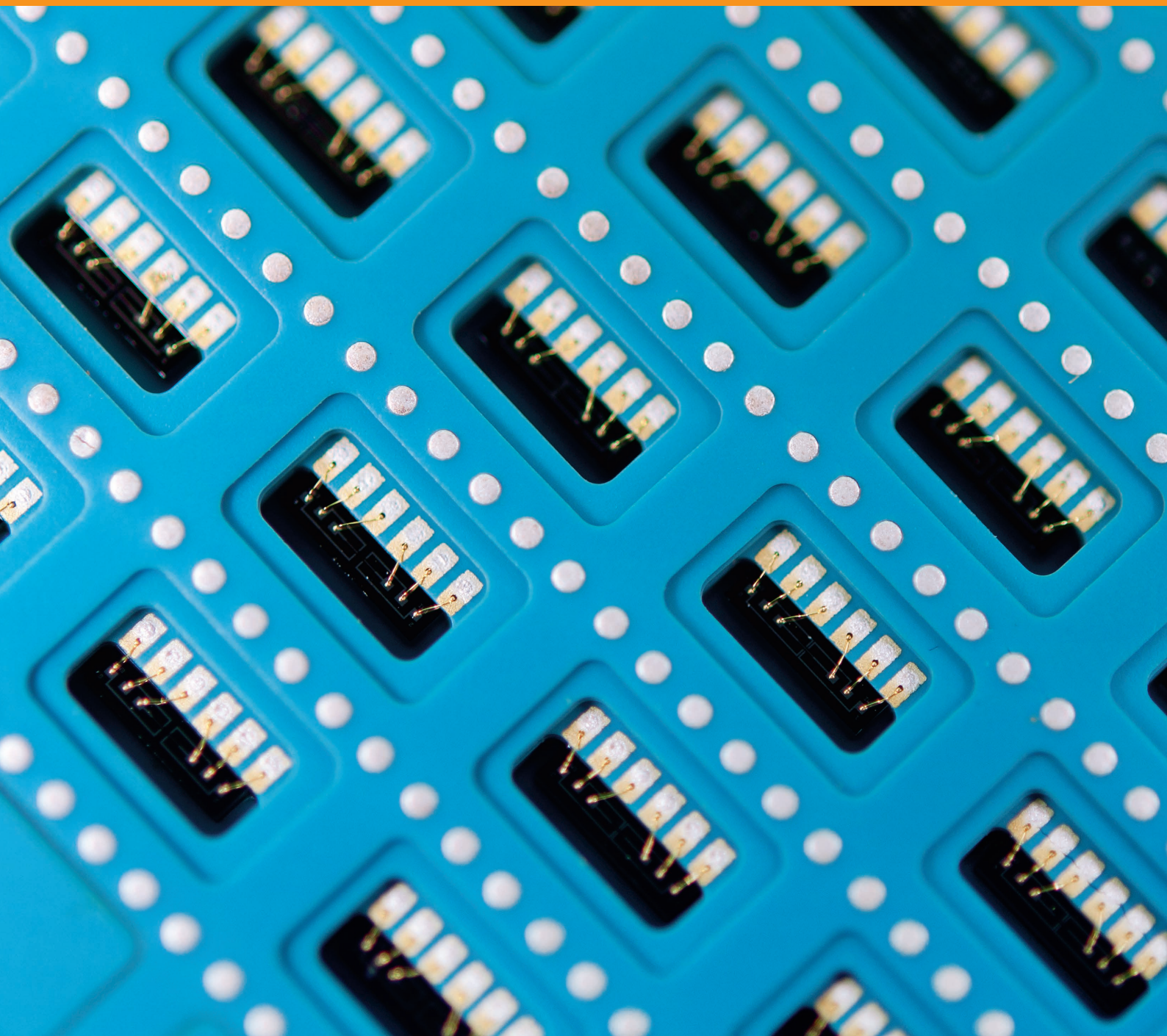
Fraunhofer
IKTS

FRAUNHOFER INSTITUTE FOR CERAMIC TECHNOLOGIES AND SYSTEMS IKTS

BUSINESS DIVISION

ELECTRONICS AND MICROSYSTEMS



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ELECTRONICS AND MICROSYSTEMS

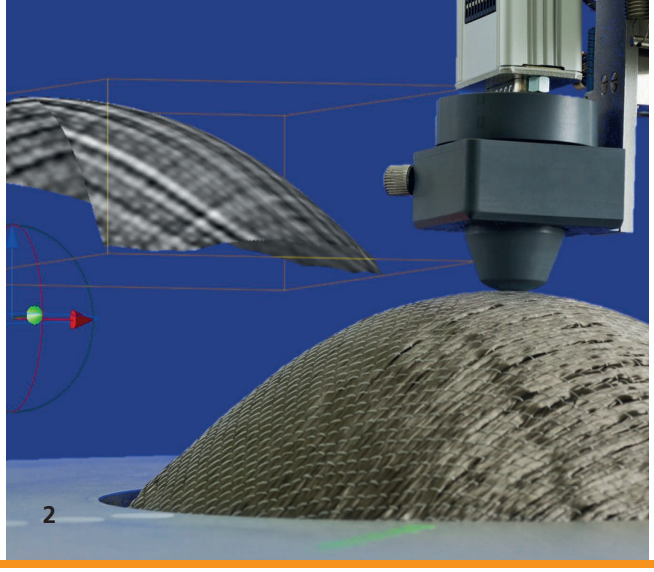
"Electronics and Microsystems" is a business division in which Fraunhofer IKTS offers materials, technologies, components, and systems for microelectronics and nanoelectronics, energy engineering, sensors and actuator technology as well as for industrial test systems.

In the future, microsystems will not only become substantially more sophisticated, more robust and smaller, they will also increasingly interact directly with their environment through enhanced functionalities. This will result in ever more complex demands being placed on the development of more cost-effective and reliable materials as well as production solutions for miniaturized assemblies. Fraunhofer IKTS resolves these challenges by taking an integrated approach to materials, processes and system design.

Fraunhofer IKTS engineers develop functional ceramic materials with extraordinary properties that make them suitable for use in harsh environments. These materials can be processed using an array of technologies (synthesis, packaging, joining, deposition and structuring technologies), depending on general requirements and customer preferences, and then be applied to sophisticated microsystems. Using standardized production processes as well as tried-and-true methods, they succeed in attaining competitive cost rates. Ceramic components can also realize additional fluid, thermal, sensor, and actuator functions that interact directly with the electronic components of signal processing and power electronics. Fraunhofer IKTS has special expertise in relation to multifunctional materials, such as piezoceramics, electrocaloric materials and shape memory alloys. These kinds of materials can be used to engineer so-called "smart" systems in which the material itself connects multiple functions with each other.

Sensors and complex sensor systems represent a focus within this business division's portfolio, enabling the team to record multiple chemical, electrochemical, electrical, thermal, acoustic, electromagnetic, mechanical and optical parameters. Adapted to customized process specifications, evaluation electronics – together with its hardware and software – are created entirely in-house at IKTS. These systems are utilized in automotive engineering and energy engineering, non-destructive testing as well as condition and process monitoring.

In the "Electronics and Microsystems" business division, customized materials, design rules, and test technologies are available so that it can continue to expand the fields of application for miniaturized systems, attenuate development cycles, and ensure systems reliability. Its comprehensive technical infrastructure and specific offerings to the industrial sector ensure that its development processes retain their industrial focus, for efficient transfer of expertise and technology to the customer.



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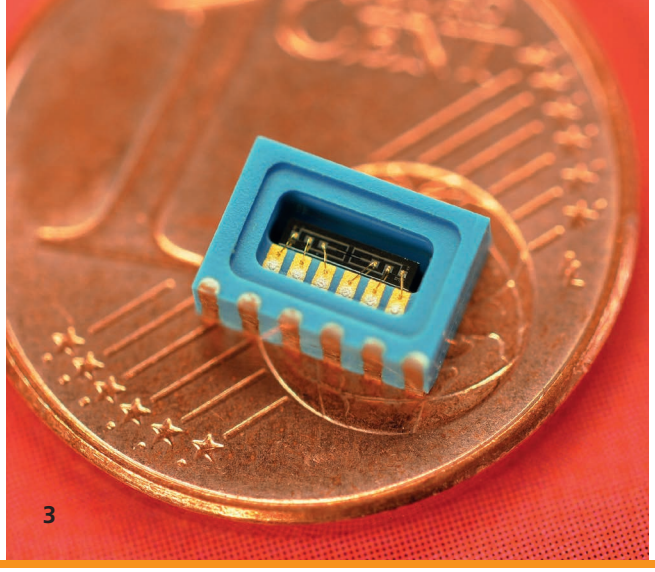

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AREAS OF APPLICATION

Electronic devices and components

As end users' demands continue to grow, so too does the need for components that guarantee the utmost reliability and most durable lifespan, as integration density and miniaturization continue to increase – even under the most adverse operating conditions. Their specific physical properties give ceramic devices tremendous advantages for high-frequency and high-temperature applications. Fraunhofer IKTS develops customer-specific solutions for solid and flexible substrates, passive components and integrated circuits. A particular specialty at IKTS is embodied by polymer ceramic composites that link the process capabilities found in plastics with properties that are typical of ceramics, such as durability and temperature resistance. These composites are especially well-suited for use in highly durable components and system encapsulations.

Sensors and sensor systems

Fraunhofer IKTS offers single-source, complete sensor solutions for use in chemical, electrochemical, electrical, thermal, acoustic, electromagnetic, mechanical, and optical sensor technologies. Building on the synthesis of functional ceramic materials and the processing of commercial materials, Fraunhofer IKTS develops sensor components for applications in chemical, process, environmental, energy, and test engineering. Depending on the requirements, these sensor components can be furnished with calibrated evaluation electronics for one or multiple parameters and are integrated into the system environment. Fraunhofer IKTS assists customers and project partners along the entire process chain: from materials synthesis and adaptation to the integration of the entire system into existing process and systems structures.

Industrial and automotive sensor systems represent one focus in this regard; so too is the non-destructive testing of metals, ceramics, and composites as well as carbon fiber-reinforced composites. The institute has honed its existing expertise in the configuration of high-temperature-resistant sensor solutions based on ceramic substrates.

Electronic microsystems

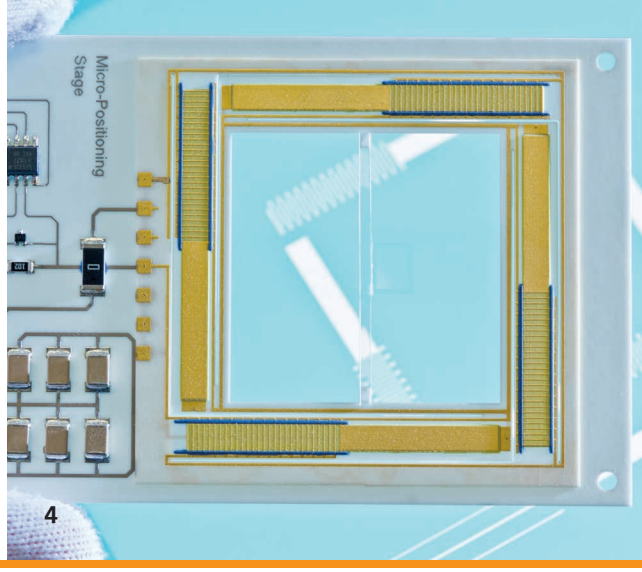
Due to their high temperature resistance, mechanical strength and the possibility to produce them in multiple panels, ceramic packaging solutions offer the benefit of being an ideal integration platform for microoptical, microelectromechanical (MEMs) and sensory systems. By enhancing them with actuators, heating and cooling elements, fluid elements and other functionalities, scientists can tap into entirely new areas of application

Areas of application

Electronic components	Electronic microsystems	Sensors and sensor systems	Intelligent materials and systems	Material parameters and reliability

Expertise

Functional ceramic materials and intelligent materials		Thin-film technology
Sensor development and assembly	Simulation and environmental simulation	Thick-film and multilayer technology
Packaging technology	Characterization and applied test engineering	Systems and structure integration



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for highly integrated products. These can be integrated on a three-dimensional basis by using the latest thick-film, multilayer (HTCC, LTCC) and thin-film technologies, and they can be miniaturized all the way down to the wafer level. These sensors can also be fully embedded into structural components.

Intelligent materials and systems

Functionality does not necessarily mean complexity. Fraunhofer IKTS works with smart systems in which different components are integrated into a total system. However, the material itself can also execute controllable functions directly. To do so, staff at Fraunhofer IKTS researches and studies the extraordinary physical properties of materials. Known as "smart materials", they can respond to physical parameters autonomously, combining electrical and mechanical functionality, e.g. to execute mechanical movements within the most confined spaces. These properties lend themselves superbly for use in microfluid technology, optics and laser engineering, as well as micromechanical systems. IKTS researchers engineer such materials, characterize their properties in meticulous detail, test them, and integrate them into components and systems.

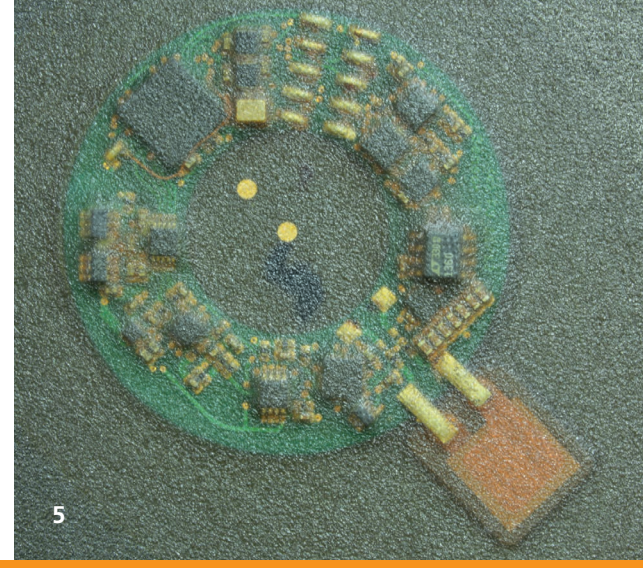
Material parameters and reliability

Shortened development cycles and increasing complexity at the component and systems levels make the reliability of nanoelectronic and microelectronic systems a central challenge. The scientists at Fraunhofer IKTS study and evaluate functional and heterogeneously integrated systems in nanoelectronics and microelectronics, as well as microsystems technology. At the heart of these endeavors is the effort to identify and measure key material parameters on a variety of scales, using mechanical and thermal test procedures as well as high-resolution microscopy. These determinations are used to subsequently derive design rules for robust components. Drawing on a broad spectrum of in-situ measurement procedures, specific material and joining requirements can be evaluated and optimized in real time in order to provide the appropriate parameters for the simulation. The knowledge acquired in this manner about materials and joining technologies, as well as the mechanisms of degradation and failure, form the basis for an improved level of reliability.

Printing inks and flexible electronics

Flexible substrates made of polymers represent an increasingly significant platform for the architecture of electronic circuits and the integration of microsystems. The temperature resistance, which is limited to a maximum of 200 °C, necessitates the application of the low-sintered inks for metallization and functional coatings. In the process, the scientists apply techniques, such as screen, inkjet, and aerosol printing. Fraunhofer IKTS offers nanosuspensions for this made from a variety of materials, such as Ag, Au, Pt, Cu, ITO, CNT or graphene. These layers are then tested for their adhesion, conductivity, and bondability using viable serial production and existing full-scale production methods.

1 *Paste production in the clean room on a three-roll mill.*
2 *EddyCus® radio wave impedance image found in a free-form carbon layer.*
3 *Size comparison of an LTCC-MEMS package.*
4 *Piezoceramic actuator platform for a level hub.*



EXPERTISE

Materials

- Single- and multilayered substrates made from oxide and non-oxide ceramics (Al_2O_3, SiN, AlN)
- Functional and electroceramics (dielectrics, piezoelectrics, resistors, magnetic materials, among others)
- Polymer ceramics

Technologies

- Thick-film and multilayer technology (complete line for HTCC, LTCC)
- Pastes, inks, ceramic green tapes
- Feedstocks for polymer ceramics
- Thin-film technology (thermal CVD, PECVD, thermal ALD, PVD, LPD)
- Injection molding and casting technology
- Microsurface and surface processing (laser embossing, microstamping)
- Technology development and optimization, techniques for scaling to the pilot-plant scale

Systems integration, packaging technology

- Packaging technology (bonding, soldering, joining, encapsulation)
- Advanced packaging (3D integration, embedding)
- Design and production of components and modules
- Design and integration of sensor systems (eddy current, ultrasound, X-ray, and chemical and physical sensor technologies)
- Structural integration of electronic components

Reliability of electronics

- Compilation of materials data at various size scales
- Material characterization and nanoanalytics (www.nanoanalytik.fraunhofer.de)
- Clarification of degradation and failure mechanisms
- Customer-specific test routines and micromechanical test engineering
- Modeling and simulation at the material, component, and systems level
- Design rules for reliable and robust components

5 *Sensor nodes integrated as MEMS into the CFRP structure.*

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 *MEMS package manufactured in multiple panels.*