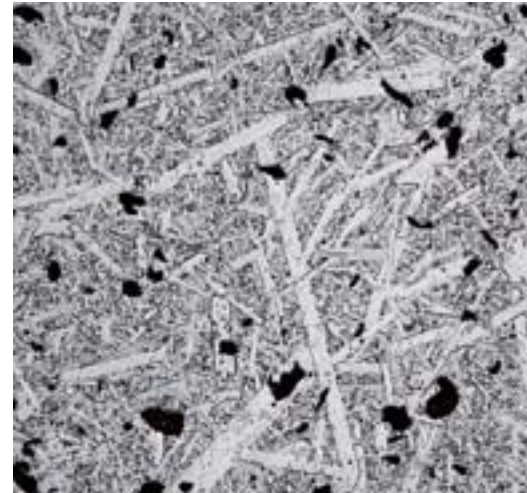


Optimised sliding surface

Laser structuring increases the breadth of application of silicon carbide bearings

In high-performance applications, modern sliding bearings make extreme demands on the materials used. For example, process fluid-lubricated bearings, such as those found in high-speed chemical pumps, must employ ceramic materials with a low-wear property profile for pumping corrosive or abrasive liquids. Sintered EKasic silicon carbide materials can solve a wide range of sliding bearing problems.



Coarse-grained microstructure of EKasic G with graphite inclusions to improve dry-running behaviour



Thrust bearing (left) and radial bearing (right) made of EKasic G with lubrication grooves and hydrodynamic structuring



When used in sliding bearings, standard SSiC (sintered silicon carbide) materials offer a whole series of advantages over other high-performance ceramics. Furthermore, the SSiC microstructure can be selectively modified to achieve further improvements in the material. ESK Ceramics of Kempten, Germany, has therefore developed a range of SSiC materials as part of its EKasic portfolio specifically for use in sliding bearings. They include EKasic G silicon carbide, a material characterised by an outstanding load capacity that withstands even high pressures and thrust forces. EKasic G has graphite particles 50 to 120 μm in size homogeneously dispersed in its structure. This considerably reduces the coefficient of friction and improves wear behaviour. The self-lubricating effect of the

graphite particles even permits temporary dry running. The material is thus ideal for tribological applications under poor lubrication conditions, for example in sliding bearings and mechanical seals. EKasic C is corrosion-resistant and, like EKasic G, highly resistant to attack by hot water. Since the water mainly corrodes the boundary layers between adjacent SiC grains (grain boundaries), a coarse-grained structure was developed for EKasic C with grain sizes up to 1.5 mm. This reduces the grain boundary surface area, providing improved corrosion resistance. The long SiC

grains also have another advantage. They are anchored deep in the ceramic, and hot water or aggressive chemicals, which corrode the material to a depth of 20 μm , therefore have no chance to dissolve out the grains and thus damage the sliding surfaces. Moreover, because of its coarse-grained surface, EKasic C has a higher load capacity, and the contact pressure of tribologically loaded systems can hence be further increased. It is thanks not least to the excellent wear behaviour that the range of applications of bearing and seal systems can be significantly expanded.

Reduced break-away torque

As already mentioned, the coarse-grained microstructure of EKasic C and EKasic G materials – besides improving corrosion resistance – also results in a tribological optimisation of the sliding surface. Since the extended SiC grains are randomly orientated on the surface of the part, this surface is not homogeneous but, when viewed under a microscope, finely undulating. The microscopic structure is a consequence of the anisotropic wear behaviour of the SiC monocrystals (grains), which – depending on their orientation – are abraded to different degrees as the bearing stops and starts under poor lubrication conditions. Even after the bearing surfaces have been run in, therefore, they are not polished to a mirror finish but still exhibit a specific surface roughness. In the same way as with shark-skin, which has reduced flow resistance due to the fact that it is not absolutely smooth, the residual roughness of the bearing surface can be seen to improve its flow properties. In addition, there is less risk of adhesive sticking between the sliding parts

and the initial break-away torque when the bearing is started up is therefore lower. This has particular advantages when these materials are used in highly loaded mechanical seals.

Improved load capacity

Moreover, selective modification of the surface of EKasic silicon carbide sliding bearings significantly improves the hydrodynamics of the lubricating fluid. If micrometer-sized cavities are introduced into the surface by laser ablation, this provides hydrodynamic support for the liquid film with increased pressure in the lubricant and a correspondingly improved load capacity of the system. The cavities are designed such that they form a wedge-shaped gap between the two sliding surfaces of the bearing. This gap is responsible for the hydrodynamic build-up of the pressure maximum. The two sliding parts then experience a lift, in the same way as a water skier, even at low sliding velocities. However, the wedge shape of the cavities can only be achieved with the necessary accuracy by special machining techniques. In the case of the ceramic EKasic sliding bearing, micromachining is carried out using a neodymium laser with a wavelength of 1064 nm. When the laser pulses are in the nanosecond range, the laser energy causes the surface to heat up for the duration of the pulse. Since thermal conduction only permits slow energy transfer into the volume, the incident energy is concentrated on a very thin layer. The surface therefore reaches very high temperatures and the SiC material is suddenly vaporised. The ma-

chining accuracy achieved in both the lateral and vertical direction is in the order of less than 1 µm. In addition, an analysis of the structured surfaces by electron microscopy does not show any damage to the ceramic material beneath the structures. The mechanical strength, and therefore the reliability, of the EKasic bearing part, is not limited by microcracks or other damage patterns.

In practice

The EKasic materials portfolio, together with the development of innovative structuring and coating technologies, can significantly improve existing bearing and seal systems. This improvement is necessary because of the continually increasing demands on modern sliding bearings, for example in pump systems. Such demands are the result of strict environmental regulations and increasingly harsh service conditions. One typical example is the exploitation of new gas and oil reserves, where modern extraction technology is penetrating into ever deeper regions characterised by higher temperatures and pressures. Pumping out highly abrasive and corrosive oil sludge mixtures from the borehole therefore requires a resistant, high-performance pump with carefully designed bearings and seals. After it was discovered that the harsh stresses were severely reducing the lifetime of borehole pumps equipped with conventional SSiC systems, and consequently the operating costs of the boring rig as a whole had increased, the pump manufacturer collaborated closely with ESK to develop a bearing system



Overloaded thrust bearing made of standard SSiC

made of EKasic C. It was not only possible to exploit the corrosion resistance of this material as well as its resistance to wear by the solid particles in the oil sludge. Even more importantly, the suitability of the parts for ceramic design considerably improved performance while simultaneously multiplying their lifetime.

A similar task faced a manufacturer of magnetically coupled cargo pumps. In addition to the need to pump a large number of different fluids with variable viscosities and solids contents as quickly as possible, the risk of failure due to incorrect operation also has to be taken into account in this sector. For example, the pump may be started up without opening the shut-off valves or the system shut down too late after the tanks are empty, leading to an interruption of the fluid flow and dry running of the bearings. These operating conditions inevitably meant that the critical loading limits of the sintered silicon carbide (SSiC) thrust bearings previously used were regularly exceeded. EKasic G has already proved valuable in many sliding and frictional systems. This material can be employed in cargo pumps to withstand extreme loads and ensure reliable pump operation. A further improvement in the load capacity of the axial bearings was achieved by the laser-induced application of hydrodynamically active fine structures on the sliding surface of the thrust bearing. Besides increasing the hydrodynamic pressure in the liquid film, this optimisation of the liquid behaviour in the sliding gap also enhances lubrication when there is insufficient process fluid. The homogeneous lubrication film that is produced acts as a spring buffer, helping to intercept axial thrust peaks in the bearing system. Overall, the changes introduced – both to the design and to the material used – have increased the critical loading limit more than tenfold.



3D microstructuring by Nd:YAG laser
(Photo: pro-micron GmbH & Co. KG)

From cpp 1/2007