Complex microoptics by 3D printing for massively parallel imaging

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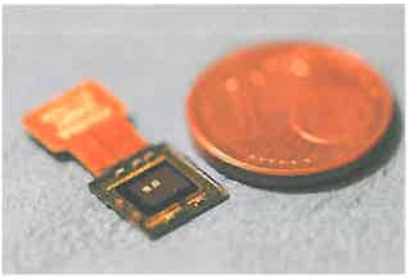
We present complex micro-optics fabricated by femtosecond 3D direct laser writing. We fabricate optical free-form lenses directly onto single mode fiber tips and achieve near-perfect centration and alignment. We measure the beam propagation of a variety of free-form surfaces such as spheres, aspheres, astigmatic lenses which deliberately introduce astigmatism, as well as diffractive structures. Flat-top intensity distributions as well as deliberately designed donuts have been achieved. When using more complex manufacturing methods, multi-lens micro-objectives can be fabricated with near-perfect alignment onto single- and multi-mode fibers (see left image), as well as on transparent surfaces or directly onto CCD or CMOS chips (see center and right image).


MTF measurements analyze the quality and fabrication accuracy of the manufactured systems and demonstrate their extremely high performance when compared with their designed parameters. Both illumination as well as imaging is possible. We will elaborate on the limits and challenges of this new field for the future. Remote imaging and microscopy is possible when using multi-core single-mode fibers. These complex micro-optical high-performance microscopy systems can be inserted into the finest syringe needles or serve as multiple objective arrays directly on CMOS imaging systems for light field cameras that look simultaneously into different directions, focus simultaneously at different distances, and carry out massively parallel tomography of a scene or an object.

This work was carried out in collaboration with Timo Gissbl, Simon Thiele, and Alois Herkommer (ITO, Stuttgart). Support from ERC, BW Stiftung, BMBF, DFG, and AvH is acknowledged.