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FRAUNHOFER INSTITUTE FOR CERAMIC TECHNOLOGIES AND SYSTEMS IKTS

20 YEARS OF FRAUNHOFER IN DRESDEN

ANNUAL REPORT 2011 2012

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Fraunhofer Institute for
Ceramic Technologies and Systems IKTS

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FOREWORD

Dear friends of IKTS,

This year, Fraunhofer IKTS celebrates its 20th anniversary! This is a good occasion to look back and celebrate the institute's success story. The story of Fraunhofer IKTS begins with 80 staff members coming from the Institute for Ceramic Technologies and Materials Science (IKTM), the Central Institute for Solid State and Materials Research (ZFW) of the Academy of Sciences and the Sächsische Ingenieurkeramik GmbH Meißen (SIK). We can say with much pride and without any exaggeration that after the merger with the Hermsdorfer Institut für Technische Keramik e.V. (HITK) Fraunhofer IKTS has become one of the world's most prestigious institutes in the field of applied ceramic research. Our sincere thanks for this development go to the team of Fraunhofer IKTS in Dresden and Hermsdorf with its more than 400 scientists, engineers and technicians as well as to our partners.

Let us now move on to the past financial year that we have ended again with a positive result. With an operating budget in Dresden and Hermsdorf of about 33 million euros our total profit rate was again above 80 % (approx. 37 % industry revenues). Therefore, we were able to largely invest in equipment and construction measures (total budget about 41 million euros). Through these investments, we were able to extend our research in the field of structural and functional ceramics, as well as to create more office space by installing a new floor at or pilot plant facility in Dresden. This year, we will complete further construction measures in Dresden and Hermsdorf resulting in a further improvement of our working conditions. Examples for investments include: the addition of an induction heating option to our SPS (spark plasma sintering) plant, the creation of test stands for the development of DeNox systems, a production line for SiC based tape cast flat filters, and process technologies for the pilot plant production of lithium ion batteries. Due to the latter investment, we were able to establish the conditions for the LiFab project which was funded by the Saxon State Ministry for Science and the Arts (SMWK/SAB). Together with our partners ThyssenKrupp System Engineering GmbH and KMS Technology Center GmbH, we are establishing a pilot line in Pleißa for the development of plants and processes used for the production of lithium ion batteries. Despite Germany's (and the Chemnitz region's) traditional strength in the field of mechanical engineering, there are still shortcomings in the field of plant engineering that we would like to resolve with this project. This is, once again, a good example of how we implement our strategy of closing the gap between laboratory development and production: "from lab to fab".

Which leads us to the topic of "building bridges". I was very pleased that the "Bridge Building Award" of the American Ceramic Society was awarded to me and the institute. I think this motto fits our work perfectly. Our strategy is downright

destined to build bridges: we are building bridges "from lab to fab", i.e. we are able to push our developments from the lab to the pilot plant scale; we are building bridges along the entire value chain "from materials to systems"; we are building bridges between structural and functional ceramics to realize synergies between these fields; we are building "technology transfer bridges" to transfer our R&D results into the industrial sector (at both national and international level); and last but not least we are building bridges between the world of ceramics and users for whom ceramics and their advantageous applications are still a whole new territory.

In this annual report, you will find various examples for building such bridges. Please enjoy reading it. As always, we would like to invite you to make use of our competencies. We would be pleased to continue building bridges together with you.

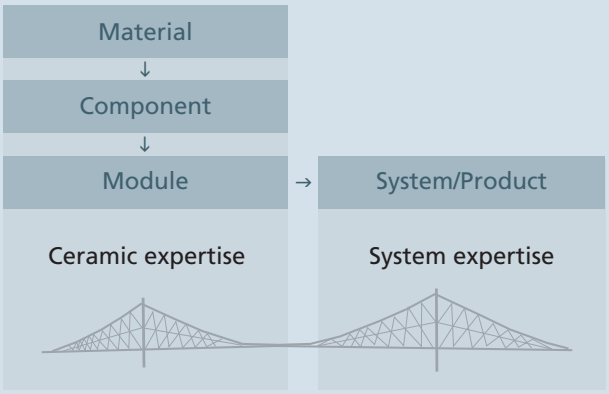
Yours,

Alexander Michaelis

Bärbel Voigtsberger

March 2012

The Fraunhofer IKTS as "one-stop shop" for ceramics



We bring worlds together

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BRIEF PORTRAIT

The work of the Fraunhofer Institute for Ceramic Technologies and Systems IKTS covers all aspects of technical ceramics from preliminary basic research to application. More than 140 well-equipped laboratories and pilot-scale facilities on nearly 20,000 square meters of usable floor space at the two locations Dresden and Hermsdorf are available for this. At Fraunhofer IKTS, high-performance ceramics know-how forms the basis of development work spanning the entire value chain up to prototype manufacture. With threefold expertise – in materials know-how, production technologies, and system/product integration – chemists, physicists, and materials scientists are supported by experienced research engineers and technicians in activities focused equally on structural and functional ceramics technology platforms.

Project partners are found among both manufacturers and users of ceramics. With extensive expertise and numerous contacts, Fraunhofer IKTS serves as a "one-stop shop" for all ceramics-related problems. Our mission is to bring together different technology worlds to give our customers access to the entire range of innovative solutions provided by ceramics. Fraunhofer IKTS possesses a number of unique capabilities:

Complete production lines from material to prototype

All standard processes for mix preparation, shaping, heat treatment, and finishing of structural and functional ceramics are available. A key area of expertise in functional ceramics is paste and film technology. We manufacture functional ceramic prototypes using the hybrid and multilayer ceramics lines in our in-house clean rooms.

Multiscale development

Developments can be scaled up from laboratory to pilot scale. In our technological production chains, we can manufacture the quantities required for market introduction. Thus, we can minimize retention cost risks and time to market.

Synergies between structural and functional ceramics

By combining different technology platforms, we enable innovative ceramic products with extended functions and considerable added value to be manufactured.

Network formers

We are currently collaborating in projects with more than 450 national and international partners. Fraunhofer IKTS is also active in numerous networks and alliances, within the Fraunhofer-Gesellschaft, for example, in the Fraunhofer Group for Materials and Components – MATERIALS.

In addition, the role of spokesperson for the Fraunhofer AdvanCer Alliance, made up of seven institutes specialized in ceramics, is held by Fraunhofer IKTS. We facilitate network formation to drive product development and obtain the necessary external expertise.

This pioneering work is made possible by a wealth of experience, extensive knowledge, and constant focus on the interests of our partners.

Sustainable quality assurance management in both institute branches

For us, quality is one of the most important factors to stand out from the competition. For this reason, we merged the management systems of both institute branches in 2011. Due to the resulting synergy effects and cost savings we are now able to expand our management system to the fields of work safety and environmental protection.

Fraunhofer IKTS has already introduced and successfully established this environmental management system in Hermsdorf. As the main focus of our research lies in the field of energy and environmental technologies we are going to implement a sustainable environmental management system in Dresden by the end of this year, which will be in accordance with DIN EN ISO 14001. This system will guarantee that our processes will comply to work safety and environmental standards as well as legal conditions and regulations while maintaining our competitiveness.

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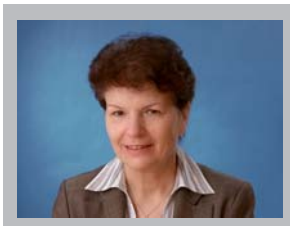

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Hardmetals and Cermets
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Nitride Ceramics, Carbide and Filter Ceramics, Precursor-Derived Ceramics,
Dr. Hagen Klemm

Processes and Components
Dr. Michael Stelter

Sintering and Characterization
Dr. habil. Mathias Herrmann

Environmental Engineering and Bioenergy
Dr. Ingolf Voigt

Energy Systems

Materials and Components
Dr. Mihails Kusnezoff

Modules and Systems
Dr. Matthias Jahn

Industrialization Energy Systems
Dr. Christian Wunderlich

Smart Microsystems

Smart Materials and Systems
Dr. Andreas Schönecker

Hybrid Microsystems
Dr. Uwe Partsch

TU Dresden, Institute for Materials Science
Inorganic-Nonmetallic Materials

Prof. Dr. habil. Alexander Michaelis
Instrumented Powder Compaction, Combinatorial Microelectrochemistry

Friedrich Schiller University of Jena

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FRAUNHOFER IKTS IN FIGURES

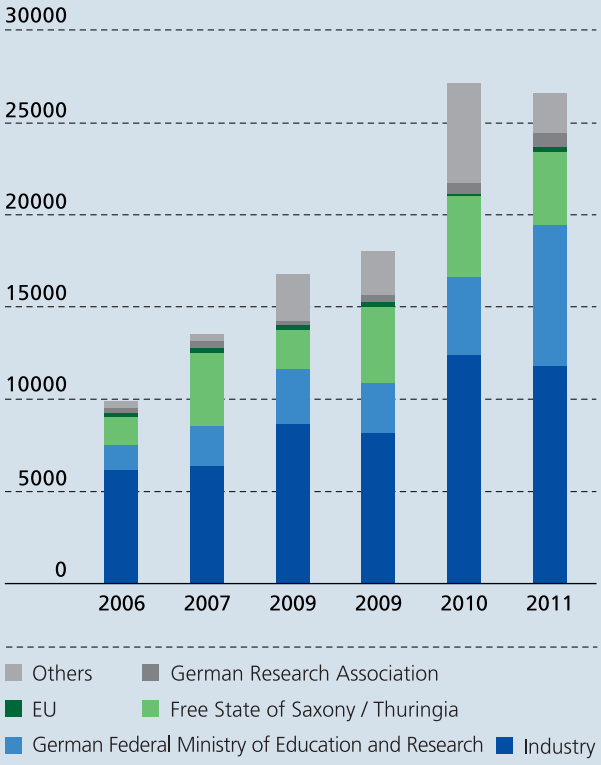
Operating budget and revenues

Due to the early publication date of this year's annual report, the operating budget and revenues for 2011 are presented before the financial statement. Any adjustments will be reflected in the following year. As in 2010, the diagrams show the financial results of both the Dresden and Hermsdorf institute branches. The operating budget of Fraunhofer IKTS has increased to 32.3 million euros: 22.6 million euros fall to the Dresden branch, and 9.7 million euros to the Hermsdorf branch. Here, we achieved synergies by splitting the work between both branches. By doing so, we proved once again that the added value which we aimed for by merging the both institutes was generated. Furthermore, 2.9 million euros were invested in equipment and additional 5.7 million euros in construction measures and the related basic equipment. In this connection, further growth is expected in 2012. In total, we earned 26.5 million euros in external funds. Fortunately, the industry revenues (11.8 million euros) of 45 % could be maintained as in the year before. The Hermsdorf branch contributed to this success with revenues of 3.8 million euros. With an increase of 0.6 million euros, Dresden was significantly above last year's results.

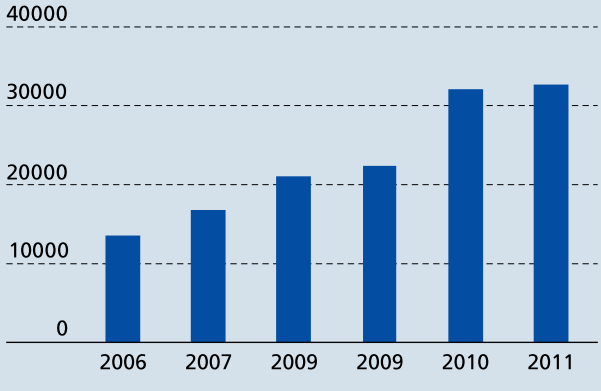
Expansion of the research basis

In 2011, Fraunhofer IKTS once again benefited from the large investments of the last years which were made within the framework of the Development Center for Energy Efficiency Systems. Especially for the large number of joint projects, these investments are the infrastructural basis for research in the field of fuel cells, photovoltaics, electricity generation from biomass, thermoelectric generators (TEG) and energy storage technologies (lithium ion batteries). We make use of the option to collaborate with strategic partners from industry and research in external laboratories and research facilities with our own equipment and staff. Through this cooperation, the

Revenue developments (in thousands of euros) at Fraunhofer IKTS for the budget years 2006–2011



Developments of operating budget (in thousands of euros) at Fraunhofer IKTS for the budget years 2006–2011



close relationship between industry and applied research can be further strengthened. Thus, the fast and exact drafting of cooperation and user agreements becomes a strategic tool. Aside from collaborations in the energy and environmental sector, the collaborations in the field of shaping and production technologies were intensified. One example is the strategic partnership with the Department of Ceramic, Glass and Construction Materials of the TU Bergakademie Freiberg (Prof. Aneziris). Within this project refractories are developed by applying new structural ceramic materials and adjusted manufacturing methods. Another example includes the cooperation with the Friedrich Schiller University Jena in which a concept of a joint Center of Energy and Environmental Chemistry (CEEC) was developed and two research groups were established. By pooling the material scientific as well as system and processing-relevant competencies, basic and applied research is significantly pushed, and thus a basis for innovation in Thuringia and especially the Jena-Saale-Holzland region is created.

Within the Fraunhofer-Gesellschaft we are closely linked. Fraunhofer's research programs significantly facilitate the generation of own IP rights and thus, the long-term opportunity to acquire new industry projects. Due to the integration of the Hermsdorf institute branch, we have further technologies and materials at hand.

Personnel development

Last year was marked by a considerable increase of staff. We created 10 new jobs for scientists and 24 jobs for graduates and technicians. In total, we have 431 full-time positions with 381 employees in Dresden and 140 employees in Hermsdorf. The cooperation with the chair of IfWW, Institute for Material Science at TU Dresden, remains an essential part of our personnel recruitment. Currently, 50 doctoral theses are being supervised.

Personnel developments at Fraunhofer IKTS
Number of employees 2006–2011, full-time equivalents
Personnel structure on December 31 of each year

In 2011, 13 apprentices were trained. By training apprentices at the IKTS, the quality of our laboratory work will be further improved, and knowledge transfer between the working groups is being supported. Regular exchange between the institute branches and departments is an increasingly important factor.

BOARD OF TRUSTEES

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

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Chairman of board of trustees
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Manager of Central Department Research and Development

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Robert Bosch GmbH, Gerlingen
Department head of Corporate Research and Development
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Dipl.-Ing. P. G. Nothnagel
Managing director of Wirtschaftsförderung Sachsen GmbH, Dresden

Dipl.-Ing. M. Philipps
Endress+Hauser GmbH & Co. KG, Maulburg
Head of business sector Sensor Technology

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

Dr. K. R. Sprung
CEO of German Federation of Industrial Research Associations

Prof. Dr. P. Woditsch
Sunicon GmbH, Freiberg

MR C. Zimmer-Conrad
Saxon Ministry of Science and the Fine Arts
Head of Technology Policy and Technology Funding Department

THE FRAUNHOFER-GESELLSCHAFT

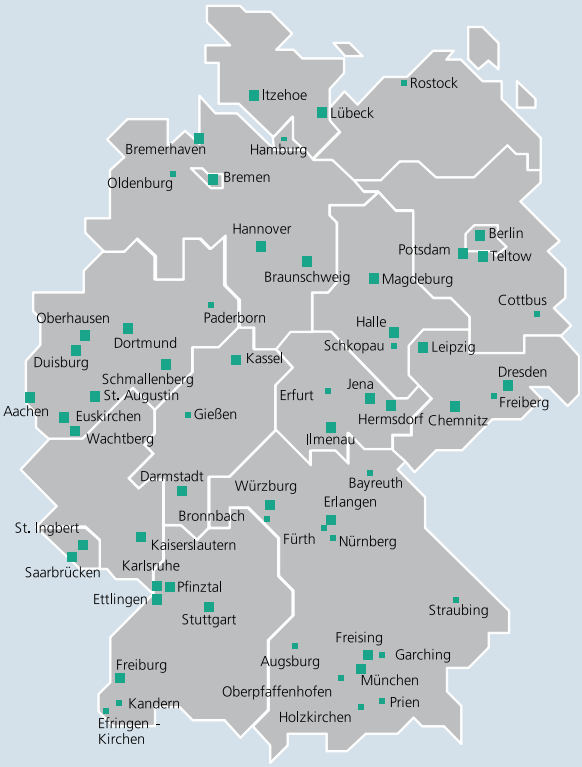
Research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. Founded in 1949, the research organization undertakes applied research that drives economic development and serves the wider benefit of society. Its services are solicited by customers and contractual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

At present, the Fraunhofer-Gesellschaft maintains more than 80 research units in Germany, including 60 Fraunhofer Institutes. The majority of the more than 20,000 staff are qualified scientists and engineers, who work with an annual research budget of €1.8 billion. Of this sum, more than €1.5 billion is generated through contract research. More than 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Almost 30 percent is contributed by the German federal and Länder governments in the form of base funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society until five or ten years from now.

Affiliated international research centers and representative offices provide contact with the regions of 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.

Locations in Germany



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.

RESEARCH FIELD MATERIALS

Department heads:
Dr. habil. Andreas Krell
Dr. Hagen Klemm

Profile

The core competency of the "Materials" research field lies in the development of new or modified ceramic materials and ceramic-metal composites (hardmetals and cermets) with the use and generation of state-of-the-art technologies.

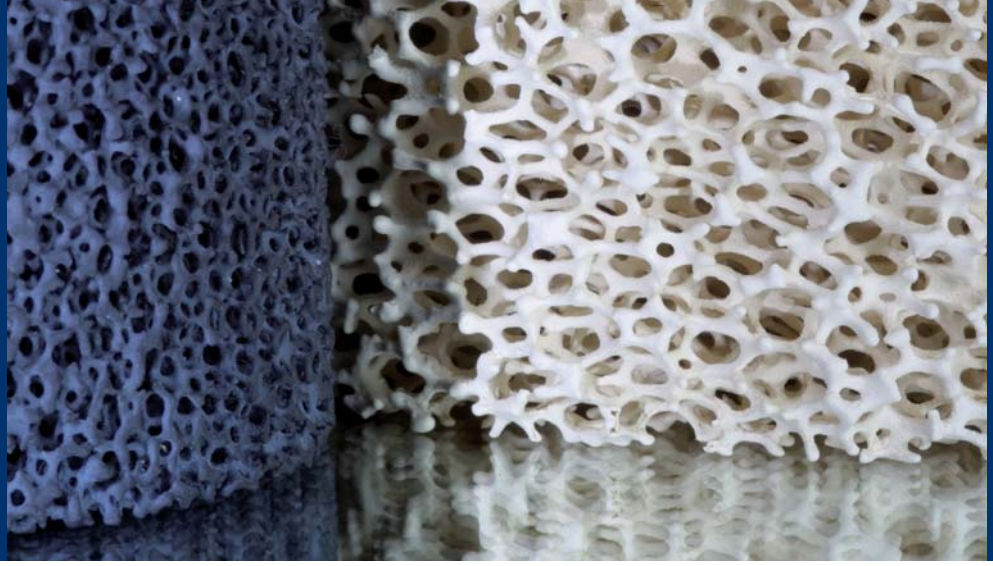
Our offering ranges from targeted synthesis of raw materials from ceramic precursors or renewable raw materials and application-oriented materials development to technological trials and manufacture of prototype parts and systems, including characterization and testing. Material-specific and technological aspects for industrial applications and safety-/health-related aspects are considered.

One focus of materials qualification is the development of low-defect and low-cost processes. Our wide range of capabilities encompasses powder processing technologies for simply structured ceramic materials as well as fiber processing and coating technologies for composite materials and functional coatings for solar applications.

The successful development of new application fields through targeted combination of structural and functional properties in ceramics and ceramic-metal composites is reflected, for example, in the development of high-temperature materials, electrically conducting ceramics, thermoelectric materials, forming tools, transparent components, functional ceramic coatings, and filters.

Services offered

- Integrated materials and process development for novel high-performance ceramics and hardmetals
- Development and supply of raw materials, trial parts, and complex components
- Expert opinions on production and application problems
- Materials testing (mechanical, tribological, electrical, and corrosive properties at room and high temperatures)
- Damage and failure analysis of components and tools
- Evaluation of safety and health risks from use of fine powders and materials
- Characterization of wetting behavior of coatings and surface tension of liquids
- Characterization of corrosion behavior under realistic application conditions (hot gas corrosion)



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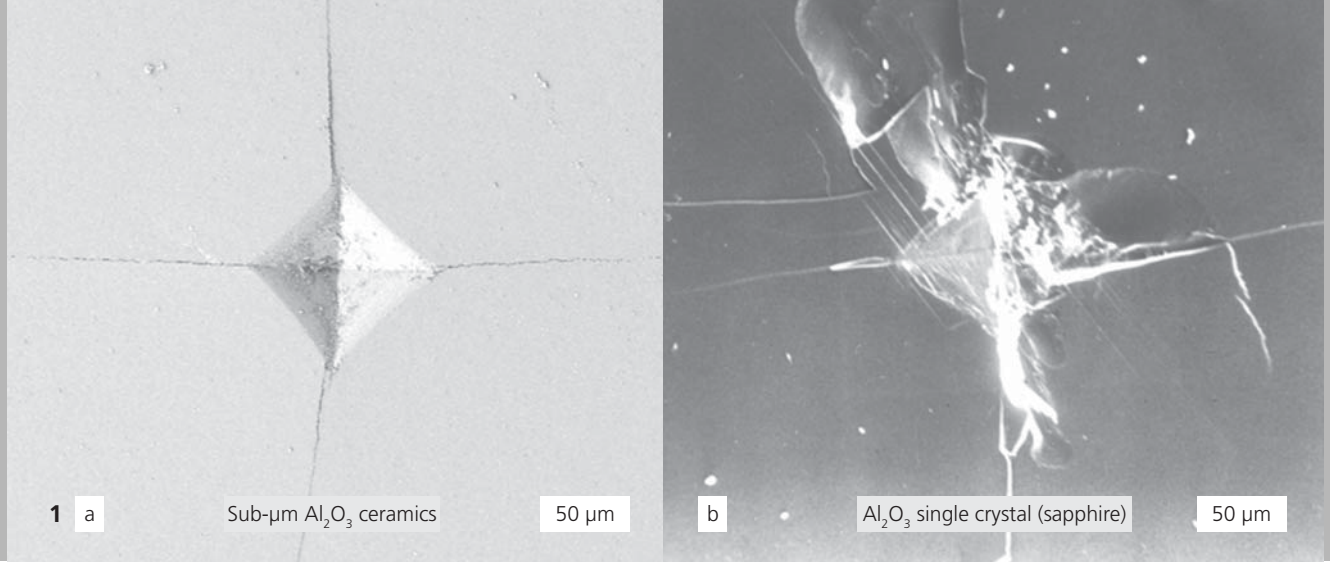


1 a Sub-µm Al_2O_3 ceramics 50 µm b Al_2O_3 single crystal (sapphire) 50 µm

INCREASE OF THE STABILITY OF OPAQUE AND TRANSPARENT ARMOR CERAMICS

Dr. Andreas Krell, Dipl.-Ing. Thomas Hutzler, Dr. Jens Klimke

Numerous previous studies investigated influences of materials selection, microstructures and basic mechanical data on the ballistic strength of ceramics under different threats or with different backing. Frequently, results seemed to reveal some apparent influences e.g. of hardness, Young's modulus or compressive strength which, however, disappeared completely at changed configurations. Understanding that

- the ballistic strength of armor ceramics is governed by the efficiency of projectile erosion and that
- the missing influence of strength indicates a strong role of the inertia (i.a. of the size) of ceramic debris,

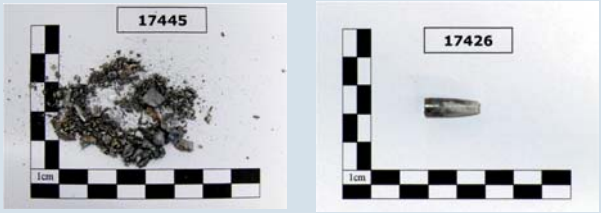
Fraunhofer IKTS had proposed the hypothesis of a hierarchic ranking of major influences as known for the wear of ceramics: it was assumed that e.g. a high hardness will give rise to strong projectile erosion if ceramic fragmentation proceeds with a sufficiently large size of the debris. This positive influence of the hardness should, however, disappear when a narrow network of cracks forms small ceramic fragments.

The present study checked this hypothesis comparing

- the ballistic performance (in depth of penetration and perforation tests) of combinations of different backing materials with about ten highly dense but differently fine or coarse grained alumina and spinel ceramics and single crystals
- with comparative measurements of the Young's modulus, the bending strength and K_{Ic}, and of statically ($4 \cdot 10^{-3}$/s) and dynamically measured (10^3/s) compressive strengths of these ballistically tested ceramics. The evaluation also included static and dynamic hardness data and the Hugoniot Elastic Limit (HEL) of such ceramics.

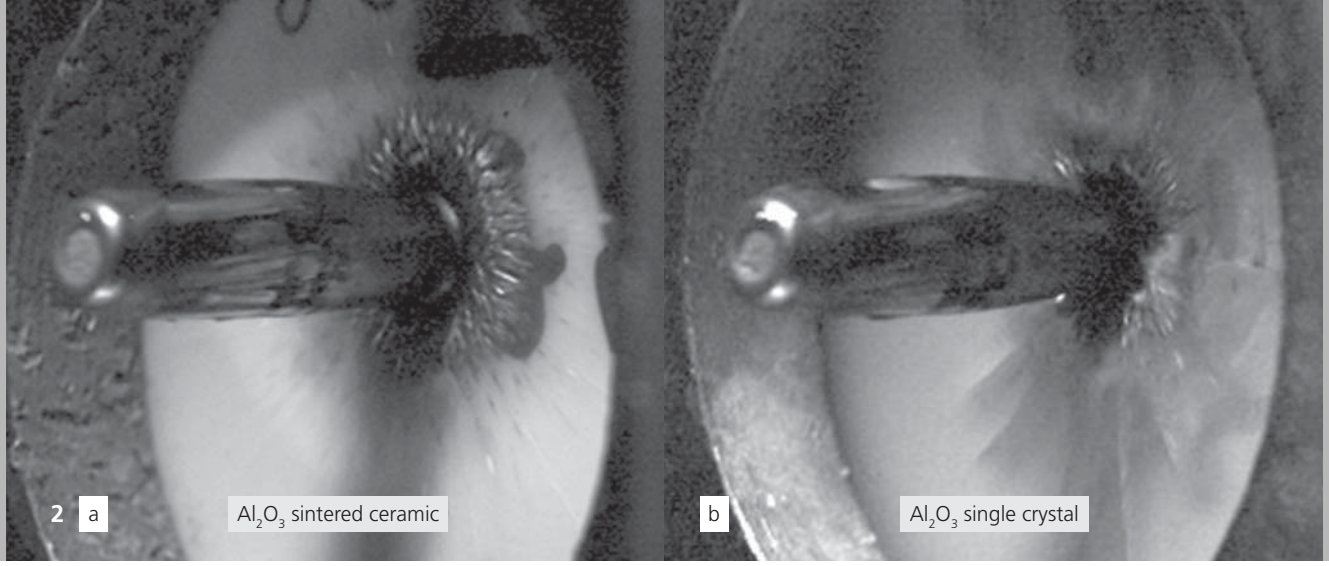
The major result is a confirmation of the idea of a hierarchic ranking of basic influences in three levels. Top priority is the mode of ceramic fragmentation. Thus, on ballistic impact the close spacing of cracks of failing sapphire (known from the crack network on Vickers tests - figure 1a/b) gives rise to small debris and less erosion of the projectile by sapphire (figure 2b) compared with polycrystalline Al_2O_3 (figure 2a). Another major influence on ceramic fragmentation and, thus, on projectile erosion comes from the dynamic stiffness of backings: the figure on the left shows a tremendously stronger projectile erosion by Al_2O_3 in front of glass than with Al backing – despite of a similar Young's modulus of Al and glass. Obviously, fragmentation will govern both the dwell and the subsequent penetration phase of the ceramic/projectile interaction: it influences the duration and extent of dwell, and on penetration it governs the force of inertia and, thus, the degree of projectile erosion.

Extremely different projectile erosion (photo: projectile fragments after perforation of 2 mm Al_2O_3 ceramic body) depending on the dynamic stiffness of backing materials



Impact of 2 mm Al_2O_3 ceramic body positioned in front of backing A: armor glass (transparent window) backing B: Al alloy (opaque armor)

Photo: E. Strassburger, Fraunhofer EMI



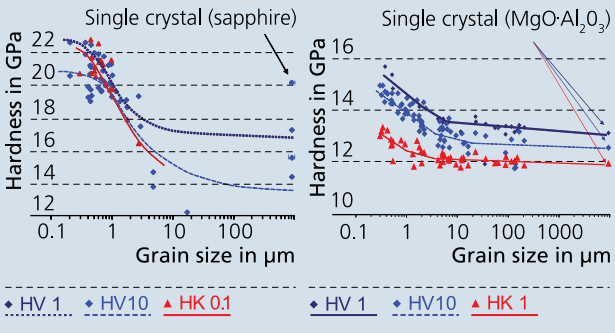
Second priority is the elastic stiffness of the ceramic body on immediate impact (during dwell). This is the reason why at same hardness but with a higher Young's modulus the ballistic strength of coarse Al_2O_3 ceramics may exceed (depending on backing and threat) that of the best (most fine-grained) spinel ceramics.

Only when matching the before mentioned conditions a high hardness (e.g. by grain sizes < 1 µm; see diagram below) will improve the ballistic strength significantly (diagram on the right). Compared with the three described influencing parameters, all strength parameters (in bending or in compression, by static or highly dynamic measurements) and K_{Ic} turned out meaningless (see red frame in the diagram on the right).

Services offered

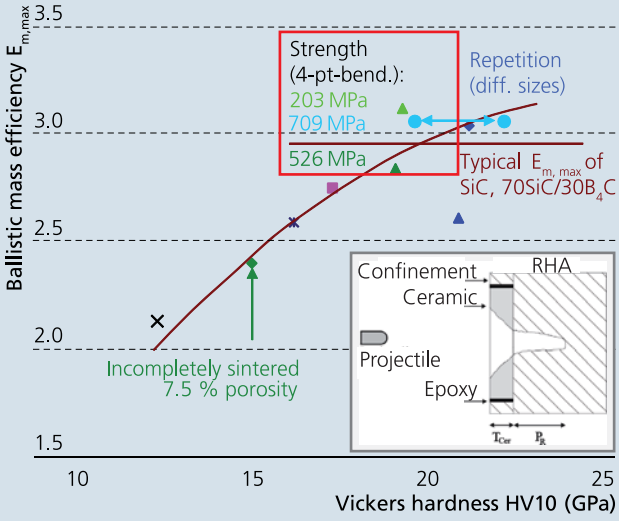
- Armor ceramics with defined properties for specific tests
- Ballistic evaluation in cooperation with Fraunhofer EMI

Increase of hardness of oxide ceramics by fine grained (sub-µm) microstructures with high sintering density; comparison of different hardness numbers



Al_2O_3 ceramics (opaque grades) Spinel ceramics (transparent)

With stiff (steel) backing strong influence of high hardness (achieved by small grain size) on the ballistic stability of Al_2O_3 ceramics – without any impact of ceramic strength



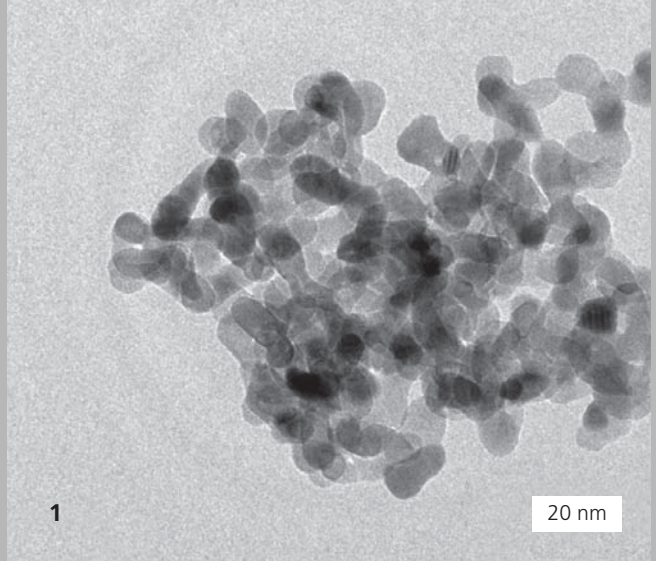
Grain size, technology:
- 0.4 µm, gelcasting, HIP
- 0.6 µm, gelcasting, HIP
- 0.5 µm, pressed
- 0.6 µm, gelcasting
- 0.7 µm, pressed
- 0.9 µm, pressed
- 10 µm, gelcasting
- 0.3 µm, pressed
- 17 µm, AD995

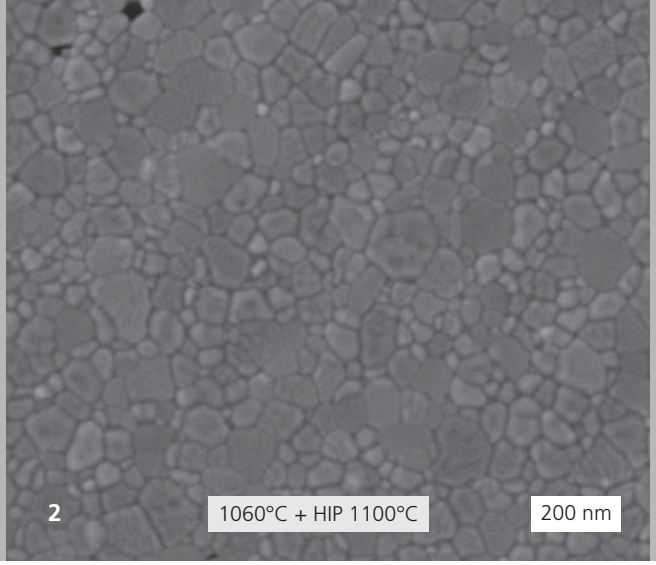
Acknowledgments

The presented work was subject of a joint project issued by WTD91 of the German Army (Bundeswehr) and realized together with the Fraunhofer Ernst-Mach Institute (EMI; ballistic investigations) between 2007 and 2011.

1 *Different fragmentation under identical load.*

2 *Different wear impact on the penetrator (high-speed photography at t = 8 µs by E. Strassburger, EMI) resulting from different fragmentation.*





TRANSPARENT TETRAGONAL ZIRCONIUM OXIDE

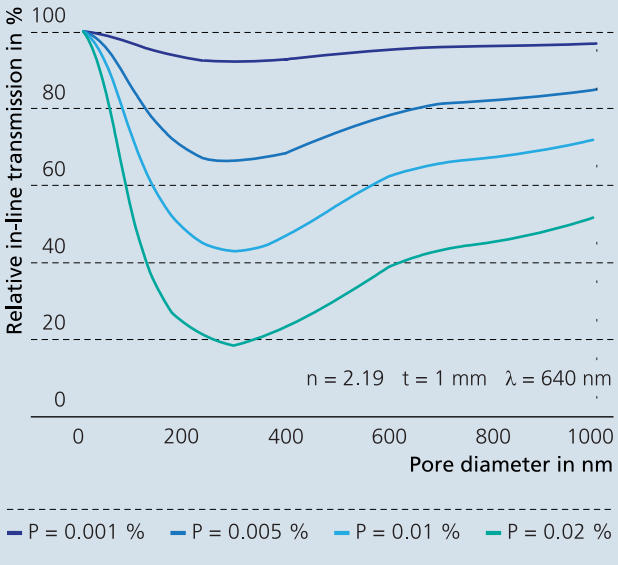
Dr. Jens Klimke, Dr. Andreas Krell

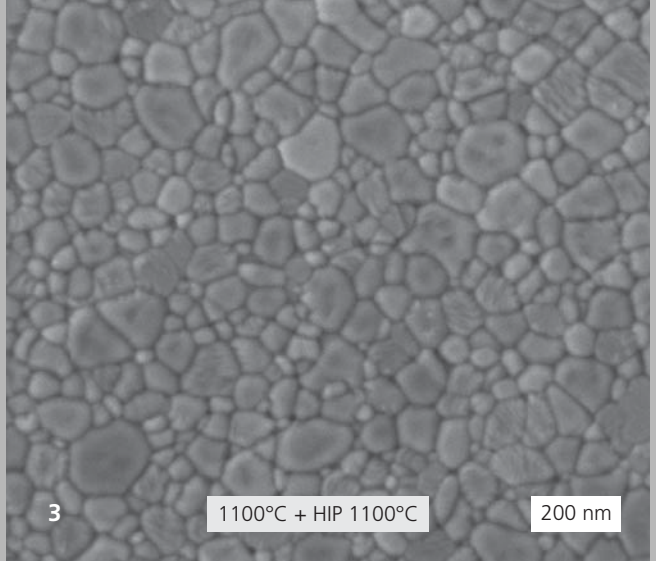
Recently, there has been considerable interest in transparent ceramics because of their unique combination of optical and mechanical properties, particularly with regard to window, laser, lamp envelope, and ballistic armor applications. However, most of the materials investigated so far have a cubic crystal structure and only few transparent non-cubic ceramics are known. The outstanding mechanical properties make the tetragonal ZrO_2 modification an interesting candidate for transparent ceramics. In addition to potential applications as high-strength windows, there is a demand for transparent and translucent tetragonal ZrO_2 ceramics for dentures. The high refractive index of all ZrO_2 polymorphs increases the scattering losses caused by residual porosity far beyond the usually known level of other transparent ceramics. In contrast to the cubic modification, however, transmission of tetragonal pore-free ZrO_2 ceramics is furthermore restricted by optical birefringence at each grain of the microstructure.

The present investigation has estimated the conditions to obtain transparent tetragonal ZrO_2 ceramics (partially stabilized by yttria) by comparing the experimental results for sintered nanopowder with scattering calculations. The Mie calculations show that, for example, a porosity of only 0.01 % reduces the transparency by 58 % at a pore size of 300 nm (diagram on the right). The validation of these calculations required extreme experimental efforts in order to provide highly dense tetragonal ZrO_2 polycrystals with grain sizes < 150 nm. A ZrO_2 nanopowder stabilized with 3 mol % yttria, which had been synthesized in cooperation with the Brno University of Technology by a special sol-gel method (figure1) and which was cold isostatically pressed at 1000 MPa, was used. To achieve full densification the pressed pellets were pre-sintered in air followed by hot isostatic pressing (HIP) at 1100°C and 200 MPa, and annealing in air at 800°C. The final densification was determined by measuring the real in-line transmission (RIT) and by SEM analysis of the microstructures. Figure 2 shows a microstructure with a mean grain size of 95 nm and with some residual porosity whereas figure 3 presents a dense sintered microstructure with a mean grain size of 118 nm. Figure 4 shows the view through a polished disk of this material.

The total forward transmission measured with a CARY4000 spectrometer with integrating sphere was 54 to 57 % in the

Simulation of the influence of porosity and pore diameter on relative in-line transmission of highly dense ZrO_2

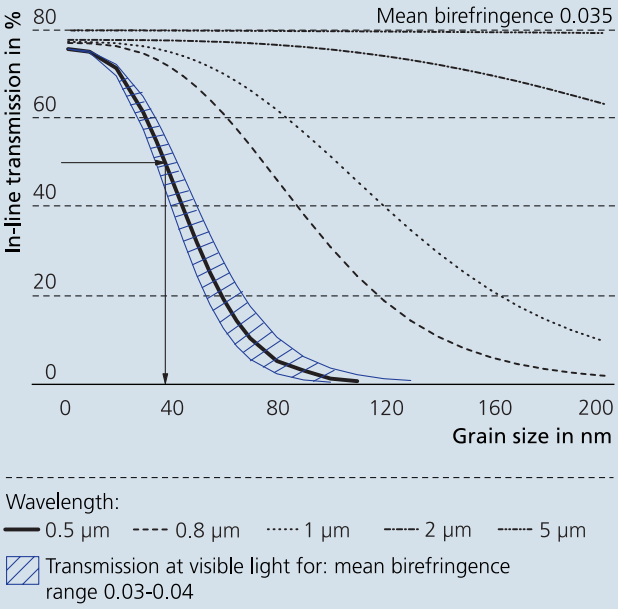




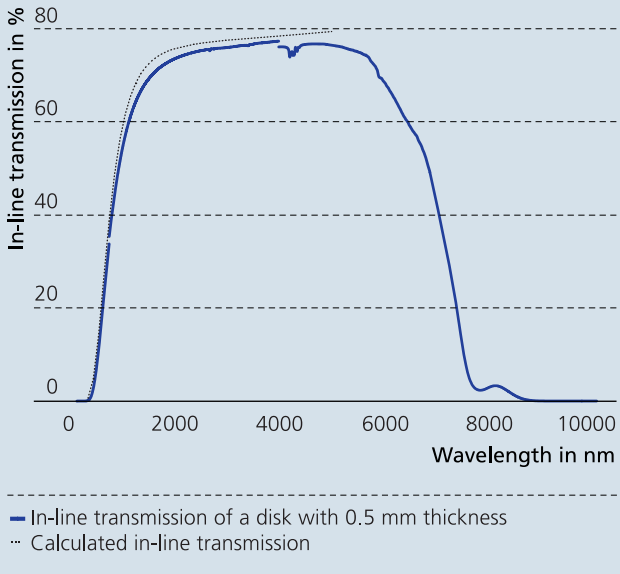
visible range despite some residual porosity. The maximum in-line transmission of 77 % in the IR range between 4 and 5 µm is in good agreement with the calculated transmission for a mean birefringence of 0.035 (diagram below).

Assuming that a transmission of at least 50 % is necessary in the visible range of light for a similarly clear look through the ceramic material as through glass windows, this transmittance demands a grain size < 40 nm if the ceramic material is 1 mm thick. However, at 50 % transmission scattering can still induce a whitish or yellowish appearance, and the transparency further decreases at larger thickness. Thus, a better quality with a transmission > 70 % should be preferred but requires grain sizes < 20 nm according to the calculation presented in the diagram on the right.The calculation also demonstrates that the influence of grain size is significantly reduced in the IR range.

Simulation of the influence of grain size on in-line transmission at different wavelength



In-line transmission of tetragonal ZrO_2: measurement and simulation



The high transmission in the midwave IR makes the dense sintered, nanoscale, tetragonal ZrO_2 attractive as a potential material for durable IR windows with improved mechanical properties.

1 *TEM micrograph of ZrO_2 (3 mol % Y_2O_3) powder.*
2 *SEM micrograph with mean grain size of 95 nm.*
3 *SEM micrograph with mean grain size of 118 nm.*
4 *Look through a disk of 0.5 mm thickness.*

1

2

CERAMIC MATRIX COMPOSITES FOR HIGH-TEMPERATURE APPLICATIONS

Dipl.-Ing. Katrin Schönfeld, Dr. Hagen Klemm

Motivation

Ceramic matrix composites (CMC) play an ever increasing role in technology due to their excellent material properties. Particularly under high temperatures (> 800°C), ceramic materials have a high potential to replace metal materials and to facilitate processes at much higher temperatures. This is of increasing importance considering energy and environmental aspects as natural resources are limited. By embedding ceramic fibers into a ceramic matrix, the otherwise brittle behavior of monolithic ceramics (catastrophic failure due to brittle fracture) has changed in a way that the cracks formed under mechanical stress are deflected and branched. Thus, a damage-tolerant behavior is given which is interesting at cyclic loading of components.

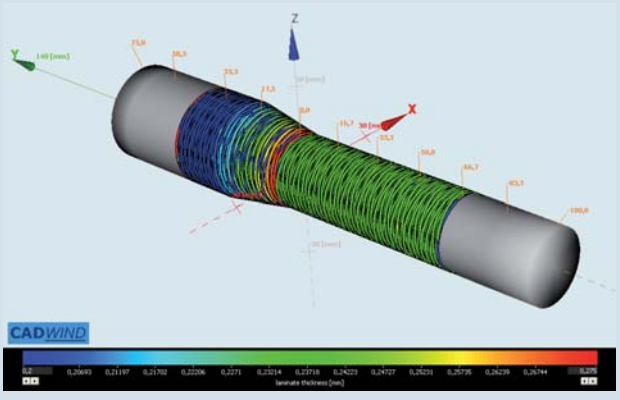
Process development

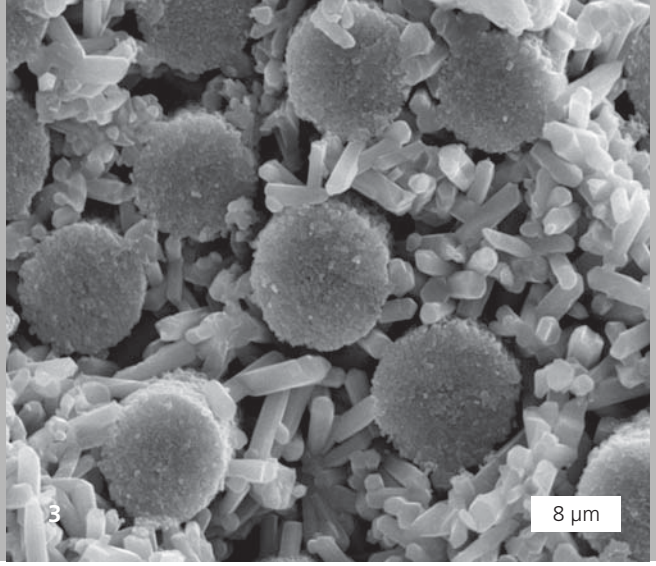
At Fraunhofer IKTS, a manufacturing technology for ceramic matrix composites was developed which is based on placing ceramic fiber bundles onto rotationally symmetric cores. With the help of a CAD program, the geometry, fiber orientation as well as winding structure can be varied. A high-temperature stable SiC fiber (UBE SA 3) was used as basic material for the development of non-oxide CMC. During the winding process, the fiber bundle was impregnated with a ceramic slurry (SiC, Si_3N_4) forming the basis for the later matrix structure. The blanks manufactured by this method were infiltrated with a preceramic SiCN precursor and pyrolized (PIP) several times, and then sintered.

Results

By specifically varying the basic materials, fiber coating, fiber orientation pattern as well as sintering conditions, SiC fiber reinforced Si_3N_4/SiC composites of different properties were manufactured. In a circular ring test, these materials showed a damage-tolerant behavior and a strength of > 200 MPa. Oxidation and corrosion tests (hot gas with high flow velocity) in the temperature range between 1200 and 1450°C were in the focus of the high-temperature characterization of these materials. The formation of a nearly dense layer on the surface of the composite material was fundamental for the high oxidation and corrosion stability. Whereas a SiO_2 protective layer which was in situ formed prevents the passing of oxygen and thus the oxidation inside the material during oxidation processes, the materials suffering hot gas corrosion had to be coated

CAD image of a planned fiber composite





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with an environmental barrier coating (EBC). EBC coatings on the basis of silicates of the Rare Earths showed promising results. It is the subject of future studies to design the surface microstructure of CMC materials with oxidation and corrosion-resistant functions.

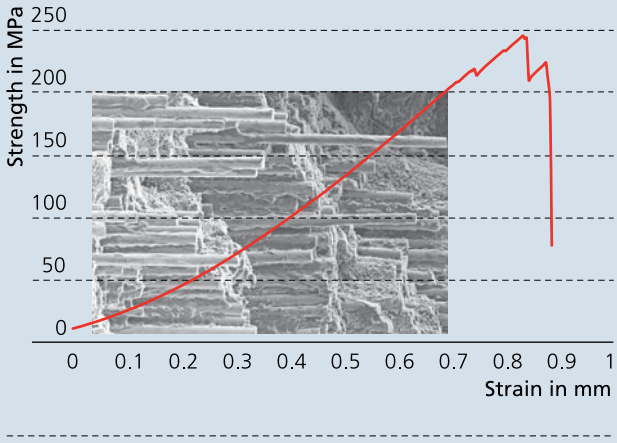
Services offered

- Materials development for ceramic matrix composites
- Manufacture of components made of ceramic composites
- Mechanical materials testing
- High-temperature characterization in oxidizing and corrosive media
- Development of environmental barrier coatings (EBC) on CMC

Acknowledgments

The presented works were financed by the EU within the framework of the Dresden Innovation Center Energy Efficiency (DIZE^{eff}).

Fracture surface of SiC fiber reinforced Si_3N_4



1 *Fiber winding process.*
2 *Components made of SiC_f/Si_3N_4.*
3 *Micrograph of a ceramic matrix composite.*
4 *Reinforced SSiC tube.*

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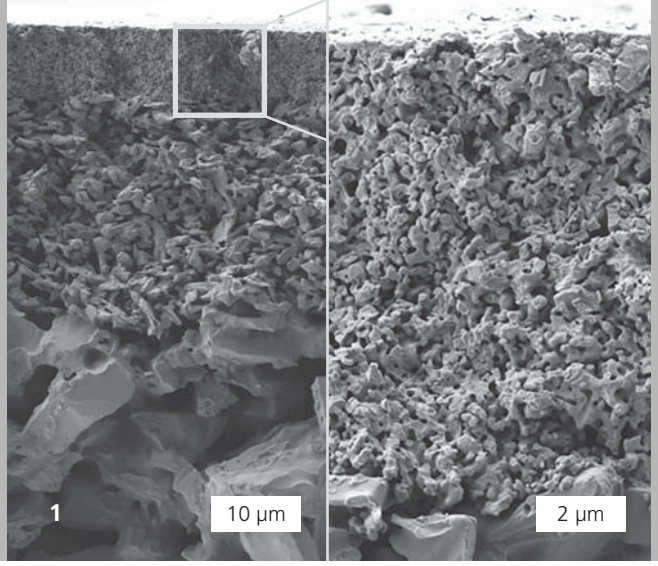

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COST-EFFECTIVE PRODUCTION PROCESSES FOR CERAMIC FILTRATION STACKS

Dipl.-Ing. Heike Heymer, Dr. Hans-Jürgen Richter, Dipl.-Ing. Olaf Scheithauer,
Dr. Burkhardt Fassauer, Dipl.-Krist. Jörg Adler

Low-cost polymer membranes are commercially used for membrane filtration. Ceramic membranes, however, show better properties in terms of chemical stability, defined pore width and long-term stability. It was the aim to develop cost-effective, industrial-scale material and technology concepts for ceramic microfiltration membranes.

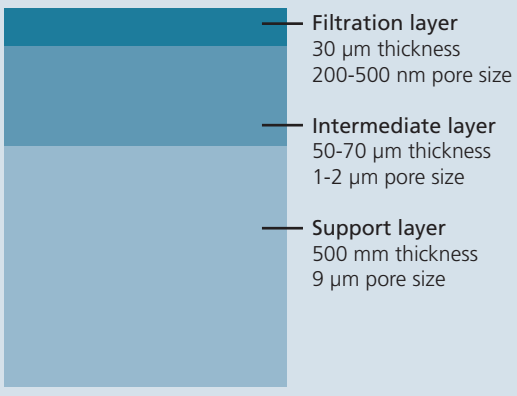
Within a project funded by the Free State of Saxony, Fraunhofer IKTS developed a concept for the manufacturing of cost-effective ceramic membranes for liquid filtration. Furthermore, all technological requirements were fulfilled to manufacture these membranes in industrial scale. In addition to material selection and technology development, testing methods for the filter elements were designed as well.

The concept provides a three-layer structure (diagram on the right). Glass-bound SiC was selected enabling the cofiring of the different porous layers. The total porosity of the material amounts to 45 %. The support strength reaches a level of 50 MPa. The used glass is chemically stable in the pH range between 1.5 and 9. In some cases, the cleaning procedure necessary for microfiltration membranes has to be adjusted to this glass. In this field, Fraunhofer IKTS has extensive experience on the basis of corrosion tests with conventional membrane cleaning agents.

A tape casting process on the basis of aqueous suspensions was developed for the manufacture of two-layer tapes (support and intermediate layer) made of glass-bound SiC (boron silicate bond). By wave-like structuring of the green tape and subsequent joining of the wavy and plane tape, flat membranes are produced. These membranes are sintered in a continuous kiln within 2.5 hours using a sintering regime that is specifically adjusted to the glass binder. Then, the filtration layer is applied by dip coating, where ten filter elements can be machine-dipped simultaneously. After another sintering step of the same kind, the multichannel elements are tested for defects by bubble point measurements. It is generally possible to consolidate all three layers during one single sintering step. This method is currently investigated. The assembly of a filter stack, consisting of 31 multichannel elements for example, was realized by embedding the single elements into polyurethane resin.

The medium to be filtrated passes the interstices between the multichannel elements in the stack. The filtrate drains off through the channels. On account of the specific membrane geometry, the laminar flow behavior is disturbed and the con-

Filter assembly



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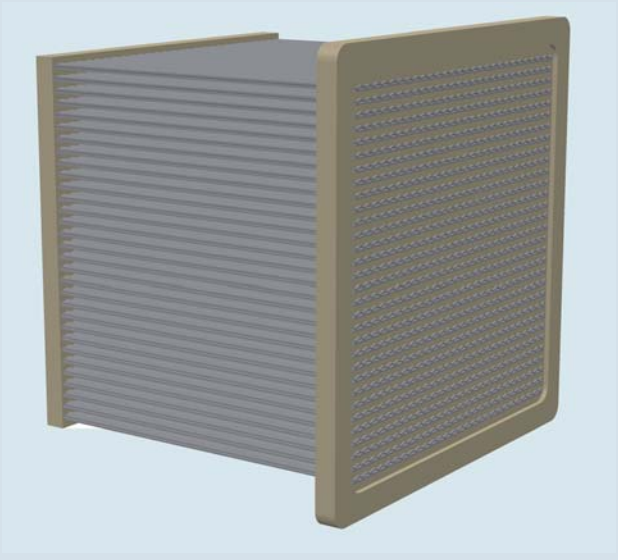
centration polarization over the membrane surface is mainly prevented so that even at low flow velocities high filtration flows can be reached. By reducing the necessary flow velocity and thus the necessary energy costs, the concept developed at Fraunhofer IKTS is a good alternative to the state-of-the-art shell-and-tube membranes made of alumina.

Due to their high chemical and abrasion stability, the developed SiC membranes can widely be used and are suitable, for example, for the filtration of biogeneous systems such as fermentation residues or sewage sludge. These media are a great challenge for filtration systems on account of the contained microorganisms and the resulting biofouling as well as the high content of fine materials. With the new system very good results have already been obtained in laboratory tests in which nutrients were retained from residual sludge during the dewatering process. At present, the membrane stacks are tested on an industrial-scale biogas plant.

3D view of a filtration module with 31 filtration elements



Services offered

- Development of materials and technologies for cost-effective ceramic membranes
- Development and manufacturing of filter modules
- Process and application tests
- Upscaling and commercialization

1 *Three-layer structure of a filter.*
2 *Folding machine (structuring of green tape).*
3 *Continuous kiln.*
4 *Test stand at an industrial-scale biogas plant.*

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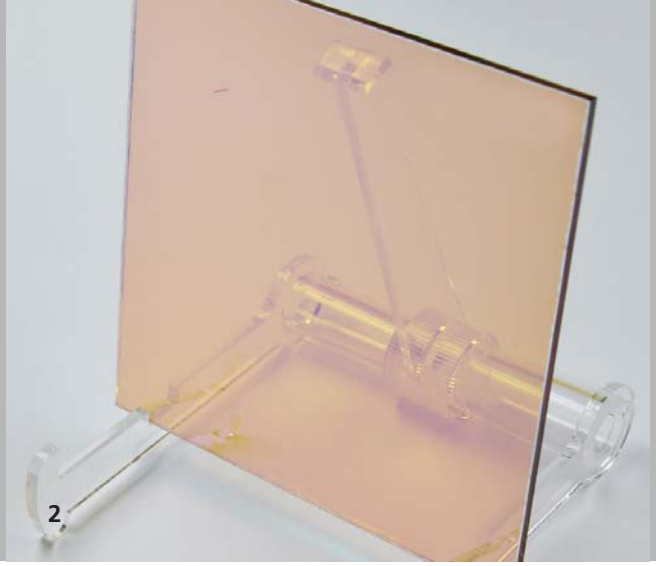


2

PLASMA-ASSISTED CHEMICAL VAPOR DEPOSITION OF FUNCTIONAL THIN FILMS

Dipl.-Ing. Stefan Uhlig, Dr. Katja Wätzig, Dr. Isabel Kinski

Plasma-assisted chemical vapor deposition (PECVD) is used for industrial solar cell production based on thin functional layers. PECVD differs from conventional CVD energy transfer (thermal) as it works via the activation of the gaseous or liquid precursors using an rf excitation (e.g. 13.56 MHz). As the thin film layers are formed at low temperatures (< 450°C) due to plasma activation, PECVD is more favorable than thermal CVD (up to > 1000°C). Thus, the materials can be customized to the properties as well as precipitated on temperature-sensitive substrates. The thin-film solar cells are based on sequentially deposited thin absorbing layers (e.g. amorphous, microcrystalline silicon or SiC_x), contact layers (e.g., transparent conductive oxides – TCO) and reflection interlayers (e.g. SiO_x, SiN_x).

Using the AK 800 of Roth & Rau AG, Fraunhofer IKTS is able to process substrate sizes of up to 50 x 50 cm² on a pilot scale, and to scale-up the technologies and materials developed and optimized at the institute. With the AK 800 system, absorbing and reflection interlayers as well as the TCO can be deposited, so that all necessary layers for thin-film solar cells can be generated in a multilayer package.

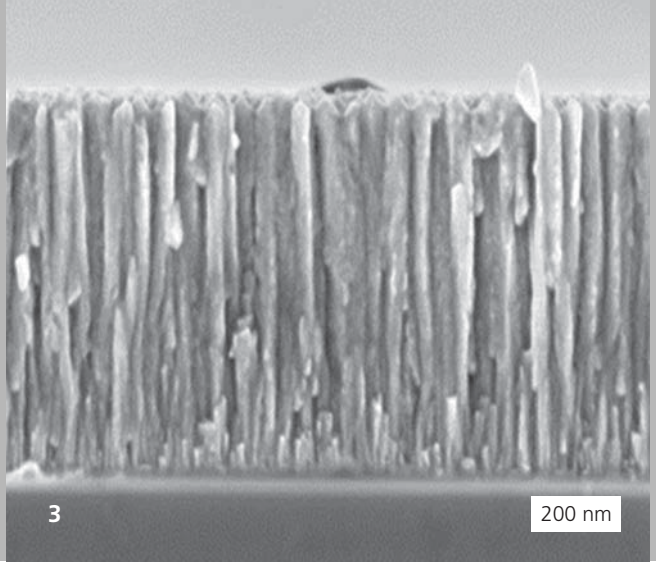
The deposition system has two reaction chambers connected by a load lock. In the chambers a pressure of 0.1 to 10 mbar and deposition temperatures of up to 450°C can be realized. The parallel plate configuration with variable plate spacing and plasma power of up to 2500 W are suited for various deposition processes and their unique process requirements. The following examples of thin silicon absorbing layers and transparent conductive zinc oxide layers emphasize the variety of the PECVD process.

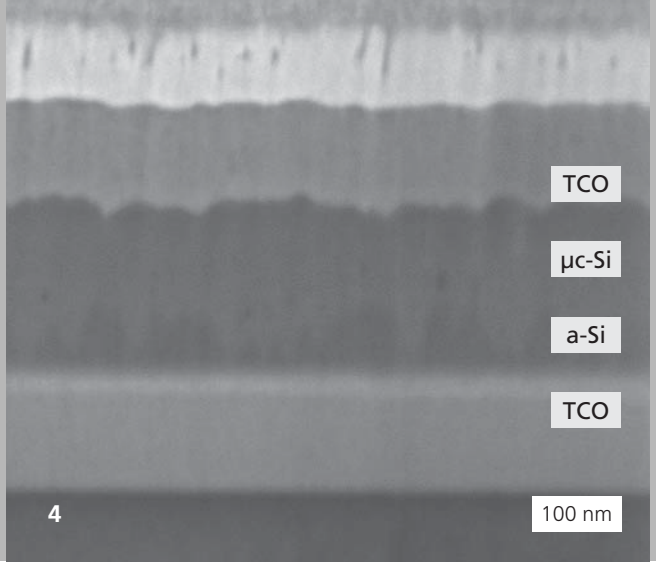
Microcrystalline and amorphous silicon

Silicon-based absorbing layers are deposited using gases (e.g. monosilane) or liquid precursors (e.g. higher silanes). By varying the process parameters the degree of crystallinity can be adjusted. Amorphous and microcrystalline silicon films (a-Si and µc-Si) have different band gaps and can be used in combination with each other, for example, in the tandem thin-film solar cell to absorb a wider range (400 to 1100 nm) of the solar spectrum, and thus contribute significantly to improve the efficiency.

Transparent conductive zinc oxide

Optoelectronic components and systems (OLEDs, thin-film solar cell) demand a transparent and conductive material to connect the optical functional layers electrically. Additionally, the conductive materials must guarantee a broad light transmission. Zinc oxide has a direct band transition of 3.4 eV and thus is an outstanding candidate for high light transmission. Adding doping elements of Group 13, zinc oxide can be changed into an n-type semiconductor. In close cooperation with the chairs of Semiconductor Physics and Inorganic Non-Metallic Materials at the Technical University of Dresden, zinc oxide layers were developed that have been deposited onto glass substrates by PECVD. The collaborative project was funded by the Dresden Innovation Center Energy Efficiency DIZE^{eff}. Using different doping agents the mechanisms for n-type or p-type conduction in zinc oxide can be analyzed. Furthermore, the influence of process parameters on the layer growth can be investigated.



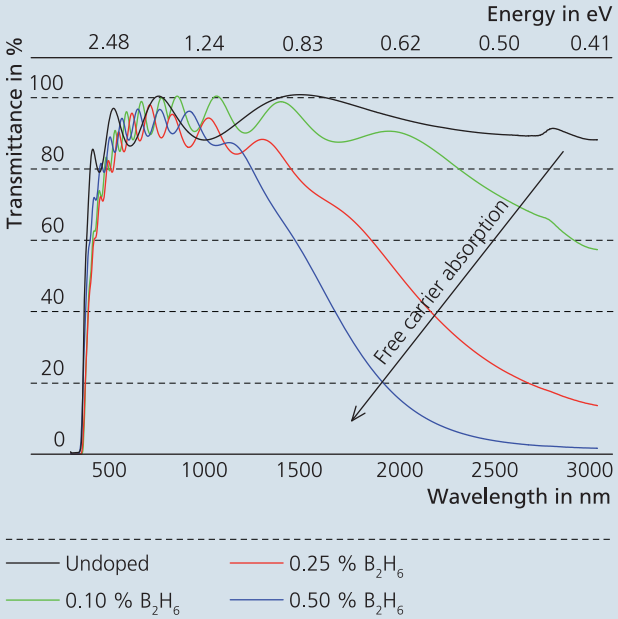


In the doped zinc oxide films (ZnO:B) a transparency of > 80 % in the visible light spectrum and high charge carrier concentrations >10^{20} cm^{-3} were observed.

Services offered

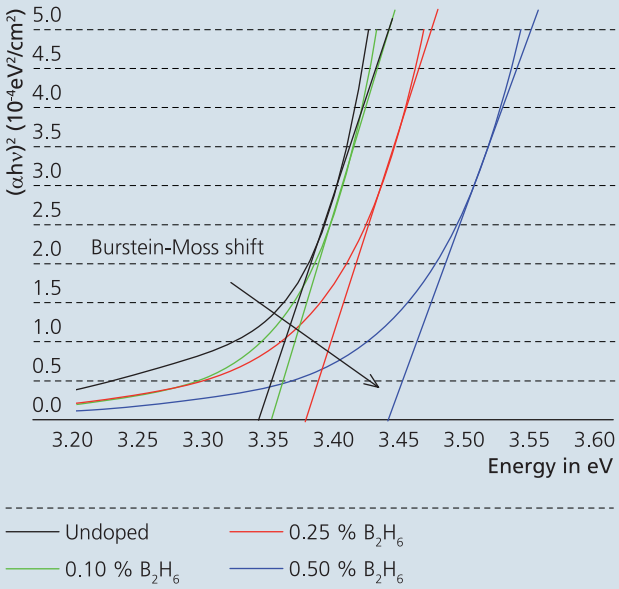
- Deposition of functional thin films
- Evaluation of PECVD process parameters
- Process transfer to pilot scale
- Synthesis of metal-organic compounds
- Evaluation of PECVD precursors

Transmittance of ZnO:B thin-films in dependence of dopand gas amount



Increasing absorption (λ > 1200 nm) caused by free charge carriers in dependence of boron amount in the zinc oxide thin films

Optical band gap and Burstein-Moss shift by doping of ZnO with boron



Shift of the optical band gap (Burstein-Moss shift) with increasing boron content of the zinc oxide thin films

1 *Two chamber PECVD tool.*
2 *a-Si thin-film on glass.*
3 *TCO thin film (ZnO).*
4 *Single-junction PV cell (FIB cut).*

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RESEARCH FIELD PROCESSES AND COMPONENTS

Department head:
Dr. Michael Stelter

Profile

The research field "Processes and Components" encompasses manufacturing processes for ceramic components and assemblies. Prototype solutions are generated on laboratory and pilot scale, small batches are produced and, if required, scaled up to pilot technologies. The value chain ranges from modification of commercial powders and raw materials to shaping, sintering, machining (green and sintered bodies), and to joining and integration technologies. The equipment enables scale-up of all individual technological processes to industrial standards, readily transferrable to the customer's site.

Design of ceramic and metallic materials as well as composite materials and their precursor products form the heart of our powder technology. Silicate and polymer ceramics are additional core areas of materials expertise. Our component design group employs a broad range of plastic and thermoplastic shaping and casting technologies as well as powder pressing. Component surfaces are treated using plasma spray processes.

The technology chains are completed with a capable and innovative green machining and finishing center. Our high standard of quality is supported by a first-class QM system and numerous certifications and expert audits.

Overall, the research unit offers outstanding possibilities for component manufacturing, system integration, and advanced materials. Prototypes and small batches can be delivered quickly, reliably, and cost effectively. We offer a flexible handling and rapid response in order to help our customers to reduce the time to market.

Services offered

- Development of ceramic processes, components and systems on a pilot scale
- Contract research and joint projects
- Services related to manufacturing processes
- Technology transfer
- Design of scientific equipment
- Feasibility studies
- Consulting and training courses

In conjunction with other research fields at Fraunhofer IKTS, namely materials development and simulation, we offer competent advice and excellent R&D to our partners. We can draw on the expertise of other institutes in the Fraunhofer AdvanCer Alliance to extend our scope.

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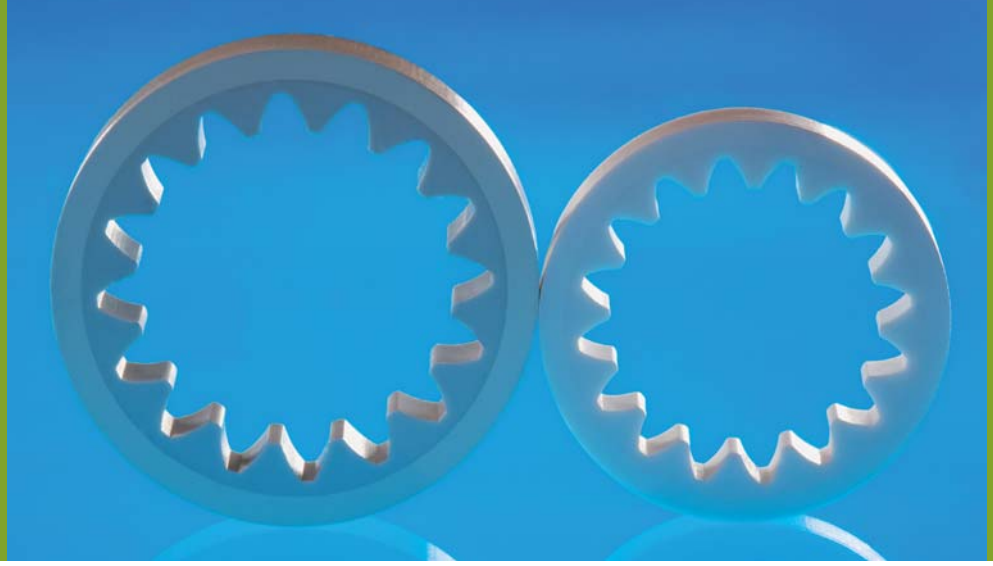

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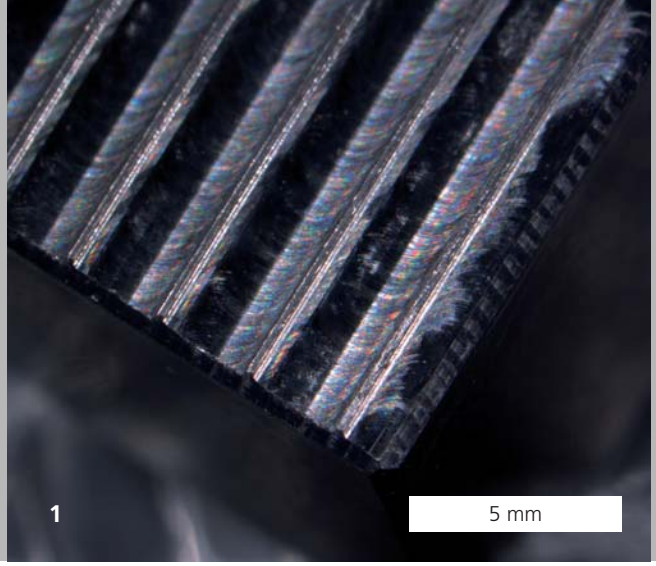
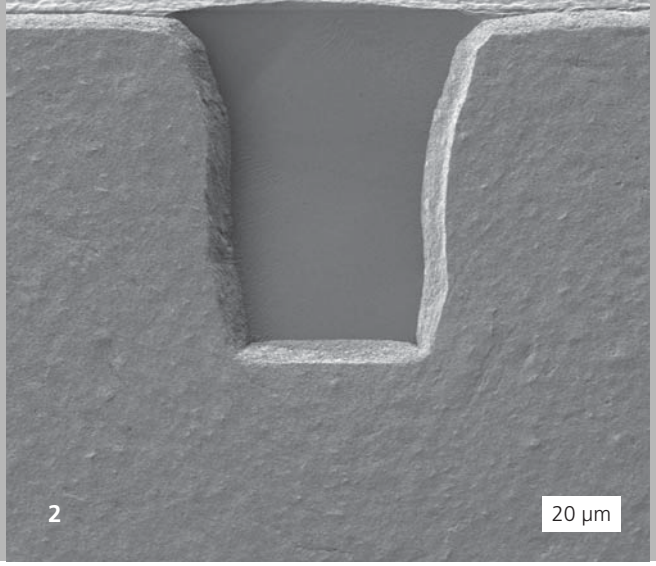




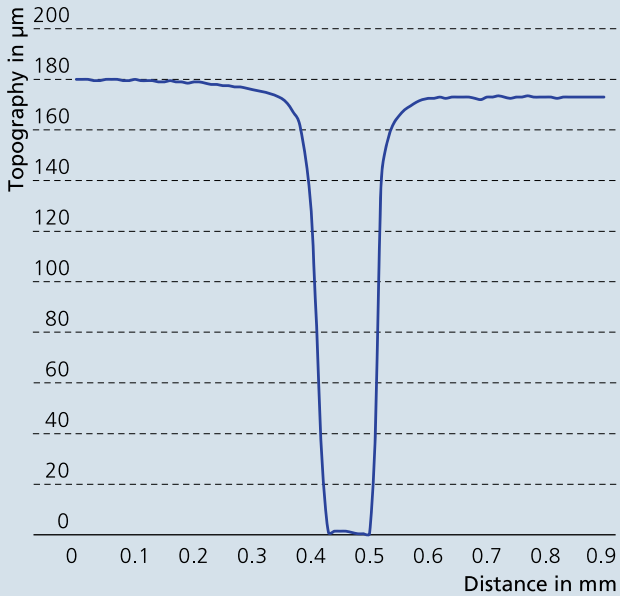
STRUCTURING OF CERAMIC GREEN TAPES BY EMBOSSING

Dip.-Ing. (FH) Anja Kucera, Dr. Tassilo Moritz

For several decades, ceramic substrates have been used to manufacture functional components in multilayer technology. The integration of channel structures allows future applications in biotechnology, sensor technology as well as micro-reaction technology. Accurate, reproducible and high throughput production technologies are essential for the cost-effective production of such structured multilayer substrates.

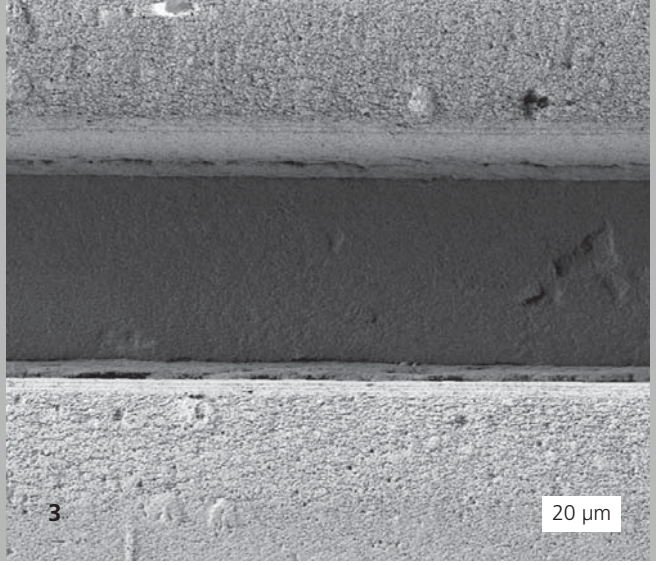
Within the framework of the EU Large Project MULTILAYER (FP7-NMP-2007-214222), the Fraunhofer IKTS developed alumina and zirconia green tapes for subsequent structuring.

Line-scan across channel structure (embossed at room temperature) inside an alumina green tape



These substrates will be used as multi-channel elements, and integrated into a micro reactor. Three dimensional structures with various aspect ratios can be generated by embossing. In the future, the roll-to-roll process shall allow an upscaling to high throughput production. In contrast to hot embossing, which is widely used in plastics industry, the ceramic green tapes are embossed at room temperature. This allows for a significant reduction of cycling time for machining.

The key aspect within the project was the development of green tapes made of water-based systems which are suited for cold embossing. Environmental aspects as well as the mechanical behavior of the binder system determine the selection of the single components. For this purpose, various tape compositions were developed. Then, their flowability during processing and elastic-plastic behavior were characterized. Amongst others, tensile testing and micro indentation tests were used for analyzing the mechanical behavior of the green tapes. As result, an optimal composition was chosen which can be used as binder system for upscaling. For optimal process control, embossing tests were carried out at a modified tensile-compression machine. The embossing tool was made of brass. The channel height and the molding geometry were modified to compensate the elastic amount of binder during embossing. Different process parameters like maximum press capacity, dwell time or impression velocity were varied during embossing to analyze their influence on the embossing result. The resulting channel structure can be seen in figure 2. Using confocal white light microscopy, the dimensions of the structure can be measured and shown.



By laminating a structured and unstructured green tape, a compound of both can be realized. For this purpose, studies on cold chemical lamination are carried out. Conventional techniques, for example hot isostatic and uniaxial lamination, are also considered. It is the main aim of lamination to obtain an excellent contact between the layers while keeping the integrated structures. The resulting channel elements allow for the transport of fluids, and simultaneously serve as mechanical interface.

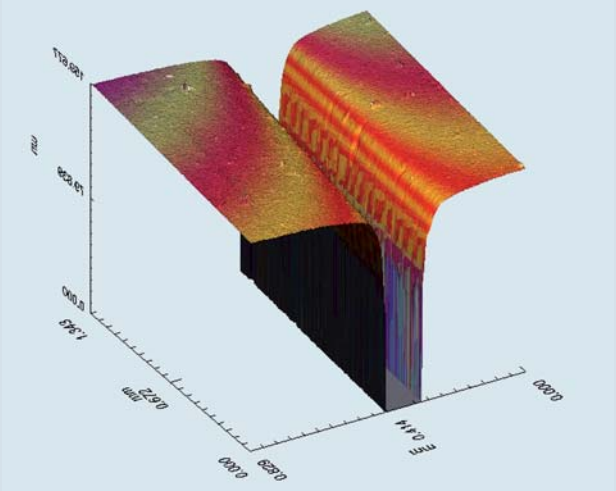
Acknowledgments

The European Commission is gratefully acknowledged for funding the MULTILAYER project (FP7-NMP-2007-214222). We thank all cooperating partners of the project consortium for contributing to the results.

Services offered

- Development of aqueous and organic as well as UV curable tape casting slips
- Development of green tapes as well as tape processing by embossing, deep drawing, corrugating, wrapping and laminating

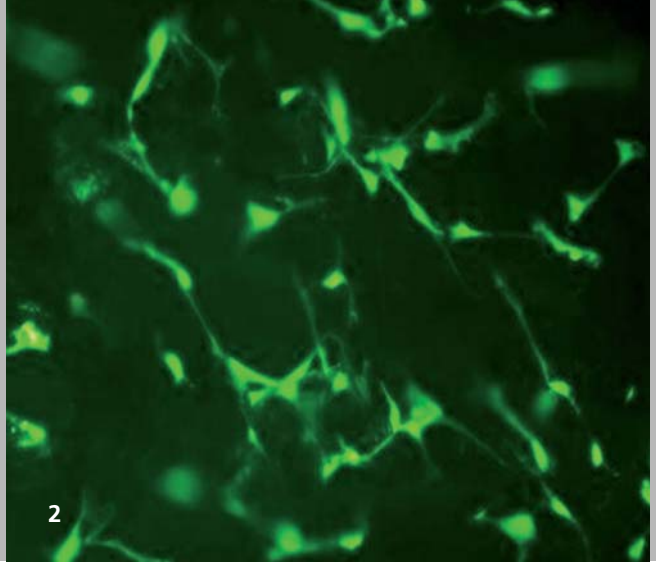
Mapping across channel structure inside a green tape



1 *Embossing tool made of steel.*

2 *REM image of a cross section through a channel in alumina green tape.*

3 *REM image of channel top view in alumina green tape.*



FREEZE FOAMING – CELLULAR STRUCTURES FOR VERSATILE APPLICATIONS

M. Sc. (Chem.) Matthias Ahlhelm, Dr. Tassilo Moritz

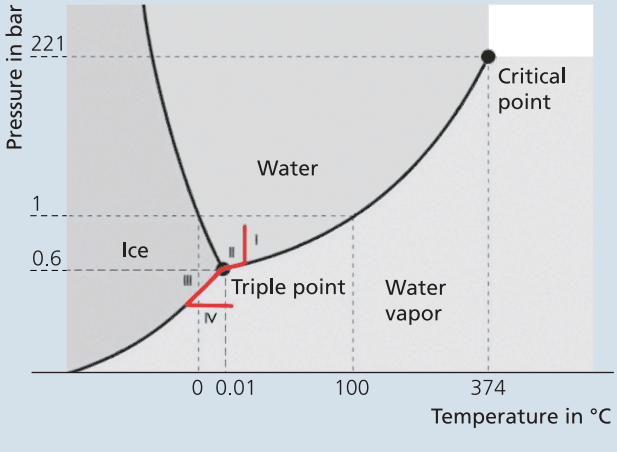
In addition to the typical properties of ceramics such as wear resistance or brittleness, porous cellular ceramics are characterized by a broad variety of possible applications. Potential applications range from biomedicine (membrane bioreactors, bone scaffolds), through biomimetics (honeycomb filters) to mechanical and plant engineering (reactors, burners, insulators and refractories).

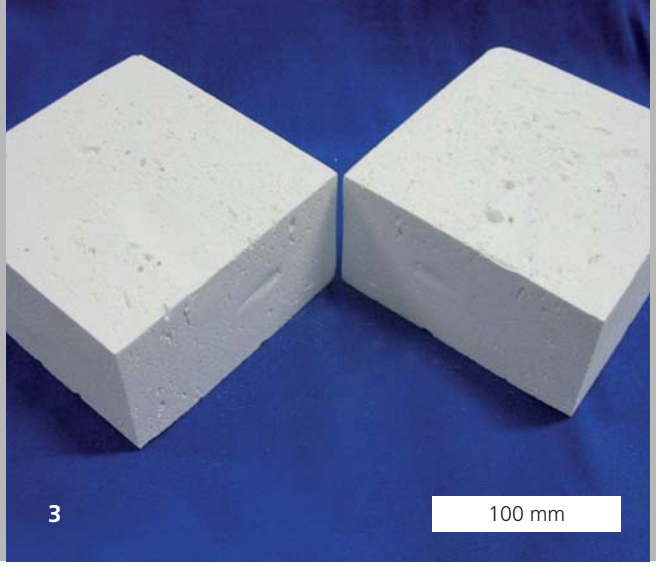
The freeze-foaming process presented here has the potential to cover at least two of these fields. Freeze-foaming is foaming of an aqueous ceramic or metallic suspension with subsequent freeze-drying to a porous, cellular structure. For this purpose, the ambient pressure is reduced in a freeze-drying device through which water vapor and residual air inflates the suspension (diagram on the right, curve sections I, II). As evaporation in aqueous suspensions causes a drop of temperature, the foaming suspension suddenly freezes at the intersection of the liquid-vapor-solid equilibrium line (triple point). By heating the panels underneath, the now stable protofoam is freeze-dried due to sublimation of the frozen water (curve section IV).

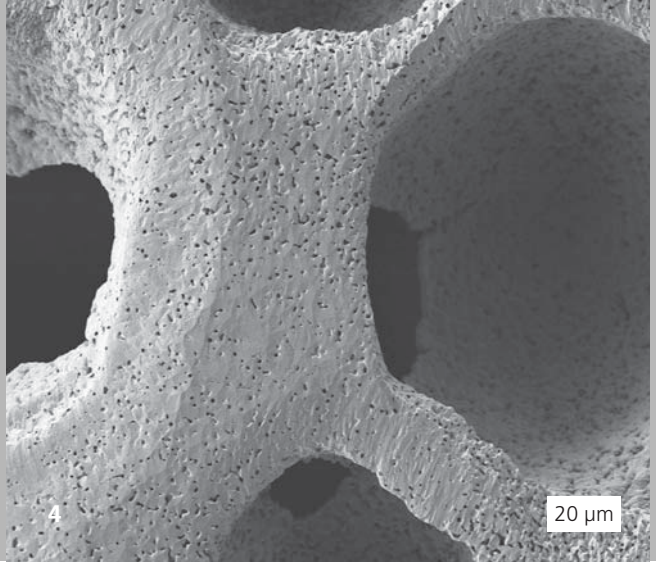
A porous, biocompatible ceramic foam was manufactured using different hydroxyapatite powders (Merck KGaA and SIGMA-ALDRICH Cooperation). It could be proved that this foam is suited for cell cultivation and even differentiation (figure 2). If toughness values similar to those of a real bone were achieved, the ceramic foam might be used as implant. The freeze-foaming technique also provides the possibility to manufacture a specific, outer shape of a porous foam by using, for example, synthetic rubber as counterpart. Figure 1 shows such a hydroxyapatite foam replica in shape of a human thumb bone. The pore structure fulfilling the requirements to cultivate cells can be characterized by non-destructive X-ray computed tomography (PROCON X-Ray, max. 150 kV) and image analyzing software (Porescan, Image J) as well as mercury porosimetry.

In further studies, the freeze-foaming technique was successfully used to up-scale the manufactured foams to bigger geometries. Using a mullite powder (NABALTEC, K0/K0c) a freeze foamed structure (235 x 114 x 70 mm³) was achieved which might be used as light-weight insulating brick in refractory industry (figure 3). As shown in the lower diagram, the first tested samples (H01-H09) have already met the necessary requirements of refractories. The determined thermal conductivity is similar to state-of-the-art products.

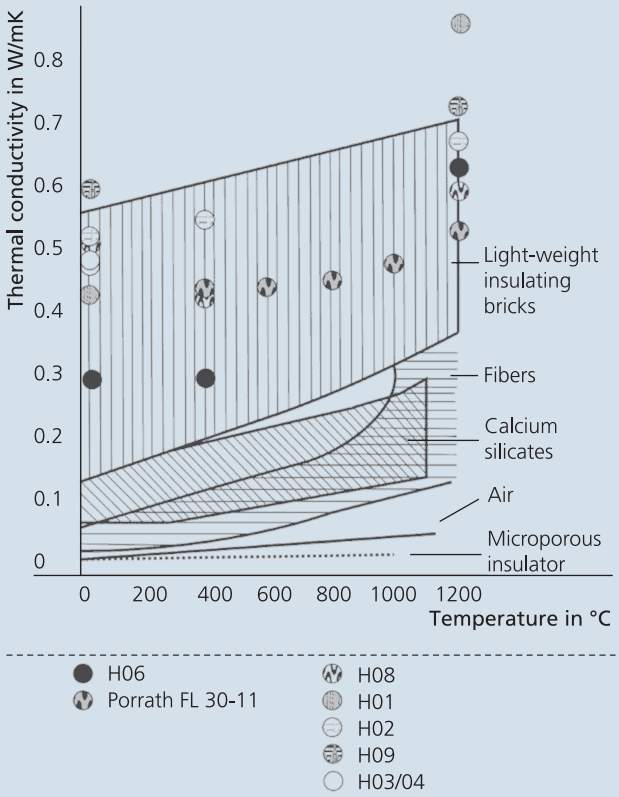
p-T diagram of water; course of freeze foaming process







Comparison of thermal conductivity values of freeze-foamed mullite samples with products of Rath AG (Porrath FL 30-11)



So far, freeze foamed cellular structures have been manufactured in laboratory scale. However, through a specific adjustment of the process parameter and the experimental equipment, the manufactured quantity can be increased. In addition to the presented starting material, other ceramic powders (like SiC, ZrO_2, Al_2O_3, hybrids) and also powder metals (e.g. steel) can be transferred to porous semifinished parts.

Services offered

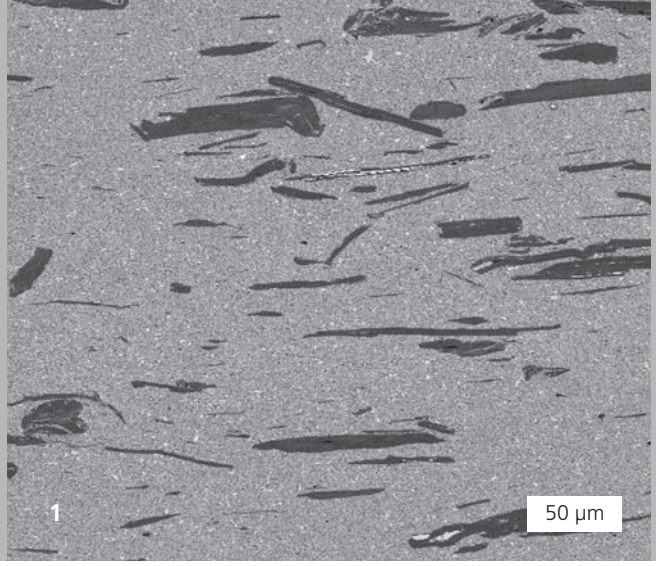
- Freeze foaming
- Freeze drying
- Development of suspensions

1 *Hydroxyapatite foam replica in shape of a human thumb bone.*

2 *Vital staining of cultivated human mesenchymal stem cells in the hydroxyapatite foam, proved using fluorescein diacetate, in cooperation with Fraunhofer IBMT.*

3 *Light-weight insulating brick by freeze foaming.*

4 *Freeze-foamed microstructure, ion-polished (hydroxyapatite).*



GRADED MULTILAYER STRUCTURES FOR REFRACTORIES

Dipl.-Ing. Uwe Scheithauer, Dipl.-Ing. Kristin Haderk

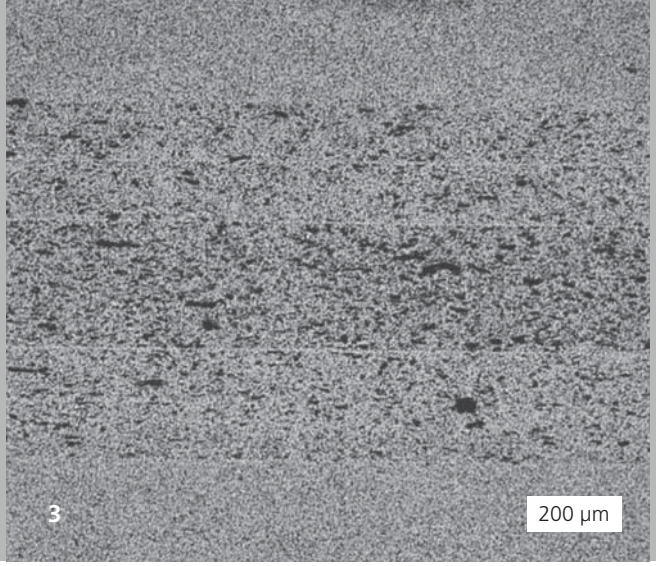
Within the framework of the DFG priority program 1418 "Refractories – Initiative to Reduce Emissions", new manufacturing and characterization methods are developed for refractories of the next generation. These components are free of carbon resulting in increased oxidation stability and reduced thermal conductivity. So, insulation properties can be improved and energy can be saved. However, carbon-containing refractories are characterized by very good thermal shock behavior.

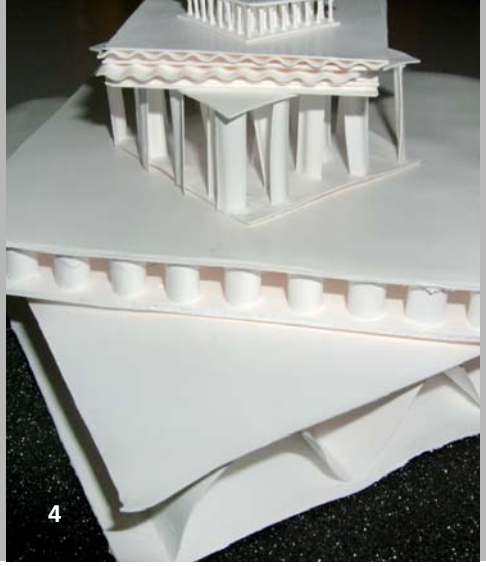
To reach a thermal shock behavior of the carbon-free refractories which is comparable with the behavior of carbon-based refractories, the ceramic multilayer technology is further developed at Fraunhofer IKTS. Ceramic green tapes are cast and laminated to large-size products. It is the aim to improve the thermal shock properties by specifically placing pores and creating a graded pore structure. For this purpose, green tapes are made of water-based slurries with different amounts of pore forming agents. These tapes are cut, stacked and laminated using a new lamination technology which guarantees a defect-free joining of the single tapes and the co-sintering to one product with a defined graded microstructure. By adapting a paper winding technology, it is possible to manufacture axially symmetrical samples as well as components with a rectangular cross-section which also have a graded microstructure in radial direction.

Cellulose fibers or graphite platelets were used as pore forming agents, which are burned-out before sintering and leave pores of defined size and orientation. During tape casting shear forces have an effect on the slurry components between doctor blade and carrier tape. Thus, the fibers (one-dimensional) and graphite platelets (two-dimensional) are arranged in casting direction and leave pores in the same direction after burn-out and sintering. A crack, which is induced by thermal shock and propagates vertically to the tape layer, is absorbed and its propagation is slowed down to increase the lifetime of the product.

By means of suitable characterization methods, the samples of different compositions are analyzed in terms of temperature-dependent conductivity (specific heat capacity, coefficient of expansion, density and conductibility of temperature) and mechanical strength as well as residual strength after thermal shock by 4-point bending. These characteristic values allow scientists at TU Bergakademie Freiberg to simulate thermal shock behavior of multilayers with different graded microstructures to identify optimal gradients. Then, these multilayer structures are realized and characterized at Fraunhofer IKTS. For this purpose, new thermal shock testing equipment is developed, which allows heating up the samples on one side to simulate the occurring stress of the real application. So far, the samples have been heated inside a furnace homogeneously and quenched in cold water. Further cooperation in this field was initiated.

The crack propagation energy, which describes how much energy is needed to propagate an initiated crack, is another important parameter to characterize the thermal shock behavior of components. Scientists at Forschungszentrum Jülich used the wedge splitting test to show that kind and amount of pore forming agents as well as their orientation have a great effect on crack propagation inside the sintered lami-

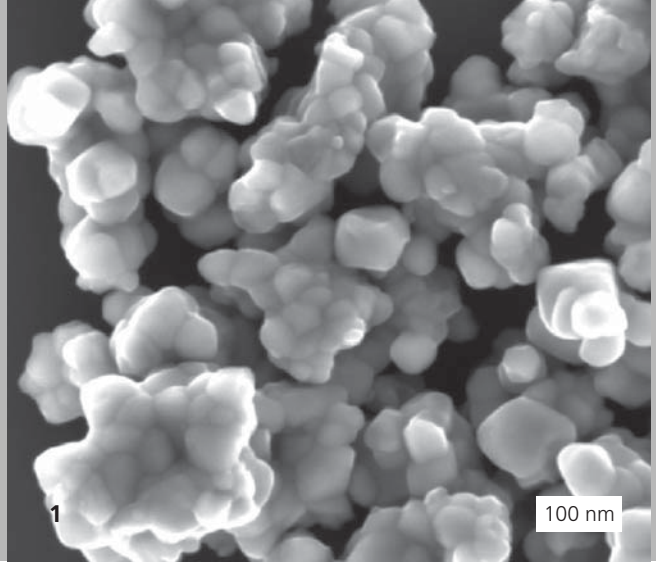




nates. Further studies with specifically graded structures are planned.

The combination of different ceramic shaping technologies and the processing of ceramic green tapes by forming allow the production of sandwich structures nearly without any limitations concerning the possible design geometries. The lamination of formed green tapes with planar green tapes, for example, might be used to produce structures with high volume and low density as well as low heat capacity. A design with defined porosity and porosity gradients is possible as well as the use and combination of different materials adapted to the different requirements like chemical or thermal resistance, mechanical strength or economic aspects. These structures might be used, e.g. as kiln furniture, furnace lining, high-temperature insulation or heat exchanger.

1 *Longitudinal section of a green tape with graphite platelets.*
2 *Wound and sintered outlet nozzles.*
3 *Cross section of a 7-layer symmetrical, graded component.*
4 *Various demonstrators for alternative applications.*

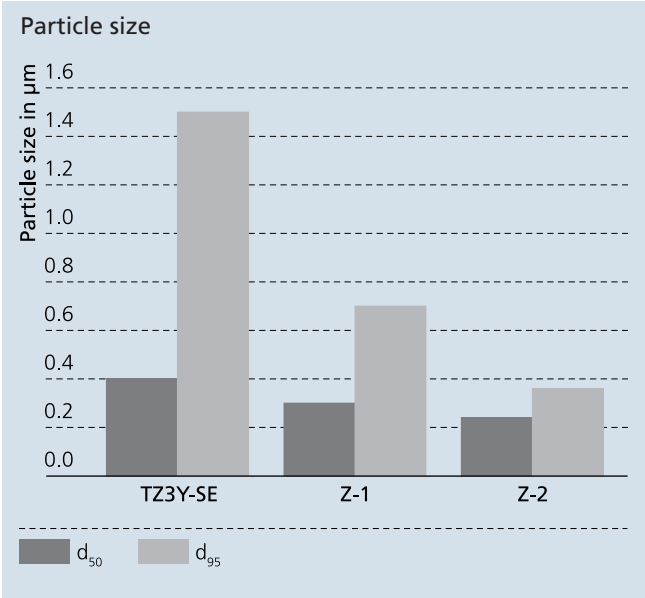


AGING-RESISTANT ZrO_2 CERAMICS MADE OF COMMERCIAL POWDERS

Dipl.-Chem. Martina Johannes, Dipl.-Ing. Jens Schneider

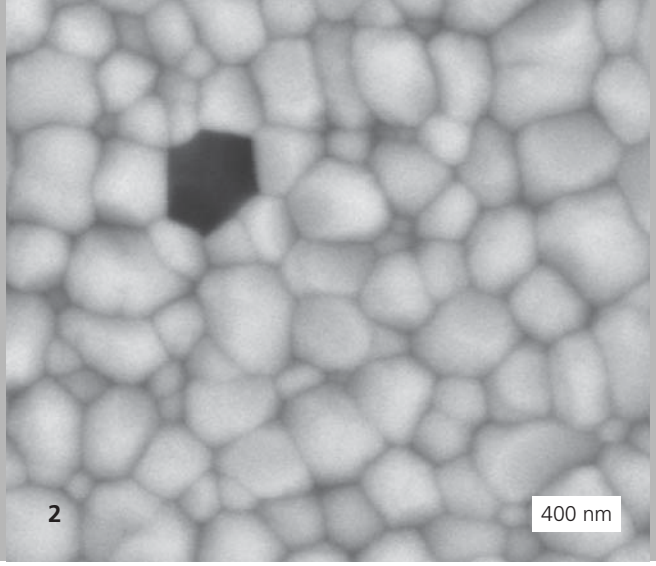
Yttrium stabilized zirconia (Y-TZP) has excellent mechanical properties such as a bending strength of more than 1000 MPa and a fracture strength of up to 8 $MPam^{1/2}$. For this reason, Y-TZP has been known as biocompatible material for joint and knee implants for several years. For about ten years, it has mainly been used as material for dental restoration processed with the help of CAD/CAM processes. On account of hydrothermal aging, however, the long-term stability of Y-TZP is influenced. Generally, the aging resistance of Y-TZP can be improved by reducing the grain size and homogeneously distributing the stabilizer (yttrium oxide). From literature it is known that fine-grained, aging-resistant microstructures can be realized by using cost-intensive (nano)powders and complex manufacturing methods. The results described in this article show that dense, finest-particle and aging-resistant zirconia can be reliably produced from commercial submicrometer powders when modern, scalable grinding techniques and grinding media (≥ 50 µm) are used. In order to show the difference, two Y-TZP batches were compared. Batch Z-1 was prepared using a standard method, batch Z-2 using an optimized method. The powders (TZ3Y-SE, Tosoh, Japan) were prepared to slurries using an attrition mill. Then they were shaped by slip casting. The obtained grain sizes for slurry and raw material can be seen in the following diagram. On account of the obtained grinding fineness, the sintering activity was significantly increased for the Z-2 batch.

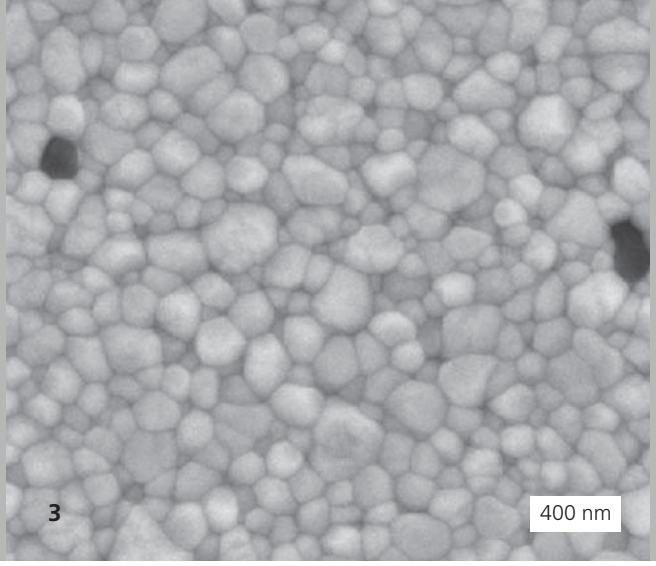
The relative densities of the sintered or hot isostatically pressed bodies came to more than 99.5 % of the theoretical density of 6.1 gm/cm³. The surface of the samples was polished (Ra 0.01 to 0.008 µm). The samples were hydrothermally treated up to



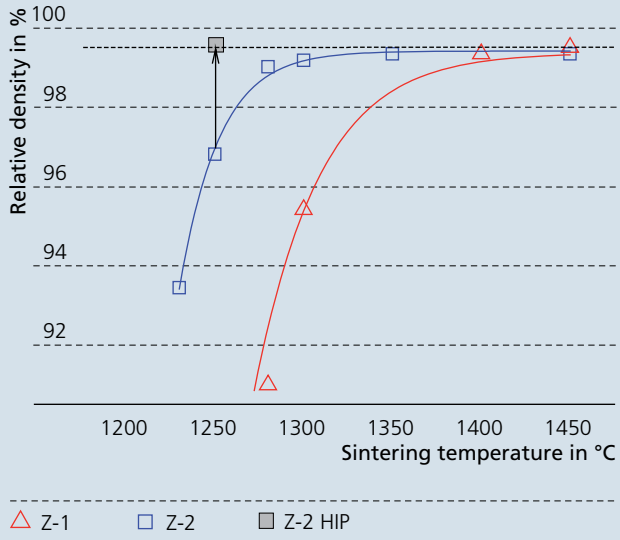
120 h in an autoclave at 134°C and 2 bar water vapor atmosphere. The phase composition of the aged samples was measured by XRD and quantified by Rietveld refinement. Furthermore, the mean grain size of the microstructure was determined using the linear intercept method: 340 ± 30 nm for Z-1 and 150 ± 30 nm for Z-2.

The diagram below shows the kinetic behavior of the hydrothermal aging process for Z-1 and Z-2. Whereas the Z-1 sample showed a fast increase of the monoclinic phase, no increase was observed for the Z-2 sample. Identical results were obtained for the TZ3Y-S raw material (Tosoh, Japan).

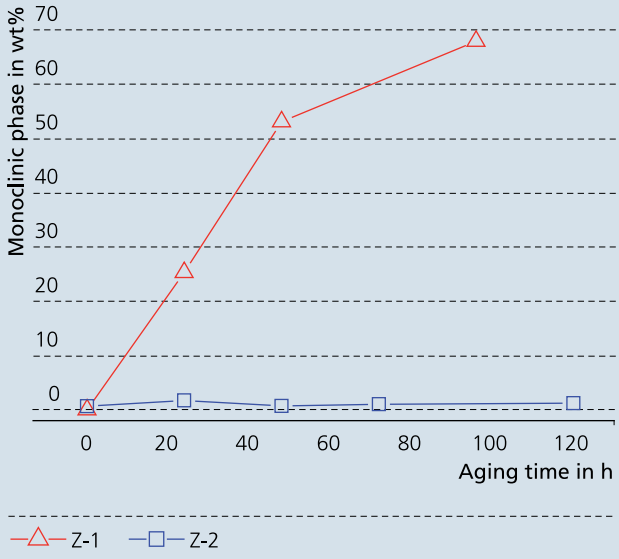




Sintering activity



Kinetic behavior of hydrothermal aging at 134°C in water vapor



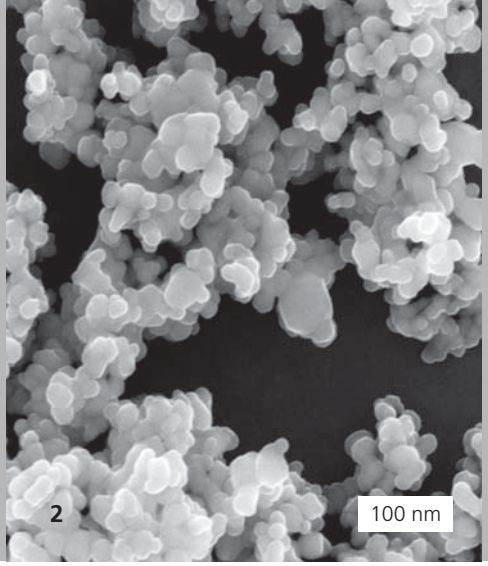
It was proved that the sintering activity of commercial powders can be increased by modern preparation techniques. The ceramics manufactured from these raw materials (TZ3Y-SE, TZ3YS) have a new material quality. So a method was developed, how long-term stable biocompatible ceramic implants can be produced from cost-effective commercial powders. In follow-up studies, the mechanical, optical (transparency) and wear properties of the fine disperse 3Y-TZP ceramics are investigated. Furthermore, it is examined if the results can be transferred to spray granulation and pressing technologies.

Services offered

- Preparation of slurries and dispersion/grinding of the used raw material, e.g. alumina, zirconia and other dispersions
- Adjusting of process parameters in laboratory attrition mills (batches from 800 g to 5 kg) and upscaling to industrial plants (50 kg batches) using grinding balls ≥ 50 µm

1 *SEM image of the TZ3Y-SE material.*
2 *SEM image of the Z-1 microstructure (340 ± 30 nm).*
3 *SEM image of the Z-2 microstructure (150 ± 30 nm).*

1



2

TRANSPARENT $MgAl_2O_4$ CERAMICS BY AUTOMATED UNIAXIAL PRESSING

Dr. Uwe Reichel, Dipl.-Ing. Henry Ludwig

Motivation

New transparent polycrystalline ceramic materials combine the advantages of advanced ceramics including high fracture toughness, hardness, chemical resistance and reliability with the special optical properties of glasses or single crystals. Using these new materials, the optical application can also be enhanced. In this case, there is the theoretical possibility, for physical reasons, to manufacture materials with outstanding optical properties (e.g. very low/high refractive index or specific spectral properties).

However, the optical principles place high demands on the polycrystalline material. In order to achieve maximum transmission, a defect-free microstructure (no pores, cavities or crystal defects) is necessary. For non-cubic materials, a maximum crystallite size in the sub µm range (smaller than 500 nm up to below 50 nm) is required to suppress birefringence. This, again, places high demands on the quality of the starting materials.

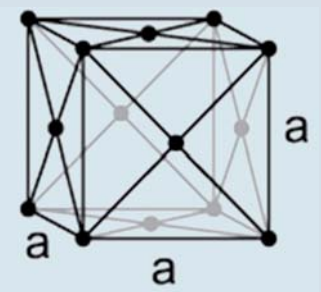
Under the aspect of a cost-effective series production, high-purity and highly disperse commercial raw materials should be used as starting material for the new transparent spinels to be developed (diagram on the right hand side). Polydisperse starting powders are essential for dense, pore-free ceramic microstructures, and thus for transparent ceramics. On the one hand, the materials should have a broader distribution of primary particle diameters below 150 nm, and on the other hand they should be free of coarser particles.

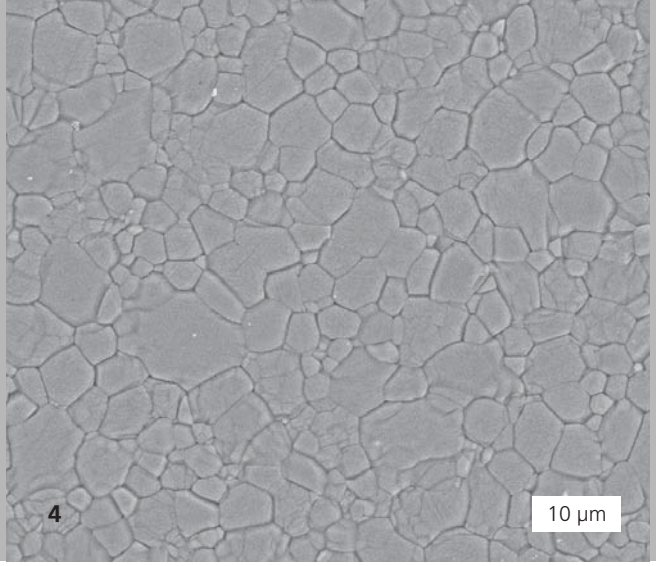
In order to adjust the material to the requirements of ceramic shaping techniques, it is necessary to add suitable dispersants as well as binders and compaction aids. Uniaxial pressing was chosen as economic shaping technique. Here, Fraunhofer IKTS has extensive knowledge. Within the framework of this project, the compatibility of the starting materials was to be improved.

Approach

On the basis of a commercially available spinel powder with d_{50} = 180 nm, SSA = 30 m²/g (BET) and a purity of > 99.95 %, compactable granulates (d_{50} = 40 µm) were realized by aqueous powder preparation in high-performance attrition mills and spray drying (two-fluid nozzle). By uniaxial pressing with compaction pressures of 200 to 300 MPa and hot isostatic pressing (HIP) that followed at 1600°C/2h under argon atmosphere, transparent spinel ceramics were manufactured.

Cubic crystal lattice of spinel





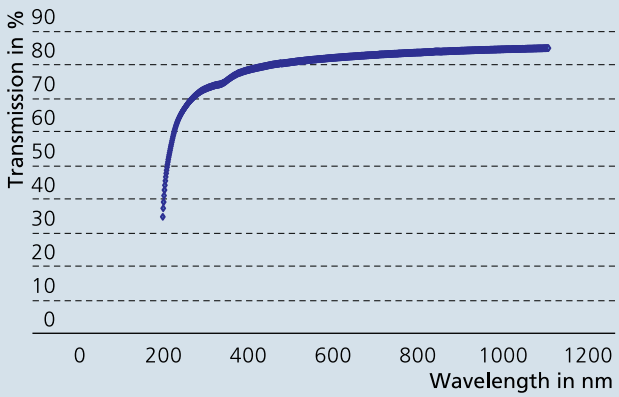
Results

For the obtained spinel ceramics with a sintering density of > 99.7 % of the theoretical density, transmission values of up to 98 % of the theoretically possible transmission (theoretical maximum transmission according to refractive index is T = 86.9 % – see diagram below) were measured. Thus, it was proved that transparent spinel ceramics can be manufactured by automated uniaxial pressing. In further studies, the mechanical properties of the transparent spinel ceramics are to be characterized.

Services offered

- Development of single-phase and multi-phase oxide ceramic components for optical applications
- Uniaxial pressing of prototypes

Transmission values for pressed $MgAl_2O_4$ spinel



Acknowledgments

The presented results are part of a current project (BMWi Reg. Nr. MF090093).

1 *View through a spinel window.*

2 *Sub-µm spinel starting powder.*

3 *Uniaxial powder press for automated production.*

4 *Microstructure of a transparent spinel.*

RESEARCH FIELD ENVIRONMENTAL ENGINEERING AND BIOENERGY

Department head:
Dr. Ingolf Voigt

Profil

The research field "Environmental Engineering and Bioenergy" encompasses the development of materials, technologies, and systems for the efficient, safe, economical generation, conversion, transportation, storage, and utilization of energy, especially bioenergy. Technologies and processes are also being developed for water and air purification.

At the core of the research activities are ceramic membranes for liquid filtration, pervaporation, vapor permeation, and gas separation as well as catalysts for exhaust gas purification and wet chemical catalysis. Another focus is on high-performance batteries and accumulators for buffering energy peaks from renewable energy sources. Powerful process technologies for comminution and disintegration of biogenic substrates as well as membrane modules and systems for substance separation and reaction are also being developed. The integration of these technologies into existing technologies (e.g., for biogas and bioalcohol generation) results in a significant increase in efficiency and offers new approaches for process development.

For environmental protection and resource conservation, innovative solutions for substitution or economical use of chemical additives are designed and efficient technologies for recovery and reuse of resources developed.

Services offered

The services we offer range from development, optimization, and planning to scientific support in the installation of facilities and transfer to continuous industrial operation. Innovative treatment technologies and extensive know-how in ultrasonic treatment, biological catalysis, and fermentation are used to enable highly efficient use of natural raw materials and biogenic waste materials.

- Situation and systems analysis at customer site and in laboratory
- Innovative process development and specification for biomass treatment
- Determination of gas potential of biogenic substrates
- Optimization of reaction kinetics for anaerobic breakdown processes
- Processes for wastewater purification and water treatment in municipal and industrial plants
- Ultrasonic application for degassing and disintegration
- Energy optimization of stirring processes
- Membrane development and testing
- Application and piloting of membrane processes
- Catalyst development and testing
- Supply of samples of ceramic membranes and catalysts for pilot and demonstration systems
- Membrane system development and prototype manufacture
- Engineering of biogas plants using new, innovative process steps
- Development of batteries and accumulators for stationary energy storage
- Provision of expert opinions and reports

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2

CNT FILMS FOR MEMBRANE SEPARATION AND CATALYSIS

Dipl.-Ing. (FH) Susanne Kämnitz, Dr. Hannes Richter

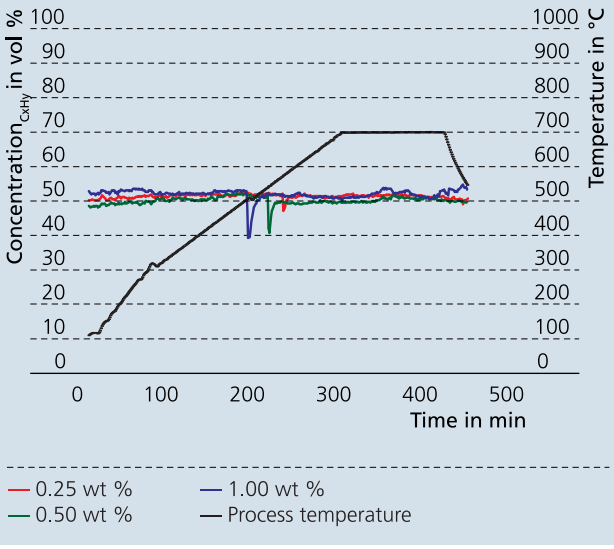
Hydrogen plays an increasing role as an energy source in the further expansion of renewable energies and their way to become profitable. In order to use hydrogen for automotive, industry and household applications efficiently, special separation processes and storage materials that achieve a storage capacity of 6.5 weight percent of hydrogen, are required. Zeolites and metal hydrides have already met these targets but the high desorption temperature and slow desorption rates have limited the range of applications so far. Carbon nanotubes (CNTs) are discussed as another high potential class of materials. Their use is currently focused on electrode materials for energy storage and the production of electrically conductive composites.

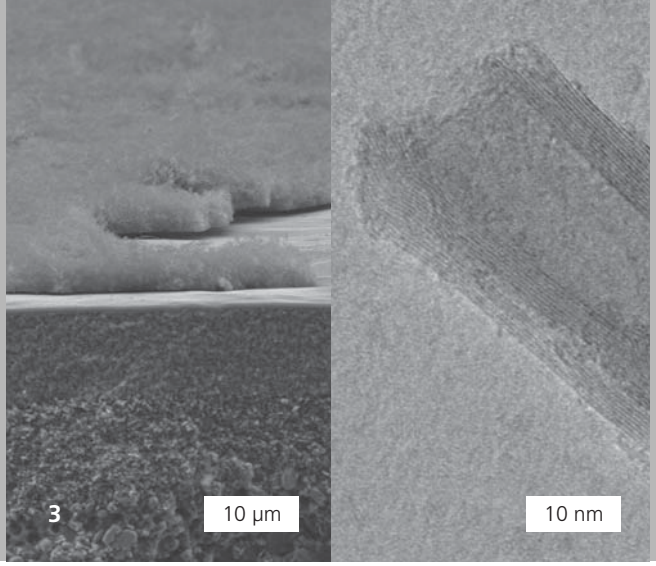
Fraunhofer IKTS developed a CVD system which allows to produce thin CNT films on the inner surface of porous ceramic tubes with different tube diameters and lengths. The deposition of the CNT films can be made from various liquid or gaseous carbon precursors. The reaction steps during the CVD processes can be analyzed directly by coupled analysis methods like IR spectroscopy and gas chromatography.

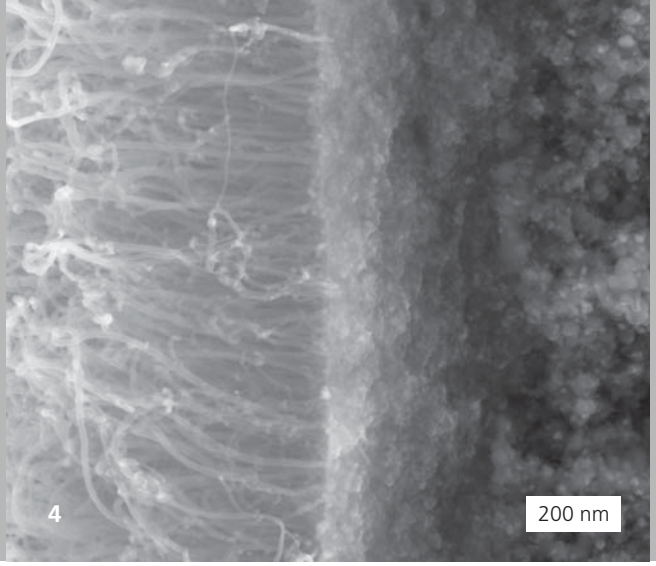
Catalyzed supports, e.g. alumina, were used for CNT deposition. The growth behavior of the deposited CNT films can be influenced by the specific selection of the catalysts, the supports and the carbon precursors. The catalytic decomposition of the carbon precursor shifted with increasing catalyst content to lower temperatures and higher CNT yield.

Uniform CNT films with thicknesses < 5 microns were deposited on porous, ceramic supports. Depending on the process parameters, oriented or unoriented CNTs with average tube diameters < 200 nm were prepared. The tube ends of the deposited CNTs were frequently closed with metal particles or carbon caps. In the gas permeation measurements, the CNT layers showed adsorption-selective gas separation properties. Single gas permeance and permselectivities were changed by varying the catalyst. An increase of the permeance and H_2/CO_2 permselectivity was found with increasing catalyst concentration and therefore increasing CNT yield. The rise in H_2 permeance is explained by adsorption and capillary effects on the surface of the nanoscale tube geometry. By adsorption measurements, the adsorption of hydrogen in the CNT films was detected.

IR analysis during the deposition of CNT films on a porous, ceramic support







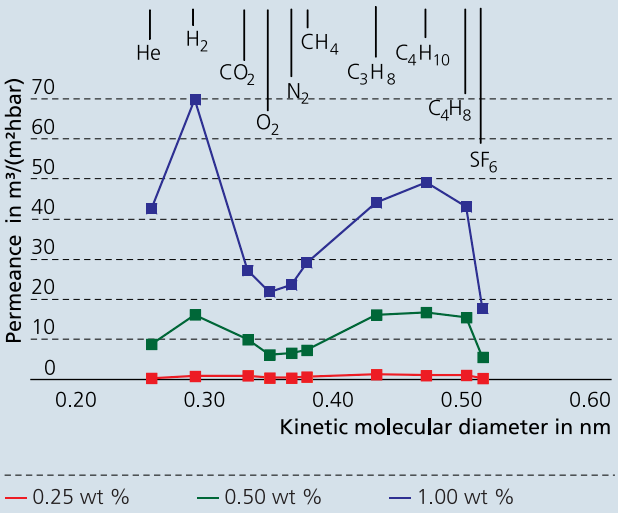
Application

The presented CNT films show high potential for the separation of gases with different molecular sizes, such as the separation of H_2 and CO_2. Furthermore, it should be possible to use these CNT films for the separation of gases with similar molecular sizes but different adsorption, such as paraffin/olefin separation. Because of their special properties, carbon nanotubes are of growing interest for future application fields, such as the provision of fuels. In addition to membrane applications, CNT layers might be used as an ideal material for the storage of gases and as a microreactor in catalytic processes.

Services offered

- Deposition of CNT films on porous, ceramic tubes and flat discs
- Optimization and further development of CNT films for applications in membrane separation, gas storage and catalysis
- Combination of membrane separation and catalytic conversion (membrane reactor)
- Customer-specific tests
- Stability tests

Single gas permeance of CNT films as a function of catalyst concentration

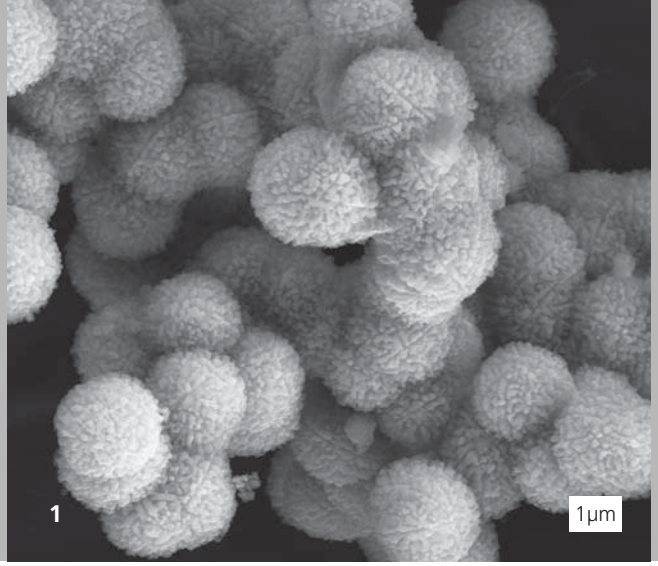


1 *CVD system at Fraunhofer IKTS Hermsdorf.*

2 *Porous, ceramic support before and after CNT deposition.*

3 *FESEM image of a deposited CNT film and HRTEM image of a closed CNT.*

4 *FESEM image with aligned CNTs.*



HYDROTHERMALLY STABLE ZEOLITE MEMBRANES FOR H_2 SEPARATION

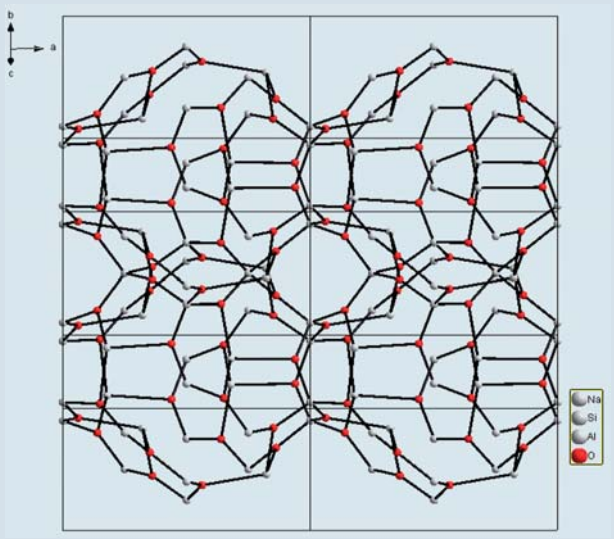
Dipl.-Chem. Christiane Günther, Dr. Hannes Richter

According to a study of the International Energy Agency the global electrical energy demand will increase by the factor of two in the next twenty years. The main energy source will remain fossil fuels (coal, oil and natural gas), which actually produce about 60% of the energy in Germany. In 2050, about 70 % of the global energy will be produced from fossil fuels. Therefore, the emissions of greenhouse gases like CO_2 will also continue to increase. Currently, about one third of the global CO_2 emmissions are produced by power plants. To decrease the CO_2 emmissions of future power plants the coal can be gasified to H_2 and CO_2 before combustion (IGCC) and subsequently the hydrogen separated from CO_2. The hydrogen can be burned in a gas turbine and the produced water steam is driving a steam turbine. In addition to the reduced CO_2 emission, the efficiency increases in comparison to conventional fossil power plants.

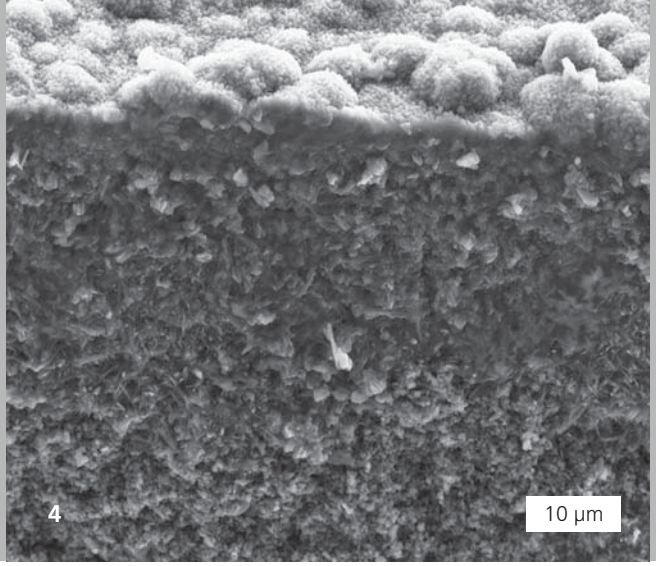
To decrease the very high efficiency losses of gas separation with conventional methods like gas scrubbing or adsorption, nanoporous membranes can be used for H_2 and CO_2 separation. This separation has to be carried out directly after the water gas shift reaction (sweet shift, 350°C, 25 bar, 25 % H_2O) setting high requirements in terms of membrane stability.

Zeolites are crystalline tectosilicates with defined nanopores. Deposited as a thin layer on top of porous substrates, comparatively cheap, thermal and hydrothermally stable membranes of high selectivity should be obtained. Sodalite (SOD) exhibits pore sizes in the range of the molecule diameter of hydrogen. Therefore, sodalite membranes are promising candidates for H_2/CO_2 separation.

Cubic crystal structure of sodalite (SOD) e.g. $[Na_8[Al_6Si_6O_{24}]Cl_2]$



First, different sodalite powders were synthesized and their hydrothermal behavior was tested. The classical easy-to-synthesize hydroxosodalite (H-SOD) was not hydrothermally stable. The Si-SOD without alumina shows excellent stabilities but could not be synthesized as a crack free membrane. Therefore, a new method was developed to stabilize the H-SOD by intercalation of sulfur into the crystal framework. The S-SOD synthesized by this method exhibits excellent thermal and hydrothermal stability and allowed the preparation of crack free membranes for the first time (figure 1).



The zeolite membranes were synthesized on the inside of asymmetric, tubular, porous, ceramic substrates (l = 250 mm). Substrates of different supporting top layers made of α-Al_2O_3 and γ-Al_2O_3 with different pore sizes were tested. The supports were seeded with zeolite powder (slurry seeding) or zeolite nanoseeds (figure 2). Under hydrothermal conditions in autoclaves the seeds grow into closed layers (figure 3).

First optimizations of seeding and synthesis led to properly intergrown layers with a thickness in the range of a few micrometers and without impurities (figure 4). By single gas permeation a 14 times higher permeation of hydrogen in comparison to CO_2 was measured. So, a thermally and hydrothermally stable membrane for a size selective separation (molsieving effect) of a H_2/CO_2 mixture was prepared for the first time. It is the objective of ongoing research to reduce the membrane defects (permeation of big molecules) still existing and to increase the H_2 permeance. That is essential for an industrial application of the new zeolite membranes.

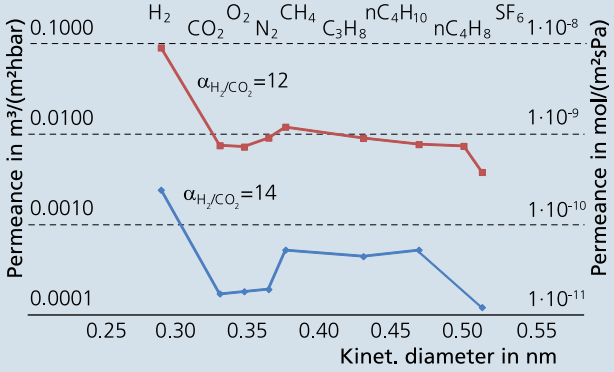
Acknowledgments

Financial support from the Helmholtz Association of German Research Centres (Initiative and Networking Fund) through the Helmholtz Alliance MEM-BRAIN is gratefully acknowledged.

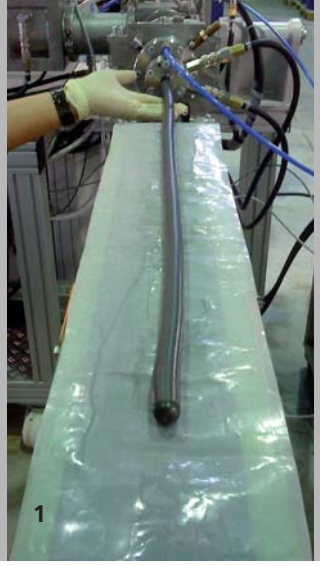
Services offered

- Development of membranes for separation of customer-specific gas mixtures
- Separation tests for membranes (single and mixed gas measurements, vapors and liquids) according to customer requirements and under consideration of technical possibilities

Single gas permeation of different S-SOD membranes



1 *SEM image of S-SOD powder.*
2 *Seeding of a membrane.*
3 *Hydrothermal synthesis in autoclaves.*
4 *SEM image of the cross section of an S-SOD membrane.*



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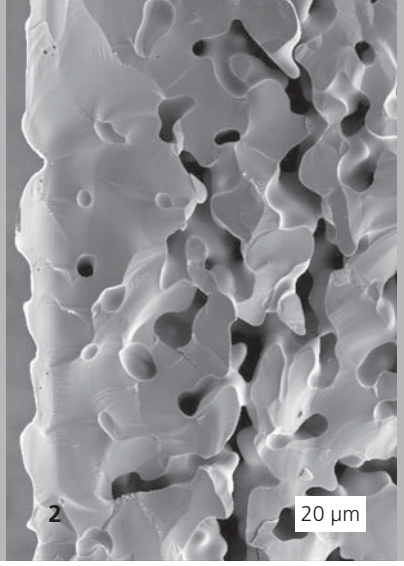

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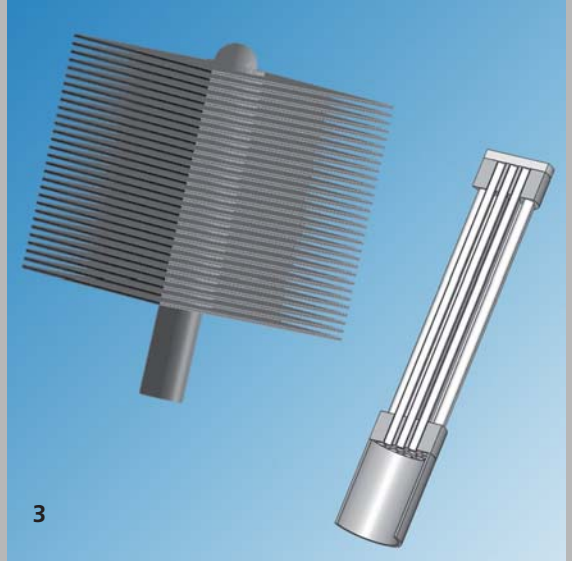

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DESIGN AND PREPARATION OF MEMBRANE COMPONENTS FOR OXYGEN PRODUCTION

Dr. Ralf Kriegel, Dr. Matthias Schulz

Oxygen permeable ceramic membranes

By using oxygen for combustion processes it is possible to save primary energy and to reduce CO_2 emissions. The combustion with pure oxygen ("oxyfuel") makes it easy to separate CO_2. Oxygen separation with the help of mixed conducting ceramic membranes at high temperature is a promising alternative to cryogenic air distillation and pressure swing adsorption because of its lower energy demand. However, for transferring this technology to industry applications, it is necessary to reduce the membrane costs significantly and thus to further develop the single channel membrane tubes available at Fraunhofer IKTS (figure 1).

Increase of oxygen permeation

An increase of O_2 permeation results in a reduction of capital costs as well as in smaller reaction chambers. At given operational conditions (e. g. for O_2 production using vacuum) and with suitable membrane materials, O_2 permeation can be realized by minimizing the membrane thickness (figure 2) and/or by maximizing the membrane surface building up complex membrane components (figure 3). In both cases, a minimal critical leakage rate must be ensured by an error-free coating process and by a gas-tight joining of single parts. The diagram at the lower left corner of page 45 shows the O_2 flux experimentally determined as well as the O_2 flux normalized to the membrane area for different BSCF membranes ($Ba_{0.5}Sr_{0.5}Co_{0.8}Fe_{0.2}O_{3-\delta}$). Highest flux is observed for an asymmetric membrane tube, but thin-walled capillaries also provide higher fluxes than a monolithic membrane tube with 1.5 mm membrane thickness. The weakening of the flux curve at higher driving forces is caused by pressure drops inside the evacuated capillary. This seems to be uncritical since an energy-efficient operation is limited to driving forces below 1 in most cases.

Evaluation of mechanical stress

Oxygen production driven by pressure differences between feed and permeate is always entailed by mechanical stress but only the maximal level of tensile stress is critical for ceramics. Tensile stress in tubular membranes with overpressure at the outside only occurs if the roundness varies. Flat membranes, however, are always under tensile stress. The maximal tensile stress grows for flat membranes with increasing distance of the supporting props. Correspondingly, a channel width of 1 mm seems to be critical. Additionally, chemical stress is induced by crystal lattice expansion increasing with decreasing oxygen partial pressure. In general, chemical stress dominates the whole stress situation. The diagram on the right shows the oxygen stoichiometry at the membrane surfaces and the calculated maximum tensile stress for tubular and flat membranes in dependence of the feed pressure. Also in this case, tubular membranes obviously show significant lower tensile stresses. So, a longer life-time can be expected.

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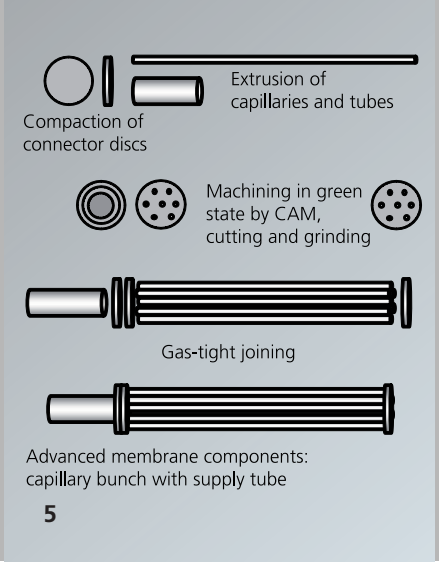

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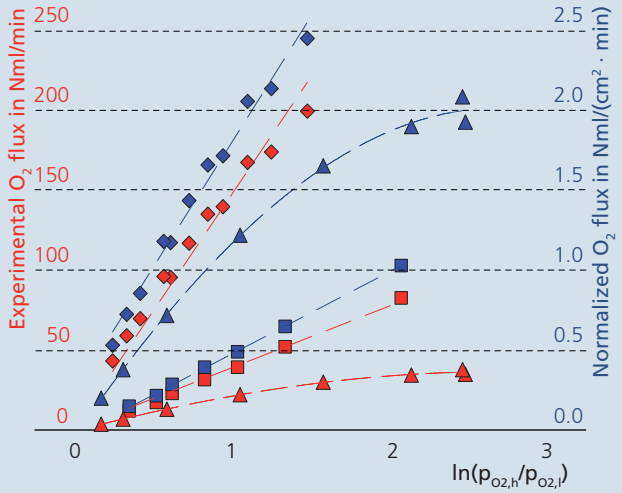
Economic efficiency and realization

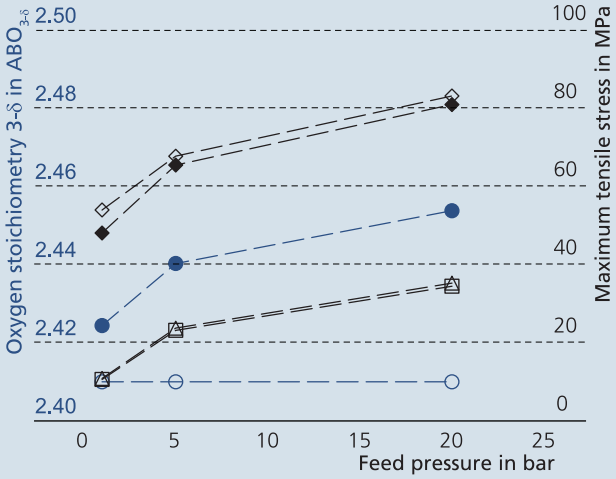
In order to evaluate the economic efficiency of the different membrane components, the costs for the production of 10,000 m² membrane surface, the O_2 flux as well as the size of the reaction chamber were calculated for the determined operating conditions. More than 50 % of the total costs were caused by the raw material for this preliminary stage of a series production. According to that, significant economic advantages were obtained for capillary bunches because of the reduced material quantities. Assuming an operating life time of five years, the total production costs were related to the amount of oxygen produced per year. In this case, capital costs of 7 €/t O_2 were obtained for the capillary bunches, 50 €/t O_2 for single channel membrane tubes, and 30 €/t O_2 for planar stacks. Because of the versatile advantages of capillary bunches or multichannel tubes ceramic parts were prepared (figure 4). In addition, machining and joining procedures were developed (figure 5) and first membrane components (figure 6) were realized. The O_2 permeation of the capillary bunches experimentally determined agrees well with the prediction.

Oxygen flux of BSCF membranes in dependence of driving force



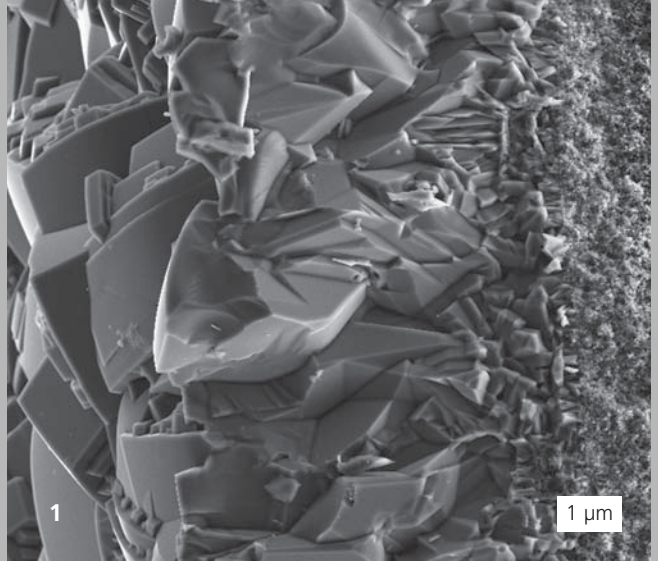
□ Membrane tube, OD: 14.2 mm, wall thickness: 1.5 mm
△ Capillary, OD: 3.2 mm, wall thickness: 0.25 mm
◇ Asymmetric membrane tube, OD: 14.4 mm, wall thickness: 1.4 mm, separation layer thickness: 0.04 mm

Oxygen stoichiometry at the membrane surfaces and resulting chemically induced tensile stress



□ Membrane tube, OD: 10 mm, wall thickness: 1 mm
△ Capillary, OD: 3.5 mm, wall thickness: 0.25 mm
◆ Flat membrane, wall thickness: 0.5 mm, prop distance (filled): 3 mm, prop distance (open): 10 mm
● O stoichiometry at feed side (filled) and permeate side (open)

1 *Extrusion of single channel membrane tubes.*
2 *Cross section of an asymmetric BSCF membrane.*
3 *CAD draft: stack of planar cells, capillary bunch.*
4 *Tubes, capillaries, capillary bunch, supply tube.*
5 *Structure of membrane components.*
6 *Bunch made of seven capillaries with supply tube.*



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CONCENTRATION OF ALCOHOLS USING HYDROPHOBIC MEMBRANES

Dr. Marcus Weyd, Dr. Hannes Richter, Dipl-Ing. Oliver Tröber

Alcohols derived by fermentation of renewables are an important alternative and supplement to fossil fuels. The carbon dioxide released during the fermentation process and the use of the alcohol was bond during the growth of the plant. Besides ethanol, which is used as additive to fuels, butanol is of rising interest in the field of fuels because its properties better come together with established fuels and their infrastructure. Butanol has a higher caloric value as compared to ethanol and is miscible with gasoline in any proportion. Furthermore, it is the only biofuel that can be added to kerosene. It is a drawback of butanol fermentation that the concentration which can be achieved by fermentation is much lower as compared to ethanol fermentation. Optimized production processes are important for an ecological and economical application of these alternative fuels.

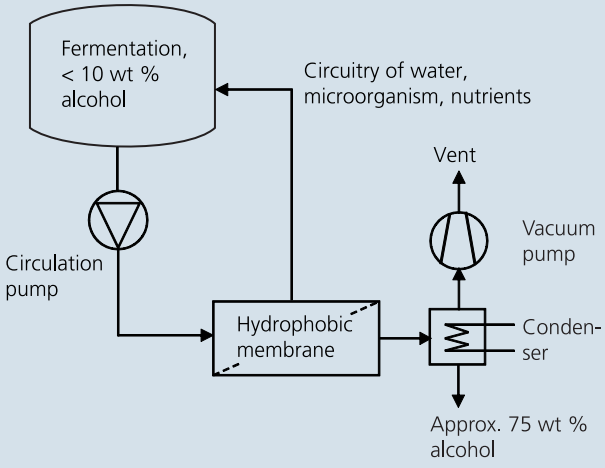
The concentration and dewatering of alcohols, in particular, are energy consuming and cost intensive. For this application, nanoporous membranes are an interesting alternative to conventional separation processes. At Fraunhofer IKTS, ceramic membranes for the efficient dewatering of solvents (e.g. ethanol) above the azeotropic composition were developed. These membranes are applied in ethanol dewatering on industrial scale.

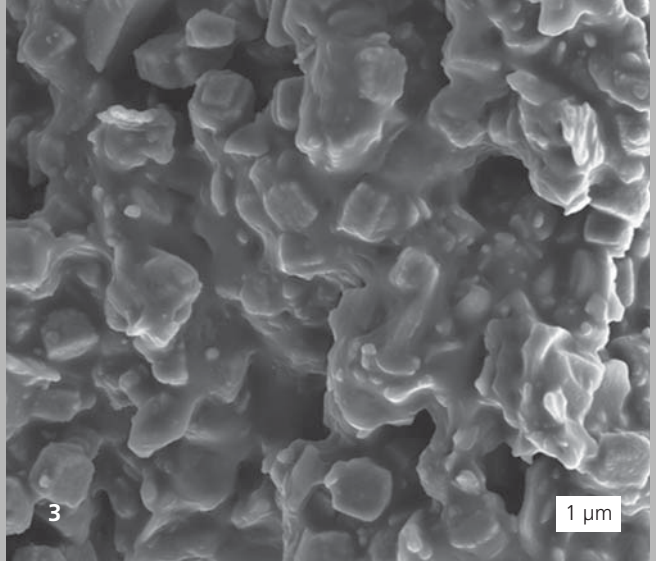
Membranes that are capable to selectively extract alcohols from aqueous solution by pervaporation are in the focus of current research. This process works at the fermentation temperature in order to recycle the retained components of fermentation and to save thermal energy as compared to conventional distillation.

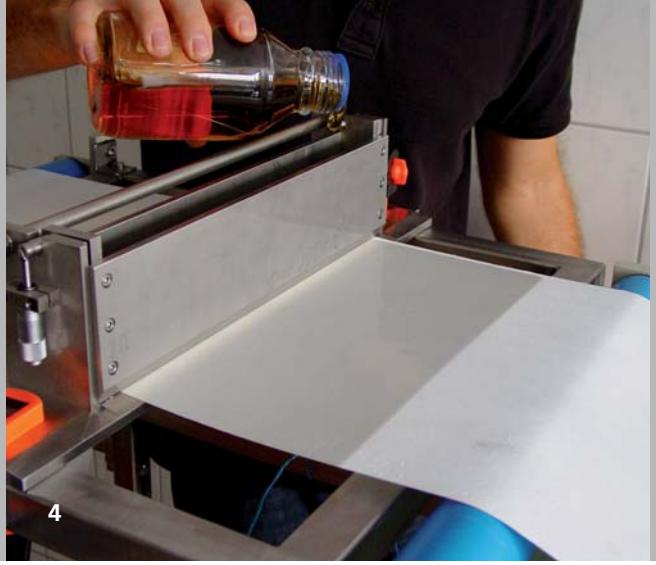
This process is of special interest when only low concentrations of alcohols are obtained by fermentation, so for example in the production of second generation biofuels and butanol.

The enrichment of alcohols from fermentation is very demanding in terms of membrane performance. So, the alcohol molecules are bigger than the water molecules that means a "sieving on a microscopic level" is not possible. Furthermore, the multi-component mixture of the fermentation broth leads to a high risk of membrane fouling. For this reason, Fraunhofer IKTS pursues two strategies: the development of pure inorganic zeolite membranes as well as the development of mixed matrix membranes where zeolite particles are embedded into a polymeric matrix.

Schematical illustration of alcohol enrichment by hydrophobic membranes



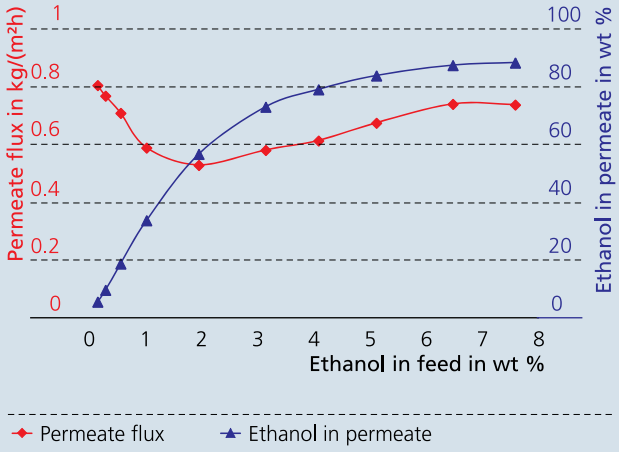




Both membrane configurations have specific advantages. So, inorganic zeolite membranes show higher fluxes and selectivities, and have a tubular shape with optimal fluid properties. With mixed matrix membranes large specific membrane areas can be realized. Additionally, their production is more cost-efficient. The zeolite membranes can be coated with additional layers in order to improve anti-fouling properties. In comparison, the properties of the mixed matrix membrane surface can be influenced by the selection of the polymer.

Pervaporation tests with binary mixtures were performed. At a feed temperature of 40°C the developed zeolite membranes showed permeate fluxes of about 0.8 kg/(m²h) and highest selectivities. So, 80 % ethanol can be extracted from a feed mixture of 5 % ethanol within one membrane step. Using mixed matrix membranes, up to 55 % ethanol was achieved. In case of butanol, 45 % butanol was extracted within one membrane step from an aqueous mixture of only 1.4 % butanol. The zeolite membranes as well as the mixed matrix membranes are suited to enrich alcohols from low concentrated mixtures even at low temperatures.

Enrichment of ethanol with a hydrophobic zeolite membrane at 40°C



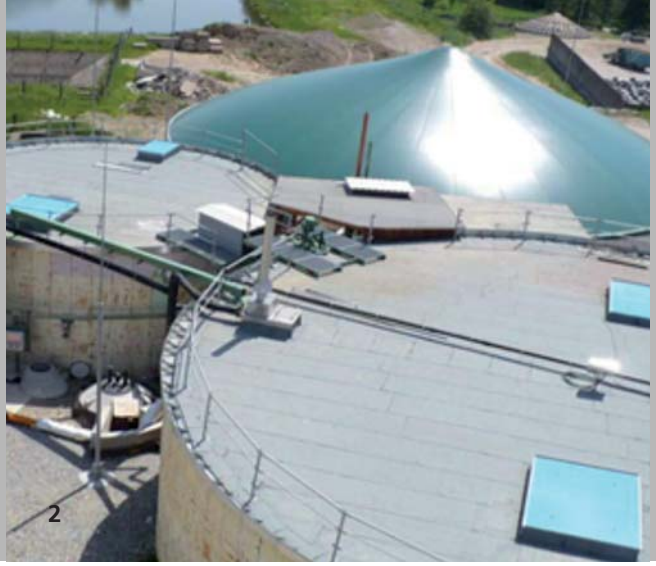
Acknowledgments

The Federal Ministry of Food, Agriculture and Consumer Protection, the Federal Ministry of Economics and Technology (22006508 and MF090032) as well as GFT Membrane Systems GmbH are gratefully acknowledged for their financial support.

Services offered

- Customer-specific testing of membranes
- Application-oriented membrane development
- Engineering, construction and equipment of membrane (test) plants
- Supply of membrane prototypes

1 *Cross section of a zeolite membrane (SEM).*
2 *Ceramic supporting tubes for zeolite membranes.*
3 *Cross section of a mixed matrix membrane (SEM).*
4 *Coating of mixed matrix membranes on pilot scale.*



BIOENERGY APPLICATION CENTER PÖHL

Dr. Eberhard Friedrich, Dr. Karin Jobst, Dipl.-Ing. André Wufka

The operation and construction of biogas plants have to meet increasing demands to stabilize and strengthen their position among future energy supply systems. Taking substrates and residues into account that have not been economically usable so far, can help to reduce the competition in biomass supply. Furthermore, it is the aim of current developments to additionally reduce the greenhouse gas potential. This includes the steady increase of efficiency of the biogas technology, an increase of the utilization rates of the substrates, the reliability and availability of equipment, and the improvement of process stability by adapted process control. New reactor designs and better materials as well as adapted energy-efficient stirring systems allow for a significant improvement of biogas technology.

Within this context, Fraunhofer IKTS is working successfully in several joint projects together with regional SMEs. These projects are funded by the EU, the Free State of Saxony, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) as well as the Federal Ministry of Education and Research (BMBF). The results of these projects are ready for testing on pilot scale. For this purpose, Fraunhofer IKTS founded the Bioenergy Application Center Pöhl at the beginning of 2011. It is located near the demonstration biogas plant (500 kW) of LEHMANN Maschinenbau GmbH.

With the establishment of the Bioenergy Application Center, Fraunhofer IKTS is able to run its fully automated pilot biogas plant for process and product testing. This is combined with extensive experiences and comprehensive skills of LEHMANN Maschinenbau GmbH in the field of design and manufacture of equipment and systems for biogas technology. Thus, the chain from research and development to design and manufacture was closed. With the retransfer of knowledge from large-scale long-term processes, new ideas and projects can be created for the benefit of our customers.

Technical equipment

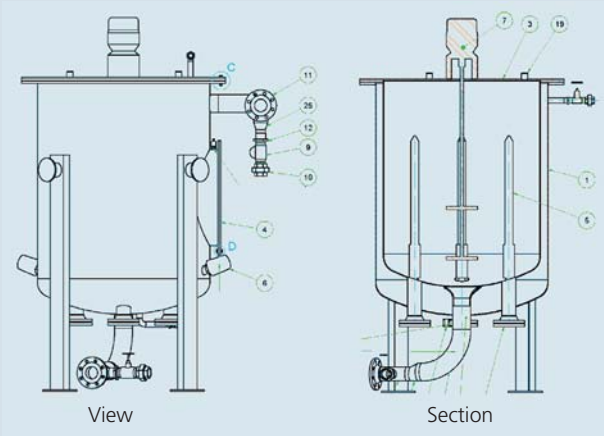
Equipment in the Bioenergy Application Center under the responsibility of Fraunhofer IKTS:

- Container for substrate pretreatment (technical equipment for deconservation as well as a twin-screw extruder incl. measurement and control technology)
- 3-stage pilot biogas plant (hydrolysis, two fermenters each 5 m³)
- Two fermenters incl. stirring systems (each 1 m³) for evaluation of mixing processes
- Reactors for gas purification and desulphurization
- Ultrasonic reactor for degasification of digestate
- Planned: biotechnical laboratory incl. analytics as well as membrane technology for accumulation of methane in the biogas

Priority tasks

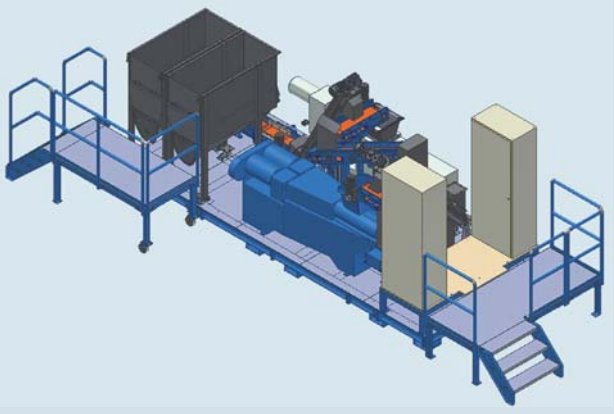
The Bioenergy Application Center offers best conditions to demonstrate the mechanisms and opertional results in the direct application. Recent R&D results are annually presented on conferences on site. The organization of thematic trainings for

Developed reactor for degasification of digestate from biogas plants by means of high-power ultrasound



View Section

Designed and produced multi-stage substrate pre-treatment system based on the developed DECONDIS® method



Services offered

- Analysis and evaluation of gas and tail gas potentials of substrates and biogenic residues as well as nutrient and trace elements application in digestion processes
- Design of digestion processes including regional substrate sources as well as special solutions; proof of profitability
- Cooperation and support for design, implementation and approval of plants and systems
- Technical and scientific monitoring of increased performance of installed biogas plants
- Development and implementation of special solutions in the field of gas purification and digester effluent treatment

planners of biogas plants, institutions and specialized agencies are also carried out. In the same context national and international conferences are planned at Fraunhofer IKTS. The Bioenergy Application Center offers best prospects for qualification of young scientists and engineers in the field of future technologies. On the one hand, young academics are promoted and on the other hand new jobs are created.

1 *Pilot biogas plant.*
2 *Demonstration plant of 500 kW.*
3 *Wheat straw – agricultural residue with high energy potential.*
4 *Wheat straw – different states of particle size reduction.*

RESEARCH FIELD SINTERING AND CHARACTERIZATION

Department head:
Dr. habil. Mathias Herrmann

Profile

Extensive sintering and analysis know-how in this research field is concentrated at both the Hermsdorf and the Dresden location. With diverse characterization methods, thermodynamic and kinetic modeling, and extensive furnace equipment from the laboratory to the pilot scale as a basis, targeted development of materials, components, and processes is possible.

Existing methods range from particle and suspension characterization and ceramographic sample preparation using conventional and ion beam-based techniques to quantitative phase and microstructural analysis. In addition, a wide range of thermoanalytical and thermophysical characterization techniques and methods for tribological, mechanical, and electrical characterization are available. Mastery of these sophisticated analytical methods is coupled to detailed process know-how as well as materials and scientific knowledge, enabling well-founded interpretation of results.

We also test electrical devices and equipment in accordance with national and international standards as well as customer-specific requirements and possess a wide range of possibilities for environmental simulation and calibration of measurement systems.

Services offered

Development projects and individual contracts for characterization of powder metallurgical and ceramic feedstocks and materials as well as for heat treatment of materials and components:

- Particle characterization from micro- to nanoscale
- Application-specific suspension characterization for all concentrations
- Determination of thermoanalytical and thermophysical characteristics
- Investigation of sintering behavior of materials and components
- Design, execution, and optimization of heat treatments, including scale-up to industrial scale
- Characterization of materials and components in terms of microstructure, phase composition, and mechanical and tribological properties
- Testing of electrical devices and equipment (CE and GS marks, in cooperation with TÜV and VDE)
- Simulation of environmental effects (temperature, climate, mechanical loads, corrosion)
- Component failure analysis and consulting on use of ceramic materials
- Calibration of measuring devices (length, temperature, electrical measurement parameters)
- Consulting on quality and environmental management systems

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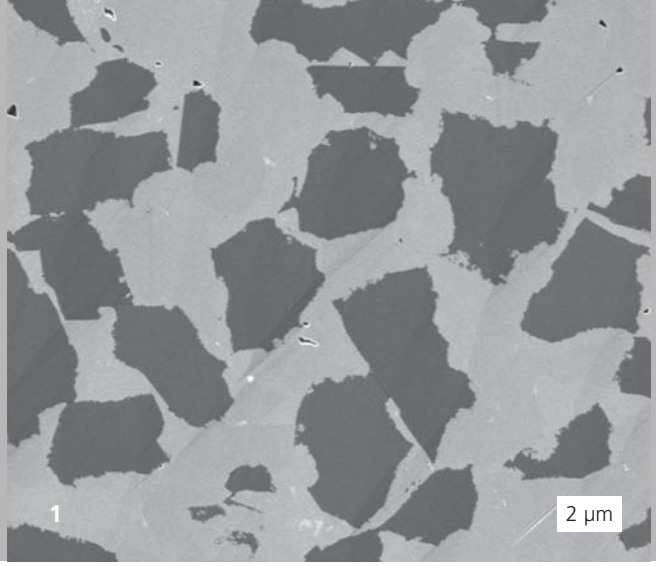

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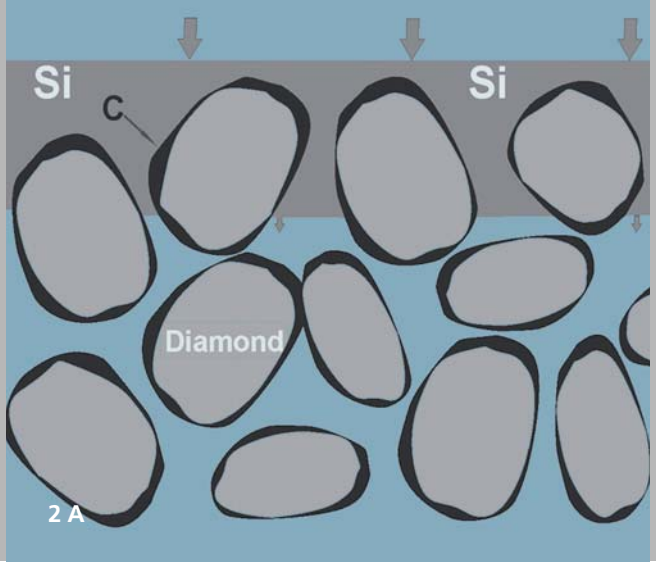


2 A

SUPERHARD SIC-DIAMOND CERAMICS

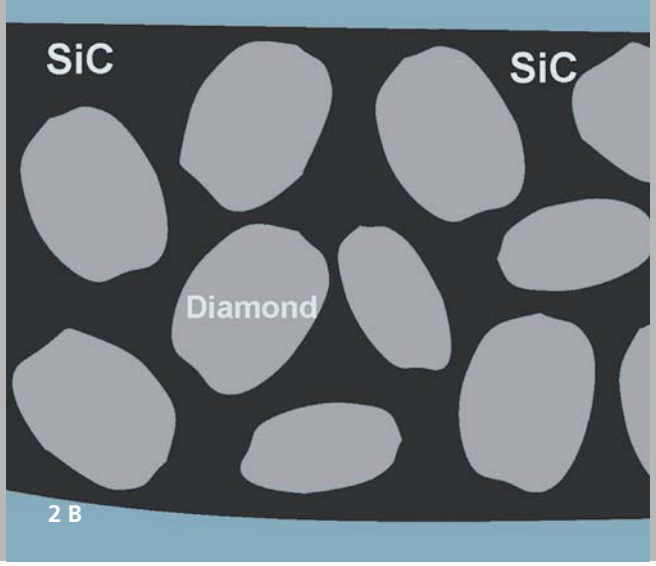
Dr. habil. Mathias Herrmann, Dipl.-Ing. Björn Matthey

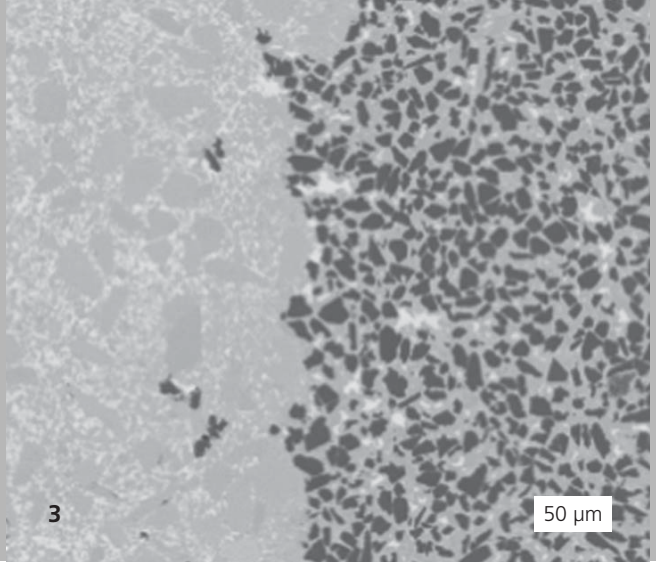
Diamond coatings or polycrystalline diamond (PCD) materials are used in cutting materials, rock drills, sensor windows, and other applications in which high hardness and chemical resistance are paramount. However, their use is limited by the high cost and size restrictions associated with the high-pressure process needed to produce them. CVD diamond coatings for ceramics were recently developed for mechanical seals in cooperation with Fraunhofer IKTS (DiaCer©) [1] and successfully introduced to the market as Diamondfaces© by EagleBurgmann Germany GmbH & Co. KG [2]. These materials also have drawbacks, namely, the lengthiness of the coating process (> 10 to 20 h) and restrictions on geometry and service life. In addition, CVD diamond coatings quickly reach their limits in abrasive loading conditions (e.g., sandblasting) and applications in which wear of more than several hundreds of microns or millimeters is tolerable.

Hence, alternatives are currently being sought with the most promising one being SiC-bonded diamond. This material contains approx. 90 % diamond and is produced commercially in high-pressure processes for drill bits [3, 4] at a comparable cost to that of traditional PCD materials or with lower diamond content and diamond grain sizes ≥ 10 µm at ambient pressure. At Fraunhofer IKTS, a fundamentally new solution for cost-effective production of diamond materials has been developed [5]. The diamond-SiC material is based on a graded composite with a SiSiC substrate and a 1- to 3-mm-thick SiC-bonded diamond coating (with a diamond content of 30 to 50 vol %) as a wear surface. The diamond particles are bonded to the SiC matrix through infiltration of the graded substrate material formed from SiC and diamond powder with silicon. The silicon reacts with the diamond and the binder used for shaping to form SiC with no change in component dimensions, thus enabling high diamond contents and a strong bond between the diamond particles and the matrix. Grading of the materials allows for a reduction in raw material and production costs. Use of diamonds with grain sizes of less than 5 to 10 µm yields completely new possibilities for material design.

Current work is focused on developing the technology for materials production and microstructural formation [6] as well as investigating the tribological behavior (interactions with metals and simulation of wear in drawing processes) in collaboration with Fraunhofer IWM in Freiburg. This work also comprises development of methods for microstructural imaging of these superhard materials and quantification of the phases and stresses to form a basis for understanding the relationships between microstructure and properties. The pronounced effect of the graphite layer thickness at the diamond-SiC interface on the hardness and wear properties is illustrated in the diagram on the right. With appropriate adaptation of the production parameters, the graphite layer thickness can be controlled and materials with hardness levels of greater than 47 GPa can be reproducibly produced.

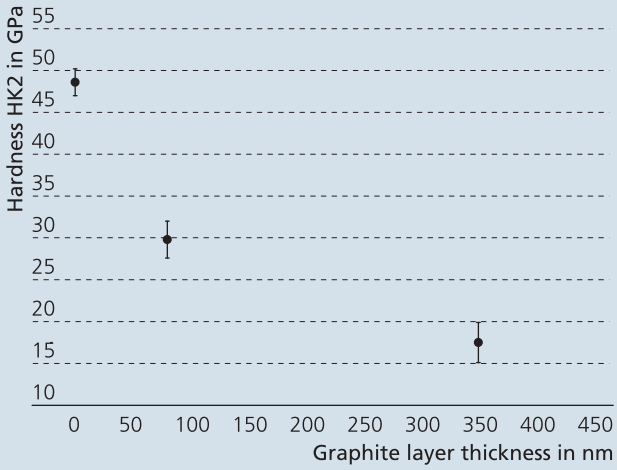
For the investigation of the microstructure new preparation methods had to be developed due to the high wear resistance. These methods can also be used for other materials which are difficult to polish like cBN or PCD materials. They allow a detailed analysis of the interface between the hard component and the matrix or binder.





Even if cost-effectiveness and diamonds seem to be mutually exclusive, the low current price of diamond powders (less than 1€/g), the availability of an effective production technology, and a service life ten times higher than that of conventional ceramic- or hard metal-based solutions enable cost-effective production of components based on these materials. Interested industry partners are invited to participate in the upcoming preliminary testing of samples and prototypes in application conditions.

Dependence of hardness (HK2) from diamond layer thickness at the interface diamond/SiC



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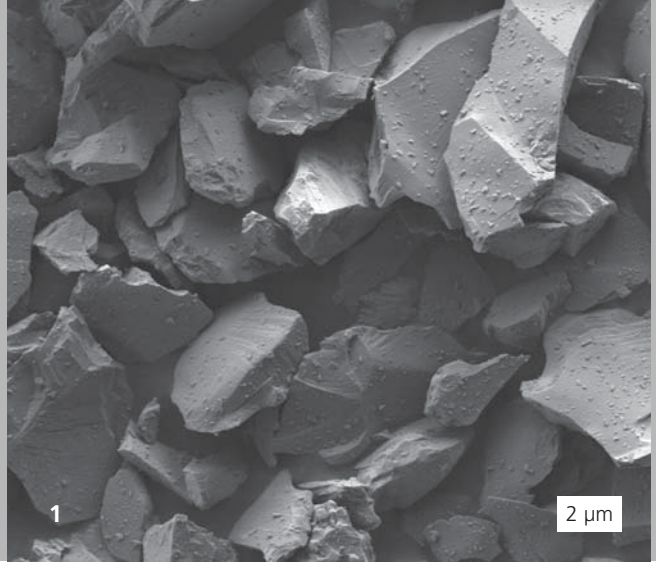
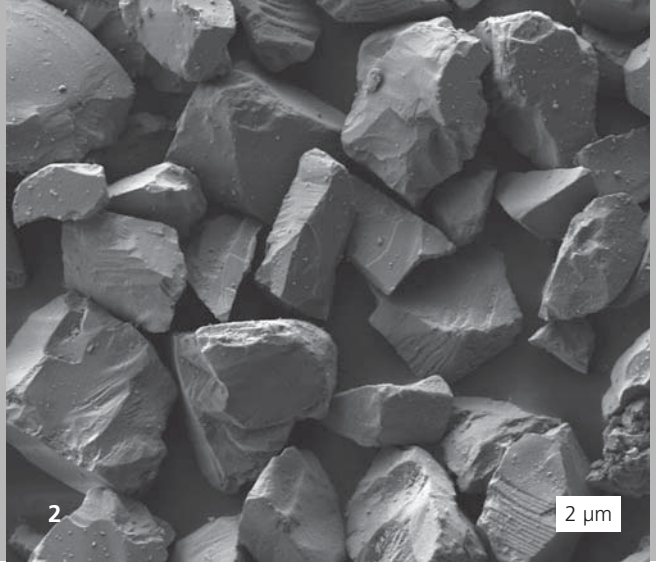
[3] P. N. Tomlinson, et al. , IDR., 6, (1985)299-304
[4] ScD Werbeblatt elementsix (2010)
[5] M. Herrmann, H. P. Martin, DE 10 2007063517 B3
[6] M. Herrmann, B. Matthey, S. Höhn, I. Kinski et al. Diamond-ceramics composites – New materials for a wide range of challenging applications; J. Europ. Ceram. Soc. (online verfügbar)

1 *Microstructure of SiC-diamond ceramics (dark diamond, grey SiC).*
2 *Schematic of material formation.*
A Preform with starting silicon infiltration.
B Structure of diamond layer after infiltration.
3 *Microstructure of material compound.*



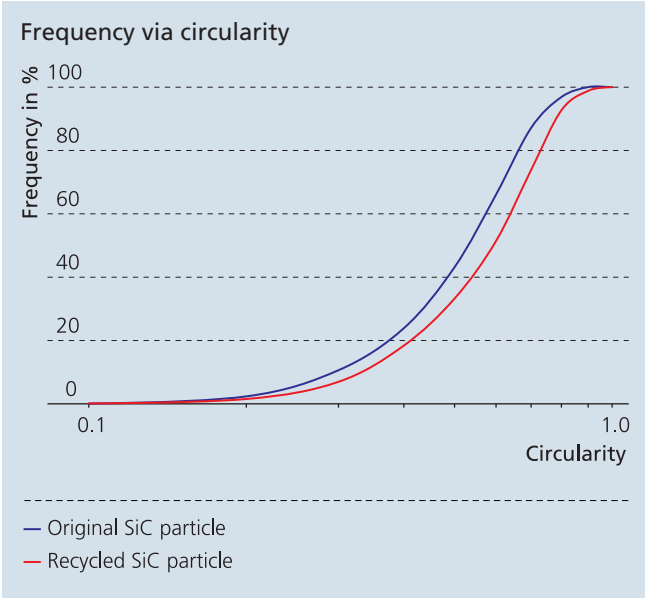


WAFER CUTTING, ABRASIVE FLOW MACHINING – ABRASIVE PARTICLES IN SUSPENSIONS

Dr. Annegret Potthoff, Dipl.-Ing. Sören Höhn

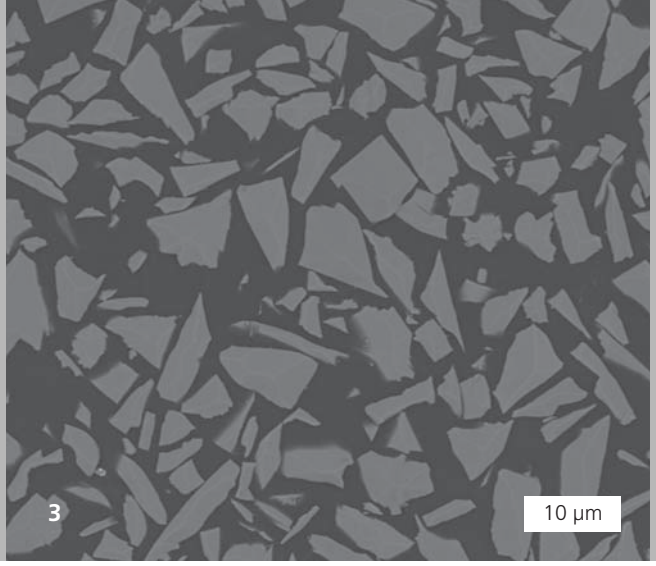
For the accurate and energy-efficient finishing of high-performance elements, technologies such as abrasive flow machining or water jet cutting are used. Silicon wafers as essential components of semiconductor and photovoltaic industries are cut from silicon ingots using wire saws. The efficiency of all these processes is mainly determined by the properties of the used suspensions.

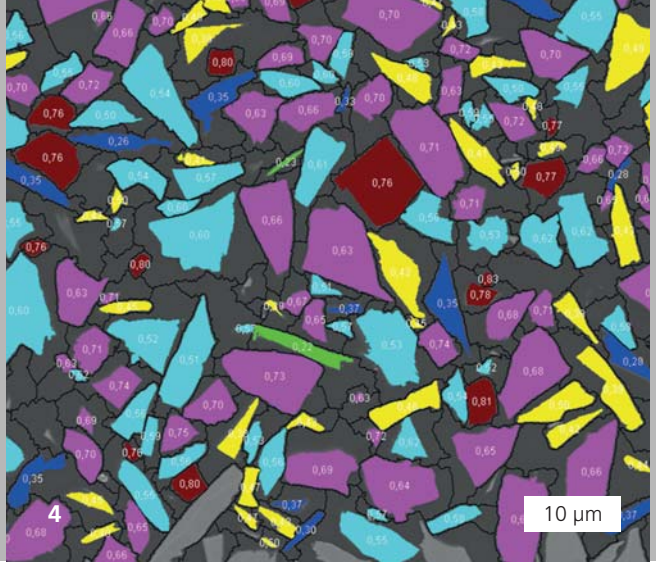
Silicon or boron carbides are commonly used as abrasive particles in grinding or sawing suspensions. The original particle sizes range from below 5 µm up to 500 µm. Whereas the size can be defined by sampling of raw materials, surface texture and particle shape are determined by the manufacturing process, and thus, their adjustment is limited. All parameters have in common that they vary during the finishing process. Therefore, relevant particle properties have to be ideally determined by offline and online analysis.



For the analysis of particle shapes, an image evaluation method was developed. Using this method, differences which cannot be recognized visually but are potentially relevant for the application can be reliably detected (figures 1 and 2). The processing steps of "embedding of sample – sample preparation by grinding and polishing – ion-beam preparation with edge sharpness – image acquisition with high resolution – detection of particles by gray-scale analysis – quantification of particles using software for image evaluation" are tools to analyze particles of all sizes (figures 3 and 4). It can be proved by measurements that particles which have been subjected to mechanical stress and recycled afterwards differ in particle shape parameters according to ISO/DIS 9276-6 such as circularity or aspect ratio.

The static image analysis provides the advantage of a very good sensitivity but the efforts for sample preparation are very high. In contrast, the dynamic image analysis is characterized by easy sample preparation and very good statistics, i.e. a large quantity of particles can be analyzed in short measurement times. Measurement systems which can also partly be used online are avaiable for coarser particles. In order to realize the analysis of finer materials (e.g. F800 grain size after application) further research and development is needed.
The properties of SiC or B_4C particles in the suspension fluid during the application significantly determine the efficiency of the process. Therefore, this aspect is also subject of current re-





search. Conclusions about the electrostatic stability and thus the agglomeration behavior of particles in fluids can be drawn from the results of surface charge measurements. Reactions at particle surfaces which are induced due to contaminations during the process or due to the (partial) formation of an oxide layer can be detected indirectly. The flow behavior of the suspension is not only determined by solid concentration and temperature but also by steric effects which can be caused, for example, by the formation of amorphous oxide compounds.

The complex characterization of particles, dissolved materials and fluids (water, organic solvents) in suspensions establishes new possibilities for the optimization of various processes such as wafer cutting, abrasive flow machining or water jet cutting. The results provide a basis for particle-based simulations. It is the aim of the joint project "AbraSus" of Fraunhofer IWM, IKTS and IPK to better understand processes by combining experimental methods and multiscale modeling.

Services offered

- Application-specific evaluation of (abrasive) particles
- Characterization of particle shapes in the nanometer and millimeter range
- Analysis of particle properties in aqueous and organic suspensions by surface charge measurements, sedimentation analysis and rheological measurements

1 *Original SiC particle.*
2 *Recycled SiC particle.*
3 *SiC sample after preparation.*
4 *Classification of particles according to a particle shape parameter.*

RESEARCH FIELD ENERGY SYSTEMS

Department heads:
Dr. Mihails Kusnezoff
Dr. Matthias Jahn
Dr. Christian Wunderlich

DEPARTMENT

MATERIALS AND COMPONENTS

Profile

The "Materials and Components" department is involved in the development and preparation of functional ceramic materials and their application in functional elements. Traditional fields are thick film technology, glass development, high-temperature fuel cells (SOFCs), and high-temperature chemical sensors. Extensive experience and outstanding technical equipment allow complex requirements and interactions in sophisticated applications such as fuel cells, lithium ion batteries and supercaps, sensors, microsystems, and packaging in complex materials systems to be controlled. At the Dresden institute branch, screen printing pastes, inks, and slurries are developed to be used in electrochemical components and microsystems.

Materials development in combination with different coating methods – especially for applications in electrochemistry and joining technology – form the basis for the development of new components (SOFC/SOEC, thermoelectric generators, sensors).

Close meshing with the "Modules and Systems" and "Industrialization Systems" departments ensures the practical relevance of the results. This allows us to give our customers attractive offers for materials, prototypes, and services along the entire process chain.

Services offered

- Development and preparation of pastes for screen printing, dispensing and roll coating as well as their pilot plant production
- Development and preparation of nanoinks for ink-jet and aerosol jet printing
- Development and preparation of sealing glasses and elements as well as solders
- Glass development for specific applications
- Development of electrode materials and coatings for lithium ion batteries and supercaps
- Testing and inspection capacity for materials and functional high-temperature components for gas sensors, SOFC/SOEC and thermoelectric generators
- Development, manufacture, and testing of SOFC stacks
- Packaging for ceramic systems
- Consulting and materials analysis

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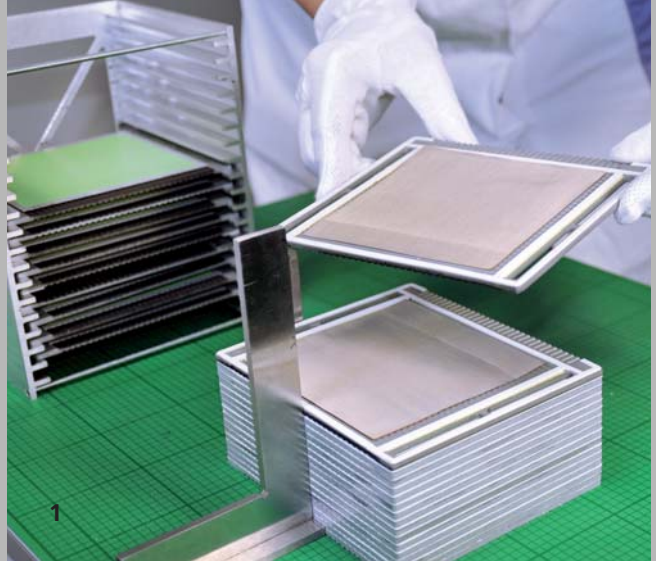

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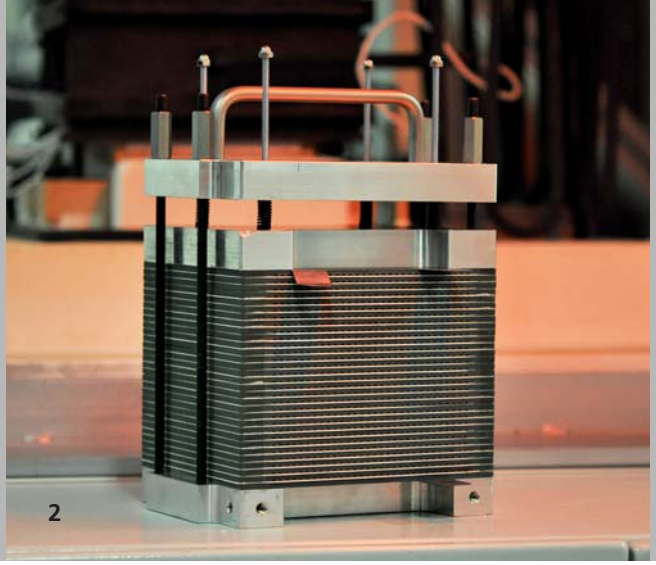

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CFY STACKS: TECHNOLOGY FOR ROBUST SYSTEMS

Dr. Stefan Megel, Dr. Mihails Kusnezoff

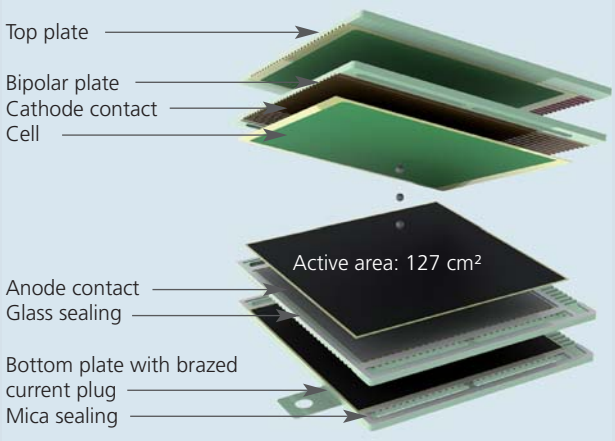
By means of long-term stable and robust solid oxide fuel cell stacks (SOFC), stationary power supply systems can be built up in modular design and controlled with minimum sensing. Planar SOFC stacks are characterized by high energy density and high electric efficiency. Using electrolyte supported cells made from fully stabilized zirconium dioxide (10ScSZ), power densities > 500 mW/cm² can be reached. On account of the thermomechanical properties of these cells, the high performance potential can only be used in stacks with CFY interconnects (Cr5Fe1Y material of Plansee SE).

The newly developed MK351 stack design consists of only a few component parts and allows for a simple and automated assembly (diagram on the right). The stack is built up from components which are either commercially available or produced in pilot scale and supplied by industry partners. The interconnects having dimensions of 130 x 150 mm are the largest interconnects that are currently manufactured by a powder metallurgical route worldwide. Within the framework of a joint development program, Plansee SE supplies these interconnects with an integrated protection layer. In collaboration with SCHOTT Electronic Packaging GmbH, the glasses for stack production are developed. The quality specifications of the part components (cells, interconnects, glass sealings) which are essential and important for stack production are determined at Fraunhofer IKTS. The tolerance chain suitably selected for all stack components guarantees for high yield, even for manual production. All stack components withstand high temperatures, temperature cycling and repeated oxidation and subsequent reduction at the gas side (redox test) under relevant operating conditions. Different studies at test samples are performed to support materials development for protective and contact layers as well as glass sealings. Joining is one main aspect of stack manufacture. For this reason, a joining apparatus was developed where joining and activation process as well as quality control of the stacks (figure 3) are automated.

The produced stacks are integrated in hot boxes for lifetime tests and thermal cycling so that simple interfaces and standardized practice-relevant testing procedures for system integration can be established. Currently, the performance degradation of a 30-cell stack (performance > 800 W) integrated in a hot box is < 1.5%/1000 h.

Performance degradation in stacks is caused by different effects: (i) formation of an oxide layer on the cathode side of the interconnect, (ii) degradation of cell performance, (iii) defects

Exploded diagram of a MK351 stack



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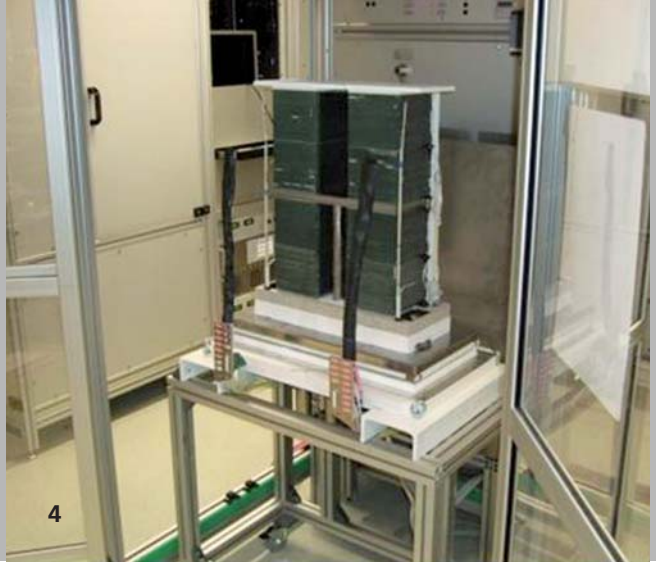

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in cell or glass sealing, and (iv) reduction of contact surfaces between cell and bipolar plate. At low absolute stack resistances in particular, small degradation effects become visible. The degradation aspect is studied within the framework of a comprehensive research program including material tests, analysis of stack failure and effects of operational conditions. Long-term degradation is to be reduced by newly developed protective layers in the future.

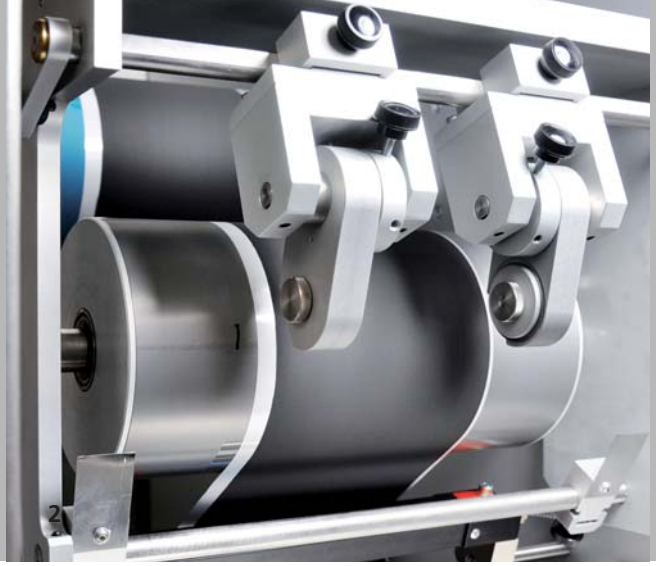
Stability against cyclic loading (thermal and redox cycles), in particular, is a challenge for solid oxide fuel cells. The use of a stable ceramic substrate and a thin anode layer makes it possible that the stack withstands air flush to the fuel side without total failure although nickel is oxidized in the anode. Thus, the stacks can be heated up and cooled for several times without feeding protective gases. A minimum performance loss of < 1 % was measured after 20 thermal cycles without gas supply. By studying the thermal cycles and the varying reduction and oxidation of the anode (redox test), the degradation can be referred to the change in the anode and its bonding, and degradation could be reduced.

A CFY stack with 30 cells was successfully integrated into a system developed at Fraunhofer IKTS for converting biogas into electricity. Together with partners from Plansee SE, AVL List GmbH, SCHOTT Electronic Packaging GmbH and Forschungszentrum Jülich a demonstration system with an electric power of > 5000 W is under development based on this stack design. The system is powered with natural gas and has an electrical efficiency of > 50 % (figure 4). This prototype is to pave the way to large SOFC systems.

Services offered

- Testing of SOFC stack components: determination of suitability and durability under real SOFC operating conditions
- Stack integration into modules
- Supply of SOFC stacks or stack modules in the power range between 0.5 to 10 kW_{el}

1 *Assembly of a 30-cell stack.*
2 *Joined 30-cell stack.*
3 *Joining apparatus.*
4 *Stack module made of eight 30-cell stacks.*



SCALEABLE ELECTRODE MANUFACTURING TECHNOLOGY FOR SUPERCAPS

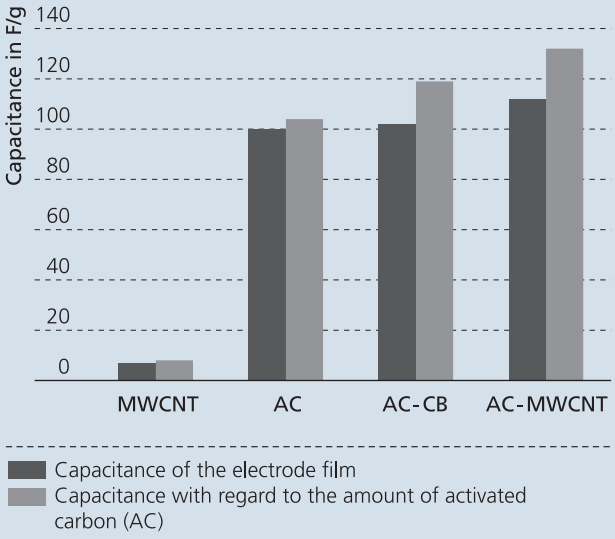
Dr. Marco Fritsch, Dr. Mihails Kusnezoff, Dr. Michael Schneider, M. Sc. Mathias Weiser

Electrical energy storage systems play a crucial role in future energy supply concepts. Supercaps comprise a group of high-performance capacitors such as electric double layer capacitor (EDLC), pseudo capacitor or hybrid capacitor. They are characterized by high power densities, short charge and discharge times and a high cycle life. In combination with lithium ion batteries, there are many interesting applications for mobile and stationary self-sustaining energy storage systems. In order to realize a change in energy policy and the predicted goals of electric mobility, scalable manufacturing technologies for components of supercaps are required.

Common EDLC supercaps store electric energy (capacitance) by forming an electric double layer on the surface of microporous carbons. The production technologies for such activated carbon powders are well advanced worldwide. At Fraunhofer IKTS, functional powders are processed to thin electrode films using material scientific and manufacturing approaches. Ceramic technologies are decisive for the dispersion of powders, preparation of casting slurries and coating of the electrodes in a continuous tape casting process. It is important that the so fabricated electrode film can be passed as a roll on downstream manufacturing processes like calendering or winding of electrode and separator.

The attainable storage capacity and the internal resistance of such a capacitor depend significantly on the electrode microstructure. The electrical contact between the activated carbon powders is of great importance. By integrating conductive nanoparticle powders like carbon black or carbon nanotubes (MWCNT) it was shown that the gravimetric capacity can be increased. The conductive powder shows negligible self-capacitance, but rather electrically isolated regions will be avoided in the electrode microstructure.

Gravimetric capacitance of EDLC films with MWCNT, AC, composite of AC/carbon black and AC/MWCNT (Swagelok® cell)



For CNT containing electrodes a dispersion procedure was developed which separates the nanotubes in the casting slurry and leads to a homogeneous electrode film after the casting process. The coating was applied on both sides of an aluminum collector tape. After densification of the electrodes by calendering, electrochemical tests were performed with Swagelok cells as well as with wound capacitors of 100 farad to evaluate the performance. The time-dependent charge and

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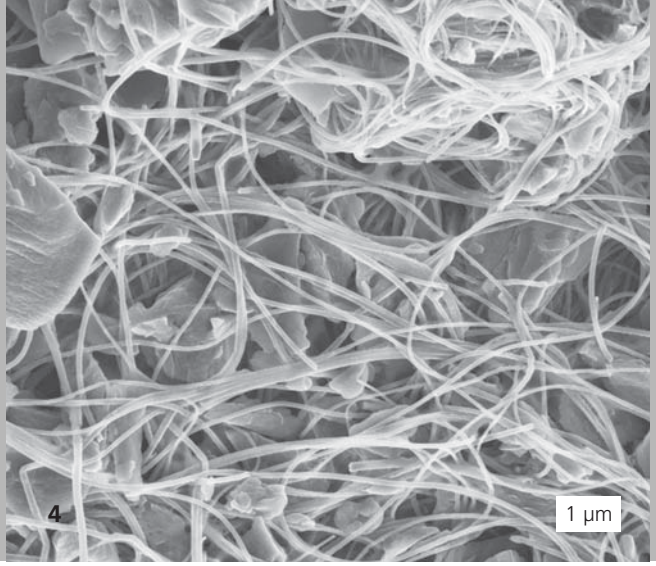

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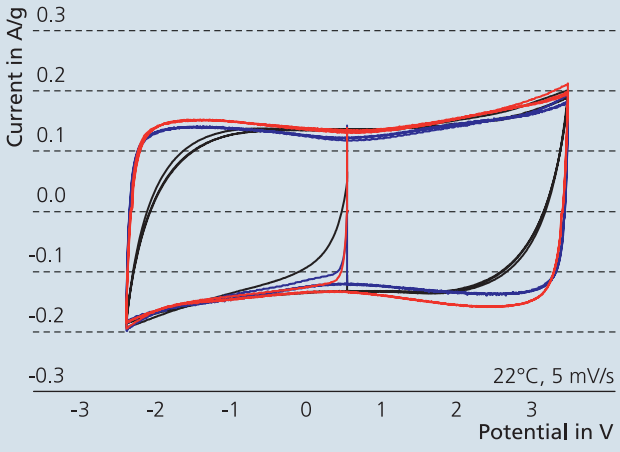
discharge behavior was significantly improved by integrating carbon nanotubes in the electrode microstructure. This was also proved with the help of increased sheet conductivities and a negligible internal resistance of the electrode film in the supercap.

The supercap development attaches importance to the use of environmental and health friendly materials. With substantial market penetration of such supercaps questions of safety, disposal and recycling will come to the fore. For this reason, Fraunhofer IKTS evaluates the use of propylene carbonate instead of acetonitrile based electrolytes. Propylene carbonate electrolytes show significantly higher temperature stability but lower intrinsic conductivity. This leads to an increase of the internal supercap resistance, which can be reduced by using thin separators. In this case, however, high demands on the surface quality of the prepared electrode film must be met as short circuits due to a penetration of surface electrode roughness through the thin separator have to be avoided. Together with industry partners the transfer of such supercap films into capacitor production is currently evaluated.

Cyclic voltammetry of activated carbon based EDLC films (Swagelok® cell)



— Film with activated carbon (AC)
— Film based on a composite of AC and carbon black
— Film based on a composite of AC and MWCNT

Acknowledgments

The German Federal Ministry of Education and Research (BMBF) as well as the project management organization PT Jülich are gratefully acknowledged for their financial support within the "SuperCap" project (03X0076B).

Services offered

- Recipe formulation of slurries and pastes
- Casting technologies for electrode films
- Evaluation of processability and performance of active materials in the manufacturing process
- Microscopic, electrochemical and mechanical characterization of thin electrodes
- Manufacture of electrode films in laboratory scale and upscaling for pilot plant solutions

1 *Tape caster.*
2 *Coating of the electrode.*
3 *Casting slurry.*
4 *Electrode microstructure based on activated carbon and carbon nanotubes.*

RESEARCH FIELD ENERGY SYSTEMS

Department heads:
Dr. Mihails Kusnezoff
Dr. Matthias Jahn
Dr. Christian Wunderlich

DEPARTMENT

MODULES AND SYSTEMS

Profile

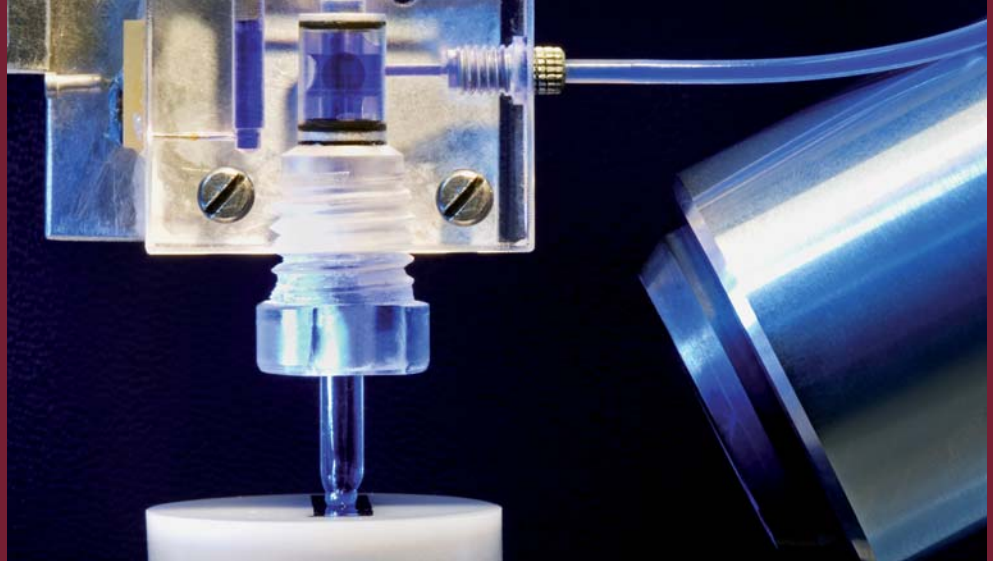
The working groups of the "Modules and Systems" department cover all subareas required for development of energy systems with their defined core research areas. Systems for the efficient provision of electricity and heat are designed, constructed, and tested under realistic conditions. Of essential importance are those systems which utilize high-temperature fuel cells (SOFC) as energy converters for stationary power supply (e.g. micro CHP with P_{el} = 1 kW).

Furthermore, electrode materials for supercaps and batteries for storage of electrical energy are investigated. Apart from the implementation of new materials and manufacturing technologies, their characterization and modeling are additional focal points.

The methodical basis for this is formed by extensive activities in the fields of multiphysics modeling and simulation of applications (SOFC, heterogeneous catalysis and batteries), as well as (spectro)electrochemistry are providing a methodological basis.

Services offered

- Component and system layout
- Simulation of chemical and electrochemical processes and reactors
    - CFD with Ansys/CFX
    - Multiphysics with Matlab, PlexPDE, Comsol and Modellica/Dymola
- Design and construction of systems
- Investigation of reaction processes in test stands and systems
- Catalyst development
- Gas analysis (FID-GC, WLD-GC, PFPD-GC and GC/MS)
- Anodic and galvanic functional layers for dielectrics, photovoltaics, corrosion and wear protection, sensors and fuel cell technology
- Developments for high-throughput screening for applications in chemical and biochemical analysis
- Microelectrochemical and spectrochemical characterization of materials for batteries and capacitors
- Investigations on electrochemical machining (ECM)
- Lifecycle analysis for components and systems



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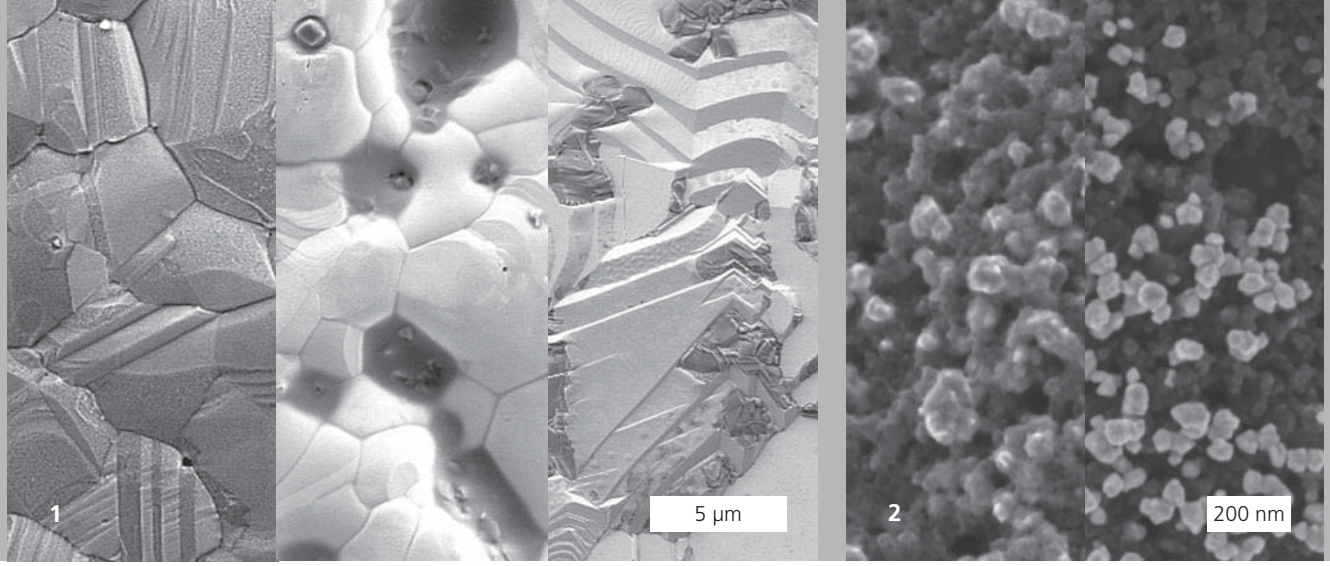


SURFACE MODIFICATION OF ELECTRODES FOR BIOSENSOR APPLICATIONS

Dr. Thomas J. Rabbow, Dipl.-Ing. Uta Gierth, Dr. Michael Schneider

Screen printing and ceramic multilayer technology are an ideal basis for building up cheap sensor systems in large quantities. The chemical inertness of the ceramic material and the easy integration of different functionalities into the sensor system are further advantages of these technologies. Electronic circuits for the analysis of measurement signals or fluidic structures can be integrated into the ceramic component as well as different sensors in a multisensor array for the screening of complex analytic fluids. The modification of the surface of a sensor by electrolytic deposition, electrophoretic layers or chemical attachment of monolayers and polymers offers the possibility to functionalize the sensor for various applications.

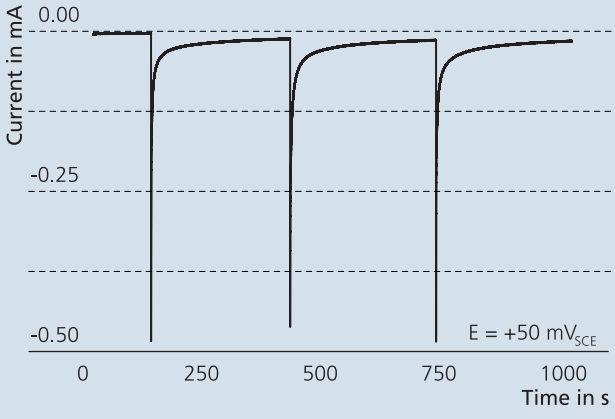
H_2O_2 sensor

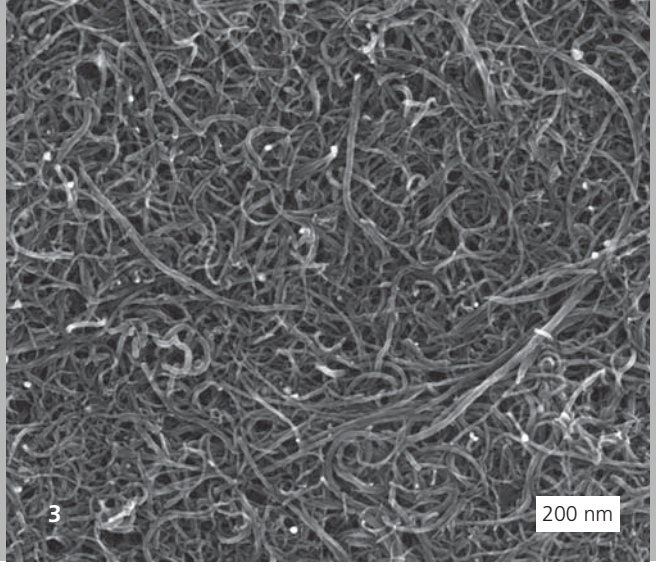
Hydrogen peroxide is a promising biomarker for respiratory gas diagnostics in case of chronic obstructive pulmonary disease. The inorganic semiconductor Prussian blue ($Fe_4^{III}[Fe^{II}(CN)_6]_3$) works as electrocatalyst for the oxidation and reduction of hydrogen peroxide. By an optimized electrochemical deposition of Prussian blue it is possible to detect hydrogen peroxide in the nanomolar range. For this purpose, it is necessary to build an open layer of Prussian blue with a high boundary surface where hydrogen peroxide can be accumulated and react with the electrocatalyst. The sensitivity can be further enhanced by an additional layer of gold nanoparticles being deposited by galvanic pulse plating. Screen printed carbon electrodes, which can be easily integrated into ceramic sensor systems, are very well suited as basis for Prussian blue sensors.

Highly sensitive microelectrodes

Microelectrode arrays for medical applications are developed to analyze with high local resolution and to stimulate biochemical processes in cell tissue and neurocytes. The miniaturization requires highly sensitive single microelectrodes in order to integrate a high number of sensor elements. The electrophoretic deposition with chemically modified carbon nanotubes makes it possible to significantly increase the electrochemically active sensor surface of the microelectrodes. Alternatively, modified carbon nanotubes can be molecularly attached on monolayers on the sensors.

Prussian blue sensor:
Amperometric detection of 250 nanomol H_2O_2





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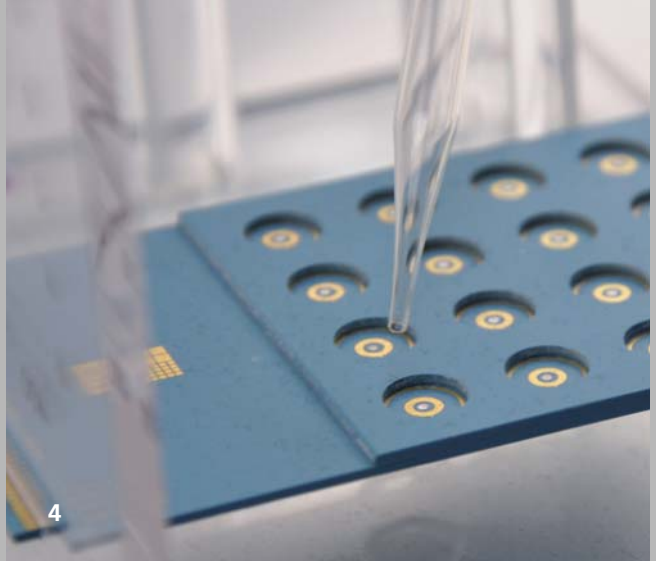

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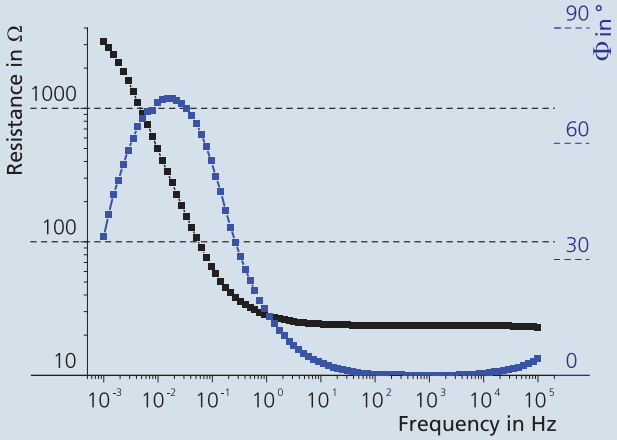
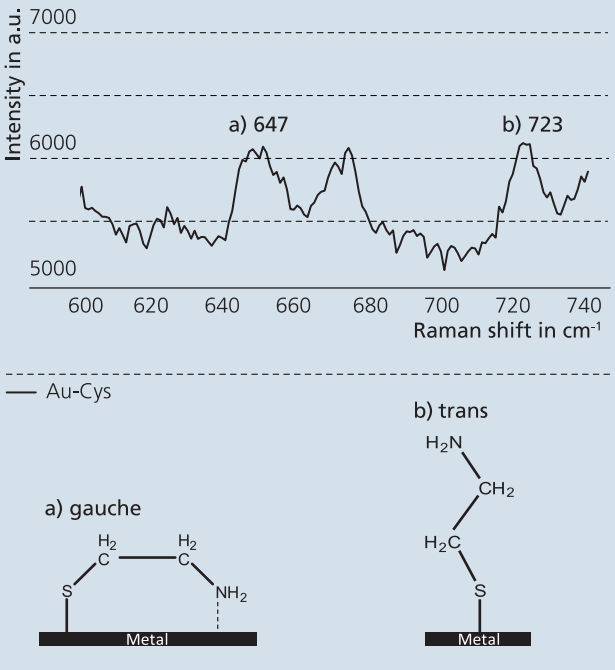
Impedance spectrum:
Electrophoretic CNT layer on gold



Raman spectroscopy:
Cysteamine monolayer on gold



Acknowledgments

AiF and BMBF are gratefully acknowledged for funding the projects „Biosensor“ (KF2087309AJ9) and “InMEAs“ (16SV5323).

Services offered

- Chemical modification of surfaces
- Electrochemical und electrophoretic functionalization
- Development and test of sensors
- Spectroelectrochemical characterization of layers and sensors

1 *Microstructure of gold layers.*
2 *Prussian blue layer on sensor with gold nanoparticles.*
3 *Electrophoretic deposition of carbon nanotubes.*
4 *Electrochemical multisensor array.*

ELECTROCHEMICAL AND SPECTROSCOPIC CHARACTERIZATON OF BATTERY MATERIALS

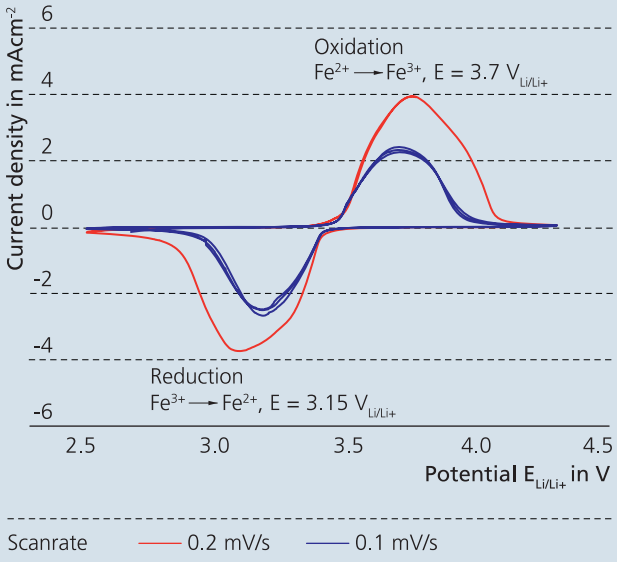
Dr. Michael Schneider, Dipl.-Chem. Ulrike Langklotz

The development of energy storage systems with improved performance and better safety is essential for the future use of renewable energies. The wide range of stationary and mobile applications requires long-living, customized materials with high power and energy density. Fraunhofer IKTS has extensive experiences in developing and manufacturing ceramic-based electrode materials with improved properties. A comprehensive understanding of the electrochemical processes, which are the basis for new energy storage concepts, as well as the electrochemical characterization of the materials are essential for this process.

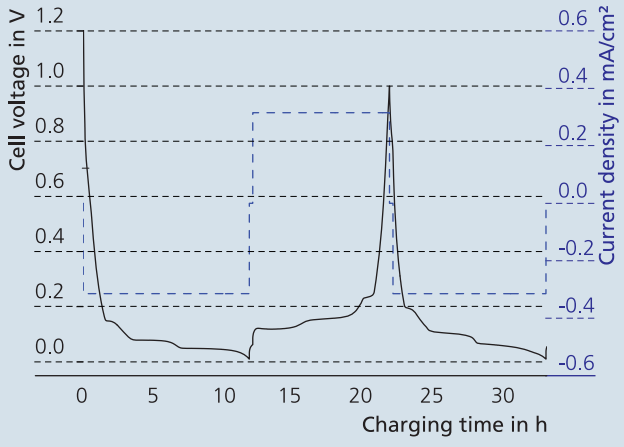
The "Electrochemistry" working group at Fraunhofer IKTS offers a wide range of electrochemical and spectroscopic methods to investigate electrochemical processes during charge and discharge processes as well as the behavior of the electrode materials. Currently, the focus is on cathode materials such as lithium-containing oxides and phosphates as well as on anode materials such as carbon, lithium titanate and silicon nanowires. For material characterization the following electrochemical methods are successfully used:

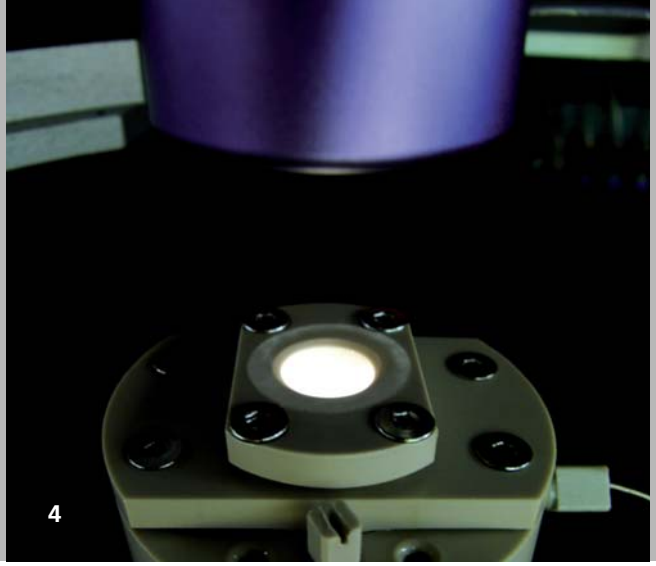
- Cyclovoltammetry (CV)
- Electrochemical impedance spectroscopy (EIS)
- Various cyclic charge-discharge experiments (e.g. CC/CV)
- Galvanostatic and potentiostatic pulse methods (GITT, PITT)

Cyclovoltammetric determination of the redox potentials of a lithium iron phosphate (LFP) cathode, measured in a three-electrode cell



Charge/discharge behavior of a carbon anode, measured versus lithium





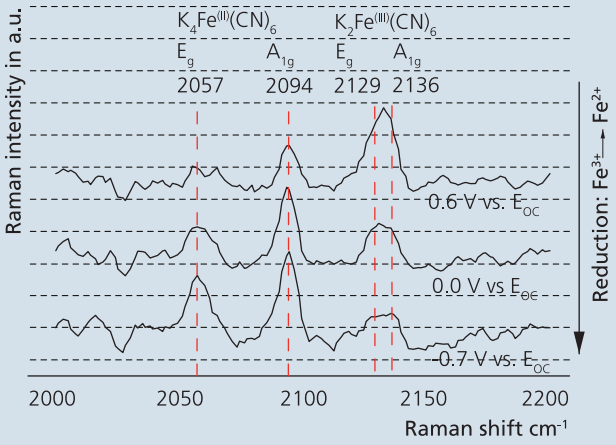
In addition to the determination of technologically significant material parameters (cell voltage, capacity, water content, cycle stability) electrochemical mechanisms are investigated. Their understanding is essential for various working groups at Fraunhofer IKTS to push the development of new materials and manufacturing technologies faster and more efficiently.

The demand for fundamental understanding of material behavior and electrochemical mechanisms requires the combination of different investigation techniques. This approach includes the development of special measuring cells and spectroscopic measurements in combination with electrochemical experiments (spectroelectrochemistry). The in-situ application of spectroscopic methods (infrared spectroscopy, Raman spectroscopy), in particular, offers various possibilities of characterizing battery materials, e.g.:

- Determination of the state of lithiation of electrode materials
- Evaluation of the state of charge
- Degradation mechanisms of electrode materials

In-situ spectroelectrochemistry allows for the direct linking of electrochemical behavior and structural properties of the electrode materials as well as the investigation of solid-electrolyte interactions.

In-situ Raman spectroscopic investigation of the electrochemical reduction of potassium prussiate

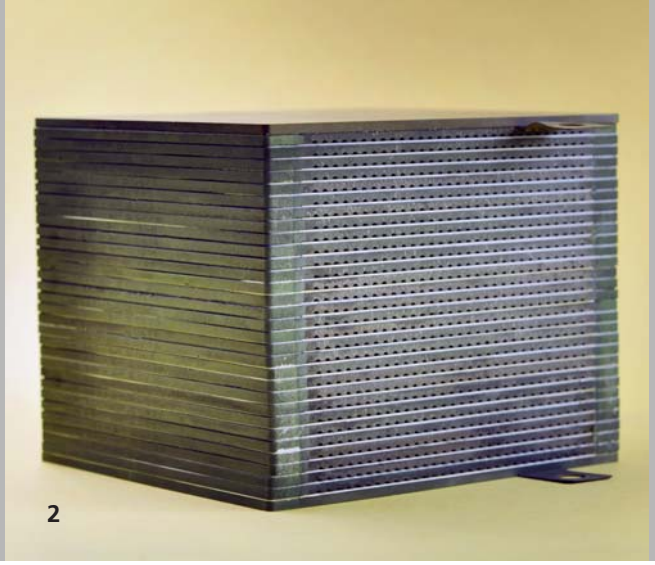


Services offered

- Electrochemical and spectroscopical characterization of electrode materials and electrolytes
- Determination of water content in electrode materials and electrolytes (Karl-Fischer titration)
- Investigation of electrochemical mechanisms

1 *Glovebox.*
2 *Screw cells for electrochemical material characterization.*
3 *Karl-Fischer titration for determination of water content.*
4 *Measuring cell for in-situ Raman spectroscopic investigations.*

1



2

DEVELOPMENT AND AUTOMATED OPERATION OF A BIOGAS SOFC SYSTEM

Dipl.-Ing. Marc Heddrich, Dr. Matthias Jahn, Dr. Mihail Kusnezoff, M. Sc. Ralf Näke, Dipl.-Ing. Aniko Weder

Motivation

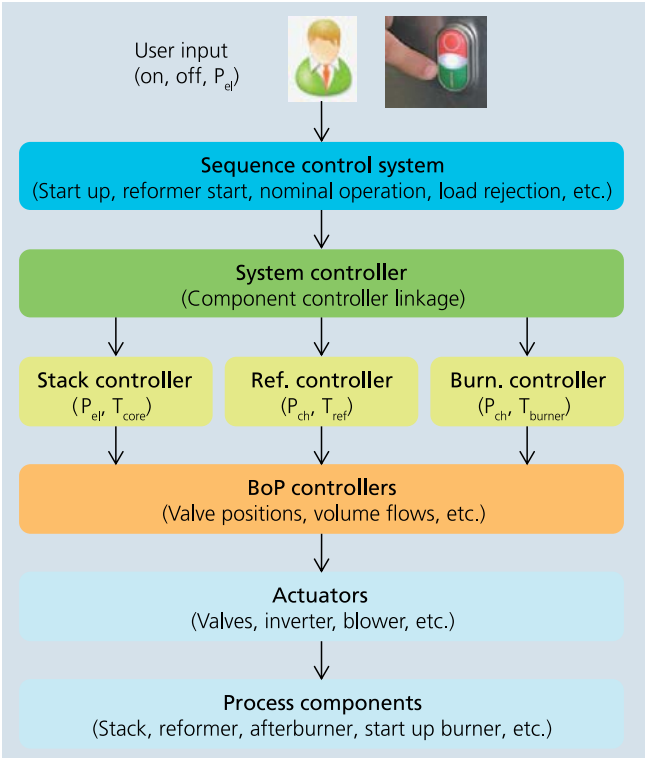
Coupling regenerative biogas production and electrochemical conversion within SOFC systems is very attractive not only for the reason of a high electric efficiency. The solid oxide fuel cell (SOFC) allows the use of biogas without prior separation of carbon dioxide. Not even water has to be made available which is normally essential for good fuel reforming resulting in a high electric efficiency. Thermodynamic calculations clearly indicate that dry reforming of biogas will yield reformate of great quality containing $x_{H2} + x_{CO} > 0.75$ at T = 800°C. Dry reforming of biogas is similar to steam reforming. Carbon dioxide replaces water as reforming agent making only a very small fraction of oxygen ($\lambda_{ref} < 0.1$) necessary. Further calculations show that this highly endothermic process has the potential for ideal electric efficiencies of up to $\eta_{el,id} = 0.6$. This makes reaching real gross efficiencies of $\eta_{el,gro} > 0.5$ without any water management possible.

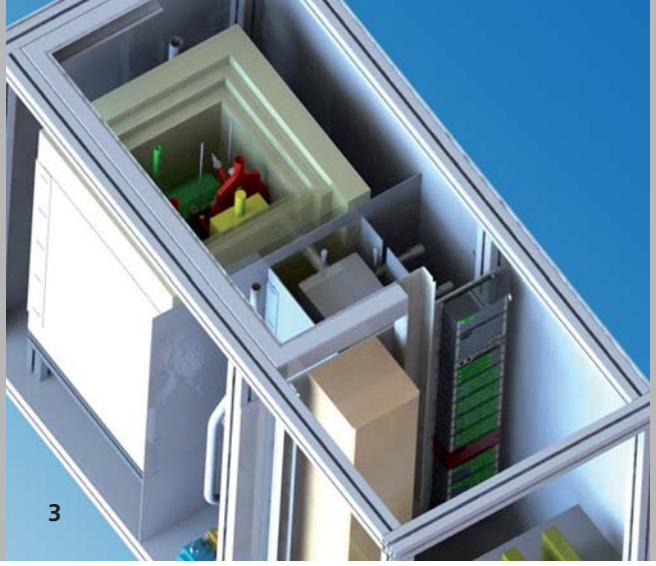
Process development

To achieve the development objectives, after system and process design the main focus lies on the reformer. Here, the strongly endothermic reforming reactions must be intelligently coupled with the exothermic anode tail gas oxidation reactions. Component testing showed that the necessary heat flux for the reforming reactions is provided for the entire projected operating range. The precalculated thermodynamic equilibrium concentrations are reached.

Automation

The aims of all our automation activities within system development are safe and unsupervised operation with fully automated system management and simple system handling with a minimal number of input requirements for the operator. The uncertainties of real-life device operation are explicitly taken into account (load rejection from the electric grid, unknown fuel compositions etc.).





To accomplish the desired unsupervised operation, a stable gas flow control with near-to-market BoP components is implemented. The control strategies especially for degradation effected components rely on adaptive model based controllers. The system controller links up and prioritizes the component controllers, and it is being set to well defined states (start up, nominal operation etc.) by the superordinate sequence control system. With all that implemented, the user merely has to enter the simplest commands like "on", "off", "nominal" or "partial load".

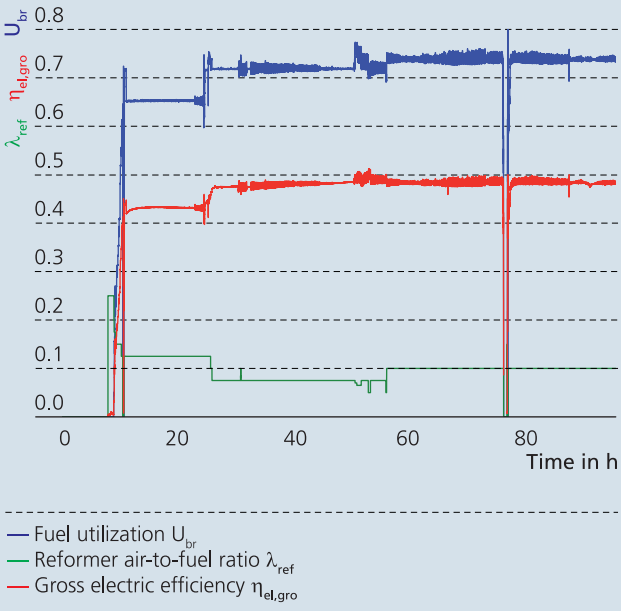
Results

The biogas SOFC system was put into operation on schedule and could directly be set to continuous operation due to the structured development process. The gross electric efficiency amounts to $\eta_{el,gro} > 45$ % for nominal operation. The good thermal coupling of the reformer allows for extremely low air-to-fuel ratios down to $\lambda_{ref} = 0.05$. As safety and risk management methods accompany the development process, a customer desired product certification is always taken into consideration.

Specification of biogas SOFC system

Fuel	Biogas	
Composition	$x_{CH4} = 0.4…0.7$	$x_{CO2} = 0.3…0.6$
El. power, gross (per number of stacks)	0.75 kW	
Reformer air-to-fuel ratio	0.1	
Stack	CFY 30 layers	
Operating temperature	850°C	
Fuel utilization	75 %	
El. efficiency, gross	0.45…0.51	
Therm. efficiency	0.40…0.48	
Total efficiency	0.88…0.94	
Start/stop capability	Yes	
Emissions	According to "Blauer Engel"	

Start-up and first operating hours

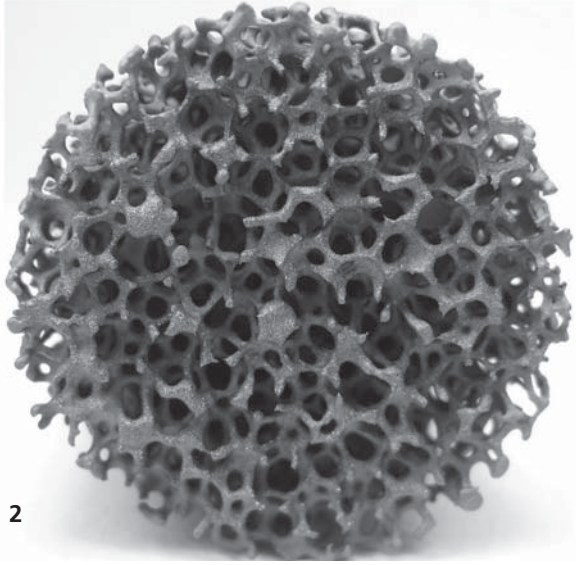


Services offered

- Component and system dimensioning
- Multiphysics simulations of chemical and electrochemical processes and reactors
- Development and operation of systems
- Reaction engineering analyses of reactors
- Catalyst development
- Operating life analyses for components and systems
- Gas analyses (FID-GC, WLD-GC, PFPD-GC and GC/MS)

1 *Straw for biogas production.*
2 *CFY stack of Fraunhofer IKTS.*
3 *System design.*
4 *System assembly.*

1



2

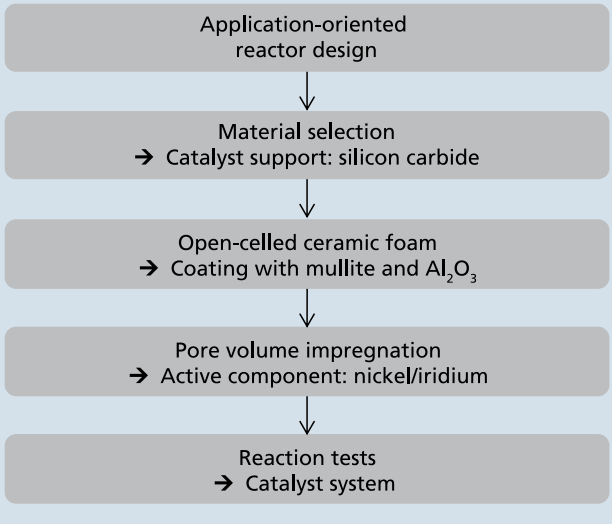
INVESTIGATION OF THE DYNAMIC BEHAVIOR OF CATALYTIC REFORMERS

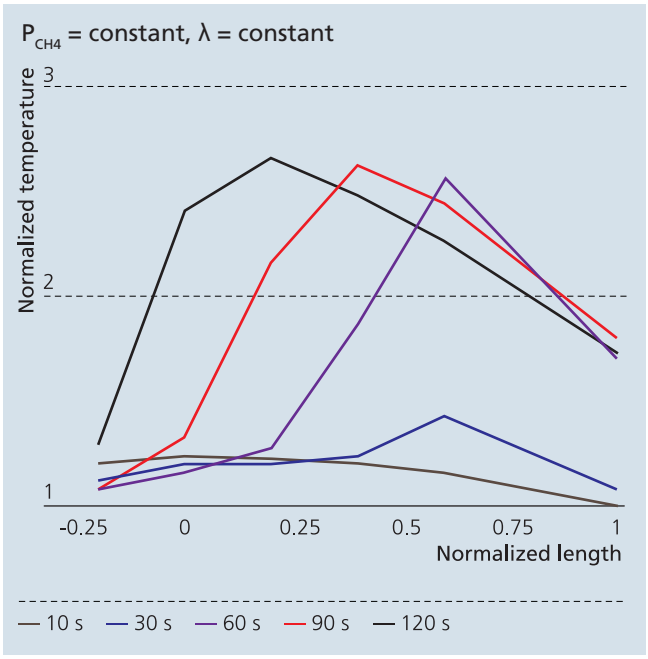
Dipl.-Ing. Markus Pohl, Dipl.-Chem. Manuela Breite, Dipl.-Chem. Dorothea Männel, Dr. Matthias Jahn

Motivation and objective

In hydrocarbon operated fuel cell systems, the necessary hydrogen and carbon monoxide containing fuel is generated by reforming processes including steam reforming, partial oxidation or a mixture of both methods. Partial oxidation is preferred for a simple and robust system concept. The reformer has to react dynamically on state changes. When starting the fuel cell system, the ignition temperature as well as the time in which an almost stationary state is reached, should be as low and short as possible. The dynamic behavior of the reformer can be influenced by a suitable reactor design and catalyst material.

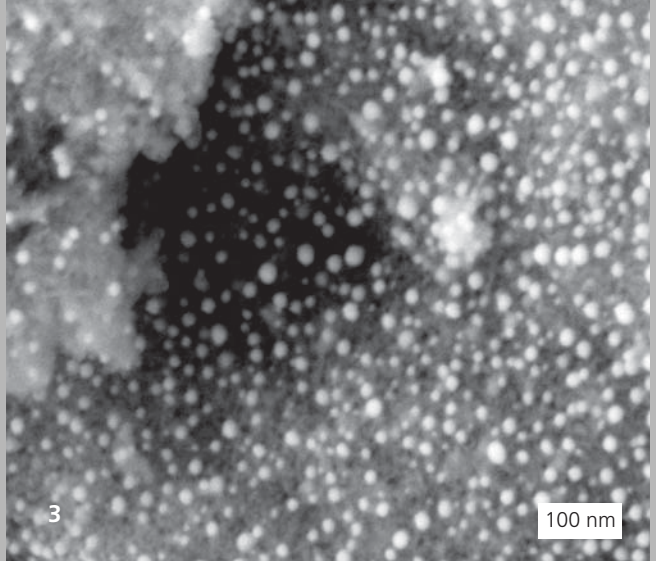
Procedure of developing catalysts

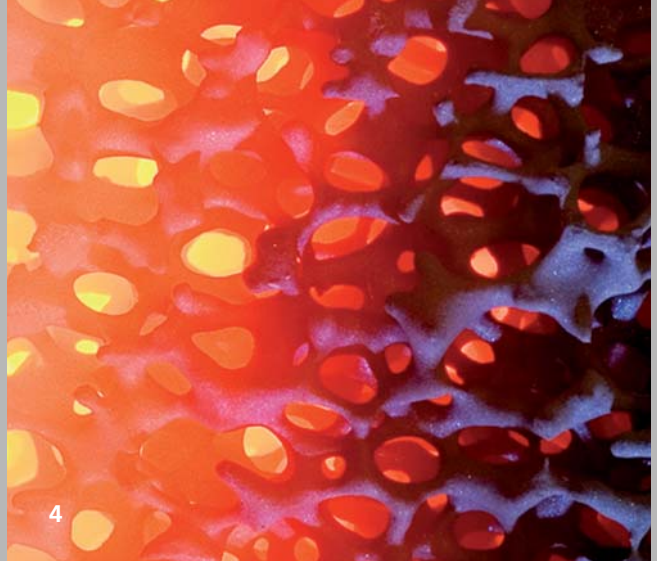




Development of the catalyst

Coated ceramic foams are used as catalysts. Their manufacturing method is shown in the diagram on the left. First, the ceramic foam is coated with a wash coat. Then, noble metal or nickel is applied as active component by pore volume impregnation. It is the aim to use as little noble metal as possible. The knowledge about the ignition temperature and the axial temperature profile is gained by measuring prototypes. When igniting the reformer, the temperature profile should be as flat as possible, i.e. the maximum temperature should be as low as possible.



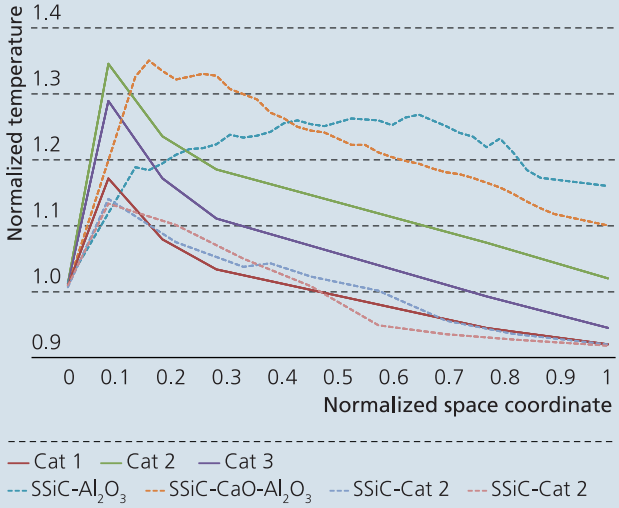


In combination with a small amount of iridium, the ignition temperature of a nickel-loaded catalyst can be reduced. The starting process is finished within 120 s after adding the educts. SiC, in comparison with cordierite, is characterized by high thermal conductivity, and thus is well suited as support material for catalysts. Tests with ceramic foam structures and ethanol show that significantly lower temperature gradients can be realized than with commercial cordierite honeycombs. Additionally, the maximum temperatures measured on the catalyst decrease.

Ignition conditions: P_{CH4} = constant, λ = constant

Active component	$T_{ignition}$	Catalyst
Nickel	> 500°C	Free of noble metals
Iridium	< 350°C	Containing noble metals
Nickel/iridium	< 500°C	Low amount of iridium

Normalized temperature profiles of different catalysts at POx of ethanol at P_{C2H5OH} = 400 W and λ = 0.28



Services offered

- Development of reactors and tests of catalytic reactions and processes
- Development of catalysts
- Measurement equipment for the validation of various fuels for different catalysts
- Development of coated foams for gas processing and after-treatment

1 *Catalyst pellets.*
2 *SiC catalyst support.*
3 *Catalyst surface with active component.*
4 *Reaction with porous medium.*

RESEARCH FIELD ENERGY SYSTEMS

Department heads:
Dr. Mihails Kusnezoff
Dr. Matthias Jahn
Dr. Christian Wunderlich

DEPARTMENT

INDUSTRIALIZATION ENERGY SYSTEMS

Profile

The "Industrialization Energy Systems" department – an interface between application and customer – pools the expertise of Fraunhofer IKTS in the field of materials and technology development. Its aim is the development of complete energy systems. Currently, research activities are focused on fuel cell generators and battery storage systems as well as other energy storage systems.

This focus enables the department to realize the development of specific systems based both on market and customer requirements and on available technological options. Based on a comprehensive validation and gap analysis of technology maturity, both the feedback into material and components development and the quick solution of identified technical aspects are guaranteed. Component availability and technologies issues identified along various steps of the value chain again are addressed together with material and component research teams.

In order to develop large series production processes and quality assurance methods, a small series production of prototypes can first be carried out in the laboratories and pilot plants of Fraunhofer IKTS or in cooperation with our customers. Thus, Fraunhofer IKTS is qualified as a contractor for the complete process of technology development and the stepwise knowledge transfer into series production at the customer's site.

Services offered

- System concepts, including simulation-assisted synthesis and dynamic simulation of complex energy conversion and storage systems
- Multi-criteria optimization of system structures according to the Pareto principle based on the customer's functional goals
- Prototype assembly, functional tests and validation of performance and lifetime parameters of energy systems in specially equipped laboratories within the performance range provide energy generation of some mW and 10 kW (focus: fuel cell and battery systems)
- Construction and operation of test stands for the study of specific aspects, e.g. in the high-temperature range
- Realization of prototype production and quality assurance processes on a laboratory, pilot plant and industrial scale

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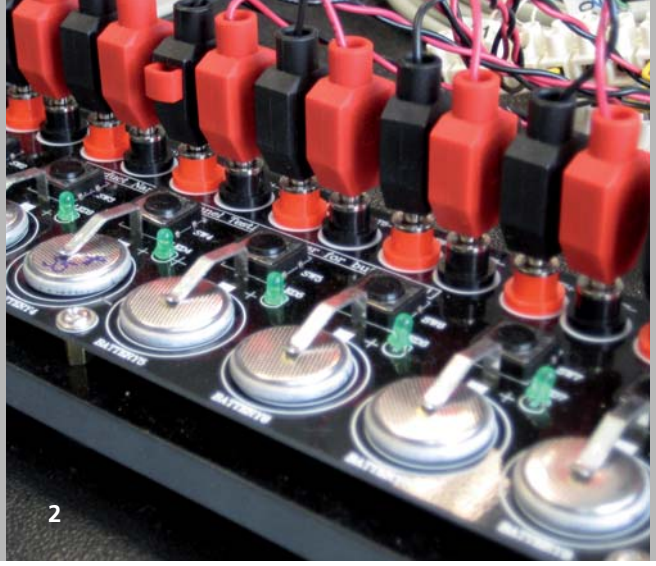

2

CHARACTERIZATION OF MATERIALS AND PROCESSES FOR LITHIUM BATTERY PRODUCTION

Dr. Mareike Wolter, Dipl.-Phys. Diana Leiva, Dipl.-Ing. Georg Fauser, Dr. Christian Bretthauer

High-performance energy storage devices significantly gain in importance due to the increasing share of renewable energies and the shift towards electric mobility. In the field of electric mobility lithium ion batteries (LIB) are considered to be a key technology as they are characterized both by high energy/power densities and high cycling capability. In addition LIB are expected to be the most promising candidate for short term and small scale energy storage devices in the field of smart grid and off grid power.

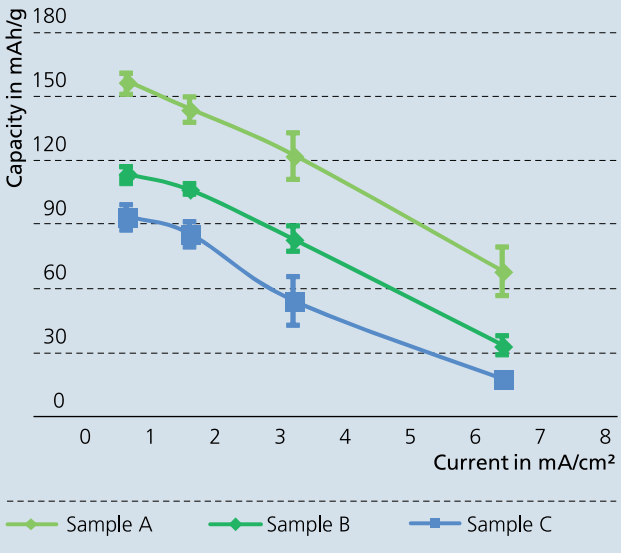
Production of lithium battery cells in pilot scale

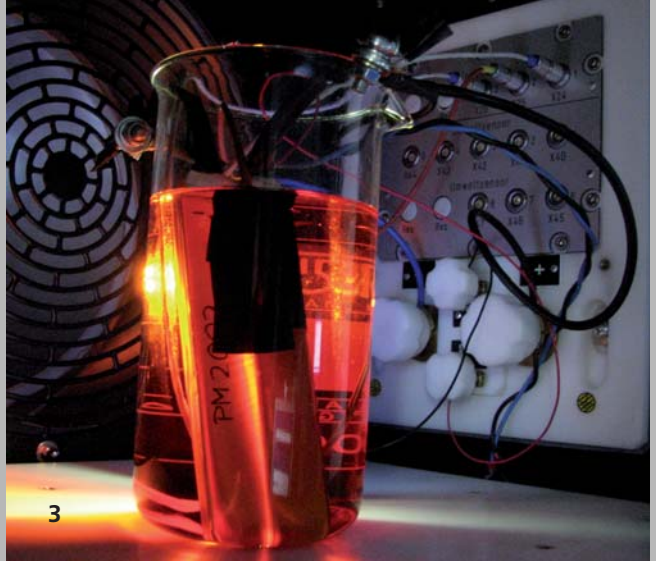
The use of high-performance storage materials as well as their processing plays a crucial role for the quality of LIB. Together with industry partners, the "Energy Storage Systems" working group at Fraunhofer IKTS is developing and optimizing innovative, pilot-scale manufacturing technologies for LIB. Cost-effective, modular and flexible (in terms of cell geometry and cell chemistry) production equipment is the primary focus. Currently one of the main tasks of Fraunhofer IKTS is to prepare optimized slurry systems and to develop production-oriented coating technologies. Production effects on life and performance are investigated by the characterization of electrodes for button and pouch cells and the subsequent post-mortem analysis. Suitable test and characterization methods are developed which can be integrated into the production process as in-line process control for quality assurance.

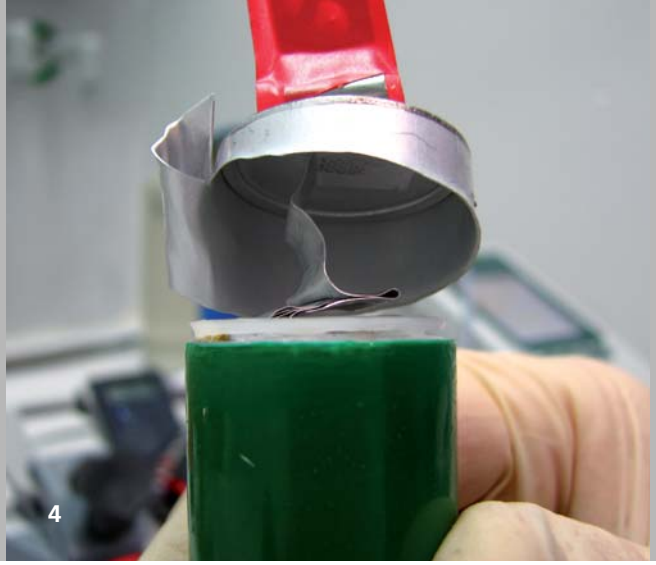
Electrical and thermal characterization

The sizes and properties of LIB cells are as widespread as the application fields. The spectrum ranges from micro batteries with a storage capacity of some milliampere hours up to large cells for industrial and automotive applications with a capacity of hundreds of ampere hours. In order to be able to characterize this spectrum of cells, various test systems are available at Fraunhofer IKTS. So, studies on button cells are performed to characterize the material properties of electrode films developed at Fraunhofer IKTS (diagram below). Commercial cells, in

Capacity per cathode mass in dependence of the discharge rate for electrodes with different active materials







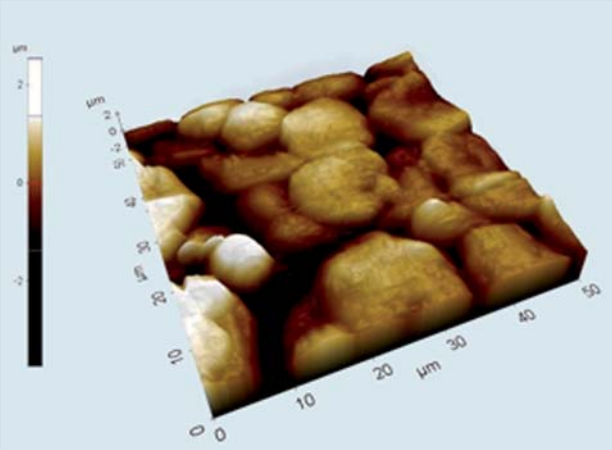
contrast, are tested under application-relevant conditions, in order to investigate their qualification for stationary energy storage systems or for electric vehicles.

Furthermore, the characterization is used to identify failure mechanisms. Typical load cycles of these applications can be simulated with the help of test systems available at Fraunhofer IKTS. In particular, the influence of the ambient temperature on the electrical properties of the cells has to be taken into account. Conclusions on the quality of the production process can be drawn from the obtained data such as performance density, cycle life or internal resistance of the cells.

Post-mortem analysis

In post-mortem analyses it is investigated why batteries failed or degraded. For this purpose, imaging methods like computed tomography, optical microscopy, SEM and AFM (diagram on the right) are used in combination with analytical methods such as energy dispersive X-ray and Raman spectroscopy as well as BET and DSC measurements. Thus, detailed information about the particular failure mechanism can be obtained and aging and failure mechanisms such as dendrite formation, exfoliation, separator densification, corrosion or contamination can be localized. These studies, again, form the basis to optimize materials and processes to electrode and cell manufacturing.

Atomic force microscopy to analyze the surface topography of a graphite anode



1 *Manufacturing of button cells.*
2 *Characterization of button cells.*
3 *Characterization of a commercial pouch cell in a temperature test chamber.*
4 *Post-mortem analysis.*

RESEARCH FIELD SMART MICROSYSTEMS

Department heads:
Dr. Andreas Schönecker
Dr. Uwe Partsch

DEPARTMENT

SMART MATERIALS AND SYSTEMS

Profile

The "Smart Materials and Systems" department is specialized in developing dielectric functional ceramics and integrating them into devices, microsystems and active structures. Research covers all aspects of the value chain, ranging from materials synthesis to functional verification in prototype systems.

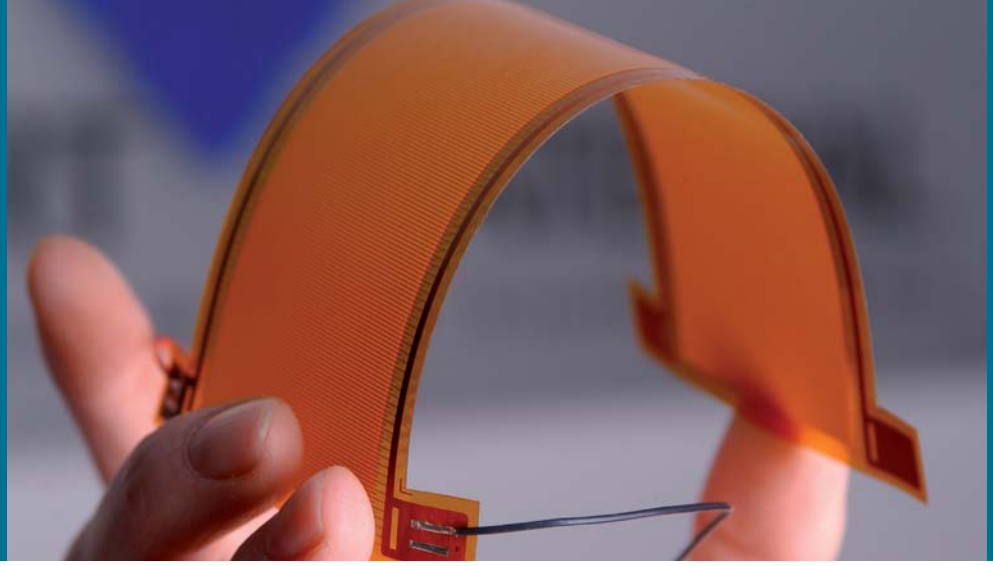
Functional optimization is accordingly performed on several scales, through utilization of property combinations of composites, functional consolidation in materials, and adaptation of components to the system environment.

Special materials expertise exists in the field of complex perovskites, which, as high-performance piezoceramic or dielectric ceramics, provide sensing, actuating, and electronic functions in monolithic components and composites with polymers, metals, glasses, and other ceramics. Thick film, multilayer, and piezocomposite technologies are available as closed technology chains.

Preparation of thin film structures is done by CVD, PVD, and sol-gel processes in combination with reactive ion etching for structuring. With this technology portfolio, we offer new materials solutions for semiconductor technology and wear protection. With regard to system applications, unique design and characterization tools are being developed and used. These tools describe the interaction of piezoelectric transducers with both electronic circuits and mechanical and acoustic subsystems and lead to innovative developments in piezotechnology, adaptronics/mechatronics and ultrasound technology.

Services offered

- Development, production and characterization of dielectric ceramics
- Technology development based on powders, fibers and coatings
- Development of components for specific applications in sensor, actuator, and ultrasound technology as well as electronics, wear protection and light-weight construction with integrated functions
- Modeling and simulation on the material, component and system level
- Characterization of dielectric, piezoelectric, and ferroelectric functional properties
- Vibration and sound field measurements
- Scientific instrument design, electronics, and software development



Department head
Smart Materials and Systems

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1

BACKSIDE PASSIVATION OF CRYSTALLINE SILICON SOLAR CELLS BY ALD

Dr. Ingolf Endler, Dipl.-Phys. Mario Krug

Introduction

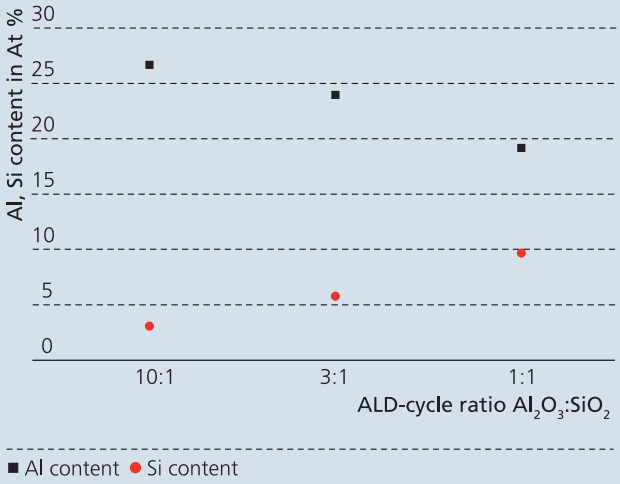
Crystalline silicon solar cells are predominant in photovoltaic applications because of their advantageous cost/performance ratio. The declining buyback price for PV electricity results in an increasing cost pressure for the production and sale of new PV modules. An enhancement of the efficiency of the solar cell can be realized by applying a backside passivation layer leading to an increased carrier life time due to reduction of undesired carrier recombination. In this way, the production costs per watt peak of PV cells can be considerably reduced.

Results

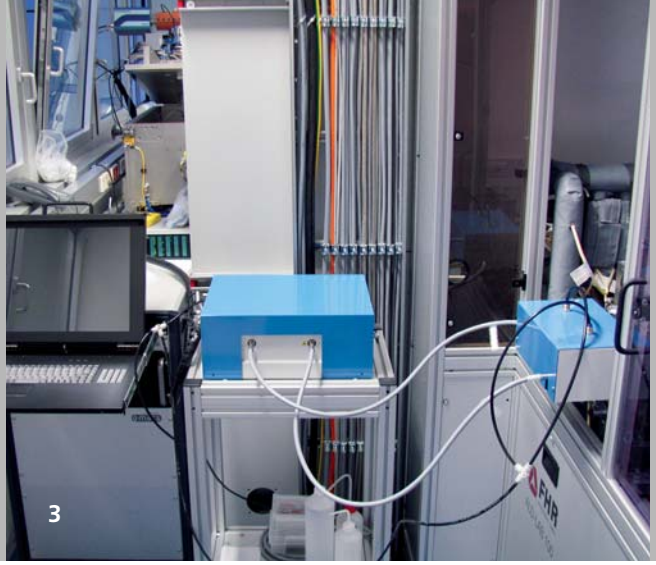
For the deposition of thin, single oxide or mixed oxide coatings Fraunhofer IKTS uses two ALD lab-coaters for substrate sizes of up to 300 mm in diameter. In the ALD process, the precursors are sequentially added, separated by purge gas pulses. A mixed oxide layer of $(Al,Si)O_x$ is deposited by inserting SiO_2-ALD cycles into Al_2O_3-ALD cycles. Trimethylaluminum (TMA), trisdimethylaminosilane (3DMAS) and ozone are used as precursors.

The stoichiometry of the mixed oxide layer can be reproducibly adjusted by the ALD-cycle ratio for both oxides. The upper diagram shows the silicon and aluminum content of the resulting mixed oxide layers.

Silicon and aluminum content of mixed oxide layers in dependence on the ALD-cycle ratio



The measured carrier life time for such backside passivated silicon in dependence on the silicon content in the $(Al,Si)O_x$ layer after different steps of thermal treatment is shown in the diagram on the right side. The carrier life time can be increased by incorporating silicon. A significant enhancement of the carrier life time can be achieved by additional thermal treatment. A maximum of the carrier life time is observed at low silicon concentration in $(Al,Si)O_x$ passivation layers. The type of thermal treatment has no significant influence on the peak value. For pure Al_2O_3 layers as well as for $(Al,Si)O_x$ layers with a higher silicon content the carrier life time is dependent on the kind of thermal treatment. Therefore, $(Al,Si)O_x$ passivation layers with optimal silicon content increase the efficiency of solar cells substantially.



Further applications

Besides the possibility of using ALD layers for backside passivation of crystalline solar cells, ALD layers are commonly used for the deposition of very thin layers with excellent conformality in microelectronic applications, e.g., for high-k layers. Because of the very low defect density and well controllable layer thickness, ALD layers are also suitable for precision optical applications as well as for barrier coatings.

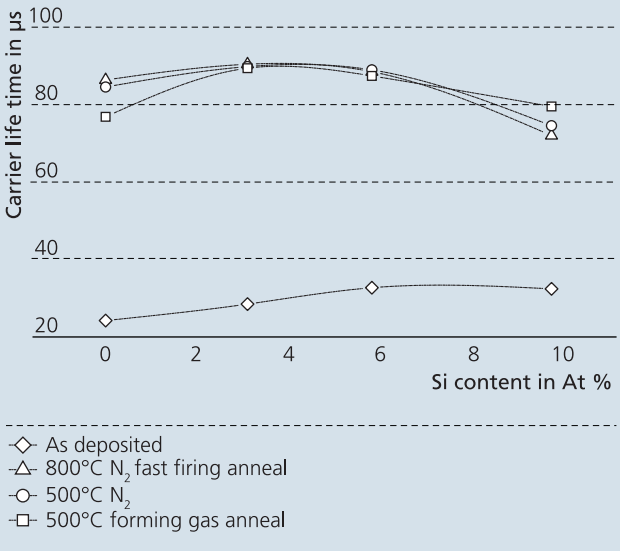
Services offered

- Testing of new ALD precursors including determination of reaction products by mass spectrometry and laser absorption spectroscopy
- Development of ALD processes
- Depositions of prototype layers for product development
- Complex characterization of deposited layers

Acknowledgments

This work was done in cooperation with NaMLab gGmbH, Fraunhofer CNT and Technical University of Dresden and was financially supported by the Saxon Ministry for Science and Art (Project No. 12461/2043 MERLIN) by means of the European Regional Development Fund and the Free State of Saxony.

Carrier life time measured on silicon wafers (CZ wafers) passivated with 20 nm $(Al,Si)O_x$ in dependence on the Si content and the type of annealing

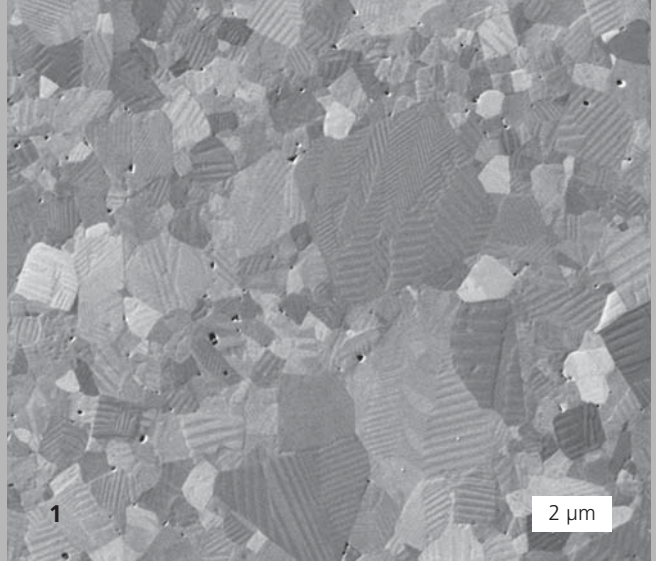


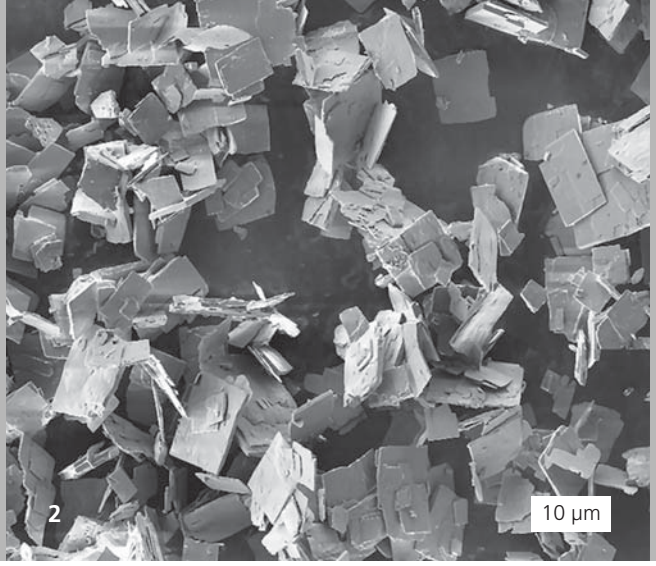
1 *ALD 300 lab-coater in the clean room of Fraunhofer CNT.*

2 *ALD 100 lab-coater at Fraunhofer IKTS.*

3 *Laser absorption spectrometer Q-MACS.*

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





PREPARATION AND CHARACTERIZATION OF ACOUSTIC TRANSDUCERS BASED ON KNN

Dr. Andreas Schönecker, Dipl.-Ing. Thomas Rödig

Motivation

The driving force for developments of lead-free piezoceramics results from environmental concerns and issued regulations by the EU. Strong support of R&D activities during the recent years resulted in a significant step forward in the development of lead-free alternatives with KNN based ceramics as one of the most promising candidates. In our work we studied possible benefits for ultrasonic transducer applications that may arise from much lower acoustic impedance of KNN based piezoceramics, compared to conventional PZT materials. The here considered samples were prepared based on our in-house standard KNN preparation process using an optimized chemical composition. Two aims were pursued: to qualify processing in order to obtain high performing acoustic transducers and to evaluate their functional benefits if used as acoustic transducers for sensing in media with low acoustic impedance.

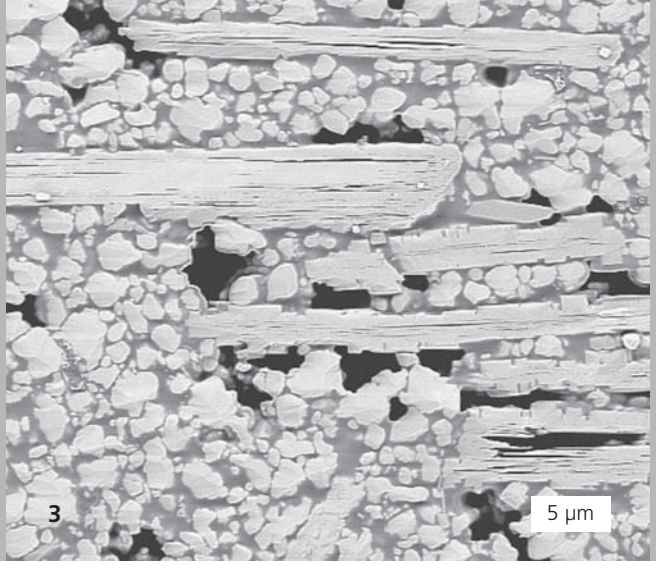
KNN material preparation

KNN ceramics were prepared by conventional mixed oxide technology using analytical grade metal oxide or carbonate powders as raw material. Further doping of 0.5 mol % Mn was done to enhance dielectric stability. The starting powders were dried, weighed according to the desired composition and mixed with ZrO_2 balls for 24 h in isopropanol. After calcining at 800°C for 6 h, the calcine was ball-milled with ZrO_2 balls in isopropanol again. The final powders were then pressed to pellets obtaining sintered discs with 10 mm diameter and 1.5 to 2 mm thickness. The discs were sintered at 1125°C and 4 h in oxygen atmosphere. Finally, thick-film electrodes were applied on both parallel surfaces.

Texture formation was achieved by reactive templated grain growth using in-house developed $NaNbO_3$ (NN) platelets. Seed preparation was based on a two-step salt melting process with formation of anisotropic seeds from Na_2CO_3, Bi_2O_3, Nb_2O_5 in a first step and transforming them into NN seeds again in a NaCl melt. In both steps, seeds were washed out from the matrix by hot water.

Textured KNN-NN ceramics of required thickness with defined contents of NN seeds were obtained by a multilayer process using single tapes with < 50 µm in thickness to get the seed aligned. The addition of NN seeds corresponded to slight NN doping. As result, the relative permittivity ε_r decreased, whereas the transition temperature between orthorhombic and tetragonal symmetry remained almost unchanged in the range between 0°C and 20°C. XRD measurement showed a clear (100)-texture of the seeded KNN-NN ceramics.
In order to get 1-3 composites, the "dice & fill" technology was applied using the water-cooled automatic dicing saw Disco 3350.

The ceramic elements were regularly arranged with pitch 250 µm, kerf 50 µm and depth of trench 800 µm. After filling with epoxy, grinding, electrode deposition and poling, usable transducers elements were obtained.



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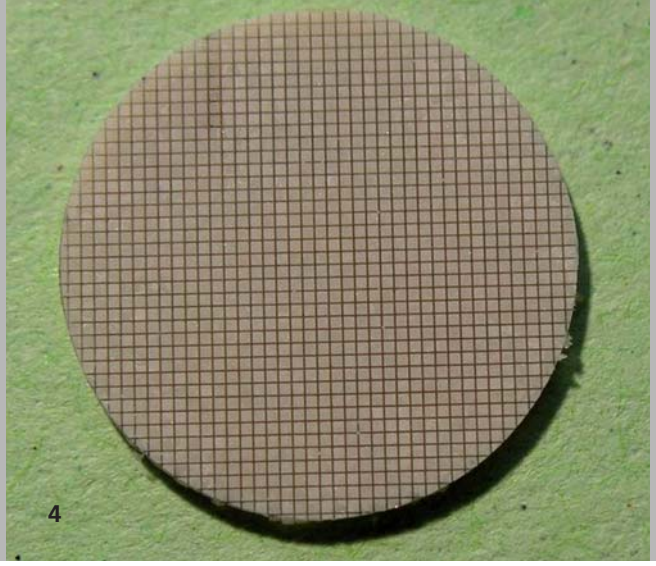

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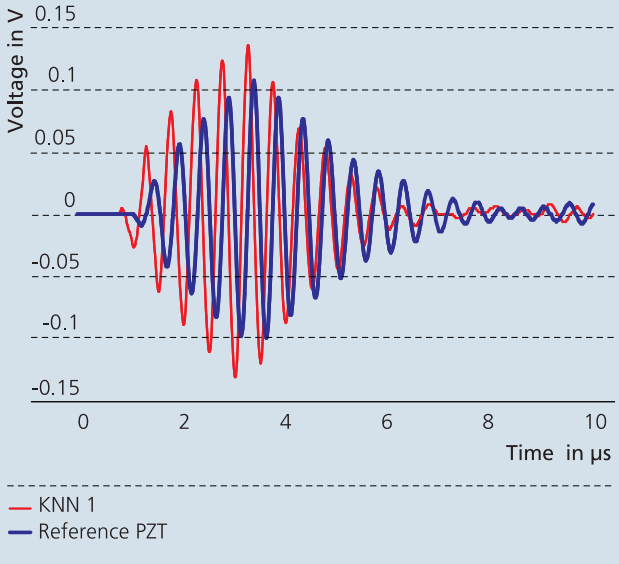
Acoustical measurements

Acoustical characterization was carried out by scanning the sound field in water using a sensitive hydrophone in a commercial test stand (AIMS Scanning Tank, Onda Corp.). The hydrophone voltage was measured which is proportional to the sound pressure. We obtained the following results:

- KNN transducers showed higher values of output power.
- Assuming a given effective acoustic impedance, KNN composites allow for higher ceramic volume fraction which causes higher sound pressure.
- High acoustic sound velocity of 5850 m/s of KKN results in a higher resonance frequency at a given thickness. This allows for higher operation frequency for a given technology compared to PZT ceramics.
- KNN transducers have the potential of increased bandwidth (expectation 20 %) allowing for higher sensitivity especially of composite transducers.

Ultrasound field



According to our results, KNN based ultrasound transducers are expected to have high potential for high frequency, wide band applications especially for objects with low acoustic impedance. Improved acoustic transducer characteristics are expected by appropriate matching and backing. This work is still in progress.

Services offered

- Development and characterization of acoustic transducers
- Studies on the use of KNN based piezoceramics in ultrasound applications

Acknoledgments

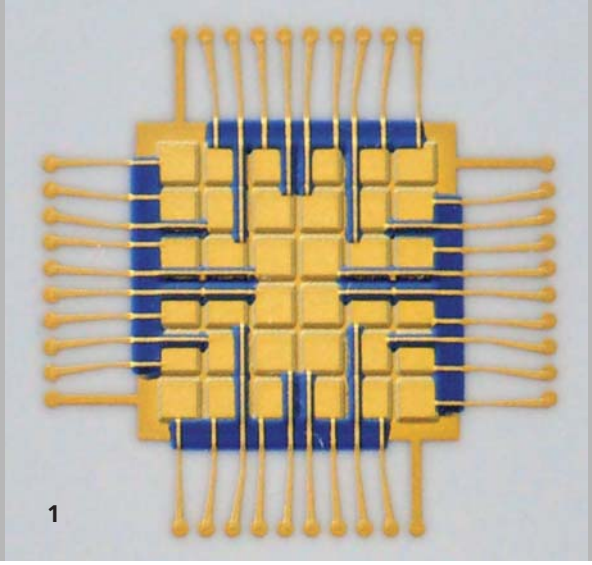
We gratefully acknowledge BMBF (Project RealMAK 03X4007H), Germans Research Foundation (Collaborative Research Center/Transregio 39 "PT-PIESA") and AIF (Project PiezoFAST 15805 BR) for funding the projects.

1 *FESEM micrograph showing the polished cross section of KNN piezoceramics.*

2 *NN seeds of optimum shape.*

3 *Cross section through a KNN green tape with aligned NN seeds.*

4 *Diced KNN disc, ready for 1-3 composite preparation.*



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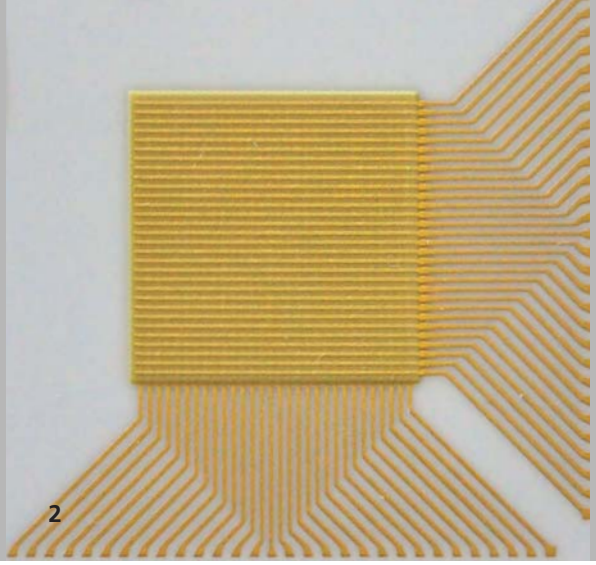


2

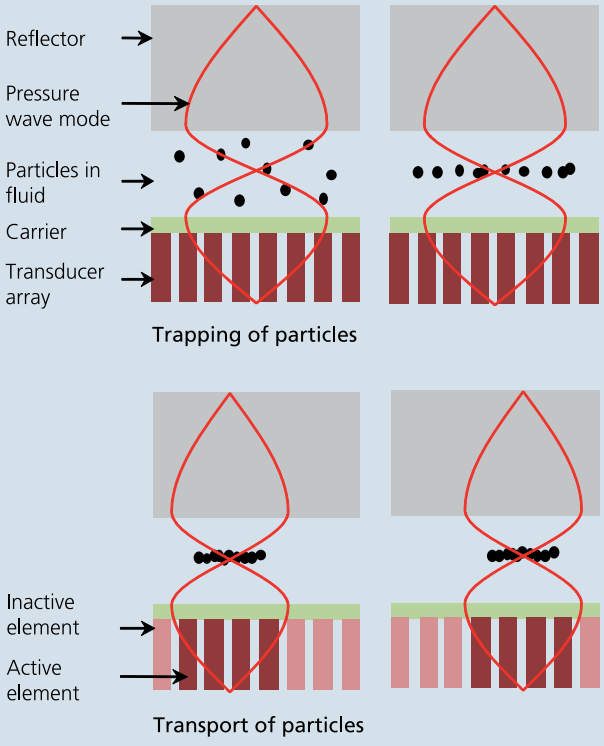
ULTRASONIC TRANSDUCER ARRAYS FOR PARTICLE MANIPULATION

Dr. Sylvia Gebhardt

Motivation

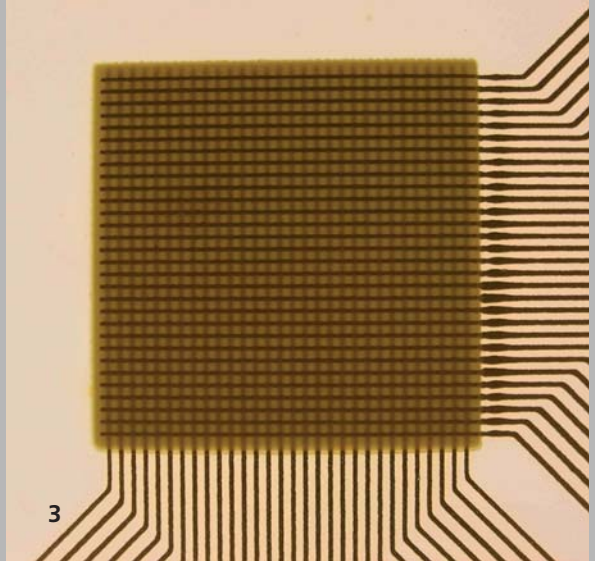
Methods for trapping and handling of small particles are especially needed in the fields of biotechnology and life science. Applications include separation and sorting of cells, investigation of cell characteristics, measurements of cell forces, and tissue engineering [1]. Ultrasonic particle manipulation tools allow for trapping and moving particles with dimensions of less than 1 µm up to hundreds of micron, e.g. cells and cell clusters. The principle of this so-called ultrasonic tweezers is based on the generation of standing ultrasound waves within a fluid channel between a transducer and a reflector layer. Particles can be trapped at the pressure node plane (diagram on the left). For some applications, movement and manipulation of particles is of special interest. Ultrasonic transducer arrays made of individually addressable elements enable for stepwise driving. Switching active single elements or subsets of elements along the array makes it possible to move trapped particles along the microfluidic chamber. Size, pitch, and number of transducer elements define precision of position control. There is a need to develop cost-effective technologies to produce 2D ultrasonic transducer arrays which allow for 3D structured acoustic fields.

Ultrasonic particle manipulation



Thick-film ultrasonic transducer arrays

Piezoceramic thick films based on lead zirconate titanate (PZT) offer the possibility of integrated microsystems solutions. The piezoceramic component is thereby directly applied onto the substrate material which results in a strong coupling between both components. Ground electrode, PZT thick film, insulation layers, and top electrode are prepared by repeated screen printing and subsequent sintering. The screen printing technology allows for excellent reproducibility and printing of patterned thick-film structures on substrates like ZrO_2, Al_2O_3, silicon and low temperature co-fired ceramics (LTCC).



To fabricate multi-element ultrasonic devices a 2D transducer array based on 6 x 6 PZT elements with 2 mm feature width and 2.3 mm pitch was screen printed on a 250 µm thick Al_2O_3 substrate (figure 1). PZT thickness was adjusted to 90 µm and 140 µm by multiple coating. Insulation and electrode layers were applied to achieve electrical connection to each single PZT element. Multilayer substrates with internal electrode layers and vias can be used if termination at the back side of the substrate has to be provided.

For preparation of a 2D ultrasonic transducer array with 900 elements and smaller electrode pitch, a crossed electrode design (figure 2) was built by printing a continuous PZT layer between 30 perpendicular arranged bottom and top electrode lines. The lines had a width of 300 µm and a pitch of 500 µm. The crossed electrode design allows for simple fabrication and connectivity with small electrode and element width.

Both designs enable for specific driving of single transducer elements or element clusters within the 2D ultrasonic array. The generation of structured acoustic fields and their application for trapping and positioning of particles or cells within a fluid chamber is under investigation.

References

[1] C. Demore, Y. Qiu, S. Cochran, P. Glynne-Jones, C. Ye, M. Hill: Transducer Arrays for Ultrasonic Particle Manipulation, Proc. Ultrasonics Symposium (IUS) 2010, IEEE, S. 412-415

Acknowledgments

We gratefully acknowledge co-operational research with the Institute for Medical Science and Technology of Dundee University, UK within the „Sonotweezers“ project.

Services offered

- Preparation of patterned PZT thick films on ZrO_2, Al_2O_3, LTCC and Si
- Development of ultrasonic transducers, sensors and actuators based on PZT thick films
- Design and construction of planar sensor and actuator systems and performance simulation

1 *2D ultrasonic transducer array.*

2 *Crossed electrode ultrasonic transducer array.*

3 *Transmitted light image of figure 2.*

RESEARCH FIELD SMART MICROSYSTEMS

Department heads:
Dr. Andreas Schönecker
Dr. Uwe Partsch

DEPARTMENT

HYBRID MICROSYSTEMS

Profile

The department "Hybrid Microsystems" is focused on the development of functional ceramic materials, miniaturized components and systems. Fields of applications are electronics packaging, high-power electronics, sensors, and energy technology (e.g. micro-fuel cells, battery technology and photovoltaics).

In addition to the development of customized pastes and inks for classic applications in hybrid electronics (e.g. conductor, resistor and encapsulating pastes for AlN), our customers benefit from an extensive know-how in the development and adaptation of magnetic materials as well as non-linear dielectrics and resistors (PTC, NTC). Furthermore, we are experts in the development and preparation of our own application-specific glasses which are used as essential composites in pastes, inks and tapes.

For the deposition of functional layers, both classic screen printing technology and additional mask-based (stencil and gravure printing) and digital printing processes (aerosol and inkjet printing) can be used, depending on the application requirements. The minimum lateral resolution of these printing methods is < 10 µm.

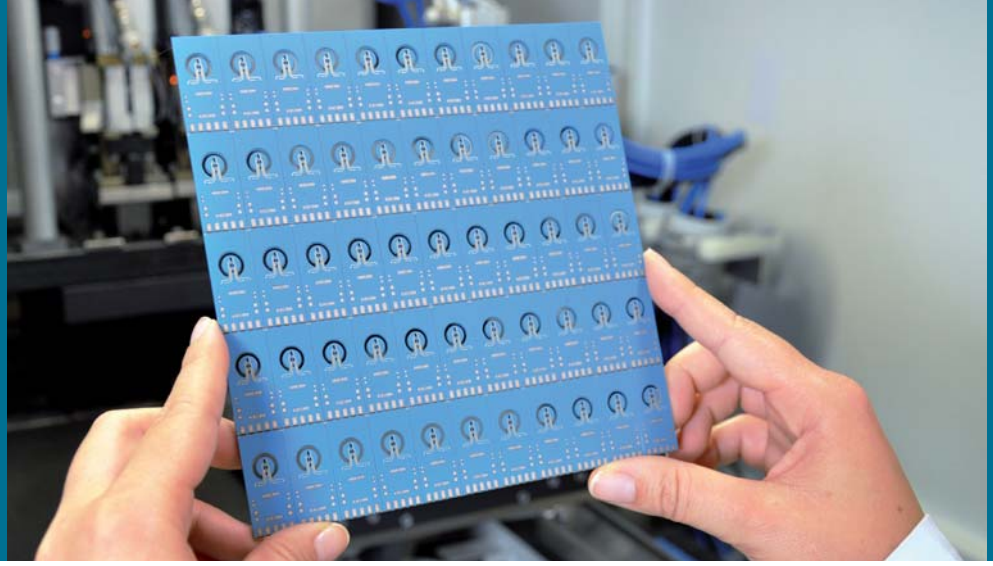
One main focus of our research activities is on the "Tape Casting Competence Center". At the Hermsdorf institute branch, we are able to develop and prepare customized ceramic tapes on a pilot scale. According to the requirements on tapes and properties of the applied slurries, different tape casting methods are used (e.g. doctor blade, comma bar and slot die).

To further process these tapes into 3D-structured components, a complete ceramic multilayer technology line (LTCCs, HTCCs) is available at Fraunhofer IKTS. In cooperation with industry partners, we also run two pilot plants in which developed materials and processes are tested and optimized with consumers in a semi-industrial environment (PV pilot plant with Roth & Rau AG, battery pilot plant with ThyssenKrupp System Engineering GmbH).

In the field of electronic packaging, we also offer our customers a wide range of technologies for electrical contacting (soldering, gluing, bonding) and for mechanical and microstructural characterization of electrical connections.

Services offered

- Development, preparation, and characterization of application-specific functional ceramic materials (inks, pastes and tapes)
- Component design, development, and characterization
- Electrical systems integration of ceramic components
- Development and optimization of technologies and assessment of scalability



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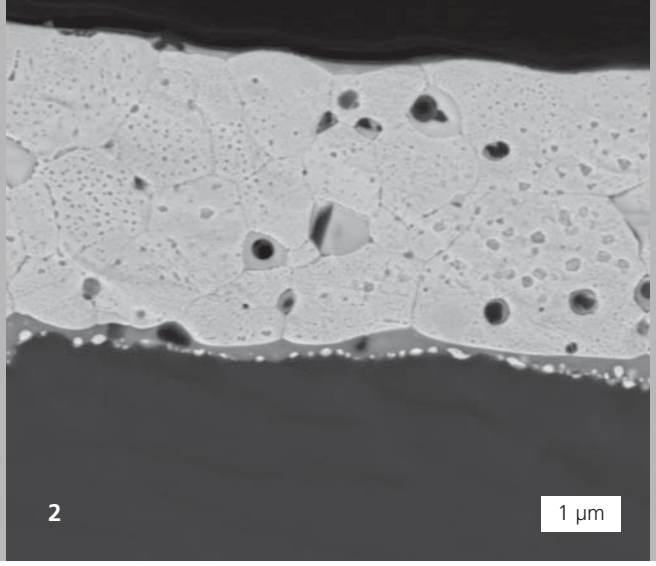


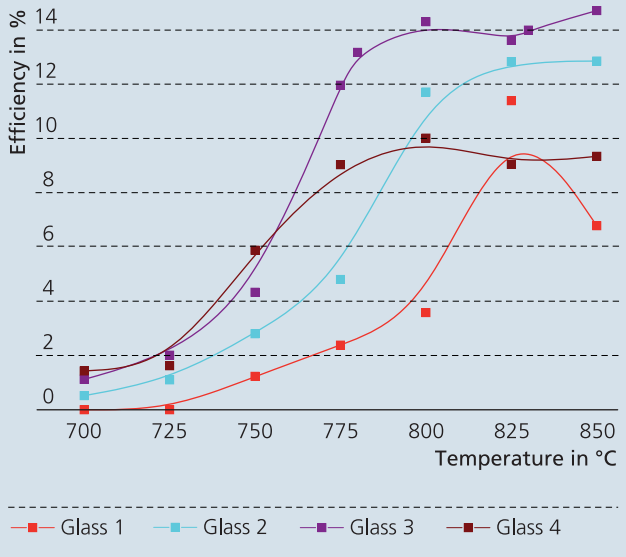
2

CUSTOMER AND TECHNOLOGY SPECIFIC PASTES AND INKS FOR PV APPLICATIONS

Dr. Markus Eberstein, Dr. Jochen Schilm, Dr. Christel Kretzschmar
Dr. Marco Fritsch, Dipl.-Ing. (FH) Robert Jurk, Dr. Sindy Mosch

Metallization is a key process step in the fabrication of crystalline Si solar cells. It determines the solar cell design and the resulting efficiency to a large extent, and is also a major cost component in the solar cell production process. Despite a number of established cell designs, metallization by screen printing and firing of thick-film pastes is preferred by the majority of cell manufacturers. Against this background, silver based pastes and inks were developed in various projects for conventional screen printing and a number of new technologies such as fine line double printing, hot melt printing and contacting of selective emitters.

Influence of glass frit composition on solar cell efficiency



The development of pastes and inks considers not only the single components (silver, glass frit, additives, organic binders) but also the basic interactions of complex pastes systems with the Si wafers as well as the formation of the microstructure during the firing process. Sintering kinetics of glass-based Ag powders were studied to draw conclusions regarding paste adhesion and electrical contact formation on the silicon wafer. Strong effects of the particle size of the silver powders and the glass viscosity were demonstrated. Furthermore, the formation of Ag colloids at the paste/Si wafer interface during firing was found to be crucial for low electrical series resistances of the front side contact, and thus also for the final efficiency of the solar cell. The composition of the paste glass represents a key feature regarding the Ag colloid formation at the paste/Si wafer interface. Figure 1 shows the influence of various heavy-metal-free glass frits used as additives in silver pastes, on the solar cell efficiencies after front side metallization. For testing the pastes in an industrial environment, a 10 MW pilot line shared by Fraunhofer IKTS and Roth & Rau AG, Hohenstein-Ernstthal, is used. A new front side paste yielding 16.5 % efficiency on 60 Ohm/sq standard wafers in the pilot line could be introduced in summer 2011. Current development is focused on lead-free front side pastes as well as on pastes for n-type cells.

Ink-jet printing is a digital printing method where droplets of a material ink are printed precisely and contactless directly on a substrate surface. For the front side metallization of PV-cells it is benficial that very thin und breakable cells can be handled and that Ag-finger width and cell shading can be reduced. Using a nanoparticle synthesis process developed at Fraunhofer

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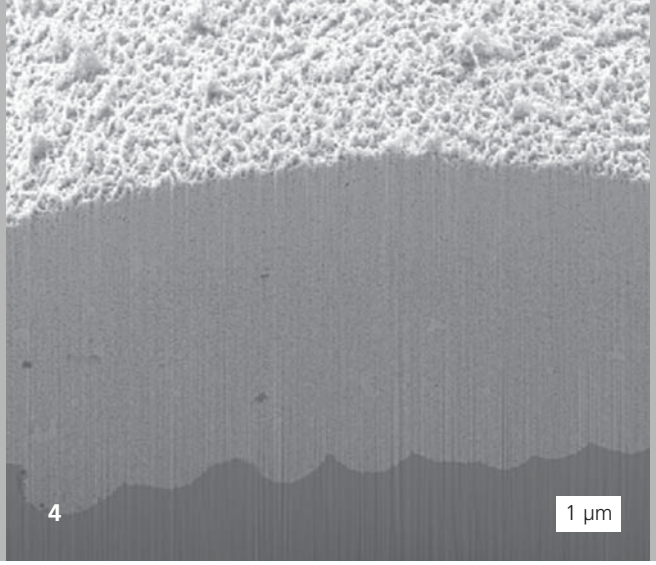

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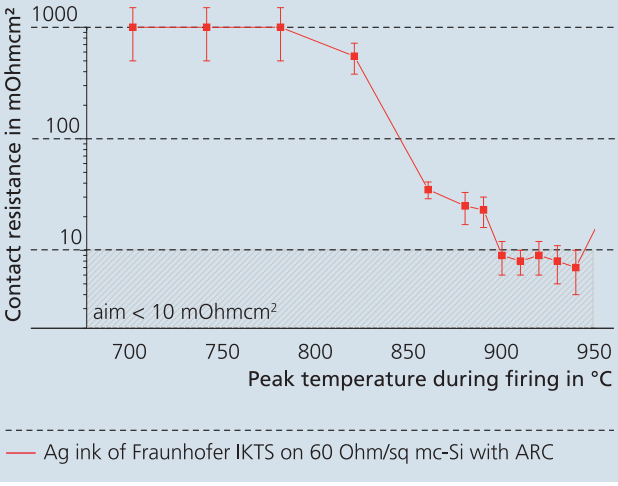
IKTS, water based Pb-free and Cd-free inks were prepared which can be printed directly on the antireflex coating (ARC) of crystalline solar cells. The optimization of the Ag particles dispersing method led to highly filled Ag inks having a solids content of up to 75 wt % and a viscosity of 20 mPas which is low enough for ink-jet printing. Using this printing method, exceptional high film thicknesses and aspect ratios of the Ag metallization of 1:3 (50 µm line width at 15 µm film thickness) were realized. The compatibility of the inks was demonstrated by means of industrial print heads from FUJIFILM Dimatix Inc. Inks with a particle size of 50 to 300 nm and a solid loading of 40 wt % turned out to be satisfactory and reproducible during the printing process.

During a rapid firing process of the cell, the ink etched the ARC – comparable to present-day thick-film pastes – and realized the electrical contact to the silicon cell. The resulting electrical conductivity of the metallization was in the range between 5 and 7 µOhmcm. Ink additives based on metal oxides play an important role in the contact mechanism as they form numerous silver seeds at the interface to the silicon. Contact resistances below 10 mOhmcm² were sufficiently low, so that a prior opening of the ARC was not necessary. In cooperation with Roth & Rau, solar cells of 6 inch (mc-Si 60 Ohm/sq and 75 Ohm/sq) were produced using this technology in a pilot line. Efficiencies of 15.9 % (best cell, 15.7 % average for eight cells of one batch) demonstrate the potential of this new printing method.

Services offered

- Paste and ink development
- Process development for thick-film and ink-jet printing
- PV-specific characterization methods

Behavior of contact resistance of an ink-jet printed Ag metallization on mc-Si with ARC



1 *Monitoring of screen printing results.*
2 *Microstructure of a screen-printed metallization.*
3 *Ink-jet printing of a solar cell.*
4 *Microstructure of an ink-jet printed Ag metallization.*

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2

WIRELESS INTERROGABLE TEMPERATURE SENSORS BASED ON CERAMIC SUBSTRATES

Dr. Michael Arnold

Motivation

Passive wireless interrogable temperature sensors based on surface acoustic wave transducers (SAW) are of great interest for wireless supervision and control of complex technical processes. One example is the acquisition of temperature values in closed reaction rooms.

The operation of such SAW sensors is based on particular crystal surfaces of piezoelectric single crystals, e.g. quartz, $LiNbO_3$, langasit or gallium orthophosphate, on which interdigital transducers are applied by thin-film processes. If certain resonance conditions are met, acoustic surface waves can be excited on these interdigital structures by means of high-frequency impulses. These generate a response signal due to the piezoelectric effect by imaging the crystal's surface and oscillation state. This state is dependent on temperature and pressure. Thus, the response signal can be used to determine these physical values.

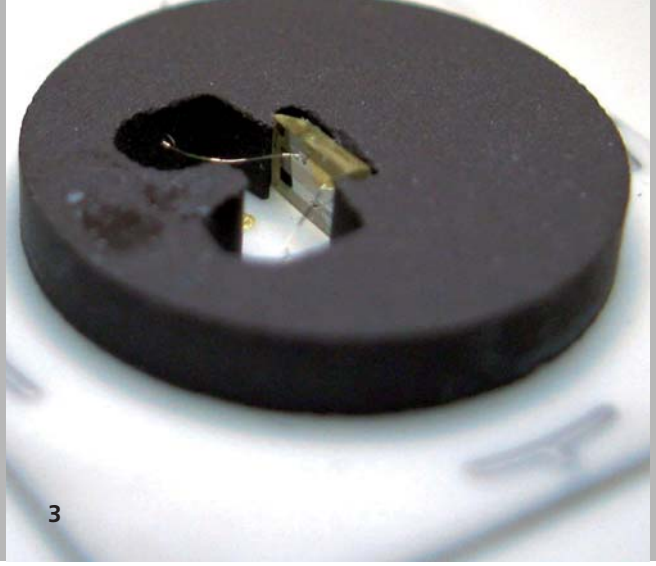
Although single crystalline SAW sensors reached technical maturity about 20 years ago and different systems have been commercially available since then, their application is currently limited by two aspects: the upper application temperature and the delicacy. The upper application temperature of conventional SAW sensors is limited by strong volume oscillations, high dielectric losses, phase shifts and increasing electric conductivity. For this reason, wireless interrogable temperature sensors can only be used up to temperatures of 350°C.

Approach

By applying piezoelectric thin films, the two main disadvantages of sturgeon oscillations, e.g. bulk waves, and high dielectric losses can be avoided. For this purpose, new SAWs were developed by applying a monocrystalline, piezoelectric layer on a polycrystalline substrate of high lattice symmetry and high surface quality by thin-film processes. In this case, only the piezoelectric layer with a thickness of about 10 µm is excited by a high frequency impulse so that bulk waves are mainly prevented.

Yttrium aluminum garnet (YAG) was chosen as substrate material on account of its high lattice symmetry. ZnO and AlN were used as thin-film compatible piezoelectric materials. The polycrystalline YAG substrates were produced by cold isostatic pressing (CIP) of reactive powders and subsequent sintering under high vacuum between 1700 and 1800°C. The sintering density obtained was 99.98 % of the theoretical density. Then, the sintered YAG blocks were cut into discs of 0.5 mm thickness, polished, sputtered with aluminum nitride and metalized with interdigital structures.

By combining substrates from YAG ceramics and sputtered single crystalline aluminum nitride layers, a piezoelectric multilayer system was realized which shows comparatively low impedance losses at high thermal loads. This was mainly caused by the lower damping due to the reduced decoupling of bulk waves. Using a complete ceramic housing for the wireless interrogable temperature sensors, their thermal and mechanical stability in terms of packaging technology was significantly improved.



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Results

New passive SAW transducers were developed in thin-film technology which can be used to build up wireless interrogable temperature sensors for the 433 MHz band. So, temperatures up to 450°C can be reproducibly measured with a resolution of 3 K above 400°C.

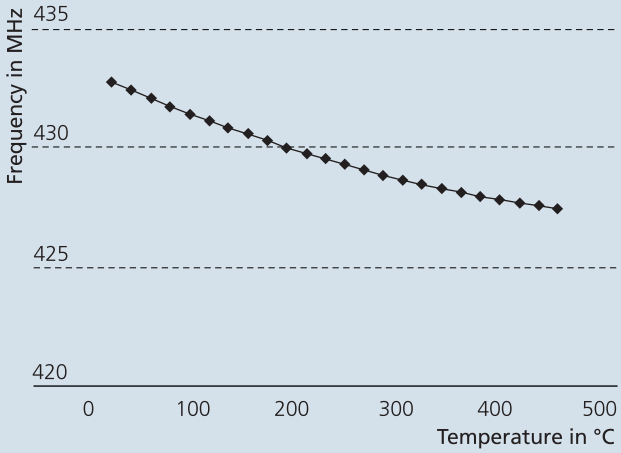
Acknowledgments

The results were obtained within the framework of a joint BMWi project (Reg.-Nr. IW091116) together with Micro-Hybrid Electronic GmbH, Siegert Thinfilm Technology GmbH and the Institute of Photonic Technology.

Services offered

- Supply of YAG substrates
- Development of application samples

Frequency-temperature curve of a 433 MHz temperature sensor based on YAG/AlN



1 *Transparent YAG ceramics.*
2/3 *Wireless interrogable temperature sensors up to 450°C with ceramic housing.*
4 *Temperature sensors in an industrial furnace.*

EVENTS AND EXHIBITIONS

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April 14, 2011
Royal visit to Dresden

The Queen Beatrix of the Netherlands, Prince Willem-Alexander and Princess Máxima were on a state visit to Germany in April. Aside from the economic relations between both countries the focus was on the development, which Germany had taken after its reunion. On their journey the royal family also came to Dresden where they visited the Fraunhofer Institute Center. There, the Queen took part in the "Dutch-German Seminar on Energy Innovations – Connecting PV Industries from Saxony and the Netherlands". About 150 Dutch and German experts accepted the invitation to join the Dutch-German Seminar on Energy Innovations which was organized by the embassy of the Netherlands in collaboration with the economic development agencies of Brabant and Saxony as well as the Fraunhofer Institute Center Dresden. It was the aim of the event to establish and develop cross-border cooperation activities in the field of photovoltaics. Thus, Dutch as well as German companies and research institutions can significantly strengthen their position in global competition.

September 21, 2011
First Hermsdorf Material and Technology Colloquium

At the suggestion of the Federal Association of Small and Medium-Sized Enterprises (BVMW), local association of the Jena/Saale-Holzland region, the first Hermsdorf Material and Technology Colloquium was organized at Fraunhofer IKTS. In three presentations, current developments in the field of energy and environmental technology, materials characterization and plastics engineering were examined. Within the framework of a lab tour, 60 participants had the opportunity to inform about the services offered by Fraunhofer IKTS.

September 21–23, 2011
ISPA 2011 – International Symposium on Macro Fiber Composite Applications

From September 21 to 23, the fifth International Symposium on Piezocomposite Applications ISPA took place in "Die Gläserne Manufaktur" of Volkswagen in Dresden. The aim of the ISPA symposium 2011 was to give participants from industry and research an overview of the variety of advanced applications as well as latest commercial developments and trends in the field of active structures. The symposium was organized by Fraunhofer IKTS, Volkswagen AG and Smart Material Corp. The program included more than 30 presentations of internationally renowned engineers and scientists, open discussions during the workshop, a poster session as well as a product display. More than 100 scientists and leading managers from nine countries, amongst them the USA, Canada, Spain, France and Singapore, came to Dresden and used this excellent platform to exchange ideas and to contact other interested partners for the collaboration of new marketable products in the field of piezoceramics. Due to the great interest the symposium series will be continued. The next ISPA will take place in Dresden in September 2013.

1 *Prof. Michaelis receives Queen Beatrix of the Netherlands within the framework of the "Dutch-German Seminar on Energy Innovations"*
2 *Prince Willem-Alexander during his speech at the seminar.*
3 *Participants of the fifth ISPA in "Die Gläserne Manufaktur" of Volkswagen in Dresden.*

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July 1, 2011
Long Night of Sciences

On July 1, Dresden universities and research facilities invited for the "Long Night of Sciences". This event, which took place for the ninth time, found general approval of the visitors. The Fraunhofer Institute Center also opened its doors and addressed children and teenagers in particular. So, little detectives could make their finger prints visible, do a jigsaw puzzle while getting information on the production process and possible applications of ceramic foams, or play chess with ceramic chess men. Furthermore, the visitors had the opportunity to observe microorganisms purifying waste water in a glassy waste water treatment plant, and to look over the shoulder of Fraunhofer scientist during automated injection molding of ceramic components.

November 4–6, 2011
Fraunhofer Talent School

After the success of 2009 and 2010, three Dresden Fraunhofer Institutes once more invited students of the tenth to thirteenth grade to a researcher's course. For one weekend, 35 young persons interested in science had the opportunity to discuss about current research topics as well as to experiment and develop own ideas in one of three workshops. At Fraunhofer IKTS, the students learned in exciting experiments, how different kinds of fuel cells work, where they can be used and how energy technology, thermodynamics, chemistry and materials sciences are combined to develop fuel cells. In 2011, the Fraunhofer Talent School took place at ten Fraunhofer institutes in Germany. The Dresden Fraunhofer institutes plan to host the fourth Fraunhofer Talent School in November 2012. www.talent-school-dresden.de

November 10, 2011
Fourth Saxon Fuel Cell Day

The Fuel Cell Initiative Saxony and EnergieCity Leipzig hosted the fourth Saxon Fuel Cell Day in Leipzig. This seminar was meant to be a presentation, information and communication platform for Saxon fuel cell developers and researchers, thus serving as German network in the field of systems development. Aside from presentations in the field of fuel cells, ten presentations dealt with chemical energy storage systems which will gain in importance in form of hybrid systems in mobile as well as stationary applications.

Awards

Böttger medal awarded to Dr. Bärbel Voigstberger

Dr. Bärbel Voigtsberger, deputy director of the Fraunhofer IKTS, Hermsdorf institute branch, was awarded the Böttger medal at the annual meeting of the German Ceramic Society (DKG). This medal made from brown Böttger stoneware at the Meissen Porcelain Manufactory has been awarded since 1929 by the DKG's board for outstanding services to the cooperation between science and industry in the field of ceramics. This prize honors the contributions of Dr. Bärbel Voigtsberger as vice chair and member of the DKG committee and as chairperson of the "Advanced Ceramics" committee.

Thuringian Research Award honors the development of ceramic membranes for oxygen generation

Dr. Ralf Kriegel and his colleagues from the Fraunhofer Institute for Ceramic Technologies and Systems in Hermsdorf are one of three prizewinners of the Thuringian Research Award 2011, which was awarded by Christoph Matschie, the Thuringian Minister of Education, Science and Culture, on April 1, 2011. The prize, which has been awarded since 1995 for outstanding

3 © Thuringian Ministry of Education, Science and Culture

research and development results, honors the pioneering work in the field of "Ceramic membranes for oxygen generation". Kriegel's research group developed a new production method for ceramic membranes which can separate 100-percent oxygen from other gases at high temperatures. This way 170 l pure oxygen can be produced per hour using a transportable testing device. Aside from power plant engineering and steel production, the ceramic membranes can be used in the glass and ceramic industry or for biomass gasification.

Professor Alexander Michaelis receives Bridge Building Award by the American Ceramic Society

Prof. Alexander Michaelis, director of the Fraunhofer Institute for Ceramic Technologies and Systems IKTS, was awarded the ACerS Bridge Building Award at the 36th International Conference and Exposition on Advanced Ceramics and Composites (ICACC) in Daytona Beach on January 23, 2012. With more than 1,100 participants from more than 50 countries, this conference is one of the most important international events in the field of advanced ceramics. The Bridge Building Award, which is annually awarded by the American Ceramic Society, recognizes individuals who have made outstanding contributions to engineering ceramics and thus significantly contributed to the visibility of the field and international advocacy. The award, in particular, recognizes the contribution of Prof. Michaelis in the field of energy and environmental technology.

Two apprentices at Fraunhofer IKTS honored for their good results

Since 2004, the Fraunhofer-Gesellschaft has been honoring its best apprentices who completed their apprenticeship with the examination mark "very good" or as best of the respective chamber of commerce and industry. In this year's ceremony, the Fraunhofer board honored two Fraunhofer IKTS apprentices and their trainers: Stephanie Kaiser (chemical laboratory technician) and her trainer Dr. Annegret Potthoff as well as Andreas Böhme (physics laboratory technician) and his trainer Christine Peschka.

1 *Prof. Sabine von Schorlemer, Saxon State Minister for Science and Arts, visiting the Long Night of Sciences.*

2 *Participants of the fuel cell workshop during the third edition of Fraunhofer Talent School in Dresden.*

3 *Research group of Fraunhofer IKTS Hermsdorf receives Thuringian Research Award.*

PARTICIPATION IN TRADE FAIRS AND EXHIBITIONS

1

January

Enertec/Terratec
Leipzig, January 25–27, 2011

February

nano tech
Tokyo, February 16–18, 2011
Joint stand of Fraunhofer-Gesellschaft

March

Innovation Materials and Technologies
Moscow, March 1–3, 2011

Z Zuliefermesse
Leipzig, March 1–4, 2011
Joint stand of Fraunhofer AutoMOBILE Production Alliance

International Dental-Schau IDS
Cologne, March 22–26, 2011

April

Hannover Messe
Hanover, April 4–8, 2011
- Joint stand of Fraunhofer IKTS/TASK GmbH
- Joint stand of Fraunhofer Fuel Cell Initiative Saxony
- Joint stand of Fraunhofer Energy Alliance
- Joint stand of LEG Thüringen

May

SMT/HYBRID/PACKAGING
Nuremberg, May 3–5, 2011
Joint stand "Future Packaging"

International Biomass Conference Leipzig
Leipzig, May 24–25, 2011
Joint stand with Fraunhofer UMSICHT

2

3 © Leipziger Messe

June

Sensor + Test
Nuremberg, June 7–9, 2011
Joint stand of Saxony

9th Dresden Engine Colloquium
Dresden, 8–9 June, 2011

Energy Harvesting and Storage
Munich, June 21–22, 2011

September

EU PVSEC
Hamburg, September 5–8, 2011

October

EuroPM
Barcelona, October 9–12, 2011

IMPAS
Long Beach, October 9–13, 2011

POWTECH
Nuremberg, October 11–13, 2011

Biotechnica
Hanover, October 11–13, 2011
Joint stand of Saxony

Materialica
Munich, October 25–27, 2011

November

FAD Conference
Dresden, November 2–4, 2011

Agritechnika
Hanover, November 13–19, 2011

Productronia
Munich, November 15–18, 2011
Joint stand with ANCeram GmbH

Hagen Symposium
Hagen, November 24–25, 2011

December

Euromold
Frankfurt/Main, November 29 – December 2, 2011
Joint stand of Fraunhofer Additive Manufacturing Alliance

1 *The "electricity from straw" exhibit is presented to the executive board of the Fraunhofer board as well as industry customers on the joint booth of the Fraunhofer Energy Alliance at Hannover Messe.*
2 *Thuringian Minister President Christine Lieberknecht visiting Ceramics Meeting Point at Hannover Messe.*
3 *First-time presentation of the transparent exhaust system at Z Zuliefermesse in Leipzig.*

COOPERATION IN GROUPS, ALLIANCES AND NETWORKS

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

Membership in Fraunhofer groups, alliances, networks and demonstration centers

Association for Manufacturing Technology and Development e.V. (GFE)

Association of Electrochemical Research Institutes e.V. (AGEF)

Association of German Engineers (VDI)

Association of the Thuringian Economy e.V., committee of research and innovation

Association of Thermal Spraying e.V. (GTS)

BioMeT Dresden Network

Ceramics Meeting Point in Dresden

DECHEMA – Society for Chemical Engineering and Biotechnology e.V.

DKG/DGM Community Committee

European Powder Metallurgy Association (EPMA)

European Research Association for Sheet Metal Working e.V. (EFB)

Expert Group on Ceramic Injection Molding (Working Group in the German Ceramic Society)

Fraunhofer Adaptronics Alliance

Fraunhofer Additive Manufacturing Alliance

Fraunhofer AdvanCer Alliance

Fraunhofer Demonstration Center AdvanCer

Fraunhofer Energy Alliance

Fraunhofer Group for Materials and Components – MATERIALS

Fraunhofer Nanotechnology Alliance

Fraunhofer Numerical Simulation of Products, Processes Alliance

Fraunhofer Sensor Network

Fraunhofer Water Systems Alliance (SysWasser)

Fuel Cell Initiative Saxony e.V. (BZS)

German Ceramic Society e.V. (DKG)

German Society for Materials Research e.V. (DGM)

International Zeolite Association

Materials Research Network Dresden e.V. (MFD)

Meeting of Refractory Experts Freiberg e.V. (MORE)

Micro-Nanotechnology Thuringia e.V. (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 e.V. (FAD)

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

Silicon Saxony e.V.

Society for Knowledge and Technology Transfer of TU Dresden mbH (GWT)

TransNanoPowder Information and Consulting Center

University of Applied Sciences Jena, university council

GROUPS, ALLIANCES, NETWORKS

THE FRAUNHOFER GROUP FOR MATERIALS AND COMPONENTS – MATERIALS

Fraunhofer research in the field of materials science and technology covers the entire value chain from the development of new materials and the improvement of existing ones to manufacturing technology on a semi-industrial scale, the characterization of materials' properties and the assessment of their performance. This work extends to the components produced from the materials and their performance in systems.
In addition to experimental tests in laboratories and pilot plants, numerical simulation and modeling techniques are applied in all these areas. The Fraunhofer Group for Materials and Components – MATERIALS encompasses the entire field of metallic, inorganic-nonmetallic, polymer and sustainable materials, as well as semiconductor materials.
The Group concentrates its expertise in the Energy & Environment, Mobility, Health, Machinery & Plant Engineering, Construction & Living, Microsystems Technology, and Safety business sectors. System innovations are achieved by means of tailor-made material and component developments and customer-specific performance assessment.

Key aims of the Group are

- To increase safety and comfort and to reduce the consumption of resources in transport, mechanical engineering and plant construction
- To raise the efficiency of systems for generating, converting and storing energy
- To improve the biocompatibility and functioning of materials used in medical engineering and biotechnology
- To increase the integration density and improve the utility properties of components in microelectronics and microsystem technology
- To improve the use of raw materials and the quality of the products made from them

The Group comprises 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
- Silicate Research ISC
- Solar Energy Systems ISE
- Systems and Innovation Research ISI
- Mechanics of Materials IWM
- Non-Destructive Testing IZFP

Permanent guests of the Group are the Institutes for:
- Industrial Mathematics ITWM
- Interfacial Engineering and Biotechnology IGB.

Chairman of the Group

Prof. Dr.-Ing. Holger Hanselka
Fraunhofer Institute for Structural Durability and System Reliability, LBF

www.materials.fraunhofer.de

FRAUNHOFER ADVANCER ALLIANCE

Systems development with high-performance ceramics

The application of high-performance ceramics allows for new applications in energy technology, mechanical and plant engineering, and medical technology. Well-known examples are combustion-chamber linings, roller bearings and implants. This innovative area has become an established field of expertise of the Fraunhofer-Gesellschaft.

Seven Fraunhofer institutes (IKTS, IPK, IPT, ISC, IWM, IZFP and LBF) have joined together to form the Fraunhofer AdvanCer. The research activities of the 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. Current R&D activities focus on joining and integration methods.

Since 2005, the Fraunhofer Demonstration Center AdvanCer has been offering training courses for technicians and engineers. The three parts being offered follow one after another, but can also be taken as single courses.

Fields of cooperation

- Materials development for structural ceramics, functional ceramics, fiber-reinforced ceramics, cermets, ceramic composites and adaptive composite materials
- Component design and development of functional 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, proof-testing and non-destructive testing
- Defect analysis, failure analysis, quality management

Services offered

- Consulting and execution of feasibility studies
- Method and technology development
- Prototype development, technology transfer
- Completion of contract research, conceptualization and execution of alliance projects
- Workshops, seminars, training programs

Spokesperson of the alliance

Dr. Michael Zins
Fraunhofer IKTS
michael.zins@ikts.fraunhofer.de

www.advancer.fraunhofer.de

1 *Shot-peened ceramic gears.*

CERAMICS MEETING POINT

Industry partners increasingly use the fast access via Ceramics Meeting Point to the research infrastructure of the Fraunhofer-Gesellschaft. The cooperation of Fraunhofer IKTS, TASK GmbH and its various members forms the basis for various industry projects, ranging from the analysis and characterization of materials to the exclusive development project for large-scale production. The opportunity to see the latest research topics in one room and to get in contact with possible suppliers is considered as added value when visiting Fraunhofer IKTS. Further Fraunhofer institutes are integrated via the Fraunhofer AdvanCer Alliance.

The institute and the ceramic manufacturers draw a bow from raw materials to systems and from prototypes to series components. TASK GmbH supports the Fraunhofer Demonstration Center AdvanCer in conducting its workshops and training courses by providing the required practice-relevant and market information. Close collaboration between the researchers of the Fraunhofer Demonstration Center AdvanCer and the ceramic manufacturers has enabled users to quickly realize their ideas. Thus, a project forum for small and medium-sized companies has developed facilitating contacts to project initiators and research institutes.

Members of Ceramics Meeting Point

TASK Technologie-Agentur Struktur-Keramik

By visiting Ceramics Meeting Point within the framework of numerous events taking place at Fraunhofer IKTS once again 1850 visitors could inform about ceramic product innovations and manufacturers in 2011. Lots of the new exhibits focus on energy and environmental technology. Suppliers' interest in this sector is growing. In addition to Hannover Messe, CERAMITEC in Munich will be one strategic focus in this field.

1 *Visitors tour through Ceramics Meeting Point.*

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Design and Characterization of LTCC/PZT modules (LMPs) for sensor and actuator applications
3rd Scientific Symposium CRC/Transregio 39 PT-PIESA – Integration of active functions into structural components, Chemnitz (12./13.10.2011), presentation

Gebhardt, S.
Integrated piezoelectrics based on PZT thick films: Advantages and limitations
International Symposium on Piezocomposite Applications – ISPA 2011, Dresden (22./23.9.2011), presentation

Geier, M.; Eberstein, M.; Partsch, U.; Völkel, L.; Böhme, R.; Mann, G.; Bonse, J.; Krüger, J.
Impact of laser treatment on phosphoric acid coated multicrystalline silicon PV wafers
26th European Photovoltaic Solar Energy Conference and Exhibition – EU PVSEC, Hamburg (5.-9.9.2011), poster

Gestrich, T.
Grundlagen der Thermoanalytik: Optimierung der Entbinderungs- und Sinterprozessen
DKG-Fortbildungsseminar »Thermoplastische Formgebung von

Technischer Keramik«, Dresden (5.-6.10.2011), presentation

Gestrich, T.; Jaenicke-Rößler, K.; Herrmann, M.
High temperature corrosion of hardmetals
Powder Metallurgy Congress and Exhibition – Euro PM2011, Barcelona, Spain (9.-12.10.2011), presentation

Gestrich, T.; Jaenicke-Rößler, K.; Leitner, G.; van den Berg, H.; Rödiger, K.
Reaktionen und Praxis beim Sintern von Hartmetallen
30. Hagener Symposium Pulvermetallurgie mit Fachausstellung – Sintern – der zentrale Prozess der Pulvermetallurgie, Hagen (24./25.11.2011), presentation

Gestrich, T.
Thermoanalytik zur Optimierung der Entbinderungsprozesse
DKG-Fortbildungsseminar »Entbinderung keramischer Formteile«, Dresden (6./7.10.2011), presentation

Glöß, B.; Fries, M.; Nebelung, M.
Flow properties of spray dried granules in dependence of production conditions
Powder Flow 2011, London, UK (6.12.2011), poster

Goldberg, A.
The multilayer technology as integration system for ceramic micro fuel cells
IMAPS European Microelectronics Packaging Conference – EMPC-2011, Brighton, UK (12.-15.9.2011), presentation

Günther, C.; Richter, H.; Voigt, I.
Entwicklung von Zeolithmembranen für die precombustion Gasaufbereitung in Kraftwerksanlagen
Thüringer Werkstofftag, Jena (30.3.2011), poster

Günther, C.; Richter, H.; Voigt, I.
H_2-permeable zeolite membranes
23. Deutsche Zeolithtagung, Erlangen (2.-4.3.2011), poster
Dresdner Werkstoffsymposium, Dresden (9./10.12.2010), poster
Network Young Membranes 2011, Amsterdam, the Netherlands (21.07.-23.7.2011), presentation

Haderk, K.; Scheithauer, U.; Richter, H.-J.; Petasch, U.; Zins, M.; Michaelis, A.
Development of graded porous calcium aluminate ceramics by ceramic tape technology for thermal shock resistant refractory materials
17th International Conference on Refractories, Praha, Czech Republic (10./11.5.2011), presentation

Haderk, K.
Development of graded porous calcium aluminate ceramics by ceramic tape technology for thermal shock resistant refractory materials
54. Internationales Feuerfest-Kolloquium 2011, Aachen (19./20.10.2011), presentation

Heddrich, M.
System tests and operation control strategies of an SOFC-CHP-device for field testing
219th Electrochemical Society Meeting, Montréal, Canada (1.-6.5.2011), poster

Heddrich, M.; Jahn, M.; Michaelis, A.; Reichelt, E.
Thermodynamic influence analysis of available fuels and reforming methods on SOFC system efficiency
12th International Symposium on Solid Oxide Fuel Cells – SOFC-XII, Montreal, Canada (1.-6.5.2011), p.955-962, presentation

Hermann, K.; Voigt, I.; Weyd, M.; Duscher, S.; Prehn, V.
Pflege heißer, hochalkalischer Flaschenreinigungsbäder durch Einsatz keramischer Membranen
DECHEMA/DWA Industrietage Wassertechnik, Frankfurt (7./8.11.2011), presentation

Herrmann, M.; Höhn, M.; Sempf, K.; Matthey, B.
Artefaktfreie Präparation und Charakterisierung von keramischen Oberflächen und Interfaces
6. Höhr-Grenzhäuser Keramik-Symposium, Höhr-Grenzhausen (29./30.9.2011), Eingeladener presentation

Herrmann, M.; Sempf, K.; Blug, B.; Höfer, M.; Schäfer, L.; Schrüfer, A; Otschick, J.
DiaCer materials – New materials for a wide range of challenging applications
European Symposium on Friction, Wear and Wear Protection 2011, Karlsruhe (25.-28.10.2011), present.

Herrmann, M.; Matthey, B.; Höhn, S.
Diamant-Keramik Komposite – Neue Werkstoffe für Verschleißanwendungen
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Herrmann, M.
Diamond-ceramic-composites – new materials for wide range of applications
Engineering Ceramics 2011 from Materials to Components, Smolenice Castle, Slovakia (8.-12.5.2011), Eingeladener presentation

Herrmann, M.
Gefügedarstellung und -bewertung
Schulungsprogramm des Fraunhofer-Demonstrationszentrums AdvanCer, Freiburg (10./11.11.2011), presentation

Herrmann, M.; Schilm, J.
Hochleistungskeramik für korrosive Anwendungen
Schulungsprogramm des Fraunhofer-Demonstrationszentrums AdvanCer, Dresden (9./10.3.2011), presentation

Herrmann, M.; Gestrich, T.; Neher, R.; Höhn, S.; Michaelis, A.
Sintern von Nichtoxidkeramik
30. Hagener Symposium Pulvermetallurgie mit Fachausstellung – Sintern – der zentrale Prozess der Pulvermetallurgie, Hagen (24./25.11.2011), Eingeladener presentation

Herrmann, M.
Structural ceramics – high performance materials for a wide range of applications
62. Berg- und Hüttenmännischer Tag – Freiberger Forschungsforum, Freiberg (15.-17.6.2011), presentation

Herrmann, M.
Thermische Entbinderungsprozesse: Mechanismen – Methoden – Verfahren
DKG-Fortbildungsseminar »Entbinderung keramischer Formteile«, Dresden (6./7.10.2011), present.

Hildebrandt, S.; Michaelis, A.; Kinski, I.
Kontaktlose Druckverfahren für Metallisierungen am Fraunhofer IKTS – Contactless printing methods for metallization at Fraunhofer IKTS
Nano Goes Makro, Erfurt (10.2.2011), presentation

Hildebrandt, S.; Waltinger, A.; Geier, M.; Eberstein, M.; Mosch, S.; Partsch, U.; Michaelis, A.; Kinski, I.
Seedlayer deposition of a novel particle-free nickel ink
26th European Photovoltaic Solar Energy Conference and Exhibition – EU PVSEC, Hamburg (5.-9.9.2011), p.1803, poster

Himpel, G.
Entbinderungs- und Sintertechnik für spritzgegossene Keramik
DKG-Fortbildungsseminar »Thermoplastische Formgebung von Technischer Keramik«, Dresden (5./6.10.2011), presentation

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Entbinderungstechnik
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Hohlfeld, K.; Gebhardt, S.; Michaelis, A.
Piezoelectric composites based on free-formed PZT elements
International Symposium on Piezocomposite Applications – ISPA 2011, Dresden (22./23.9.2011), poster

Höhn, S.
Charakterisierung der Formkörper: Defektentstehung, Nachweis, Vermeidung
DKG-Fortbildungsseminar »Entbinderung keramischer Formteile«, Dresden (6./7.10.2011), present.

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Charakterisierung von Granulat- und Grünkörperstrukturen über Ionenstrahlpräparation und bildanalytische Verfahren
DKG-Herbstsymposium »Charakterisierungsverfahren in der keramischen Aufbereitung: Vom Pulver bis zum Grünkörper«, Erlangen (29./30.11.2011), presentation

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Quantification on internal structures of spray-dried granules
12th Conference of the European Ceramic Society – ECerS XII, Stockholm, Sweden (19.-23.6.2011), presentation

Hu, W.; Flössel, M.; Suchanek, G.; Jaenicke-Rößler, K.; Gebhardt, S.; Schönecker, A.; Gerlach, G.
Determination of the polarization state in LTCC/PZT piezoelectric sensor-actuator modules
International Conference 'PIEZO 2011-Electroceramics for End-Users VI', Sestriere, Italy (28.2.-2.3.2011), presentation

Hufenbach, W.; Fischer, W.-J.; Michaelis, A.; Gebhardt, S.; Geller, S.; Tyczynski, T.; Heinig, A.; Weder, A.; Hohlfeld, K.
Integration of piezoceramic and electronic functional elements in glass fibre-reinforced polyurethane composite structures
3rd Scientific Symposium CRC/Transregio 39 PT-PIESA – Integration of active functions into structural components, Chemnitz (12./13.10.2011), poster

Jackschik, S.; Benner, F.; Kupke, S.; Endler, I.; Mikolajik, T.
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guidance for improvements
26th European Photovoltaic Solar Energy Conference and Exhibition – EU PVSEC, Hamburg (5.-9.9.2011), 2CV.4.41, poster

Jobst, K.; Deutschmann, A.; Friedrich, E.
Optimierung von Mischprozessen zur Biogaserzeugung – Ein Beitrag zur Steigerung der Effizienz von Biogasanlagen
4. Innovationskongress Biogas 2011, Osnabrück (12./13.5.2011), p.99-104, presentation

Jobst, K.
Optimierung von Mischprozessen zur Biogaserzeugung
6. Fachtagung Biogas 2011 – Energieträger der Zukunft, Braunschweig (8./9.6.2011), poster

Jobst, K.; Deutschmann, A.; Lincke, M.; Lomtscher, A.; Eberhard, F.
Optimierung von Mischprozessen zur Biogaserzeugung
Fachtagung Regenerative Energie als Zukunftstechnologie, Köthen (13./14.10.2011), poster

Johannes, M.; Lausch, H.; Sandkuhl, O.; Rudolph, H.; Udart, M.; Herold, V.
Strukturierung keramischer Implantatoberflächen mittels Schlickerguss
Zukunftsarena Oberflächentechnik und 8. Thüringer Biomaterial-Kolloquium 2011, Zeulenroda/Triebes (13.-15.9.011), poster

Johannes, M.; Sandkuhl, O.
Strukturierung von Hochleistungskeramik mittels Schlickerguss
DKG-Jahrestagung Saarbrücken (28.-30.3.2011), poster

Junige, M.; Knaut, M.; Geidel, M.; Riedel, S.; Endler, I.; Wojcik, H.; Albert, M.; Merkel, U.; Bartha, J.W.
Characterization of ruthenium ALD and PVD thin films for in-situ process control by spectroscopic ellipsometry
6. Workshop Ellipsometry des Arbeitskreises Ellipsometrie Paul Drude e.V. (AKE), Berlin (21.-24.2.2011), presentation

Kämnitz, S.; Kaltenborn, N.; Richter, H.; Voigt, I.
Adsorption selective carbon membranes on ceramic supports
International Congress on Membranes and Membrane Processes – ICOM, Amsterdam, the Netherlands (23.-29.7.2011), poster

Keitel, U.
Characterization of fluid devices
International Symposium on Piezocomposite Applications – ISPA 2011, Dresden (22./23.9.2011), presentation

Khavrus, V.O.; Weiser, M.; Fritsch, M.; Ummethala, R.; Salvaggio, M.G.; Schneider, M.; Kusnezoff, M.; Leonhardt, A.
CCVD of aligned carbon nanotubes on aluminium foils and their test as components of supercapacitors
International Conference on the Science and Application of Nanotubes – NT11, Cambridge, UK (10.-16.7.2011), poster

Khavrus, V.O.; Weiser, M.; Fritsch, M.; Ummethala, R.; Salvaggio, M.G.; Schneider, M.; Kusnezoff, M.; Leonhardt, A.
Direct growth of aligned carbon nanotubes on aluminium foils and their application as components of supercapacitors
4th International Conference on Carbons for Energy Storage/ Conversion and Environment Protection – CESEP, Vichy, France (25.-29.9.2011), presentation

Kinski, I.; Meinhard, S.; Henke, B.; Herrmann, M.; Schweizer, S.
Nano-crystalline $SrAl_20_4$ persistent phosphors doped with EU^{2+} and Dy^{3+}
219th Electrochemical Society Meeting, Montréal, Canada (1.-6.5.2011), presentation

Kircheisen, R.; Schulz, M.; Kriegel, R; Töpfer, J.
Sauerstoffstöchiometrie, Sauerstoffffluss und CO_2-Stabilität von $Sr(Co_{0,8}Fe_{0,2})_{1-x}Ti_xO_{3-\delta}$ für sauerstoffpermeable Membranen
DKG-Jahrestagung, Saarbrücken (28.-30.03.2011), presentation
Symposium Hochleistungskeramik, Karlsruhe (25./26.10.2011), poster

Kita, J.; Missal, W.; Wappler, E.; Bartnitzek, T.; Pawlowski, B.; Kipka, A.; Moos, R.
Development of a novel LTCC-chip for fast DSC-analysis
IMAPS/ACerS 7th International Conference and Exhibition on Ceramic Interconnect and Ceramic Microsystems Technologies – CICMT 2011, San Diego, California, USA (5.-7.4.2011), poster

Klemm, H.
Development of ceramic materials for gas turbine applications
4th German-Polish Colloquium Science and Art in Europe, Otzenhausen (19.-22.10.2011), presentation

Klemm, H.; Bales, A.; Nake, K.; Michael, G.
High-temperature characterization of ceramic materials by hot-hardness measurement
35th International Conference and Exposition on Advanced Ceramics

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and Composites – ICACC 2011, Daytona Beach, Florida, USA (23.-28.1.2011), presentation

Klemm, H.
Hochleistungskeramik für Hochtemperaturanwendungen
Schulungsprogramm des Fraunhofer-Demonstrationszentrums AdvanCer, Dresden (9./10.3.2011), presentation

Klemm, H.; Nake, K.; Bales, A.; Michael, G.
Hochtemperaturcharakterisierung von keramischen Werkstoffen durch Wärmehärtemessung
Fachausschusssitzung FA 12 Härteprüfung, Dresden (23./24.3.2011), presentation

Klemm, H.; Kunz, W.; Bales, A.; Oberländer, A.; Schönfeld, K.; Michaelis, A.
Hot gas corrosion of non-oxide ceramic fibre composites
9th International Meeting of Pacific Rim Ceramic Societies – PacRim 9, Cairns, North Queensland, Australia (10.-14.7.2011), presentation

Klemm, H.
Keramische Faserverbundwerkstoffe am IKTS
21. Kuratoriumssitzung, Fraunhofer IKTS, Dresden (10.5.2011), presentation

Klemm, H.; Schönfeld, K.; Herrmann, M.; Lippmann, W.
Keramische Faserverbundwerkstoffe für Hochtemperaturanwendungen
Zukunft Energie, Dresden (11.-13.5.2011), presentation

Klemm, H.
Low-cost-Technologien zur Herstellung von Bauteilen aus keramischen Faserverbundwerkstoffen
Fraunhofer-Symposium »Netzwert« 2011, München (28./29.11.2011), presentation

Klemm, H.; Müller, A.
Material- und Verfahrensentwicklung von kostengünstigen kurzfaserverstärkten Verbundwerkstoffen
6. MV Ceramic Composites im CCeV, Dresden (10./11.10.2011), presentation

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Non-oxide ceramic fibre composites
9th International Meeting of Pacific Rim Ceramic Societies – PacRim 9, Cairns, North Queensland, Australia (10.-14.7.2011), presentation

Krell, A.; Wätzig, K.; Klimke, J.
Effects and elimination of nanoporosity in transparent sintered spinel ($MgAl_2O_4$)
SPIE Defense, Security + Sensing, Window & Dome Technologies and Materials XII, Orlando, Florida, USA (25.-29.4.2011), Paper 801602, presentation

Krell, A.
Hochleistungskeramik für Verschleißanwendungen
Schulungsprogramm des Fraunhofer-Demonstrationszentrums AdvanCer, Dresden (9./10.3.2011), presentation

Krell, A.; Wätzig, K.; Klimke, J.
Influence of the structure of $MgO{\cdot}nAl_2O_3$ spinel lattices on transparent ceramics processing and properties
12th Conference of the European Ceramic Society – ECerS XII, Stockholm, Sweden (19.-23.6.2011), presentation

Kriegel, R.; Schulz, M.; Ritter, K.; Kiesel, L.; Pippardt, U.; Stahn, M.; Voigt, I.
Advanced membrane design for oxygen separation
2nd International Conference on Energy Process Engineering, Efficient Carbon Capture for Coal Power Plants, Frankfurt/Main (20.-22.6.2011), presentation

Kriegel, R., Voigt, I.
Demonstration of oxygen separation with BSCF membranes
12. Jülicher Werkstoffsymposium (5./6.9.2011), presentation

Kriegel, R.
Entwicklung und Musterfertigung sauerstoffpermeabler keramischer Membranen
22. Treffen des Arbeitskreises »Keramische Membranen«, Frankfurt/Main (5.5.2011), present.

Kriegel, R.; Schulz, M.; Voigt, I.; Sommer, E.
Sauerstoff-Membranen in Kleinanwendungen – Ein Einstieg in die Kommerzialisierung?
Thüringer Werkstofftag 2011, Jena (30.3.2011), poster

Krug, M.
ALD deposition of passivation layers
Novel High k Application Workshop, Dresden (30.3.2011), present.

Kucera, A.
Deep drawing and embossing of tapes
Public Workshop on Tape Assembly, Stockholm, Sweden (29.3.2011), presentation

Kucera, A.; Richter, H.-J.; Moritz, T.
Structuring of UV-curable ceramic green tapes

4M 2011 Conference, Stuttgart (8.-10.11.2011), presentation

Kucera, A.; Richter, H.-J.; Moritz, T.
Development of UV curable alumina tapes and their 3D structuring
12th Conference of the European Ceramic Society – ECerS XII, Stockholm, Sweden (19.-23.6.2011), poster

Kühnert, J-T.; Voigt, I.; Richter, H.; Weyd, M.; Tusel, E.; Brüschke, H.E.A.
Progress in NaA-zeolite membrane preparation and implementation in the bioethanol production process
International Congress on Membranes and Membrane Processes, Amsterdam, the Netherlands (23.-29.7.2011), poster

Kühnert, J-T.; Weyd, M.; Richter, H.; Voigt, I.; Tusel, E.; Brüschke, H.E.A.
Evolution of membrane supports for dewatering of ethanol
International Scientific Conference on Pervaporation, Vapor Permeation and Membrane Distillation, Torun, Poland (8.-11.9.2011), presentation

Kusnezoff, M.; Michaelis, A.; Trofimenko, N.
Electrochemical phenomenain MEA electrodes
Widjaja, Sujanto (Ed.) u.a.; The American Ceramic Society (ACerS): 35th International Conference and Exposition on Advanced Ceramics and Composites – ICACC 2011, Daytona Beach, Florida, USA (23.-28.1.2011), No.4, p.37-60, presentation

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Maßgeschneiderte keramische Schichtheizelemente, hergestellt durch thermisches Spritzen
DKG-Jahrestagung 2011, Saarbrücken (28.-30.3.2011), presentation

Lackner, G.; Endler, I.; Meißner, F.; Shvartsman, V.V.; Bezugly, V.; Boucher, R.; Thieme, M.; Mkandawire, M.; Meiss, J.; Pfützner, S.; Michaelis, A.; Lupascu, D.C.
Carbon naotubes in solar cell application
26th European Photovoltaic Solar Energy Conference and Exhibition – EU PVSEC, Hamburg (5.-9.9.2011), poster

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Carbon nanotubes in solar cell application
2nd International Conference Organic Photovoltaics, Würzburg (21.9.2011), poster

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Infiltration study of vertically-aligned carbon nanotube forest (va-CNT) with different organic semiconductor materials forming a composite
9th Ferrocene Colloquium, Chemnitz (14.-16.2.2011), present.

Langklotz, U.; Schneider, M.; Seifert, C.; Michaelis, A.
Ramanspektroskopie an foliengegossenem LCO-Elektrodenmaterial
Zukunft Energie, Dresden (11.-13.5.2011), poster

Langklotz, U.; Schneider, M.; Michaelis, A.
Thickness dependency of the relative permittivity ε_r of very thin oxide films investigated by micro-EIS
International Workshop on Impedance Spectroscopy – IWIS 2011, Chemnitz (28.-30.9.2011), present.

Lankau, V.; Martin, H.-P.
Charakterisierung und Modifikation der elektrischen Eigenschaften von festphasen-gesintertem SiC
DGM/DKG-Symposium Hochleistungskeramik »Hochleistungskeramik als Systemkomponenten« in Verbindung mit dem Abschlusskolloquium des SFB 483 »Hochbeanspruchte Gleit- und Friktionssysteme auf der Basis ingenieurwissenschaftlicher Werkstoffe«, Karlsruhe (25./26.10.2011), poster

Lenz, C.; Ziesche, S.; Partsch, U.
Piezoresistive Miniaturkraftsensoren in LTCC
10. Dresdner Sensor Symposium – DSS, Dresden (5.-7.12.2011), poster

Lenzner, K.; Glöß, B.; Eckhard, S.
Granulatcharakterisierung
DKG-Fortbildungsseminar »Technologische Grundlagen der Granulierung und Granulatverarbeitung«, Dresden (14./15.4.2011), presentation

Lenzner, K.; Glöß, B.; Eckhard, S.
Granulatcharakterisierung – Werkzeug für Optimierung von Produktentwicklung und Sprühprozessen
DKG-Fortbildungsseminar »Sprühtrocknung«, Dresden (8./9.11.2011), presentation

Lincke, M.; Fassauer, B.; Schwarz, B.; Wufka, A.; Friedrich, E.; Jobst, K.

PRESENTATIONS AND POSTERS

Erhöhte und bedarfsorientierte Biogasproduktion auf Basis des DECONDIS-Verfahrens: Optimierung von Mischprozessen zur Biogaserzeugung
6. Fachtagung Biogas 2011 Energieträger der Zukunft, Braunschweig (8./9.6.2011), presentation

Lomtscher, A.; Jobst, K.; Friedrich, E.
Bewertung von Mischprozessen mittels Prozess-Tomographie: Ein neuer Weg zur Optimierung von Rührprozessen
14. Köthener Rührer-Kolloquium, Köthen (16.6.2011), presentation

Lubkowski, G.; Kuhnhenn, J.; Suhrke, M.; Weinand, U.; Endler, I.; Meißner, F.; Richter, S.
Gamma radiation effects in vertically aligned carbon nanotubes
Conference on Radiation Effects on Components and Systems – RADECS, Sevilla, Spain (19.-23.9.2011), poster

Mannschatz, A.; Ahlhelm, M.; Moritz, T.; Michaelis, A.
3D visualization of flow pattern in injection molded green parts
International Conference on Injection Molding of Metals – MIM2011, Ceramics and Carbides, Orlando, USA (14.-16.3.2011), presentation

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Enabling co-sintering of ATZ/ZTA ceramic compounds by two-compoent injection moulding with intermediate green tapes
Powder Metallurgy Congress and Exhibition – Euro PM2011, Barcelona, Spain (9.-12.10.2011), presentation

Marschallek, F.; Adler, J.; Böttge, D.; Füssel, A.; Jahn, M.; Michaelis, A.
Combustion in porous media – advances in process design and materials longterm stability
8th European Congress of Chemical Engineering – ECCE, Berlin (25.-29.9.2011), poster

Martin, H.-P.; Schilm, J.; Dannowski, M.; Pfeiffer, P.
Keramikbasierte thermoelektrische Generatoren für Fahrzeuge
9. Dresdner Motorenkolloquium »Der Dieselmotor – neue Herausforderungen«, Dresden (8./9.6.2011), p.133-143, presentation

Martin, H.-P.; Feng, B.; Conze, S.; Kinski, I.
Keramische Thermoelektrika als Werkstoff für thermoelektrische Generatoren
Zukunft Energie, Dresden (11.-13.5.2011), presentation

Martin, H.-P.
Untersuchungen zu Ta-Ni-Legierungen als Hochtemperaturlot für SiC-SiC Verbunde
Workshop Hochtemperaturfügen 2011 – Anwenderkreis Hochtemperaturfügen, ifw Jena (3.11.2011), presentation

Mayer-Uhma, T.; Potthoff, A.; Thieme, P.
Chemical and physical characterization of slurry and variation of the zeta potential
26th European Photovoltaic Solar Energy Conference and Exhibition – EU PVSEC, Hamburg (5.-9.9.2011), poster

Meißner, F.; Endler, I.; Jakisch, L.; Thomas, J.; Schönecker, A.; Michaelis, A.
Composites of aligned carbon nanotubes and polymers
International Conference on the Science and Application of Nanotubes – NT11, Cambridge, UK (11.-16.7.2011), poster

Meißner, T.; Potthoff, A.
Characterization of iron-based nanomaterials in terms of ecotoxicological relevance
6th International Conference on the Environmental Effects of Nanoparticles and Nanomaterials, London, UK (19.-21.9.2011), poster

Meißner, T.
Chemical-physical nanoparticle characterization to promote toxicological investigations
5th International Seminar »Nanotechnology, Energy, Plasma, Lasers« – NEPL-2011, Hermsdorf/Jena (1.-3.11.2011), presentation

Meißner, T.; Potthoff, A.
Fe-NANOSIT – Charakterisierung von eisenbasierten Nanomaterialien
1. Clustertreffen NanoCare/NanoFuture, Frankfurt (10./11.5.2011), poster

Meulenberg, W.A.; Baumann, S.; Kriegel, R.
Processing and properties of asymmetric oxygen transport membranes
Werkstoffsymposium, Jülich (5./6.9.2011), presentation

Meulenberg, W.A.; Voigt, I.; Kriegel, R.; Baumann, S.; Ivanova, M.; van Gestel, T.
Ceramic membranes for gas separation in advanced fossil power plants
Efficient Carbon Capture for Coal Power Plants, Frankfurt/Main (20.-22.6.2011), presentation

Michaelis, A.
Ceramic materials and technologies for fuel cells, batteries and

supercapacitors
Nanotech-Saxony Workshop der WFS, Tokyo, Japan (16.2.2011), presentation

Michaelis, A.
Ceramics for energy and environmental technology with focus on fuel cells, photovoltaics, energy storage systems and membranes
Third International Symposium on Advanced Ceramics and Technology for Sustainable Energy Applications – ACTSEA-2011, Pingtung, Taiwan (30.10.-2.11.2011), present.

Michaelis, A.
Hochleistungskeramik für die Energie- und Umwelttechnik
Regionalforum Dresden im Rahmen des DGM-Tages, Dresden (16.6.2011), presentation

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Hochleistungskeramik für die Energie- und Umwelttechnologie
MFD-Materialforschungstournee 2010/2011, Dresden (12.1.2011), presentation

Michaelis, A.
Innovationspotenziale für High Tech Märkte durch Einsatz von Hochleistungskeramiken
Entwicklung und Perspektiven der Keramik für High Tech Märkte, Ehrenkolloquium zum 60. Geburtstag von Frau Dr. Voigtsberger, Dresden (26.5.2011), presentation

Michaelis, A.
Keramische Materialien und Systeme für die Energietechnologien: Photovoltaik, Batterien und Brennstoffzellen
11. Leibniz-Konferenz »Solarzeitalter 2011«, Lichtenwalde (12./13.5.2011), presentation

Michaelis, A.
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EFDS-Hauptjahresversammlung, IKTS Dresden (22.11.2011), present.

Michaelis, A.
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Michaelis, A.
PV technology and the future
Dutch-German Seminar on Energy Innovations, Dresden (14.4.2011), presentation

Michaelis, A.
Thickfilm and multilayer ceramic technology for innovative fuel cell systems
35th International Conference and Exposition on Advanced Ceramics and Composites – ICACC 2011, Daytona Beach, Florida, USA (23.-28.1.2011), presentation

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12th International Symposium on Solid Oxide Fuel Cells – SOFC-XII, Montreal, Canada (1.-6.5.2011), p.269-277, presentation and poster

Moos, R.; Missal, W.; Kita, J.; Wappler, E.; Gora, F.; Kipka, A.; Bartnitzek, T.; Bechtold, F.; Schabbel, D.; Pawlowski, B.
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Sensor 2011, fms-Sondersession 2011, Workshop Sensorforschung für Medizin und Technik. Ergebnisse aus der industriellen Gemeinschaftsforschung, im Rahmen der Sensor + Test 2011, Nürnberg (9.6.2011), p.4-9, presentation

Moritz, T.
Entwicklungstrends im Keramikspritzguss
Entdeckungsreise in eine Welt der Keramik, Koblenz (13.4.2011), presentation

Moritz, T.
Fehlerquellen bei der Herstellung keramischer Werkstoffe
Schulungsprogramm des Fraunhofer-Demonstrationszentrums AdvanCer, Freiburg (10./11.11.2011), presentation

Moritz, T.
Formgebung
Schulungsprogramm des Fraunhofer-Demonstrationszentrums AdvanCer, Dresden (9./10.3.2011), presentation

Moritz, T.
Keramische Formgebung unter Verwendung organischer Additive
DKG-Fortbildungsseminar »Entbinderung keramischer Formteile«, Dresden (6./7.10.2011), presentation

Moritz, T.; Mannschatz, A.; Kucera, A.; Baumann, A.; Richter, H.-J.
Multifunctional ceramic component solutions by inmould labeling and multi component injection moulding
III. International Research and Practice Conference and Specialized Exhibition on Modern Ceramic Materials, Properties, Technology, Applications, Novosibirsk, Russia (14.-19.9.2011), presentation

PRESENTATIONS AND POSTERS

Mosch, S.; Paproth, A.; Partsch, U.; Wolter, K.-J.
Chipanschlusskontaktierung mittels aerosolgedruckter Strukturen
Systemintegration in der Mikroelektronik »smt hybrid packaging«, Nürnberg (3.-5.5.2011), present.

Müller, A.
Injection moulding of carbon short-fibre filled preceramic polymers
Nanocomposite, Paris, France (7.6.-10.6.2011), presentation

Müller, A.
Injection moulding of carbon short-fibre filled preceramic polymers
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Müller, S.; Richter, J.; Voigt. I.
Entwicklung von CNT-Schichten für Anwendungen in der Gastrennung
Thüringer Werkstofftag, Jena (30.3.2011), poster

Näke, R.
Verfahrenstechnische Entwicklung und automatisierter Betrieb eines Biogas-SOFC-Systems
4. Sächsischer Brennstoffzellentag, Leipzig (10.11.2011), presentation

Oberländer, A.; Michaelis, A.; Pezzotti, G.; Kinski, I.
Investigation of the structure and optical properties of cubic gallium oxynitride synthesized using a hydrothermal processing route
7th SRK Workshop on Advanced Materials, Busan, South Korea (10.-12.11.2011), presentation

Oehme, F.
Grünbearbeitung technischer Hochleistungskeramik: Methoden, Instrumente und Entwicklungsrichtungen
Schulungsprogramm des Fraunhofer-Demonstrationszentrums AdvanCer, Berlin (4./5.5.2011), presentation

Oehme, F.
Hochpräzisionsbearbeitung mittels Koordinatenschleifen
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Ortmann, C.; Oberbach, T.; Richter, H.; Puhlfürß, P.
Properties of infiltration prepared ZTA bioceramics
12th International Conference and Exhibition of the European Ceramic Society, Stockholm, Sweden (19.-23.6.2011), presentation

Partsch, U.
Multilayerbasierte Komponenten und Mikrosysteme
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Pawlowski, L.; Börner, S.
Entwicklungsbegleitende Charakterisierung von Rohstoffen und Schlickern in der Folienherstellung
DKG-Herbstsymposium »Charakterisierungsverfahren in der keramischen Aufbereitung: Vom Pulver bis zum Grünkörper«, Erlangen (29./30.11.2011), present.

Pawlowski, B.; Barth, S.; Fischer, M.; Bartsch, H.; Hoffmann, M.; Müller, J.
SiCer – ein innovativer Substratwerkstoff für MEMS
Thüringer Werkstofftag, Jena (30.3.2011), poster

Peschel, M.; Schilm, J.; Eberstein, M.; Kretzschmar, C.; Krause, J.; Völkel, L.; Partsch, U.; Michaelis, A.
Synthesis and characterisation of new lead-free glasses for the front metallization of solar cells
26th European Photovoltaic Solar Energy Conference and Exhibition – EU PVSEC, Hamburg (5.-9.9.2011), poster

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Peschel, M.
Synthesis and characterization of new lead-free low melt sealing glasses
85. Glastechnische Tagung der Deutschen Glastechnischen Gesellschaft, Saarbrücken (30.5.-1.6.2011), poster

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Pfeifer, T.; Nousch, L.
System design and process layout for a SOFC micro-CHP unit with reduced operating temperature
European Fuel Cell 2011 Piero Lunghi Conference & Exhibition, Rome, Italy (14.-16.12.2011), presentation

Pigorsch, E.; Pensold, S.; Höhn, S.
Ion beam etching – A new high-resolution structural analysis method for paper coatings
106. Zellcheming-Jahrestagung, Wiesbaden (28.-30.6.2011), presentation

Pohl, M.
Fast start-up with ceramic fuel cell components
Beitrag zur Achema 2012, Frankfurt am Main (18.-22.6.2012), presentation

Pohl, M.; Jahn, M.; Michaelis, A.; Locke, C.
Prozessintensivierung in Hinblick auf das Temperaturverhalten eines SSiC-Katalysatorsystems bei der partiellen Oxidation
44. Jahrestreffen Deutscher Katalytiker mit Jahrestreffen Reaktionstechnik, Weimar (14.-18.3.2011), poster

Pohl, M.
Zündverhalten edelmetallfreier katalytischer Schaumkeramik bei der partiellen Oxidation
44. Jahrestreffen Deutscher Katalytiker mit Jahrestreffen Reaktionstechnik, Weimar (14.-18.3.2011), poster

Pönicke, A.; Triebert, A.; Sempf, K.; Gestrich, T.; Schilm, J.; Martin, H.-P.; Böhm, G.; Schnee, D.
Aktivlöten von Kupfer mit Aluminiumnitrid- und Siliziumnitridkeramik für die Hochleistungselektronik
DKG-Jahrestagung 2011, Saarbrücken (28.-30.3.2011), presentation

Pönicke, A.; Arnold, S.; Schilm, J.; Kusnezoff, M.
Mechanische Eigenschaften induktiv gelöteter YSZ-Metall-Verbunde mit Reaktivloten an Luft
2. W3-Kolloquium »Fügen von Metall, Keramik und Glas«, Hanau (29.11.2011), presentation

Pötschke, J.; Richter, V.; Holke, R.
Efficacy of VC and CR_3C_2 grain growth inhibitors in sintering binderless WC
Powder Metallurgy Congress and Exhibition – Euro PM2011, Barcelona, Spain (9.-12.10.2011), poster

Posdziech, O.; Mai, B.E.; Wunderlich, C.; Voss, S.
Status and market opportunities of solid oxide fuel cells based co-generation systems
International Gas Union Research Conference – IGRC, Seoul, South Korea (19.-21.10.2011), poster

Potthoff, A.; Meyer, A.
Charakterisierung des Aggregations- und Agglomerationszustandes nanoskaliger keramischer Partikel
DKG-Herbstsymposium »Charakterisierungsverfahren in der keramischen Aufbereitung: Vom Pulver bis zum Grünkörper«, Erlangen (29./30.11.2011), present.

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Charakterisierung von Nanopartikeln
DGM-Fortbildungsseminar »Nanoanalytik«, Dresden (28.-29.11.2011), presentation

Potthoff, A.
Pulver- und Suspensionscharakterisierung
DKG-Fortbildungsseminar »Technlogische Grundlagen der Granulierung und Granulatverarbeitung«, Dresden (14./15.4.2011), presentation

Räthel, J.; Herrmann, M.
Temperature distribution during FAST/SPS densification
12th Conference of the European Ceramic Society – ECerS XII, Stockholm, Sweden (19.-23.6.2011), presentation

Rabbow, T.J.; Wachtel, R.; Michaelis, A.; Stepowicz, J.K.; Eichler, R.; Decker, M.; Vonau, W.
Elektrochemische Abscheidung von Preußisch Blau für die Atemgasanalytik – Methodenvergleich und Schichtcharakterisierung
10. Dresdner Sensor Symposium – DSS, Dresden (5.-7.12.2011), poster

Rebenklau, L.
Aspekte der Aufbau- und Verbindungstechnik bei der Verbindungsbildung auf keramischen Dickschichtverdrahtungsträgern und LTCC-Substraten sowie Oberflächen auf der Basis polymerer Dickfilmpasten: Verfahrenscharakterisierung – Eigenschaftsmerkmale – Methoden und Verfahren
TAE-Seminar: Verbindungstechnologien der Aufbau- und Verbindungstechnik in der Elektronik, Ostfildern-Nellingen (4.-6.7.2011), presentation

Reichel, U.
Advanced biocompatible ceramics for implants
ERA.Net RUS Pilot Joint Call,

PRESENTATIONS AND POSTERS

Brokerage Event, Yekaterinburg, Russia (28.2.-2.3.2011), presentation

Reichel, U.
Advanced ceramic materials – history-present-prospects
III. International Research and Practice Conference and Specialized Exhibition on Modern Ceramic Materials, Properties, Technology, Applications, Novosibirsk, Russia (14.-19.9.2011), presentation

Reichel, U.
Ceramic nanomaterials – research & development
ERA.Net RUS Pilot Joint Call, Brokerage Event, Yekaterinburg, Russia (28.2.-2.3.2011), poster

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DIREKT Heißpressen von nanoskaligen Y-TZP-Pulvern
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Reichel, U.; Ludwig, H.; Kurland, H.-D.; Grabow, J.; Müller, F.A.
DIREKT-Heißpressen nanoskaliger Y-TZP-Pulver
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Reichel, U.
Durchsichtige Keramik: Vision oder Wirklichkeit?
407. JENAer Carl-Zeiss-Optikkolloquium, Jena (15.11.2011), present.

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Mikrostruktur und Eigenschaften mit Nanometallfluorid dotierter Aluminiumoxid-Keramik
DGM-Symposium Hochleistungskeramik 2011, Karlsruhe (25./26.10.2011), presentation

Reichel, U.
Structure design of ceramic materials based on nanopowders
III. International Research and Practice Conference and Specialized Exhibition on Modern Ceramic Materials, Properties, Technology, Applications, Novosibirsk, Russia (14.-19.9.2011), presentation

Reinhardt, K.
AgPd pastes for AIN
IMAPS European Microelectronics Packaging Conference – EMPC-2011, Brighton, UK (12.-15.9.2011), presentation

Reinhardt, K.; Partsch, U.; Völkel, L.
On the processing of hotmelt screen printing pastes
26th European Photovoltaic Solar Energy Conference and Exhibition – EU PVSEC, Hamburg (5.-9.9.2011), poster

Reuber, S.; Schneider, M.; Stelter, M.; Michaelis, A.
Portable micro-SOFC system based on multilayer technology
219th Electrochemical Society Meeting, Montréal, Canada (1.-6.5.2011), presentation

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Portable µ-SOFC system based on multilayer technology
12th International Symposium on Solid Oxide Fuel Cells – SOFC-XII, Montreal, Canada (1.-6.5.2011), p.251-258, presentation

Richter, H.; Fischer, G.
Full zeolite bodies for zeolite membranes and adsorption applications
12th International Conference and Exhibition of the European Ceramic Society, Stockholm, Sweden (19.-23.6.2011), presentation

Richter, H.; Voigt, I.
Nanoporöse anorganische Membranen für enge Nanofiltration und Gastrennung
DKG-Arbeitskreis »Keramische Membranen«, Frankfurt/Main (5.5.2011), presentation

Richter, H.; Müller, S.; Kaltenborn, N.; Voigt, I.
Tailoring of gas separating properties of carbon membranes on ceramic substrates
4th International conference on carbons for energy storage/storage and environment protection (CESEP´11), Vichy, France (25.-29.9.2011), presentation

Richter, H.; Günther, C.; Voigt, I.
Zeolite membranes for hydrogen separation
12. Jülicher Werkstoffsymposium (5./6.10.2011), presentation

Richter, H.-J.; Kucera, A.; Moritz, T.
Fabrication of ceramic tapes with nano-zirconia powder
12th Conference of the European Ceramic Society – ECerS XII, Stockholm, Sweden (19.-23.6.2011), presentation

Richter, H.-J.; Haderk, K.; Grzesiak, A.; Graf, C.; Refle, O.
Studies on 3D printing for manufacturing of dental ceramics
12th Conference of the European Ceramic Society – ECerS XII, Stockholm, Sweden (19.-23.6.2011), poster

Richter, J.; Kriegel, R.; Kahn, R.; Glüsing, J.; Ruhe, N.; Beckmann, M.; Böhning, D.; Müller, M.; Ma, M.
A combined catalyst and oxygen carrier system for the processing of tar containing gases

10th International Conference on Catalysis in Membrane Reactors – ICCMR10, St. Petersburg, Russia (20.-24.6.2011), poster

Richter, J.; Kriegel, R.; Kahn, R.; Glüsing, J.; Ruhe, N.; Beckmann, M.; Böhning, D.; Müller, M.; Ma, M.
A combined catalyst and oxygen carrier system for the processing of tar containing gases
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Rödel, C.; Potthoff, A.
Dispersion analysis in ceramic processing
2nd workshop dispersion analysis, Berlin (17.3.2011), presentation

Rödel, C.; Michaelis, A.; Fries, M.; Potthoff, A.
Einfluss von Rohstoffmodifizierungen auf die Wirkung von organischen Additiven in Al_2O_3-Suspensionen
5. Symposium Produktgestaltung in der Partikeltechnologie, Pfinztal (19./20.5.2011), presentation

Rödig, T.
Innovative Keramiken für piezoelektrische Generatoren
Schulungsprogramm des Fraunhofer-Demonstrationszentrums AdvanCer, Dresden (9./10.3.2011), presentation

Rödig, T.
Piezoelectric generator module for wireless sensor nodes in aerospace structures
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Rost, A.; Schilm, J.; Kusnezoff, M.; Michaelis, A.
Separatoren aus Li-Ionen leitender Keramik
Kraftwerk Batterie, Aachen (28.2.-2.3.2011), presentation

Rudolph, H.; Johannes, M.; Ehrt, R.; Luthardt, R.G.
Analyse des Verbundes zwischen Lithiumdisilikat-Verblendkeramik und dichtgesintertem Zirkoniumdioxid
60. Jahrestagung der DGPro e.V. - Deutsche Gesellschaft für Prothetische Zahnmedizin und Biomaterialien, Hamburg (12.-14.5.2011), presentation

Rutkowski, B.; Baumann, S.; Beck, T.; Huang, B.; Malzbender, J.; Kriegel, R.; Steinbrech, R.W.
Microstructural investigations of the hexagonal phase in BSCF membrane material after high temperature exposure
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Sauchuk, V.; Megel, S.; Schilm, J.
High temperature steels and interconnection for SOFC
1st Joint European Summer School for Fuel Cell and Hydrogen Technology, Viterbo, Italy (22.8.-2.9.2011), presentation

Scheithauer, U.; Haderk, K.; Richter, H.-J.; Petasch, U.; Zins, M.; Michaelis, A.
Laminated multilayer for thermal shock resistant refractories based on the material system calcium-aluminate
54. Internationales Feuerfest-Kolloquium 2011, Aachen (19./20.10.2011), presentation

Scheithauer, U.; Haderk, K.; Richter, H.-J.; Petasch, U.; Zins, M.; Michaelis, A.
Lamination techniques for new multilayer for thermal shock resistant refractories based on the material system calcium-aluminate
17th International Conference on Refractories, Praha, Czech Republic (10./11.5.2011), presentation

Schilm, J.; Rost, A.; Pönicke, A.; Kusnezoff, M.
Fügetechnologien für SOFC
8. Löttechnisches Kolloquium des DVS 2011, Hanau (7.6.2011), presentation

Schilm, J.; Rost, A.; Pönicke, A.
Sealing materials and joining techniques for SOFC
1st Joint European Summer School for Fuel Cell and Hydrogen Technology, Viterbo, Italy (22.8.-2.9.2011), presentation

Schmidt, J.; Kinski, I.; Michaelis, A.; Uhlig, S.
Plasma-enhanced CVD of ZnO with varying doping levels on different substrates
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Plasma-Enhanced CVD of ZnO with varying doping levels on different substrates
4. Verbundtreffen des Dresdner Innovationszentrums Energieeffizienz, Dresden (8.11.2011), presentation

Schmidt, R.; Kretzschmar, C.; Eberstein, M.
Influence of film thicknesses on the electrical properties of RuO_2-thick film resistors on aluminium nitride ceramics (AIN)

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Schmidt, R.; Kretzschmar, C.; Eberstein, M.
Schichtdickenabhängigkeit einer 100 Ohm/Sq Widerstandspaste auf Aluminiumnitrid-Keramik
DKG-Jahrestagung 2011, Saarbrücken (28.-30.3.2011), presentation

Schneider, J.; Johannes, M.
Use of stirred media mills in the production of nanostrucutured ceramics
5th International Seminar »Nanotechnology, energy, plasma, lasers«, Hermsdorf/Jena (1.-3.11.2011), presentation

Schneider, M.; Schroth, S.; Richter, S.; Schubert, N.; Michaelis, A.
Choline chloride based ionic liquid – an alternative electrolyte for ECM?
7th International Symposium on Electrochemical Machining Technology – INSECT, Vienna, Austria (3./4.11.2011), presentation

Schneider, M.; Schroth, S.; Schubert, N.; Michaelis, A.
Untersuchungen zum Elektrochemischen Bearbeiten (ECM) von Hartmetallen
33. Ulmer Gespräch, Ulm (12./13.05.2011), presentation

Schönecker, A.; Nicolai, M.; Schlenkrich, F.; Henschke, T.; Uhlig, S.
Investigation of domain switching of PZT and KNN-based ceramics
20th IEEE International Symposium on Applications of Ferroelectrics jointly held with the International Symposium on Piezoresponse Force Microscopy – ISAF PFM 2011, Vancouver, Canada (24.-27.7.2011), presentation

Schönecker, A.
Preparation and charakterization of acoustic transducers based on KNN
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Schubert, N.; Schneider, M.; Michaelis, A.
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Funktionell modifizierte anorganisch-organische Kompositwerkstoffe
DKG-Jahrestagung, Saarbrücken (28.-30.3.2011), presentation
18. Symposium Verbundwerkstoffe und Werkstoffverbunde, Chemnitz (30.3.-1.4.2011), presentation

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High performance electro-technical components with polymer-ceramic casting
5th International Seminar »Nanotechnology, energy, plasma, lasers«, Hermsdorf/Jena (1.-3.11.2011), presentation

Schubert, R.
Polymer-ceramic composites for technical applications with thermal load
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Schwarz, B.
Möglichkeiten der Substratvorbehandlung – Stand und neue Entwicklungen
Biogas-Schwerpunkt: Optimierung, Bernburg (23.3.2011), presentation

Schwarz, B.
Stand und neueste Entwicklungen auf dem Gebiet der Substratvorbehandlung für den Biomasseeinsatz in Biogasanlagen
Sächsische Biogastagung, Groitzsch (6.10.2011), presentation

Schwarz, B.
Verfahrenstechnische Untersuchungen zur Substratbehandlung mittels separater Hydrolysestufe
Fachtagung Regenerative Energien als Zukunftstechnologie, Köthen (13./14.10.2011), presentation

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Stand und neueste Entwicklung auf dem Gebiet der Substratvorbehandlung für den Biomasseeinsatz in Biogasanlagen
Biogas-Fachtagung Thüringen, Dermbach (8.11.2011), present.

Seuthe, T.; Grehn, M.; Eichler, H.J.; Mermillod-Blondin, A.; Rosenfeld, A.; Bonse, J.; Eberstein, M.
Strukturierung von Silikatgläsern mit unterschiedlicher Komposition durch ultrakurze Lichtpulse
85. Glastechnische Tagung der Deutschen Glastechnischen Gesellschaft (DGG), Saarbrücken (30.5.-1.6.2011), presentation

Standke, G.; Petasch, U.; Mammitzsch, L.; Adler, J.;

Michaelis, A.
Katalytische Funktionsschichten auf zellularen keramischen Strukturen
Workshop »Funktionelle Materialien für die chemische Technik«, Dresden (6.10.2011), poster

Stein, J.; Potthoff, A.
Aufbereitung und Charakterisierung von Suspensionen
DKG-Fortbildungsseminar »Sprühtrocknung«, Dresden (08./09.11.2011), presentation

Steinbrech, R.W.; Rutkowski, B.; Malzbender, J.; Huang, B.; Kriegel, R.; Beck, T.
Creep behaviour of BSCF oxygen transport membranes
35th International Conference and Exposition on Advanced Ceramics and Composites – ICACC 2011, Daytona Beach, Florida, USA (23.-28.1.2011), presentation

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Highly efficient planar micro-SOFC
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Trockenpressen – Technologische Aspekte
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Stockmann, J.
Verbindungstechnik
Schulungsprogramm des Fraunhofer-Demonstrationszentrums AdvanCer, Freiburg (10./11.11.2011), presentation

Svoboda, H.
Charakterisierung des Pressverhaltens
DKG-Fortbildungsseminar »Sprühtrocknung«, Dresden (8./9.11.2011), presentation

Sydow, U.; Herrmann, M.; Schneider, M.; Kleebe, H.-J.; Michaelis, A.
Electrochemical corrosion of SSiC and LPS-SiC ceramic materials
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Thiele, J.; Kaltenborn, N.; Richter, H.; Voigt, I.
Polymerabgeleitete SiBCN Keramik-Membranen für die Hochtemperatur-Gastrennung
DKG-Jahrestagung, Saarbrücken (28.-30.3.2011), poster

Thiele, M.; Sempf, K.; Berger, L.-M.; Spatzier, J.
Thermophysical and micro-structural studies on thermallly sprayed chromium carbide coatings
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Toma, L.-F.; Langner, S.; Barbosa, M.M.; Berger, L.-M.; Rödel, C.; Potthoff, A.
Influence of the suspension characteristics and spraying parameters on the properties of dense suspension-HVOF sprayed Al_2O_3 coatings
International Thermal Spray Conference – ITSC 2011, Hamburg (27.-29.9.2011), poster

Tröber, O.; Richter, H.; Voigt, I.
Organophilic zeolite filled membranes for pervaporation
International Scientific Conference on Pervaporation and Vapor Permeation, Torun, Poland (8.-11.9.2011), presentation

Tröber, O.; Richter, H.; Voigt, I.
Tailor made zeolites for different applications in composite materials
23. Deutsche Zeolithtagung, Erlangen (2.-4.3.2011), poster

Tröber, O.; Richter, H.; Voigt, I.; Nagel, M.; Grimm, T.; Liebert, T.; Homuth, M.; Heft, A.; Schimanski, A.; Grünler, B.
Verfahren zur Herstellung nanopartikulärer Zeolithe für die Anwendung in Kompositen
DKG-Jahrestagung, Saarbrücken (28.-30.3.2011), poster

Tröber, O.; Richter, H.; Stachel, D.; Voigt, I.
Zeolite nano particle preparation for highly permeable mixed matrix membranes
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Trofimenko, N.; Kusnezoff, M.; Michaelis, A.
Recent development of electrolyte supported cells with high power density
219th Electrochemical Society Meeting, Montréal, Canada (1.-6.5.2011), presentation

Trofimenko, N.; Kusnezoff, M.; Michaelis, A.
Recent development of electrolyte supported cells with high power density
12th International Symposium on Solid Oxide Fuel Cells – SOFC-XII, Montreal, Canada (1.-6.5.2011), p.315-325, presentation

Uhlig, S.
Domain related topography formation during CMP of lead-free and lead containing

PRESENTATIONS AND POSTERS, TEACHING ACTIVITIES OF IKTS EMPLOYEES

ferroelectric ceramics
20th IEEE International Symposium on Applications of Ferroelectrics jointly held with the International Symposium on Piezoresponse Force Microscopy – ISAF PFM 2011, Vancouver, Canada (24.-27.7.2011), poster

van Gestel, T.; Bram, M.; Meulenberg, W.A.; Puhlfürß, P.; Richter, H.; Voigt, I.; Wolf, M.J.; Bouwmeester, H.J.M.
Microporous membranes for hydrogen separation: State of the art and future prospects
12. Jülicher Werkstoffsymposium, Jülich (5./6.10.2011), presentation

Vashishta, L.; Voigt, I.; Richter, H.; Kühnert, J-T.; Weyd, M.
Ceramic membranes for the separation of glucose and the enrichment and dewatering of ethanol
International Conference on Membranes – ICM-2011, Kottayam, India (16.-19.9.2011), presentation

Voigt, I.; Hoyer, T.; Fischer, G.; Kämnitz, S.; Köhler, B.; Sikora, R.; Tupaika, F.; Niemz, F.-G.; Schulze, T.
Ceramic hollow fiber contactors for membrane extraction
International Congress on Membranes and Membrane Processes – ICOM, Amsterdam, the Netherlands (23.-29.7.2011), poster

Voigt, I.
Development of ceramic NF membranes with a cut-off below 450 D
International Workshop on Implementation of Nanomembrane Technology in the Pharmaceutical Industry, Sofia, Bulgaria (9./10.9.2011), presentation

Voigt, I.
Innovations in ceramic membranes
International Workshop on Recent Development on Membrane Technology for Industrial Applications, Chennai, India (10./11.2.2011), presentation

Voigt, I.; Richter, H.; Kriegel, R.; Weyd, M.
Innovations in ceramic membranes
8th European Congress on Chemical Engineering – ECCE, Berlin (25.-29.9.2011), presentation

Voigt, I.; Richter, H.; Kriegel, R.; Kaltenborn, N.
Neue anorganische Membranen für Anwendungen in der Energie- und Umwelttechnik
Thüringer Werkstofftag 2011, Jena (30.03.2011), presentation

Voigt, I.; Richter, H.; Kühnert, J-T.; Weyd, M.; Tusel, E.; Brüschke, H.E.A.
Sustainable, energy efficient and economic biorefineries by membrane enhanced processes
International Congress on Membranes and Membrane Processes, Amsterdam, the Netherlands (23.-29.7.2011), presentation

Voigtsberger, B.
Micro- and nanostructured functional ceramics for future applications
5th International Seminar Nanotechnolgy, Energy, Plasma, Lasers – NEPL-201, Hermsdorf/Jena (1.-3.11.2011), presentation

Wätzig, K.; Krell, A.; Michaelis, A.
Highly transparent Al-rich MgO n Al_2O_3 spinel (1<n<2.5) by reaction sintering of MgO and Al_2O_3
Glass and optical materials division annual meeting, Savannah, USA (15.-19.5.2011), presentation

Wätzig, K.; Grimm, M.; Scholz, S.; Michaelis, A.; Kinski, I.
Polycrystalline silicon thin films using PE CVD and high order silanes
26th European Photovoltaic Solar Energy Conference and Exhibition – EU PVSEC, Hamburg (5.-9.9.2011), 3AV.1.33, poster

Weidmann, S.K.; Kremmer, K.; Schneider, M.; Fürbeth, W.
Nanochemical impregnation of Modified Phosphoric Acid Anodised (MPAA) layers – a promising replacement for Chromic Acid Anodising (CAA)
European Corrosion Congress - EUROCORR 2011, Stockholm, Sweden (4.9.-8.9.2011), presentation

Weiser, M.; Dörfler, S.; Schneider, M.; Althues, H.; Michaelis, A.; Kaskel, S.
Elektrochemische Kupferabscheidung auf ausgerichteten MWCNTs
YoungNanoProfessionals-Workshop, Frankfurt am Main (8.11.2011), poster

Weiser, M.; Lämmel, C.; Schneider, M.; Michaelis, A.
Kapazitätsbestimmung an EDLC-Materialien – ein Methodenvergleich
Zukunft Energie, Dresden (11.-13.5.2011), poster

Weiser, M.; Dörfler, S.; Schneider, M.; Althues, H.; Michaelis, A.; Kaskel, S.
Platin Pulse Plating auf ausgerichteten MWCNTs
YoungNanoProfessionals-Workshop, Frankfurt am Main (8.11.2011), presentation

Weiser, M.; Fritsch, M.; Kusnezoff, M.; Schneider, M.; Michaelis, A.; Leonhardt, A.; Khavrus, V.; Malcher, P.; Pfannmöller, E.; Kramer, D.; Kohrs, K.
Superkondensatoren auf Basis von Verbundwerkstoffen nanostrukturierter Kohlenstoffmodifikationen
Kraftwerk Batterie, Aachen (28.2.-2.3.2011), presentation

Weyd, M.; Richter, H.; Voigt, I.; Herrmann, K.; Kühnert, J-T.
Bioethanolgewinnung unter Verwendung keramischer Membranen
enertec/TerraTec 2011, Leipzig (25.-27.1.2011), presentation

Weyd, M.
Verfahrenskonzepte zum Einsatz keramischer Membranen
Arbeitskreis »Keramische Membranen«, Frankfurt/M. (5.5.2011), presentation

Wufka, A.
Improving the efficiency of biogas plants by the introduction of innovative processes
Biogaz Europe 2011, Nantes, Frankreich (25./26.10.2011), presentation

Wufka, A.; Friedrich, E.
Leistungssteigerung in der Biogasproduktion
enerTec – Forum enertec dezentral – Internationale Fachmesse für Energie, Leipzig (25.-27.1.2011), presentation

Ziesche, S.
Ceramic interface and multilayer technology for micro fuel cells
IMAPS/ACerS – 7th International Conference and Exhibition on Ceramic Interconnect and Ceramic Microsystems Technologies – CICMT 2011, San Diego, USA (5.-7.4.2011), presentation

Zins, M.
Anwendungen und Lieferanten keramischer Hochleistungskomponenten
Schulungsprogramm des Fraunhofer-Demonstrationszentrums AdvanCer, Dresden (9./10.3.2011), presentation

Zins, M.
Einkauf von technischer Keramik: Richtig anfragen leicht gemacht
BME-Forum »Einkauf von Technischer Keramik«, Nürnberg (12.5.2011), presentation

Zins, M.
Eigenschaften keramischer Hochleistungswerkstoffe
Schulungsprogramm des Fraunhofer-Demonstrationszentrums AdvanCer, Dresden (9./10.3.2011), presentation

Zins, M.
Keramische Hochleistungswerkstoffe: Einsatzbereiche, Entwicklungstrends
DKG-Fortbildungsseminar »Entbinderung keramischer Formteile«, Dresden (6./7.10.2011), present.

Zins, M.
Keramische Werkstoffe und Anwendungen – Entwicklungstrends und -angebote
DKG-Fortbildungsseminar »Thermoplastische Formgebung von Technischer Keramik« Dresden (5./6.10.2011), presentation

Zschippang, E.; Klemm, H.; Herrmann, M.; Sempf, K.; Guth, U.; Michaelis, A.
Ternary electro-conductive composites based on silicon nitride-silicon carbide
12th Conference of the European Ceramic Society – ECerS XII, Stockholm, Schweden (19.-23.6.2011), presentation

Teaching activities of IKTS employees

Dr. Barth, S.
Vorlesung
»Keramische Verfahrenstechnik«
Fachhochschule Jena, Fachbereich Scitec (WS11/12)

Dr. Fries, M.
Vorlesung
»Produktgestaltung keramische Sprühgranulate«
Georg-Simon-Ohm-Hochschule Nürnberg (13.12.2011)

Dr. habil. Herrmann, M.
Vorlesung und Studentenbetreuung
»Technische Keramische Werkstoffe«
University of Witwatersrand, Johannesburg, Südafrika
(03/2011 und 09/2011)

Dipl.-Ing. Höhn, S.
Vorlesung
»Keramografie«
Im Rahmen der Lehrveranstaltung »Metallografie«
TU Dresden, Institut für Werkstoffwissenschaft
(10.01.2011)

Dr. Jahn, M.
Vorlesung
»Chemische Verfahrenstechnik/ Reaktionstechnik«
HTW Dresden, Chemieingenieurwesen (SS11)

Dr. Kriegel, R.
Vorlesung
»Keramische Verfahrenstechnik«

TEACHING ACTIVITIES OF IKTS EMPLOYEES, PARTICIPATION IN BODIES AND TECHNICAL COMMITTEES

Fachhochschule Jena, Fachbereich Scitec (WS11/12)

Dr. Kusnezoff, M.; Dr. Stelter, M.; Dr. Partsch, U.; Dr. Jahn, M.; Heddrich, M.
Vorlesung »Keramische Funktionswerkstoffe« TU Dresden, Institut für Werkstoffwissenschaft (SS11)

Prof. Dr. Michaelis, A.
Vorlesung und Praktikum »Keramische Werkstoffe« TU Dresden, Institut für Werkstoffwissenschaft (WS10/11; WS11/12)

Prof. Dr. Michaelis, A.; Dr. Rebenklau, L.; Dr. Schönecker, A.
Kapitel: »Technologien der Dickschichttechnik« in der Vorlesungsreihe »Hybridtechnik« TU Dresden, Fakultät Elektrotechnik und Informationstechnik (WS11/12)

Möhring-Lotsch, N.
Lehrtätigkeit »Personalführung« Verwaltungs- und Wirtschaftsakademie Magdeburg VWA gemeinnützige GmbH (2011)

Dr. Rebenklau, L.
Vorlesung »Dickschichttechnik« und »Multilayerkeramik« in der Vorlesung von Prof. Michaelis »Funktionskeramik« TU Dresden, Institut für Werkstoffwissenschaft (SS11)

Dipl.-Ing. Svoboda, H.; Dr. Fries, M.
Vorlesung »Pulveraufbereitung und -konfektionierung« im Rahmen der Lehrveranstaltung »Keramische Werkstoffe« (25.11.2011)

Dr. Voigt, I.
Vorlesung »Keramische Verfahrenstechnik« Fachhochschule Jena, Fachbereich Scitec (WS11/12)

Dr. Zins, M.
Vorlesung »Metalle, Kunststoffe, Keramiken – Technische Keramik als Leichtbaustoff« TU Dresden, Institut für Werkstoffwissenschaft (WS10/11, WS11/12)

Participation In bodies and technical committees

Dipl.-Krist. Adler, J.
- DGM Fachausschuss »Zellulare Werkstoffe«
- FAD Förderkreis Abgasnachbehandlungstechnologien für Dieselmotoren e.V.

Dr. Beckert, W.
- Fraunhofer-Allianz »Numerische Simulation von Produkten und Prozessen« NUSIM

Dr. Faßauer, B.
- Fraunhofer-Allianz SysWasser
- Wasserwirtschaftliches Energiezentrum Dresden – e.qua impuls e.V.

Freund, Susanne
- Fraunhofer-Allianz AdvanCer, Geschäftsstelle

Dr. Friedrich, E.
- Fachverband »Biogas«

Dr. Fries, M.
- DGM/DKG-Arbeitskreis »Verarbeitungseigenschaften synthetischer keramischer Rohstoffe«, Leiter
- DKG-Fachausschuss »Verfahrenstechnik«
- ProcessNet-Fachgruppe »Agglomerations- und Schüttguttechnik«
- DKG-Fachausschusses FA III »Verfahrenstechnik«

Dr. Gestrich, T.
- Gemeinschaftsausschuss »Pulvermetallurgie«, Expertenkreis »Sintern«
- GEFTA-Arbeitskreis »Thermophysik«

Dipl.-Ing. Gronde, B.
- Gemeinschaft »Thermisches Spritzen e.V.«
- DVS-Arbeitsgruppe »Thermisches Spritzen«

Dr. Herrmann, M.
- DGM-Fachausschuss »Thermodynamik, Kinetik und Konstruktion der Werkstoffe«

Dipl.-Ing. Jaenicke-Rößler, K.
- GEFTA-Arbeitskreis »Thermophysik«
- GEFTA-Arbeitskreis »Messunsicherheit von Thermodilatometern«

Dr. Kaltenborn, N.
- DKG-Arbeitskreis »Kohlenstoff«

Dr. Klemm, H.
- DKG-Arbeitskreis »Verstärkung keramischer Stoffe«
- DIN Normenausschuss »Materialprüfung NMP 291«
- Carbon Composites e.V., Arbeitskreis »Ceramic Composites«

Dr. Krell, A.
- Associate Editor des »Journal of the American Ceramic Society«

Kunath, R.
- Arbeitskreis »Dresdner Informa-

tionsvermittler e.V.«
- Arbeitskreis »Spezialbibliotheken«

Dr. Kusnezoff, M.
- DIN/VDE, Referat K 141, DKE Deutsche Kommission, »Elektrotechnik Elektronik Informationstechnik«
- Arbeitskreis »Aufbau- und Verbindungstechnik für Hochtemperatursensoren«

Dipl.-Ing. Ludwig, H.
- DGM-Fachausschuss »Biomaterialien«

Prof. Dr. Michaelis, A.
- »World Academy of Ceramics« WAC
- WAC Forum Committee (2010-2014), Mitarbeit
- DKG-Vorstandsmitglied
- DGM/DKG-Gemeinschaftsausschuss »Hochleistungskeramik«, Arbeitskreis »Koordinierung«
- DGM/DKG-Gemeinschaftsausschuss »Hochleistungskeramik«, Arbeitskreis »Funktionskeramik«, Leitung
- DECHEMA-Arbeitsausschuss »Angewandte Anorganische Chemie«
- AGEF-Arbeitsgemeinschaft Elektrochemischer Forschungsinstitutionen e.V.
- DPG-Deutsche Physikalische Gesellschaft
- Institutsrat des IfWW, TU Dresden
- FZ Rossendorf, Vereinsmitglied
- Fa. Roth & Rau, Aufsichtsratsmitglied
- AiF Wissenschaftlicher Rat
- Solarvalley Mitteldeutschland e.V., Vorstand
- Beirat Arbeitskreis »Photovoltaik Silicon Saxony«
- Hochschulrat der Westsächsischen Hochschule Zwickau
- Dresdner Gesprächskreis
- NanoChem, BMBF, Gutachter
- Gutachterausschuss »Interne Programme« der Fraunhofer Gesellschaft
- Lenkungsgremium Innovationszentrum Energieeffizienz TUD
- Beirat eZelleron GmbH
- Vorstand Materialforschungsverbund Dresden e.V. MFD, Mitglied
- Energiebeirat des Wirtschaftsministeriums Sachsen
- Beirat Industrielles Netzwerk Erneuerbare Energien Sachsen EESA
- Dresden concept
- Clean Tech Media Award, Jurymitglied
- Gutachterausschuss »Märkte von Übermorgen« der Fraunhofer-Gesellschaft
- Editorial Board des »Journal of Ceramic Science and Technology«
- Editorial Board des »International Journal of Materials Research«

Dr. Moritz, T.
- ENMAT »European Network of Materials Research Centres«, Vice President
- Management Committee of COST action MP0701 »Nanocomposite Materials«
- DECHEMA-Fachausschuss »Nanotechnologie«
- DKG-Expertenkreis »Keramikspritzguss«, Vorstandsvorsitzender

Dipl.-Phys. Mürbe, J.
- VDI-Bezirksverein Dresden, Arbeitskreis »Granulometrie«

Nake, K.
- DGM-Arbeitskreis »Härteprüfung und AWT«, Fachausschuss »FA-12«

Dr. Nebelung, M.
- ProcessNet-Fachgruppe »Agglomerations- und Schüttguttechnik«
- ProcessNet-Fachgruppe »Trocknungstechnik«

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

Dipl.-Ing. Pönicke, A.
- DVS-Ausschuss für Technik, Arbeitsgruppe W3 »Fügen von Metall, Keramik und Glas«

Dr. Potthoff, A.
- DGM/DKG-Arbeitskreis »Prozessbegleitende Prüfverfahren«
- DECHEMA/VCI-Arbeitskreis »Responsible Production and Use of Nanomaterials«
- Fraunhofer-Allianz »Nanotechnologie«

Dr. Rebenklau, L.
- VDI/VDE-GMM Fachausschuss 5.5 »Aufbau- und Verbindungstechnik«
- VDE/VDI-Gesellschaft für Mikroelektronik, Mikro- und Feinwerktechnik
- Arbeitskreis »Aufbau- und Verbindungstechnik für Hochtemperatursensoren«

Dr. Reichel, U.
- DKG-Fachausschuss 6 »Werkstoffanwendungen«
- DKG-Arbeitskreis »Verarbeitungseigenschaften synthetischer keramischer Rohstoffe«

Dr. Richter, H.
- International Zeolite Association

Dr. Richter, H.-J.
- DGM/DKG-Gemeinschaftsausschuss »Hochleistungskeramik«, Arbeitskreis »Keramische Membranen«
- DGM/DKG-Gemeinschaftsausschuss »Hochleistungskeramik«, Arbeitskreis »Biokeramik«

PARTICIPATION IN BODIES AND TECHNICAL COMMITTEES

- DGM/DKG-Gemeinschaftsausschuss »Hochleistungskeramik«, Arbeitskreis »Generative Fertigung keramischer Komponenten«

Dr. Richter, V.
- DECHEMA/VCI-Arbeitskreis »Responsible Production and Use of Nanomaterials«
- Fraunhofer-Allianz »Nanotechnologie«
- EPMA-Arbeitskreis »European Hard Materials Group«
- VDI-Fachausschuss »Schneidstoffanwendung«
- DIN-Normenausschuss »Werkstofftechnologie«, AA »Hartmetalle«
- DIN-Normenausschuss »Materialprüfung«, AA »Sintern«
- DGM/DKG-Gemeinschaftsausschuss »Pulvermetallurgie«, Expertenkreis »Sintern«

Dr. Schilm, J.
- DGG-Fachausschuss 1 »Physik und Chemie des Glases«
- DKG/DGG-Arbeitskreis »Glasig-kristalline Multifunktionswerkstoffe«
- DVS-Ausschuss für Technik, Arbeitsgruppe W3 »Fügen von Metall, Keramik und Glas«

Dr. Schönecker, A.
- Beirat der Smart Material GmbH Dresden

Dipl.-Chem. Schubert, R.
- DKG-Expertenkreis »Keramikspritzguss«

Standke, Gisela
- DGM Fachausschuss »Zellulare Werkstoffe«

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

Dr. Stelter, M.
- Brennstoffzellen Initiative Sachsen e.V., Vorstand
- DGM/DKG-Gemeinschaftsausschuss »Hochleistungskeramik«, Arbeitskreis »Energie«

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

Dr. Voigt, I.
- GVC-Fachausschuss »Produktionsintegrierte Wasser- und Abwassertechnik«
- ProcessNet-Arbeitsausschuss »Membrantechnik«
- DGM/DKG-Gemeinschaftsausschuss »Hochleistungskeramik«, Arbeitskreis »Keramische Membranen«, Leiter
- DGM/DKG-Gemeinschaftsausschuss »Hochleistungskeramik«, Arbeitskreis »Koordinierung«

Dr. Voigtsberger, B.
- DKG-Mitglied des Präsidiums und Vorstandes
- DGM/DKG-Gemeinschaftsausschuss »Hochleistungskeramik«, Arbeitskreis »Koordinierung«, Vorsitz
- Hochschulrat Fachhochschule Jena
- MNT Mikro-Nano-Technologie Thüringen e.V., Mitglied des Vorstandes
- Wirtschaftsbeirat der Ministerpräsidentin Thüringens
- IHK Ostthüringen zu Gera, Ausschuss für Industrie und Forschung

Dr. Wunderlich, C.
- Brennstoffzellen Initiative Sachsen e.V., Vorstand
- VDI-Fachausschuss »Brennstoffzellen«

Dr. Zins, M.
- Fraunhofer-Allianz AdvanCer, Sprecher
- DKG-Koordinierungsgruppe »Strukturwerkstoffe Fachausschüsse«
- Fachausschuss »Pulvermetallurgie«
- DKG-Fachausschuss »Keramikanwendungen«
- Deutsche Messe AG, Fachmessebeirat »Industrial Supply«
- Messe München, Fachbeirat »Ceramitec«
- Institut für Prozess- und Anwendungstechnik Keramik, RWTH Aachen, Vorstand

Advisory boards for symposia and conferences

Freund, S.
- Schulungsprogramm des Fraunhofer-Demonstrationszentrums AdvanCer »Keramische Hochleistungswerkstoffe – Block I: Werkstoffe und Verfahren«, Dresden (9./10.3.2011), Organisation

Dr. Fries, M.
- DKG-Fortbildungsseminar »Technologische Grundlagen der Granulierung und Granulatverarbeitung«, IKTS Dresden/TU Dresden (14./15.4.2011), Organisation
- DKG-Fortbildungsseminar »Sprühtrocknung«, IKTS Dresden/TU Dresden (9./10.11.2011), Organisation
- DKG-Symposium »Charakterisierungsverfahren in der keramischen Aufbereitung«, Erlangen (29./30.11.2011), Programmausschuss

Dr. Gestrich, T.
- 30. Hagener Symposium Pulvermetallurgie »Sintern – der zentrale Prozess der Pulvermetallurgie«, Hagen (24./25.11.2011), Programmausschuss

Dr. Herrmann, M.

- DKG-Fortbildungsseminar »Entbinderung keramischer Formteile«, IKTS Dresden (6./7.10.2011), Organisation

Dr. Jahn, M.

- 4. Sächsischer Brennstoffzellentag, Leipzig (10.11.2011), Organisation

Prof. Dr. Michaelis, A.

- Workshop »Technologien für dezentrale Energiespeicherung auf Basis innovativer Akkumulatoren«, Dresden (24.3.2011)
- DKG-Jahrestagung 2011, Saarbrücken (28.-30.3.2011)
- ISPA 2011 International Symposium on Piezocomposite Applications, Dresden (22./23.9.2011)
- Symposium Hochleistungskeramik DKG/DGM 2012, Karlsruhe (25./26.10.2011)
- ProcessNet DECHEMA-Diskussionstagung »Anorganisch-Technische Chemie«, Frankfurt/Main (2011), Vorbereitungskomitee
- 2. Dresdner Werkstoffsymposium »Werkstoffe für die Mobilität«, Dresden, TUD IfWW (8./9.12.2011)
- DKG-Jahrestagung 2012/Symposium Hochleistungskeramik DKG/DGM 2012, Nürnberg (5.-7.3.2012)
- 10th CMCEE International Symposium on Ceramic Materials and Components for Energy and Environmental Applications, Dresden (20.-23.5.2012), Organisationskomitee
- ProcessNet DECHEMA-Diskussionstagung »Anorganisch-Technische Chemie«, Frankfurt/Main (2012), Vorbereitungskomitee
- MSE 2012 Materials Science and Engineering, Darmstadt (25.-27.09.2012)
- Materialforschungstournee des MFD, Dresden (2011/2012)
- Vision Keramik 2013+

Dr. Moritz, T.

- DKG-Fortbildungsseminar »Plastische und Thermoplastische Formgebung«, Dresden (5./6.10.2011), Organisation

Dr. Reichel, U.

- III. International Research and Practice Conference and Specialized Exhibition on Modern Ceramic Materials, Properties, Technology, Applications, Novosibirsk, Russland (14.-19.9.2011)
- 5th International Seminar »Nanotechnology, Energy, Plasma, Lasers – NEPL-2011«, Hermsdorf, Jena (1.-3.11.2011)

Dr. Schneider, M.

- International Workshop on Impedance Spectroscopy, Chemnitz (28.-30.9.2011), Program Committee
- 7th International Symposium on ElectroChemical Machining Technology – INSECT 2011, Wien (3./4.11.2011), Advisory Board

Dr. Schönecker, A.

- PT-PIESA-Workshop »Hochleistungswerkstoffe« (21.9.2011)
- ISPA 2011 – International Symposium on Piezocomposite Applications, Dresden (22./23.9.2011)

Dr. Stelter, M.

- 4. Sächsischer Brennstoffzellentag, Leipzig (10.11.2011), Moderation

Dr. Voigt, I.

- DGM-Symposium Hochleistungskeramik 2011, Karlsruhe (25./26.10.2011)

Dr. Voigtsberger, B.

- DGM-Symposium Hochleistungskeramik 2011, Karlsruhe (25.-26.10.2011)
- 5th International Seminar »Nanotechnology, Energy, Plasma, Lasers – NEPL-2011«, Hermsdorf, Jena (1.-3.11.2011)

Dr. Wunderlich, C.

- 15th European Fuel Cell Forum 2011, Lucerne, Switzerland (28.6.-1.7.2011), Advisory Board

Dr. Zins, M.

- BME-Forum »Einkauf von Technischer Keramik«, Nürnberg (11./12.5.2011), Fachliche Leitung

Dissertations

Klein, Cornelia
Sol-Gel-Verfahren für die Herstellung von ZrO_2-Schichten
Dissertation 2011
IKTS Dresden – TU Freiberg, Fakultät für Chemie und Physik

Wätzig, Katja
Transparente $MgAl_2O_4$-Keramik aus Precursor-abgeleiteten Spinell-Pulvern oder per Reaktionssintern von MgO-/Al_2O_3-Gemischen
Dissertation 2011
IKTS Dresden – TU Freiberg, Fakultät für Chemie und Physik

Diploma theses

Arnold, Sébastien
Bruchmechanische Untersuchung gelöteter Metall-Keramik-Verbunde
Diplomarbeit 2011
IKTS Dresden – TU Dresden, Fakultät Maschinenwesen, Institut für Oberflächen- und Fertigungstechnik

Bachmann, Elisa
Herstellung und Charakterisierung von Katalysatoren zur Reformie-

PARTICIPATION IN BODIES AND TECHNICAL COMMITTEES, DISSERTATIONS, DIPLOMA THESES

rung von Ethanol für den Betrieb in einer Hochtemperaturbrennstoffzelle
Bachelorarbeit 2011
IKTS Dresden – HTW Dresden, Fakultät Maschinenbau/Verfahrenstechnik

Gierth, Paul
Untersuchungen zu Lötverfahren für Photovoltaik-Dickschichtpasten
Diplomarbeit 2011
IKTS Dresden – TU Dresden, Fakultät Elektrotechnik, Institut für Aufbau- und Verbindungstechnik

Görlitz, Henrik
Entwicklung und Charakterisierung von Titanoxid-Kompositen als Material für den Einsatz als Thermoelektrikum
Diplomarbeit 2011
IKTS Dresden – TU Dresden, Fakultät Maschinenwesen, Institut für Werkstoffwissenschaft

Hagemann, Ralf
Modifikation von hydrophoben Zeolithmembranen und deren Charakterisierung durch Pervaporation und alternative Verfahren
Diplomarbeit 2011
IKTS Hermsdorf – Fachhochschule Jena, Fachbereich SciTec

Korneli, Marcel
Untersuchungen zum Einfluss der Fließ- und Presseigenschaften von Granulaten auf Eigenschaftsschwankungen trockengepresster Grünkörper
Diplomarbeit 2011
IKTS Dresden – TU Dresden, Fakultät Maschinenwesen

Krause, Robert
Partielle Oxidation von LPG für Brennstoffzellanwendungen
Bachelorarbeit 2011
IKTS Dresden – HTW Dresden, Fakultät Maschinenbau/Verfahrenstechnik

Lenz, Christian
Miniaturkraftsensor in LTC-Technologie
Diplomarbeit 2011
IKTS Dresden – TU Dresden, Fakultät Elektrotechnik und Informationstechnik, Institut für Feinwerktechnik und Elektronik-Design

Matthey, Björn
Rolle der Grenzflächen in gradierten Siliciumcarbid-Diamant-Kompositwerkstoffen
Diplomarbeit 2011
IKTS Dresden – TU Bergakademie Freiberg, Fakultät für Werkstoffwissenschaft und Werkstofftechnologie

Neumann, Josephine
2D Modell eines auf dem Prinzip der partiellen Oxidation arbeitenden monolithischen Reformers für den Einsatz in einem SOFC-System
Diplomarbeit 2011
IKTS Dresden – TU Dresden, Fakultät Maschinenwesen

Nousch, Laura
Systemkonzeption und Prozessauslegung für eine SOFC-Anlage mit reduzierter Betriebstemperatur
Diplomarbeit 2011
IKTS Dresden – TU Dresden, Fakultät für Maschinenwesen, Institut für Energietechnik

Schalomon, Jens
Experimentelle Untersuchungen zum Betriebsverhalten des Reformers im Hinblick auf die Systemintegration in ein Brennstoffzellensystem
Bachelorarbeit 2011
IKTS Dresden – Hochschule Lausitz Senftenberg, Institut für Chemieingenieurwesen/Verfahrenstechnik

Schliephake, Angelika
Deaktivierungsverhalten von Oxidationskatalysatoren beim Einsatz zur Nachbehandlung von SOFC-Abgas
Bachelorarbeit 2011
IKTS Dresden – HTW Dresden, Fakultät Maschinenbau/Verfahrenstechnik

Schubert, Nora
Untersuchungen zum Electrochemical Machining (ECM) von Cobalt
Masterarbeit 2011
IKTS Dresden – TU Dresden, Fakultät Mathematik und Naturwissenschaften, Institut für Physikalische Chemie

Schütz, Matthias
Labortechnische Untersuchungen zur Bewertung und Auslegung einer separaten Hydrolysestufe für landwirtschaftliche Biogasanlagen
Masterarbeit 2011
IKTS Dresden – TU Dresden, Fakultät für Forst-, Geo- und Hydrowissenschaften, Institut für Abfallwirtschaft und Altlasten

Semisch, Jan
Entwässerung kommunaler Klärschlämme unter Einsatz natürlicher Flockungshilfsmittel
Diplomarbeit 2011
IKTS Dresden – TU Dresden, Fakultät Forst-, Geo- und Hydrowissenschaften, Fachrichtung Wasserwesen, Institut für Siedlungs- und Industriewasserwirtschaft

Wagner, Sebastian
Theoretische und experimentelle Untersuchungen zur heterogenen Katalyse von CO und H_2 aus SOFC-Abgas
Bachelorarbeit 2011
IKTS Dresden – HTW Dresden, Fakultät Maschinenbau/Verfahrenstechnik

Wanke, Andreas
Applikationsuntersuchungen zum Aerosoldruck von polymeren Leitpasten/-tinten
Diplomarbeit 2011
IKTS Dresden – TU Dresden, Fakultät Elektrotechnik, Institut für Aufbau- und Verbindungstechnik

Wieden, Stefanie
Labortechnische Untersuchungen zum chemischen und biologischen Aufschluss von lignozellulosehaltigen Reststoffen am Beispiel von Weizenstroh zur Effektivierung der Biogaserzeugung
Masterarbeit 2011
IKTS Dresden – TU Dresden, Fakultät für Forst-, Geo- und Hydrowissenschaften, Institut für Abfallwirtschaft und Altlasten

ART AT FRAUNHOFER IKTS 2010–2011

Continuity and creative genius have been characterizing the creative research atmosphere at Fraunhofer IKTS for 20 years. So, the artist Jochen Rohde is an integral part of the exhibitions. In the past two years, he organized two exhibitions with Manara Grund showing acrylic paintings and botanic subjects. This was a wonderful symbiosis harmonizing the abstract art of Jochen Rohde and the representationalism of Manara Grund's natural objects.

The graphic artist Mechthild Mansel and the art student Judith Michael organized the exhibition "Light and Motion". Mechthild Mansel says about her work: "It is my central concern to uncover the variety of human state, the basic patterns of inner feelings as well as their adequate expression in order to bring it into a general and personal interpretation. Color is an important carrier of emotion. The vibrations of colors seeing with our eyes subconsciously address us like music which is also strongly influencing my work."

Light is a central topic for Judith Michael. "I take pictures of light. I use natural and artificial light as motive, e.g. sunlight, spectral colors in refractions, but also self-made LEDs as light source on the animation board. I study the change of natural and artificial light. It is the aim to create an artistic symbiosis of own motions, the motion of light sources as well as their change. The term "light painting" is characterizing my experimental photography."

At the end of this exhibition year, Fraunhofer IKTS staff presented photographs showing "structures". The exhibition lives on the viewer's feel for details and combines the various possibilities of seeing one object with the photographic styles.

Grit Kaiser

1 *Mechthild Mansel – Acrylic painting (cut-out).*
2 *Jochen Rohde – Acrylic painting (cut-out).*
3 *Manara Grund – Photography (cut-out).*
Picture on the right *Judith Michael – Photography (cut-out).*

EVENTS / TRADE FAIRS 2011

Conferences

10th International Symposium on Ceramic Materials and Components for Energy and Environmental Applications – CMCEE
Dresden/Munich, May 20–24, 2012

Electrochemical Colloquium
Dresden, November 29–30, 2012

Events

Girls' Day
Dresden, April 26, 2012

Long Night of Sciences
Dresden, July 6, 2012

Fraunhofer Talent School
Dresden, November 2012
www.talent-school-dresden.de

Seminars / Workshops

DKG seminars

Technological fundamentals of granulation and granule processing
Dresden, April 18–19, 2012

Thermoplastic shape-forming of advanced ceramics – technology and training
Dresden, October 10–11, 2012

Debinding of ceramic bodies
Dresden, October 11–12, 2012

Spray drying of ceramic suspensions
Dresden, November 7–8, 2012

Please find further information at www.dkg.de

Seminars of the Fraunhofer Demonstration Center AdvanCer

Introduction into Advanced Ceramics

Part I: Materials, technology
Dresden, March 14–15, 2012

Part II: Machining
Berlin, May 9–10, 2012

Part III: Construction, testing
Freiburg, November 8–9, 2012

Please find further information at
www.advancer.fraunhofer.de

Participation in trade fairs

Biogas Convention and Trade Fair
Bremen, January 10–12, 2012

nano tech
Tokyo, February 15–17, 2012

FuelCell Expo
Tokyo, February 29 – March 2, 2012

Jenaer Industry Days
Jena, March 28–29, 2012

Hannover Messe
Hanover, April 23–27, 2012

IFAT
Munich, May 7–11 2012

SMT/HYBRID/PACKAGING
Nuremberg, May 8–10, 2012

Sensor & Test
Nuremberg, May 22–24, 2012

CERAMITEC
Munich, May 22–25, 2012

ACHEMA
Frankfurt, June 18–22, 2012

European Fuel Cell Forum
Lucerne, June 26–29, 2012

ICIM (International Conference on Inorganic Membranes)
Twente, July 10–13, 2012

IMPAS 2012
San Diego, September 9–13, 2012

EU PVSEC
Frankfurt, September 24–28, 2012

Materialica
Munich, October 23–25, 2012

Innovation Day Thuringia
Erfurt, November 2, 2012

Electronica
Munich, November 13–16, 2012

Hybridica
Munich, November 13–16, 2012

HOW TO REACH US

How to reach us in Dresden

by car

- At the three-way highway intersection "Dresden West" exit Autobahn A4 onto Autobahn A17 in direction "Prag" (Prague)
- Exit at "Dresden Prohlis" (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 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 (the road name will change to An der Rennbahn and then to Winterbergstrasse)
- Fraunhofer IKTS is on the left side of the road (Winterbergstrasse 28)

by train

- From Dresden main railway station take train S1 (direction Bad Schandau) or train S2 (direction Pirna) to stop "Haltepunkt Strehlen"
- 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 Winterbergstrasse 28 (distance is approximately 7 miles or 10 km)
- Or use suburban train S2 (underground train station) to stop "Haltepunkt Strehlen"

How to reach us in Hermsdorf

by car

- From exit Bad Klosterlausnitz/Hermsdorf (A9, exit 23) 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

- From exit Hermsdorf-Ost (A4, exit 56a) 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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