundamental level, while at the same time master the drafting and integration of complex physical testing systems, we can offer our customers unique solutions for materials issues in production and quality monitoring.

Network creator

We are currently associated with over 450 national and international partners in our ongoing projects. In addition, Fraunhofer IKTS is active in numerous alliances and networks. Within the Fraunhofer-Gesellschaft, for example, we work with the Fraunhofer Group for Materials and Components. Furthermore, Fraunhofer IKTS serves as the spokesperson for the Fraunhofer AdvanCer Alliance, which consists of four institutes that specialize specifically in ceramics. We are in a position to support the development of networks that are needed to develop successful processes, and also to convey and to integrate expertise that goes beyond our own abilities. Our efforts on the front lines of research are based on a wealth of experience and knowledge acquired over many years, which is geared toward our partners´ interests.

Standardized management for sustainable quality assurance

Quality, traceability, transparency and sustainability: to us, these are our most important tools for setting ourselves apart from the competition. The IKTS therefore administers a standardized management system per DIN EN ISO 9001, as well as an environmental management system in accordance with DIN EN ISO 14001. Furthermore, each site of the institute is certified according to additional guidelines, including the German Medical Devices Act, and is regularly subjected to a variety of industrial audits.

CORE COMPETENCIES OF FRAUNHOFER IKTS

MATERIALS AND SEMI-FINISHED PARTS

STRUCTURAL CERAMICS

Oxide ceramics

Non-oxide ceramics

Hard metals and cermets

Powders and suspensions

Polymer ceramics

Fiber composites

Composite materials

Ceramic foams

FUNCTIONAL CERAMICS

Non-conducting materials

Dielectrics

Semiconductors

Ion conductors

Magnets

Pastes and tapes

Solders, brazes and glass sealings

Precursor-based inks and nanoinks

Composites

ENVIRONMENTAL AND PROCESS ENGINEERING

Substrates
- Granulates
- Plates
- Tubes
- Capillaries
- Hollow fibers
- Honeycombs
- Foams

Membranes and filters
- Oxides, non-oxides
- Zeolites, carbon
- MOF, ZIF, composites
- Ion and mixed conductors

Catalysts
- Oxides
- Metals, CNT

RAW MATERIAL AND PROCESS ANALYSIS, MATERIALS DIAGNOSTICS, NON-DESTRUCTIVE EVALUATION

Analysis and evaluation of raw materials
- Analysis of particles, suspensions and granulates
- Chemical analysis

In-process characterization in ceramic technology
- Characterization
- Process simulation and design
- Quality management

Characterized materials
- Steel, non-ferrous metals
- Ceramics, concrete
- Materials of semiconductor industry
- Plastics, composite materials (GFRP und CFRP)
- Biomaterials and tissues

Process design, process monitoring

TECHNOLOGY

Powder technology

Shaping

Heat treatment and sintering

Final machining

Precursor technology

Fiber technology

Additive manufacturing

Pilot production and upscaling

Coating technology

Joining technology

Thick-film technology

Multilayer
- HTCC, LTCC

Aerosol and inkjet-printing

Thin-film technology

Electrochemical machining

Galvanics

Materials separation
- Filtration
- Pervaporation
- Vapor permeation
- Gas separation
- Membrane extraction

Catalysis

Biomass technology
- Preparation
- Conversion

Photocatalysis

Chemical process engineering

Material and component characterization
- Microstructure and phases
- Mechanical and physical properties
- High-temperature properties
- Corrosion

Technologies
- Micro- and nanoanalytics
- Ultrasound testing
- High-frequency eddy current
- Optical methods
- X-ray methods

COMPONENTS AND SYSTEMS

Component design

Prototype production

Wear-resistant components

Tools

Optical components

Heating systems

Medical device technology and implants

Filters

System definition and plant development

Modeling and simulation

Design and prototype production

Validation/ CE marking

Test stand construction

Support in field tests

Samples and prototypes
- Membranes, filters
- Membrane modules
- Membrane plants

Filtration tests
- Laboratory, pilot, field
- Piloting

Modeling and simulation
- Materials transport
- Heat transport
- Reaction

Reactor development

Plant design

Component and system behavior
- Damage analysis
- Failure mechanisms
- Measurement and simulation of component behavior
- Testing in accordance with certified and non-certified standards

Components, systems and services
- Sensors and sensor networks
- Testing heads and systems
- Structural health monitoring
- Data analysis and simulation
- Biomedical sensor systems
- Testing in accordance with certified and non-certified standards

Component behavior, reliability analysis, lifetime and quality management, calibration

FRAUNHOFER IKTS IN FIGURES

FRAUNHOFER IKTS IN PROFILE

Budget and revenues

With an overall budget of 54.1 million euros in 2015, Fraunhofer IKTS is at the same level as the previous year. At 5.4 million euros, the investment budget for the institute was approximately 1.3 million euros higher than in 2014. Project-specific investment support from the Free State of Saxony totaling 2.76 million euros went towards energy and environmental technology as well as a Bio-Nanotechnology Applications Lab. The Hermsdorf site invested an additional 1.71 million euros for the battery pilot plant.

In line with the strategic realignment occurring at the Dresden-Klotzsche site, the operating budget was reduced to about 2.45 million euros while new working fields were solidified through investments and preliminary research projects. Over the short term, this means a reduction in the share of revenues from direct industry projects to 24.1 %, but over the long term it should significantly improve the competitiveness of the site.

IKTS revenues from industry of 16.1 million euros amounted to a financing share of 33.4 % from direct industry projects (36 % adjusted for the effects of integration). The best result was achieved by Hermsdorf with a share of 43.15 % and absolute industry revenues of 5.14 million euros.

Overall, the institute saw a sharp decline in funding from the Free State of Saxony and Thuringia to 1.5 million euros, due in part to shifting project start dates to the end of 2015 or to 2016. However, this was balanced out by a comparable increase in BMBF project volumes.

At 1.25 million euros, the EU project volume share was relatively low for IKTS; increasing this share remains a strategic goal of the institute. The different cost accounting methods used by the various funding agencies proved to be a challenge, causing uncertainty in the calculation of costs and hence in financial planning.

Personnel development

The employee count at IKTS remained at the level of 2014. However, the number of scientists increased by 4.2 %. Salary adjustments in the employment contracts and the associated changes in employee grouping resulted in a slight change in the structure and growth in the group of graduates. At the Hermsdorf site, student employment was boosted through the cooperation with Friedrich Schiller University Jena.

Expansion of the research basis

Within the classic working field of IKTS, the area of additive manufacturing was expanded further. The extended equipment basis enables processing of oxide and non-oxide ceramics as well as integration of non-destructive test methods.

The Bio-Nanotechnology Applications Lab is operated by Fraunhofer IZI and Fraunhofer IKTS, and provides research infrastructure for handling interdisciplinary topics ranging from basic biomedical research and process development to validation of new technologies. With the biological and medical know-how of Fraunhofer IZI and the expertise in developing new ceramic materials and innovative measurement techniques of Fraunhofer IKTS, an ideal basis is provided for completion of international projects.

The working field of membrane technology has advanced to become a core activity in the US through the expansion of demonstration and test facilities at Fraunhofer CEI.

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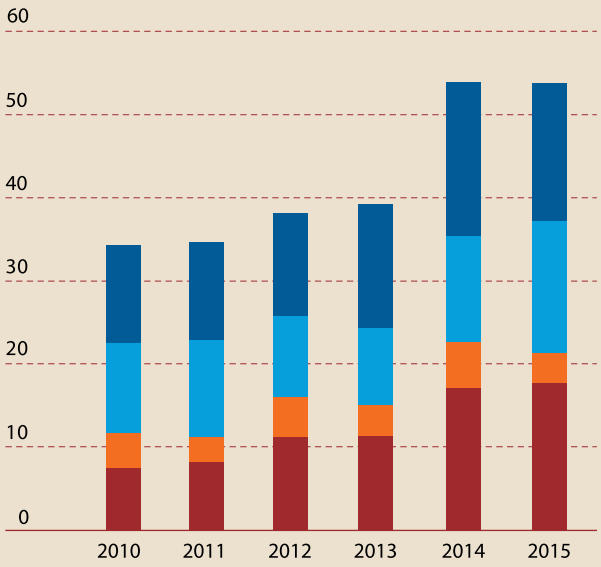
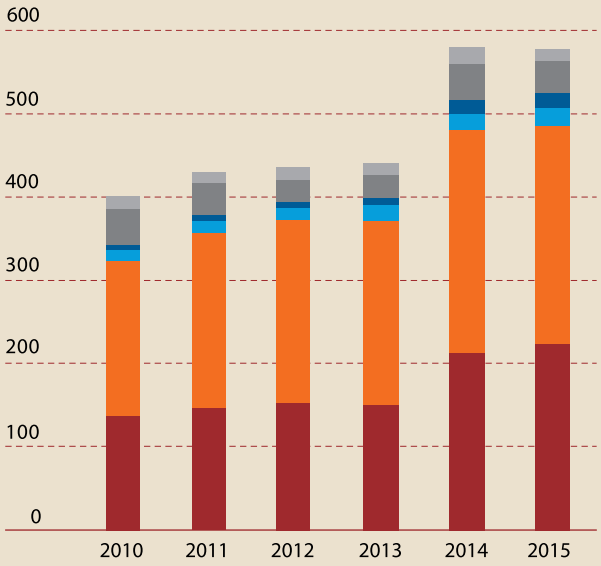
Revenue (in million euros) of Fraunhofer IKTS for the budget years 2010–2015



	2010	2011	2012	2013	2014	2015
Industrial revenue	11.8	11.9	12.6	14.4	18.6	16.3
Public-sector revenue	11.1	11.8	9.8	9.4	12.9	16.4
EU and other revenue	4.3	3.2	5.0	4.2	5.5	3.6
Institutional support	7.7	8.5	11.5	11.6	17.2	17.8
=	**35.0**	**35.3**	**38.9**	**39.6**	**54.2**	**54.1**

Personnel developments at Fraunhofer IKTS

Number of employees 2010–2015, full-time equivalents, personnel structure on December 31 of each year



	2010	2011	2012	2013	2014	2015
Apprentices	15	13	16	14	19	15
Student workers, trainees, undergraduate students	43	40	27	28	44	38
Part-time and contract workers	6	6	5	8	16	18
PhD candidates	13	14	15	19	20	21
Employees with university degrees and technicians	187	211	221	223	267	260
Scientists	137	147	154	150	214	223
=	**401**	**431**	**438**	**442**	**580**	**575**

1 *Institute management of IKTS, f.l.t.r.: Prof. Michael Stelter, Dr. Christian Wunderlich, Prof. Alexander Michaelis, Dr. Michael Zins, Dr. Ingolf Voigt.*

ORGANIZATIONAL CHART

Institute Director	Prof. Dr. habil. Alexander Michaelis
Deputy Institute Director / Head of Administration	Dr. Michael Zins
Deputy Institute Director / Marketing and Strategy	Prof. Dr. Michael Stelter / Dr. Bärbel Voigtsberger
Deputy Institute Director	Dr. Ingolf Voigt
Deputy Institute Director	Dr. Christian Wunderlich

Materials

Nonoxide Ceramics
Dipl.-Krist. Jörg Adler
- Nitride Ceramics and Structural Ceramics with Electrical Function
- Carbid Ceramics and Filter Ceramics

Oxide Ceramics
Dr. Isabel Kinski
- Materials Synthesis and Development
- Pilot Manufacturing of High-Purity Ceramics
- Oxide and Polymerceramic Composites*

Processes and Components
Dr. Hagen Klemm
- Powder Technology
- Shaping
- Component Development
- Finishing
- Process Technology and Silicate Ceramics

* certified according to DIN EN ISO 13485

Sintering and Characterization / Non-Destructive Testing
Dr. habil. Mathias Herrmann
- Thermal Analysis and Thermal Physics*
- Heat Treatment
- Ceramography and Phase Analysis

Environmental and Process Engineering

Nanoporous Membranes
Dr. Hannes Richter
- Zeolithe Membranes and Nano-Composites
- Carbon-Based Membranes
- Membrane Prototypes

High-Temperature Separation and Catalysis
Dr. Ralf Kriegel
- High-Temperature Membranes and Storages
- High-Temperature Separation
- Catalysis and Materials Synthesis

Biomass Technologies and Membrane Process Engineering
Dr. Burkhardt Faßauer
- Biomass Conversion and Water Technology
- Mixing Processes and Reactor Optimization
- Membrane Process Technology and Modeling
- Technical Electrolysis and Geothermal Energy

Chemical Engineering and Electrochemistry
PD Dr. Matthias Jahn
- Modeling and Simulation
- Process Systems Engineering
- Electrochemistry

Technische Universität Dresden	
ifWW – Inorganic-Nonmetallic Materials	Prof. Dr. habil. Alexander Michaelis
IAVT – Electronic Packaging Laboratory	Jun.-Prof. Henning Heuer
DCN – Dresden Center for Nanoanalysis	Prof. Dr. habil. Ehrenfried Zschech
Friedrich-Schiller University Jena	
Technical Environmental Chemistry	Prof. Dr. Michael Stelter
Iowa State University	
Aerospace Engineering	Prof. Dr. rer. nat. et Dr.-Ing. habil. N. Meyendorf

- Powder and Suspension Characterization*
- Quality Assurance Laboratory* and Mechanics Laboratory
- Chemical and Structural Analysis
- Hard Metals and Cermets
- Accredited Test Lab*

* accredited according to DIN EN ISO/IEC 17025

Energy Systems / Bio- and Medical Technology

Materials and Components

Dr. Mihails Kusnezoff

- Joining Technology
- High-Temperature Electrochemistry and Catalysis
- Ceramic Energy Converters
- Materials MCFC

System Integration and Technology Transfer

Dr. Roland Weidl

- System Concepts
- Validation
- Mobile Energy Storage Systems
- Stationary Energy Storage Systems
- Thin-Film Technologies

Bio- and Nanotechnology

Dr. Jörg Opitz

- Biological, immunological and optical Nanosensors
- Acoustical Diagnostics

Electronics and Microsystems Engineering

Smart Materials and Systems

Dr. Holger Neubert

- Multifunctional Materials and Components
- Applied Material Mechanics and Solid-State Transducers
- Systems for Condition Monitoring

Hybrid Microsystems

Dr. Uwe Partsch

- Thick-Film Technology and Photovoltaics
- Microsystems, LTCC and HTCC
- Functional Materials for Hybrid Microsystems
- Systems Integration and Electronic Packaging
- Technical Center Renewable Energy HOT
- Ceramic Tapes

Testing of Electronics and Optical Methods

Dr. Mike Röllig

- Optical Test Methods and Nanosensors
- Speckle-Based Methods
- Reliability of Microsystems

Systems for Testing and Analysis

Jun.-Prof. Henning Heuer

- Electronics for Testing Systems
- Software for Testing Systems
- Eddy Current Methods
- Ultrasonic Sensors and Methods

Microelectronic Materials and Nanoanalysis

Prof. Dr. habil. Ehrenfried Zschech

- Micro- and Nanoanalysis
- Materials and Reliability for Microelectronics

Project Group Berlin

Dipl.-Ing. R. Schallert

BOARD OF TRUSTEES

The president of the Fraunhofer-Gesellschaft has appointed the following people to the board of trustees at Fraunhofer IKTS:

Dr. A. Beck
Saxon State Ministry for Science and the Arts, Dresden
Head of Department "Bund-Länder-Research Institutes"

Dipl.-Ing. R. Fetter
Thuringian Ministry for Economy, Science and the Digital Society, Erfurt
Department "Institutional Research"

Dr. habil. M. Gude
Thuringian Ministry for the Environment, Energy and Nature Conservation, Erfurt
Head of Department "Energy and Climate"

Dr. P. Heilmann
arXes-tolina GmbH, Berlin
Manager

A. Heller
Landrat of the Saale-Holzland-Region, Eisenberg

Prof. Dr. Ch. Kaps (emer.)
Formerly Bauhaus University Weimar,
Faculty Civil Engineering,
Chair of Building Chemistry

Dr. W. Köck
Plansee SE, Reutte
Executive Director

A. Krey
State Development Corporation of Thuringia (LEG), Erfurt
Manager

Dr. R. Lenk
CeramTec GmbH, Plochingen
Head of Service Center Development

Dr. C. Lesniak
3M Technical Ceramics, branch of 3M Deutschland GmbH, Kempten
Senior Laboratory Manager

Dr. H. H. Matthias
TRIDELTA GmbH, Hermsdorf
Managing Director

Dr. R. Metzler
Rauschert GmbH, Judenbach-Heinersdorf
Managing Director

P. G. Nothnagel
Saxony Economic Development Corporation, Dresden
Managing Director

M. Philipps
Endress + Hauser GmbH & Co. KG, Maulburg
Head of Business Division Sensor Technology

Dr.-Ing. W. Rossner
Siemens AG, München
Head of Central Department Technology, Ceramics

Dr. K. R. Sprung
AiF Projekt GmbH, Berlin
CEO

Dr. K.-H. Stegemann
X-FAB Dresden GmbH & Co. KG
Division Manager Solar Cell and Module, Manager Business Development

Dr. D. Stenkamp
TÜV Nord AG, Hannover
Board of Management

MR C. Zimmer-Conrad
State Minister for Economic Affairs, Labour and Transportation, Dresden
Head of Department "Innovation Policy, Technology Funding"

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 nearly 24,000 staff are qualified scientists and engineers, who work with an annual research budget of more than 2.1 billion euros. Of this sum, more than 1.8 billion euros is generated through contract research. More than 70 % of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Almost 30 % 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.

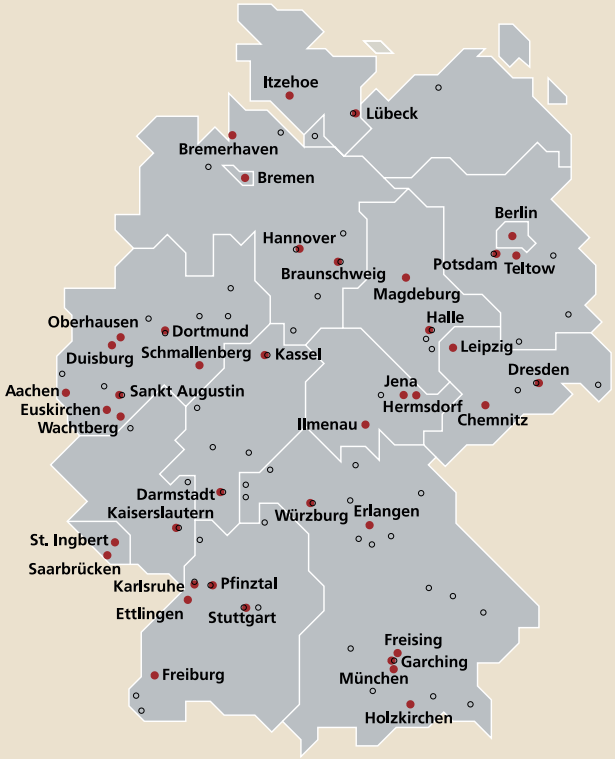
International collaborations with excellent research partners and innovative companies around the world ensure direct access to regions of the greatest importance to present and future scientific progress and economic development.

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.

Fraunhofer locations in Germany



Main locations ● Secondary locations ○

RETROSPECTIVE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EVENTS AND HIGHLIGHTS

March 25–26, 2015

Second International Symposium on Optical Coherence Tomography for Non-Destructive Testing OCT4NDT

In March 2015, Dresden was the center of the optical coherence tomography (OCT) world. More than 60 people from 18 countries congregated at Fraunhofer IKTS to exchange information about industrial applications for this non-contact process. The high-level symposium program and the accompanying industrial exhibition were well received by the international OCT community. Thanks to the resonating success of the event, it will be continued in the future. The 3rd OCT4NDT symposium is scheduled for 2017 in Linz, Austria.

April 20–23, 2015

11th International Conference and Exhibition on Ceramic Interconnect and Ceramic Microsystems Technologies CICMT

In 2015, for the first time ever, the CICMT was held by Fraunhofer IKTS in Dresden under the auspices of the American Ceramic Society (ACerS), IMAPS Deutschland, and the Deutsche Keramische Gesellschaft (DKG / German Ceramic Society). Over the last decade the conference series has evolved into one of the foremost international forums for discussion of the latest R&D in the fields of ceramic microsystem and ceramic interconnect technologies. More than 140 participants from 19 nations came to Dresden to present their research results.

June 12, 2015

Prime Minister of the Czech Republic Bohuslav Sobotka visits Fraunhofer IKTS in Dresden

Czech Prime Minister Bohuslav Sobotka paid a visit to Fraunhofer IKTS in Dresden on June 12 while in Germany to meet with government officials. Sobotka was accompanied by the Minister President of Saxony Stanislav Tillich, the Saxonian Minister of Economic Affairs Martin Dulig, and the Czech Minister of Transport Dan Tok. At Fraunhofer IKTS, Sobotka was

informed about current developments in environmental and energy research. At the heart of the government talks was the furthering of the Saxonian-Czech cooperation in matters related to the economy, transport, science, the environment, and education.

August 25, 2015

Thuringians Minister of Economic Affairs, Science, and the Digital Society Wolfgang Tiefensee at IKTS Hermsdorf

On August 25, the Thuringian Minister of Economic Affairs, Science and the Digital Society visited the Hermsdorf site of Fraunhofer IKTS as well as local technology firms to find out more about the latest research and product developments in advanced and functional ceramics. Ceramic products from Hermsdorf are used, e.g., in environmental and energy technologies, medical technology, optics, test equipment, and the aerospace industry. Minister Tiefensee praised the close networking of companies from diverse industries with Fraunhofer IKTS as an important driver of the Thuringian economy.

September 16, 2015

Fraunhofer Industry Day "Smart Materials"

Although the range of potential applications for smart materials and microsystems is dazzling, smart sensors, energy converters, and piezoelectric actuators are still not yet widely used in many industries. The topic of the second Fraunhofer "Smart Materials" Industry Day was hence to stimulate cooperation between engineers and designers in product development and to explore the question of how organizational and network structures can contribute to accelerating technology transfer to industrial production of smart materials and better aligning research projects to the needs of companies. More than 60 regional representatives from science, economy, and various associations were updated on the latest research projects during the program and took the opportunity to network in the subsequent get-together.

September 17–18, 2015

International Symposium on Piezocomposite Applications ISPA

The sixth ISPA symposium took place in September 2015 at Fraunhofer IKTS in Dresden. The event focused on scientific and technological developments as well as market requirements and future trends in the field of piezoelectric ceramics and their integration into various matrix materials. Over 75 participants and 11 exhibitors from 9 countries made the symposium and the accompanying industrial exhibition an outstanding platform for the exchange of knowledge. The successful symposium series will be continued in 2017 in Dresden.

1 *The participants of the OCT4NDT symposium discussed industrial applications of optical coherence tomography.*
2 *For the first time, CICMT took place at Fraunhofer IKTS in Dresden.*
3 *During the tour through the institute: Institute Director Prof. Alexander Michaelis, Saxonian Minister-President Stanislav Tillich, Saxonian Minister of Economy Martin Dulig and Czech Prime Minister Bohuslav Sobotka.*
4 *Thuringians Minister Wolfgang Tiefensee with Dr. Ingolf Voigt and Dr. Isabel Kinski at Fraunhofer IKTS in Hermsdorf.*

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September 22–24, 2015

Dresden Battery Days

Fraunhofer IKTS held the first "Dresden Battery Days" in 2015, drawing 85 participants from industry and research. Topics were low-cost, optimized active materials and components, efficient production of electrodes, production-optimized cell and module designs, and improved product yield in the manufacturing of lithium-ion batteries. The "Dresden Battery Days" is the partner event to the "Graz Battery Days" – in the future the event shall be held alternately in Graz and in Dresden on a yearly basis and will address specific aspects of the latest battery research and development.

October 2, 2015

Fraunhofer IZI and Fraunhofer IKTS open Bio-Nanotechnology Applications Lab in Leipzig

On October 2, 2015, the Leipzig-based Fraunhofer Institute for Cell Therapy and Immunology (IZI) and Fraunhofer IKTS officially presented their new equipment inventory for the interdisciplinary management of materials and bioscience issues. Secretary of State Uwe Gaul, in Leipzig for the bionection partnering conference, attended the opening ceremony. The Bio-Nanotechnology laboratory equipment was funded through an investment of three million euros from the Saxonian State Ministry for Science and the Arts (SMWK) under funding from the European Regional Development Fund (EFRE).

October 30, 2015

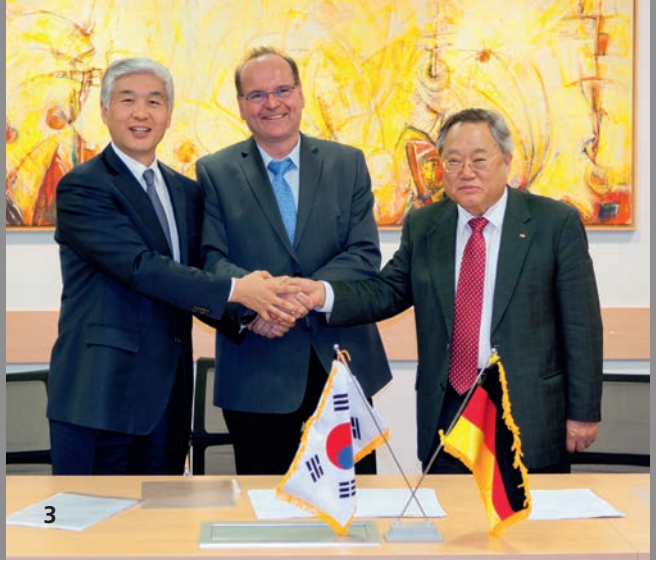
Inauguration of new Application Center for Membrane Technology in Schmalkalden

In the presence of the Thuringian Secretary of State Georg Maier and other invited guests, Ingolf Voigt, Deputy Director of Fraunhofer IKTS, opened the extension of the "Application Center for Membrane Technology" in Schmalkalden on October 30, 2015. With this extension, the rising demand for efficient separation techniques in the fields of water and waste water technology, energy and environmental technology, biotechnology, and food technology is met. Secretary of State Maier praised this step as a clear sign of the successful cooperation between research and Thuringian businesses involved in environmental and process technology. With its service offering, the Application Center for Membrane Technology particularly targets small and medium-sized businesses. Complementing the membrane development work performed at the Hermsdorf site, test systems are developed and built according to customer specifications, lab and field tests are conducted, and processes for product separation and purification are optimized in Schmalkalden. The application center also offers consulting on water management, membrane testing, and process design for waste water purification and water treatment.

November 19, 2015

Fraunhofer IKTS signs MoU with South Korean research institutes

On November 19, Institute Director Prof. Alexander Michaelis signed a memorandum of understanding on behalf of Fraunhofer IKTS with Korea Institute of Materials Science and Yonsei University from South Korea. The partners agreed to cooperate in research projects and in joint seminars and publications on materials science, bio- and nanotechnology, environmental and process technology, and energy. In 2016, a joint research center will be built on Yonsei International Campus to provide a central point of contact for academic-industry cooperation with companies, startups, and other research institutions.



Awards

October 5, 2015

Thuringian partnership receives prestigious US Environmental Award

In recognition of their ceramic nanofiltration membranes, Fraunhofer IKTS and inopor GmbH from Veilsdorf received the 2015 Corporate Environmental Achievement Award from the American Ceramic Society (ACerS). Filtration and treatment of water is becoming an important global issue. With porous membranes exhibiting the appropriate pore sizes, microorganisms, dissolved organic matter, and salts can be separated from waste water with little energy and no additional chemicals. Fraunhofer IKTS succeeded in developing the world's first ceramic nanofiltration membrane with a pore size of less than 1 nm. Together with inopor GmbH, the institute is producing these membranes on an industrial scale and has already realized numerous applications.

November 23, 2015

Two IKTS trainees among the top Fraunhofer trainees in 2015

Congratulations go out to chemistry laboratory technician Daniela Möbius and physics laboratory technician Jan Ullmann. They completed their training with the grade of "very good" and were among the best trainees at Fraunhofer in 2015. The ceremony recognizing the top trainees was held on November 23 at the headquarters of the Fraunhofer-Gesellschaft in Munich. The teams under Beatrice Bendjus and Lars Rebenklau were honored as the best Fraunhofer trainers.

December 14, 2015

Germany's top physics laboratory technician trainee trained at Fraunhofer IKTS

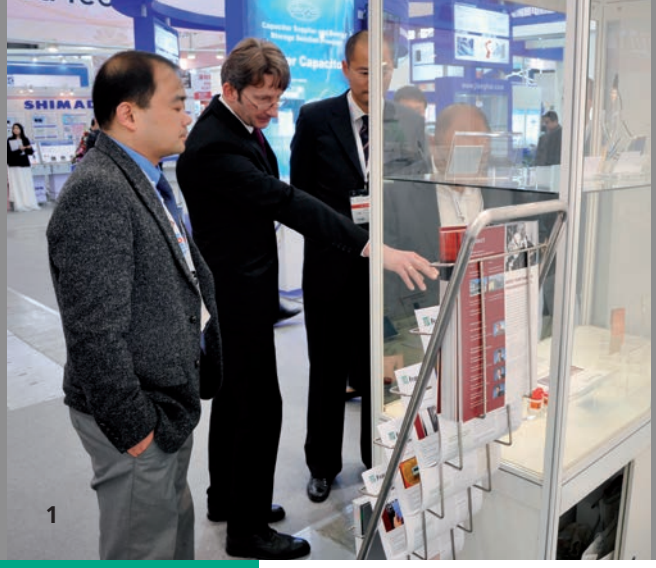
Scoring an outstanding 98.50 points in his final exam with the Chamber of Commerce and Industry (IHK), Jan Ullmann was the best IHK trainee in Saxony and the best IHK physics laboratory technician trainee in all of Germany. The honoring of the country's best took place on December 14 in Berlin. Based on this success, Fraunhofer IKTS received the title of "Outstanding Training Company in 2015" from the Dresden Chamber of Commerce and Industry.

1 *More than 75 people from nine different countries took part in ISPA 2015.*

2 *IKTS project coordinator Dr. Jörg Opitz (center) gives a tour of BNAL to Secretary of State Uwe Gaul (right), Prof. Frank Emmrich, Director of Fraunhofer IZI (left), and other guests.*

3 *MoU signing at Fraunhofer IKTS: Prof. Alexander Michaelis with Director of the Institute for Global Convergence Technology Muhwan Shin (left) and Director of the Korea Institute of Materials Science Hai-Doo Kim (right).*

4 *F.l.t.r.: Ingolf Voigt and Petra Puhlfürß (Fraunhofer IKTS), Cheryl Brayman (inopor GmbH), and ACerS President Prof. Kathleen A. Richardson at the awards ceremony in Columbus, Ohio, USA.*



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TRADE FAIR REVIEW 2015 – SCIENCE MEETS MARKET

The unique properties of high-performance ceramics secure their competitiveness in diverse applications. Fraunhofer IKTS as one stop shop for ceramics offers partners extensive R&D services from materials to systems. Last year the institute presented selected research highlights at 41 trade shows in Germany and around the world.

Highlights

Fuel cell systems developed in Dresden enable off-grid power generation. The "Energy" business division presented trade show visitors in Germany and Asia the eneramic® power generator which is mobile and operated with liquefied petroleum gas, and gave a live demonstration to show the launch readiness of the system.

Fraunhofer IKTS debuted at electronica China in Shanghai with a booth in the German Pavilion, where the "Electronics and Microsystems" business division provided information on the production of customer-specific thick-film pastes. An exclusive user workshop on power electronics of the future took place alongside the trade show.

Innovative solutions for the process industry awaited visitors at the ACHEMA World Forum in Frankfurt, Germany. The "Environmental and Process Engineering" business division presented a measurement technique developed in-house for monitoring inaccessible pipes and corrosion-prone components in systems. IKTS researchers also demonstrated the latest generation of a mobile oxygen generator for the first time. With mixed conducting ceramic membranes, these systems generate 250 normal liters of pure oxygen per hour via a high-temperature separation process while consuming considerably less energy than comparable air separation systems do. Oxygen generators are used, e.g., in hospitals, waste water treatment plants, steel production, biomass gasification, and the chemical industry.

In 2015, IKTS continued its tradition of using the platform of the world's largest industrial trade show, Hannover Messe, to showcase its structural ceramic technologies and applications for medical technology, optics, mechanical engineering, and the automotive industry. Great interest was shown in the filigree and customized ceramic parts made by additive manufacturing. These parts offer exciting new opportunities for use in medical technology, microreactors and microdevices, and the jewelry industry and can be realized resource-efficiently and tool-free in the future. In the field of non-destructive testing, IKTS scientists demonstrated a semi-automated measuring device for live imaging 2D and 3D ceramic specimens based on optical coherence tomography (OCT). Testing is done contact- and contamination-free in a matter of seconds. Hence, it is suitable for industrial-scale application and can additionally be implemented in existing processes.

Overview 2015

nano tech
Tokyo, January 28–30

ChemTech India
Mumbai, January 28–31

Leichtbau-Tagung
Oberhausen, February 11–12

Fuel Cell Expo
Tokyo, February 25–27

Battery Japan
Tokyo, February 25–27

LOPEC
Munich, March 4–5

Energy Storage
Düsseldorf, March 8–11

IDS International Dental Show
Cologne, March 10–15

JEC Composites Show
Paris, March 10–12

electronica China
Shanghai, March 17–19

Hannover Messe
Hannover, April 13–17

FCMN Frontiers of Characterization and Metrology for Nanoelectronics
Dresden, April 14–16

ThEGA-Forum
Weimar, April 20

Ceramics Expo
Cleveland, April 28–30

SMT Hybrid Packaging
Nuremberg, May 5–7

Wind & Maritime
Rostock, May 6–7

DGZfP DACH-Tagung
Salzburg, May 11–13

PCIM Europe
Nuremberg, May 19–21

Sensor+Test
Nuremberg, May 19–21

Electrical Energy Storage
Munich, June 10–12

RapidTech
Erfurt, June 10–11

ACHEMA
Frankfurt a.M., June 15–19

Energy Saxony Summit
Dresden, June 24

Carbon
Dresden, July 12–16

Laser World of Photonics
Munich, July 22–25

Cancer Diagnosis & Therapy Congress
London, September 3–4

Materialsweek
Dresden, September 14–17

Euromat
Warsaw, September 20–24

ISPA International Symposium on Piezocomposite Applications
Dresden, September 17–18

Dresden Battery Days
Dresden, September 22–24

200. DGZfP-Arbeitskreis
Dresden, October 1

EuroPM European Powder Metallurgy Congress and Exhibition
Reims, October 4–7

Semicon Europa
Dresden, October 6–8

World of Energy Solutions
Stuttgart, October 12–14

Kraftwerkstechnisches Kolloquium
Dresden, October 13–14

Ceramitec
Munich, October 20–23

FAD Conference
Dresden, November 4–5

productronica
Munich, November 10–13

PRORA Fachtagung "Prozessnahe Röntgenanalytik"
Adlershof, November 12–13

Hagener Symposium
Hagen, November 25–27

Dresdner Sensor-Symposium
Dresden, December 7–9

1 *electronica China, Shanghai: Dr. Eberstein presents the IKTS thick-film paste range.*
2 *ACHEMA, Frankfurt a.M., Germany: premiere of the mobile oxygen generator.*
3 *ceramitec, Munich, Germany: the leading international trade show for the ceramic industry brings together manufacturers, suppliers, and scientists from more than 40 different countries.*
4 *Hannover Messe: Fraunhofer IKTS offers partnerships from technology and prototype development to application in the fields of of fuel cells and batteries.*

HIGHLIGHTS FROM OUR BUSINESS DIVISIONS

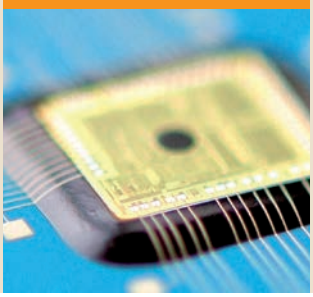
Materials and Processes

The "Materials and Processes" business division provides a central point of contact for all matters related to development, manufacturing, and qualification of high-performance ceramics for a wide range of applications. A wealth of experience has been accumulated in all relevant materials and technologies, for which requirement-related functional solutions are developed. The scope of activities encompasses the entire process chain, making this division crucial to all other business divisions.

Mechanical and Automotive Engineering

High-performance ceramics are key components in mechanical and automotive engineering. Due to their outstanding properties, they are often the only available options. The "Mechanical and Automotive Engineering" business division offers high-performance ceramic, hard metal, and cermet wear parts and tools as well as parts for specific loading conditions. A new core area comprising test systems for monitoring components and production facilities based on optical, elastodynamic, and magnetic effects has also been established.

Electronics and Microsystems



The "Electronics and Microsystems" business division offers manufacturers and users unique access to materials, technologies, and know-how to help them develop robust, high-performance electronic components. Focus is on sensors and sensor systems as well as power electronic components and "smart" multifunctional systems. With the help of innovative test methods and systems, Fraunhofer IKTS provides support along the entire value-added chain – from materials to integration of complex electronic systems.

Energy

Ceramic materials and technologies form the basis for improved and fundamentally new applications in energy technology. To that end, Fraunhofer IKTS develops, builds, and tests innovative components, modules, and complete systems, focusing mainly on ceramic solid-state ionic conductors. Applications range from electrochemical energy storage systems and fuel cells, solar cells, energy harvesting modules, and thermal energy systems to solutions for biofuels and chemical fuels.

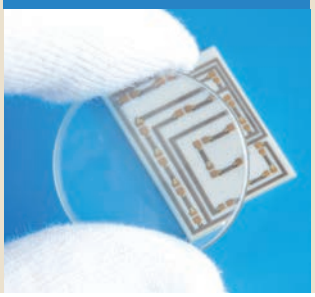
Environmental and Process Engineering

Fraunhofer IKTS develops innovative materials, technologies, and systems for safe, efficient, environmentally, and climate-friendly conversion of energy and substances. Focus is on processes involving conventional and biological energy sources as well as strategies and processes for water and air purification and treatment, and for recovery of valuable raw materials from waste. New reactor designs for the chemical industry are made possible by ceramic technologies.

Bio- and Medical Technology

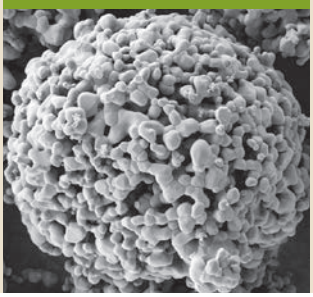
Fraunhofer IKTS makes use of the outstanding properties of ceramic materials to develop dental and endoprosthetic implants and surgical instruments. In well-equipped, certified laboratories, the interactions between biological and synthetic materials are investigated and applied towards the development of improved materials, analytics, and diagnostics. In part unique optical, acoustic, and bioelectrical techniques are available for this purpose.

Optics

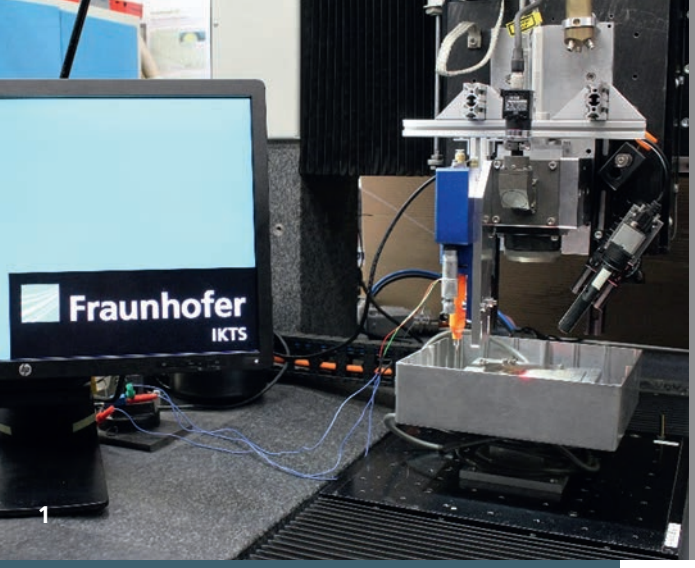


Fraunhofer IKTS develops ceramic materials and components for photonics, lighting applications, and ballistic protection. Phase synthesis combined with materials and technology expertise yields innovative luminescent materials, active optoceramics, optical and decorative elements, and transparent ceramics for defense applications. Optical technologies are also used in measurement and diagnostic systems in medicine, life sciences, and industry.

Materials and Process Analysis



Fraunhofer IKTS offers a wide range of test, characterization, and analysis methods for materials properties and production processes. As a reliable, multiply accredited, and audited service provider, Fraunhofer IKTS assists in the investigation of fundamental aspects of materials science, application-specific issues, and measurement-related developments. Characteristic parameters are not only determined but also interpreted within the context of the respective application to uncover any potential for optimization.



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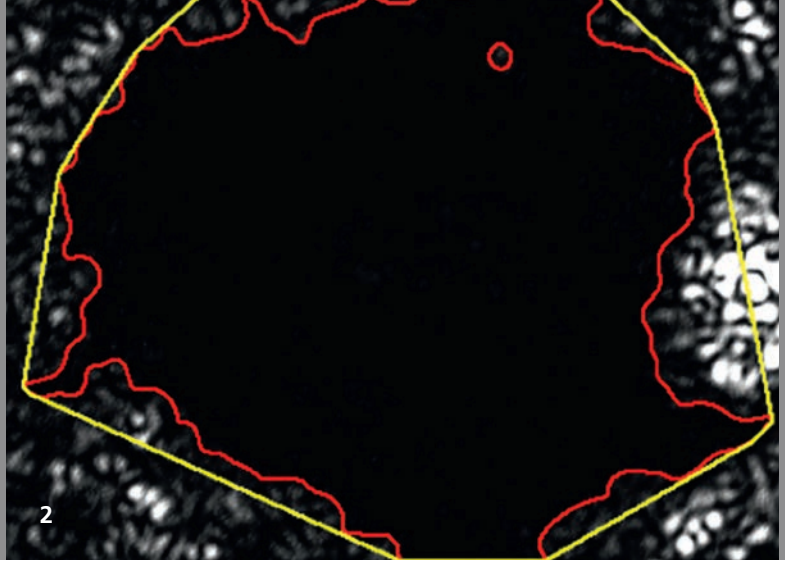


2

QUALITY CONTROL OF LASER CLADDING BY LASER SPECKLE PHOTOMETRY

Dr. Beatrice Bendjus, Dr. Ulana Cikalova, Dr. Mike Röllig

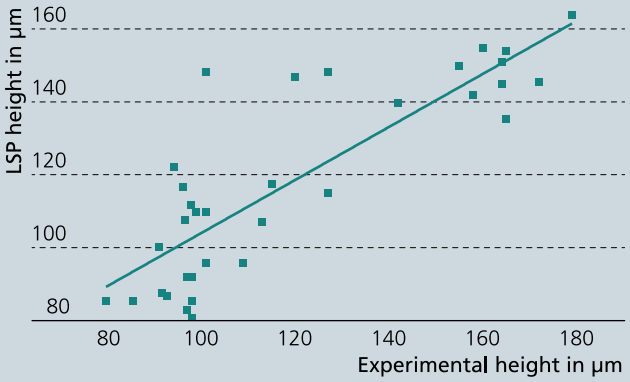
In electrical engineering and electronics applications in which electrical contacts are only selectively required (e.g. grinding and plug contacts), micro-laser cladding is used for local selective application of contacts with precious metals. Mass production requires quality control of the contacts with the potential for high-speed inspection. Laser speckle photometry (LSP) can be used for this purpose. LSP is a contactless inspection method that was developed at Fraunhofer IKTS. It is based on the analysis of temporal changes in optical speckle patterns (interference patterns) resulting from exposure of test objects to coherent light. In a joint project of Fraunhofer IKTS and ILT, use of LSP for indirect determination of the precious metal content as well as the geometry of the contacts is being examined.

The gold contacts are applied by needle dispensing, dried to drive off the binder, and remelted with a laser. In LSP, the necessary temporal and lateral resolution of the interference pattern is achieved through use of a CMOS camera. Interference excitation is simultaneously effected through reheating of the contacts with the machining laser.

Pulse processing enables a gold contact with a diameter of about 200 microns and a thickness of several 10 microns to be remelted within 100 milliseconds. By parallelization (e.g., by a cascading beam splitter), dozens of contacts can be functionalized per second. The LSP signals change with the gold content and the diameter and height of contacts and can therefore be used as a parameter for calibration. Currently an accuracy of approximately ± 7 % can be achieved. Exemplified by the parameter "contact height" the correlation between the measurements obtained using a reference method and LSP is shown in the diagram below. Up to 100 contacts per second can be recorded and evaluated externally, making 100 % inspection possible in principle. Micro-laser cladding and LSP have been successfully tested in an experimental setup.

The project was funded within the Fraunhofer program MEF.

Calibration curve for contact heights determined by confocal microscopy vs. LSP height



1 *Experimental setup at ILT Aachen.*

2 *Speckle pattern of a contact, showing an envelope line for estimation of contact heights.*

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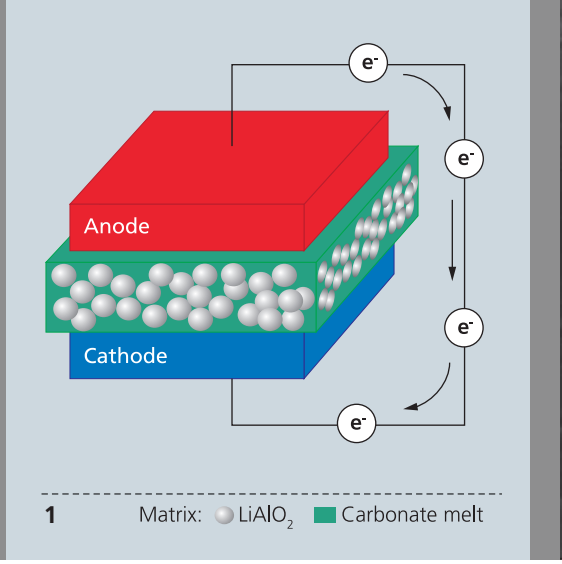

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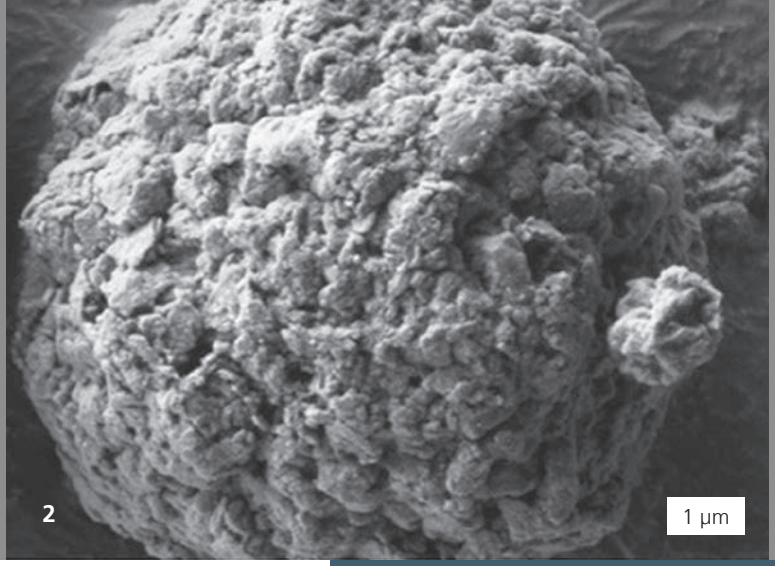


2

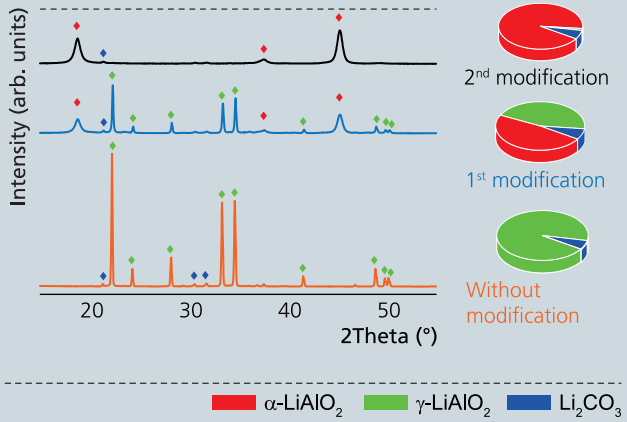
STABILITY OF MATRIX MATERIALS FOR APPLICATION IN MCFCs

Dipl.-Ing. Christoph Baumgärtner, Dr. Katja Wätzig, Dr. Mihails Kusnezoff, Dr. Mykola Vinnichenko

The Molten Carbonate Fuel Cell (MCFC) is presently one of the most mature and efficient fuel cell technologies, enabling electrical energy efficiencies of up to 48 % for 350-kW to 3-MW systems. Both the electrolyte storage capacity and the cell lifetime depend on the stability of the key component, the porous matrix made of submicron $LiAlO_2$ particles holding the molten carbonate electrolyte by means of capillary forces. Particle coarsening and/or phase transformations during long-term operation may reduce the matrix electrolyte retention capability and impact cell life.

Although $LiAlO_2$ nanopowder synthesis has already been reported, the stability in MCFC operating conditions remains an important challenge. The newly established Fraunhofer Attract group "Materials MCFC" works on addressing basic aspects of the effects of synthesis parameters on the coarsening behavior and phase transformations in $LiAlO_2$ to enable more stable and simultaneously cost-efficient material. The research infrastructure covering powder synthesis, matrix preparation by tape casting, materials testing, and materials characterization in cells and half cells was established for this purpose. The solid- state reaction between AlOOH (Sasol Germany GmbH) and Li_2CO_3 (Sigma-Aldrich Chemie GmbH) was selected as the most promising approach due to its relative simplicity, good scalability, and cost-efficient starting materials. Different mixing/milling and drying approaches using either solvent- or water-based media were tested. Variation of calcination times and temperatures over wide ranges yielded information on the kinetics of the calcination process. The powders were characterized in terms of crystalline structure, porosity, crystallographic phases, and morphology using XRD, Brunauer-Emmett-Teller surface analysis, differential thermal analysis, and scanning electron microscopy. In the present work, the feasibility of chemically modifying the initial slurry in order to block undesirable $LiAlO_2$ phase transformations during calcination at temperatures as high as 700 °C was demonstrated. This improvement resulted in a stable $LiAlO_2$ phase over a wider temperature range and is important for high-temperature application of this material.

Phase composition of $LiAlO_2$ prepared from AlOOH and Li_2CO_3 by solid-state reaction at T = 700 °C without and with two different modifications of the initial slurry



This study was supported in part by Fraunhofer Attract "Innovelle" and BMWi "MCFC_Next" projects.

Bundesministerium für Wirtschaft und Energie

1 *Schematic of the MCFC cell.*
2 *Granule of an AlOOH-Li_2CO_3 mixture obtained by spray drying of a water-based slurry.*

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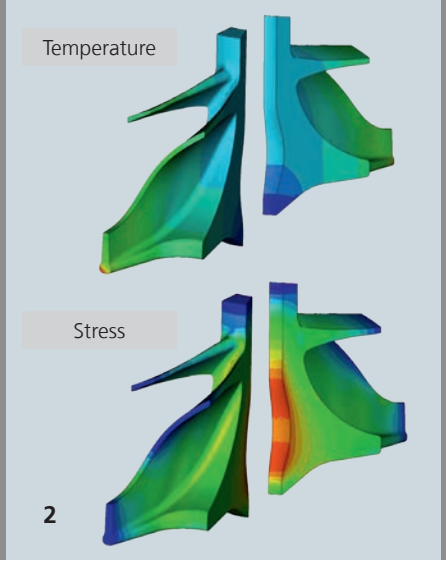


2

HIGH-PERFORMANCE CERAMICS FOR GAS TURBINES – FROM MATERIALS TO COMPONENTS

Dipl.-Ing. Willy Kunz, Dipl.-Ing. Johannes Abel, Dr. Tassilo Moritz, Dipl.-Ing Jens Stockmann, Dr. Hagen Klemm

Rotor for a micro gas turbine

With the development of renewable energies, the European environmental policy aims at decreasing fossil fuel consumption and pollutant emissions, thus emphasizing the need for reliable provision of energy at peak loads. Stationary gas turbines supply power very flexibly and produce comparatively little emissions because of their high efficiency. Micro gas turbines are predestinated for local and independent energy conversion with combined heat and power generation. Recent research and development activities have been focused on decreasing emissions and fuel consumption of such turbomachines. This can be achieved by increasing the efficiency through a higher operating temperature or a lower amount of cooling. Both approaches result in significantly higher turbine component temperatures. Metal alloys are already operating at their physical limits in terms of temperature and cannot tolerate any significant increases. Hence, substitution of metal turbine parts by high-performance ceramic materials can offer tremendous benefits.

A silicon nitride (Si_3N_4) rotor for a radial-flow micro gas turbine with a capacity of 30 kW_{el} was developed within the scope of a Fraunhofer project. The ceramic rotor exhibits long-term stability up to 1200 °C at maximum operating loads and can be mass-produced.

This project was a collaboration of five Fraunhofer institutes: IKTS (material development, fabrication), IPK (tool production, final shaping), SCAI (simulation, shape optimization), IFF (testing, lean gas tests), and IWS (bonding, coating).

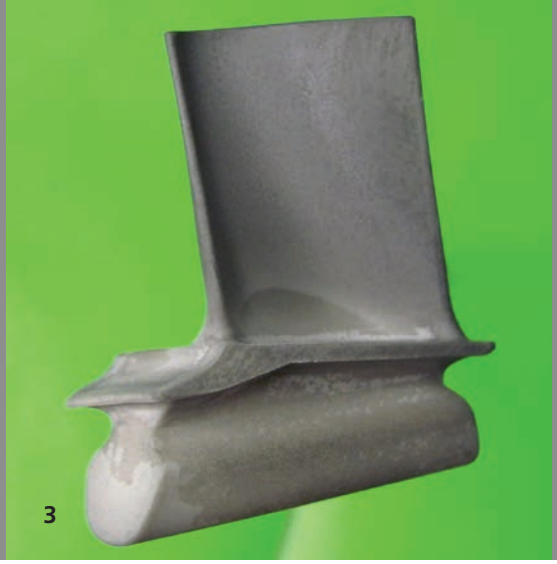
Si_3N_4 high-performance ceramics are suitable for rotating parts and high thermomechanical loads because of their excellent mechanical properties from room temperature up to 1400 °C. Dependent on chemical composition, sintering and after-treatment, specific properties can be amplified. To adapt the material properties to the operational stresses and to optimize the component design a repetitive adjustment of both is necessary.

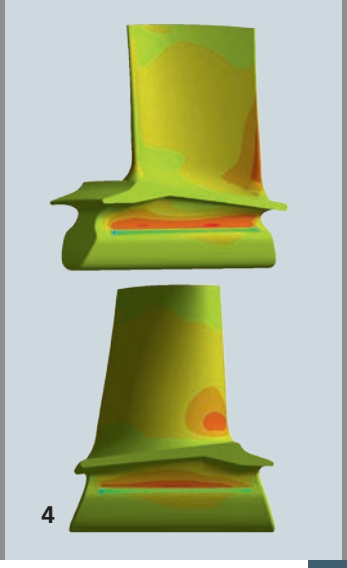
The illustration of a realistic profile of operational demands via simulative coupling of thermal and (fluid-)mechanical loads done by Fraunhofer SCAI was the groundwork for material development. Based on this data, specific development aims could be defined. The adjustment of the material properties was done by a targeted design of the grain boundary. This led to high strength as well as high oxidation resistance and fatigue strength up to 1200 °C.

Material data for micro gas turbine rotor

Operating temperature	1200 °C
Fracture toughness	6.8 MPa $m^{1/2}$
Strength	~ 1000 MPa
Fatigue strength at 1200 °C	~ 500 MPa

The near-net-shape process of ceramic injection molding (CIM) was used for fabrication. This method is very suitable for the production of high quantities with low loss of material. In this process, a heated thermoplastic compound composed of ceramic powders and an organic binder (feedstock) is pressed into a mold cavity under high pressure to form a near-net-shaped part. The large volume of the rotor (148 cm^3) imposed numerous demands on the mold cavity and the feedstock, with the





greatest challenge proving to be the debinding process. This problem was solved by an innovative combination of chemical and thermal treatment of the part to enable sintering of defect-free rotors.

Having undergone minor structural modifications, the Capstone® C30 gas turbine located at Fraunhofer IFF Magdeburg is now ready for installation of the ceramic rotor.

Turbine blades for a helicopter turbine

Airplane and helicopter engines and stationary gas turbines basically work according to the same principle. The difference is that in the former, the energy from the turbine stage is converted into thrust, not electricity. Also, a jet engine is constructed as an axial turbine, in which the gas stream does not change direction. The rotor is usually not a single part, but rather a ring with several blades attached to it.

In another Fraunhofer project, ceramic blades for the first stage of a Klimov GTD 350 helicopter engine were developed and produced. The goal was to make the blade and its material capable for operation at 1400 °C. The first part of the material development process was similar to that of the rotor for the micro gas turbine. First, a predictive simulation of the thermal and mechanical loads was made in collaboration with Fraunhofer IPK Berlin. Small changes were made to the blade geometry based on the requirements of the ceramic material. Because of the very high operating temperature, a material exhibiting very high creep and corrosion resistance was developed.

Due to their filigree shape with free-form surfaces, the blades were difficult to fabricate with a 5-axis milling machine. Very good mechanical properties (strength and hardness) are beneficial for operation but lead to time-consuming and expensive milling and grinding processes. Tool wear and process duration can be minimized by green machining, in which compacted powder is shaped by milling. Despite the filigree geometry of the blades, green machining was found to be suitable for fabrication. After finishing the sintering process, grinding was necessary only at the fitting surfaces at the blade roots.

The fabricated blades will be tested in cooperation with EURO-K GmbH.

Material data for helicopter engine blade

Operating temperature	1400 °C
Fracture toughness	6.1 MPa $m^{1/2}$
Strength	~ 700 MPa
Fatigue strength at 1200 °C	~ 450 MPa

Europa fördert Sachsen
EFRE
Europäischer Fonds für regionale Entwicklung
Gefördert aus Mitteln der Europäischen Union und des Freistaates Sachsen.

1 *Radial turbine rotor made of silicon nitride.*
2 *Simulated temperature and stress distributions at maximum load.*
3 *Engine blade made of silicon nitride.*
4 *Simulated stress distribution at maximum load.*

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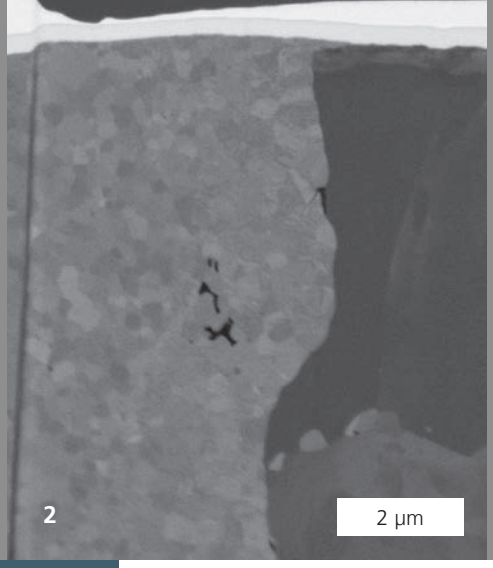

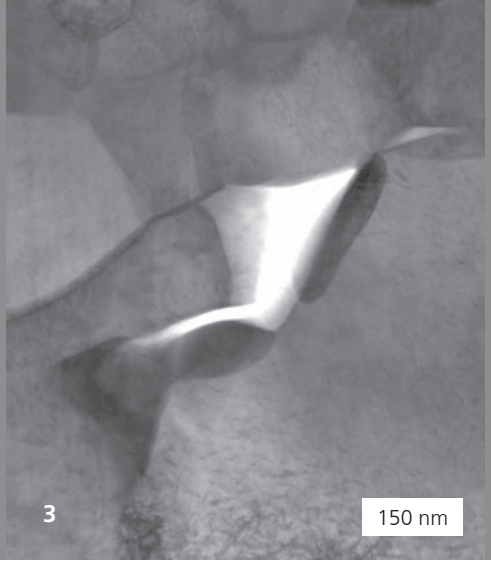

INTERFACE INVESTIGATIONS IN STEEL-CERAMIC COMPOSITE LAYERS

Dr. Uwe Mühle, Dipl.-Ing. Anne Günther, Dr. Tassilo Moritz, Dr. Mathias Herrmann

Tape casting can be used in a novel way to manufacture metal-ceramic composites with high process and resource utilization efficiency. This process, which includes the conventional sintering process, can be used with a wide range of products, especially steel-zirconia composites. The combination of Crofer 22 APU and zirconia is employed in fuel cell technology, a field in which Fraunhofer IKTS researchers are among the leaders. This material combination can also be applied in the manufacturing of high-temperature filter systems, membranes for gas separation, and tooling equipment.

The second group of suitable materials is the combination of zirconia with high-alloy 17-4 PH steel, commonly known as "surgical steel". These composites can be interesting alternatives for typical surgical instruments, such as bipolar scissors, grippers, and tweezers (Figure 1).

The properties of these products can only be improved when an understanding of the behavior of the incorporated materials at the microscale and the nanoscale is given. A key enabler for the further development of co-sintered steel-ceramic composites is knowledge of the mechanical, chemical, and long-term properties. The established characterization methods (optical and scanning electron microscopy) must be supplemented with imaging and analytical transmission electron microscopy (TEM). This requires the development of a proper method for preparation based on the focused ion beam technique (FIB).

The first experiments were focused on the application of a lift-out preparation technique at the boundary between steel and ceramics using the experience gained from other categories of materials.

This preparation technique was successfully used with various combinations of materials, especially densly sintered materials (Figure 2). The stability and feasibility of porous materials were achieved through infiltration with an epoxy material and subsequent curing.

Energy-dispersive X-ray spectroscopy (EDX) in the TEM was mainly used for elemental analysis. Crystallographic structures were investigated using electron diffraction. For both applications, the thickness of the TEM foil was maintained above a minimum value for ensuring the robustness of the specimen.

The scanning TEM (STEM) was operated in bright field mode to give the best results due to the high beam intensity used (Figure 3). In this mode, EDX spectra and elemental mappings of regions of interest were obtained. The alloying elements in the steel formed precipitations of oxidic nature at the interface between the steel and the ceramic layer. The effect of these precipitations on the mechanical behavior and under corrosion conditions will be the subject of further investigations.

1 *Bipolar scissors made of a laminated steel-ceramic composite.*
2 *Steel-ceramic composite TEM specimen prepared by using the FIB technique.*
3 *Interface showing precipitations.*

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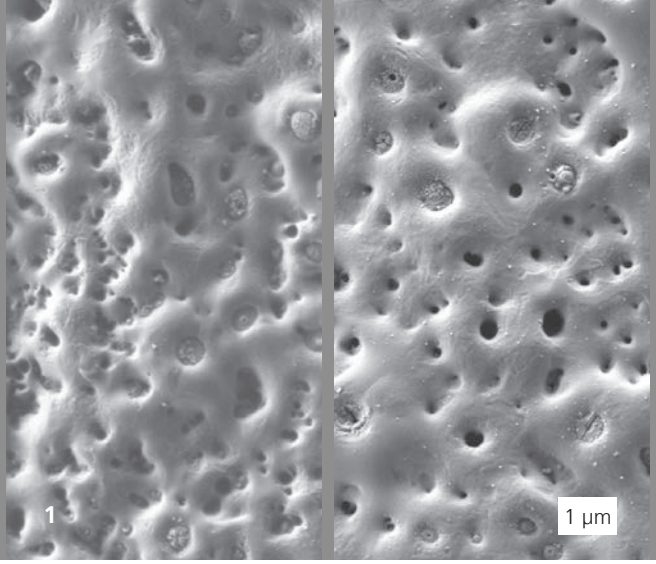

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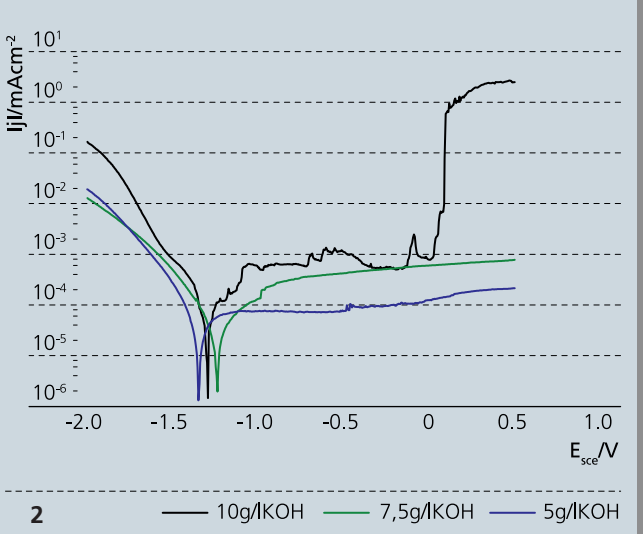

2

PLASMAELECTROLYTIC OXIDATION OF MAGNESIUM

Dr. Michael Schneider, Dipl.-Ing. Kerstin Kremmer

The high susceptibility of magnesium alloys to corrosion greatly restricts their use in lightweight construction. Previous attempts to improve the corrosion protection mainly involved organic coating systems on magnesium alloys. A further option is afforded by plasmaelectrolytic oxidation. This technique is similar to conventional anodizing in terms of the equipment used but employs a much higher applied voltage. This leads to dielectric breakdown of the conventionally formed oxide coatings due to the higher field strengths. The electric field strength causes ionization of the oxygen gas generated on the electrode interface, resulting in discharge of microscopic arcs (microsparks) on the surface of the material. The lifetime and the number of these sparks depend on the conditions, e.g., voltage or bath composition, under which the sparks are formed. This process is associated with pronounced localized heat generation, which causes the metals to be locally melted and thermochemically oxidized. The formed oxides are usually crystalline high-temperature modifications (e.g., MgO) with typical properties of oxides such as high resistance to chemicals. Due to the high resistivity, no electron transfer reactions (e.g., oxygen reduction) take place. Therefore, corrosion reactions are strongly inhibited. In the past, plasmaelectrolytic oxidation was usually carried out in fluoride-containing electrolytes. Recent research and development work has been focused on using fluoride-free electrolytes, which are less harmful in terms of health, safety, and the environment. One drawback of plasmaelectrolytic oxidation is the use of high voltages, which is associated with high energy consumption. Therefore, a further objective of research is to decrease the breakdown voltage.

The oxide layers formed usually exhibit a number of pores or sinkholes, which can act as sites for initiation of localized corrosion.

For approximately two years now, the working group on electrochemistry at Fraunhofer IKTS has been collaborating with colleagues at DECHEMA-Forschungsinstitut to develop a novel procedure that works with a lower breakdown voltage and in fluoride-free anodizing electrolytes and that allows for the simultaneous incorporation of encapsulated corrosion inhibitors into the oxide layer. The aim is to achieve a significant improvement in the corrosion protection of plasmaelectrolytic oxide layers on magnesium alloys.

Funding of this work by AiF (grant no. IGF 472-ZBG) is gratefully acknowledged.

1 *SEM images of the surfaces of two plasmaelectrolytic oxide (PEO) layers prepared on AZ31 using various electrolytes.*
2 *Current density versus potential for PEO layers prepared on AZ31 using various electrolytes.*

Forschungsnetzwerk Mittelstand AiF

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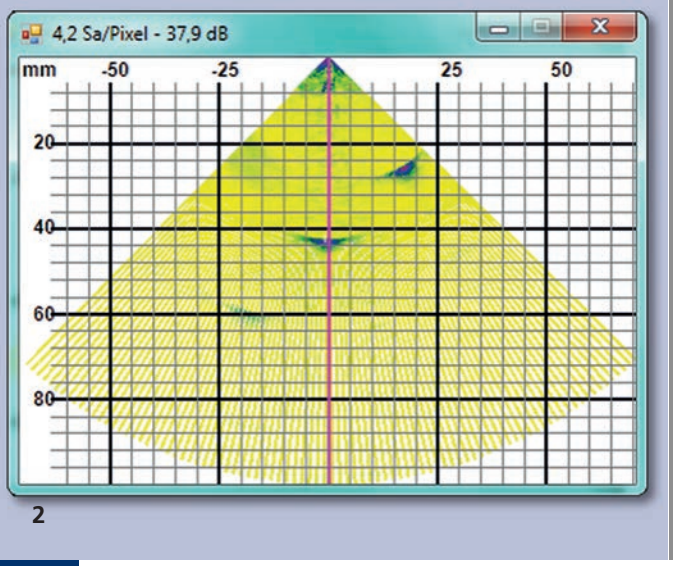


2

NEW HIGHLY SENSITIVE PHASED ARRAY PROBES BASED ON PMN-PT COMPOSITES

Dr. Thomas Herzog, Dipl.-Ing. Susan Walter, Dr. Frank Schubert, Jun.-Prof. Henning Heuer

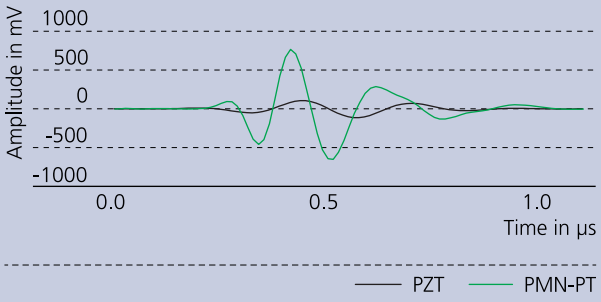
The single crystals of lead magnesium niobate/lead titanate (PMN-PT) are well known for their excellent piezoelectric properties and therefore make PMN-PT a promising material for the development of highly sensitive ultrasound transducers. Furthermore, they can be processed using the dice and fill composite technique as is used for PZT ceramics.

Piezoelectric 1-3 composites based on PMN-PT single crystals were developed, characterized, and used for the manufacturing of phased array probes in cooperation with the Korean company IBULE photonics. The goal of this project was to show that the new highly sensitive composite materials can be used for the manufacturing of ultrasound transducers and the conventional PZT-based composites can be replaced without extensive adjustment of the technological process. Phased array probes were manufactured from both composite materials with the same parameters, and then compared. For this purpose, ultrasound tests were performed on a simple polystyrene test body (Rexolite®) with a flat back wall at a distance of 18 mm as well as on a titanium test body with three diagonally situated side drill holes of diameter 0.5 mm.

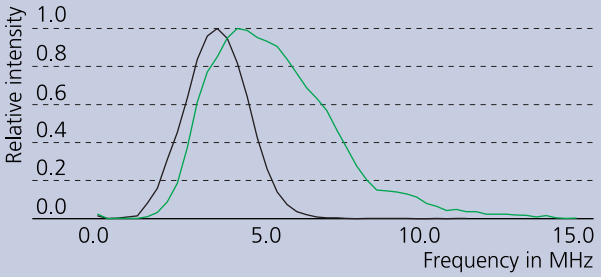
The results showed a sensitivity level that was more than 10 dB higher and a bandwidth that was 20 % higher for the PMN-PT-based transducer than for the conventional PZT-based one.

The new PMN-PT-based transducers are particularly interesting for applications where low signal-to-noise ratios can be expected due to geometric attenuation or long travel paths in the material under test.

Echo signals from a back wall at a distance of 18 mm



Frequency spectra of the above signals



1 *PMN-PT-based phased array probe on titanium test body with diagonally situated side drill holes.*

2 *Phased array sector scan between -45° and +45° with clear indication of drill holes.*

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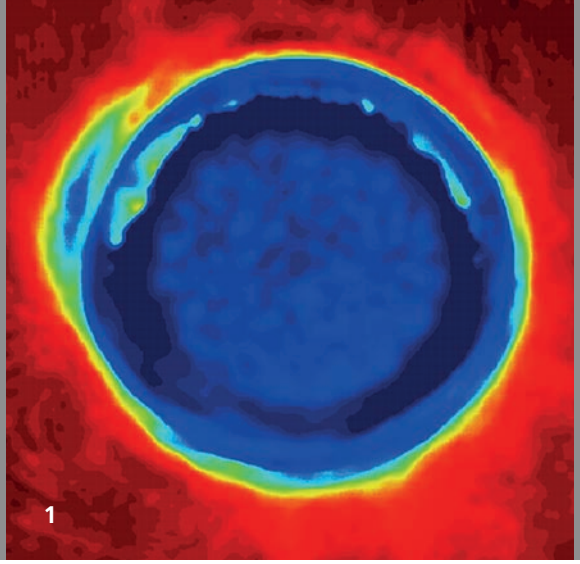
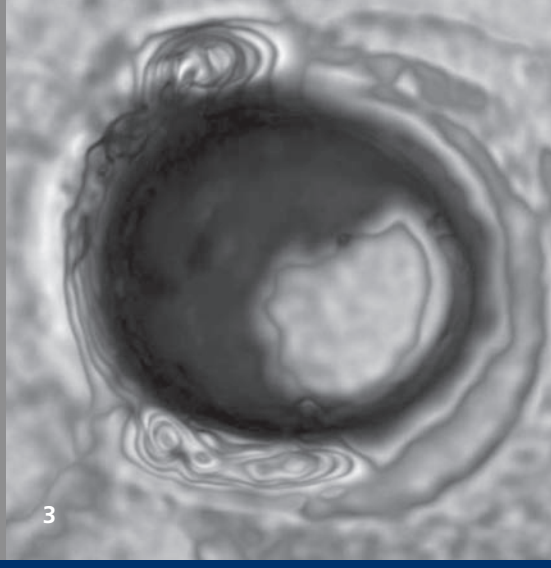


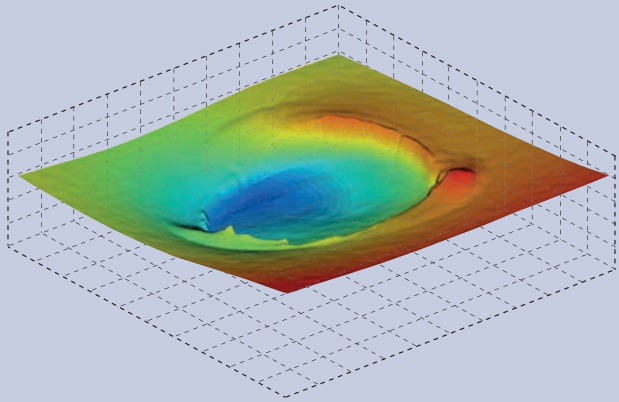


3D WELD NUGGET CHARACTERIZATION BY HIGH-FREQUENCY ULTRASOUND

Dipl.-Ing. Raffael Hipp, Dipl.-Ing. Andreas Gommlich, Dr. Frank Schubert

Resistance spot welding represents a well-established industrial joining technology due to its high cost-effectiveness and process reliability. Traditionally, the quality of a resistance spot weld has been tested destructively by the chisel test, in which the button of the weld spot is measured geometrically. Based on the assumption that constant process parameters, such as material type, welding time and electrode force, and other statistically varying parameters lead to similar but not identical results, the process quality can be characterized by the evaluation of random samples. However, for 100 % in-line testing, a non-destructive inspection method needs to be applied. The ultrasonic pulse-echo technique represents such a method. With conventional single-channel transducers, spot welds can be characterized by the evaluation of the echo signals integrated over the aperture of the transducer. However, in order to get a space-resolved evaluation of the spot weld in terms of high-resolution C-scan images, a mechanical scanner or an ultrasonic matrix array is necessary. The latter usually requires high-performance multi-channel electronic measuring equipment. Reference measurements based on high-resolution Scanning Acoustic Microscopy (SAM) showed that with this imaging approach, the lateral size of the weld nugget can be measured precisely. In contrast to conventional single-channel testing, this method also allows imperfections and other discontinuities to be localized and taken into account in the weld assessment. By considering the topography of the weld region and the coarse-grained nature of the microstructure inside the weld nugget, it is additionally possible to estimate the thickness of the weld nugget for full 3D characterization of the nugget. The thickness evaluation is based on the attenuation of the back wall echo caused by ultrasonic grain scattering. In practice, the mechanical scanning of the SAM can be replaced by the electronic scanning of an ultrasonic matrix array. The large number of channels and the high performance of the measuring equipment needed for such an approach are provided by PCUS pro Array II, the newly developed Fraunhofer IKTS in-house hardware platform. It offers 128 transmit and 128 receive channels and is fully cascadable so that even more than 128 channels can be addressed.

Topography of a resistance spot weld caused by indentation of the welding tong



1 *Color-coded back wall echo for estimation of the weld nugget thickness, showing the coarse-grained microstructure in the interior of the nugget.*

2 *Photomicrograph of a resistance spot weld with a coarse-grained microstructure and a void.*

3 *Typical C-scan of a spot weld with a light area indicative of an incomplete fusion.*

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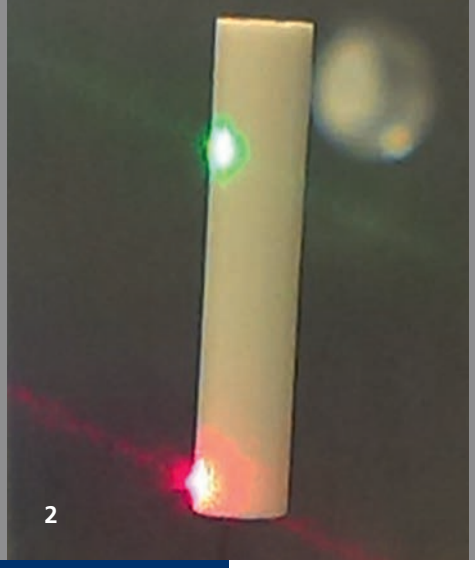


VIBRATION ANALYSIS: AN INTEGRAL METHOD FOR TESTING OF CERAMIC COMPONENTS

Dipl.-Ing. Martin Barth, Dr. Frank Duckhorn, Dr. Bernd Köhler, Dipl.-Math. Kilian Tschöke, Dr. Constanze Tschöpe, Dipl.-Ing. Thomas Windisch

Motivation

The increased application of high-performance ceramics, functional ceramics, and ceramics in composite materials imposes high demands on material properties and the absence of defects. Even the smallest of flaws – especially cracks – can lead to total component failure. Very often one is faced with the task of testing large numbers of components with only moderate efforts and costs.

Vibration analysis is a nondestructive method that can be used to identify a multitude of nonconformities. Any features that influence the vibration properties can be sensed. These especially include inner and surface connected flaws in parts otherwise considered to be defect-free. If applicable, the vibration analysis yields the information needed rapidly and therefore cost-efficiently. At Fraunhofer IKTS, a wealth of experience in the vibration analysis of (sintered) metal parts and tissue products is currently being applied towards quality assurance of ceramic components.

Challenges and features

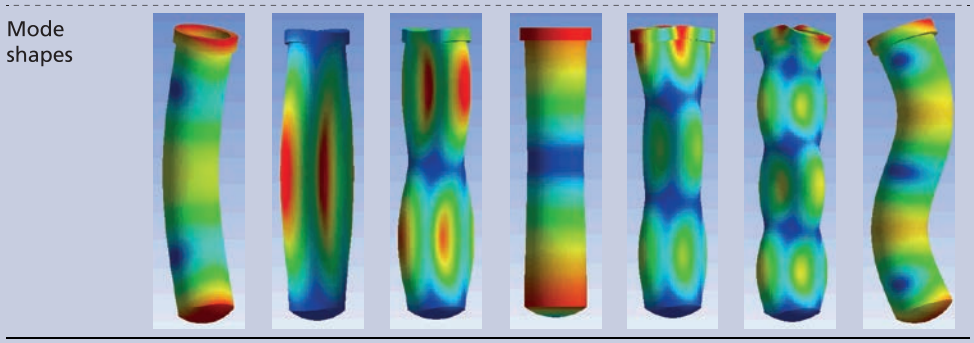
A part is usually excited by impact and vibrates freely. The support should not significantly influence the vibration. However, even if it does, some influences can be tolerated, as long as they involve vibrational modes that are not necessary for the assessment of the part quality. This requires optimization of the positions and the nature of the support. For the same reason, detection has to be nearly free from feedback.

Characteristics

As an integral testing method, vibration analysis yields a number of global parameters such as resonant frequencies and damping constants for various vibrational modes. These quantities are influenced by both intolerable changes in geometry, micro-, and macrostructure (= defects) and "normal" variations in geometry and mass. Therefore, reliable defect detection requires the selection and combination of appropriate features.

Application example 1: Ceramic electrolyte tubes

Na-ß-aluminate electrolyte tubes (Figure 1) show relevant resonance at frequencies above 10 kHz (Figure 3), which can be sensed by high-quality microphones. The tubes are excited by an automated clapper. For the present investigations, five tubes were used: three good parts, one with an increased leak rate, and one with a crack. It was first verified that tube detection was possible (detection rate: 99 %), irrespective of the striking position. After that a good/bad decision was made for unknown cups using a statistical model based on two good tubes as references. The remaining tubes ("Good3", "Leak", and "Crack") were compared to this model using two striking positions (P1 and P2). The following table shows the detection rates, which, with the exception of striking position P1 with a crack, were higher than 90 %. From this result, it was concluded that differentiation between good and bad parts was possible. Furthermore, the need for several striking positions for cups with cracks was recognized.



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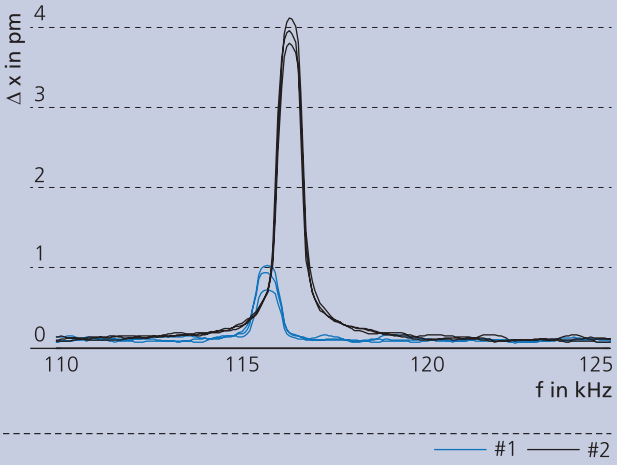
Detection rate for good/bad sorting of tubes "Good3", "Leak", and "Crack" and striking positions P1 and P2

Name	Position	Detection rate
Good3	P1	96 %
	P2	98 %
Leak	P1	98 %
	P2	100 %
Crack	P1	16 %
	P2	92 %

Selected eigen frequency of a cylindrical ceramic hollow part



Application example 2: Cylindrical ceramic hollow part

As expected, the FEM simulation of the part with a length of only a few millimeters (Figure 2) only revealed significant resonance at relatively high frequencies of more than 100 kHz. Hence, the usual method of mechanical excitation along with vibration detection by microphones could not be used, and wide-band excitation by a laser pulse and detection by a laser vibrometer were employed instead. After the excitation and detection positions were optimized, significant eigenmodes could be identified and evaluated. For the sake of clarity, a single peak in the full vibration spectrum was selected. The complete measurement cycle – including positioning of the part in the measurement setup – was repeated three times. The resonant frequency was completely stable for each part, but the good/bad sorting results differed significantly. Further investigations will show how flaws can be distinguished from other (tolerable) variations in the parts.

Summary

Vibration analysis must be adapted specifically to each part and to each defect type for a given part. This adaptation includes selection of an appropriate means of signal excitation and signal detection, signal preprocessing, and compensation of tolerable property changes (e.g., mass and geometry variations) as well as automated evaluation of signals and sorting into "good" and "bad" parts.

Services offered

The applicability of vibration analysis for customers' parts can be examined. If the analysis yields a positive result, the customer can order the on-site design, setup, and leveling of a testing device. This includes installation of automated data evaluation systems and appropriate training.

1 *Ceramic cup with automated mechanical excitation and microphone.*

2 *Cylindrical part with excitation laser (green) and detection laser (red).*

3 *FEM simulation of the mode shapes and their eigen frequencies in kHz.*

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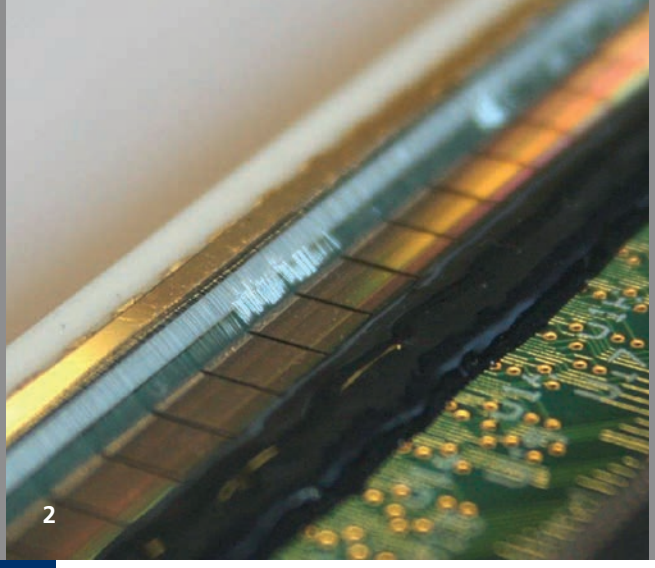

2

L100 X-RAY LINE DETECTOR FOR FAST IN-LINE APPLICATIONS

Dr. Peter Krüger, M. Sc. Susanne Hillmann, Jun.-Prof. Dr. Henning Heuer

In the context of a strategic alliance with Fraunhofer IPMS and Fraunhofer FEP, a novel X-ray line detector was developed. X-ray detectors are gradually replacing the X-ray films still common in radiography today and are essential for X-ray computed tomography. In conventional indirectly converting detectors, the incoming X-ray photons are converted into visible light, which is then converted into electrical signals by photodiodes for subsequent processing. The intermediate step of converting the X-ray photons into light photons has potentially negative effects on the detector's resolution and linearity. To overcome this difficulty, the L100 X-ray line detector presented here works as a directly converting detector, which means that the X-ray photons are directly converted into electrical signals in a kind of a photodiode.

The advantages of this concept are a significant improvement in resolution and linearity as well as the possibility of estimating the energy of each photon presented by the single-photon sensitivity, which in turn can be efficiently used for dual-energy applications, such as material sorting.

Line detectors are used when moving objects need to be analyzed or if the size of the test specimen only permits the use of a well-collimated illuminating beam for elimination of undesirable scattered radiation. The line detector developed in the present work is assembled using application-specific integrated circuits (ASICs) to enable low-cost manufacturing and high configuration flexibility.

The prototypes currently under test have a line length of 102.4 mm and achieve a resolution of 100 µm in test conditions.

They can be constructed with two different kinds of absorber materials, enabling detection of X-ray photons in energy ranges of 30–200 keV and 2–40 keV. Thus, the X-ray line detector can be used for both imaging and diffraction applications. The minimum counting time of the detector is 20 µs, which makes it possible to examine the test objects at a speed of around 50 m/s (dependent on the test design).

Combined with the XVision X-ray computed tomography control and analysis software, customized X-ray microtomography systems with intuitive user interfaces can be constructed.

1 *L100 X-ray line detector, complete system.*
2 *Close-up of the active area of the L100: absorber (upper left) wire-bonded to the readout electronics (lower right).*

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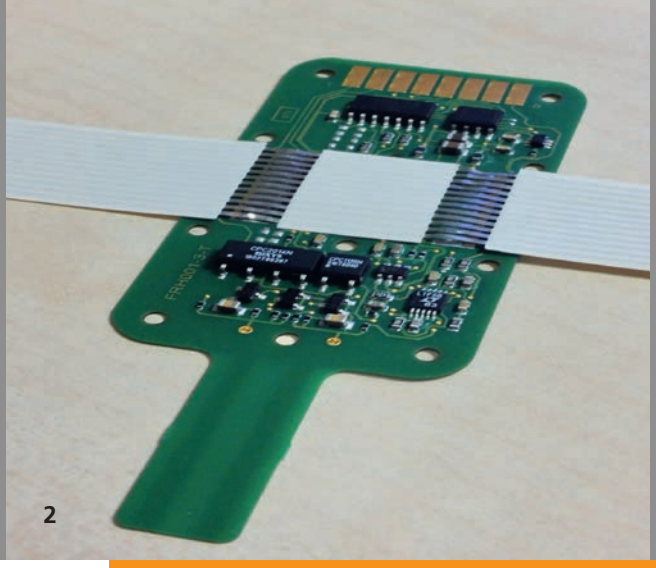

RELIABLE DESIGN OF SHM ELECTRONICS FOR APPLICATION IN HARSH ENVIRONMENTAL CONDITIONS

Dipl.-Ing. Robert Schwerz, Tobias Gaul, Dr. Mike Röllig, Bernd Frankenstein

Even novel sensors work in conjunction with measurement and signal-evaluating electronics. Research at Fraunhofer IKTS is focused on developing sensor systems based on ultrasonic guided waves for structural health monitoring (SHM). These SHM systems are used on safety-relevant structures of machines located in harsh environments. An example is a sensor ring system for underwater inspection of weld seams on steel-based foundation structures located in the ocean.

Design of sensor systems with robust handling, long-term functionality, and reliability is a prerequisite for customer acceptance and cost efficiency. Within the scope of the current "Sensormanschette" project, solutions were found for an SHM system for use at a depth of 20–40 m below the water surface and with a service life of 10 years. Hermetic encapsulation in water and diverse liquids, pressure resistance of electronics, shape adaptation on curved steel surfaces, and robust handling by deep sea divers were realized. In general, the functional targets of very low ultrasonic signal losses had to be kept sight of in every work step. The inner design of the sensor nodes and the selection of the packaging materials were critical aspects.

The encapsulation design was based on significantly enlarged diffusion paths for liquid molecules and use of materials of very low hygroscopicity. Additionally, three barrier levels were integrated for protection from infiltrating moisture: a cover foil (polymer carrier with multiple inorganic layers), an embedding material for the sensor nodes (thermoplastic), and an encapsulation material for the electronics (epoxy-ceramic composite or liquid-resistant polyurethane). Avoidance of interdiffusion pathways for liquid media, even under mechanical force and bending conditions, was crucial. Micromechanical investigation of resistance to crack initiation under bending was performed. Care was also taken to avoid air inclusions and voids in the embedding materials because of their potential to form diffusion pathways. Underfill materials were applied under the electronic components to avoid air gap creation and thus prevent spontaneous cracking under high-pressure loading in underwater conditions. Piezoceramic sensor elements to generate ultrasonic waves were successfully embedded in the electronic substrate, thereby generating cost advantages over isolated external piezoelectric patches, reducing the number of critical electromechanical contacts, and contributing to greater system reliability. The final packaged solution was then tested in pressure chambers and released for testing at the underwater location.

1 *Example foundation node from the "UnderWaterInspect" project.*
2 *Layout for reliable sensor electronics.*

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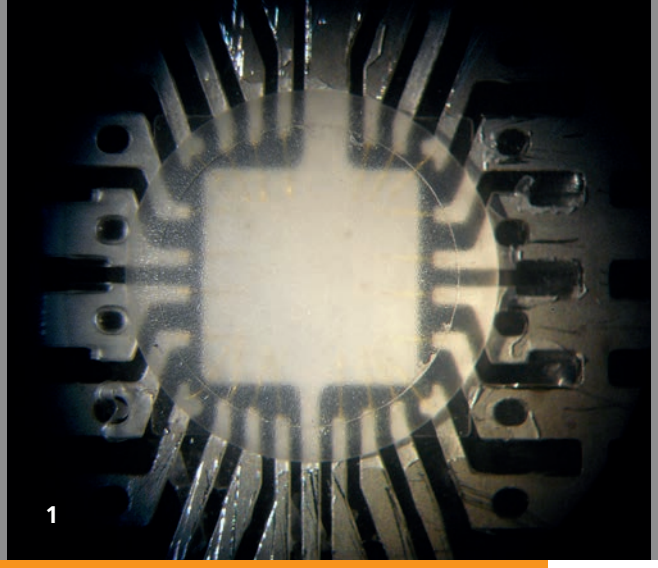
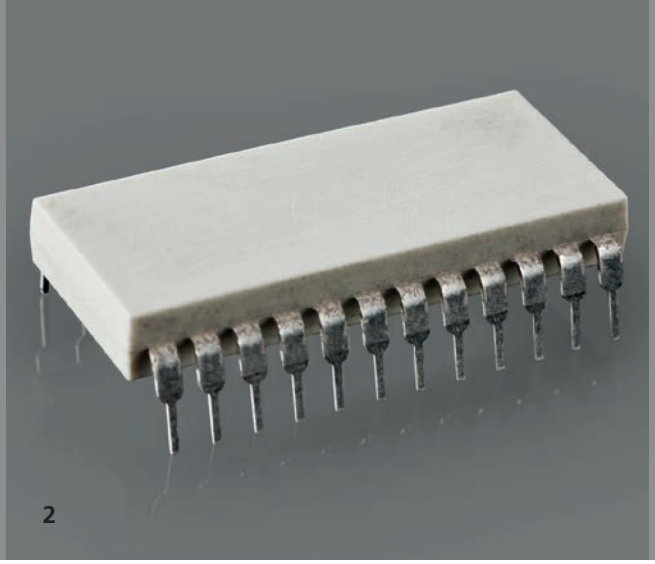




POLYMER-CERAMIC HOUSINGS FOR HIGH-TEMPERATURE MICROSYSTEMS

Dipl.-Chem. Ralph Schubert, Dipl.-Ing. (FH) Jeannette Kuhn, Markus Beyreuther

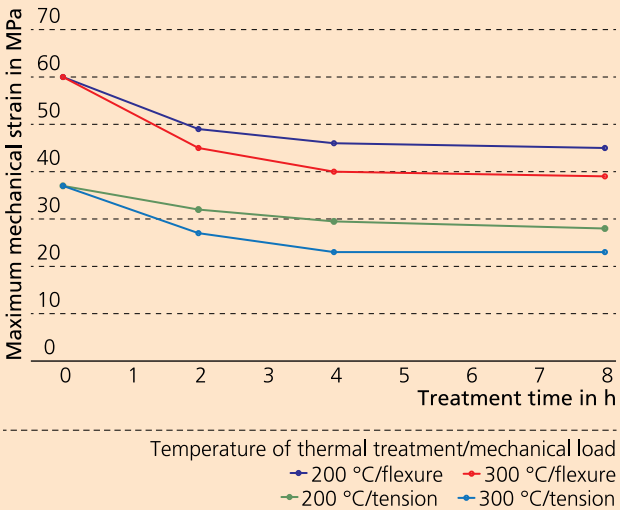
Modern electronic and mechatronic systems have to comply with strict environmental regulations while simultaneously facing growing cost pressures. Thus, a higher service temperature of up to 300 °C is being pursued in many fields, including the automotive industry, power engineering, and industrial metrology. This requires new solutions for the development of materials and technologies for packaging of integrated circuits, with hermetic housing being a key aspect.

Polymer-ceramic composite materials developed at Fraunhofer IKTS are used for the implementation of thermally stable hermetic housings. Polymer-ceramic composites consist of ceramic fillers and a matrix of organosilicon polymers. The polymer matrix can be transformed into a ceramic-like structure by heat treatment, resulting in a composite with enhanced thermal stability.

Following the selection of appropriate systems of silicone resins and optimized filler combinations, two composite systems for a two-step housing technology were developed. The first step comprises the encapsulation of the mechanically sensitive microelectronic component and bonding wires with a low-viscosity, cold-plastic pourable material by dip coating and subsequent thermal crosslinking. In the following step, a mechanically stable housing is formed out of a highly filled polymer-ceramic composite by thermoplastic joining and thermal crosslinking of two housing shells.

Investigations regarding the thermomechanical stability of the polymer-ceramic housing materials during heat treatment showed an initial reduction in flexural and tensile strength up to 300 °C but a sufficient and stable mechanical strength at higher temperatures.

Thermomechanical stability of polymer-ceramic housing materials



1 *Primary encapsulation of microelectronic component by dip coating with pourable polymer-ceramic system.*
2 *Highly filled polymer-ceramic composite housing for encapsulated microelectronic components produced by warm pressing/injection molding.*

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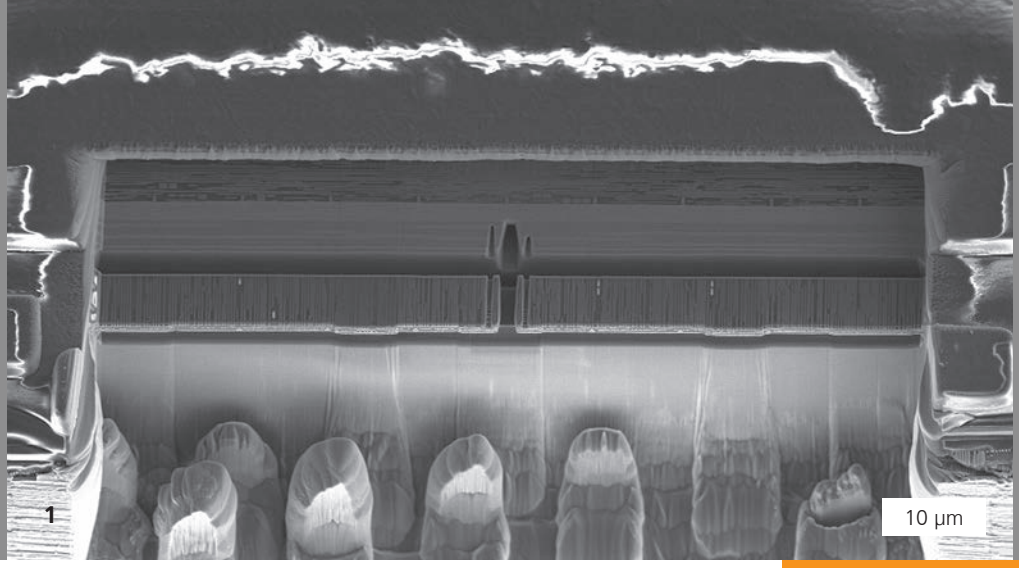

1

MULTISCALE MATERIALS DATABASE FOR 3D IC MICROELECTRONICS

Dipl.-Ing. Christoph Sander, Dr. André Clausner, Dr. Martin Gall, Prof. Ehrenfried Zschech

The microelectronics industry has been pursuing the strategy of shrinking technology nodes to increase the transistor density and efficiency for decades now. This trend has been governed by "Moore's law", which states that the costs per transistor are halved approximately every two years. However, this economic law has come up against its physical limits, forcing new approaches, such as "More than Moore", to be taken. These concepts entail further integration of microelectronics elements through 3D stacking of silicon-based dies (3D-integrated circuits, or "3D IC" for short), leading to thermomechanical stresses due to the thermal expansion mismatch between the integrated materials. To guarantee the reliability of a 3D IC, it is necessary to perform FEM simulations with precise materials properties (e.g., CTE, Young's modulus, and Poisson's ratio). Often, these materials properties cannot be determined with standard characterization techniques and thus new, advanced methods are needed. In addition, the scales of the 3D IC parts differ by several orders of magnitude, making FEM models of complete 3D ICs very complex. An alternative approach is the simplification of a 3D IC model using mean values for the materials properties for distinct parts of the 3D IC. These materials properties form a multiscale materials database.

One part of a 3D IC that can be simplified in an FEM model is the back end of line (BEOL), the on-chip wiring level, comprising a mesh of dielectrics and copper. The characterization of the mean values for CTE and Young's modulus requires specimen sample preparation using the focused ion beam (FIB) technique in the scanning electron microscope (SEM). Precisely defined regions of the BEOL are excavated in the form of free-standing cantilevers to allow investigation of the elongation under the influence of heat and the compliance under mechanical loading. In the characterization of the coefficient of thermal expansion, the elongation of the specimen on a hot stage is observed in the SEM at a high resolution and is analyzed using automated image analysis routines. For determination of the Young's modulus, the free-standing cantilevers are each loaded at the free end with a nanoindenter. During loading, the cantilevers bend and the loading forces and displacements are recorded with a high resolution.

With these two methods, anisotropic CTE and Young's modulus behavior can be investigated for various regions of the BEOL as a function of copper volume fraction and dominant copper line direction. Complex BEOL structures can be modeled with less detail using these effective materials properties, with mean materials properties replacing distinct BEOL building blocks. In FEM simulations of microelectronic devices at the chip package or transistor level, these BEOL simplifications enable analysis of larger models or a significant decrease in computing time with the same level of accuracy as that of detailed BEOL models.

1 *SEM image showing two free-standing cantilevers for the investigation of the coefficient of thermal expansion and the Young's modulus. The back end of line (BEOL) was excavated utilizing the focused ion beam (FIB) technique.*

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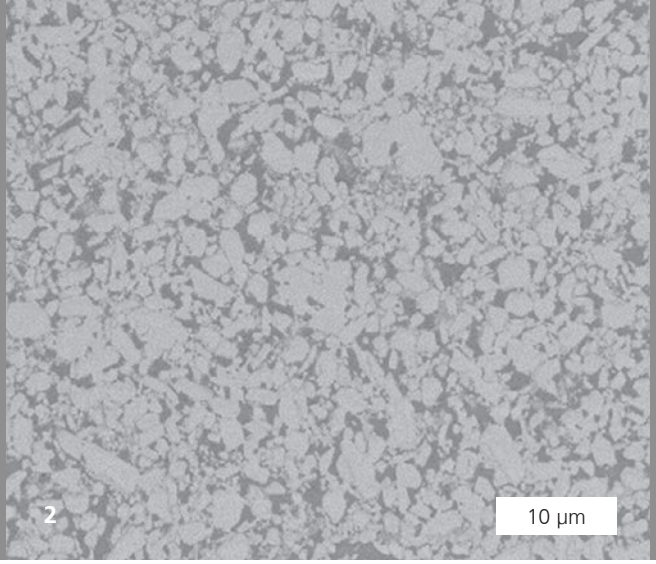

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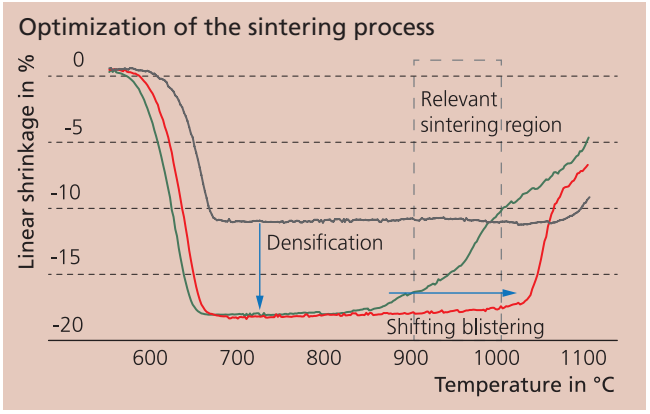
OPTIMIZATION OF SODIUM ION CONDUCTING GLASS-CERAMICS FOR SOLID ELECTROLYTES

Dr. Jochen Schilm, Dr. Axel Rost, Dipl.-Ing. Dörte Wagner, Dr. Katja Wätzig, Dr. Marco Fritsch

The evaporation of sodium at high temperatures (> 1600 °C) and the formation of a multiphase microstructure make the sintering of typical sodium-conducting solid-state electrolytes (i.e., NASICON and Na-ß"-Al_2O_3) an arduous task. Glass-ceramic materials in the system Na_2O-Y_2O_3-SiO_2 present an alternative that allows sintering below 1000 °C while achieving comparable conductivities. The aim of the present work was to produce dense monolithic and planar membranes by tape casting and pressureless sintering in air. The development of sintering-active glass-ceramic materials with ionic conductivities comparable to those of NASICON and commercial Na-ß-Al_2O_3 ceramics was the starting point of this work. The sintering process was optimized in order to achieve suitable process control for tape casting as an established ceramic shaping technology. A major challenge was the formation of porous microstructures during sintering at temperatures of above 800 °C due to evaporation of gaseous substances (H_2O and CO_2) in the highly viscous glass melt and the resultant volume expansion (foaming) of the components (see diagram). This hindered the formation of the conductive crystalline phase $Na_5YSi_4O_{12}$ with a dense microstructure and promoted the formation of the less conductive phases $Na_3YSi_3O_9$ and $Na_9YSi_3O_{18}$. Optimization of the glass synthesis process through combination of an adjusted grinding and precrystallization step shifted this behavior to higher temperatures. Furthermore, the average particle size of the prepared powders was reduced to less than 2 µm, which can be taken as a requirement for preparation of substrates with a thickness of less than 100 µm (Figure 1). Glass-ceramic materials with an ionic conductivity of $1.4 \cdot 10^{-3}$ S cm^{-1} at 25 °C in conjunction with an increase of the sintered density from 85–90 % to 97 % of the theoretical value were realized with the optimized process



(Figure 2). The doctor blade process was used for the fabrication of planar glass-ceramic substrates based on glass powders. Adhesion of the glass was avoided through modification of the sintering substrates and the heat treatment step; freestanding substrates with a thickness of 90 µm at the highest density were achieved. The dimensions of the sintered substrates were in the range of 50 x 50 mm.

Services offered

- Development/optimization of ion-conducting glass and glass-ceramic materials
- Sintering/shaping technologies for solid-state electrolytes
- Characterization of physical and electrochemical material properties
- Manufacturing and testing of cells

1 *Cross section.*
2 *Na^+-conducting glass-ceramic substrates.*

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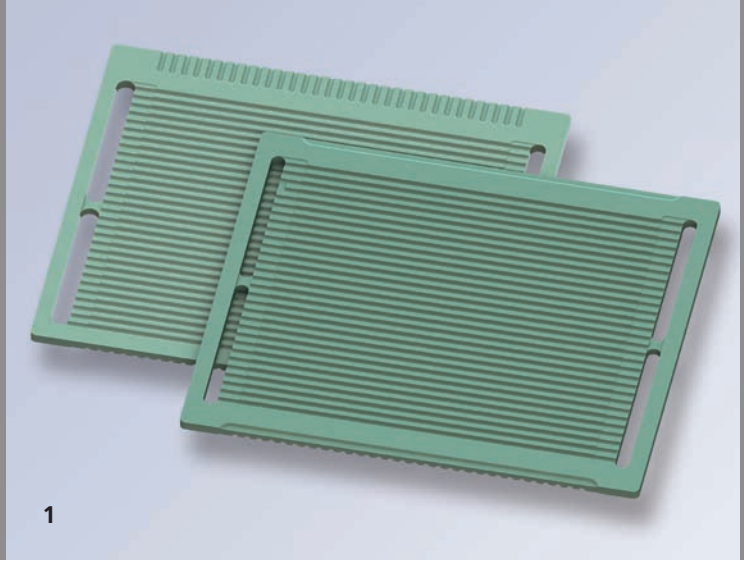

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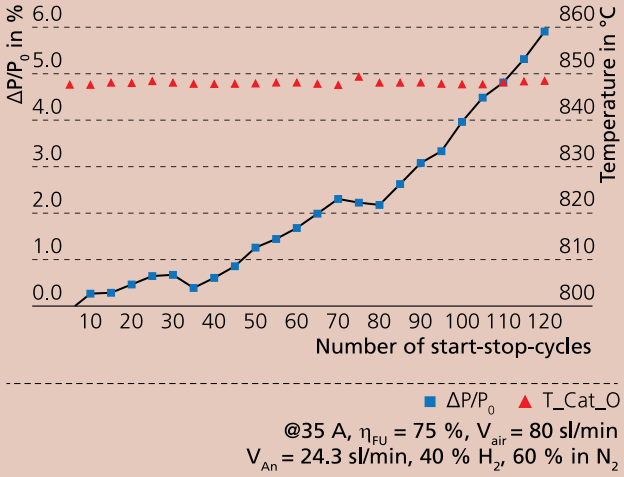
CFY-STACKS – PROGRESS THROUGH DESIGN DEVELOPMENT

Dr. Stefan Megel, Dr. Mihails Kusnezoff, Dr. Nikolai Trofimenko, Dr. Jochen Schilm

The development of CFY-stacks is a long-standing focus of R&D activities at Fraunhofer IKTS. With stack design MK351, a good platform for enabling proliferation of SOFCs in a wide range of applications was created. Stacks with high efficiencies and low degradation rates (0.7 %/1000 h over > 20.000 h) perform as reliable components in a variety of SOFC systems developed in internal and external projects. In close collaboration with Plansee SE, Fraunhofer IKTS was able to improve the MK351 stack design. The new MK352 stacks are more robust, can be easily integrated into SOFC systems, and feature a lower pressure drop along the air path. Moreover, this stack type affords a reduction in production costs and an enhancement in yield, both of which are very important for commercialization of the CFY-stack technology. The new stack is based on a symmetrical interconnect design enabling compensation for tolerances resulting from net-shape pressing technology and simpler stack integration into larger modules. By modifying the tolerance chain for all of the stack components, it was possible to improve manufacturing system and performance robustness. In hotbox tests with a 30-cell stack, a new benchmark for start/stop cyclability was set. The stack showed a power degradation of 0.5 %/10 cycles over more than 120 cycles (Figure 1).

Layout changes in the air channels of the interconnect flow field led to a pressure drop that was more than 50 % lower than that of the actual MK351 design. Thus, the total SOFC system efficiency can be enhanced due to the lower energy consumption of the air blower insofar as less power is needed to supply the air to the stacks.

Degradation of 30-cell stack during start/stop cycling in hotbox operation without fuel path purging



After completion of successful validation of MK352 design in standard testing of performance, long-term stability and start/stop cyclability, the new robust, efficient and cost-efficient stack platform will be available for various SOFC systems.

Services offered

- Test of stack components for SOFC/SOEC under real operating conditions
- Development of stack modules for utilization in SOFC systems
- Purchase of SOFC/SOEC stacks and modules

1 *Interconnect of MK351 (back) and MK352 (front).*

2 *MK352 30-cell stack ready for delivery.*

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ULTRASONIC TESTING OF OFFSHORE TURBINE STRUCTURES

Dr. Bianca Weihnacht, Dr. Lars Schubert, Dipl.-Math. Kilian Tschöke, Dr. Peter Neumeister, Dr. Holger Neubert

Motivation and objectives

Due to the growing number of offshore wind parks in the North Sea and the Baltic Sea, the demand for adapted and cost-efficient monitoring methods is rapidly increasing. Figure 1 shows the EnBW Baltic 1 wind park, the first commercially operated offshore wind park in the Baltic Sea.

The focus of wind farm monitoring lies on the foundations of the plants, which are permanently exposed to tidal, wave, and wind forces. The steel-concrete-steel connection (grouted joint) between the monopile, which is driven into the seafloor, and the transition piece, the access and service platform, is a central element in a monopile foundation. Figure 2 shows a service platform, which allows access to the turbine. Maintenance and inspection are performed from this transition piece.

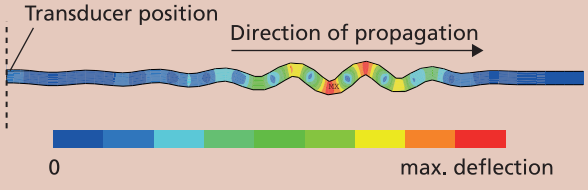
Methods for monitoring the concrete hardening process and for the detection of defects in the grouted joints are currently not available for offshore structures. However, techniques and acoustic methods known, e.g., from bridge construction can be used for monitoring the concrete hardening process and the concrete quality. The challenge lies in developing a sensor-actuator system for a test object with the size, structure, and geometry of a monopile foundation. Furthermore, access to the turbine, which is currently only possible via the transition piece (Figure 2), must be taken into account.

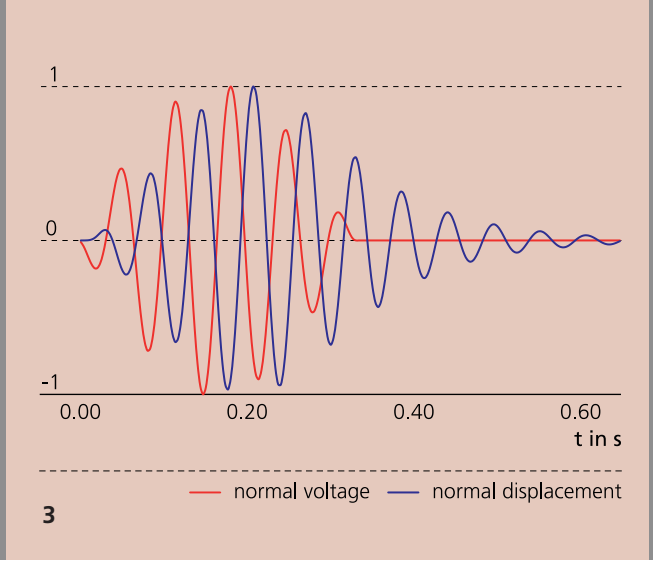
The first step was to develop the methods to be used as a basis for monitoring the grouted joints by guided waves. This was realized by simulations in order to estimate the frequency range from dispersion curves and determine the necessary acoustic power of the ultrasonic transducer based on an optimum receiving level. The accessibility in the turbine and the attenuation caused by the surrounding water and the seafloor were taken into account. The simulation results also yielded information regarding the minimum detectable size of defects in the concrete.

Transducer layout and design

The transducer layout focused on the dimensioning of the piezo-electric element, where the conversion from electrical excitation to mechanical wave took place, and on the acoustic wave transmission into the tested structure. In the present case, the latter was a thick sheet made of construction steel. Finite element (FE) analysis utilizing the FE package ANSYS was used with parametric models generated for this purpose. By varying the height of the piezoelectric element, the number of piezo-electric layers, and the geometry of the sonotrode, it was possible to develop a configuration with the maximized deflection at

Simulation of transducer radiation pattern





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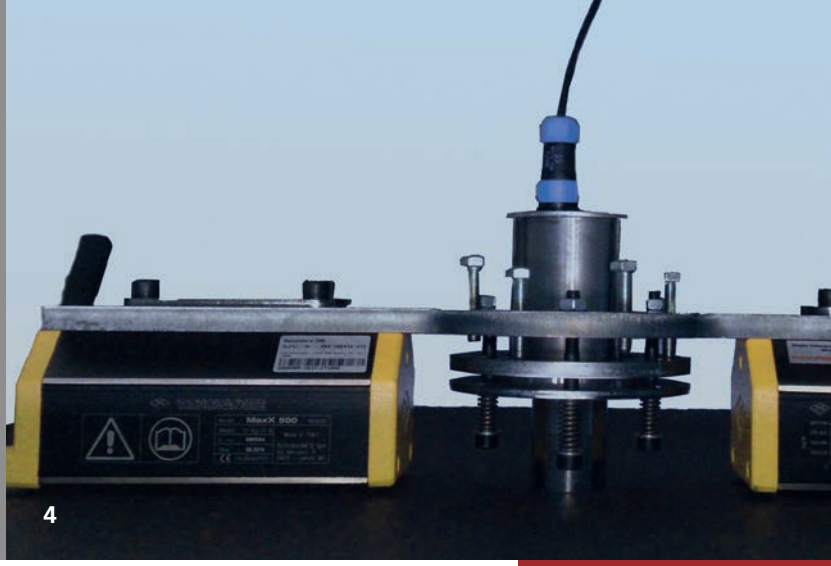

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the optimum rate of decay. The simulations showed that in transient operating mode, which is typical for acoustic structural monitoring, a backing brings no additional benefit. Furthermore, the optimum transducer height was found to depend on the geometry of the structure under consideration. The Figure on the left-hand side shows the axisymmetric FE model of the steel sheet with an induced bending wave. The transducer (not shown) is situated along the rotational axis on the sheet on the left side of the figure.

Figure 3 shows the electrical voltage and the resulting displacement at the bottom side of the steel sheet right below the transducer as a function of time. The distinct vibrational decay is indicative of a very clean and concentrated induced signal.

The simulation also takes into account the acoustic force over time inside the piezoelectric element as well as between the sonotrode and the sheet. From this information, the necessary preloads in the piezoelectric element and the required contact force of the transducer assembly were derived. The latter formed the basis for the design of the transducer support. Since permanent installation of supporting structures was not the desired solution for the present case, a magnetic mount with permanent magnets was developed. This had the main advantages of not requiring any additional power supply and being commercially available in various sizes in the form of lifting magnets. The actual transducer assembly consisted of a piezoelectric element and a sonotrode. It was mounted on a baseplate via a rotating pivot mount to enable flexible positioning of the transducer. An interchangeable sonotrode tip allowed for simple adaption of the sonotrode to different curvatures of the contact surface.

Experimental validation

The transducer construction and the inspection technique were validated in laboratory experiments and onshore measurements. The simulation-based design of the actuator was successfully verified by 3D laser vibrometry. Figure 4 shows the laboratory setup. The emitted acoustic power corresponded to the simulation predictions. In a further step, it was possible to carry out acoustic measurements on an onshore monopile to confirm the feasibility. Offshore measurements will follow.

Summary

The monitoring and testing of offshore wind turbines imposes completely new demands on measurement equipment and the applied technologies. The developed ultrasound test equipment can be used for the monitoring of concrete hardening in grouted joints during the erection of wind turbines and for defect detection in these joints during operation.

With initial simulations using in-house simulation tools, design and layout of ultrasonic transducers, and test measurements, Fraunhofer IKTS offers a complete development chain for adapting existing structural monitoring techniques to customized and technically challenging applications or developing completely new techniques. The transducers specifically developed for the monitoring of grouted joints and the corresponding measurement equipment can be adapted to requirements of various applications. The offer also includes measurements for process development and validation performed by Fraunhofer IKTS.

1 *Baltic 1 offshore wind farm.*
2 *Transition piece in an offshore wind power plant.*
3 *Simulation of transducer radiation pattern.*
4 *Laboratory setup of a manufactured actuator for laser vibrometry measurements.*

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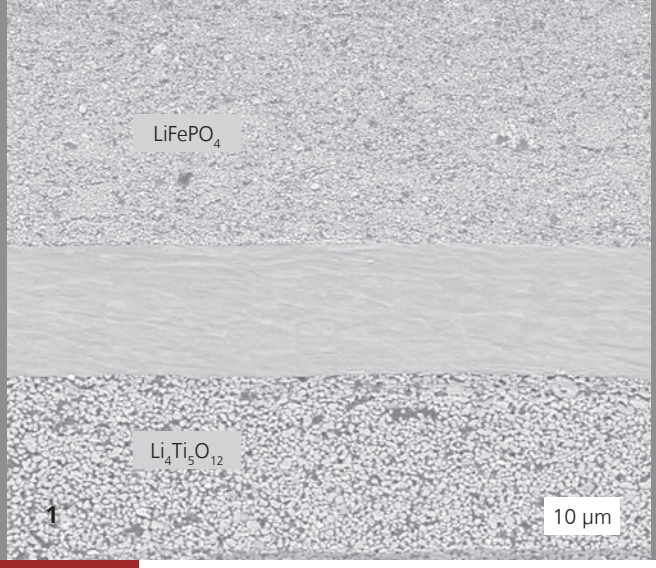

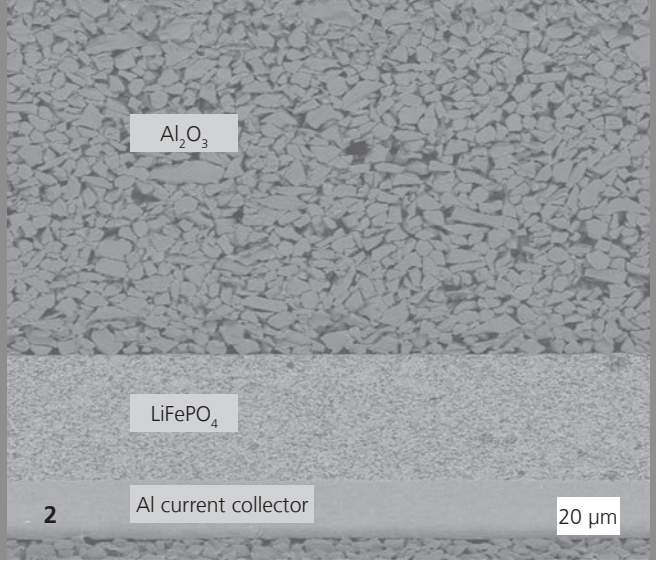

EMBATT BIPOLAR BATTERY: NEW BATTERY DESIGN FOR HIGHER ENERGY DENSITY

Dr. Mareike Wolter, Dr. Kristian Nikolowski, Dr. Marco Fritsch, Dipl.-Ing. Stefan Börner, Dipl.-Chem. Beate Capraro

Availability of low-cost battery systems and energy densities higher than 450 Wh/L are prerequisites for wide-scale market penetration of electric vehicles. To meet these requirements, the established monopolar Li-ion cell technology employs active materials with increased energy densities or optimized cell and system packaging. With the EMBATT battery design, Fraunhofer IKTS and partners IAV GmbH and ThyssenKrupp System Engineering GmbH are taking a new approach. The consortium jointly develops large-scale lithium bipolar batteries as well as the associated manufacturing technologies and concepts for direct integration into vehicle chassis. The EMBATT bipolar battery consists of stacked cells, in which the current collector of the negative electrode of one cell is in contact with the positive electrode of the next cell. Thus, two electrochemical cells connected in series share one current collector – one side of the bipolar electrode serves as the anode in one cell and the other side as the cathode in the next cell.

Through this simple stacking of cells, the bipolar battery design does away with complex cell packaging and delivers a stack voltage resulting from the number of single cells in the stack. The advantages of this design are numerous: low internal resistance in the stack, the option to use very large electrode areas, and elimination of the need for extensive cell connections as are found in conventional battery systems. The EMBATT design thus transfers the high energy density from the cell level directly to the battery system.

In the first step of the recently started project, the partners developed a cell design optimized for subsequent manufacturing and vehicle integration. Fraunhofer IKTS developed the design of the bipolar electrode as well as suitable environmentally friendly and efficient production processes.

Based on the results of studies conducted to determine the optimal electrode balancing, bipolar electrodes were prepared with $Li_4Ti_5O_{12}$ (LTO) as the anode and $LiFePO_4$ (LFP) as the cathode material. Use of $LiNi_{0.5}Mn_{1.5}O_4$ (LNMO) on the cathode side in the future will allow for a further increase in the cell voltage and hence the energy density of the stack. Studies on the optimal synthesis conditions of this so-called high-voltage cathode material are currently underway.

Technologies aimed at simplifying future cell production by enabling a ceramic separator to be applied directly to the electrode are also being developed. This will eliminate the need for an additional separator component for the bipolar battery.

In initial tests, bipolar stacks achieved the expected performance with the prepared electrodes and separators.

1 *Bipolar LTO/LFP electrode.*
2 *Ceramic separator directly coated on LFP cathode using water-based process.*

SAB Sächsische AufbauBank

Europa fördert Sachsen EFRE Europäischer Fonds für regionale Entwicklung
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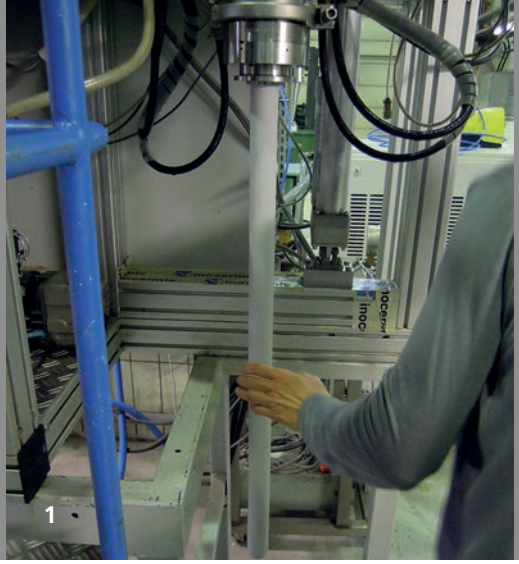

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cerenergy® – LOW-COST CERAMIC HIGH-TEMPERATURE BATTERY

Dr. Matthias Schulz

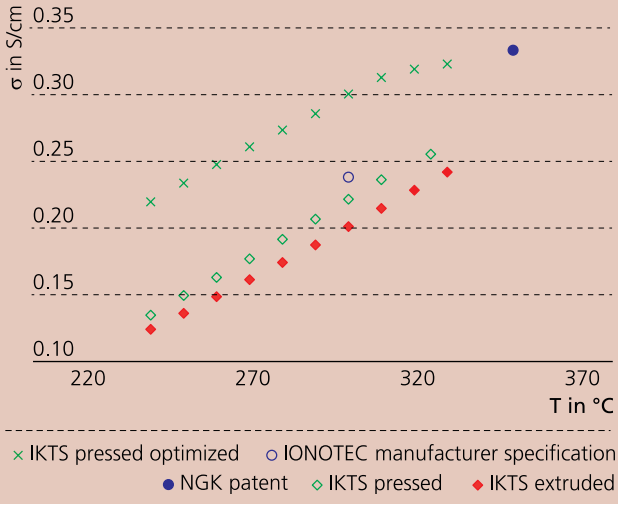
cerenergy® is the Fraunhofer IKTS technology platform for "low-cost" ceramic sodium batteries. Development work is focused on use of high-temperature Na/$NiCl_2$ and Na/S batteries for economical stationary energy storage in connection with renewable energies for increased power generation. With target costs of €100/kWh (at the cell level), economical battery applications in combination with photovoltaics and wind energy will be made possible. The desired system size ranges from 10 kWh for household use up to a few MWh for commercial applications. The defined cerenergy® goals will be realized by:

- Highly efficient mass production of the ceramic core component, the sodium-beta-alumina solid electrolyte
- Robust, cheap cell design based on minimizing costs instead of maximizing performance

The production of the ceramic sodium-beta-alumina electrolyte by extrusion is key to the success of cerenergy®. Extrusion yields a much higher productivity than that achievable with (state-of-the-art) pressing technology. Through ongoing optimization of the ceramic processing parameters, electrolyte samples with the desired properties could be manufactured. Dense electrolyte tubes with single-ended capping were obtained. The ionic conductivity and the Na-ß"-alumina phase content were determined experimentally to be 0.21 S/cm and 94 %, respectively. These values are slightly lower than those of pressed beta-alumina samples and hence need some improvement.

Furthermore, the extrusion process has to be scaled up to realize electrolytes with realistic geometries. A robust cell design, mainly consisting of standard components, was developed, and thermomechanical stresses were checked by FEM analyses. The cell lid was redesigned to replace the conventional thermocompression bonding technology. The goal of this innovation was to develop a method for sealing the ceramic-ceramic and the metal-ceramic joints in a single step.

Sodium ion conductivity of sodium beta alumina from Fraunhofer IKTS and from competitors



1 *Extrusion of Na-ß"-alumina electrolyte tubes.*

2 *cerenergy® Na/$NiCl_2$ cell design.*

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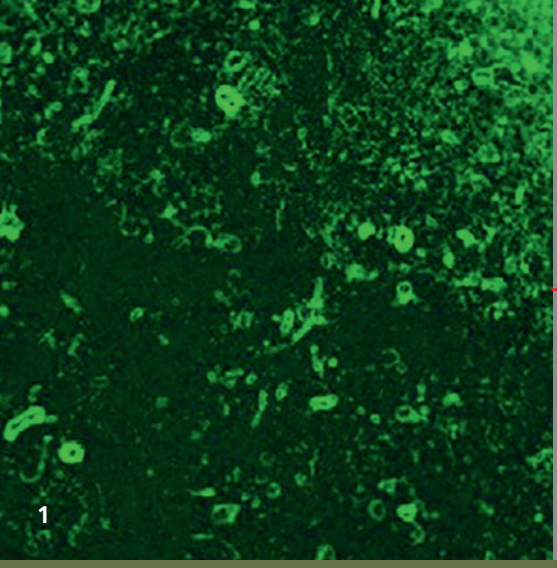

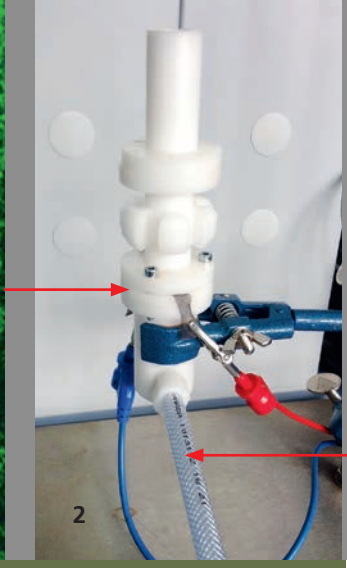

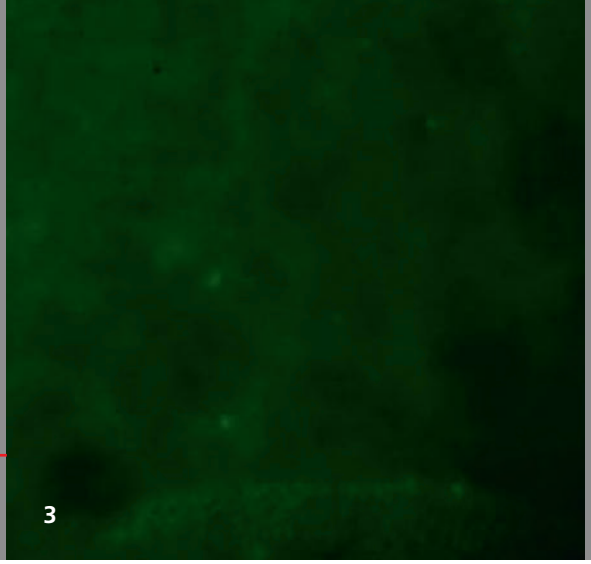

CERAMIC SEPARATION MODULE FOR PATHOGEN DIAGNOSTICS IN UNTREATED AND SURFACE WATER

Dr. Holger Lausch, Dipl.-Chem. Petra Puhlfürß, Dr. Michael Arnold

Motivation

The aim of the "ROWdix" project is to develop a better, faster, and more efficient diagnostic tool for detecting pathogenic microorganisms in water and thus better protect the population and reduce the costs associated with ensuring water quality. Diagnostics of water samples is currently performing using time-consuming culture-based or complicated membrane filtration procedures followed by biochemical and/or serological identification. The complete culture test, from sampling to results, takes several days and does not provide the restrictiveness for first-in, first-out (FIFO) pathogen detection using current diagnostic methods. To overcome the existing obstacles to FIFO detection of contaminating microorganisms, an innovative, PCR-based tool mockup serving as a functional prototype was developed.

Research approach

FIFO detection requires rapid test processing and a high concentration of microorganisms in the water samples. A ceramic dissolution module (CerSep) with a maximum height of 25 cm and a diameter of 5 cm for integration into a sight glass with a detection tool was developed to achieve this. The separation of specific bacteria and the associated toxins from the contaminated liquid requires the use of ceramic micro-/nanofiltration cascades employing mechanical, electrical, and gravitation gradients to separate successively defined bacterial and broad-spectrum protein toxins produced by accompanying nuisance materials such as algae blooms, scums, and mats, fat particles, eukaryotic microorganisms, water fleas, single algae cells, protozoa, and metazoans. This was the focus of development work. The setup consisted of large-pored, washable, sliding, theoretically reusable filter units.

The challenge consisted in separating the target bacteria from the accompanying materials in the liquid without causing damage and enabling accurate downstream analysis (regulation, number of colony-forming units, activity, and genetic stability). Besides size-dependent filter membranes with sizes of 5–200 nm for toxins and 300–800 nm for bacteria, prefilter membranes with sizes of 3–40 µm were modified. The influence of the respective ceramic material (Al_2O_3, ZrO_2, or TiO_2) on the hydrophobicity or hydrophilicity of the filter membranes was also investigated.

Application

For the use case of separation and concentration of the bacterium *Escherichia coli*, a three-stage processing module with 40-µm, 5-µm, and 600-nm Al_2O_3 filters was developed and tested successfully.

Thüringer Aufbaubank

EFRE EUROPA FÜR THÜRINGEN
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1 *Isolate at 600 nm (fluorescence).*
2 *Filtration cascade with filters of different dimensions and substrate (membrane carrier).*
3 *Filtrate at 600 nm (fluorescence).*

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CATALYTICALLY FUNCTIONALIZED FILTERS FOR SMALL WOOD-BURNING APPLIANCES

Dr. Uwe Petasch, Dr. Daniela Haase, Dipl.-Krist. Jörg Adler

Wood and solid fuel heating plays a pivotal role in the transition to renewable energy and has become established as a low-cost, environmentally friendly alternative to oil and gas heating. The second phase of the first Federal Emission Control Act (BImSchV), in force in Germany since January 1, 2015, prescribes maximum permissible emissions for domestic wood-fired appliances (wood stoves and masonry heaters) of 40 mg/m³ particulate matter and 1250 mg/m³ carbon monoxide. State-of-the-art wood stoves with "ECOplus" combustion technology developed through a partnership between Hark Kamin- und Kachelofenbau GmbH & Co. KG in Duisburg, the Fraunhofer Institute for Building Physics IBP in Stuttgart, and Fraunhofer IKTS in Dresden meet these requirements. At the heart of this system is a ceramic foam filter that optimizes combustion and reduces particulate emissions. Catalysts adapted to the specific operating conditions of the wood-burning appliance can be additionally used to minimize emission of gaseous pollutants, such as hydrocarbons (HC) and carbon monoxide (CO). The temperature conditions in the wood- burning appliance during operation strongly affect catalytic activity and aging resistance.

In a subsequent research project conducted with Hark, the potential of using catalyzed filters to improve the environmental friendliness of wood-burning appliances was investigated in wood-fired stoves. Based on the temperature and emission characteristics found in investigations to be valid under typical application conditions, suitable catalysts were identified and selected for the development of catalyzed ceramic foam filters with efficient reduction of CO and HC emissions. The catalyst efficiency was investigated in the laboratory and, with the assistance of Fraunhofer IBP, in real operating conditions in wood-burning appliances. The high catalytic activity remained nearly unchanged in long-term aging tests under rated load and alternating load conditions as well as with use of non-compliant fuels. In addition, no wear or decrease in efficiency of the catalyzed filters has been found in application tests performed to date. Field tests are currently underway to lay the groundwork for market introduction of the catalyzed filters; the corresponding mass production processes have already been developed.

Services offered

- Development of ceramic deep-bed filters and ceramic-supported catalysts for exhaust treatment
- Production and analysis of test samples and at small scale

1 *ECOPlus wood stove by HARK (Source: HARK GmbH & Co. KG).*
2 *Filter with integrated catalyst "ECOPlusKAT" (Source: HARK GmbH & Co. KG).*

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WATER TREATMENT USING autartec® SYSTEMS

Dipl.-Ing. Franziska Saft, Dipl.-Ing. Marc Lincke, Dr. Burkhardt Faßauer

Background and motivation

Autarkic, flexible, decentralized supply and storage technologies for electricity, heat, and water are gaining in importance in rural areas, where infrastructure often has to be removed as a result of demographic change. These technologies enable growth of urban areas in regions around the world with increasing populations without the need for grid expansion. They also support efforts to improve urban resilience in the face of increasingly extreme weather-related events. Under these circumstances, the autartec® alliance, an association of 11 corporations and 4 research institutions, was formed to develop advanced flexible, decentralized supply and storage technologies for modular integration into building parts, such as walls, ceilings, and staircases. The modular components can be prefabricated at low cost and are easy to use in new and existing buildings.

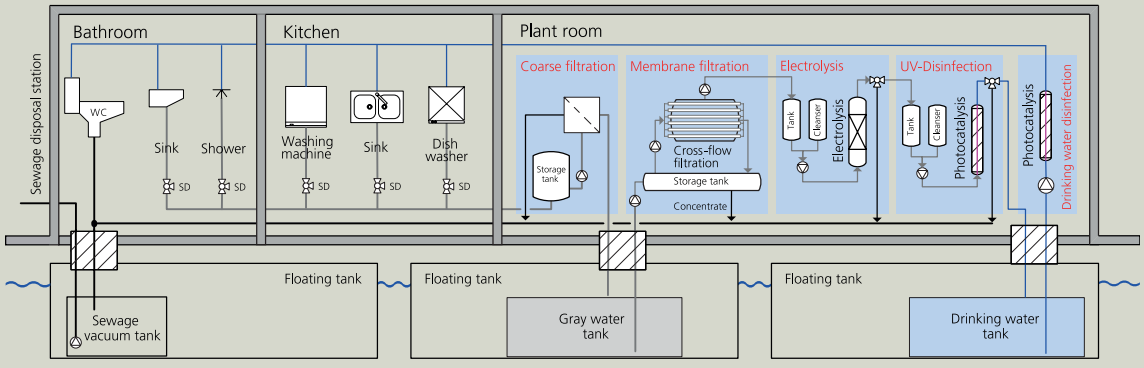
The research findings will be demonstrated in the form of a floating house ("FreiLichtHaus", Figure 1) that embodies the idea of self-sufficiency or autarchy. Funding of 8.2 million euros over a period of three years is being provided by the Federal Ministry of Education and Research of Germany (BMBF) to support the autartec® alliance. Fraunhofer IKTS has the task of developing and testing non-chemical and non-biological water and waste water treatment systems in line with the latest practices.

Research objectives

Decentralized waste water treatment systems are already the state of the art. Normally, because these systems are based on biological techniques, their performance and availability are limited. Substances such as pharmaceutical residues cannot be broken down biologically. Biological systems are also inflexible in that they cannot be switched on and off freely.

autartec® water treatment systems get around these problems by being based solely on physical and physicochemical processes, such as filtration, electrolysis, and photocatalysis.

Flowchart and water cycle of the autartec® water supply and treatment system

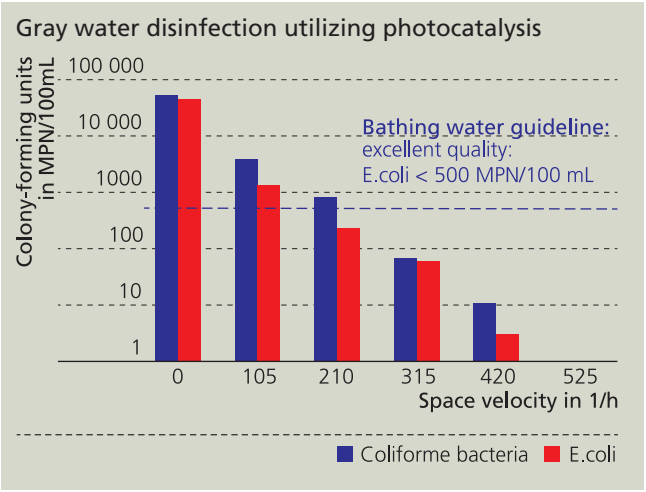


The goal of the present research was to develop reactors and process chains combining the above processes in a very confined installation space and with the highest energy efficiency possible to refine waste water up to drinking water quality. These strict purification standards can be met using functionalized high-strength ceramic materials and components, such as membrane filters and cellular monoliths. Recent results demonstrated the efficiency of these key components in waste water treatment.

Results

The first challenge was to build test rigs for all process steps in such a way that they could be freely interconnected and operated continuously. With these test rigs, the entire process chain could be examined at pilot-plant scale. Based on compositional analysis of real domestic waste water (gray water), standardized recipes for the generation of synthetic model water fractions (e.g., shower, washing machine, and sink) were developed so that the experiments could be conducted under reproducible conditions. The results showed that particle- and bacteria-free permeates could be generated in stable operating conditions using ceramic membranes during cross-flow and gravity-flow operation. The residual organic pollutants were completely removed in an additional oxidative waste water treatment step. A specific permeate flux of up to 30 L/(m²h) was achieved during gravity-flow operation.

The results of gray water oxidation experiments demonstrated the applicability of electrochemical and photocatalytic processes for the energy-efficient breakdown of organic contaminations, especially persistent trace substances, such as pharmaceutical residues (e.g., Diclofenac). Even intermediate decomposition products generated during water treatment were mineralized completely. In parallel with the practical experiments, a conceptual design for an integrated, largely closed-loop water supply and treatment system was developed based on a detailed use and load case analysis. Because energy is limited in the autarkic floating house powered with renewable energy sources, the requirement of economical use of available energy is especially difficult to meet.



The focus of subsequent development work will be on coordination of the individual components to optimize their operating behavior and cleaning performance.

Conclusions and outlook

Integration and demonstration of the new components in a floating, autarkic house structure are planned for 2017. This attractive and unique advertising platform will provide a springboard for future performance enhancements and acquisition of new partners for the application of advanced non-chemical and non-biological autartec® water treatment systems.

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und Forschung

1 *autartec® »FreiLichtHaus« (Source: Fraunhofer IVI).*
2 *Domestic gray water fractions.*
3 *Ceramic membrane module for submerged application.*
4 *Photocatalysis module.*

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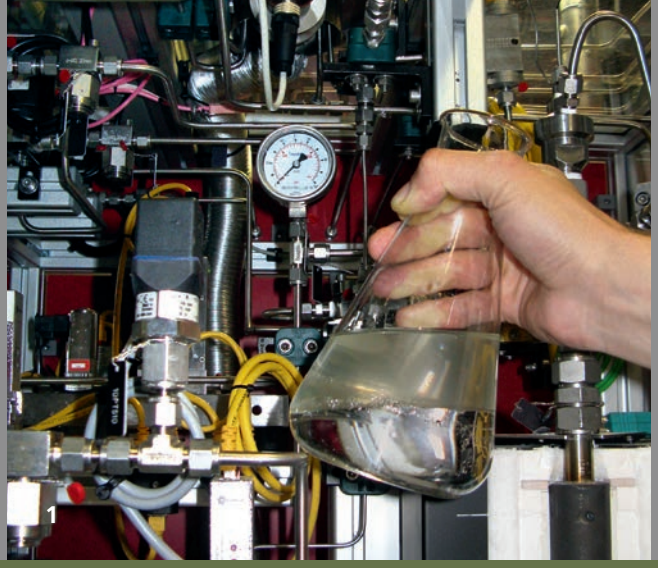

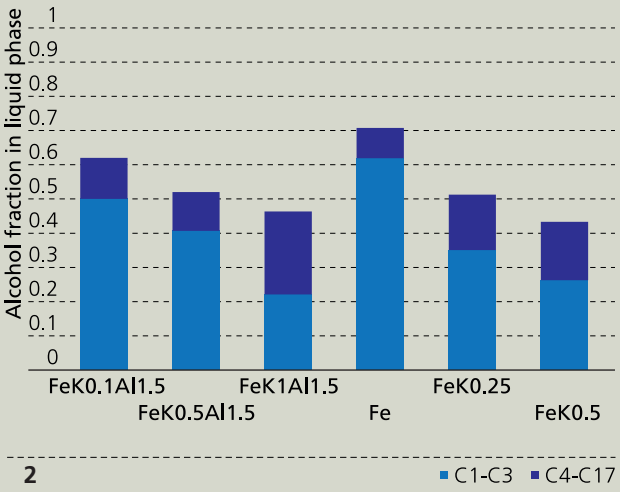

SYNTHESIS OF HIGHER ALCOHOLS ON IRON-BASED CATALYSTS

Dipl.-Ing. (FH) Erik Reichelt, M. Sc. Max Schaller, Dr. Matthias Jahn

Higher alcohols are important basic chemicals that are used in detergent production or as fuel additives. Currently these compounds are mainly synthesized by hydroformylation of olefins. These olefins are generally produced by refining of crude oil. However, not only because of sustainability reasons but also because of the established route having several complex process steps, the development of a technology for direct synthesis from synthesis gas is the subject of current research activities. Besides modified methanol synthesis, which mainly produces branched alcohols, Fischer-Tropsch synthesis offers a potential pathway towards higher alcohols. Here, research is focused on molybdenum disulfide-based catalysts. A disadvantage of this route is the risk of contamination of the product with sulfur. In both cases, the high pressure levels (p = 50–100 bar) are disadvantageous for the application of the process. From early works on Fischer-Tropsch synthesis, it is known that iron catalysts are active for the synthesis of alcohols with high selectivity under certain conditions. Besides process conditions ($\vartheta \approx 200$ °C, $p < 40$ bar), the low catalyst costs make this type of modified Fischer-Tropsch synthesis an attractive alternative to the mentioned processes.

The studies on aluminum- and potassium-promoted precipitated iron catalysts show that activity and selectivity strongly depend on pretreatment of the catalyst and on process conditions. High alcohol selectivities are reached at low temperatures and mild pretreatment conditions. Because alcohol synthesis is favored at low residence times, the technical realization of the process necessitates the development of a recycle process. The selectivity can also be influenced by the applied promoters. An increasing amount of potassium on one hand leads to a lowered overall alcohol selectivity but on the other hand increases the selectivity towards higher alcohols. The addition of aluminum does not influence the selectivity in the investigated range but can have a positive influence on the long-term stability of the prepared catalysts.

Besides studies on the alcohol selectivity of different promoted iron catalysts and the influence of process conditions, the overall process, including synthesis gas production, is considered. Apart from large-scale industrial application of the Fischer-Tropsch-based alcohol synthesis process, small-scale applications for decentralized production are interesting. Here, the work at Fraunhofer IKTS is focused on the coupling of the synthesis step with high-temperature electrolysis. By utilizing the waste heat from the highly exothermic synthesis step for the vaporization of water, it is possible to achieve a highly efficient process. Different process designs are compared with the help of process simulation software in order to identify a promising concept.

1 *Product fractions obtained from Fischer-Tropsch synthesis.*
2 *Alcohol fraction in the liquid product for catalysts of differing composition (ϑ = 250 °C, p = 20 bar.)*

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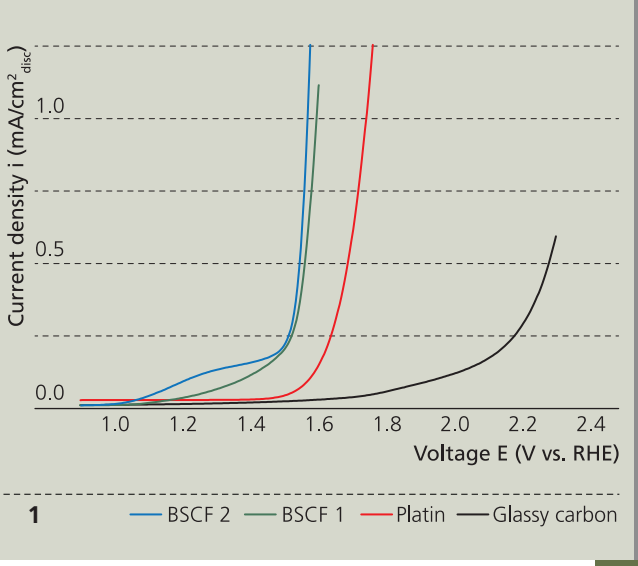

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ELECTROCATALYSTS FOR IMPROVING THE EFFICIENCY OF ALKALINE WATER ELECTROLYSIS

Dr. Benjamin Jäger, Dr. Ralf Kriegel

The extensive use of renewable energy leads to fluctuating feed-in of energy to the grid, giving rise to a need for highly efficient storage of excess energy. Conversion into chemical energy is especially suitable for long-term storage. Water electrolysis is a promising process in the context of "power-to-gas" strategies.

The electrolysis process efficiency is proportional to the cell voltage and directly influences the overall storage process efficiency. All real electrolysis units suffer from overpotential in both the anode and the cathode reaction, with the four-electron anode reaction having the highest overpotential. Electrocatalysts can significantly lower the required cell voltage. Thus, use of inexpensive electrocatalysts offers great potential for increasing efficiency.

Figure 1 shows the decomposition voltage in alkaline water electrolysis without a catalyst (glassy carbon = catalyst support) as well as for platinum and $Ba_{0.5}Sr_{0.5}Co_{0.8}Fe_{0.2}O_{3-\delta}$ (BSCF)-coated electrodes. As the voltage was being raised, a substantial current flux already occurred below the theoretical decomposition voltage of 1.23 V. This was due to oxidation of Fe/Co in the BSCF catalyst. With respect to the oxygen evolution reaction, the required voltage was observed to approach the expensive platinum catalyst level (shift to the left).

During use under alkaline water electrolysis process conditions, the cell voltage reduction amounted to ca. 100 mV by using an electrode as shown in Figure 2 at a current density of 1500 A/m², corresponding to an efficiency increase of 4 %. Through adaptation of the coating process, a cell voltage reduction of 300 mV at a current density of 5000 A/m² was achieved in the electrolysis test rig using an electrode. This yielded an efficiency increase of 12 % over that of the standard setup without electrocatalysts. Furthermore, the applied coating was chemically and electrochemically stable.

Services offered

- Development of electrocatalysts
- Electrocatalytic activity measurements
- Coating of electrodes

Acknowledgments

The German Federal Ministry of Education and Research BMBF and Project Management Jülich are gratefully acknowledged for their financial support. All partners involved in the joint project "Katalytische Mischmetalloxide" of the innovative regional growth core "Partikeldesign Thüringen" (grant no. 03WKCN02C) are also thanked.

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1 *Linear sweep voltammograms of two BSCF electrocatalysts versus platinum.*
2 *BSCF electrocatalyst-coated electrode.*

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NF MEMBRANES FOR THE CLEANING OF "RECYCLE WATER" IN OIL SAND EXTRACTIONS

Dipl.-Chem. Petra Puhlfürß, Dr. Hannes Richter, Dr. Marcus Weyd, Dr. Ingolf Voigt

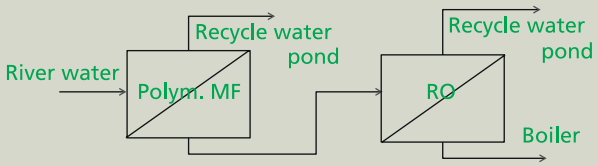
Oil sands, also known as "tar sands" or "bituminous sands", can be either loose sands or partially consolidated sandstone saturated with a highly viscous form of petroleum. Compared with conventional techniques, extraction of oil from tar sands is expensive and hence depends on oil prices and the availability of efficient and sustainable extraction techniques.

Oil extraction from oil sands requires a large amount of water for different processes. Hot water used to reduce the viscosity of the oil makes up the largest share. After oil/water separation, the water is sent to the tailings ponds and can be reused as "recycle water" without any further treatment. River water is primarily used as boiler feed water, but it also finds use as cooling water in the summer. Due to their resistance to organic matter and oil residues, desalination behavior, and thermal stability, ceramic nanofiltration membranes (NF membranes) can contribute to the development of new and more efficient recycling processes, including partial heat recovery.

In a current project started in 2013 together with partners Shell Global Solutions International B.V., Shell Canada Ltd., and Andreas Junghans - Anlagenbau und Edelstahlbearbeitung GmbH & Co. KG, 19-channel elements with ceramic NF membranes are being tested in an oil field in Canada.

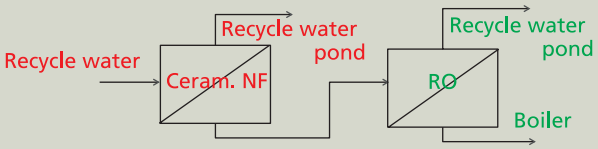
The goal of this project is to make the recycle water usable for other purposes besides the current one (boiler feed water). From an environmental point of view, use of recycle water instead of river water would be beneficial, but this is currently not possible due to the high residual bitumen and solids contents of the tailings.

Current method for preparing boiler feed water: treatment of river water



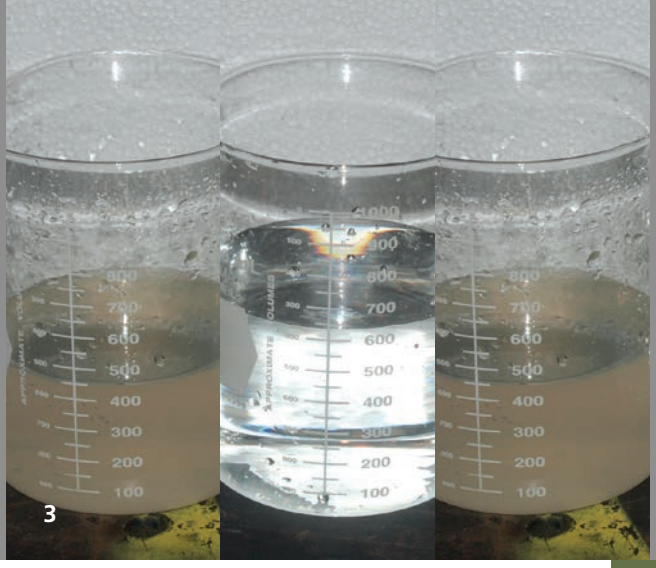
Ceramic NF membranes completely remove suspended solids and residual bitumen and at the same time reject most of the multivalent ions, thereby enabling a much higher yield in the subsequent reverse osmosis process.

New approach for preparing boiler feed water: treatment of "recycle water".



The 19-channel NF membranes showed rejection of alkaline earth metals (Ca and Mg) of up to 80 % and of alkali metals (Na and K) of up to 55 %. The permeate was free of organic matter. Long-term tests performed over several months confirmed the stability of the membranes.

Economically feasible preparation of the large amount of boiler feed water and cooling tower water required is not



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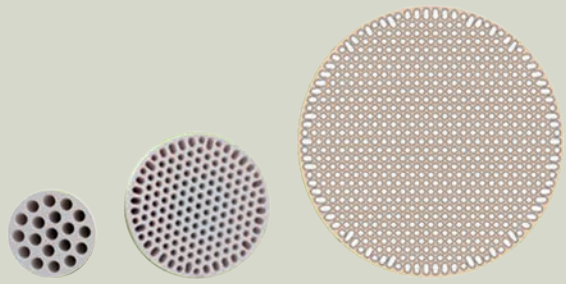
Desalination of "recycle water" using ceramic 19-channel NF membranes

	Feed	Permeate	Retentate
Ca^{2+}	23 ppm	5 ppm	26 ppm
Mg^{2+}	12 ppm	2 ppm	14 ppm
Na^{+}	325 ppm	137 ppm	368 ppm
K^{+}	16 ppm	7 ppm	19 ppm
TOC	44 ppm	1.5 ppm	70 ppm

possible with the 19-channel NF membranes due to the prohibitively high membrane costs. For this reason, Fraunhofer IKTS is looking for ways to reduce the membrane fabrication costs. One approach is to increase the membrane surface area per membrane element and thus reduce handling requirements. The ultimate goal is to use honeycomb substrates with a surface area of up to 20 m^2 per element instead of 19-channel tubes. In the first scale-up phase, ceramic NF membranes were prepared on 163-channel substrates with a membrane surface area of 1.3 m^2 per element, five times as high as it originally was. The sol-gel process, on which membrane preparation is based, was adapted to the smaller channel diameter and the reduced suction of the 163-channel substrate.

Scale-up of membrane surface area per element (0.25 m^2, 1.3 m^2, 5 m^2).



In lab measurements, the membranes showed the same flux and retention behavior as that of 19-channel NF membranes.

Comparison of retention of 19-channel and 163-channel NF membranes determined in lab tests using polyethylene glycol 600

	Flux	Retention
19-channel NF membrane	21 l/(m^2hbar)	81 %
19-channel NF membrane	24 l/(m^2hbar)	69 %
19-channel NF membrane	25 l/(m^2hbar)	71 %
163-channel NF membrane	16 l/(m^2hbar)	80 %
163-channel NF membrane	19 l/(m^2hbar)	71 %

The next step is to increase the membrane surface area to approx. 5 m^2 per element. This requires the use of new handling technologies due to the size and weight of the elements. This development work started in 2015.

Acknowledgments

We thank Shell Global Solutions International B.V., Shell Canada Ltd., and Alberta Innovates – Energy and Environment Solutions for financial support. In addition, we thank Andreas Junghans - Anlagenbau und Edelstahlbearbeitung GmbH & Co. KG and the Rauschert GmbH as well as its subsidiary inopor GmbH for a fruitful partnership.

1 *"Recycle water" from oil sand treatment.*
2 *3.5-m^2 module for field tests with 19-channel NF membranes.*
3 *Samples for field tests (feed, permeate, and retentate).*
4 *163-channel NF membranes with membrane surface areal element of 1.3 m^2.*

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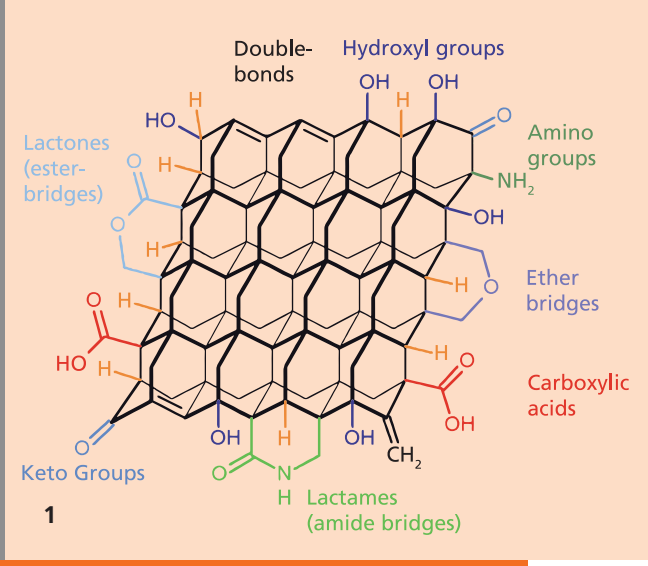

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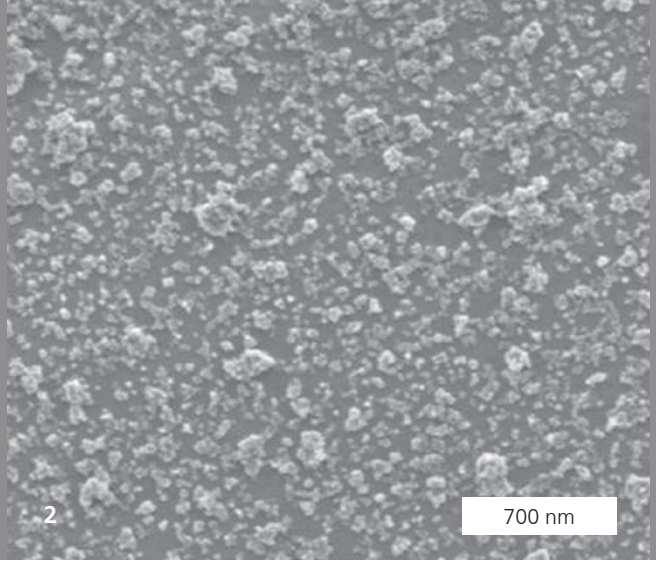

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DEVELOPMENT OF NANODIAMOND-BASED COATINGS FOR TITANIUM ALLOY IMPLANTS

M. Sc. Afnan Qurban Shaikh, Dr. Daria Kovalenko, Dr. Jörg Opitz

Several million people worldwide suffer from fractures due to accidents or systemic skeletal diseases, such as diabetes mellitus. This can result in loss of bone tissue and hinder mobility. By means of implants and prosthetics, lost mobility can be largely restored.

The choice of implant is not an easy decision, since bone healing is a very complex and dynamic process. Within the first few seconds of implantation, numerous physiochemical reactions in which different organic and inorganic biomolecules are adsorbed on the surface take place. Another important factor is the biocompatibility of an implant material. The term "biocompatibility" is defined as the ability of a material to perform both structurally and functionally in a specific application with an appropriate host response.

Titanium and its alloys are normally the first choice for such applications due to their excellent mechanical properties and biocompatibility. In particular, they are the favored material for implants (osteal, dental, and coronary stents, etc.). The presence of a native oxide layer on these materials provides a certain amount of resistance to corrosion. However, in long-term use, metals have been observed to corrode, producing metal ions that diffuse into the surrounding tissue, which can induce inflammation and might lead to implant failure and repeat surgery.

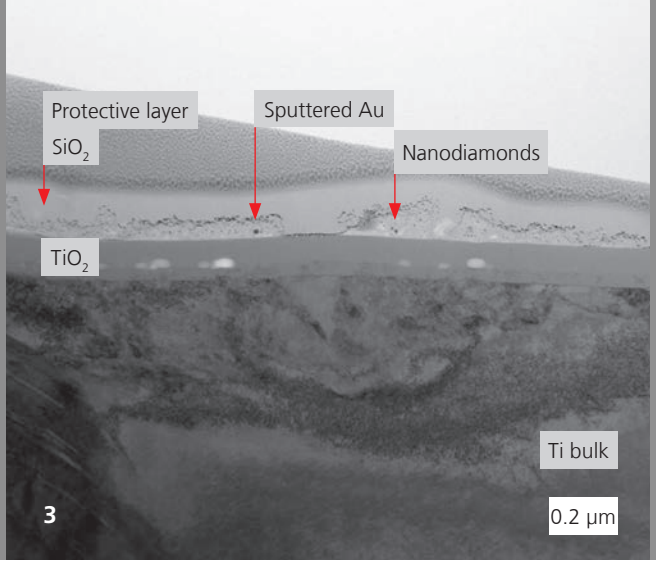
Various surface modification techniques have been used on titanium-based materials in attempts to enhance their properties.

Fraunhofer IKTS in cooperation with the "Biomaterial Innovation for Medicine and Technology" working group of Max Bergmann Center for Biomaterials at TU Dresden perform surface modifications of titanium-based materials for such metal-based biomedical applications with detonation nanodiamonds.

Detonation nanodiamonds (DNDs) are carbon-based nanoscale materials with excellent properties. Besides displaying typical diamond properties, such as high thermal conductivity and extreme hardness, these nanoparticles possess different functional groups on their surfaces resulting from the purification process performed after detonation synthesis. These functional groups allow biological and chemical tuning of nanodiamonds for use in various fields. Nanodiamonds have proven to be non-toxic and biocompatible in-vivo, making them favorable candidates for biomedical applications.

Methodology and mechanism

DNDs are first chemically functionalized with (phosphate) anchor groups known for their great affinity with titanium oxide surfaces. The functionalized detonation nanodiamonds are then immobilized and incorporated into the titanium oxide surface through the electrochemical process of anodic oxidation performed to increase the oxide layer thickness. The hydrostatically stable phosphate group structure supports the formation of monolayers and bilayers. This phosphate-based coordination leads to nanodiamond-to-titanium oxide layer binding with a strength that could not be achieved via electrostatic or hydrogen bridging.



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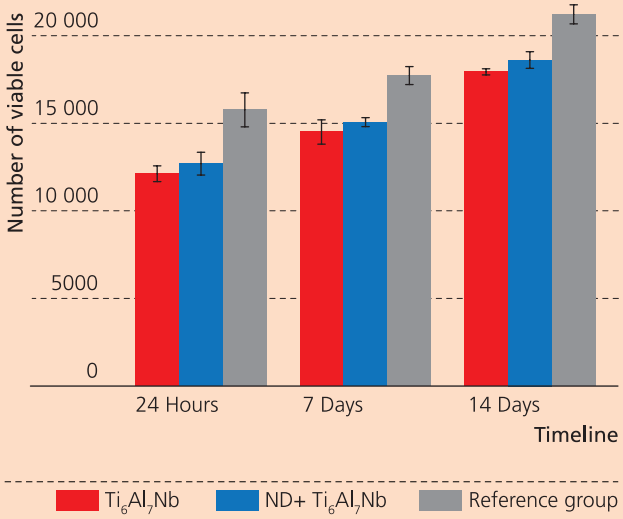
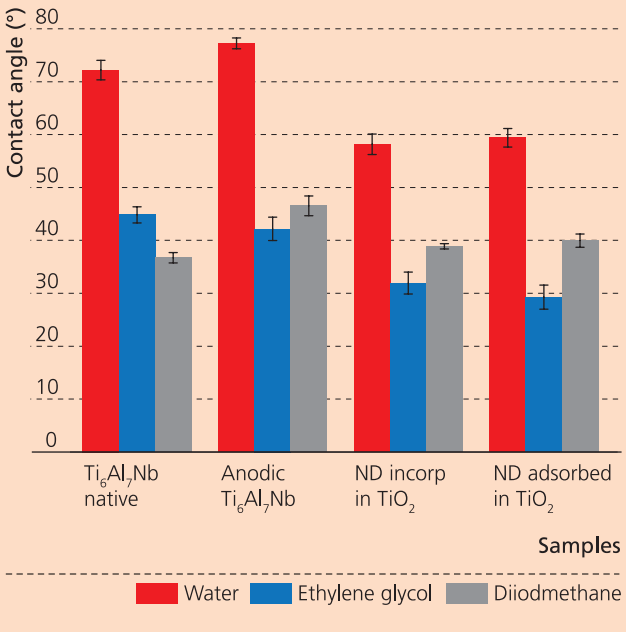
Effects of using nanodiamond-based coatings

- Biocompatibility: improvement in surface wettability and surface energy; improvement in hydrophilicity associated with the increased biocompatibility
- Cellular response: increase in cell adhesion, proliferation, and no cytotoxicity
- Corrosion resistance: improvement in corrosion resistance based on capacitive behavior and high impedance values, particularly at lower frequencies (nanodiamond-coated titanium-based material)
- Improvement in wear resistance and strength
- Formation of a barrier layer preventing diffusion of metal ions into surrounding tissues

Cytotoxicity assessment



Contact angle measurements



Services offered

- Biochemical surface modification of nanodiamonds
- Surface modification of titanium and other valve metals for a variety of applications (aerospace, industrial, and biomedical)
- Antimicrobial coatings

1 *DND structure.*
2 *SEM image of DND on TiO_2.*
3 *STEM image.*

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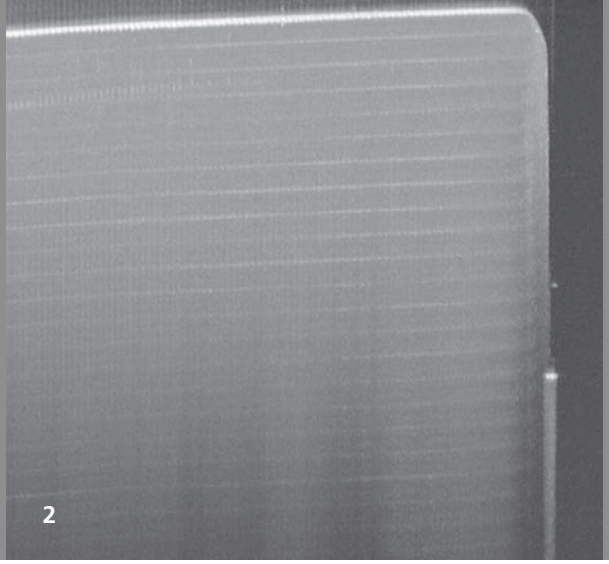

PROCESS MONITORING IN ADDITIVE MANUFACTURING

Dipl.-Ing. (FH) Christian Wolf, Dipl.-Ing. Andreas Lehmann, Dr. Daria Kovalenko, Dr. Tassilo Moritz, Dipl.-Ing. Uwe Scheithauer, Dr. Bernd Köhler, Dr. Jörg Opitz

Additive manufacturing is becoming an integral element of manufacturing processes for complex components. A shift in scale from prototyping and small batch production to mass production is accompanying this development. The range of materials that can be used with additive technologies is also expanding as new technologies emerge. Besides different polymers and metals, ceramics are now also used in additive manufacturing processes. With the ever-growing role of additive manufacturing systems in industrial production, the need for in-line process monitoring technologies is becoming more pressing. Monitoring systems must meet a myriad of requirements, and the preferred technologies should also have multi-material capabilities.

Established as a medical imaging technique (e.g., in ophthalmology and dermatology), optical coherence tomography (OCT) is now, for the first time ever, to be applied in process monitoring. The focus of research efforts at Fraunhofer IKTS lies mainly on the in-line monitoring of additive manufacturing processes. With OCT, analysis of surfaces as well as internal structures of different materials is possible. In the processing of metals (e.g., laser cladding), OCT is restricted to surface imaging, but for other materials, it is also capable of revealing internal structures and detecting defects, such as delamination or inclusions. Thus, for example, it allows for examining the adhesion of the individual layers in 3D-printed ceramics to be examined. By adding other optical technologies, such as Raman spectroscopy, it is possible to monitor additional process characteristics, such as the degree of cure during the curing process for plastics.

Ultrasonic technology has traditionally been used primarily for non-destructive testing of metal parts, such as hollow shafts, but it can also be used in additive manufacturing. Particularly when water baths are used for 3D printing of ceramic components, application of ultrasonic technologies for reliable detection of pores and delamination is practical. With ultrasonic technology, it is also possible to detect defects in additively manufactured metals.

The different technologies developed and used at Fraunhofer IKTS focus on in-process measurements to allow defects to be detected and segregated, and the necessary process adjustments to be made during the manufacturing process. This makes the Fraunhofer IKTS testing technologies the key to achieving highly efficient certified additive manufacturing systems. Continuous monitoring of different additive manufacturing processes is an important basis for transfer to industrial-scale production and for ensuring consistent product quality.

1 *OCT surface projection of a component formed by additive manufacturing.*
2 *Cross-sectional image of a component formed by additive manufacturing.*

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GEMSTONES MADE FROM TRANSPARENT POLYCRYSTALS

Dr. Jens Klimke

Gems and jewelry have fascinated people since ancient times. High-quality gemstones are rare and precious due to their scarcity in nature. Simple imitations made of colored glass do not have the effect of gemstones, such as ruby, spinel, and diamond, because of the low refractive index and low hardness of glass, making it less resistant.

The first successfully produced synthetic single-crystal gems were rubies manufactured by Verneuil in 1902. The Verneuil process is still used today, but there are also a number of more advanced methods of growing single crystals for jewelry applications, mostly based on the Czochralski process. These synthesis methods are relatively time-consuming and energy-intensive. In addition, the crystals must be faceted in a costly manner by hard machining and the maximum size is limited by the dimensions of the single crystals.

Fraunhofer IKTS has been developing transparent ceramics for 15 years now. Transparent ceramics consist of a plurality of individual crystals that are essentially fully densified in a sintering process. In conventional ceramics, this succeeds only partially. Because the remaining pores scatter light, ceramics are opaque. Transparent polycrystalline colored "rubies" and "sapphires" were presented and patented by Fraunhofer IKTS several years ago, but the birefringence of the individual crystallites limited the maximum transmission of the ceramics. Therefore, focus of recent development work was on ceramic synthesis of the cubic crystal systems of spinel and fully stabilized ZrO_2 to achieve complete transmission with the corresponding effects.

The ceramic production method offers several advantages. New color options and effects arise from the microstructured polycrystals, near-net-shape production is possible due to the relative ease of processing the green ceramic, and completely new design options that were not possible with single crystals are feasible.

The gemstones produced by Fraunhofer IKTS process are currently being analyzed and cataloged by the German Foundation for Gemstone Research in Idar-Oberstein in terms of their gemological properties.

Acknowledgements

Parts of the presented research were supported by King Abdulaziz City for Science and Technology (Riyadh, Saudi Arabia).

1 *Polycrystal of cubic ZrO_2.*
2 *Polycrystals of spinel and ZrO_2.*

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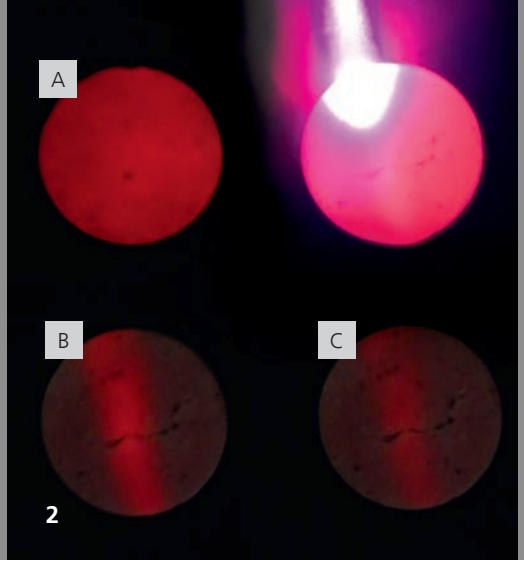

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TRANSPARENT AND OTHER OPTICALLY ACTIVE CERAMICS FOR OPTICAL APPLICATIONS

Dr. Isabel Kinski, Dr. Michael Arnold, Dr. Stefan Barth, Dr. Uwe Partsch

For maximizing luminous and lighting efficacies, the technological approaches used for designing high-performance lighting applications tend to employ polycrystalline ceramic converter materials.

Fraunhofer IKTS takes different routes in the development of phosphor powders and ceramic converter materials. Besides commercially available raw materials, precursors and educts are synthesized in bottom-up synthesis processes. Nanoscaled phosphor powders can be produced or further processed according to requirements using the classic ceramic route with shaping and sintering to form ceramic bulk components.

High transparencies can be achieved by eliminating defects and secondary phases by controlling the ceramic process. With a defined porosity incorporated in the ceramic, scattering effects can be tailered leading to higher luminous efficacies. Homogeneous dispersion of the phosphor in other inorganic matrices (ceramics) provides a means of adjusting the thermal conductivity and the thermal expansion coefficient. By printing phosphor powders, component labeling can be realized as well. Commercially available phosphor powders have successfully been used in the development of pastes for screen printing as well as inks for labeling components in a hot forming process.

Other phosphor conversion materials developed at Fraunhofer IKTS can be excited by standard blue light for white lighting (e.g. YAG:Ce) but also with UV light or other wavelengths. Depending on the thickness of the ceramic, different emission colors (red, green, orange, or yellow) can be produced, by either total or partial conversion of the excitation light through additive color mixing.

Besides the conversion of the excitation wavelength, other ceramic phosphor properties have been employed in the development of diagnostic materials. For example, a reversible temperature-dependent afterglow can be used in thermal history sensors.

1 *Printed phosphor powder for component labeling.*
2 *Red phosphor for thermal history sensing with thermally triggered phosphorescence.*
3 *Transparent YAG:Ce for solid-state lighting applications.*

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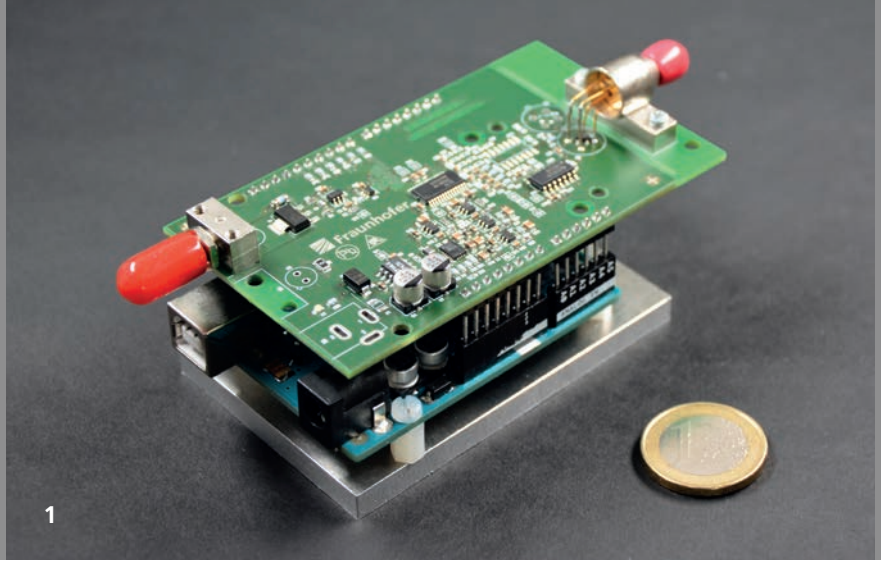

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ROBUST READ-OUT UNIT FOR OPTICAL SPECTRAL SENSORS

Dipl.-Phys. Roland Wuchrer, Dr. Thomas Härtling

Spectral sensors detect environmental parameters, such as temperature, humidity, gas concentration, mechanical strain, or stress, on the basis of a specific change in their spectral properties. The sensors are often based on detection of wavelength shifts or evaluation of ratiometric changes in two peak signals. These optical sensors offer unique characteristics, such as high sensitivity, electrical passivity, and applicability under extreme conditions (temperature, humidity, electromagnetic fields, etc.). The many different sensor types range from single-point sensors and multiplexed optical fiber versions to two-dimensional sensors. Although many of the sensors have been developed to the application stage, market introduction is often still hampered by read-out systems that lack the necessary miniaturization and robustness for field application as well as the required cost-effectiveness.

This situation motivated Fraunhofer IKTS to develop the wavelength-sensitive photocurrent-based detection system for optical signals shown in Figure 1. The core element is a commercially available wavelength-sensitive photodiode (WSPD) that includes two p-n junctions with different spectral sensitivities. The photocurrents of the two junctions are compared electronically on the circuit board shown above. This approach combines the simplicity of an intensity measurement setup with the robustness of spectral readout. The circuitry was tested to detect wavelength shifts in optical signals and revealed a resolution of 0.08 nm in a first development iteration. Hence, subnanometer resolution is possible without the need for a heavy, vibration-damped, and air-conditioned optical spectrometer. The circuit board is completed by a temperature monitor, a stable power supply, and a light source (LED) with an LED driver.

Both the light source and the detection element are designed for fiber coupling so as to allow for maximum versatility of the final optical sensor system.

It is important to note that the resolution of the system is achieved only if the spectral behavior of the optical signal is precisely known. However, this is the case for most of the optical sensors in use, so the versatility of a spectrometer is not needed.

The goals of the next development iteration are to further miniaturize the overall circuit board and increase the spectral resolution. However, already with the current system, harnessing of the dormant potential of spectral sensor technology in process monitoring, chemical analysis, biosensing, and many other field applications can be envisaged.

1 *Sampling unit for optical wavelength shifts below 0.1 nm.*

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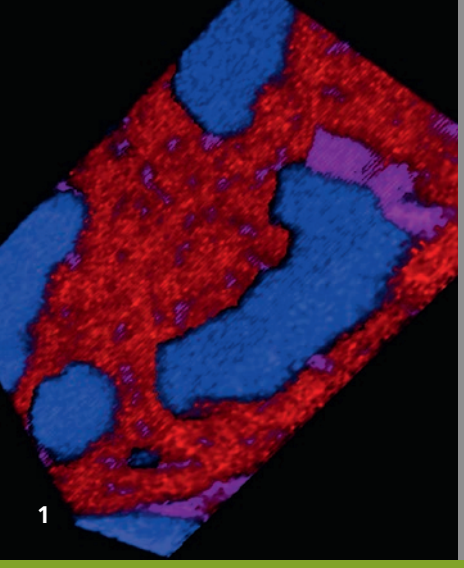
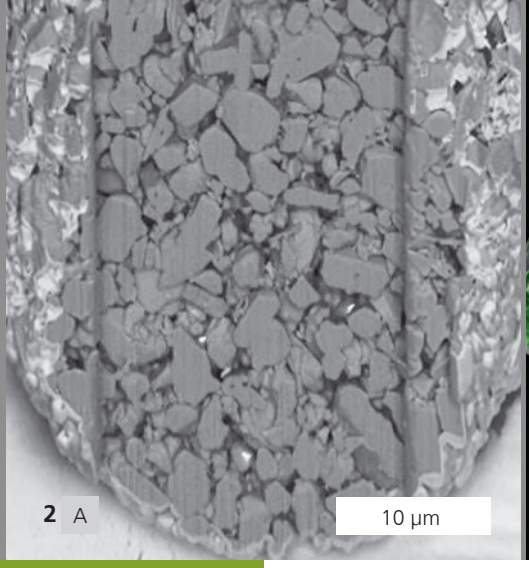
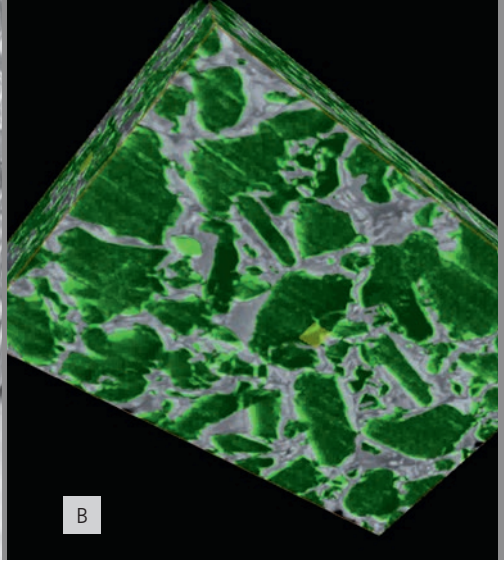






1 2 A B

HIGH-RESOLUTION THREE-DIMENSIONAL CHARACTERIZATION OF CERAMIC MATERIALS

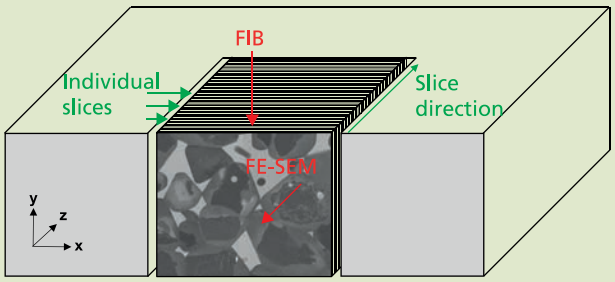
Dr. Sören Höhn, Dr. Jürgen Gluch, Dipl.-Ing. Kerstin Sempf

Development and optimization of high-performance materials hinge on the availability of high-resolution analysis methods. For the majority of samples, conventional two-dimensional images of cross-sections provide limited information about shape, stereoscopic layout, and character of individual components. The three-dimensional representation of structures and defects yields additional information about expected material properties. As an example demonstrating the scientific validity of this method, computed tomographic measurements were performed on ceramic foams. The microstructure was geometrically characterized and material data for the component construction were derived from the results. For high-performance ceramic materials, in which structural sizes are in the submicron and nanometer ranges, the lateral resolution of conventional computed tomography is generally not sufficient.

At Fraunhofer IKTS, two techniques, focused ion beam (FIB) tomography and X-ray nanotomography, are established for three-dimensional structural analysis down to the nanoscale.

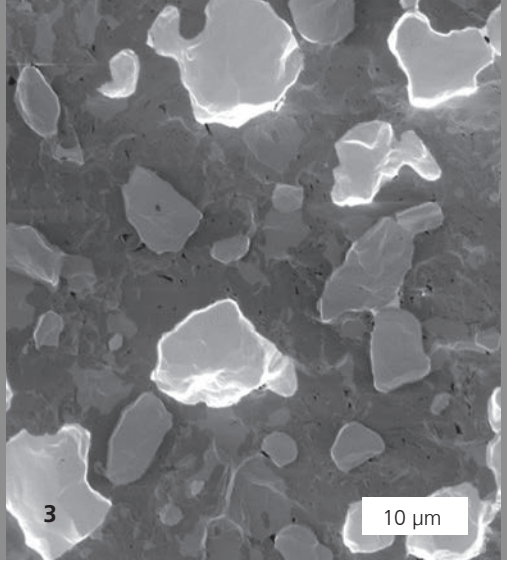
FIB tomography is based on the preparation of a series of slices using a focused ion beam (FIB) and a high-resolution, high-contrast image from a field-emission scanning electron microscope (FE-SEM). With this method, structures can be displayed up to a lateral resolution of about 10 nm (scheme on the right- hand side). Suitable 3D software can produce a volume data set by combining several individual cross-sectional images. In combination with energy-dispersive X-ray analysis (EDS), additional three-dimensional element distribution images can be created, as shown in Figure 1 for a $MoSi_2/Si_3N_4$ composite material. A titanium diboride/boron nitride (TiB_2/BN) composite material was used to demonstrate the capabilities of the FIB tomography technique.

Principle of FIB tomography



This composite material is usually used for evaporation boats, e.g., for evaporation of aluminum. The boron nitride content in this material generates good thermomechanical properties. The electrical conductivity, which is needed for the direct heating, is provided by TiB_2 particles. In order to achieve reproducible conductivity, the TiB_2 needs to form a three-dimensional network. If the network is disturbed by local inhomogeneities or by aging, uniform heating of the material is not possible. In order to understand the performance of the material over time, it is important to know the distribution of the TiB_2 phase. A prerequisite for efficient material design is appropriate three-dimensional characterization. This was achieved using field-emission scanning electron microscopy.

By choosing the right imaging conditions, i.e., by using the in-lens detector, it was possible to differentiate between percolated and isolated TiB_2 grains (Figure 3). The electrically conducting percolated TiB_2 phase appeared bright in the FE-SEM



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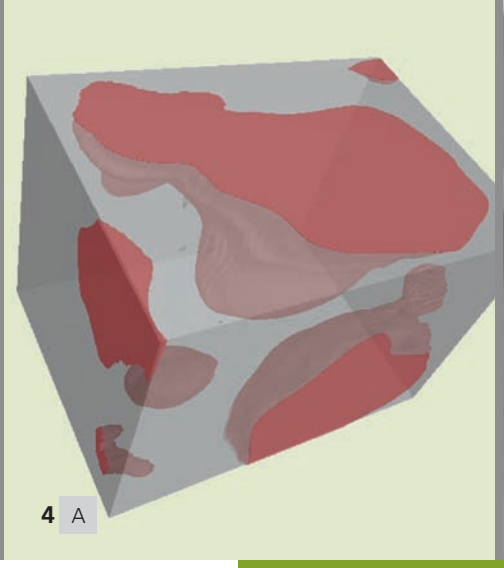

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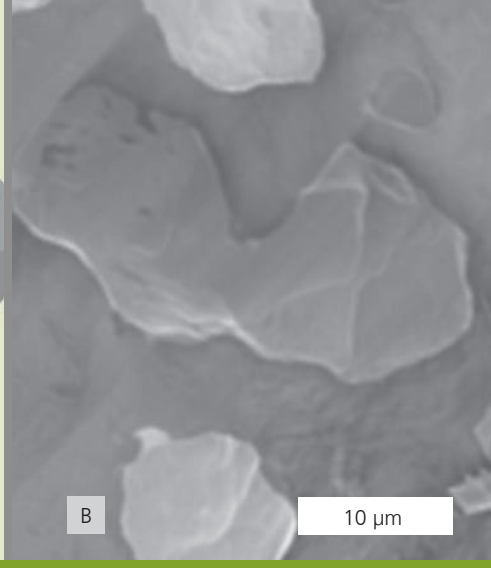


B

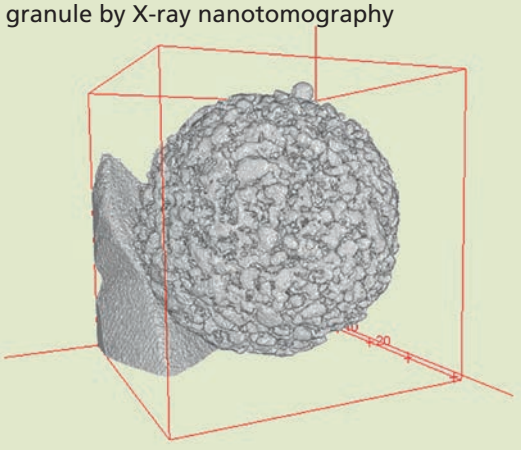
image, whereas the non-conducting isolated particles were dark. A three-dimensional representation of the TiB_2 network was produced using FIB tomography. The three-dimensional slicing technique (Figure 4A) confirmed the assumption that dark TiB_2 particles are not incorporated in the three-dimensional network. This technique verified the results that were obtained by two-dimensional FE-SEM imaging (Figure 4B).

Fraunhofer IKTS has established X-ray nanotomography as a modern non-destructive method for the analysis of structures and defects in ceramic materials. The method permits the non-destructive investigation of structural and functional materials at a microscopic level with a resolution down to 50 nm. If the X-ray absorption contrast between the components of a material is too low, contrast enhancement is achieved through Zernike phase contrast. This accentuates interfaces and surfaces as well as delamination and cracks. Through use of in-situ test stages, various experiments can be carried out under direct observation. This enables the recording of four-dimensional data sets in the X-ray microscope to supplement the three-dimensional information. With miniaturized thermal and mechanical equipment, which are positioned in the beam path of the X-ray microscope, experiments can be performed on a microscopic level and their effects can be observed. The 3D figure on the left-hand side shows the three-dimensional visualizations of an Al_2O_3 granule recorded by X-ray nanotomography. A FIB tomography generated structure belonging to the same granule batch is shown in Figure 2A and 2B.

Services offered

- Generation of high-resolution 3D data sets for 3D micro-structural analysis composition (EDS) and failure analysis
- High-resolution 2D and 3D X-ray microscopy with a pixel resolution of 32 nm
- Investigation of kinetic processes, in-situ experiments: temperature chamber, chemical reaction chamber, mechanical tests
- High-contrast imaging with various detection methods
- Recording and reconstruction of 3D and 4D data sets (tomography, laminography, time-lapse imaging, and time-resolved tomography)
- Data evaluation, segmentation
- Characterization of devices and materials

3D visualization of the micro-structure of an Al_2O_3 granule by X-ray nanotomography



1 3D-EDS of a $MoSi_2/Si_3N_4$ sample (magenta: Yb, red: N, blue: Mo).

2 3D visualization of the micro-structure of an Al_2O_3 granule by FIB tomography (A) and reconstructed 3D volume (B).

3 FE-SEM image of BN/TiB_2 composite material recorded by in-lens detector.

4 Reconstructed 3D volume (A) of an isolated TiB_2 particle (B) in the BN matrix.

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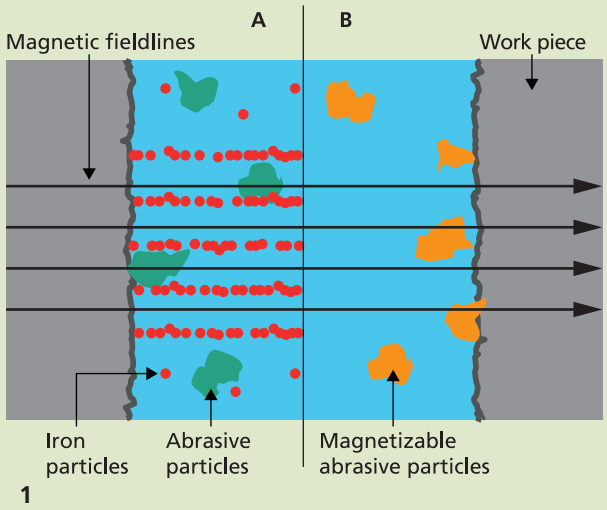

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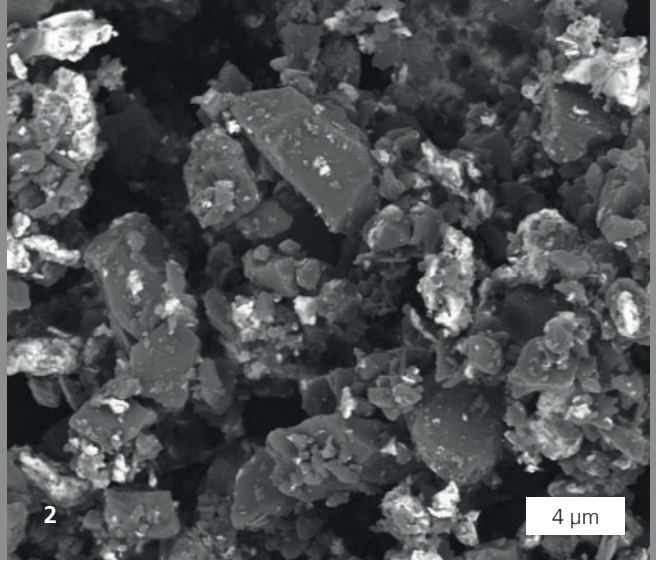


2

SMART FLUIDS – SWITCHABLE ABRASIVE SUSPENSIONS FOR FINISHING

Dipl.-Ing. Tina Bremerstein, Dr. Annegret Potthoff

In many industries, abrasive machining methods are utilized for finishing (deburring, polishing, and rounding) of complex components. For example, in abrasive flow machining (AFM), a highly viscous polymeric carrier medium containing abrasive particles is alternately extruded through the top and bottom of the work piece, thus acting as a deformable "grindstone". In contrast, hydro erosive grinding (HEG) employs low-viscosity suspensions of fine abrasive particles and oil, which are pumped with high pressure through microscopic holes and round the edges due to erosion.

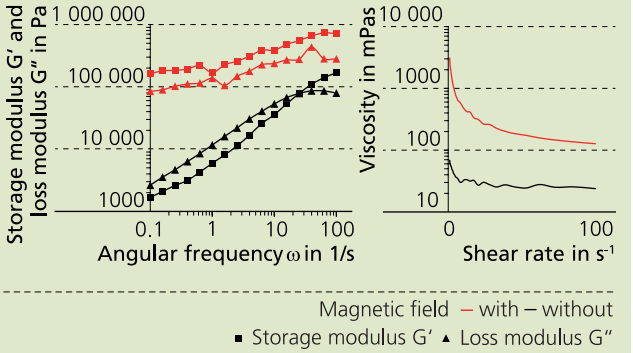
In both machining processes, high surface quality is achieved through removal of material with particle sizes in the micron range. However, up to now the processes have been non-directional, yielding dead zones or regions with undesired material removal.

In the BMBF project "SmartStream", both processes are being developed to enable specific local finishing by the use of magnetic fields and magnetorheological fluids (smart fluids), thus increasing process selectivity, performance, efficiency, and reproducibility.

In the design of the switchable low- and high-viscosity abrasive media, various characterization methods (rheology depending on the magnetic field, particle size, particle shape, and composition) that are also used for conventional abrasive suspensions are employed.

Two basic types of smart fluids are being developed (Figure 1). For type A, conventional abrasive media are mixed with iron particles, which align themselves along the field lines when a magnetic field is applied and thus increase the solidity or viscosity. In the case of type B, the abrasive particles themselves are magnetizable, and they hence move to the work piece when a magnetic field is applied and intensify the removal of material.

Increase in viscosity of an AFM paste (left) and an HEG oil (right) due to the application of a magnetic field



Due to the switchable strong increase in solidity (see diagram), a significant and specific increase of material removal efficiency is expected in both machining processes.

The authors give thanks to the BMBF for the funding (Project number 02PN2164).

Bundesministerium für Bildung und Forschung

1 *Schematic illustrating the working principle for smart fluids of type A and type B.*
2 *Magnetizable abrasive particles.*

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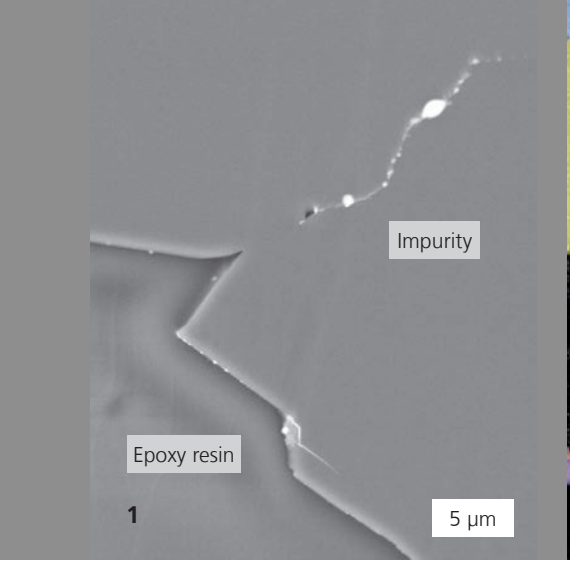

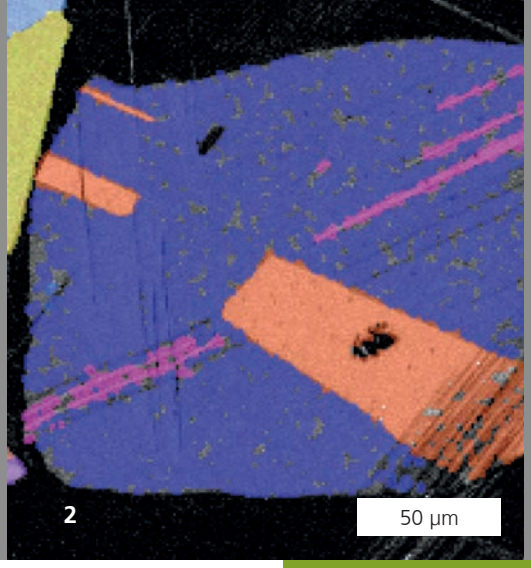

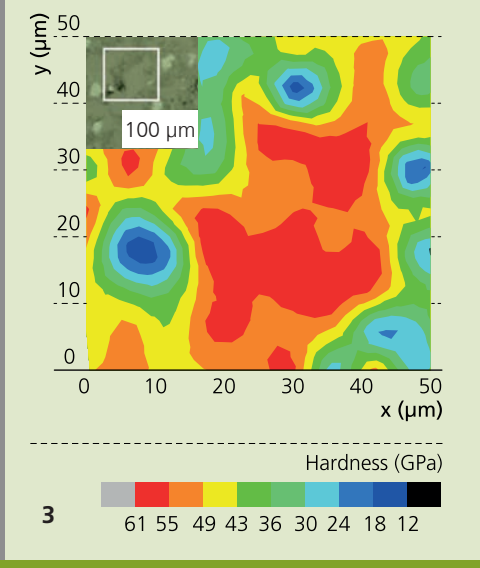

CHARACTERIZATION OF SUPERHARD MATERIALS

Dr. Mathias Herrmann, Dipl.-Ing. Björn Matthey, Dipl.-Ing. Anne-Kathrin Wolfrum, Dr. Andre Clausner

Superhard materials of hardness > 45 GPa are typically composed of wear-resistant materials based on diamond and cubic boron nitride (cBN). Commercially available superhard materials include PCD (polycrystalline diamond) and PCBN (polycrystalline cubic boron nitride). In addition, wear-resistant ceramic-bonded cBN and diamond materials have been developed at Fraunhofer IKTS. These materials are prepared in ambient pressure conditions, allowing for geometries that are unattainable in high-pressure processes. The possibilities for SiC-bonded diamond materials are especially diverse and include such geometries as pipes, seals, and bearings.

The strong effect of interfaces and damage to the metastable hard materials in the material preparation stage on the properties of superhard materials spurred the development and testing of suitable preparation and characterization methods at Fraunhofer IKTS. Besides methods for determining mechanical properties, damage-free methods for preparing superhard powders, materials, and hard component-matrix interfaces were developed for subsequent analysis of microstructure-property correlations. Scanning electron microscopy can be employed, e.g., for detection of defects in diamond or CBN grains (Figure 1). The use of an EBSD (electron backscatter diffraction) detector enables determination of twinning or the precise grain size distribution of diamond grains in PCD. Epitaxial growth of SiC on diamond in reactively produced diamond-SiC composites can also be detected using these methods. Transformation of cubic boron nitride to the stable hexagonal boron nitride modification or of diamond to graphite can be verified by micro-Raman spectroscopy with local internal stress analysis.

Improvement of nanoindentation techniques to allow integration of an in-situ indenter into the SEM has created the possibility of detecting distributions of elastic properties and hard-ness in materials with submicron resolution. This in turn enables investigation of grain boundary phases in multiphase materials. Figure 3 shows a hardness map for a boron suboxide (B_6O) material. The high hardness of the B_6O grains and the pronounced drop in hardness at the grain boundaries and in the oxide binder phase regions are evident. This drop in hardness is also the reason for the extreme differences in hardness between B_6O single crystals and sintered materials (< 33–38 GPa).

Services offered

- Microstructural and failure analysis of materials and components
- Characterization of diamond and cBN powders and materials
- High-resolution mapping of elastic properties and hardness

1 *Ion beam preparation for detection of defects and inclusions in superhard powder particles.*
2 *EBSD analysis for detection of twinning in CBN grains.*
3 *Hardness map of LPS-B_6O (hardness given in GPa).*

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ELECTRICAL AND MECHANICAL CHARACTERIZATION OF MATERIALS

Dipl.-Ing. Roy Torke

Use of materials and components in industrial and household applications requires extensive characterization of their properties and application behavior. The accredited quality and reliability laboratory at Fraunhofer IKTS is specialized in testing electrical and mechanical properties of tools and components. Diverse unique test setups, which can be customized for specialized measurement tasks, are available.

Characteristics, such as dielectric strength, permittivity, and specific volume and surface resistance are determined in the lab using accredited procedures for materials including those developed at Fraunhofer IKTS. The information thus yielded can be applied toward making well-founded estimates of material or component suitability, following the degradation process during use, and understanding degradation mechanisms. Safety tests can aptly support declarations of conformity for the issuance of VDE and TÜV marks.

Accredited measurement methods for calibration of various electrical properties are currently under development. Tensile strength, compressive strength, uniaxial flexural strength, biaxial flexural strength, impact strength, fracture energy, fracture toughness, shear strength, torsional strength, and adhesion are well-known terms of mechanical strength of materials that are determined in the lab using the appropriate methods. Structure and component testing is also possible with the extensive test equipment available in the lab.

Special methods can be employed, e.g., to simulate aging of components and systems. The lab is equipped with a vibration test stand with vibration loading of up to 100 g and impact loading of up to 200 g for component, structure, and real simulated mechanical load testing and failure prediction.

Environmental effects can also be determined in accordance with DIN 60068, MIL, or other standards. Typical tests include thermal cycling from -80 °C to 200 °C and classic thermal shock for ceramics, as well as aging in hydrothermal conditions or in salt spray tests.

Services offered

- Simulation of environmental influences according to relevant standards
- Safety testing
- Informational testing according to customer's specifications
- Determination of electrical and mechanical material properties
- Mechanical load testing
- Calibration of various parameters

1 *High-voltage equipment for dielectric strength testing (100 kV AC, 130 kV DC).*
2 *Environmental test chamber.*
3 *Shaker.*

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ICC6

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From Lab to Fab

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DKG Deutsche Keramische Gesellschaft e. V.

Fraunhofer IKTS

ICF International Ceramic Federation

COOPERATION IN GROUPS, ALLIANCES AND NETWORKS

Membership in Fraunhofer Groups, Alliances and Networks

Scientists at Fraunhofer IKTS are active in numerous thematically oriented networks, alliances and groups. Therefore, our customers benefit from having a coordinated range of joint services available to them.

AMA Association for Sensors and Measurement

American Ceramic Society (ACerS)

Association Competence Center for Aerospace and Space Technology Saxony/ Thuringia (LRT)

Association for Manufacturing Technology and Development (GFE)

Association of Electrochemical Research Institutes (AGEF)

Association of German Engineers (VDI)

Association of the Thuringian Economy, Committee of Research and Innovation

Association of Thermal Spraying (GTS)

biosaxony

Carbon Composites (CCeV)

Ceramics Meeting Point Dresden

Competence Center for Nano Evaluation nanoeva®

Competence Network on Optical Technologies (Optonet)

Cool Silicon

DECHEMA – Society for Chemical Engineering and Biotechnology

Deutsche Glastechnische Gesellschaft (DGG)

DIN – German Institute for Standardization

Deutsche Keramische Gesellschaft (DKG / German Ceramic Society)

DKG/DGM Community Committee

DRESDEN concept

Dresden Fraunhofer Cluster Nanoanalysis

Dresdner Gesprächskreis der Wirtschaft und der Wissenschaft

Dual Career Network Central Germany

Energy Saxony

Ernst Abbe University of Applied Sciences Jena, university council

European Powder Metallurgy Association (EPMA)

European Rail Innovation Center

European Research Association for Sheet Metal Working EFB)

European Society of Thin Films (EFDS)

Expert Group on Ceramic Injection Molding in the German Ceramic Society

Expert Group on High-Temperature Sensing Technology in the German Society for Materials Science

Fraunhofer Adaptronics Alliance

Fraunhofer Additive Manufacturing Alliance

Fraunhofer AdvanCer Alliance

Fraunhofer Battery Alliance

Fraunhofer Cluster 3D Integration

Fraunhofer Energy Alliance

Fraunhofer Group for Materials and Components – MATERIALS

Fraunhofer Group for Microelectronics

Fraunhofer Lightweight Design Alliance

Fraunhofer Nanotechnology Alliance

Fraunhofer Numerical Simulation of Products and Processes Alliance

Fraunhofer Textile Alliance

Fraunhofer Water Systems Alliance (SysWasser)

German Acoustical Society (DEGA)

German Biogas Association

German Electroplating and Surface Treatment Association (DGO)

German Energy Storage Association (BVES)

German Engineering Association (VDMA)

German Society for Materials Research (DGM)

German Society for Non-Destructive Testing (DGZfP)

German Thermoelectric Society (DTG)

Hydrogen Power Storage & Solutions East Germany

International Energy Agency (IEA) Implementing Agreement on Advanced Fuel Cells

International Zeolite Association

KMM-VIN (European Virtual Institute on Knowledge-based Multifunctional Materials AISBL)

Materials Research Network Dresden (MFD)

medways

Meeting of Refractory Experts Freiberg (MORE)

Micro-Nanotechnology Thuringia (MNT)

NanoMat – Supraregional Network for Materials Used in Nanotechnology

Nanotechnology Center of Excellence for "Ultrathin Functional Layers"

ProcessNet – an Initiative of DECHEMA and VDI-GVC

Research Association for Diesel Emission Control Technologies (FAD)

Research Association for Measurement Technology, Sensors and Medical Technology Dresden (fms)

Research Association on Welding and Allied Processes of the German Welding Society (DVS)

Silicon Saxony

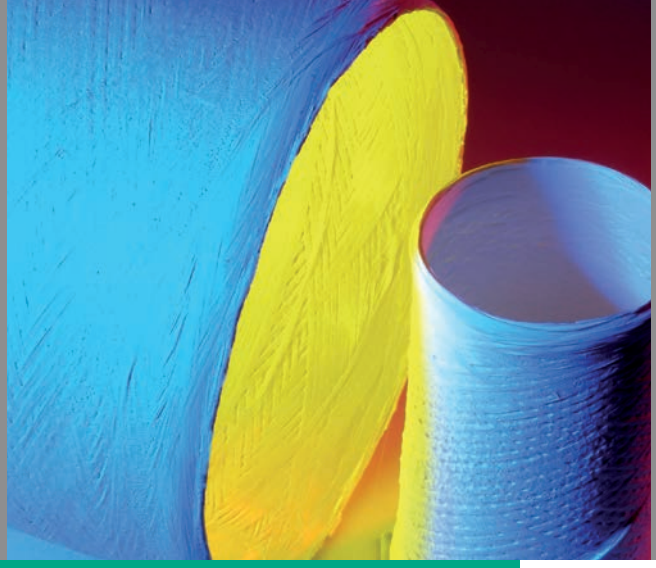
smart³

SmartTex Network

Society for Corrosion Protection (GfKORR)

Wasserwirtschaftliches Energiezentrum Dresden

WindEnergy Network Rostock



FRAUNHOFER GROUP FOR MATERIALS AND COMPONENTS – MATERIALS

The Fraunhofer Group MATERIALS integrates the expertise of 15 Fraunhofer Institutes working in the field of materials science. Fraunhofer materials research covers the entire value chain, from new material development and improvement of existing materials through manufacturing technology on a quasi-industrial scale, to the characterization of properties and assessment of service behavior. The same research scope applies to the components made from these materials and the way they function in systems. In all these fields, experimental studies in laboratories and technical institutes are supplemented by equally important numerical simulation and modeling techniques – across all scales, from individual molecules up to components and process simulation. As far as materials are concerned, the Fraunhofer MATERIALS Group covers the full spectrum of metals, inorganic non-metals, polymers and materials made from renewable resources, as well as semiconductor materials. The Group's expertise is concentrated specifically in the fields of energy and environment, mobility, health, machine and plant construction, building construction and living, microsystems technology and safety. Innovative systems are developed using materials and components customized for specific applications, and based on the assessment of the behavior of a material or component under specific conditions of use. Strategic forecasts promote the development of novel, future-oriented materials and technologies.

Objectives of the Group are:

- Enhancing safety and comfort and reducing resource consumption in the fields of transport, machine and plant construction, building construction and living
- Increasing the efficiency of systems for energy generation, energy conversion, energy storage and distribution
- Improving the biocompatibility and functioning of medical materials and materials used in biotechnology
- Increasing integration density and improving the usability characteristics of microelectronic components and microsystems
- Enhancing the utilization of natural resources and improving the quality of products made with them
- Development of recycling concepts

Members are the Fraunhofer Institutes for

- Applied Polymer Research IAP
- Building Physics IBP
- Structural Durability and System Reliability LBF
- Chemical Technology ICT
- Manufacturing Technology and Advanced Materials IFAM
- Wood Research, Wilhelm-Klauditz-Institut, WKI
- Ceramic Technologies and Systems IKTS
- High-Speed Dynamics, Ernst-Mach-Institut, EMI
- Microstructure of Materials and Systems IMWS
- Silicate Research ISC
- Solar Energy Systems ISE
- Systems and Innovations Research ISI
- Mechanics of Materials IWM
- Non-Destructive Testing IZFP
- Wind Energy and Energy System Technology IWES
- Industrial Mathematics ITWM (assoc. institute)
- Interfacial Engineering and Biotechnology IGB (assoc. institute)
- Integrated Circuits IIS (assoc. institute)

Group chairman

Prof. Dr.-Ing. Peter Elsner, Fraunhofer ICT
www.materials.fraunhofer.de

FRAUNHOFER ADVANCER ALLIANCE

Systems development with high-performance ceramics

The usage of high-performance ceramics allows for new applications in energy engineering, mechanical and plant engineering, and medical technology. Well-known examples are highly efficient tools and coatings, new material and manufacturing technologies for medical-technical products as well as creative solutions for energy and resource saving industrial processes. At present, AdvanCer is working in a joint project developing systems solutions and test methods for the oil and gas industry as well as for deep sea mining. It is the objective to develop new diamond-ceramic and hard metal materials as well as the appropriate manufacturing technologies. So, components may be realized which allow for the maintenance-free operation in up to 6000 m depth in the sea.

Four Fraunhofer Institutes (IKTS, IPK, ISC/HTL and IWM) have joined together to form the Fraunhofer AdvanCer Alliance. It is the aim of AdvanCer to develop individual systems solutions with advanced ceramics for industry. The research activities of the Fraunhofer Alliance extend along the entire value-added chain from modeling and simulation through application-oriented materials development, production and machining of ceramic parts to component characterization, evaluation and non- destructive testing under application conditions. Development work is conducted and supported by modeling and simulation methods.

Furthermore, AdvanCer has established a comprehensive range of training and consultancy services to support small and medium-sized companies in solving complex tasks ranging from prototype development to technology transfer.

Fields of cooperation

- Materials development for structural and functional ceramics, fiber-reinforced ceramics, cermets and ceramic composites
- Component design and development of prototypes
- Systems integration and verification of batch-production capabilities
- Development of powder, fiber and coating technologies
- Materials, component and process simulation
- Materials and component testing
- Defect analysis, failure analysis, quality management
- Analysis of energy demand for thermal processes and to improve energy efficiency
- Increase of efficiency using ceramic components

Services offered

- Development, testing and evaluation of materials
- Prototype and small series production
- Technology development and technology transfer
- Process analysis and design
- Consulting, feasibility studies, training programs

Spokesperson of the Alliance

Dr. Michael Zins
michael.zins@ikts.fraunhofer.de
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1 *Test stand for the tribological testing of ceramic materials and components (Source: Dirk Mahler/Fraunhofer).*

1

CERAMICS MEETING POINT – CERAMIC APPLICATIONS

The Ceramics Meeting Point is an integral part of the public relations activities of Fraunhofer IKTS. The closed production chain from powder to component is displayed, not only from a scientific point of view but also as a mirror of technologies and capacities available in the industry. The visitor gets an impression of current focal points in research and is simultaneously informed about which manufacturers offer certain product types commercially. With respective touchable models, the trust in the economic feasibility of new ideas is strengthened and the initiation of new projects facilitated.

Ceramic Applications of the Goeller Verlag, which took over the TASK GmbH business, embodies the new label of the cooperation with its currently 43 partners and members. The opportunity to see the latest research topics up to systems testing in one room and to get into contact with possible suppliers will be extended. The members of the Fraunhofer AdvanCer Alliance also benefit from this infrastructure.

In the workshops and training courses of the Fraunhofer AdvanCer Alliance and the Deutsche Keramische Gesellschaft (DKG / German Ceramic Society), the Ceramics Meeting Point is used to present the state of the art in industry and to show the practical relevance desired by the participants. Thus, a project forum particularly for small and medium-sized companies has developed, facilitating contacts to project initiators and research institutes. By visiting the Ceramics Meeting Point within the framework of numerous events taking place at Fraunhofer IKTS, more than 1500 visitors informed themselves about ceramic product innovations and manufacturers in 2015.

The highlight in 2015 was the "Technical Ceramics Day" at the ceramitec in Munich, Germany. All together 1214 visitors participated in the event, making it the most visited at the forum. The Fraunhofer AdvanCer Alliance together with Ceramic Applications was responsible for the scientific organization of the lecture program.

1 *Forum "Technical Ceramics Day" at ceramitec 2015.*

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8. PRORA - Fachtagung "Prozessnahe Röntgenanalytik", Berlin (12.–13.11.2015), Presentation

Teaching activities of IKTS employees

Dr. Eberstein, M.
Lecture
"Dickschichttechnik"
TU Bergakademie Freiberg, Institut für Keramik, Glas- und Baustofftechnik (5.6.2015)

Dr. Fries, M.
Lecture
"Granulationsverfahren und Granulatcharakterisierung in der keramischen Industrie"
TU Bergakademie Freiberg (10.6.2015)

Dr. Fries, M.; Bales, A.; Dr. Eckhard, S.
Practical training
"Demonstrationspraktikum Pulveraufbereitung: Technologie – Granulatcharakterisierung – Instrumentierte Pressverdichtung"
IKTS Dresden (16.–17.6.2015)

Dr. Gluch, J.
Lecture
"Tutorial '3D Characterization': Nanotomography"
Materials Weekend, Warschau (19.–20.9.2015)

Dr. Härtling, T.
Lecture and seminar
"Nanotechnologie und Nanoelektronik"
TU Dresden, Fakultät Elektrotechnik und Informationstechnik (SS 15)

Jun. Prof. Heuer, H.
Lecture
"Sensorsysteme für die zerstörungsfreie Prüfung und Strukturüberwachung"
TU Dresden, Institut für Aufbau- und Verbindungstechnik der Elektronik IAVT (WS 15/16)

Dr. Höhn, S.
Lecture
"Keramographie", im Rahmen der Lehrveranstaltung "Metallografie"
TU Dresden, Institut für Werkstoffwissenschaft (2.2.2015)

Dr. Jahn, M.
Lecture and practical training
"Technische Chemie II/Reaktionstechnik"
HTW Dresden, Chemieingenieurwesen (SS 15)

Dr. Jahn, M.
Lecture and practical training
"Brennstoffzellensysteme und Elektrolyse"
im Rahmen des Studienganges "Regenerative Energiesysteme"
TU Dresden (WS 15/16)

Prof. Meyendorf, N.
Degree course
"Zerstörungsfreie Prüfung"
M.Sc. (NDT)
Studiengangsleiter
DIU Dresden International University (2015)

Prof. Meyendorf, N.
Lecture and practical training
"Mikro- und Nano-Zerstörungsfreie Prüfung"
TU Dresden, Institut für Aufbau- und Verbindungstechnik der Elektronik IAVT (WS 15/16)

Prof. Meyendorf, N.
Lecture
"NDE and SHM"
University of Dayton, UD-Fraunhofer Project Center (2015)

Prof. Meyendorf, N.
Lecture
"Nanocharacterization"
University of Dayton, UD-Fraunhofer Project Center (2015)

Prof. Meyendorf, N.
Complex lecture
"NDE and SHM"
University of Dayton, General Electrics Cincinnati (2015)

Prof. Michaelis, A.; Dr. Kusnezoff, M.; Dr. Neumeister, P.; Dr. Rebenklau, L.
Lecture
"Keramische Funktionswerkstoffe"
TU Dresden, Institut für Werkstoffwissenschaft (WS 15/16)

Prof. Michaelis, A.
Lecture and practical training
"Keramische Werkstoffe"
TU Dresden, Institut für Werkstoffwissenschaft (SS 15)

Prof. Michaelis, A.; Dr. Kinski, I.; Dr. Herrmann, M.; Dr. Klemm, H.; Dr. Moritz, T.; Dr. Potthoff, A.; Dr. Gestrich, T.; Dr. Kusnezoff, M.; Dr. Neumeister, P.; Dr. Partsch, U.
Lecture
"Prozesse – Gefüge – Eigenschaften keramischer Werkstoffe"
TU Dresden, Institut für Werkstoffwissenschaft (WS 15/16)

Dr. Moritz, T.
Lecture
"Keramikspritzgießen"
TU Bergakademie Freiberg (17.6.2015)

Dr. Moritz, T.
Lecture series
"Grundlagen der Technischen Keramik"
Kunsthochschule Halle, Burg Griebichenstein (SS 15)

Dr. Mühle, U.
Lecture
"Spezielle Methoden der Mikrostrukturanalytik" (SS 15)
"Industrielle Halbleiterfertigung" (WS 15/16)
TU Bergakademie Freiberg, Fakultät Werkstoffwissenschaft und Werkstofftechnologie

Dr. Neumeister, P.
Lecture
"Bruchkriterien und Bruchmechanik"
TU Dresden, Institut für Festkörpermechanik (SS 15)

Dr. Opitz, J.
Lecture
"Biomolekulare Nanotechnologie"
"Introduction to Nanotechnology"
TU Dresden, Max-Bergmann-Zentrum, TU Dresden, Institut für Werkstoffwissenschaft (WS 15/16)

Dr. Rosenkranz, R.
Lecture
"Physikalische Fehleranalyse in der Halbleiterindustrie"
TU Dresden, Institut für Werkstoffwissenschaft (25.11.2015)

Dr. Schneider, M.
Lecture
"Rastersondenmikroskopie/AFM"
im Rahmen der Lehrveranstaltung

"Materialdiagnostik"
TU Dresden, Institut für Werkstoffwissenschaft (9.7.2015)

Prof. Stelter, M.
Lecture
"Technische Chemie I / II"
Friedrich-Schiller-Universität Jena (SS 15; WS 15/16)

Prof. Stelter, M.
Lecture
"Technische Umweltchemie"
Friedrich-Schiller-Universität Jena (SS 15; WS 15/16)

Prof. Stelter, M.
Lecture
"Energiesysteme – Materialien und Design"
Friedrich-Schiller-Universität Jena (WS 15/16)

Dr. Voigt, I.
Lecture and practical training
"Keramische Verfahrenstechnik"
Ernst-Abbe-Hochschule Jena, Fachbereich SciTec (WS 15/16)

Dr. Zins, M.
Lecture
"Metalle, Kunststoffe, Keramiken – Technische Keramik als Leichtbaustoff"
TU Dresden, Institut für Werkstoffwissenschaft (WS 15/16)

Prof. Zschech, E.; Prof. Stamm, M.; Dr. Mühle, U.; Dr. Rosenkranz, R.; Dr. Kopycinska-Müller, M.
Lecture and practical training
"Physical Characterization of Organic and Organic-Inorganic Thin Films"
TU Dresden, Institut für Angewandte Photophysik (WS 15/16)

Prof. Zschech, E.; Dr. Kopycinska-Müller, M.
Lecture
"Microscopy for Nondestructive methods classes"
Master course in English Non-Destructive Testing M. Sc. (NDT)
DIU Dresden International University (2015)

Participation in bodies and technical committees

Bodies

Dr. Berger, L.-M.
- Editorial Board of the Journal "Surface Engineering", Maney Publishing

Dr. Gall, M.
- IEEE Transactions on Device and Materials Reliability – TDMR, Editor
- IEEE International Interconnent Technology Conference – IITC, Technical Committee

Prof. Heuer, H.
- SPIE Involvement: Conference, Program Committee

Dr. Härtling, T.
- AMA Verband für Sensorik und Messtechnik e.V., Representative

Dr. Kinski, I.
- American Ceramic Society – ACerS
- Materials Research Society – MRS

Dr. Köhler, B.
- Editor-in-Chief of the Journal "Case Studies in Nondestructive Testing and Evaluation", Elsevier Verlag

Dr. Kusnezoff, M.
- Fraunhofer Energy Alliance, Representative
- SOFC Symposium of ICACC Conference Series organized by American Ceramic Society in Daytona Beach, Organizer
- VDMA Working Group High Temperature Fuel Cells, Coordinator
- European Fuel Cell Forum –EFCF–, Scientific Advisory Committee

Dr. Martin, H.-P.
- KMM-VIN, European Virtual Institute on Knowledge-based Multifunctional Materials

Prof. Meyendorf, N.
- Editor-in-Chief of the "Journal of Nondestructive Evaluation", Springer Verlag
- Publication series "Dresdner Beiträge zur zerstörungsfreien Prüftechnik", Wolter, K.-J.(Hrsg.); Meyendorf, N.(Hrsg.); Heuer, H. (Hrsg.), Dresden: TUDpress, Start 2010
- Materialforschungsverbund Dresden e.V. MFD, Chairman: Barkhausen Award Committee
- Arxes-Tollina GmbH, Member of advisory board
- DGM Industrie Beirat "Werkstoffwoche"
- DGZfP - German Society for Non-Destructive Testing
- Dresdner Gesprächskreis der Wirtschaft und der Wissenschaft e.V.
- The American Society for Nondestructive Testing
- SPIE - the international society for optics and photonics
- Joint Labs Berlin, Technical Safety
- Network "Prognostik, Prüfung und Sicherheit von Verbundwerkstoffkomponenten für den Leichtbau und Verkehrstechnik", Director
- Network "Zuverlässige Leistungselektronik", Director
- UD-Fraunhofer Joint Research Center, Co-Director

Prof. Michaelis, A.
- Editorial Board of the "International Journal of Materials Research", Hanser Verlag
- Editorial Board of the "Journal of Ceramic Science and Technology", Göller Verlag
- Publication series "Competencies in Ceramics", Michaelis, A.(Hrsg.), Stuttgart: Fraunhofer Verlag, Start 2006
- Publication series "Kompetenzen in Keramik und Umweltverfahrenstechnik", Michaelis, A.(Hrsg.), Stuttgart: Fraunhofer Verlag, Start 2008
- Publication series "Applied Electrochemistry in Material Science", Michaelis, A.(Hrsg.); Schneider, M.(Hrsg.), Stuttgart: Fraunhofer Verlag, Start 2009
- AGEF e.V. Institute at Heinrich-Heine-Universität, Arbeitsgemeinschaft Elektrochemischer Forschungsinstitutionen e.V.
- American Ceramic Society – ACerS
- Ceramic and Glass Industry Foundation (CGIF), Member Board of Trustees CGIF
- DECHEMA Society for Chemical Engineering and Biotechnology
- DECHEMA working group "Angewandte Anorganische Chemie"
- Deutscher Hochschulverband
- DGM German Society for Materials Research
- DKG Member of executive board and chairman of the research community of the Deutsche Keramische Gesellschaft, Research advisory board, Director of the scientific works
- DPG-Deutsche Physikalische Gesellschaft
- DRESDEN concept e.V.
- Dresdner Gesprächskreis der Wirtschaft und der Wissenschaft e.V.
- Energy advisory council of the Wirtschaftsministeriums Sachsen
- EPMA European Powder Metallurgy Association
- Fraunhofer AdvanCer Alliance, Spokesperson
- Fraunhofer USA, Board of directors
- Company Roth & Rau, Member of supervisory board
- Evaluation team "Interne Pro-

gramme" of the Fraunhofer Gesellschaft, Chairman
- GreenTec Awards, Member of the jury
- Helmholtz-Zentrum Dresden-Rossendorf
- IFW Dresden e.V.
- Materialforschungsverbund Dresden e.V. MFD, Executive board
- NOW GmbH, Member of advisory board
- Silicon Saxony e.V.
- Solarvalley Mitteldeutschland e.V., Executive board
- "World Academy of Ceramics" WAC

Dr. Richter, H.
- International Zeolite Association
- American Ceramic Society – ACerS

Dr. Schneider, M.
- Publication series "Applied Electrochemistry in Material Science", Michaelis, A.(Hrsg.); Schneider, M.(Hrsg.), Stuttgart: Fraunhofer Verlag, Start 2009
- DGO-Bezirksgruppe Sachsen der Deutschen Gesellschaft für Galvano- und Oberflächentechnik, Chairman
- GfKORR Fachbeirat der Gesellschaft für Korrosionsschutz e.V.

Prof. Stelter, M.
- Center for Energy and Environmental Chemistry CEEC, Jena, Member of directorate
- MNT Mikro-Nano-Technologie Thüringen e.V., Member of the executive board
- Clusterboard, Free State of Thuringia
- RIS3 working group "Nachhaltige Energie und Ressourcenverwendung", Free State of Thuringia
- VDMA, Working group Research and Innovation in Medical Technology

Dr. Voigt, I.
- BVMW German Association for Small and Medium-sized Businesses
- DECHEMA Society for Chemical Engineering and Biotechnology
- DGM/DKG/DGMT/ProcessNet-working group "Keramische Membranen", Director
- DKG, Deutsche Keramische Gesellschaft / German Ceramic Society, Member of executive board
- American Ceramic Society – ACerS
- DGM German Society for Materials Research
- University council of Ernst-Abbe-Hochschule Jena

Dr. Wunderlich, C.
- Fuel Cell Energy Solutions GmbH, Member of advisory board
- Energy Saxony e.V., Deputy chairman
- European Fuel Cell Forum, International board of advisors

Prof. Zschech, E.
- Federation of the European Materials Societies – FEMS, Member of executive board, President 2014/2015
- European Society of Thin Films – EFDS, 2010-2015, Chairman of scientific advisory board
- SEMI 3D Stacked Integrated Circuit – 3DS IC Committee, Inspection and Metrology Task Force
- European Alliance for Materials – A4M, Member of executive board
- The European Platform on Advanced Materials and Technologies – EUMAT, Member of the steering board
- Institute of Lightweight Construction and Hybrid Systems at University Paderborn, Member of scientific advisory board
- Center of Advanced Materials and Technologies, Warsaw, Poland, Member of executive board
- DRESDEN concept consortium "Information technologies and microelectronics"
- Cool Silicon e. V., Dresden, Member of executive board

Dr. Zins, M.
- Fraunhofer AdvanCer Alliance, Spokesperson
- Editorial Board of the Journal "Ceramic Applications", Göller Verlag, Chairman

Technical committees

Dipl.-Krist. Adler, J.
- DGM technical committee "Zellulare Werkstoffe"
- FAD-Förderkreis "Abgasnachbehandlungstechnologien für Dieselmotoren e.V."

Dr. Beckert, W.
- Fraunhofer Numerical Simulation of Products and Processes Alliance NUSIM

Dr. Berger, L.-M.
- DVS technical committee 2 "Thermisches Spritzen und Autogentechnik"
- DIN/DVS joint committee NA 092-00-14 AA "Thermisches Spritzen und thermisch gespritzte Schichten"

Dipl.-Math. Brand, M.
- Technical committee "Schallemissionsprüfung (SEP)" of the German Society for Non-Destructive Testing DGZfP

Dr. Eberstein, M.
- DGG technical committee 1 "Physik und Chemie des Glases"
- DKG/DGG working group "Glasig/kristalline Multifunktionswerkstoffe"

Dr. Faßauer, B.
- Fraunhofer Water Systems Alliance (SysWasser)
- Wasserwirtschaftliches Energiezentrum Dresden – e.qua impuls e.V.
- Fachverband "Biogas"

Freund, S.
- Fraunhofer AdvanCer Alliance, Central office

Dr. Fries, M.
- DKG working committee "Hochleistungskeramik", working group "Verarbeitungseigenschaften synthetischer keramischer Rohstoffe", Director
- DKG specialist committee FA 3 "Verfahrenstechnik"
- ProcessNet technical group "Agglomerations- und Schüttguttechnik", Member of advisory board
- ProcessNet technical group "Trocknungstechnik", Member of advisory board

Dr. Gall, M.
- Fraunhofer Nanotechnology Alliance
- Europäische Forschungsgemeinschaft Dünne Schichten e.V. (EFDS)

Dr. Gestrich, T.
- Working committee "Pulvermetallurgie", expert group "Sintern"
- GEFTA working group "Thermophysik"

Dipl.-Ing. Gronde, B.
- Community "Thermisches Spritzen e.V."

Dr. Hentschel, D.
- DGZfP technical committee "ZfP in der Luftfahrt", Deputy director

Dr. Herrmann, M.
- DGM technical committee "Field Assisted Sintering Technique / Spark Plasma Sintering"
- GfKORR working group "Korrosion keramischer Werkstoffe"

Dr. Kaiser, A.
- GEFTA working group "Thermophysik"
- DGM technical committee "Thermodynamik, Kinetik und Konstitution der Werkstoffe"

Dr. Kinski, I.
- DGK working group "Festkörper-NMR-Spektroskopie"
- DGK working group "AK13 Pulverdiffraktometrie"

Dr. Klemm, H.
- DGM/DKG joint committee "Hochleistungskeramik", working group "Verstärkung keramischer Stoffe"
- DIN committee for standardization "Materialprüfung NMP 291"
- DIN committee for standardization "Materialprüfung NMP 294"
- Carbon Composites e.V., working group "Ceramic Composites"

Kunath, R.
- Working group "Spezialbibliotheken"

Dr. Kusnezoff, M.
- DIN/VDE, Referat K 141, DKE Deutsche Kommission, "Elektrotechnik Elektronik Informationstechnik"
- DIN/VDE, Referat K 384, DKE Deutsche Kommission, "Brennstoffzellen"
- DGM working group "Aufbau- und Verbindungstechnik für Hochtemperatursensoren", Director of working group AVT

Dr. Lausch, H.
- VDE/VDI Gesellschaft Mikroelektronik, Mikro- und Feinwerktechnik, GMM technical committee 4.7 "Mikro-Nano-Integration"
- VDE/DGMT/BMBF Begleitforschung "Intelligente Implantate", External member
- biosaxony – Verein für Biotechnologie & Life Sciences e. V.
- InfectoGnostics Forschungscampus Jena/Funding initiative "Forschungscampus – öffentlich-private Partnerschaft für Innovationen" of the BMBF
- Deutsche Plattform NanoBio-Medizin

Dipl.-Ing. Ludwig, H.
- DGM technical committee "Biomaterialien"

Dr. Martin, H.-P.
- German Thermoelectric Society
- DVS committee for technology, working group W3 "Fügen von Metall, Keramik und Glas"

Prof. Meyendorf, N.
- DGZfP technical committee "Materialcharakterisierung"
- DGZfP technical committee "Zustandsüberwachung"
- DGZfP technical committee "Luftfahrt"
- DGZfP technical committee "Hochschullehrer im Lehrgebiet ZfP"
- VDI-GME division 1 "Werkstofftechnik" FA101 "Anwendungsnahe zerstörungsfreie Werkstoff- und Bauteilprüfung"
- DGZfP working group Berlin
- ASNT Miami Valley Section

Dr. Moritz, T.
- European Network of Material Research Institutes (ENMat), President
- DECHEMA technical committee "Nanotechnologie"
- DKG expert group "Keramikspritzguss", Chairman of executive board
- Editorial board of the cfi/Ber. DKG, Chairman
- Management Committee of COST action MP1105 "Flame-retardant Materials"
- DKG technical committee III "Verfahrenstechnik"
- EPMA-Additive Manufacturing Group

Dipl.-Phys. Mürbe, J.
- VDI-Bezirksverein Dresden, working group "Granulometrie"

Dr. Petasch, U.
- FAD-Förderkreis "Abgasnachbehandlungstechnologien für Dieselmotoren e.V."

Dr. Potthoff, A.
- DGM/DKG working group "Prozessbegleitende Prüfverfahren"
- DECHEMA/VCI working group "Responsible Production and Use of Nanomaterials"
- DIN committee for standardization NMP NA 062-08-16 AA "Chemische Oberflächenanalyse und Rastersondenmikroskopie"
- DIN committee for standardization NMP NA 062-08-17-03 UA "Gesundheits- und Umweltaspekte"
- Fraunhofer Nanotechnology Alliance

Pötschke, J.
- VDI technical committee "Schneidstoffanwendung"
- EPMA working group "European Hard Materials Group"

Dipl.-Ing. Räthel, J.
- DGM technical committee "Field Assisted Sintering Technique / Spark Plasma Sintering (FAST/SPS)"

Dr. Rebenklau, L.
- VDE/VDI Gesellschaft Mikroelektronik, Mikro- und Feinwerktechnik, GMM technical committee 5.5 "Aufbau- und Verbindungstechnik"
- Working group "Aufbau- und Verbindungstechnik für Hochtemperatursensoren"
- DVS working group A 2.4 "Bonden im DVS"

Dr. Reichel, U.
- DGM technical committee "Field Assisted Sintering Technique / Spark Plasma Sintering (FAST/SPS)"

Dr. Richter, H.-J.
- DGM/DKG working committee "Hochleistungskeramik", working group "Biokeramik"
- DGM technical committee "Additive Fertigung"
- Fraunhofer Additive Manufacturing Alliance

Dr. Richter, V.
- VDI technical committee "Schneidstoffanwendung"
- DECHEMA/VCI working group "Responsible Production and Use of Nanomaterials"
- DGM working group "Materialkundliche Aspekte der Tribologie und der Endbearbeitung"
- DIN committee for standardization "Werkstofftechnologie" (NWT), AA "Probenahme und Prüfverfahren für Hartmetalle"
- DIN committee for standardization "Materialprüfung" (NMP), AA "Nanotechnologien"
- DGM/DKG working committee "Pulvermetallurgie", expert group "Sintern"
- Fraunhofer Nanotechnology Alliance
- EPMA working group "European Hard Materials Group"

Dr. Rost, A.
- DVS committee for technology, working group W3 "Fügen von Metall, Keramik und Glas"
- DKG/DGG working group "Glasigkristalline Multifunktionswerkstoffe"

Dr. Schilm, J.
- DGG technical committee 1 "Physik und Chemie des Glases"
- DKG/DGG working group "Glasigkristalline Multifunktions-

werkstoffe"
- DVS committee for technology, working group W3 "Fügen von Metall, Keramik und Glas"

Dr. Schneider, M.
- GfKORR working group "Korrosion keramischer Werkstoffe", Chairman

Dr. Schubert, F.
- DGZfP technical committee "Ultraschall", subcommittee "Modellierung und Bildgebung"
- DGZfP technical committee "Ultraschall", subcommittee "Phased Array", Deputy director
- DGZfP working group Dresden, Director

Dipl.-Chem. Schubert, R.
- DKG expert group "Keramikspritzguss"

Dipl.-Ing. Stahn, M.
- VDI-Entwicklung, Konstruktion, Vertrieb

Standke, G.
- DGM technical committee "Zellulare Werkstoffe"

Prof. Stelter, M.
- DGM technical committee "Werkstoffe der Energietechnik"
- medways e.V. (The industry association for Medical Technology and Biotechnology)
- Optonet e.V. (Photonics Network Thuringia)

Dipl.-Min. Thiele, S.
- GTS community "Thermisches Spritzen e.V."

Dr. Voigt, I.
- ProcessNet technical group "Produktionsintegrierte Wasser- und Abwassertechnik"
- ProcessNet technical group "Membrantechnik"
- DGM/DKG joint committee "Hochleistungskeramik", working group "Keramische Membranen", Chairman
- DGM/DKG joint committee "Hochleistungskeramik", working group "Koordinierung", Director

Dr. Weidl, R.
- EFDS Europäische Forschungsgesellschaft Dünne Schichten e.V.
- BVES German Energy Storage Association, working 2 "Roadmap der Energiewende und Rolle der Energiespeicher"
- Center for Energy and Environmental Chemistry CEEC, Jena

Dr. Weyd, M.
- DGMT Deutsche Gesellschaft für Membrantechnik e.V.

Dr. Wunderlich, C.
- VDI technical committee "Brennstoffzellen"

Dr. Zins, M.
- DKG coordination group "Strukturwerkstoffe Fachausschüsse"
- DKG division 1 "Chemie-/Maschinen-/Anlagenbau", Chairman
- DKG working committee "Pulvermetallurgie"
- Deutsche Messe AG, Advisory board "Industrial Supply"
- Messe Munich, Advisory board "Ceramitec"
- Institut für Prozess- und Anwendungstechnik Keramik, RWTH Aachen, Executive board

Committees for symposia

Dr. Eberstein, M.
- IMAPS/ACerS/DKG 11th International Conference and Exhibtion on Ceramic Interconnect and Ceramic Microsystems Technologies – CICMT 2015, Dresden (20.–23.4.2015), Local organizing committee

Freund, S.
- AdvanCer-Schulungsprogramm Einführung in die Hochleistungskeramik Teil I: Werkstoffe, Verfahren, Anwendungen, Dresden (11.–12.6.2015), Organization and moderation

Dr. Gall, M.
- 18th IEEE International Interconnect Technology Conference – IITC/24th Materials for Advanced Metallization Conference – MAM, Grenoble, France (18.–21.5.2015), Technical committee
- 2015 IEEE International Reliability Physics Symposium – IRPS, Monterey, CA, USA (19.–23.4.2015), Technical committee

Dr. Gestrich, T.
- 34. Hagener Symposium Pulvermetallurgie "Pulvermetallurgie - Effiziente Prozesse - besondere Eigenschaften", Hagen (26.–27.11.2015), Chairman of the program committee

Dr. Härtling, T.
- Second International Symposium on Optical Coherence Tomography for Non-Destructive Testing – OCT4NDT, Dresden (25.–26.3.2015), Organizer
- Second International Symposium on Optical Coherence Tomography for Non-Destructive Testing – OCT4NDT, Session 1 "OCT technology" (Part 2), Dresden (25.–26.3.2015), Session chair

Jun. Prof. Heuer, H.
- Smart Sensors, Actuators, and MEMS VII, SPIE Conference, Barcelona (4.–6.5.2015), Conference committee
- 12th International Conference on Science and Technology "Technological Systems of Information in Production Engineering", Kazimierz Dolny, Poland (27.–29.5.2015), Conference committee

Dr. Klemm, H.
- 11th International Symposium on Ceramic Materials and Components for Energy and Environmental Applications – CMCee, Session T2S2 "Advanced Ceramic Coatings for Power Systems", Vancouver, Canada (14.–19.6.2015), Session organizer
- 6th International Congress on Ceramics – From Lab to Fab – ICC6, Dresden (21.–25.8.2016), Conference committee, International advisory board

Dr. Köhler, B.
- 19th World Conference on Nondestructive Testing – WCNDT 2016, München (13.–17.6.2016), Scientific program committee "Nano-Technologies and High-Resolution NDT"
- 11th International Symposium on Ceramic Materials and Components for Energy and Environmental Applications – CMCee, Session T4S11 "Materials Diagnostics and Structural Health Monitoring of Ceramic Components and Systems", Vancouver, Canada (14.–19.6.2015), Session organizer

Dr. Krell, A.
- Symposium Ceramics Vision 2015, Dresden (15.–16.1.2015), Organizer

Dr. Kusnezoff, M.
- 11th International Symposium on Ceramic Materials and Components for Energy and Environmental Applications – CMCee, Session T1S1 "High-temperature Fuel Cells and Electrolysis", Vancouver, Canada

(14.–19.6.2015), Session organizer
- 39th International Conference and Exhibition on Advanced Ceramics and Composites – ICACC 2015, Daytona Beach (25.–30.1.2015), S3: 12th International Symposium on Solid
- Oxide Fuel Cells (SOFC): Materials, Science and Technology, Degradation, Modeling and Simulation / Novel Processing and Design, Symposium chair

Dr. Martin, H.-P.
- Industry Day "Charakterisierung mechanischer Eigenschaften bei hohen Temperaturen", Dresden (1.–2.6.2016), Organizer

Dr. Megel, S.
- 11th International Symposium on Ceramic Materials and Components for Energy and Environmental Applications – CMCee, Session T1S1 "High-temperature Fuel Cells and Electrolysis", Vancouver, Canada (14.–19.6.2015), Session organizer

Prof. Meyendorf, N.
- SPIE Conference "Smart Materials and Nondestructive Evaluation for Energy Systems 2015", San Diego, California (9.–10.3.2015), Conference chair
- SPIE Conference "Sensors and Smart Structures Technologies for Civil, Mechanical, and Aerospace Systems", Las Vegas, Nevada (21.–24.3.2016), Program committee

Prof. Michaelis, A.
- Symposium Ceramics Vision 2015, Dresden (15.–16.1.2015), Organizer
- 39th International Conference and Exhibition on Advanced Ceramics and Composites – ICACC 2015, Daytona Beach (25.–30.1.2015), Co-chair
- 39th International Conference and Exhibition on Advanced Ceramics and Composites – ICACC 2015, Daytona Beach (25.–30.1.2015), 2nd European Union - USA Engineering Ceramics Summit, Advanced Ceramic Technologies: Current Status and Future Prospects II, Session chair
- IMAPS/ACerS/DKG 11th International Conference and Exhibition on Ceramic Interconnect and Ceramic Microsystems Technologies – CICMT 2015, Dresden (20.–23.4.2015), Conference committee, Chair
- 90th DKG Annual Conference & Symposium on High-Performance Ceramics 2015, Bayreuth (15.–19.3.2015), Member of program committee
- 11th International Symposium on Ceramic Materials and Components for Energy and Environmental Applications – CMCee, Vancouver, Canada (14.–19.6.2015), Co-chair
- 6th International Congress on Ceramics – From Lab to Fab – ICC6, Dresden (21.–25.8.2016), Conference committee, Chair

Dr. Moritz, T.
- DKG-Symposium "Additive Fertigung: Verfahren und Anwendungen in der Keramik", Erlangen (1.–2.12.2015), Program committee
- IMAPS/ACerS/DKG 11th International Conference and Exhibition on Ceramic Interconnect and Ceramic Microsystems Technologies – CICMT 2015, Dresden (20.–23.4.2015), Chair

Dr. Opitz, J.
- 11th International Symposium on Ceramic Materials and Components for Energy and Environmental Applications – CMCee, Session T4S11 "Materials Diagnostics and Structural Health Monitoring of Ceramic Components and Systems", Vancouver, Canada (14.–19.6.2015), Session organizer
- 39th International Conference and Exhibition on Advanced Ceramics and Composites – ICACC 2015, Daytona Beach (25.–30.1.2015), FS3: Materials Diagnostics, Nondestructive Evaluation and Structural Health Monitoring of Ceramic Components and Systems, Session chair
- Second International Symposium on Optical Coherence Tomography for Non-Destructive Testing – OCT4NDT, Session 2 "OCT applications", Dresden (25.–26.3.2015), Session chair

Dr. Partsch, U.
- IMAPS/ACerS/DKG 11th International Conference and Exhibition on Ceramic Interconnect and Ceramic Microsystems Technologies – CICMT 2015, Dresden (20.–23.4.2015), Local organizing committee

Pfeifer, T.
- 11th International Symposium on Ceramic Materials and Components for Energy and Environmental Applications – CMCee, Session T1S1 "High-temperature Fuel Cells and Electrolysis", Vancouver, Canada (14.–19.6.2015), Session organizer

Dr. Richter, H.
- 11th International Symposium on Ceramic Materials and Components for Energy and Environmental Applications – CMCee, Session T3S4 "Porous and Cellular Ceramics for Filter and Membrane Applications", Vancouver, Canada (14.–19.6.2015), Session organizer

Dr. Rölling, M.
- Second International Symposium on Optical Coherence Tomography for Non-Destructive Testing – OCT4NDT, Dresden (25.–26.3.2015), Organizer

Dr. Schilm, J.
- 39th International Conference and Exhibition on Advanced Ceramics and Composites – ICACC 2015, S3: 12th International Symposium on Solid Oxide Fuel Cells (SOFC): Materials, Science and Technology "Electrical and Mechanical Reliability Electrochemical Performance and Stability", Daytona Beach (25.–30.1.2015), Session chair

Dr. Schneider, M.
- 8th International Workshop on Impedance Spectroscopy – IWIS 2015, Chemnitz (23.–25.9.2015), Program committee
- 11th International Symposium on Electrochemical Machining Technology – INSECT 2015, Linz (12.–13.11.2015), Advisory board

Dr. Schönecker, A.
- Symposium Ceramics Vision 2015, Dresden (15.–16.1.2015), Organizer
- ISPA 2015 – International Symposium on Piezocomposite Applications, Dresden, Germany (17.–18.9.2015), Conference organizer

Dr. Schubert, F.
- 19th World Conference on Non-Destructive Testing – WCNDT 2016, München (13.–17.6.2016), Scientific program committee "Structural Health Monitoring"

Prof. Stelter, M.
- 11th International Symposium on Ceramic Materials and Com-

ponents for Energy and Environmental Applications – CMCee, Session T4S3 "Novel, Green, and Strategic Processing and Manufacturing Technologies", Vancouver, Canada (14.–19.6.2015), Session organizer

Dr. Voigt, I.
- 39th International Conference and Exhibition on Advanced Ceramics and Composites – ICACC 2015, Daytona Beach (25.–30.1.2015), S9: Porous Ceramics: Novel Developments and Applications, Membranes and High SSA Ceramics II, Session chair
- 11th International Symposium on Ceramic Materials and Components for Energy and Environmental Applications – CMCee, Session T3S4 "Porous and Cellular Ceramics for Filter and Membrane Applications", Vancouver, Canada (14.–19.6.2015), Session organizer

Dr. Wolf, C.
- Second International Symposium on Optical Coherence Tomography for Non-Destructive Testing – OCT4NDT, Dresden (25.–26.3.2015), Organizer

Dr. Wolter, M.
- Dresden Battery Days 2015, Dresden (22.–24.9.2015), Organization
- 6th International Congress on Ceramics – From Lab to Fab – ICC6, Dresden (21.–25.8.2016), Conference committee, International advisory board

Dr. Wunderlich, C.
- Second International Symposium on Optical Coherence Tomography for Non-Destructive Testing – OCT4NDT, Fraunhofer IKTS Dresden (25.–26.3.2015), International advisory board
- 11th International Symposium on Ceramic Materials and Components for Energy and Environmental Applications – CMCee, Session T1S1 "High-temperature Fuel Cells and Electrolysis", T1S1-07. SOFC & SOEC System Concept Analyses, Test and Demonstration, Oral, Vancouver, Canada (14.–19.6.2015), Session organizer

Dr. Zins, M.
- 90th DKG Annual Conference & Symposium on High-Performance Ceramics 2015, Bayreuth (15.–19.3.2015), Member of program committee
- ceramitec 2015, Technical Ceramics Day, München (22.10.2016), Moderator

Prof. Zschech, E.
- 3rd Dresden Nanoanalysis Symposium, Dresden (17.4.2015), Scientific coordinator
- 2015 International Conference on Frontiers of Characterization and Metrology for Nanoelectronics – FCMN, Dresden, Germany (14.–16.4.2015)

Dissertations 2015

Ahlhelm, Matthias
Gefrierschäume – Entwicklung von zellularen Strukturen für vielfältige Anwendungen
Dissertation 2015
Fraunhofer IKTS – TU Clausthal, Fakultät für Natur- und Materialwissenschaften, Institut für Nichtmetallische Werkstoffe

Berger, Lutz-Michael
Carbide und Oxide als Verschleißschutz – Von der Synthese zur thermisch gespritzten Schicht
Habilitation 2015
Fraunhofer IKTS – TU Wien, Fakultät für Technische Chemie, Institut für Chemische Technologien und Analytik

Brandt, Björn
Modellierungsansätze und neue Brennhilfsmittelkonzepte für die LTCC-Drucksintertechnologie
Dissertation 2015
Fraunhofer IKTS – TU Dresden, Fakultät Maschinenwesen, Institut für Werkstoffwissenschaft – BAM Bundesanstalt für Materialforschung und -prüfung

Eckhard, Susanna
Experimentelle und modellbasierte Untersuchungen zum Einfluss der Granulatstruktur auf die mechanischen Granulateigenschaften
Dissertation 2015
Fraunhofer IKTS – TU Hamburg-Harburg, Institut für Feststoffverfahrenstechnik und Partikeltechnologie

Hildebrandt, Stefanie
Entwicklung und Evaluierung von Metallisierungen mit partikelfreien/-haltigen Tinten mit Inkjet- und Aerosol-Druck
Dissertation 2015
Fraunhofer IKTS – TU Dresden, Fakultät Maschinenwesen, Institut für Werkstoffwissenschaft

Mühle, Uwe
Spezielle Anwendungen der Transmissionselektronenmikroskopie in der Siliziumhalbleiterindustrie
Habilitation 2015
Fraunhofer IKTS – TU Bergakademie Freiberg, Fakultät für Werkstoffwissenschaft und Werkstofftechnologie

Jurk, Robert
Synthese von Edelmetalltinten für den Inkjetdruck funktioneller Schichten mit dem Anwendungsbeispiel der Frontseitenmetallisierung kristalliner Solarzellen
Dissertation 2015
Fraunhofer IKTS – TU Dresden, Fakultät Maschinenwesen, Institut für Werkstoffwissenschaft

Füssel, Alexander
Untersuchungen zum Hochtemperaturverhalten von Siliciumcarbid-Schaumkeramik für Brenneranwendungen
Dissertation 2015
Fraunhofer IKTS – TU Dresden, Fakultät Maschinenwesen, Institut für Werkstoffwissenschaft

Niese, Sven
Lab-based in-situ X-ray microscopy – Methodical developments and applications in materials science and microelectronics
Dissertation 2015
Fraunhofer IKTS – Brandenburgische Technische Universität Cottbus

Seuthe, Thomas
Strukturelle Änderungen in Silicatgläsern unterschiedlicher Komposition durch Bestrahlung mit Femtosekunden-Laserpulsen
Dissertation 2015
Fraunhofer IKTS – TU Dresden, Fakultät Maschinenwesen, Institut für Werkstoffwissenschaft

Theses 2015

Becker, Arnulf
Festkommaportierung des generalisierten Mel-Cepstrum
Bachelor's thesis 2015
Fraunhofer IKTS - BTU Cottbus-Senftenberg, Fakultät Maschinenbau, Elektrotechnik und Wirtschaftsingenieurwesen

Chen, Lili
Crack detection of ceramics based on the method of Laser Speckle Photometry
Master's thesis 2015
Fraunhofer IKTS – DIU Dresden

International University, Master Course in Non-Destructive Testing

Fröhlich, Selina
Herstellung und Charakterisierung feinskaliger 1-3 Piezokomposite mittels Soft-Mold-Technologie für die Entwicklung hochfrequenter Ultraschallwandler
Master's thesis 2015
Fraunhofer IKTS – Ernst-Abbe-Hochschule Jena

Gaska, Florian
Messung der Lumineszenzantwort an Einzelpartikeln von Aufkonversionsmaterialien
Bachelor's thesis 2015
Fraunhofer IKTS – Berufsakademie Sachsen, Staatliche Studienakademie Riesa

Gerner, Norman
Die Eignung von keramischen Pulvern und keramischen Formstoffkombinationen beim Stahlgießen von Gussprodukten
Master's thesis 2015
Fraunhofer IKTS – TU Clausthal, Institut für Metallurgie

Gößel, Martin
Basaltfaserkomposite mit polymerkeramischer Matrix – Entwicklung, Herstellung und Charakterisierung hinsichtlich mechanischer und korrosiver Beanspruchbarkeit
Bachelor's thesis 2015
Fraunhofer IKTS – HTW Dresden, Fakultät Maschinenbau/Verfahrenstechnik

Gyenes, Adrian
Entwicklung von reproduzierbaren Modellsystemen unterschiedlich belasteter Grauwässer für die labortechnische Bewertung von AOP-Prozessen
Master's thesis 2015
Fraunhofer IKTS – TU Dresden, Fakultät Umweltwissenschaften, Institut für Siedlungs- und Industriewasserwirtschaft

Harms, Stefan
Untersuchung zur zerstörungsfreien Detektion von Rissen an Rohrstrukturen mit geführten Wellen
Master's thesis 2015
Fraunhofer IKTS – TU Bergakademie Freiberg, Fakultät Geowissenschaften, Geotechnik und Bergbau, Institut für Geophysik und Geoinformatik

Heilmann, Stefan
Charakterisierung von co-gesinterten Metall-Keramik Verbundfolien
Diploma thesis 2015
Fraunhofer IKTS – TU Dresden, Fakultät Maschinenwesen, Institut für Werkstoffwissenschaft

Hermsdorf, Manja
Prüfstand zur Untersuchung des ferroelektromechanischen Materialverhaltens an piezokeramischen Probekörpern unter Mehrfeldbelastung
Diploma thesis 2015
Fraunhofer IKTS – TU Dresden, Fakultät Elektrotechnik, Institut für Festkörperelektronik

Kidszun, Claudyn
Labortechnische Untersuchungen zu Möglichkeiten der bedarfsgerechten Biogaserzeugung durch zielgerichtete Verfahrensführung
Diploma thesis 2015
Fraunhofer IKTS – TU Dresden, Fakultät Umweltwissenschaften, Institut für Abfallwirtschaft und Altlasten

Körnig, André
Modellgestützte Konzeption und Aufbau eines Demonstrators für neuartige keramische fluidische Mischerstrukturen durch Folientechnologie
Diploma thesis 2015
Fraunhofer IKTS – TU Dresden, Fakultät Maschinenwesen, Institut für Verfahrenstechnik und Umwelttechnik

Kronsbein, Antje
Beiträge zur Charakterisierung des Prozessablaufes und der Verbindungsbildung beim Mikroschweißen für Hochtemperaturwerkstoffe
Diploma thesis 2015
Fraunhofer IKTS – TU Dresden, Institut für Aufbau- und Verbindungstechnik der Elektronik (IAVT) – TU Dresden, Zentrum für mikrotechnische Produktion (ZmP)

Küttner, Marco
Sinteruntersuchungen am Glaskeramik-System LATP
Bachelor's thesis 2015
Fraunhofer IKTS – TU Bergakademie Freiberg, Fakultät Maschinenbau, Verfahrens- und Energietechnik

Kuzeyeva, Nataliya
Charakterisierung von Rührreibschweißmischverbindungen von Leichtbaumaterialien mittels Ultraschall
Master's thesis 2015
Fraunhofer IKTS – DIU Dresden International University, Masterstudiengang ZFP

Liu, Luhao
Design and implementation of a read-out electronics for a plasmonic sensor
Master's thesis 2015
Fraunhofer IKTS – TU Dresden, Fakultät Elektrotechnik und Informationstechnik, Institut für Festkörperelektronik

Müller, Christin
Untersuchung zur Rolle von B_2O_3, Kohlenstoff und SiO_2 auf die Verdichtung und Eigenschaften flüssigphasen-gesinterter B_6O-Werkstoffe
Diploma thesis 2015
Fraunhofer IKTS – TU Dresden, Fakultät Maschinenwesen, Institut für Werkstoffwissenschaft

Niehues, Mark
Studies on the probe area- and device stiffness functions for the calibration of nanoindentation experiments
Bachelor's thesis 2015
Fraunhofer IKTS – TU Dresden, Fakultät Mathematik und Naturwissenschaften, Institut für Festkörperphysik

Paustian, Dirk
Hydrophobierung keramischer Membranen und Evaluierung für eine Membranreaktoranwendung
Master's thesis 2015
Fraunhofer IKTS – FSU Jena, Chemisch-Geowissenschaftliche Fakultät

Pohl, Andrea
Spektroskopische Ellipsometrie und Infrarotspektroskopie an Polymeren
Master's thesis 2015
Fraunhofer IKTS – DIU Dresden International University, Masterstudiengang ZFP

Presser, André
Entwicklung und Modellierung eines Verfahrenskonzepts zur Kopplung von Biogaserzeugung und Fischer-Tropsch-Synthese für die Herstellung chemischer Produkte
Diploma thesis 2015
Fraunhofer IKTS – TU Dresden, Fakultät Maschinenwesen, Institut für Energietechnik

Raufeisen, Sascha
Untersuchungen zum pyroelektrokatalytischen Oxidationsvermögen von Lithiumniobat und Lithiumtantalat im aquatischen System
Master's thesis 2015
Fraunhofer IKTS – FSU Jena, Chemisch-Geowissenschaftliche Fakultät

Schäfer, Paul
Erprobung von zellulären keramischen Bauteilen zur photokatalytischen Wasseraufbereitung
Master's thesis 2015
Fraunhofer IKTS – TU Dresden, Fakultät Umweltwissenschaften, Institut für Siedlungs- und Industriewasserwirtschaft

Schaller, Max
Synthese höherer Alkohole an promotierten Eisenkatalysatoren im Festbettreaktor
Master's thesis 2015
Fraunhofer IKTS – Universität Rostock, Institut für Chemie

Schneider, Annemarie
Reaktionstechnische Untersuchungen an Co- und Fe-basierten Katalysatorsystemen für die Fischer-Tropsch-Synthese
Diploma thesis 2015
Fraunhofer IKTS – TU Dresden, Fakultät Maschinenwesen, Institut für Verfahrens- und Umwelttechnik

Striegler, Maria
Korrosion von SiC-Diamantkompositen in wässrigen Lösungen
Bachelor's thesis 2015
Fraunhofer IKTS – Hochschule Fresenius - University of Applied Sciences, Fachbereich Chemie und Biologie

Téllez Villamizar, Camilo Eduardo
Preparation and characterization of a low temperature resistor paste based on Carbon/Polymer composites using screen printing technique
Master's thesis 2015
Fraunhofer IKTS – TU Dresden, Fakultät Maschinenwesen, Institut für Werkstoffwissenschaft

Tscharntke, Franziska
Entwicklung einer extrudierfähigen kaltplastischen Masse auf Basis von Aluminiumoxid
Diploma thesis 2015
Fraunhofer IKTS – TU Dresden, Fakultät Maschinenwesen, Institut für Werkstoffwissenschaft

Weiße, Maik
Evaluierung einer in situ Hydrophobierungs-Methode zur Auftrennung von Öl / Wassergemischen mittels keramischer Membranen
Master's thesis 2015
Fraunhofer IKTS – FSU Jena, Chemisch-Geowissenschaftliche Fakultät

EVENTS AND TRADE FAIRS – PROSPECTS

Conferences and events

Girls Day
April 28, 2016, Dresden, Maria-Reiche-Strasse

Industry Day: Characterization of mechanical properties at high temperatures
June 1–2, 2016, Dresden, Winterbergstrasse

Researcher's Night Dresden
June 10, 2016, Dresden, Winterbergstrasse

6th International Congress on Ceramics (ICC6)
Congress and Exhibition www.icc-6.com
August 21–25, 2016, Dresden, International Congress Center

Symposium: Anodizing – oxide layers from hard to smart
November 24–25, 2016, Dresden, Winterbergstrasse

Ceramics Vision
January 17, 2017, Hermsdorf, Stadthaus

Please find further information at
www.ikts.fraunhofer.de/en/events.html

Seminars and workshops

AdvanCer training program:
Introduction into advanced ceramics

Part I / 2016: Materials, technologies, applications
June 16–17, 2016, Dresden

Part II / 2016: Design, testing
November 10–11, 2016, Freiburg

Please find further information at
www.advancer.fraunhofer.de/en.html

Participation in trade fairs

MedTec Europe
Stuttgart, April 12–14, 2016
Joint Fraunhofer booth

Wind & Maritime
Rostock, April 13–14, 2016

Powtech
Nuremberg, April 19–21, 2016

Control
Stuttgart, April 26–29, 2016
Joint Fraunhofer booth

Hannover-Messe
Hannover, 25.–29. April 2016
Joint booth Fraunhofer Adaptronics Alliance, Hall 2
Joint booth Ceramics Applications, Hall 6
Joint booth Energy Saxony, Hall 27

Printed Electronics
Berlin, April 27–28, 2016

ACHEMAsia
Beijing, May 9–12, 2016

PCIM Europe
Nuremberg, May 10–12, 2016
Joint booth ECPE European Cluster for Power Electronics

Sensor+Test
Nuremberg, May 10–12, 2016
Joint booth "Forschung für die Zukunft"

Mittelstandstag
Bischofswerda, May 24, 2016

IFAT
Munich, May 30 – June 3, 2016
Joint Fraunhofer booth and joint booth Fraunhofer SysWasser Alliance

Cancer Diagnostics Conference & Expo
Rome, June 13–15, 2016

WCNDT
Munich, June 13–17, 2016

Actuator
Bremen, June 13–15 Juni, 2016
Joint booth Fraunhofer Adaptronics Alliance

Rapidtech
Erfurt, June 21–23, 2016
Joint booth Fraunhofer Additive Manufacturing Alliance

EFCF
Lucerne, July 5–8, 2016

Ostthüringische Kooperationsbörse des verarbeitenden und produzierenden Gewerbes
Dornburg, September 15, 2016

AM Expo
Lucerne, September 20–21, 2016

Innotrans
Berlin, September 20–23, 2016
Joint booth Saxony Economic Development Corporation

World Cancer Conference
London, September 26–28, 2016

WorldPM
Hamburg, October 9–13, 2016

World of Energy Solutions
Stuttgart, October 10–12, 2016
Joint booth Fraunhofer Battery Alliance

World Cancer Congress
Paris, October 31 – November 3, 2016

Electronica
Munich, November 8–11, 2016

Medica
Düsseldorf, November 13–17, 2016
Joint Fraunhofer booth

Hagener Symposium
Hagen, November 24–25, 2016

FAD Conference
Dresden, November 2016

Composites
Stuttgart, November 29 – December 1, 2016
Joint Fraunhofer booth

Academix
Erfurt, Dezember 2016

Please find further information at
www.ikts.fraunhofer.de/en/tradefairs.html

HOW TO REACH US AT FRAUNHOFER IKTS

Please find further information and direction sketches at www.ikts.fraunhofer.de/en/contact.html

How to reach us in Dresden-Gruna

By car

- Highway A4: at the three-way highway intersection "Dresden West" exit onto Highway A17 in direction "Prag" (Prague)
- Exit at "Dresden Prohlis/Nickern" (Exit 4)
- Continue 2 km along the secondary road in direction "Zentrum" (City center)
- At the end of the secondary road (Kaufmarkt store will be on the right side), go through traffic light and continue straight ahead along Langer Weg in direction "Prohlis" (IHK)
- After 1 km, turn left onto Mügelner Strasse
- Turn right at the next traffic light onto Moränenende
- Continue under the train tracks and turn left at next traffic light onto Breitscheidstrasse
- Continue 3 km along the An der Rennbahn to Winterbergstrasse
- Fraunhofer IKTS is on the left side of the road
- Please sign in at the entrance gate

By public transport

- From Dresden main station take tram 9 (direction "Prohlis") to stop "Wasaplatz"
- Change to bus line 61 (direction "Weißig/Fernsehturm") or 85 (direction Striesen) and exit at "Grunaer Weg"

By plane

- From Airport Dresden-Klotzsche take a taxi to Winterberg-strasse 28 (distance is approximately 7 miles or 10 km)
- Or use suburban train S2 (underground train station) to stop "Haltepunkt Strehlen"
- Change to bus line 61 (direction "Weißig/Fernsehturm") or 85 (direction Striesen) and exit at "Grunaer Weg"

How to reach us in Dresden-Klotzsche

By car

- Highway A4: exit "Dresden-Flughafen" in direction Hoyerswerda along H.-Reichelt-Strasse to Grenzstrasse
- Maria-Reiche-Strasse is the first road to the right after Dörnichtweg

- From Dresden city: B97 in direction Hoyerswerda
- Grenzstrasse branches off to the left 400 m after the tram rails change from the middle of the street to the right side
- Maria-Reiche-Strasse branches off to the left after approximately 500 m

By public transport

- Take tram 7 from Dresden city to stop "Arkonastraße"
- Turn left and cross the residential area diagonally to Grenzstrasse
- Follow this road for about 10 min to the left and you will reach Maria-Reiche-Strasse

- Take suburban train S2 to "Dresden-Grenzstraße"
- Reverse for ca. 400 m
- Maria-Reiche-Strasse branches off to the right

By plane

- After arriving at airport Dresden use either bus 80 to bus stop "Grenzstraße Mitte" at the beginning of Dörnichtweg and follow Grenzstrasse for 150 m
- Or take suburban train S2 to "Dresden-Grenzstraße" and walk about 400 m further along Grenzstrasse

How to reach us in Hermsdorf

By car

- Highway A9: exit "Bad Klosterlausnitz/Hermsdorf" (Exit 23) and follow the road to Hermsdorf, go straight ahead up to the roundabout
- Turn right to Robert-Friese-Strasse
- The 4th turning to the right after the roundabout is Michael-Faraday-Strasse
- Fraunhofer IKTS is on the left side

- Highway A4: exit Hermsdorf-Ost (Exit 56a) and follow the road to Hermsdorf
- At Regensburger Strasse turn left and go straight ahead up to the roundabout
- Turn off to right at the roundabout and follow Am Globus
- After about 1km turn off left to Michael-Faraday-Strasse
- Fraunhofer IKTS is on the left side

By train

- From Hermsdorf-Klosterlausnitz main station turn right and walk in the direction of the railway bridge
- Walk straight into Keramikerstrasse (do not cross the bridge)
- Pass the porcelain factory and the Hermsdorf town house
- Turn right, pass the roundabout and walk straight into Robert-Friese-Strasse
- After 600 m turn right into Michael-Faraday-Strasse
- Find Fraunhofer IKTS after 20 m

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