KFM 2: High-resolution Lithography and 3D Patterning

Chair: Theo Scherer (KIT Karlsruhe)

Time: Monday 9:30–10:30 Location: EMH 025

KFM 2.1 Mon 9:30 EMH 025

Diffractive Microoptics in Porous Silicon Oxide — •Leander Siegle[1], Dajie Xie[2], Corey A. Richard[2], Paul V. Braun[2], and Harald Giessen[1] — [1]4th Physics Institute, University of Stuttgart, Stuttgart, Germany — [2]Beckman Institute for Advanced Science and Technology, University of Illinois Urbana-Champaign, Urbana, IL, USA

We demonstrate focusing as well as imaging using diffractive microoptics, manufactured by two-photon polymerization grayscale lithography (2GL) that has been written into porous silicon oxide. While typical doublet lens systems require support structures that hold the lenses in place, our optics are held by the porous media itself, decreasing both the fabrication time and design constraints. Compared to the typical two-photon polymerization fabrication process, 2GL offers better shape accuracy while simultaneously increasing throughput. To showcase 2GL fabricated optics in porous media, we fabricate singlet diffractive lenses with a diameter of 500 μm and numerical apertures of up to 0.6. We measure focusing efficiency and analyze the shape of the system with the 3D fluorescence signal of the photoresist. Furthermore, we design, print, and optimize a doublet lens system for imaging purposes with a thickness below 60 μm and examine the high-resolution imaging performance with a USAF 1951 resolution test chart.

KFM 2.2 Mon 9:50 EMH 025

3D-printed astigmatism-free microendoscope for in-vivo optical coherence tomography in coronary arteries — •Pavel Ruchka[1], Alok Kushwaha[2], Rouyan Chen[2], Simon Thiele[3], Alois Herkommer[3], Robert McLaughlin[2], Harald Giessen[1], and Jiawen Li[2] — [1]4th Physics Institute and Research Center SCoPE, University of Stuttgart, 70569 Stuttgart, Germany — [2]School of Electrical and Mechanical Engineering, Australian Research Council Centre of Excellence for Nanoscale BioPhotonics, Institute for Photonics and Advanced Sensing, University of Adelaide, Adelaide, SA 5005, Australia — [3]Institute of Applied Optics (ITO) and Research Center SCoPE, University of Stuttgart, 70569 Stuttgart, Germany

In the past few years, intravascular microendoscopy gained increasing significance in medical imaging and cardiovascular medicine, as such diseases are among the biggest causes of death in the world. A fundamental challenge in microendoscopy is the fabrication of a small fiber-optic probe that can achieve similar functions as large complex optics, namely high resolution and extended depth of focus. Moreover, existing methods of fabrication cannot correct astigmatism/nonchromatic aberrations, which arise due to the use of catheter sheets and limit the resolution of at least one axis. Here, we introduce a two-photon 3D-printed lens on an optical fiber for cardiovascular in-vivo endoscopy, forming a Bessel beam with high resolution over a focal length of hundreds of micrometers, corrected for astigmatism arising due to catheter usage, and used for intracoronary imaging in a live pig.

KFM 2.3 Mon 10:10 EMH 025

3D beam-shaping by 3D printed holographic triplet on a fiber — •Zihao Zhang, Leander Siegle, Pavel Ruchka, and Harald Giessen — 4th Physics Institute and Research Center SCoPE, University of Stuttgart, Germany

Non-Gaussian beams are crucial for many research areas such as imaging and material processing. To create arbitrary beams, beam-shaping with diffractive and holographic optical elements can be used. For example, beam-shaping for glass cutting provides a number of focus copies at tailored positions in a three-dimensional working space, resulting in precisely controlled energy deposition within a volume of transparent materials. Often these beam-shaping optics are quite complicated and bulky. However, in some specific scenarios there is a demand not only for the miniaturization and simplicity, but also for the ability to adapt and change the focal distribution rather rapidly. Here, we present a beam-shaper triplet, 3D printed on a single-mode fiber using the maskless rapid additive manufacturing technique of two-photon polymerization (2PP). The triplet comprises a collimating diffractive lens, a tailored phase mask, and a focusing lens. As a result, we demonstrate several 3-dimensionally distributed arrays of focal spots produced by such a triplet with tailored phase masks. The triplet which is 3D-printed on a single fiber can easily be adjusted for the desired foci distribution. Our technique can play a crucial role in the miniaturization of beam-shaping setups for laser cutting, imaging, and optical trapping.