



**1** Washer-like sensor systems with different sensor arrangements on the surface of a hardened steel substrate.

**2** Sensor systems with additional wear protection coating (on the right, partially deposited).

## APPLICATION-SPECIFIC SENSOR SYSTEMS

The customer request is the focus of sensor developments at the Fraunhofer IST. This involves the geometry of the base body, as well as the type and number of the sensor systems that are combined in a thin-film system. Currently in this regard piezo-resistive and thermo-resistive sensors are available, in which the requirements of the client are appropriately implemented.

### Variable and integrable

Many of our customers require sensor systems that can be easily integrated into existing systems, components or even products in order to monitor screw connections in particular. The Fraunhofer IST offers thin-film sensor systems in different geometries. In most cases, basic bodies made of hardened steel are used, reminiscent in their geometry of the shape of washers.

### The sensory thin-film system

On the basic body a DiaForce® film that was specially developed at the Fraunhofer IST, is deposited in a PACVD process. Then individual circular electrode structures are manufactured out of chromium, and these structures form the load measuring sensor surfaces (see Fig.1 and Fig. 2). This is followed by an electrically-isolating SiCON® intermediate layer, a hydrocarbon coating modified with silicon and oxygen, which

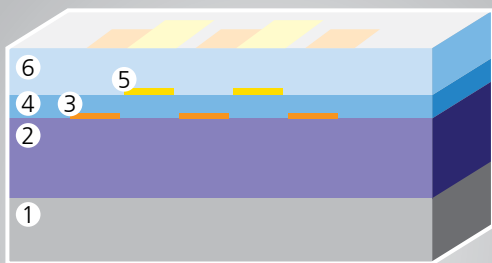
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6. Insulating and wear-protection layer (SiCON®)
5. Temperature meander structure
4. Insulating and wear-protection layer (SiCON®)
3. Electrode structure Cr
2. DiaForce®
1. Steel base body

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likewise is deposited in the PACVD process. Upon this both the conductive tracks are structured to the contacting points as well as temperature-measuring meander structures out of chromium. These structures are protected against wear with a second and final SiCON® layer (see Fig. 3).

### Sensor characteristics

In test stands of the Fraunhofer IST the temperature-dependent and load-dependent characteristic curves of each individual sensor structure are measured. In the case of piezo-resistive sensors characteristic linear resistance dependencies on the load.

are obtained. Measurements are taken by a full-bridge or half-bridge circuit at a constant voltage of five volts. The thermo-resistive meander structures likewise show linear resistance dependencies. They are structured in a so-called four-wire arrangement; via the outer conductors a constant current of 10 mA, for example, is applied and the voltage change is measured via the inner conductors. Due to the fact that the piezo-resistive DiaForce® sensor film, as an amorphous carbohydrate film, is a semiconductor it has an exponential resistance dependency on temperature. This effect can be compensated through the additional integration of temperature-compensating structures in the contacting area. Sample

characteristic curves of a force sensor structure and of a temperature meander are presented in the adjacent diagram.

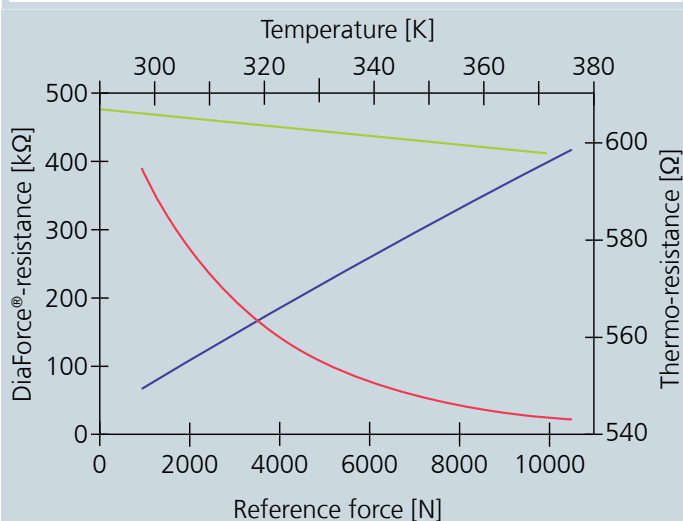
### Advantages of our sensor systems

- Individual sensor designs
- Geometry independence
- Combination of force and temperature sensors possible
- Temperature compensation can be integrated if required
- Data transfer wired or wireless via Bluetooth Low Energy
- Wide range of applications

### Application examples

- Use in test stands
- Monitoring of screw connections in wind turbines
- Sensory moment connections for the monitoring of building structures
- Vibration measurement in production plants

Load-dependent and temperature-dependent resistance curve of a sensor structure and the linear resistance dependency on the temperature of a meander structure.



- DiaForce® piezo-resistive
- DiaForce® thermo-resistive — Meander thermo-resistive

3 Schematic presentation of the coating system.