

Two-photon polymerization (2PP) enables the production of high-precision microstructures using additive manufacturing – from microfluidic components and micromechanical components to optical elements.

## Additive manufacturing reaches new heights

UpNano and SmarAct combine high-end optics and high-end motion.

3D printing has come of age – from the workbench to high-tech industry. With the help of two-photon polymerization, this technology has reached a new dimension: UpNano's NanoPro VT combines adaptive voxel size for maximum printing speed with high-precision motion technology from SmarAct. The result: structures in the nanometer range, manufactured faster and more precisely than ever before.

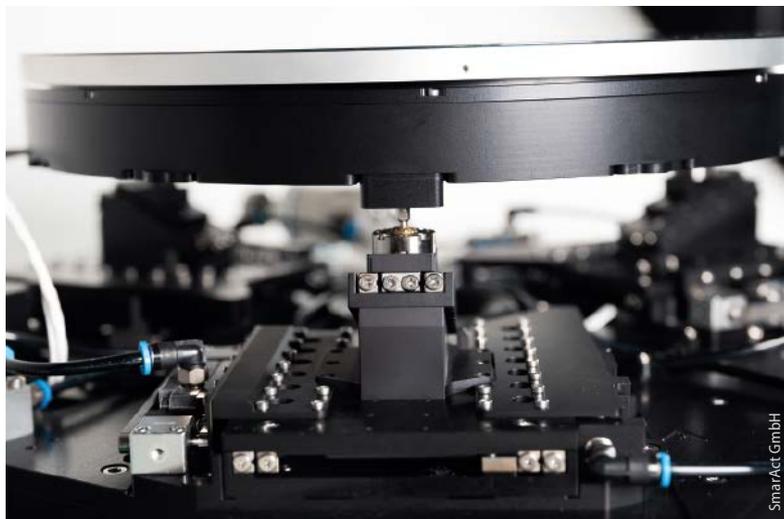
**3**D printing has evolved from a niche innovation to a driving force behind the manufacturing revolution – disruptive, versatile, and limitless in its applications. While entire houses are already being built layer by layer on a large scale,

high-precision additive manufacturing in the nanometer range – for example, through two-photon polymerization (2PP) – is opening up completely new possibilities for science and industry. Here, material innovation and precision merge to create structures that set new standards even under the microscope.

Two-photon polymerization belongs to the family of stereolithography (SLA) methods: The raw material is in liquid form as a resin and is cured by absorption of optical radiation. The optics define how large the smallest volume elements – voxels – can be. As the name suggests, 2PP requires two photons for the polymerization reaction. Since the simultaneous absorption of two photons is an extre-

mely rare event, this only happens in a small area of the focus with a particularly high energy density. This allows voxel sizes of less than 100 nanometers to be achieved.

However, the voxel size has a huge impact on printing time: typical laser sources for 2PP have repetition rates of up to 100 MHz. With a voxel size of 1 μm, this means it takes just under three hours to fill one cubic centimeter. If the voxel size is reduced to 100 nm, it takes almost four months to fill the same volume – which is not really worth it. To speed up the process, manufacturers' creativity knows no bounds; often, the size or shape of the voxel is adjusted in one way or another. With its patented “adaptive resolution” method, the



Perfection in motion: SmarAct's high-end motion systems set new standards in additive manufacturing.

Vienna-based high-tech company UpNano has reduced the printing time of a structure from an original 16 days to 2.5 hours on its NanoOne tabletop device.

With the NanoPro VT platform – for voxel tuning – the company is setting new standards. The variability of the voxel size is significantly increased by using a lens changer: a high-resolution lens can be used for the finest contours and switched to a lower magnification for “volume work.” This reduces the printing time for the same component by a further factor of 10.

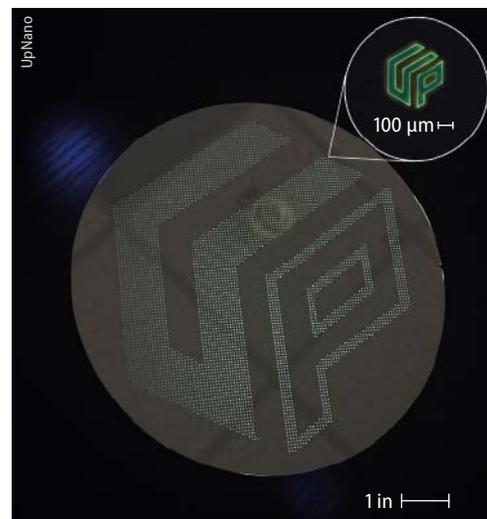
Microscope lenses with high magnification are used for printing. Because they can reproduce an enormous level of detail, they have a very small working field. To cover the largest possible printing area, the optics or components must be moved. This places high demands on the motion technology – after all, the nanometer-scale resolution enabled by 2PP should not be negated by a repeat accuracy of a few micrometers.

On the micrometer and sub-micrometer scale, every small irregularity on the print bed, every

slight deflection, every scratch counts. UpNano has a strong partner for this in the Oldenburg-based high-tech company SmarAct: a five-axis system developed in-house by SmarAct enables high-precision movement in the plane and allows the print bed to be tilted slightly and varied in height to compensate for the smallest unevenness.

Changing lenses also requires maximum precision in movement. The optics must focus quickly and accurately – repeatable within a range of a few tens of nanometers. Here, too, SmarAct provides a comprehensive solution that covers several other movement tasks in the machine in addition to this one.

The NanoPro VT enables the printing of entire semiconductor wafers, opening up an enormous range of applications, such as in chip-level optics or microfluidics. Particularly exciting is the potential for direct integration of optical, microfluidic, and semiconductor-based functional elements in a single manufacturing step. This ability to print highly complex structures directly onto sensitive substrates shortens development



The NanoPro VT enables the production of extremely delicate structures on an industrial scale using additive manufacturing – such as printing entire wafers with microstructures.

cycles, increases design freedom, and creates space for completely new functionalities.

SmarAct has been a reliable partner to leading technology companies for more than twenty years – from the initial idea to series production. With modular high-precision positioning systems, advanced metrology, and powerful automation solutions, as well as its own manufacturing expertise and unconditional commitment to innovation, the company is helping to shape the future of additive manufacturing on a nanometer scale.

## Companies

**SmarAct GmbH**  
Schütte-Lanz-Str. 9  
26135 Oldenburg  
phone: +49 (0) 441 800-8790  
e-mail: info@smaract.com  
Website: www.smaract.com

**UpNano GmbH**  
Modcenterstr. 22/D36  
1030 Vienna  
Austria  
phone: +43 (0) 1 890-1652  
e-mail: office@upnano.com  
Website: www.upnano.com