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Extract from the annual report 2020
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9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

SMART SCREW CONNECTION – THIN-FILM SENSOR REPORTS LOOSE SCREWS

Screws in important joints such as in bridges, wind-power plants or machines on production lines which become loose over time pose a considerable safety risk. The research center IoT-COMMs – part of the Fraunhofer Cluster of Excellence Cognitive Internet Technologies CCIT – has therefore developed an intelligent screw connection which enables wireless and energy-independent monitoring. A thin-film sensor, developed at the Fraunhofer IST, thereby measures both the forces acting on the screw connection and changes in the ambient temperature at the installation site. The aim is the realization of an energy-independent monitoring of structures such as bridges, scaffolding or wind-power plants through permanent long-term surveillance.

Thin-film sensor technology

The integration of the sensor technology into the screw connection is performed at the Fraunhofer IST through the application of a thin-film system to the surface of washers. For this purpose, the piezoresistive DiaForce® film developed at the Fraunhofer IST is first homogeneously deposited on the washer by means of a PACVD process (plasma-assisted chemical vapor deposition). After this, individual electrode structures made from chromium are fabricated which form the sensor surfaces for the load measurement as well as a structure for temperature compensation (see Figure 3). On a subsequent electrically insulating SiCON® intermediate layer (a hydrocarbon film modified with silicon and oxygen which is also deposited using the PACVD process), both conductor paths to the contact points and a temperature-measuring meander structure made from chromium are composed. These structures are protected against abrasion by a second SiCON® sealing layer (adjacent Figure). On test rigs at the Fraunhofer IST, the temperature-dependent and load-dependent linear characteristics of each individual sensor structure can be measured.

Properties of the “Smart Screw Connection”

The smart screw connection is a fully integrated IoT device which enables wireless and energy-independent monitoring of screwed joints. For this purpose, the sensory washer system is connected to a screw body in which the power supply and data transmission are integrated (see Figure 1). With the aid of the wireless transmission technology mioty®, the sensor system regularly transmits measured values to a cloud-linked control body. Prior to assembly, the screws are configured in the manipulation-proof programming unit “FunkeyBox” and receive their own security key. As a result, the sensor data is tamper-proof during transmission to the base station or backend. Thanks to energy harvesting technology the screw connection does not require an external power supply. Inside the screw is a thermogenerator which, when exposed to even the smallest temperature gradients, generates electrical energy via the screw thread. Alternatively, the sensor and transmitter can be powered by a solar cell or battery (see Figure 2).

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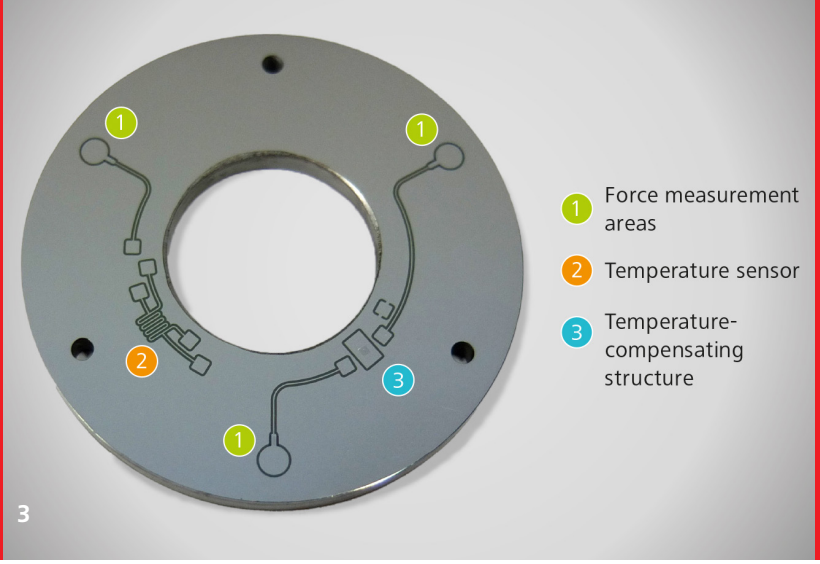

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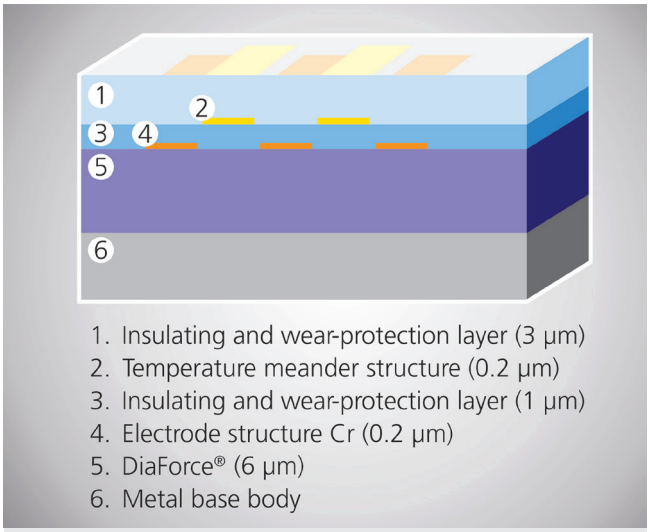

Schematic representation of the thin-film system.

1 *Deployment of the smart screw connection.*
2 *Wireless and energy-independent monitoring.*
3 *Sensory washer.*

Outlook

Following a market study and user workshops, the achieved project results will be utilized to optimize and realize screws for three selected target applications and to make them available to potential users in the form of evaluation kits.

The project

This solution is being developed within the framework of the Fraunhofer Research Center IoT-COMMs in collaboration with the Fraunhofer institutes IIS, IST and AISEC. The FIoT-COMMs is part of the Cluster Initiative CCIT (Cluster of Excellence Cognitive Internet Technologies) of the Fraunhofer-Gesellschaft.

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