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Two-photon polymerization: A femtosecond laser-based technology for additive manufacturing in life sciences and microoptics

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3D printing has been widely adopted on the macroscopic domain not only for rapid prototyping but also in manufacturing. Several technologies ranging from the consumer market to an industrial level have been established. However, on the micron-scale the possibilities to go into the third dimension are limited as the voxel sizes are dominated either by the diameter of particles in powder-based additive manufacturing, by the thickness of the filaments, or the diameter of the droplets in inkjet printing. These constraints can be circumvented when using femtosecond laser-based photopolymerization in liquid photopolymers for creating 3D microstructures. Here, the solidification of the material is strongly confined to the focal spot of focused laser pulses where the intensities are sufficiently high to trigger two-photon absorption. Hence, two-photon polymerization (2PP) is an inherent 3D technology with voxel sizes down to 100 nm. The exposure strategy is similar as in conventional 3D printing. The volume to be written is scanned in 3D, typically in a layerwise fashion. As in UV-lithography a subsequent solvent wash (development step) is needed to get rid of the unexposed, and still liquid, resin. We will demonstrate representative application examples from different fields of research. In life sciences 2PP-written 3D structures can be used as substrates for cell cultivation, as they mimic the natural, porous environment which is required for proper cell expression. On the other hand, 2PP can be used for diffractive and refractive microoptical elements which reveal excellent surface quality and directly benefit from the freedom in design which only 3D printing can offer.

Biography

Sonke Steenhusen studied Physics in Würzburg and joined Fraunhofer Institute for Silicate Research ISC in late 2007 beginning his work in the field of additive manufacturing. At the same institute he developed machines for two-photon polymerization and investigated the 3D patterning of hybrid polymers for applications in microoptics. He is (co-)author of several papers in the field of 3D lithography. He is currently the Deputy Head of the Optics and Electronics Department at the same institute which is dedicated to the development and processing of novel materials for optical and electronic applications. His research interest includes: additive manufacturing, 3D printing, hybrid polymers, nanocomposites and two-photon polymerization.

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