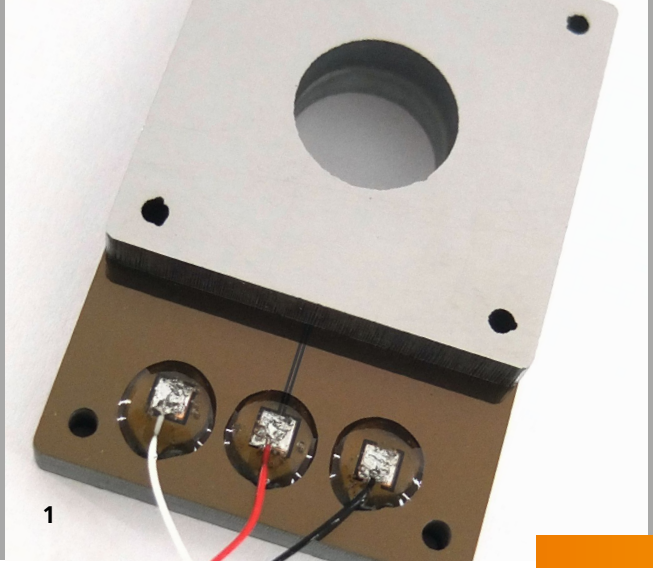

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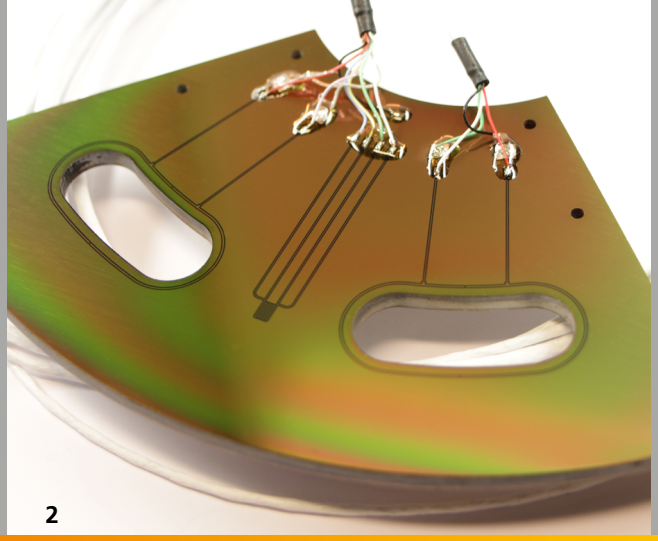

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Extract from the annual report 2016
To the website: www.ist.fraunhofer.de/en.html

ULTRA-HIGH-PERFORMANCE SENSOR-CONTROLLED MOMENT CONNECTIONS

In timber constructions, post-and-beam connections are often used for bracing the building. However, the requirements made of these connections differ from case to case. When exposed to wind or relatively weak seismic events these connections must, for example, be as stiff as possible to minimize any resulting deformations. In the case of strong earthquakes, on the other hand, soft connections are advantageous as then, due to the possibility of deformation, no critical stresses can build up – although the building may vibrate, it does not collapse. In order to be able to monitor building structures, various modules with sensorized thin-film systems were constructed at the Fraunhofer IST which, installed in newly developed moment connections, can in direct frictional contact pick up the loads and temperatures occurring.

Multifunctional coating system

The sensor modules shown in Figures 1 and 2 are equipped with a multifunctional coating system on their surfaces which not only has a high wear resistance but also is equipped with piezoresistive and, in some cases, even additional thermoresistive sensor structures (see Figure 2). A diagram of the structure of the multifunctional coating system is shown in Figure 3.

The sensorized coating system is based on a development of the Fraunhofer IST, the piezo resistive amorphous hydrocarbon layer DiaForce® (5), deposited homogeneously on the polished substrate in a layer 6 µm thick. Chrome electrode structures are applied to this sensor layer in a layer 200 nm thick. This in turn is covered with an insulating intermediate layer of silicon- and oxygen-modified hydrocarbon SiCON® (d ~ 1 µm) (3). The conductor tracks and the area of the contact points are made of chromium deposited on this intermediate layer with a thickness of 200 nm (2). If local temperature measurement is wanted, additional meander structures, also made of chromium, are added for this purpose (see Figure 2). Finally these structures are insulated with a further layer of SiCON® (d ~ 3 µm) (1) and protected against wear. The total thickness of the coating system is only around 10 µm. Vacuum-coating methods alone are used to create the layers: plasma-assisted chemical vapor deposition (PACVD) for the amorphous hydrocarbon layers of DiaForce® and SiCON®, and physical vapor deposition (PVD) for the electrode layers of chromium.

Use of the sensor modules in the experimental set-up

In order to investigate the load-bearing and deformation behavior of these innovative sensor modules, they were installed in a moment connector and, in a test rig of a project partner, the Institute of Building Materials, Concrete Construction and Fire Safety (IBMB) of the Technical University of Braunschweig, subjected to cyclic loading according to DIN EN 12512. The opposite graph shows the measurement curves for a force and temperature sensor. The shape of the force sensor curve clearly reflects the cyclic stresses. The temperature increase of 4 K which may be observed is due to the energy dissipated by friction.

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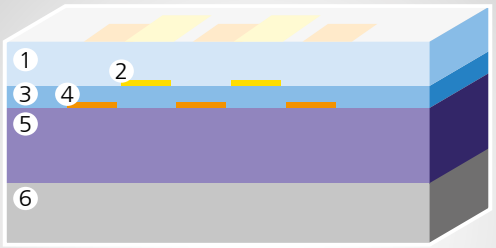
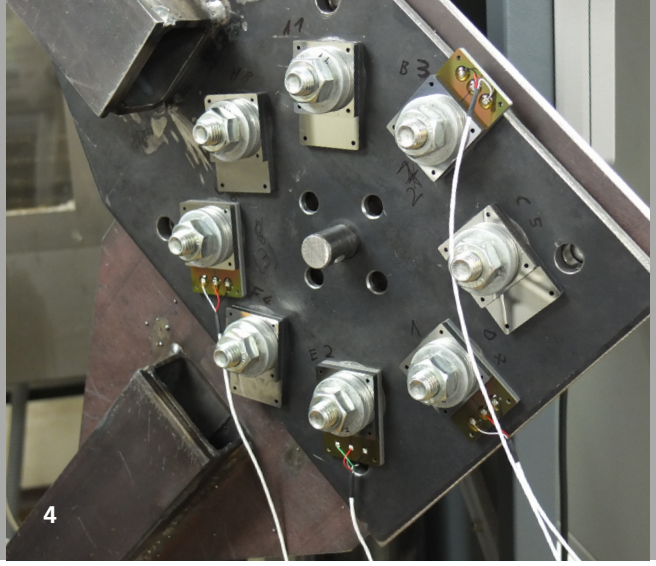


1. Insulating and wear-protection layer (3 µm)
2. Temperature meander structure (0.2 µm)
3. Insulating and wear-protection layer (1 µm)
4. Electrode structure Cr (0.2 µm)
5. DiaForce® (6 µm)
6. Steel base body

3



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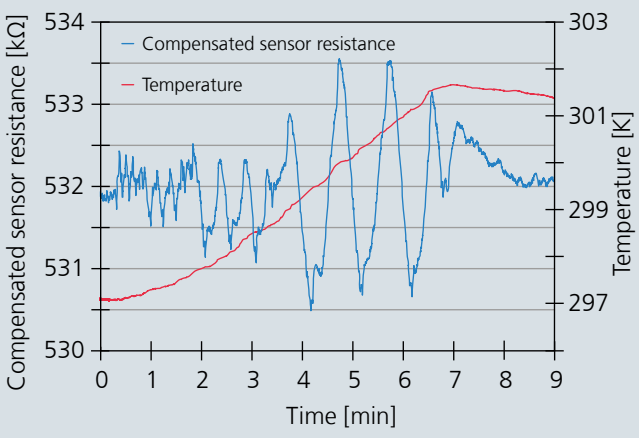
The project

The sensor modules for moment connections with ultra-high-performance capability were produced in collaboration with Pitzl Metallbau GmbH & Co. KG and the Institute of Building Materials, Concrete Construction and Fire Safety (IBMB) of the Technical University of Braunschweig with support from the Fraunhofer Institute for Wood Research, the Wilhelm Klauditz Institute WKI, and within the KF 217881 project "Development of sensor-controlled moment connections with ultra-high-performance capability, with a great energy-dissipation potential for wooden buildings in earthquake zones", which was funded by the ZIM program ("Central Innovation Program – SMEs").

Example of measurement results from piezo and thermo-resistive sensors in the multi-functional coating system.



1 *Square sensor module with annular force-measuring sensor structure.*

2 *Sensor element with force-measuring sensor structures and additional meander structure for local temperature measurement.*

3 *Schematic of the multi-functional coating system.*

4 *Arrangement of the individual sensor modules in the moment connector.*

CONTACT

Dr. Saskia Biehl
Phone +49 531 2155-604
saskia.biehl@ist.fraunhofer.de

Fraunhofer Institute for Surface Engineering and Thin Films IST | Bienroder Weg 54 E | 38108 Braunschweig | Germany