



# Fraunhofer

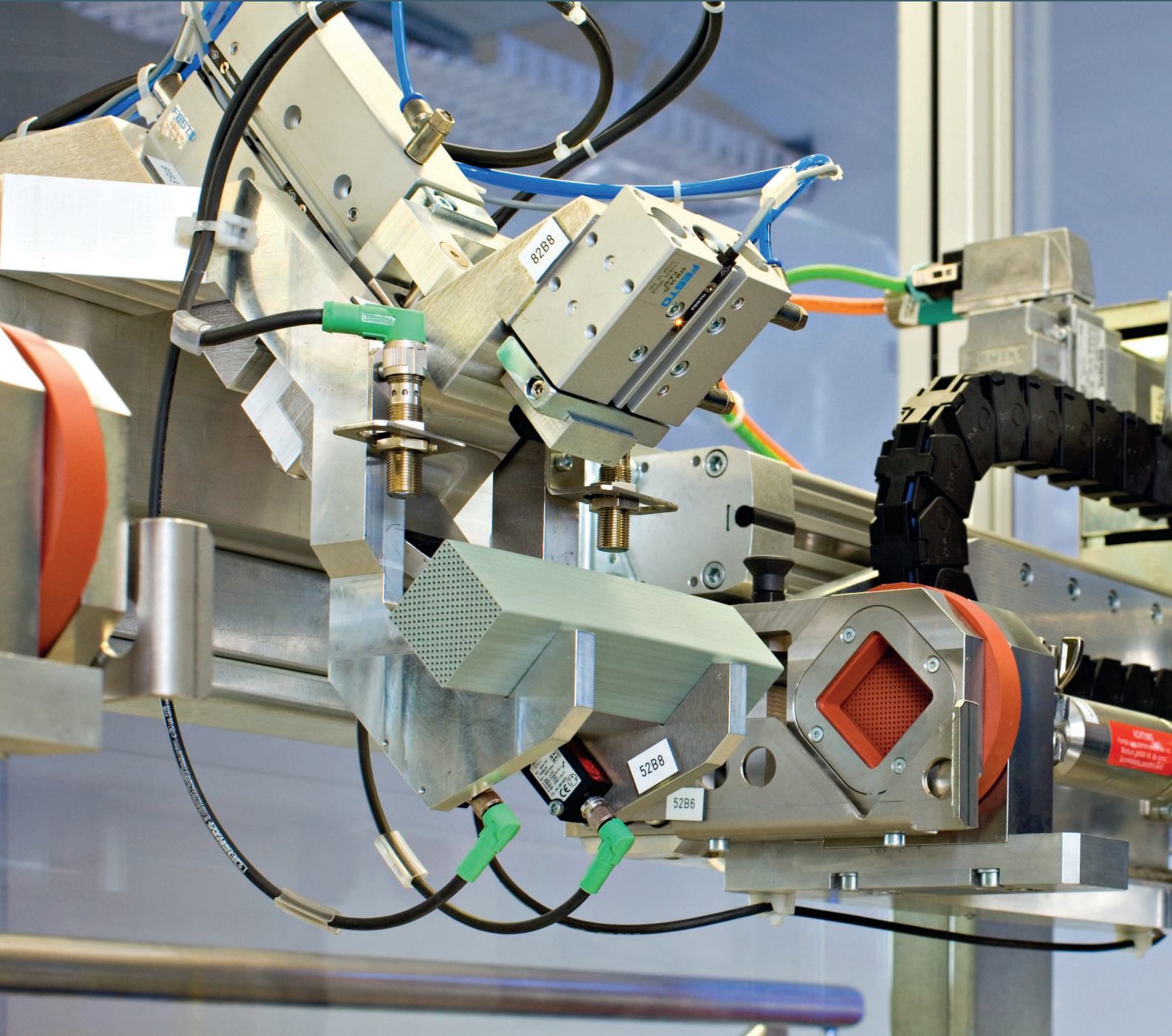
IKTS

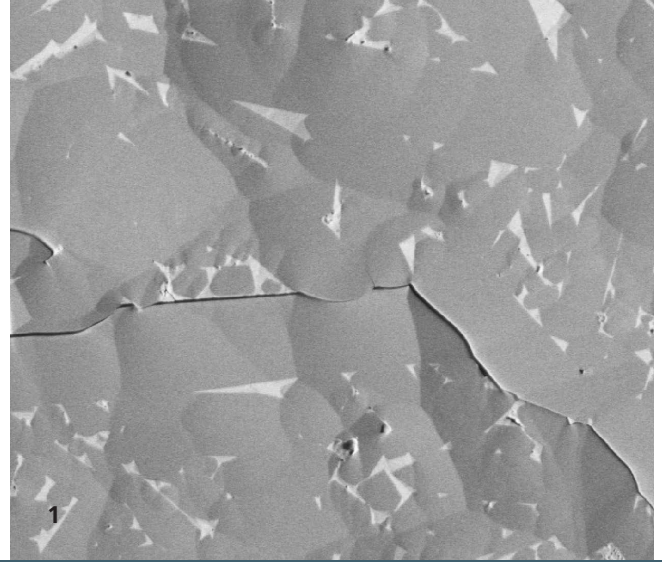
FRAUNHOFER INSTITUTE FOR CERAMIC TECHNOLOGIES AND SYSTEMS IKTS



BUSINESS DIVISION

## MATERIALS AND PROCESSES





# MATERIALS AND PROCESSES

Fraunhofer IKTS's "Materials and Processes" business division offers oxide, non-oxide and silicate materials as well as composite materials, glasses, hard metals and cermets. Depending on commercially available raw materials and pre-ceramic preliminary stages, these materials are qualified for use in actual applications. They are the prerequisites to manufacturing prototypes and small-scale series (with ceramics custom-fit to the application), which are based on sustainable process developments.

New fields of application are unlocked by systematically linking structural features with the functional properties of ceramic materials and ceramic-metal composites. Concepts like these can be found in temperature-resistant materials, conductive ceramics, luminescent materials, transparent ceramics, polycrystalline abrasives and functional coatings, among other materials.

Fraunhofer IKTS sets the standard and continuously optimizes its powder technological manufacturing processes to keep them on the cutting edge in every respect – from the utmost purity to the maximum cost efficiency. This enables IKTS to establish the basis for materials and process engineering that parallels today's industries. It produces components and parts in multiple lines of technology. It is possible to upscale these products to small- and medium-scale series in-house on equipment and machinery suited for industry.

This broad spectrum of shaping services ranges from pressing, casting and plastic molding to additive manufacturing as well as multilayer technologies and direct printing processes. A large quantity of heat treatment methods, as well as the high-performance green machining and finishing reflects the comprehensive range of expertise and services covered by the Fraunhofer IKTS portfolio. With its expertise in coating processes – including chemical vapor deposition for example, or thermal spraying, surface level properties can be modified and

components customized to individual specifications. Here as well, our customers benefit from the closed technology chains, which make it possible for IKTS to take a laboratory development to pilot-plant scale.

IKTS employees additionally possess the expertise honed by decades of experience in production-tailored and customer-specific component design, and in characterizing material and production processes. This also includes failure and defect analyses of parts and components, and consulting services on how to utilize ceramic components. In addition, the scope of services also includes creating production concepts and evaluating production processes while considering cost, quality assurance and energy efficiency. When introducing innovative technologies and realizing new products, Fraunhofer IKTS can support its partners until the transition to production is launched.



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## EXPERTISE

### Materials development

At Fraunhofer IKTS, materials development signifies, for the most part, further development, optimization and enhancement of commercially available ceramic raw materials for each application. Knowledge about the interaction of ceramic raw materials, additives, and their sintering behavior is essential in order to systematically adjust the microstructure according to the desired properties. In many cases, innovative materials also require chemical synthesis of phases or the application of chemical precursor bonds. Fraunhofer IKTS uses the variety of these precursors in order to convert them into functional materials, such as coatings, nanoparticles, and bulk materials.

### Powder technology and semi-finished products

Fraunhofer IKTS produces customized powders for ceramic and metal materials, and for composite materials. Homogeneous products with well-defined properties, such as compaction behavior, flowability and structure, as well as electric, magnetic, or catalytic functions are the objective. Powders and additives are selected according to the specifications profile, then homogenized, crushed, classified and prepared as sus-

pensions, dry mixtures or granulates. In the process, laboratory findings can be transferred to pilot-plant scale on the basis of reliable routines. A multitude of materials are available at Fraunhofer IKTS as pastes and inks for coating technologies, including screen, gravure, inkjet and aerosol printing. In addition, powders are carefully selected with regard to their application, converted to suspensions, and their technological behavior optimized during the film or layer formation process.

### Shaping

Fraunhofer IKTS is developing manufacturing design concepts based on nearly every potential outcome of the ceramic shaping process. At IKTS, powder technology processes, such as uniaxial and isostatic dry pressing, are applied at high level and under high throughput capacities, and continuously refined. As thermoplastic shaping methods, 1K and 2K injection molding processes and microinjection molding are used particularly for new types of material combinations. 3D printing is primarily used to realize quantities of a small and medium scale. IKTS has the full spectrum of extrusion facilities at its fingertips, so that multichannel elements, honeycomb geometries and tubes can be manufactured from structural and functional ceramics.

#### Areas of application

Oxide ceramics	Non-oxide ceramics	Silicate ceramics	Fiber composite materials	Hard metals	Precursor ceramics	Glasses and solders	Coatings	Specialty and functional ceramics
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#### Expertise

Powder technology

Casting

Thin-film technology

Fiber technology

Joining

Pressing

Green machining

Thick-film technology

Heat treatment and sintering

Upscaling

Plastic shaping

Additive manufacturing

Multilayer technology

Finishing



In fact, extensive semi-finished ceramics are produced and processed at the highest level – including multilayer ceramics and ceramic microsystems technology – using the tape casting technology of the institute. A unique area of expertise offered at Fraunhofer IKTS is the connection between ceramic tape casting technologies and conventional processes, such as injection molding. Scientists can functionalize components using thick-film technology. With its innovative methods, like electrophoresis, gel casting and freeze casting, the institute offers a full portfolio of services in suspension molding. In principle, all processes are available for both development tasks and for direct contract assignments.

### Heat treatment and sintering

Fraunhofer IKTS has full command of the modeling and testing of debinding and sintering processes for materials and components using ultramodern measurement technology. Building on this foundation, the institute designs, conducts and optimizes heat treatment processes on the laboratory and pilot-plant scale. A broad range of heat treatment plants is available on-site, at temperatures reaching up to 2500 °C. This allows researchers to work within the most diverse range of atmospheres (high vacuum, oxidizing, inert, reductive), and with special gases and pressure-supported processes (hot isostatic pressing, gas pressure sintering, FAST/SPS, hot pressing). In addition, specific techniques, such as reaction bonding and cofiring, are mastered.

### Green machining and finishing

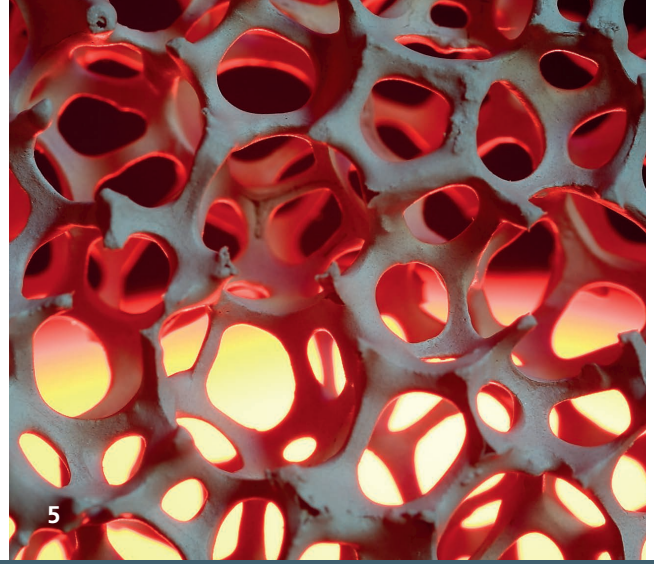
Concerning green machining and finishing, Fraunhofer IKTS develops and offers economically feasible processing concepts for cutting, grinding, lapping and polishing of ceramic components. These range from ceramic-suitable clamping and handling techniques to the selection of ultrahard, high-

performance cutting materials along with the associated processing parameters. Fraunhofer IKTS possesses ultramodern systems technology for this purpose.

### Joining

Ceramic components frequently satisfy only a portion of the overall matrix of properties sought in the part or system. That is why technologies and materials are developed at Fraunhofer IKTS that enable a firm bond between various materials for a shared task or function. The spectrum ranges from the thermally cycling joints through vacuum-sealed applications with  $\text{Al}_2\text{O}_3$  isolators, the metallization of oxide and nitride ceramics to high-temperature resistant bonds for carbide and nitride ceramics. Crystallizing glass solders and reactive solders upon contact with air, play a special role. Such joining bonds are frequently realized with the aid of easy-to-apply pastes and green films that IKTS supplies application-suitable.

- 1 *Micrograph of silicon nitride ceramics for material optimization.*
- 2 *Pilot plant for 1K and 2K injection molding and micro-injection molding.*
- 3 *Stamping of ceramic green tapes.*
- 4 *System for plasma spraying of wear-resistant coatings, thermal insulation, non-stick coatings, insulation and contact layers.*



# MATERIALS

## Oxide ceramics

- Alumina, zirconia, titania
- ZTA and ATZ materials
- Mixed oxides, spinel, perovskites, yttrium aluminium garnet
- Ferrites
- Boron suboxide

## Non-oxide ceramics

- Silicon nitride, SiAlON
- Silicon carbide (SiC, LPS-SiC, OBSC, RBSiC, NSiC, SiSiC, RSiC)
- Boron carbide, boron nitride
- Aluminum nitride
- Superhard materials (SiC/diamond, diamond, cBN-reinforced materials)
- Transition metal carbides and borides (TiC, ZrC, TiB<sub>2</sub>)

## Silicate ceramics

- Cordierite, mullite, steatite
- Zeolites

## Fiber composite materials

- Oxide and non-oxide CMC
- Short- and long-fiber-reinforced ceramics

## Hard metals

- Tungsten carbide-cobalt, mixed carbide hard metals
- Binder-free tungsten carbide
- Cermets

## Precursor ceramics

- Precursors
- Oxide and non-oxide polymer-derived ceramics
- Polymer ceramics

## Glasses and solders

- Crystallizing glasses
- Metal and active solders, reactive solders

## Coatings

- Inks and pastes
- Thin films
- CNT
- Hard material- and wear-resistant coatings
- Oxidation- and corrosion-resistant coatings
- Insulation coatings
- Catalysts and washcoats

## Specialty and functional ceramics

- Porous ceramics
- Solid-state ion conductors (e.g., sodium-beta aluminate)
- Thermoelectric materials
- Low-temperature cofired ceramics (LTCC)
- High-temperature cofired ceramics (HTCC)
- Ceramic magnetic materials
- Lead-free piezoceramics (barium titanate, potassium sodium niobate)
- Lead zirconate titanate, lead/magnesium niobate-lead titanate
- Piezoelectric fiber composites

5 *Open-cell foam ceramics for filters, burners, reformers or solar receivers.*

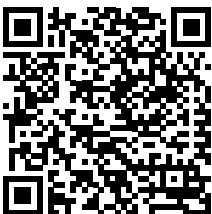
# FRAUNHOFER IKTS IN PROFILE

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](http://www.ikts.fraunhofer.de)



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