Optical Design, Simulation and Applications of 3d-printed Microoptics

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Femtosecond direct laser writing as a 3D-printing technology has transformed the field of micro-optics. Over the last decade, complexity and surface quality of printed optical components have ever increased from simple micro-lenses to multi-element systems [1], printed spectrometers [2] and OCT-probes [3]. This rapid development reflects the large potential and application range of 3D-printing technology. Especially medical applications, like OCT, fluorescence or endoscopy require small scale optical systems with high fidelity. But similar, industrial metrology or imaging applications can profit from the many degrees of freedom and miniaturization potential of this technology.

However, the almost unlimited design freedom regarding surface shape, microstructures, apertures and geometry has to be controlled during the optical design process under limiting manufacturing and material constraints. Due to the small size of only 10-1000 micron, moreover diffraction effects need to be considered by appropriate wave-optical simulations.

This paper highlights relevant aspects in the design and simulation of 3d-printed systems. It presents multiple design examples, ranging across micro-optical imaging-, illumination- and sensing-systems for various applications.

[1] Thiele, S., Arzenbacher, K., Gissibl, T., Giessen, H., & Herkommer, A. M.
„3D-printed eagle eye: Compound microlens system for foveated imaging”
Science advances 3(2) (2017), e1602655.

[2] Toulouse, A., Drozella, J., Thiele, S., Giessen, H., & Herkommer, A. "3D-printed miniature spectrometer for the visible range with a 100× 100 μm^2 footprint."
Light: Advanced Manufacturing 2(1) (2021), 20-30.

[3] Li, J., Thiele, S., Quirk, B. C., Kirk, R. W., Verjans, J. W., Akers, E., ... & McLaughlin, R. A. “Ultrathin monolithic 3D printed optical coherence tomography endoscopy for preclinical and clinical use”
Light: Science & Applications, 9(1) (2020), 1-10.