Superlubrication for ceramic bearings on silicon nitride-silicon carbide basis

Dr. Eveline Zschippang, Dr. Mathias Herrmann, Dr. Tobias Aman*, Dr. Andreas Kailer* (*Fraunhofer IWM)

Approximately 20 % of the energy in technical processes and systems is lost due to friction. Therefore, minimizing friction is an essential part of increasing energy efficiency. In order to significantly reduce friction losses, researchers from the Fraunhofer institutes IKTS, IWM, IWS and IPA are working on transferring superlubrication from laboratory scale to machine elements in the Fraunhofer internal program PREPARE (project "SupraSlide"). Ceramics made of silicon nitride (Si_3N_4) and silicon carbide (SiC) are corrosion-resistant, wear-resistant and have a high thermal load capacity – an ideal material for plain bearings. Researchers at Fraunhofer IKTS have developed Si_3N_4 and Si_3N_4-SiC ceramics and modified their surfaces by lapping and polishing. Within the scope of the project, different microstructures and material compositions were realized and their tribological properties were tested at Fraunhofer IWM in Freiburg. There, superlubrication was demonstrated in a model test using water-based lubricants. The test also showed that even a lapped surface is sufficiently smooth to achieve superlubrication – a major advantage for industrial implementation. Composite materials made of Si_3N_4 with SiC particle reinforcement were particularly promising. Figure 1 shows the surface of the Si_3N_4 material with SiC reinforcement following the tribological test (ball on three plates), on which the smoothing is clearly visible. The individual phases were detected and the topology assessed by using different detectors. There is no selective wear of the phases SiC, Si_3N_4 or the grain boundary phase under the test conditions. At Fraunhofer IKTS, test specimen were manufactured from the developed Si_3N_4 and Si_3N_4-SiC materials in order to test them under practical test conditions on the sliding pad tribometer. Using water-based lubricants, superlubrication was achieved for the Si_3N_4-based materials. The pairing of Si_3N_4 (sliding pad) and SSiC (ring) showed superlubrication in large areas with coefficients of friction below 0.01 (Figure 2). These promising results indicate: wear-resistant ceramics have the potential to create a new generation of plain bearings, which enable significant energy savings, lower wear and therefore a longer service life.

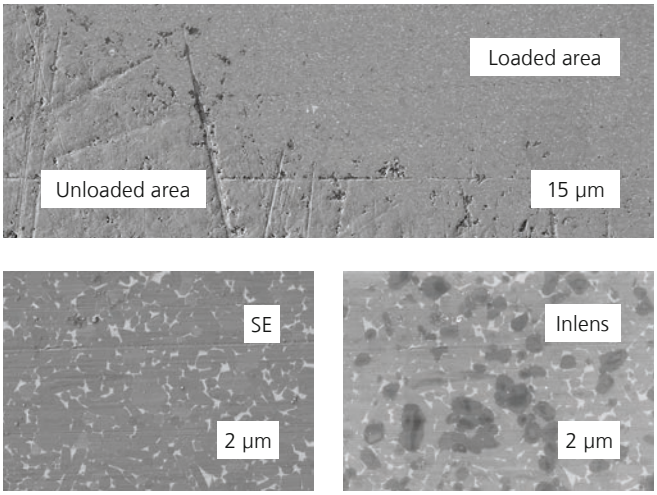

Figure 1: SEM image of the Si_3N_4 material with SiC reinforcement after test (top) low magnification, (bottom) image of the stressed surface using SE (left) and inlens detection (right).

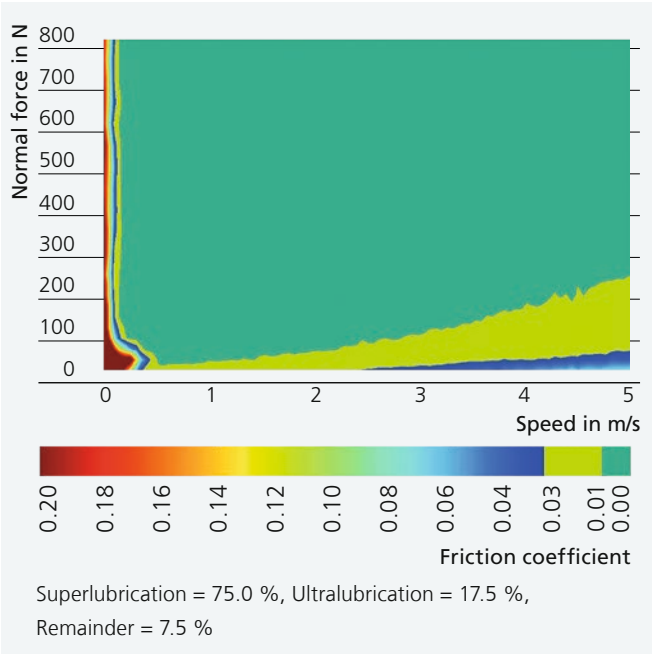

Figure 2: Demonstrated superlubrication (75 %) for the pairing Si_3N_4-SiC (sliding pad) / SSiC (ring).

Services and cooperation offered

- Development of ceramics for use as bearing materials
- Characterization and failure analysis of materials and components

Fraunhofer IWM

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Contact Eveline Zschippang • Phone +49 351 2553-7983 • eveline.zschippang@ikts.fraunhofer.de