Fraunhofer
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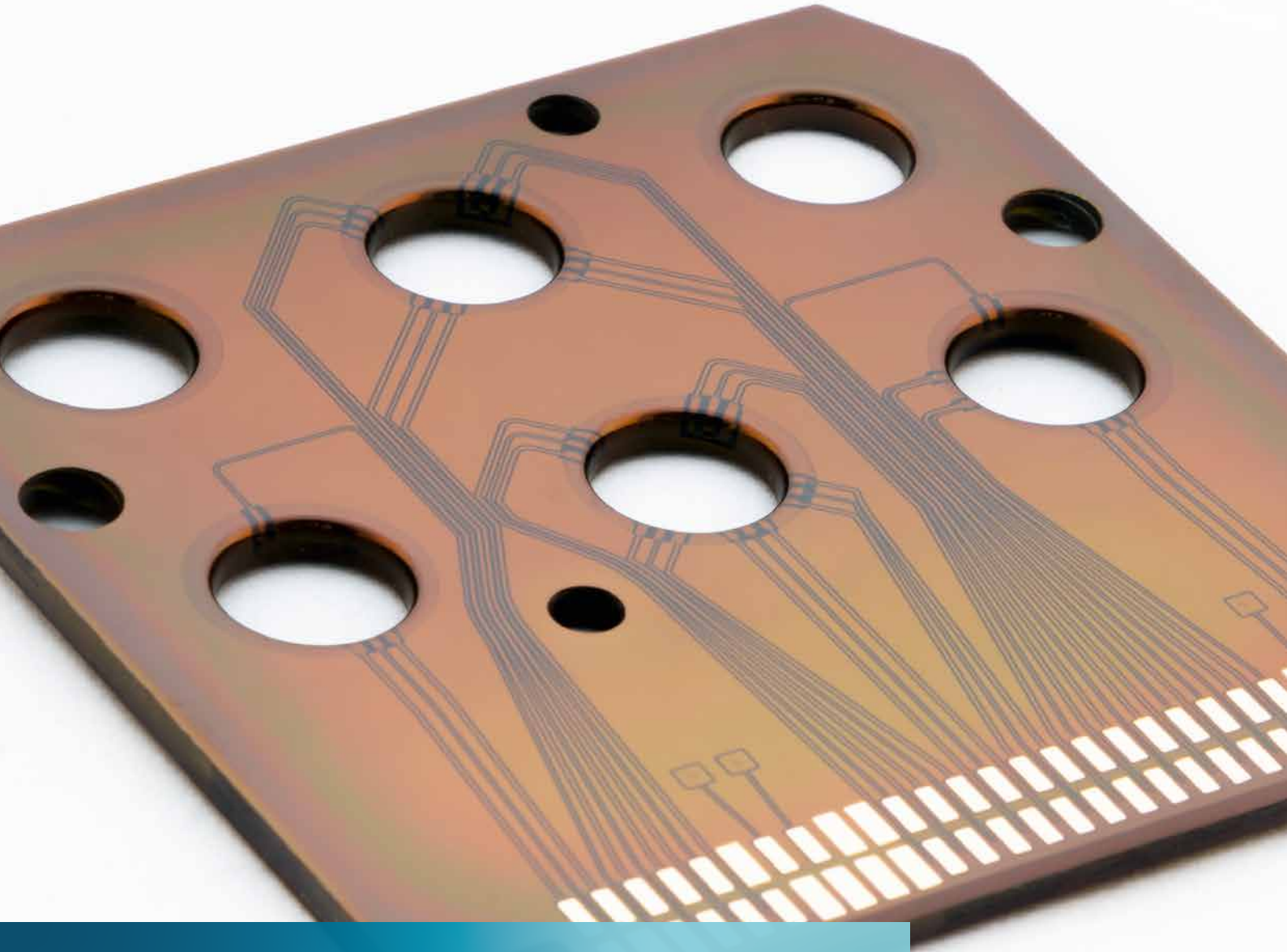


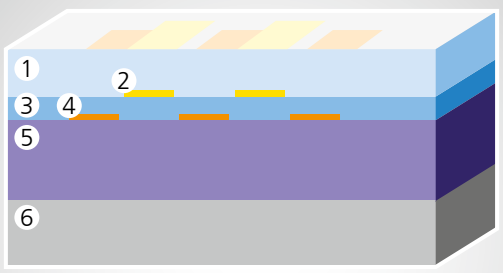
Sensors for production

Smart Factory

Multi-sensor system – universal and individual

The measurement of force, pressure, temperature, wear and other variables directly in main load zones or on tool active surfaces by means of thin-film sensors provides valuable data in order to optimize existing production processes or simulation models. The application of wear-resistant and tribologically adapted thin-film sensors enables measurements in areas which were previously difficult to access.

That is why a multifunctional thin-film system was developed at the Fraunhofer IST for the local measurement of the pressure and temperature distribution on surfaces, for example the surface of tools. This is a wear-resistant multi-layer system that, in addition to local force and pressure measurement on complex-shaped surfaces, also makes it possible to measure the local temperature and wear in the main load-carrying areas of the component – without the integration of additional measuring devices. The sensor modules can be individually designed, integrated into existing machines, or deposited directly onto 2D and 3D components with complex shapes.



1. Insulating and wear-protection layer (3 µm)
2. Temperature meander structure (0.2 µm)
3. Insulating and wear-protection layer (1 µm)
4. Electrode structure Cr (0.2 µm)
5. DiaForce® (6 µm)
6. Metal base body

1

Schematic representation of the multifunctional film system.

The thin-film system

The thin-film system consists of the following functional layers precipitated onto a steel base body (see Figure 1):

- a piezoresistive sensor layer (material: DiaForce®, d ~ 6 µm),
- a lithographically structured metal layer (material: chrome, d ~ 0.2 µm),
- an insulation and wear-protection layer (material: SICON®, d ~ 1 µm),
- a temperature meander structure (material: chrome, d ~ 0.2 µm), and
- an insulation and wear-protection layer (material: SICON®, d ~ 3 µm).

The production process

The surfaces being treated are coated by means of plasma-assisted chemical vapor deposition (PACVD) with the DiaForce® piezoresistive and tribologically resistant hydrocarbon film with a thickness of 6 µm. To enable the measurement of local loads, individual circular electrode fields made of chrome are produced on the sensor layer by means of physical vapor deposition (PVD) in combination with photolithography and wet chemical etching. An insulation layer with a thickness of 1 µm is also deposited, consisting of the SICON® hydrocarbon film modified with silicon and oxygen. On top of this insulation layer, another chrome layer with a thickness of 0.2 µm is applied in a second PVD process. This is subsequently structured so that, on the one hand, it exhibits a meander structure used for temperature measurement. On the other hand, it contains conductive paths from the electrode structures previously produced for force measurement to the contacting area. Since the sensor structures have to be protected against wear, a final SICON® covering layer with a thickness of 3 µm is also deposited.

The benefits of integrated thin-film sensors

The multifunctional thin-film systems developed at the Fraunhofer IST offer a number of advantages compared to conventional measurement systems, including:

- Optimization of simulations
- Optimization and monitoring of production processes
- Improving the understanding of operating states
- Optimization of maintenance intervals
- Reduction of scrap
- Consultation and training

One thin-film system – many applications

Sensor systems for plastic injection molding

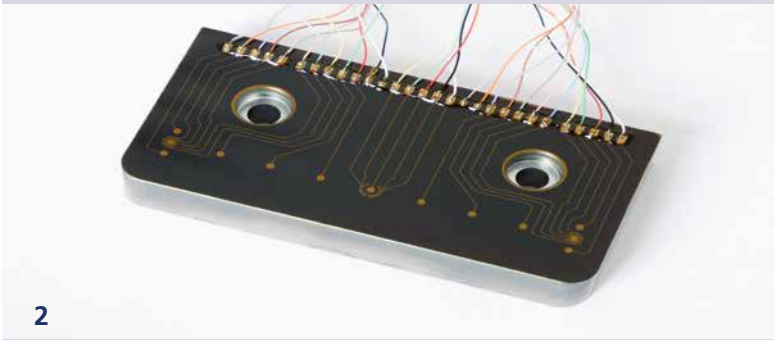
Wear-resistant thin-film sensor systems play an ever greater role in many different applications, especially for the real-time capturing of process data – also in plastic injection molding. The innovative multifunctional thin-film system makes it possible to capture both the temperature distribution and the flow front dynamics on the injection molding tool surface in direct contact with the plastic melt, during the plastic injection molding process.

Sensor systems for sheet metal bending and deep drawing processes

Production defects such as creases, cracks, and constrictions on the shaped sheet metal often occur while manufacturing sheet metal parts, thus increasing the scrap rate. With the integration of thin-film sensor systems, it is possible to regulate process control, thereby compensate for fluctuations and minimize the number of bad parts. The novel thin-film sensor system developed at the Fraunhofer IST is in direct contact with the workpiece being shaped and makes it possible to accurately measure the pressure and temperature distribution so that the behavior of the sheet metal in the bending and drawing process can be determined precisely.

Washer sensor systems

Washers with an integrated thin-film sensor system have a broad range of potential applications in many different fields ranging from high racks to production facilities and wind power plants to building and bridge construction. The special feature of the washer sensor system developed at the Fraunhofer IST is that the measuring points to locally determine the pressure and temperature distribution can be precipitated onto the component according to customer specifications. This means that the sensor system can be individually adapted to the specific needs and requirements of the customer.



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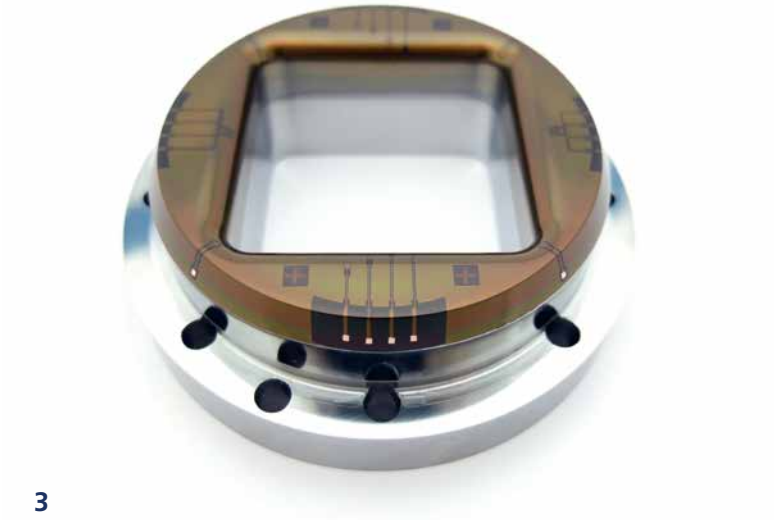
Sensory insert for plastic injection molding with a complete thin-film sensor system.



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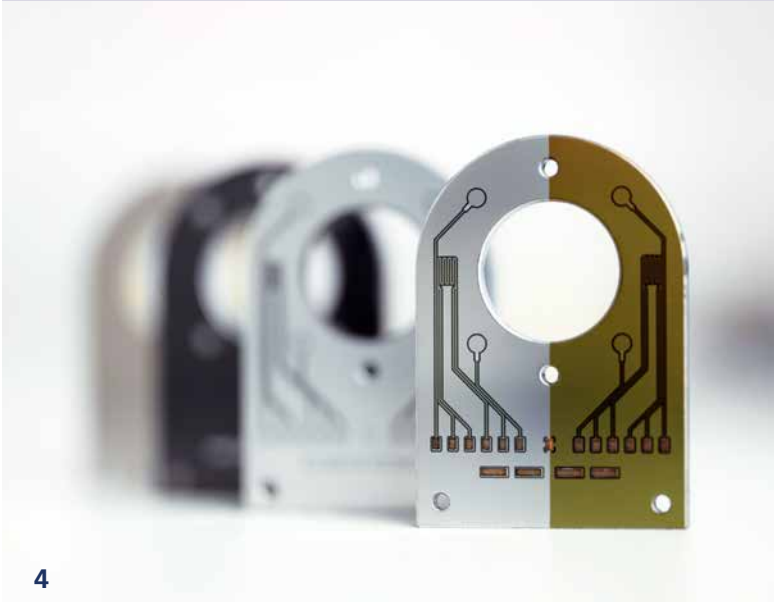
Deep drawing tool with complete sensor setup.



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Various stages in the production of the washer sensor system.

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