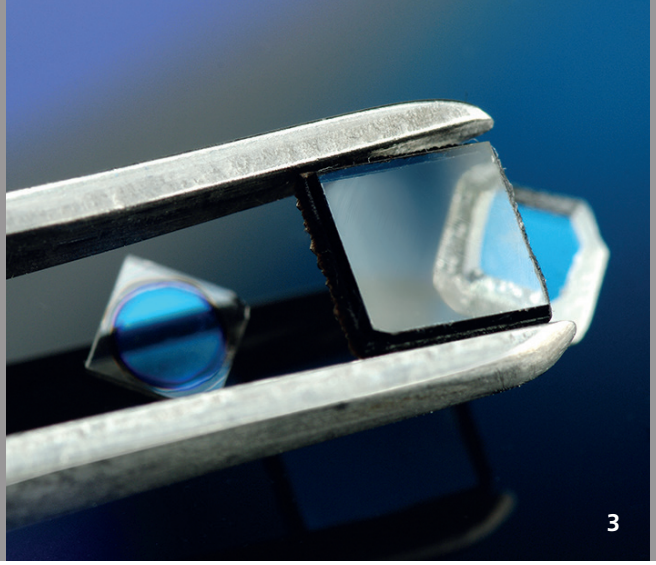

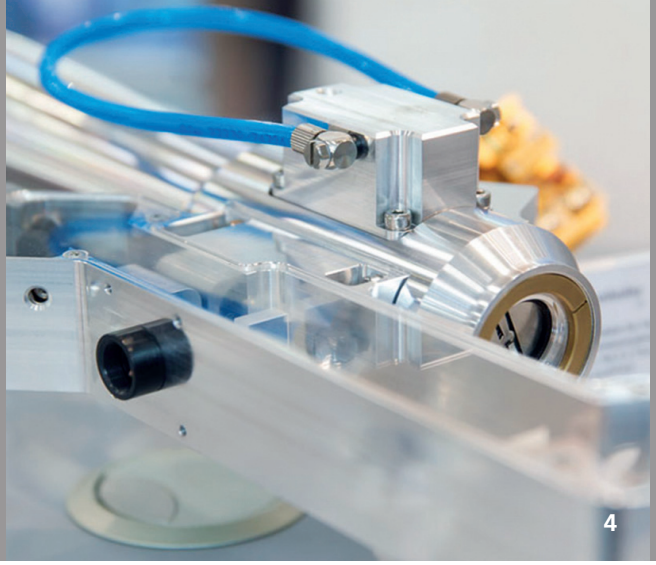

HIGH-POWER OPTICS MADE OF MONOCRYSTALLINE DIAMOND

Task

In laser processing, conventional optical materials are being pushed to their limits as power densities increase and as the demand for lightweight construction and material durability grows. The use of single-crystal synthetic CVD diamond as optics material provides unique potential for the future of high-power laser applications thanks to its extremely large refractive index, excellent thermal conductivity, high hardness and chemical resistance, including radiation resistance for short wavelengths. Poly-crystalline diamond has already become established for the long-wavelength range (i.e. for CO_2 lasers) as optical material, and while refractive spherical or aspherical optics from single-crystal diamond are suitable for the area around 1 µm, they are not yet commercially available.

Method and Results

As part of Fraunhofer's internal, market-oriented preliminary research – »Diamond4Optics« – Fraunhofer ILT, IAF and IPT are examining the potential of diamond as an optical material for high-power laser applications. To accomplish this, the institutes have generated single-crystal diamonds having dimensions up to 7 x 7 mm² with chemical vapor deposition (CVD) and processed them into spherical and aspherical optics for beam guiding and shaping. The synthetic diamonds exhibit optical quality, low birefringence and absorption and can be deposited in parallel with overall rates of up to 30 µm/h (60 substrates simultaneously). In operation at 2 kW laser power, first demonstrator optics show no focal position shift through a thermally induced refractive index gradient on account of the high thermal conductivity and low absorption. They also enable diffraction-limited focusing.

Applications

The project aims to develop a process chain from design through production, to operation and qualification of optical components made of single-crystal CVD diamond for high-power applications. By optimizing the diamond deposition process, Fraunhofer IAF has created fundamentally new opportunities for diamond-based applications. The single-crystal diamond lenses are aimed at the market of beam guidance systems for high-power lasers with short wavelengths (VIS to NIR). Due to their superior mechanical and optical material properties, the optics should find their way into applications for laser material processing, space technology, medical technology and metrology in the near future.

Contacts

Dipl.-Ing. Carlo Holly, M.Sc.
Telephone +49 241 8906-509
carlo.holly@ilt.fraunhofer.de

Dipl.-Ing. Dipl.-Wirt.Ing. Martin Traub
Telephone +49 241 8906-342
martin.traub@ilt.fraunhofer.de

3 Spherical lens made of monocrystalline diamond.
4 Measuring device for diamond substrates in high-performance tests.