High-speed 3D laser lithography with high NA-objectives for 3D micro and nanofabrication

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Three-dimensional (3D) direct laser writing (DLW) based on two-photon polymerization allows for versatile fabrication of micro- and nanostructures for a large variety of applications [1,2]. Nowadays, DLW has been established as standard tool in many scientific research laboratories covering the demands of research areas such as photonics, micro-optics, microfluidics, tissue engineering, optical telecommunications and mechanical metamaterials.

Here, we present the combination of our technical advantages of DLW to meet more of the high demands of 3D micro and nanofabrication in the scientific community and industry. (i) Highest resolution is achieved by the use of high-NA (NA= 1.4) objectives, which allow for feature sizes down to 150 nm. (ii) Ultra-high precision positioning for 3D structuring carried out either by means of a sample scanning routine relative to a fixed laser focus or by scanning the laser beam inside the photoresist. (iii) High-speed fabrication based on the latter scanning mode has been enabled by the integration of a galvo mirror system that deflects the laser beam for typical writing speeds of 20 mm/s or better. (iv) Limited structural heights due to the working distance of microscope objectives have been overcome with the in-house developed 3D Dip-in Laser Lithography (DiLL) [3].

The combination of these developments paves the way for a broad range of applications. Here, we present results achieved by means of our 3D Laser Lithography system on 3D photonic crystals, artificial extracellular matrices for tissue engineering, micro- and nanofludic devices for microchannels, magnetic helical micromachines, photonic wire bonding and mechanical metamaterials. The following figures exemplified some of the above mentioned applications for an illustrative overview of the applicability of our DLW technology. Moreover, we evaluate fabrication possibilities of photonic colorized materials (see Fig. 4) and diffractive optical elements potentially employed for security labels and sensors.

References

[1] S. Kawata et al., Nature **412** (2001), 697
[2] www.nanoscribe.de
[3] T. Bückmann et al., Adv. Mater., **24** (2012) 2710
[4] J.H. Atwater et al., Appl. Physics Letters, **99** (2011) 151113
[5] F. Klein et al., Adv. Mater., **22** (2010) 868
[6] S. Tottori et al., Adv. Mater. **24** (2012) 709

Figures

Fig. 1 Micro-photonic parabolic light directors along the publication [4]

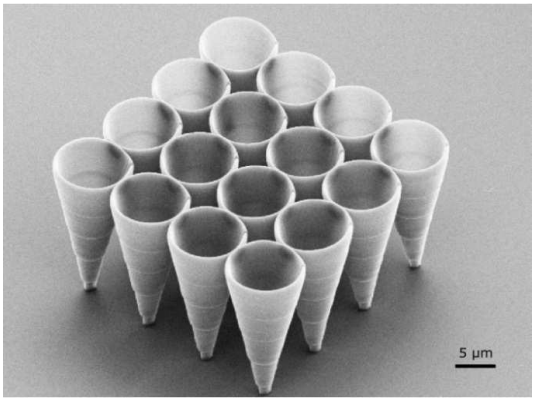

Fig. 2 Biocompatible 3D scaffold for cell studies in tissue engineering along the publication [5]

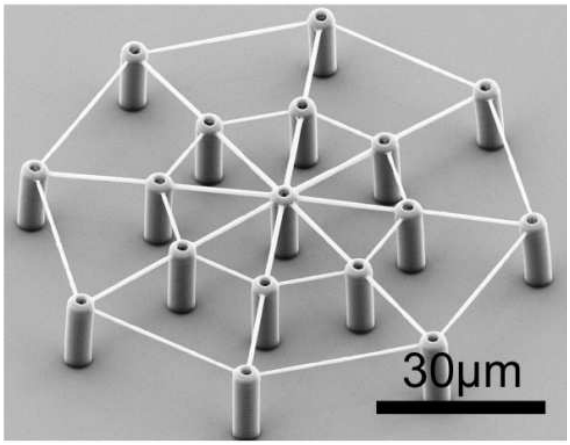

Fig. 3 Magnetic helical micromachines, structures coated with nickel [6]

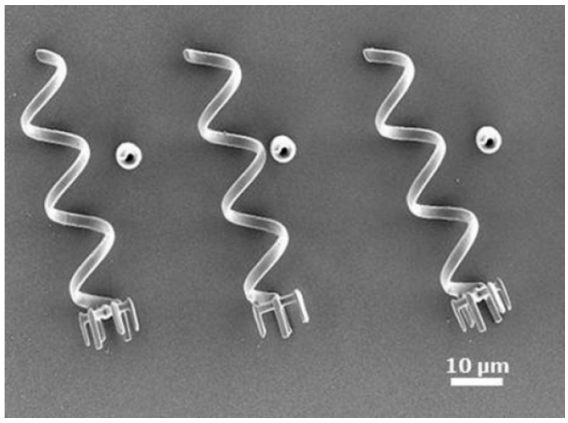

Fig. 4 Photonic colorized elements