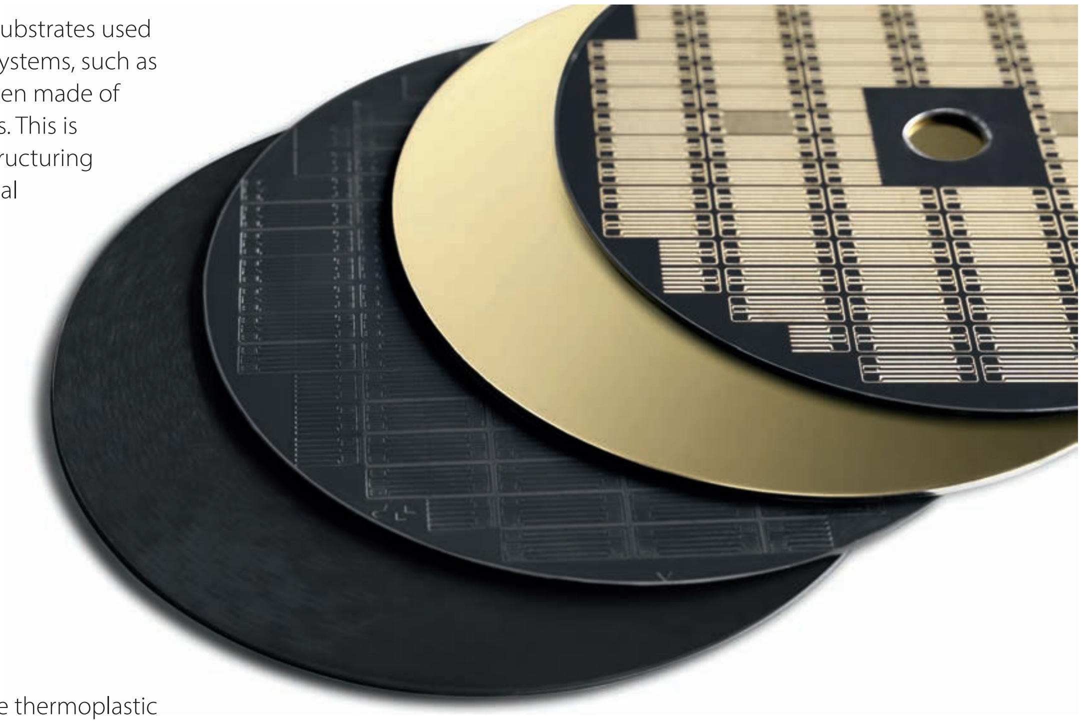
A Simplified Way to Functionalize, Individualize and Integrate MEMS

Microsystems Rethought

Substrates for microelectromechanical systems (MEMS) are usually made of silicon, ceramic or glass. However, with the Ensinger Microsystems Technology (EMST), the tiny helpers can be produced much easier. Lithography in the cleanroom becomes obsolete. Instead, extremely fine structures are implemented during injection molding of the polymer wafer and metallically functionalized. This allows for meeting individual requirements – also in terms of system integration.

Until now, the rigid substrates used for building microsystems, such as sensors, have mostly been made of silicon, ceramics or glass. This is because lithographic structuring requires various chemical solvents, coatings and temperature-intensive process steps. Many plastics fail to meet these technical requirements or are only affordably priced as a film material. This is different with polyether ether ketone (PEEK), which scores with its outstanding properties.



From plastic wafer to functionalized chip: The substrate made of Tecacomp PEEK LDS is equipped with conductor paths and vias and enables numerous sensor functions within a very small space. © Ensinger

Multi-Talented PEEK

PEEK is a semi-crystalline thermoplastic with very high chemical and temperature resistance. These properties are crucial for use in microsystems technology. The electrically insulating and highly inert plastic has high strength, is resistant to radiation and fulfills the requirements of Directive 2011/65/EU RoHS as well as numerous industrial standards for the production of food and pharmaceuticals, medical and aerospace technology and the oil and gas industry.

At Ensinger GmbH, Nufringen, Germany, the material has been further optimized in years of development work with cooperation partners. Wafers made of Tecacomp PEEK LDS (**Fig. 1**) support the laser direct structuring (LDS) developed for the MID process (short for molded interconnect devices). This allows for the precise realization of ultra-fine conductor paths and contact pads.

Metallizable and Biocompatible

With its optimized surface roughness (<30 nm R_a), Tecacomp PEEK LDS is an extremely reliable bonding substrate for metallic thin films such as electroless metallization, electroplating or PVD (physical vapor deposition) coatings. The thermal expansion coefficient can be adapted to the metal used for the respective thin film – for example gold, nickel or copper. The high temperature resistance (long-term up to 260 °C, short-term up to 300 °C) also enables wire bonding as well as thermo-compressive, reflow and conventional soldering. With Tecacomp PEEK MED LDS grey, Ensinger also offers a biocompatible variant of the compound from which wafers suitable for medical technology (type: Tecawafer PEEK MT LDS grey) are produced. Plastics from Ensinger's MED and MT standard portfolio are preferably tested on the product in accordance with ISO 10993, depending on their intended application. They fulfill the requirements specified in the respective test. However, the biocompatibility assessment can also be customized.

EMST instead of Lithography

Ensinger Microsystems Technology (EMST), which was invented and pat-

Fig. 1. Wafers made of Tecacomp PEEK LDS allow for ultra-fine structures of 1 to 100 µm using laser direct structuring (LDS). © Ensinger

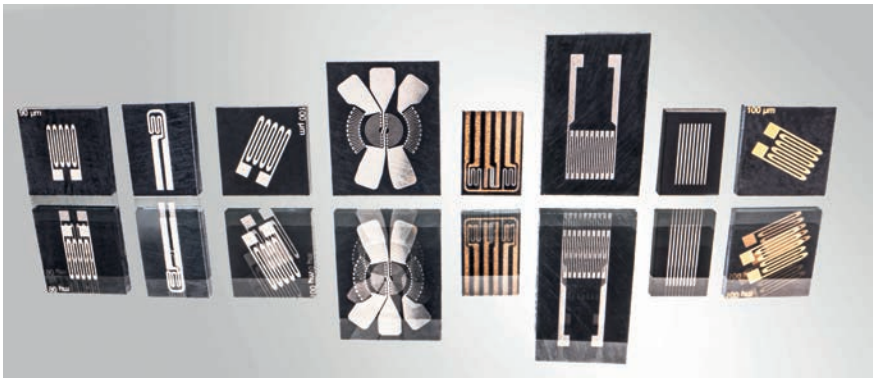


Fig. 2. The EMST enables the production of individualized MEMS based on wafers made of high-performance plastic. The physical characteristics of the microsystem are realized through the properties of the applied metals. © Ensinger

ented with the Institute of Microproduction Technology (IMPT) at Leibniz University Hannover, Germany, now opens up new possibilities for the functionalization, integration and individualization of microsystems.

In the injection molding process, so-called Tecawafers made of PEEK LDS are pre-structured and feature extremely precise surface structures, which are transferred by tool inserts machined to micrometer precision. These structures can have resolutions in the usual range of lithography for microsystems of 1 to 100 µm. Functionalization is achieved by PVD processes.

This means that the physical properties of the microsystem are enabled by the characteristics of different metals or alloys. For example, temperature sensors are made with platinum, magnetic field sensors use nickel-iron alloys or various other systems can be created from more complex layer stacks. After functionalization, the structures are exposed by polishing processes and can therefore be modelled quickly and reproducibly (**Fig. 2**).

Small Structures, Great Freedom

Thanks to the injection molding process, the size, structure and shape of the microsystems can now be designed much more freely than it would normally be possible with lithography. Individualized microsystems are also much more cost-efficient and flexible – both in terms of the size of the individual sensor or sensor array, as well as regarding the unit quantity, the wafer format or the number of wafers.

As the shape of the substrate can also be designed freely, new options for system integration can now be offered. This opens a new door to the integration of microsystems in assemblies or in specific applications. In combination with the laser direct structuring that Tecacomp PEEK LDS supports, the new degrees of freedom with regard to substrate geometries mean that sensor arrays or sensor carriers can now be installed directly as components and no longer need to be housed or connected using complex contacting »

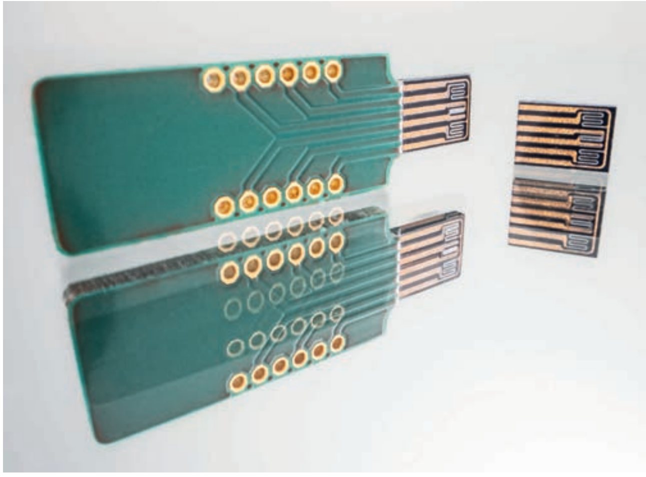


Fig. 3. This compact flow sensor for respiratory and dialysis machines measures both the direction of flow and the temperature with precision. © Ensinger

technologies in order to be installed in the target application.

Individualized Sensors for Medical Technology

Sensors are being used in a growing number of medical applications. Thanks to high energy efficiency and miniaturization, they enable new portable applications and increasingly compact end devices. EMST allows one or more sensors to be integrated in the smallest of spaces. For example, flow sensors (**Fig. 3**) for respiratory and dialysis devices have been developed that measure both the direction of flow and the temperature with high precision.

Magnetic sensors, in particular AMR sensors (**Fig. 4**), which are based on the anisotopic magnetoresistive effect, offer a wide range of applications. They are used, for example, to measure the speed in dental drills, enable the localization and 3D navigation of so-called "smart pills" in the gastrointestinal tract or the exact positioning of instruments in robot-assisted minimally invasive surgery (RMIS).

Compact Design

AMR sensors are demanding in terms of their PVD thin-film system on the PEEK substrate, the structural geometry of the imprinted microstructure and the subsequent assembly and connection technology in the application environment. Ensinger offers an individualized, functionalized and integrated solution. The sensors are realized on the PEEK substrate, which was designed directly in a format with mounting points for subsequent installation. The conductor paths and vias are produced using LDS and PVD processes. The controller and the analogue-to-digital converter are fixed directly onto the functionalized substrate using reflow soldering.

As the substrate has the sensor properties, no components other than the controller and the converter need to be attached. The power supply and display connection are provided via USB-C. The self-learning AMR sensor can be used in a wide variety of applications and demonstrates all the combined advantages of the EMST.

Conclusion

Overall, the Ensinger Microsystems Technology offers a wide range of innovations for the production of MEMS. The new design freedom has resulted in a large number of applications that are industrialized for series production at Ensinger. These include, for example, pressure, temperature, flow and magnetic field sensors (AMR, GMR and eddy current), strain gauges, current sensors and transformers. Manufacturing without lithography processes enables significantly more efficient and flexible production. ■

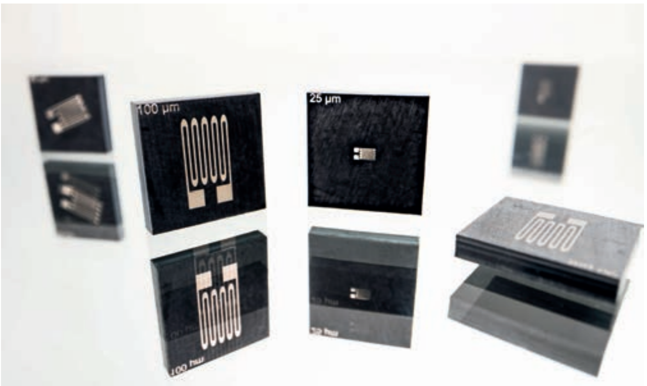


Fig. 4. AMR sensors can be used, for example, for speed measurement in dental drills, in 3D localization systems with "smart pill" technologies or for positioning in robot-assisted minimally invasive surgery (RMIS). © Ensinger

Info

Text

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Company Profile

The **Ensinger Group** is engaged in the development, production and sale of compounds, semi-finished materials, composites, finished parts and profiles made of engineering and high-performance plastics. To process the thermoplastic polymers, Ensinger uses a wide range of production techniques, such as extrusion, machining, injection molding, casting, sintering and pressing. With a total of 2700 employees at 34 locations, the family-owned company is represented in all major industrial regions worldwide with production facilities or sales offices.

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