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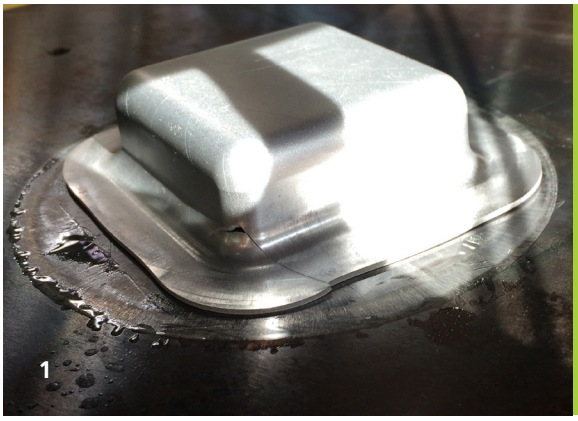
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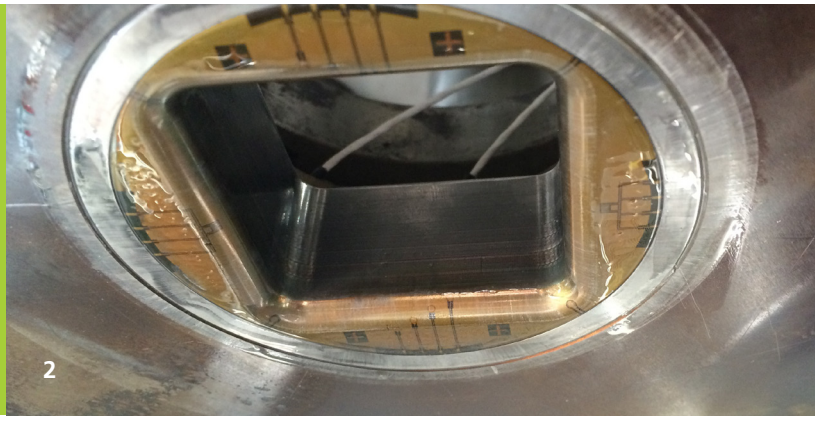
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1 *Deep drawn sheet metal with fissure.*

2 *Integrated deep-draw sensor tool.*

3 *Schematic of the multifunctional coating systems.*

4 *Deep-drawing die with complete sensor system.*

THIN FILM SENSOR SYSTEM FOR THE DEEP-DRAWING PROCESS

The fourth industrial revolution – Industry 4.0 – can only succeed when not only the data processing is set value on but also the sensor technology which is responsible for the measurement data. In recent years industry has increasingly felt the need for a sensor system which is used directly on component surfaces in contact with the workpiece so as to be able to capture measurement data locally even during the process. A multifunctional thin film system is therefore being developed at the Fraunhofer IST for the local measurement of pressure and temperature distribution over the surface of deep-drawing dies. It is a multilayer system with which not only is local measurement of force or pressure on surfaces with complex shapes possible but also local temperature measurement at different parts of the component. The system also has a high wear resistance.

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Manufacturing process

The multifunctional thin film system developed at the Fraunhofer IST consists of the following five layers, which are deposited one by one on the surface of the die:

- a piezoresistive sensor layer (DiaForce®) 6 µm thick
- individual force measurement areas consisting of chromium electrode structures produced by the lift-off process; d = 200 nm
- an insulating and wear-protection interlayer 1 µm thick made of SICON®
- chromium meander structures for local temperature measurement made by photolithography; d = 200 nm
- a further insulating and wear-protection layer 3 µm thick made of SiCON®

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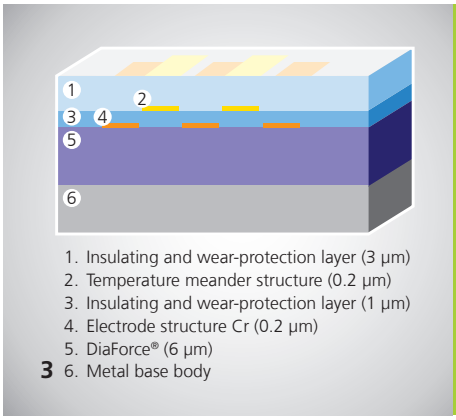

1. Insulating and wear-protection layer (3 µm)
2. Temperature meander structure (0.2 µm)
3. Insulating and wear-protection layer (1 µm)
4. Electrode structure Cr (0.2 µm)
5. DiaForce® (6 µm)
6. Metal base body

3

4

Figure 3 shows a schematic diagram of the structure of this layer system while the die with the complete thin film sensor system can be seen in Figure 4. The fourth illustration also reveals the complexity of the sensor structure: the contacts are arranged on the outer unloaded sloping surface while the measuring points are on the top face or inside the second curve of the die.

Test procedure

The performance of the sensorized tool with the multifunctional thin film system was investigated in a deep-drawing machine at the Fraunhofer Institute for Machine Tools and Forming Technology IWU. An example of measurement results from the forming process is shown in the diagram to the right. During the deep-drawing process there is a considerable drop in resistance due to the compressive load applied to the piezoresistive thin film sensor system by the aluminum sheet being formed. With this process, local heating of the surface amounts to only 1 K. The maximum permitted load during the sheet-metal deep-drawing process can therefore be derived directly from precharacterization and is 430 MPa.

Advantages of multifunctional thin film sensors

The multifunctional thin film systems developed at the Fraunhofer IST offer a number of advantages over conventional measurement systems. For instance:

- Optimization of simulation
- Optimization and monitoring of production processes
- Improvement of the understanding of operating conditions
- Optimization of maintenance intervals
- Reduction in the reject rate

The project

The results described were obtained within the SensoFut project (Sensorized Future – Sensing of temperature and pressure in harsh environments), on which the Fraunhofer IST worked together with the Fraunhofer Institute for Machine Tools and Forming Technology IWU and Sirris, the Belgian research association. SensoFut is funded in the 13th Cornet Call (Collective Research Networking) by the Federal Ministry of Economics and Technology (BMWI) and the German Federation of Industrial Research Associations (AiF) and ran from 1.1.2014 to 30.6.2015.

Example results from a deep-drawing process.