Protection and Security

Amid geopolitical tensions, hybrid threats and Germany's renewed emphasis on resilience and defense readiness, industry and research are undergoing fundamental change. These geopolitical trends mean that there are now additional expectations of industry and research, such as reshoring (bringing production back to the home country), reducing dependency on foreign technologies and resources, and building more robust supply chains. Against the backdrop of Germany's National Security Strategy and the recommendations issued by the Commission of Experts for Research and Innovation (EFI), technological capabilities for security and defense research are becoming increasingly important.

For decades, Fraunhofer IKTS has been carrying out research into materials, technologies and systems for demanding applications – expertise that is particularly relevant given today's security policy landscape. IKTS clusters this expertise within the focus area "Protection and Security", aligning its work with the needs of civil protection and disaster response, emergency services and armed forces, while at the same time strengthening the dual-use approach that the EFI highlights as a key foundation for technological sovereignty.

Technology Platforms for Security-Related Solutions

Ceramic components and systems demonstrate their strengths wherever conventional materials reach their limits under extreme operating conditions – scenarios that are critical when it comes to protecting infrastructure, defense, disaster response and military operations. Their low weight, extreme hardness, high energy absorption capacity and resistance to heat and corrosion open up new possibilities for robust communication and sensor systems, resilient energy supply and ballistic protection. Fraunhofer IKTS provides high-performance material and technology platforms for this purpose in the areas of protective ceramics, ceramic microsystems, energy conversion and storage, as well as non-destructive testing.

Personal and Vehicle Protection

Fraunhofer IKTS develops high-performance ceramics for ballistic protection of personnel, vehicles and critical infrastructure. Used in body armor vests as well as in modular vehicle and structural protection systems, the materials combine low weight with high energy absorption capacity. The focus here is on tailored high-performance ceramics such as aluminum oxide, silicon carbide and boron carbide. Research is increasingly exploring hybrid ceramics – incorporating titanium carbide or diamond, for example – in order to achieve higher protection classes and address specific threat scenarios. Due to their high hardness and significantly lower weight compared to armor steel, these materials are suitable for a wide range of modern protection solutions. Cemented carbides, cermets and ultra-high-temperature ceramics (UHTCs) are also being optimized for protective and functional applications in military and security contexts.



Lightweight, durable protective ceramics for emergency services (Source: pexels).

Advanced processing technologies enable the production of low-defect transparent high-performance ceramics with strong protective performance and excellent optical properties. Development in this field was significantly strengthened in 2025 through the expansion of a research and development center in Hermsdorf and the integration of the transparent ceramics division of CeramTec-ETEC GmbH, including the PERLUCOR® brand. This enables the production of large-format transparent components that can be further functionalized, for example by means of integrated sensor technologies.

Communications and Electronic Systems

Communications and electronic systems have to function reliably in security and defense applications even under extreme conditions, including large temperature fluctuations, high levels of mechanical stress and electromagnetic interference. At the same time, devices are becoming smaller and more complex, and are also expected to last longer, so they are required to meet much more rigorous standards in terms of performance and reliability.

With its LTCC and HTCC technology platforms, Fraunhofer IKTS develops robust modules for radar, high-frequency and communication systems. These stand out for their high level of reliability, optimized thermomechanical matching and hermetic packaging – features that are essential for command-and-control systems, battlefield sensing and unmanned platforms. Another focus is on power electronics systems that enable energy supply, signal processing and control across a wide

Contact Maria Kaminski • Phone +49 351 2553-7891 • maria.kaminski@ikts.fraunhofer.de



Sensory and electronic systems for reconnaissance and infrastructure monitoring (Source: gettyimages).

range of devices. Ceramic substrates and highly integrated packages enable compact architectures that are resistant to heat and vibration. For monitoring safety-critical parameters such as pressure, temperature and acceleration, IKTS provides sensor systems based on piezoresistive, piezoelectric and capacitive measurement principles. High-performance ultrasonic transducers are used in sonar systems.

IKTS has extensive expertise in designing robust electronic systems for harsh civil and military environments. The systematic selection of materials, packaging technology and system architectures – tailored to demanding load profiles – is crucial for reliability. To this end, IKTS employs accelerated aging methods, simulations, digital twins, materials characterization with modeling and physics-of-failure analyses supported by high-resolution imaging. Across the entire value chain, a key focus is trusted electronics, for example based on unique component identification, tamper-resistant modules and integrated protection mechanisms.

Energy and Supply Systems

Resilient energy supply is essential for disaster response, military deployments and the broader energy system. Mobile, robust and low-maintenance energy systems – such as multi-fuel-capable fuel cells and battery hybrid solutions – ensure operational readiness for communications infrastructure, medical facilities and water treatment systems.

Ceramic energy converters and storage systems developed at Fraunhofer IKTS enable operation using locally available fuels and renewable energy sources. For stationary electrical storage, ceramic high-temperature battery cells ($Na/NiCl_2$) are deployed at scales up to the MWh range. Ceramic SOC cells can be used both in fuel cell mode (SOFC) to generate electricity and heat from fuels such as hydrogen, ammonia or methane, and in electrolysis mode (SOEC) for hydrogen, syngas and e-fuel production. Implemented in container-based systems, they enable scalable, decentralized supply with a high level of redundancy and adaptability. In addition, Fraunhofer IKTS develops solutions for monitoring critical infrastructure – including bridges, pipelines and subsea cables – to detect wear, gradual damage and threats at an early stage. Monitoring systems and integrated safety sensors based on ultrasonic and acoustic emission methods enable targeted maintenance and prevent tampering. Real-time data on loads, temperatures and disruptions enhance operational stability and support rapid decision-making in crisis situations.



Self-sufficient systems (energy, water) for civilian and military supply (Source: gettyimages).

Interdisciplinary Research and Network

These research activities are inherently interdisciplinary and involve regional, national and international partners. At the initiative of the Saxon Ministry of Science and together with Fraunhofer FKIE and Leibniz IFW Dresden, Fraunhofer IKTS coordinates the ERDF research network Innovations for Integrated Security and Sustainability (I2SN). With its 16 partners, the network strengthens security research and promotes dual-use approaches as well as synergies between academia, industry and security stakeholders.

I2SN brings together expertise in materials technologies, energy systems and cyber/IT security, creating a platform for innovative solutions in the areas of both internal and external security. Shared services along with exchange and transfer formats facilitate the transition from research findings to real-world applications, ranging from protection systems and resilient energy infrastructures to secure digital ecosystems.