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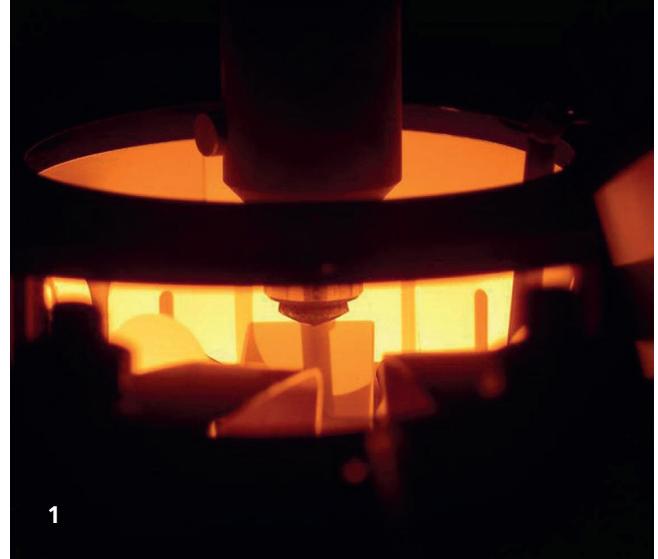
FRAUNHOFER INSTITUTE FOR CERAMIC TECHNOLOGIES AND SYSTEMS IKTS



BUSINESS DIVISION

MATERIALS AND PROCESS ANALYSIS





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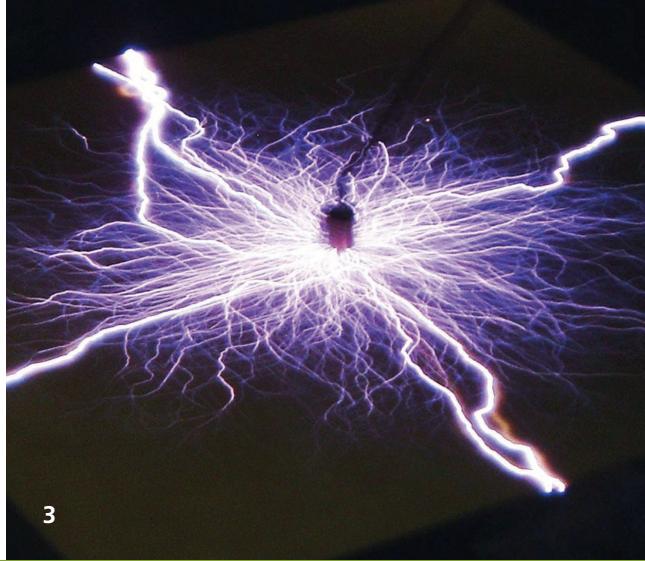
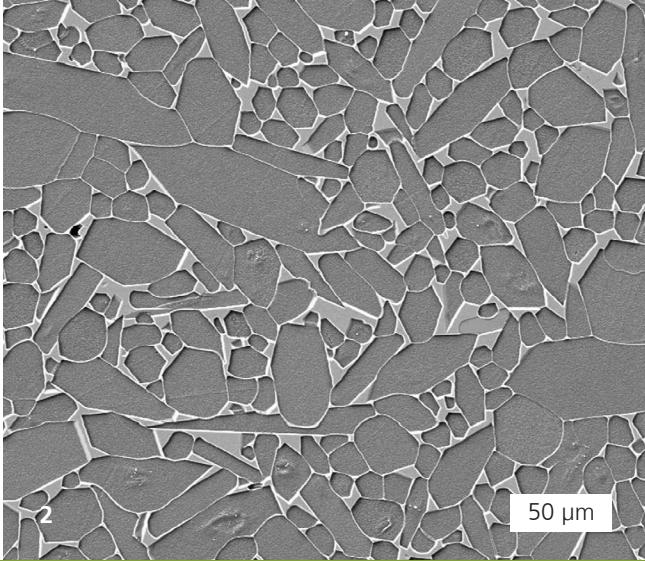
Through its "Materials and Process Analysis" business division, Fraunhofer IKTS provides users and manufacturers of materials and components with a comprehensive portfolio of methods for testing, characterization, and analytical methods for material properties and production processes. The focus here is on ceramic materials, components, and processes for technical applications, including lightweight construction as well as materials for microelectronics, nanoelectronics, photonics and biomedicine.

How do microstructure and composition influence the macroscopic properties of a material, and hence the product itself? Can a less expensive material replace an existing one, without any loss to the quality of the product? How can production processes be configured to make them stable, cost-effective, efficient and sustainable? What quality standards must be observed and enforced? In order to respond to these and other questions associated with the application and production of materials, the complex interrelationships that exist among raw materials, production technology, material structures and properties, as well as the operating conditions must be considered as a whole. In this regard, not only are the key performance indicators identified – they are interpreted as well.

Fraunhofer IKTS sees itself as first contact for any issues that involve chemical, thermal, microstructural, mechanical, tribological, electrical and electrochemical analysis, assessment and optimization of materials and components, as well as the manufacturing processes involved. Aside from all of the necessary standard analytical methods, the institute also has the world's most exceptional tools at its disposal – especially to identify, define and quantify the properties at extreme temperatures. With its vast reservoir of expertise in processes, materials and analysis as its foundation, Fraunhofer IKTS consults with and assists clients with the development of new materials and products, clarification of complex failure mechanisms and

achievement of legal and quality standards. With accredited laboratories for determining characteristic values for powders, suspensions, thermophysical and electrical/dielectrical materials, electrical components and component systems, the institute is in a position to perform a variety of quality assurance and certification tasks commissioned by the customer – from products and processes to the study and analysis of prototypes.

Fraunhofer IKTS is a reliable, manifold accredited and regularly audited service provider devoted to the investigation and evaluation of materials science principles, application-specific questions and metrological developments.



AREAS OF APPLICATION

Raw materials analysis and evaluation

Detailed knowledge of the materials used and their processing characteristics is paramount to the development and optimization of stable, economical and sustainable production processes, thus resulting in products of superior quality. Fraunhofer IKTS assists clients and project partners with analysis and evaluation of materials on a scale spanning the nm to mm range, conducted at the institute or at client/partner premises. Researchers study materials that run the gamut from oxide ceramics, non-oxide ceramics and hard metals to carbon-based materials and glass or organic raw materials (certified according to DIN EN ISO/EC 17025).

Characterization along the entire process chain

Fraunhofer IKTS has the expertise and the tools to provide characterization at every step of processes involving ceramic, powder metallurgical, and associated technologies – from preparation and conditioning of raw materials, suspensions, and pastes to drying and granulation, shaping and thermal treatment to finishing. The data collected from such characterization can be directly applied to the analysis of individual process steps or to the properties of semi-finished products. These

data are also useful in establishing methods for process and product monitoring, and as a basis for process modeling.

Materials and component characterization

Knowledge of the micro-scale and nano-scale structure of the material and its changes during application are essential to predict and ensure product quality and lifetime, even under extreme loads. In this regard, Fraunhofer IKTS has the capability to analyze the microstructures and properties of materials and components subjected to a broad range of temperatures. Fraunhofer IKTS supports its clients from the preparation of test samples through to interpretation of the determined properties. In addition, it has comprehensive experiences that ranges from analysis and evaluation of aging processes to evaluation of failure of ceramic components. This makes it possible to optimize high-performance ceramics, hard metals and cermets, super hard materials, graded materials, metal-ceramic composites, and materials for microelectronics and nanoelectronics. The institute uses its vast expertise to study the corrosion phenomena that influence ceramic materials and to model, simulate and optimize materials and components exposed to high temperatures of up to 2400 °C.

Areas of application

Raw materials analysis and evaluation

Characterization along the entire process chain

Materials and component characterization

Component and systems performance

Analytics for micro- and nanoelectronics

Modeling and simulation

Areas of application

Services and consulting

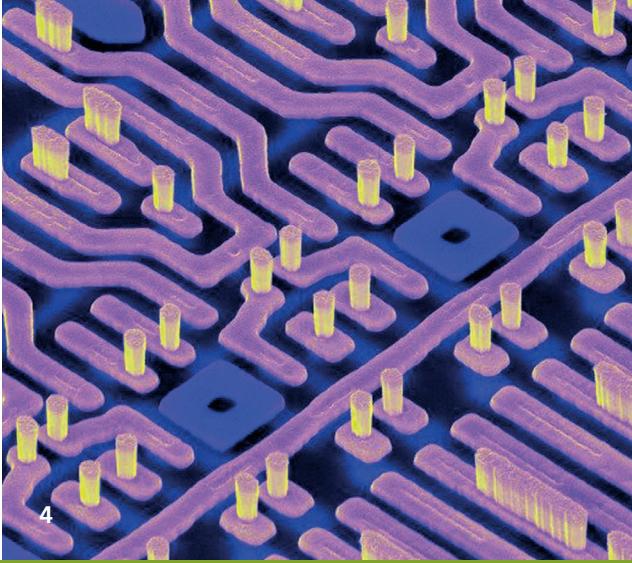
Method development and optimization

Lifespan and failure analysis

Applied industrial and research projects

Development of applied test systems

Determination of material and component parameters



Component and systems performance

Component lifespan and reliability must be studied in light of the conditions of their future use within the system. Fraunhofer IKTS offers a comprehensive selection of thermo-mechanical, chemical, electrical, physical, and climatic test processes to elucidate failure mechanisms, optimize products and achieve certifications more swiftly. Its primary focus is on structural and functional ceramic components, hard metals, cermets, components of high-performance electronics and sensor systems, components based on composite materials, and components used in filtration and catalysis.

The comprehensive expertise on materials and technology forms the basis for substantial analysis of defects and permits lifetime predictions of components under the conditions to which ceramics are exposed. In addition to test planning, testing, and evaluation, Fraunhofer IKTS offers its clients specific in-line and off-line test stands and highly specialized, application-specific testing.

Analytics for micro- and nanoelectronics

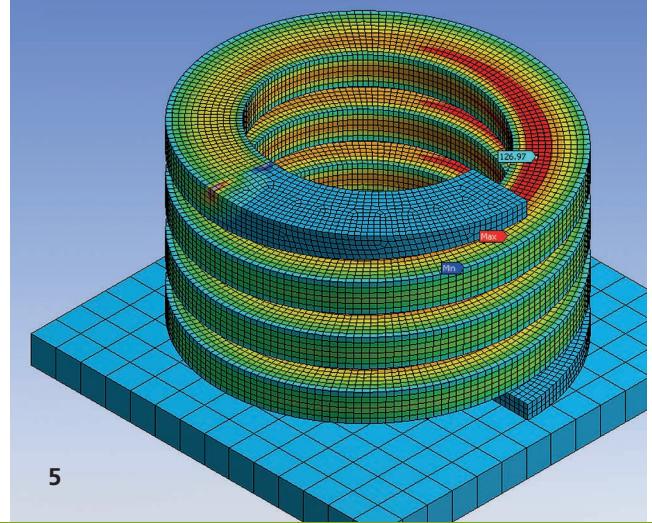
Fraunhofer IKTS specializes in application-based physical microanalysis and nanoanalysis with the aid of which technical and design solutions are developed for microelectronics, nanoelectronics, and optical electronics. New materials and production technologies demand innovative concepts in order to ensure performance and reliability as electronic applications become increasingly sophisticated. Thanks to many years of experience and its vast array of technical equipment and facilities, Fraunhofer IKTS is uniquely capable of qualifying known analytical methods, and its in-house developed methods, for use in services and equipment developments. In addition to high-resolution processes of ion and electron microscopy, and X-ray technologies, Fraunhofer IKTS also in-

vestigates new approaches to the analysis of mechanical properties on the micro and nano levels. It applies and advances new methods to characterize electrical and mechanical mechanisms of degradation in-situ.

Modeling and simulation

It is possible to curtail product cycles dramatically, and to minimize development risks, by simulating material properties, components, production technologies and systems environments. Even in the early development phases, the Fraunhofer IKTS team has access to software resources (FEM, CFD, systems simulation) for the simulation of thermal, mechanical and electrical processes, along with fluid-mechanical and reaction-technological processes in components and systems. With many years of experience in the use of flexible programming tools, the institute can also prepare and analyze user-specific model descriptions for new kinds of applications, particularly using coupled mechanisms (coupling matrix analyses, multiphysics).

- 1 Heat durability testing (recipient of test stand at 1000 °C).
- 2 SEM image of the micro-structure of an Si_3N_4 ceramic component.
- 3 High-voltage testing.
- 4 Microelectronic circuitry.



METHODS AND TECHNICAL EQUIPMENT

Analysis of ceramic raw materials and processes

- Chemical and phase composition (XRF/XRD)
- Particle size and shape analysis in the nano- to millimeter range
- Suspension characterization (rheological properties, surface conductivity, suspension stability)
- Thermal analysis as well as thermophysical and chemical properties (TG/DTA DSC, dilatometry including gas analytics in a wide variety of atmospheres from -150 °C to 2400 °C)

Structural and microstructural analysis

- Standard methods of ceramographic preparation
- Ion beam preparation techniques (BIB/FIB)
- High-resolution analysis of microstructures and surfaces using FESEM (EDX, WDX, EBSD)
- TEM cross-sectional analysis including EDX, EELS, EFTEM
- X-ray computer tomography in the micro- and nano-range, X-ray microscopy
- Pore distribution (Hg porosimetry, permeation porosimetry, N₂/Kr adsorption and N₂/Kr desorption, pycnometry)
- X-ray diffractometry, from room temperature to 1400 °C

Physical properties of materials and components, from room temperature to high temperatures

- Mechanical strength, fracture toughness, elastic constants and hardness up to 1550 °C
- Nanohardness, local elastic properties (AFM, AFAM, nano-indenter), adhesion strength
- Properties of porous and highly porous materials (e.g. membranes, particle filters, catalysts)
- Thermophysical properties (including heat conductivity, heat capacity, thermal expansion coefficient)
- Electrical and dielectrical properties (specific resistance from μΩcm to 10¹⁵ Ωcm)

Corrosion and tribological properties

- Corrosion in solutions (T < 250 °C, pressure up to 35 bar) and gases (T < 2000 °C), hot gas testing (burner test stands up to 1500 °C, gas velocity up to 100 m/s)
- Electrochemical characterization
- Tribology and wear (oscillating sliding testing at room temperature and higher temperatures, abrasion testing)

Quality and safety testing

- Climate chambers (-80 °C to 1000 °C), salt spray chamber
- Unicameral and bicameral temperature shaker
- Vibration test stand for 600 kg and 200 g
- Specific contact resistance, surface resistance, dielectric strength, creeping and dielectric properties

Accredited laboratories (DIN EN ISO/EC 17025)

- Thermoanalysis and thermophysics
- Particle and suspension characterization
- Laboratory for quality assurance and reliability

Modeling and simulation

- Finite element analysis (FEM): ANSYS (Emag/Mech), COMSOL Multiphysics, FlexPDE, Atila
- Flow velocity simulation: Fluent
- Systems simulation: Matlab/Simulink, Simulation X, Dymola/Modelica
- Thermodynamic simulation: FactSage

5 Stress distribution inside a ceramic spring.

FRAUNHOFER IKTS IN PROFILE

The Fraunhofer Institute for Ceramic Technologies and Systems IKTS conducts applied research on high-performance ceramics. The institute's three sites in Dresden and Hermsdorf (Thuringia) represent Europe's largest R&D institution dedicated to ceramics.

As a research and technology service provider, Fraunhofer IKTS develops modern ceramic high-performance materials, customized industrial manufacturing processes and creates prototype components and systems in complete production lines from laboratory to pilot-plant scale. Furthermore, the institute has expertise in diagnostics and testing of materials and processes. Test procedures in the fields of acoustics, electromagnetics, optics, microscopy and laser technology contribute substantially to the quality assurance of products and plants.

The institute operates in eight market-oriented business divisions to demonstrate and qualify ceramic technologies and components as well as non-destructive test methods for new industries, product concepts and markets beyond the established fields of application. Industries addressed include ceramic materials and processes, mechanical and automotive engineering, electronics and microsystems, energy, environmental and process engineering, bio- and medical technology, optics as well as materials and process analysis.

www.ikts.fraunhofer.de



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COVER Scanning electron
microscopy with dual-beam
device (Zeiss NVision 40 with
EDX and EBSD system).