Lensless holographic endoscopes realized with direct laser writing

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Recently, 3D imaging endoscopes have made their way into endoscopy and enable three-dimensional visualization which allows improved handling during e.g., medical diagnosis. A key disadvantage of current 3D imaging endoscopes is the requirement of bulky optics attached to the proximal tip of the endoscope. The optical mounts have a larger diameter than the light-guiding fiber which requires more extensive surgery in the human body, whereas a minimally invasive intervention is desirable.

Here, high-precision 3D printing based on two-photon polymerization (TPP) enables the fabrication of passive optics directly on photonic devices drastically reducing the overall optical footprint. As an example, we present work on a multicore fiber with a printed DOE (diffractive optical element), compensating phase differences of the light between individual cores. Thus, the phase is taken into account in the measurement data in addition to the intensity, enabling 3D imaging. While each multicore fiber has an individual distribution of phase differences, an individual DOE design is required. It is shown how the DOE is fabricated rapidly and stitching-free with high alignment precision using maskless 3D lithography.

This method enables minimally invasive 3D endoscopes with fiber diameters of less than 500µm.