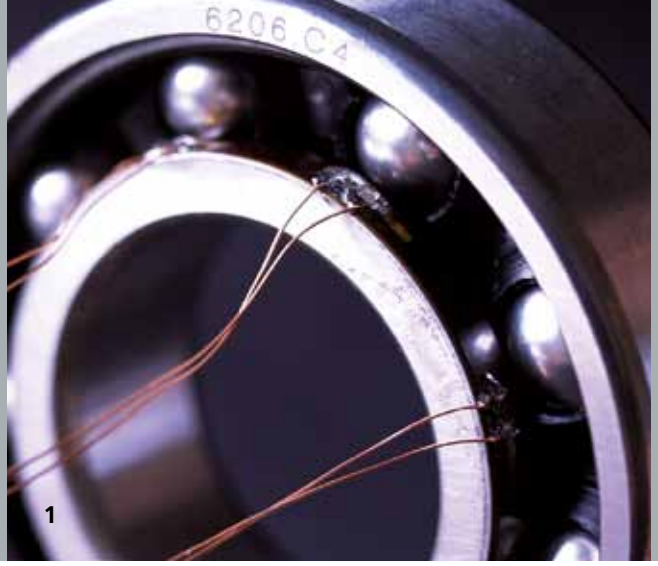

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PIEZORESISTIVE THIN-FILM SENSOR SYSTEM IN DIRECT ROLLING CONTACT IN BEARINGS

With modern plasma coating techniques multifunctional surfaces can be produced which not only have optimum tribological properties but also offer sensor capabilities. In collaboration with the bearing manufacturers Schaeffler Technologies AG & Co. KG, bearings with a thin-film sensor system similar to a "skin for machines" have been created which permit on-line measurement.

One of the greatest challenges in the field of sensor systems is the detection of load distributions in bearing races since here the rolling elements exert Hertzian contact stresses which may fall in the GPa range. At the Fraunhofer IST research has been in progress for many years into a coating system which under extremely high loading is capable of spatially resolved detection of the force exerted by each individual rolling element.

Sensorized thin-film systems

The sensorized carbon film Diaforce® is piezoresistive under normal (perpendicular) application of force and exhibits very good tribological properties. This high-tech layer is coated directly onto the bearing ring by the PACVD process. Chromium electrodes (d = 200 nm) are then deposited on this sensor layer (d = 6 µm) by the lift-off process. These determine the local measurement spot over which the ball bearings will later roll. In this way the individual ball contacts can be measured and the load distribution in the bearing detected. The contact areas of the electrodes are coated with gold (Figs. 2 and 3), thereby allowing measurement wires to be soldered on. Finally, an isolating and anti-wear coating of SiCON® (d = 3 – 4 µm) is deposited. Fig. 1 shows the completed sensorized bearing with the thin-film system on the inner bearing ring.

Static characterization of the thin-film system

The force sensors undergo static testing on a test rig developed at the Fraunhofer IST. This revealed a linear relationship between resistance and load at each sensor structure. The result: as the load increases, a linear fall in resistance from 20 – 40 Ohm/N is measured which is dependent on the size of the sensor structure. This behavior is reversible which means that when the load is removed the original resistance is restored (top graph).

Sensor properties of the thin-film system

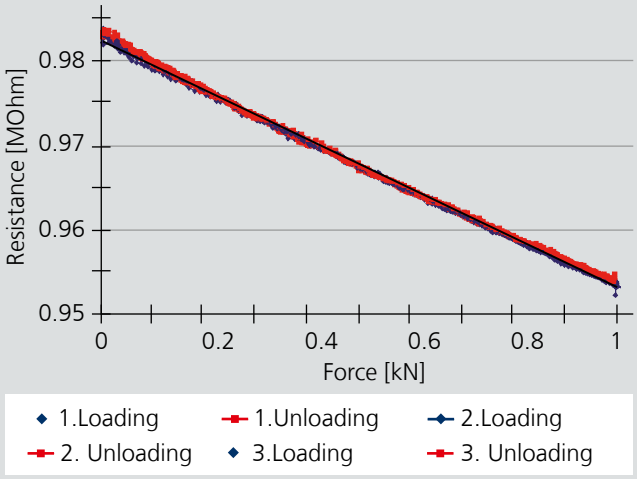
FAG bearings (6206.C4) with the integrated piezoresistive coating system DiaForce® -Cr-SiCON® underwent dynamic testing on a test rig at Schaeffler Technologies AG & Co. KG. The objective of these investigations was to detect bearing ball rollover by changes in the resistance or voltage of the force sensors and record the load distribution present in the bearing race.

Outlook

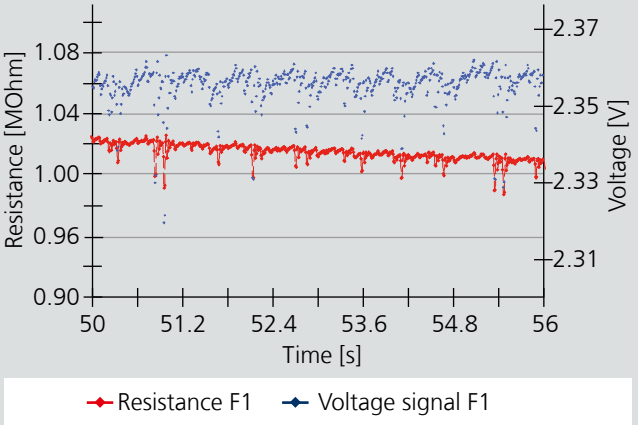
In the next step the wear resistance of piezoresistive thin-film systems, which measure directly within bearing races, must be optimized with a view to long-term stability in service under high loads and at high speeds of rotation.

3

Linear characteristic curve of sensor resistance plotted against load.



Testing force sensors on the test rig at Schaeffler Technologies AG & Co. KG. The resistance curve reflects ball contact (cage with 13 balls; speed of rotation: 100 rpm; normal load: 1500 N).



1 *Bearing with integrated thin-film sensor system.*

2 *Two inner bearing rings with piezoresistive coating system in the raceway of the rolling elements.*

3 *Inner bearing ring with the piezoresistive sensor coating DiaForce® and the chromium electrodes with gold contacts structured onto it.*

CONTACT

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