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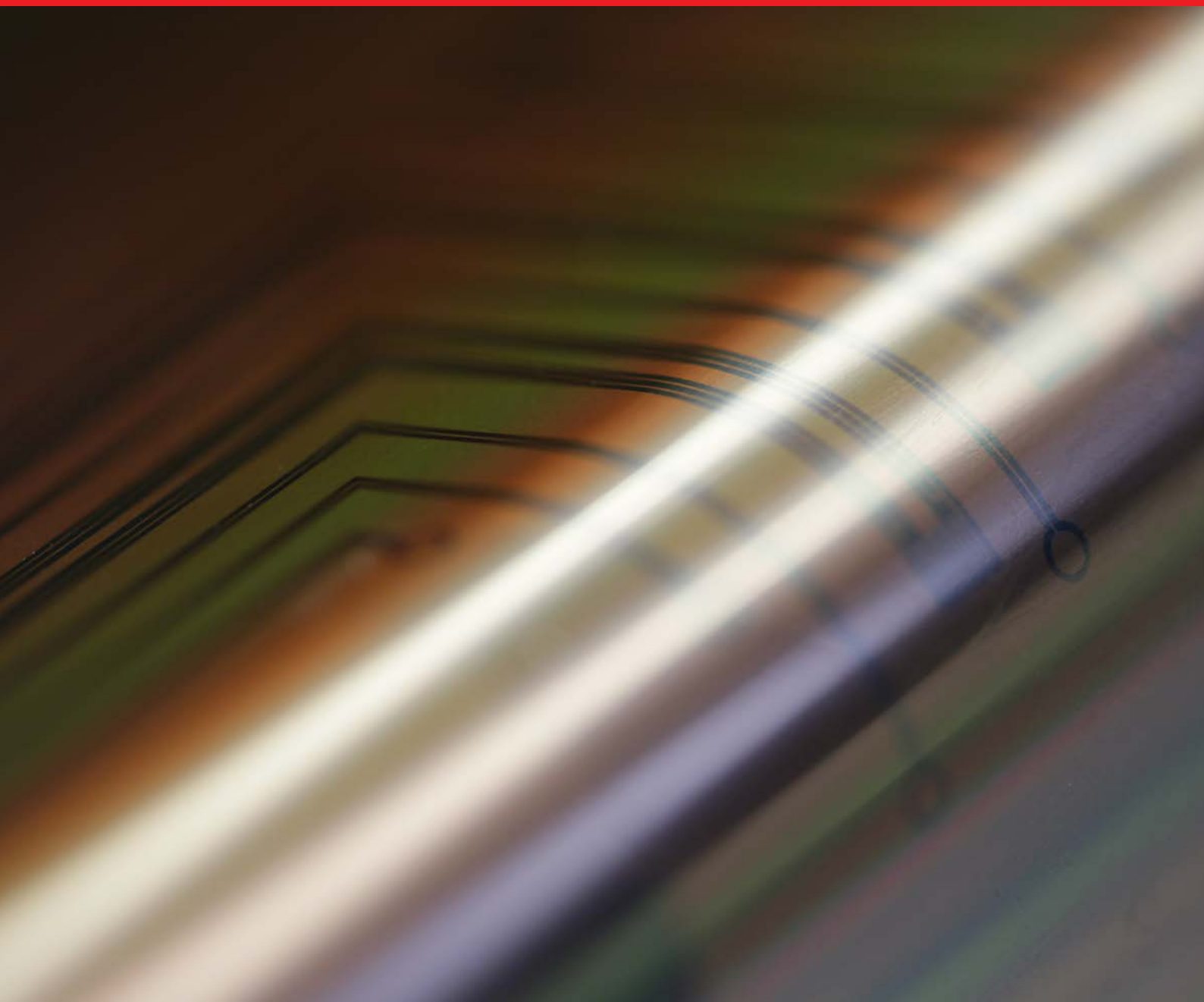
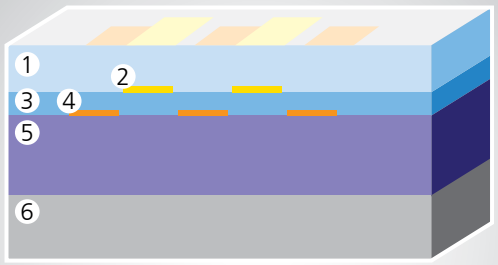
FRAUNHOFER INSTITUTE FOR SURFACE ENGINEERING AND THIN FILMS IST

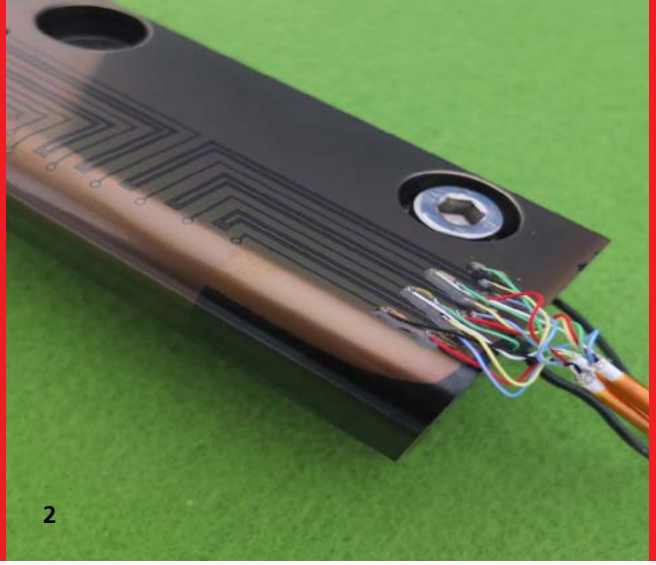
SMART FACTORY – SENSORS FOR PRODUCTION





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



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MULTI-SENSOR SYSTEM – UNIVERSAL AND INDIVIDUAL

The fourth industrial revolution – Industry 4.0 – can only succeed if the sensor systems responsible for the measurement data are further developed in parallel with data processing. Over the last few years, the industry has increasingly demanded sensors used directly on component surfaces in contact with the work piece so that local measurement data can be captured even during the process. That is why a multifunctional thin film system was developed at 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 the complex shaped surface, 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.

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 lithographic 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 in 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 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 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

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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 force distribution and the temperature distribution on the injection molding tool surface in direct contact with the plastic melt, simultaneously 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, increasing the scrap rate. With the integration of thin film sensor systems, it is possible to regulate process control and thereby compensate for fluctuations and minimize the number of bad parts. The novel thin film sensor system developed at Fraunhofer IST is in direct contact with the work piece 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 rack to production facilities and wind power plants to building and bridge construction. The special feature of the washer sensor system developed at 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 the sensor system can be individually adapted to the specific needs and requirements of the customer.

1 *Schematic representation of the multifunctional film system.*

2 *Metal strip drawing tool with complete thin film sensor system.*

3 *Deep drawing tool with complete sensor setup.*

4 *Various stages in the production of the washer sensor system.*

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