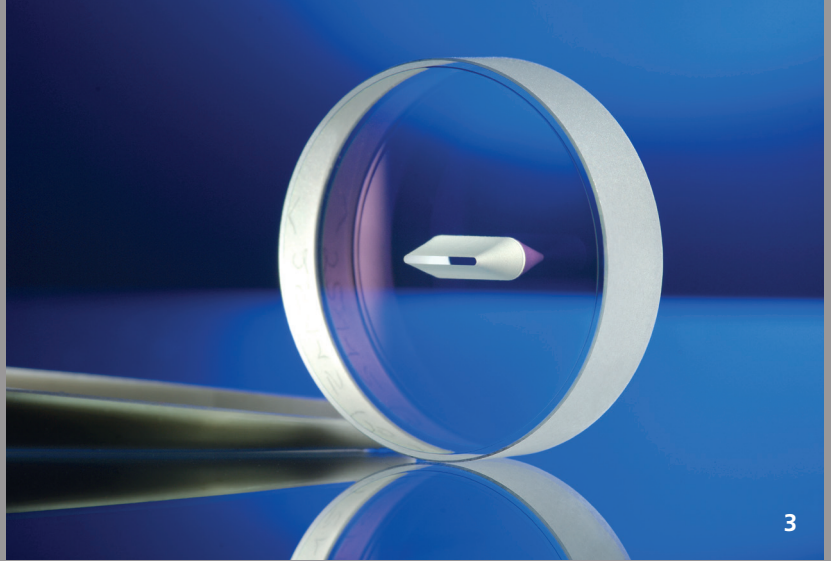

CHIPPING-FREE LASER PROCESSING OF MIRROR SUBSTRATES FOR GEOMETRIC SEPARATION OF RAY BUNDLES

Task

When High Harmonics are generated from ultra-short pulsed laser radiation in enhancement cavities in bow-tie arrangement, there is the problem of outcoupling the Harmonics from the cavity because dichroites do not exist for short wavelengths in the range of some 10 nm. One way of outcoupling is to drill a small hole on the order of 100 µm in one of the resonator mirrors on the optical axis. So that the losses for the Fundamentals are minimized, the mirror surface needs to be as undamaged as possible around the hole. In particular, chipping should be avoided. The hole must be undercut because the incident angle of the Fundamentals and Harmonics on the mirror amounts to a few degrees in the ring resonator.

Method

The undercut openings are structured into the uncoated mirror substrates with Inverse Laser Drilling. For this process, ultrashort pulsed lasers are only suitable to a limited extent due to non-linear effects in the propagation through the glass. Instead, a laser beam source is used with a pulse duration of several 100 ps. First, the process parameters are adjusted to minimize process-related induced tension, as these are partly responsible for chipping. In a further step, Fraunhofer ILT has examined whether the surface can be protected by contact bonding another mirror substrate onto the substrate before processing, and removing again after processing.

Result

Undercut openings of various geometries, adapted to the enhancement cavity's fundamental transverse mode structure, were structured into standard mirror substrates of various optical materials such as quartz glass, Corning ULE and sapphire. With the steps described above, chipping can be prevented completely. Thanks to this, it is possible to drill holes with large aspect ratios and an undercut in polished vitreous bodies without further impairing the polished surface. The method has been patented by the Fraunhofer-Gesellschaft.

Applications

In general, the process can be used to make optical systems with small openings for separating or coupling ray bundles. Examples of this, in addition to the above-described mirrors, include spatial filters and interleaving mirrors.

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3 Undercut and chip-free slot in a ULE mirror substrate with a diameter of 25 mm and thickness of 6.35 mm.