Design of 3D printed optics for terahertz beam shaping

The application areas of terahertz (THz) technology are diverse and range from spectroscopy and non-destructive material testing to wireless communication. In addition to off-axis parabolic mirrors, refractive optics made of polymers or silicon are used to form THz radiation. These lenses are manufactured from solid material by machining or from powder by compression molding. Compared to the commonly used polymer HDPE, TOPAS offers several advantages: It exhibits particularly low absorption and dispersion in the THz range, making it especially suitable for the fabrication of THz optics. Combined with commercially available, precise 3D filament printers, this material makes it possible to efficiently produce free-form lenses for THz beam shaping. This innovation is part of the Fraunhofer Prepare project TERAPID, currently being carried out jointly with Fraunhofer HHI.

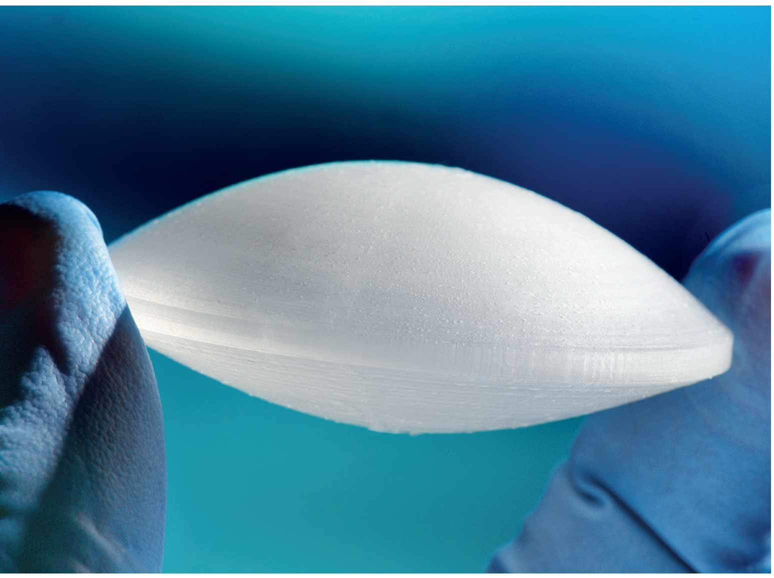
Transmission optimization

When refractive lenses are designed for THz applications, the transmission of the material is a critical parameter, in addition to the image quality. Compared to conventional glass lenses for the visible or infrared spectrum, polymer lenses for THz frequencies exhibit significantly greater absorption. To minimize volume absorption and spherical aberrations, the partners in TERAPID selected a Fresnel design with aspherical segments for the imaging optical system.

Diffraction limited optics

Fraunhofer ILT designed different lenses with identical focal lengths, diffraction limited imaging for axis-parallel beams and a different number of Fresnel zones with an aspherical surface. The TOPAS lenses were 3D-printed in different qualities by the project partner Fraunhofer HHI. To compare imaging performance and transmittance, HHI had HDPE lenses with the same focal length and design conventionally machined. Compared with an aspherical lens without segmentation, the center thickness of both Fresnel lenses with three zones was reduced by about 50 percent. The lenses are diffraction limited, but scattering losses occur at the edges of the Fresnel zones. In the next step, a bi-aspherical f-theta lens was designed and fabricated from TOPAS. The diffraction-limited imaging could be shown over the 15 mm x 15 mm scan field with a mirror scanner.

Author: Sarah Klein M. Sc., sarah.klein@ilt.fraunhofer.de



3D-printed TOPAS aspherical lens for terahertz beam shaping.

Contact

Dr. Martin Traub
Group Manager Optics Design and Diode Lasers
Phone +49 241 8906-342
martin.traub@ilt.fraunhofer.de