A NEW HORIZON IN HIGH-RESOLUTION TWO-PHOTON 3D-PRINTING

Markus Lunzer, Sabrina Strobel, Denise Mandt, Peter Gruber

UpNano GmbH, 1030 Vienna, Austria

Multiphoton lithography is a high-resolution micropatterning and 3D printing technique, which allows real free form stereolithography down to the nanoscale [1].

For more than two decades, high-resolution 3D printing systems based on multiphoton excitation have been developed. Despite their high potential, these systems never achieved widespread industrial application, due to the limited production capacity they provided. Even substantial device-related advancements such as the integration of galvanometer scanners, which provided a significant boost in scanning speed, could not bring the technology to an industrial production level. Slow writing speeds and thus low throughput rates are the main reasons why multiphoton lithography is still considered a technology for mostly academic research. It is therefore mainly used for prototyping of polymeric micro parts with high-resolution structural elements ≥170 nm and surface requirements below 10 nm.

UpNano has enhanced the 2PP process in 3D printing to increase the throughput by a factor of up to 100, and enables for the first time batch and small series production of high-resolution microparts. An optimized optical system, a powerful 1-Watt femtosecond laser and the patented writing mode “Adaptive Resolution” are the key innovations of the NanoOne system. This system provides a scanning speed of up to 1500 mm/s in combination with a low-magnifying 4x objective, resulting in a throughput of over 200 mm^3/h.

Ultrafast high-precision 3D-printing requires reactive materials, especially optimized for this purpose. Therefore, proprietary two-photon materials have been developed, tested and optimized by UpNano. The high throughput of UpNano’s technology now even allows to fabricate macroscopical specimens for mechanical testing. Hence, the process parameters and mechanical properties of the printed polymers are currently evaluated in-depth in an ongoing research program in cooperation with TU Wien. One goal of the project is to evaluate the miniaturization of test methods to also specify much smaller pieces.

The versatile NanoOne printing system covers a broad range of dimensions from several tens of millimeters down to the nanometer range. By variation of the focusing objective (60x, 20x, 10x, 4x) resolution, the total volume and print time can be adapted. Whereas a 60x objective permits highest precision, achievable printing times as well as volume and size of printed parts will be limited. A lower-magnifying 4x objective allows for very high printing volumes in short time, yet at a coarser resolution.

The UpNano technology now enables a wide range of applications especially for research and industry in the medical, chemical and electronic field that previously seemed unachievable, including microneedles, extremely precise filter elements, micro-lens arrays, microfluidic elements, photonic crystals and many more. It is our aim to provide both industry and academia with an additive manufacturing technology that allows fast iteration cycles for prototyping and part design and permits serial production of high-resolution micro parts.

[1] LaFratta, C. N.; Fourkas, J. T.; Baldacchini, T.; Farrer, R. A. Multiphoton Fabrication. *Angew. Chem. Int. Ed.* **2007**, *46* (33), 6238–6258.