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FRAUNHOFER INSTITUTE FOR MANUFACTURING TECHNOLOGY AND ADVANCED MATERIALS IFAM

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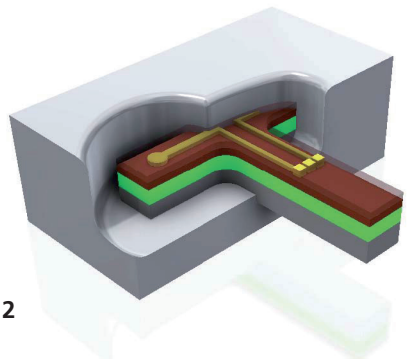
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1 *Aluminum high pressure die casting part with integrated piezoresistive DiaForce® sensor.*
2 *Schematic structure of the sensor system for integration into aluminum.*

CAST TRONICS®

CASTING INTEGRATION OF DIAFORCE®-BASED SENSORS INTO ALUMINUM CASTINGS

The *CAST*TRONICS® technology allows the direct integration of electronic sensors and adaptronic functional elements into castings during the die casting process.

Sensors cast into the part allow mechanical loads in the part such as compressive and tensile forces, deformations or vibrations to be detected, measured and assessed. Due to their integration during the casting process, the sensors can be embedded into the part directly at the point where the loads occur in order to warn of overloading or damage to the part. This enables **structural health monitoring**, which is particularly crucial advantage for safety components. Furthermore, the vibration behavior of components as well as their acoustics can be actively influenced by integrated piezo actuators (structural health control).

Conventional sensors for monitoring the load state of components and their deformation – for example, strain gauges – have to be applied to the surface of a part. **Integrated sensors cast into the part** offer the advantage that after the casting process, they are protected against soiling, damage or loss, not only during further mechanical machining processes on the casting, but also during assembly and operation. In addition, integration during casting allows an optimum bond to be created between the sensor elements and the material structure. Additional machining and joining processes for application of the sensors can be eliminated.

Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM
Shaping and Functional Materials

Prof. Dr.-Ing. habil. Matthias Busse
Wiener Strasse 12
28359 Bremen | Germany

Contact
Dipl.-Wi.-Ing. Christoph Pille

Phone +49 421 2246-227
Fax +49 421 2246-77227
casting@ifam.fraunhofer.de

www.ifam.fraunhofer.de

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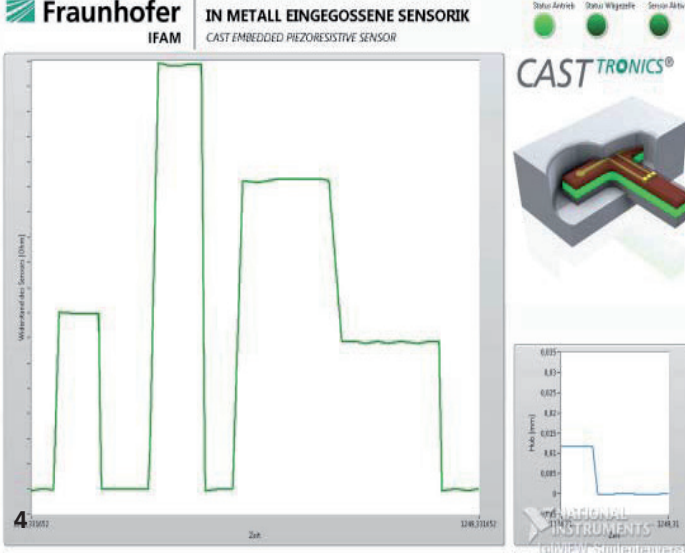

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A piezoresistive thin-film sensor system has been developed at the Fraunhofer Institute for Surface Engineering and Thin Films (IST). These system's sensors are distinctive in that they can detect both dynamic and static loads without being elastically deformed themselves. Conventional piezoelectric sensors do not enable static loads to be measured, and also do not allow a preload to be set. Furthermore, the use of force sensors based on strain gauges or piezoelectric materials also implies additional weight and elasticity, and higher costs.

In contrast, the force-sensing DiaForce® film, which is based on a hydrocarbon film similar to diamond, allows both a static and a dynamic measurement of forces. The DiaForce® sensor film is a tribologically resistant film (hardness 20 GPa) that in an integrated state records measurements directly in the main loading zones of the part without elastic deformation. The film thickness of the sensor is just 6 µm. The structure of the whole thin-film sensor system is shown in Figure 3.

The Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM has succeeded in integrating piezoresistive sensors with DiaForce® technology – direcly into aluminum parts during die casting or chill casting production processes (Figure 1).

The special composition of the sensor film withstands direct contact with the 700 °C aluminum melt. Thermal insulation of the sensor to protect against thermal loads or destruction is not necessary with the technology developed by the Fraunhofer Institutes IST and IFAM. The sensor embedded in the aluminum changes its electrical resistance in a linear relationship when a mechanical force is applied (Figures 2 + 4). The measuring principle for evaluating the sensor signals, on the other hand, is based on conventional resistance measuring methods.

3 *Demonstrator for measurement of dynamic loads and static deformation of the casting.*

4 *Load-dependent resistance curve of the piezoresistive thin-film sensor system cast into aluminum.*