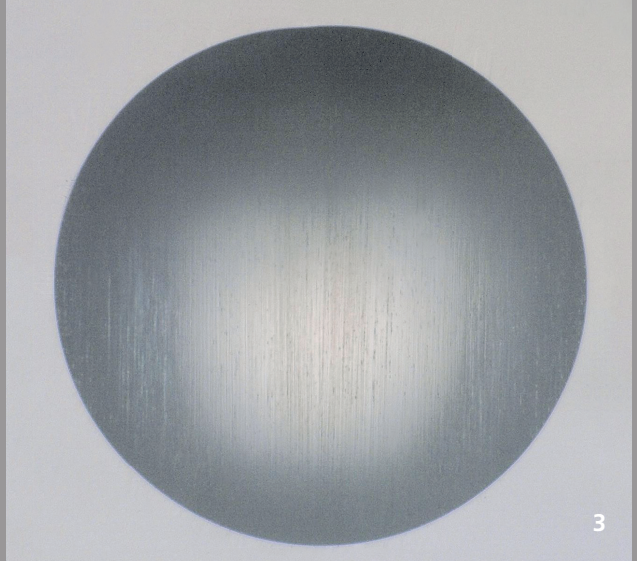

LASER-BASED HEALING OF SUBSURFACE DAMAGE IN GLASS

Task

In the conventional production of optical components made of glass, microcracks – so-called »subsurface damage (SSD«) – are commonly induced under the processed edge layer during grinding and polishing steps. These SSD must be removed with a time-consuming chain of increasingly finer grinding and polishing steps. In each of these process steps, material is removed down to the deepest damage of the previous step, whereby new, smaller defects are caused again. This iterative process means that producing high quality optics is associated with high throughput times and costs. Alternative processes such as hot pressing, on the other hand, are limited to high quantities, can only treat compressible geometries and have lower accuracy.

Method

An alternative approach is the use of CO_2 laser radiation (λ = 10.6 µm). This radiation is absorbed near the surface, with typical optical penetration depths of a few tens of micrometers, thereby making laser polishing of fine-ground glass possible: A thin edge layer is melted and, due to the surface tension, smoothens. However, the locally limited melting of the surface can potentially also be used to heal subsurface damage. To test this hypothesis, Fraunhofer ILT surface treated rough-ground flat samples of fused silica and N-BK7 with a laser polishing process and examined them for remaining SSD.

Results

Using the flat samples with a diameter of 30 mm made of fused silica and N-BK7, Fraunhofer ILT could show that the originally existing SSD of up to 80 µm depth was completely eliminated after laser processing. Healing can already be performed at speeds up to a factor of four faster than the conventional laser polishing process. The pure process time of the laser-based SSD healing is, therefore, less than 2 seconds for an N-BK7 lens with a diameter of 30 mm, for example.

Applications

Laser polishing to heal subsurface damage in glass components can be used to reduce the complexity of process chains in optics manufacturing, thus lower throughput times and unit costs. This applies in particular to the production of aspheres and free-form surfaces.

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2 Ground fused silica surface with spherical grinding (Ø ~ 3 mm). Depths: spherical grinding approx. 150 µm, subsurface damage approx. 70 µm.

3 Laser-polished fused silica surface with spherical grinding (Ø ~ 3 mm).