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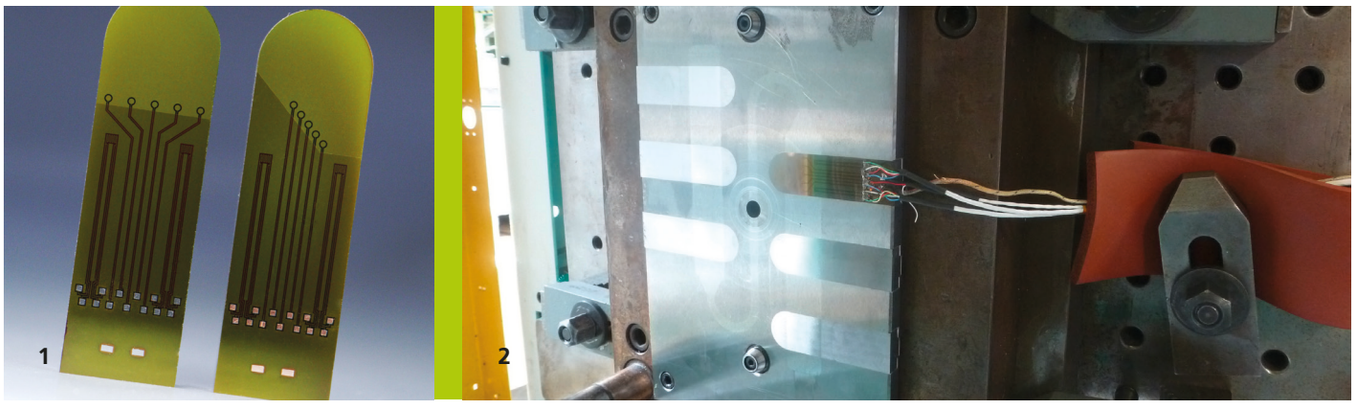

1 *Sensor modules with different structure designs.*

2 *Sensor module integrated into the injection molding line at Sirris in Belgium.*

MULTIFUNCTIONAL THIN FILM SENSOR MODULES

Wear-resistant thin film sensor systems are playing an ever greater role in the most varied applications, especially in the field of real-time acquisition of process data. For this reason the aim of the EU's »Sensorized Future« project is, among other things, to create a sensorized thin-film system which simultaneously during the plastic injection molding process picks up both the force and also the temperature distribution at the surface of the mold. For this purpose individual sensor modules have been developed at the Fraunhofer IST which can be fitted very precisely into the mold (see Fig. 2).

Thin film sensor systems with non-stick properties for plastics

At the Fraunhofer IST a thin film sensor system has been developed which consists of the following functional layers on a steel base body:

- the piezoresistive sensor coating (material: DiaForce®, d ~ 6 µm)
- a lithographically structured metal layer (material: chromium, d ~ 250 nm), and
- an isolating and wear-protective layer which at the same time has very good detachment properties with respect to the polymer melt (material: SiCON®, d ~ 3 µm).

In a plasma-assisted chemical vapor deposition process (PACVD) the surfaces to be treated are coated with the piezoresistive and tribologically resistant hydrocarbon coating DiaForce® in a thickness of 6 µm. The sensor coating has a hardness in the region of 24 GPa and a coefficient of friction with respect to steel in the region of 0.17. To make measurement of local loads possible, individual circular electrode arrays made of chromium are installed on the sensor coating by physical vapor deposition (PVD) in combination with photolithography and wet-chemical etching. The chromium layer has a thickness in the region of 0.2 µm. A 1.5 µm thick electrical isolation

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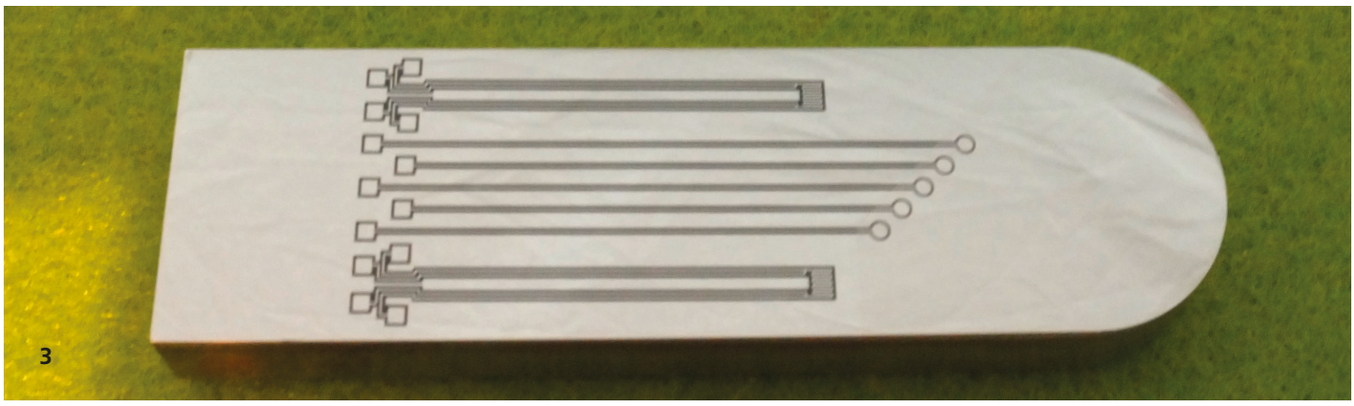

coating consisting of a hydrocarbon layer modified with silicon and oxygen is deposited locally. In a second PVD process a further chromium layer 0.2 µm thick is applied to this isolation coating. This layer is then structured with a meander design which is used for temperature measurement. Secondly, it contains conductors which run from the electrode structures already created for force measurement right up to the electrical connection area. The sensor structures must be protected against wear, which is the reason for the deposition of a final 3 µm thick top coating consisting of a further hydrocarbon layer modified with silicon and oxygen.

Integration of the sensor modules into the injection molding system

The wear resistance of the sensorized thin-film systems was investigated in the injection molding unit at the Sirris research institute in Belgium. Here polycarbonate (PC) and acrylonitrile butadiene styrene (ABS) were used as test polymers. In the tests the mold temperature was 60 °C while the melt temperature was 230 °C. The injection phase lasted in each case 1.8 s and a maximum pressure of 1000 bar was held for 3 s and was followed by a cooling phase of 25 s. Several hundred injection molding cycles were carried out with each plastic, after which the sensor surfaces were analyzed. Absolutely no traces of wear could be found.

Outlook

During the further course of the project, the focus will be on sensor properties. It is planned to record the temperature and also the force curves of the sensor structures and compare them with those of reference sensors, located extremely close to them beneath the surface of the mold.

The project

The "Sensorized Future" project is funded in the 13th Cornet Call (Collective Research Networking) by the Federal Ministry of Economics and Technology (BMWI) with the support of the German Federation of Industrial Research Associations (AiF) and runs until 30. 6. 2015.

3 *Sensor system without SiCON protective layer.*