

Hybrid 2D & 3D Lithography

Combining two enabling technologies

Maskless UV lithography & Two-Photon Polymerization.

In the world of microstructures, there are three big trends for the fabrication of complex devices: maskless lithography, grayscale lithography and two-photon polymerization (2PP). Maskless lithography equipment exposes patterns directly from data without costly and time-consuming photomask fabrication. This technique offers much higher flexibility and faster design iterations. Grayscale lithography, a special type of maskless lithography, allows the creation of complex 2.5D topography in a positive photoresist. Two photon polymerization (2PP) is a technique to create free-standing fully 3 dimensional structures.

As 2PP technology is known to be slow, we decided to combine it with high-throughput standard lithography technologies, creating an integrated, full 3D exposure technique. For maximum flexibility, we used a standard maskless aligner as UV lithography system and combined it with a bespoke 2PP setup.

The first step for a co-exposure of UV and 2PP is to split the design into two sub-designs:

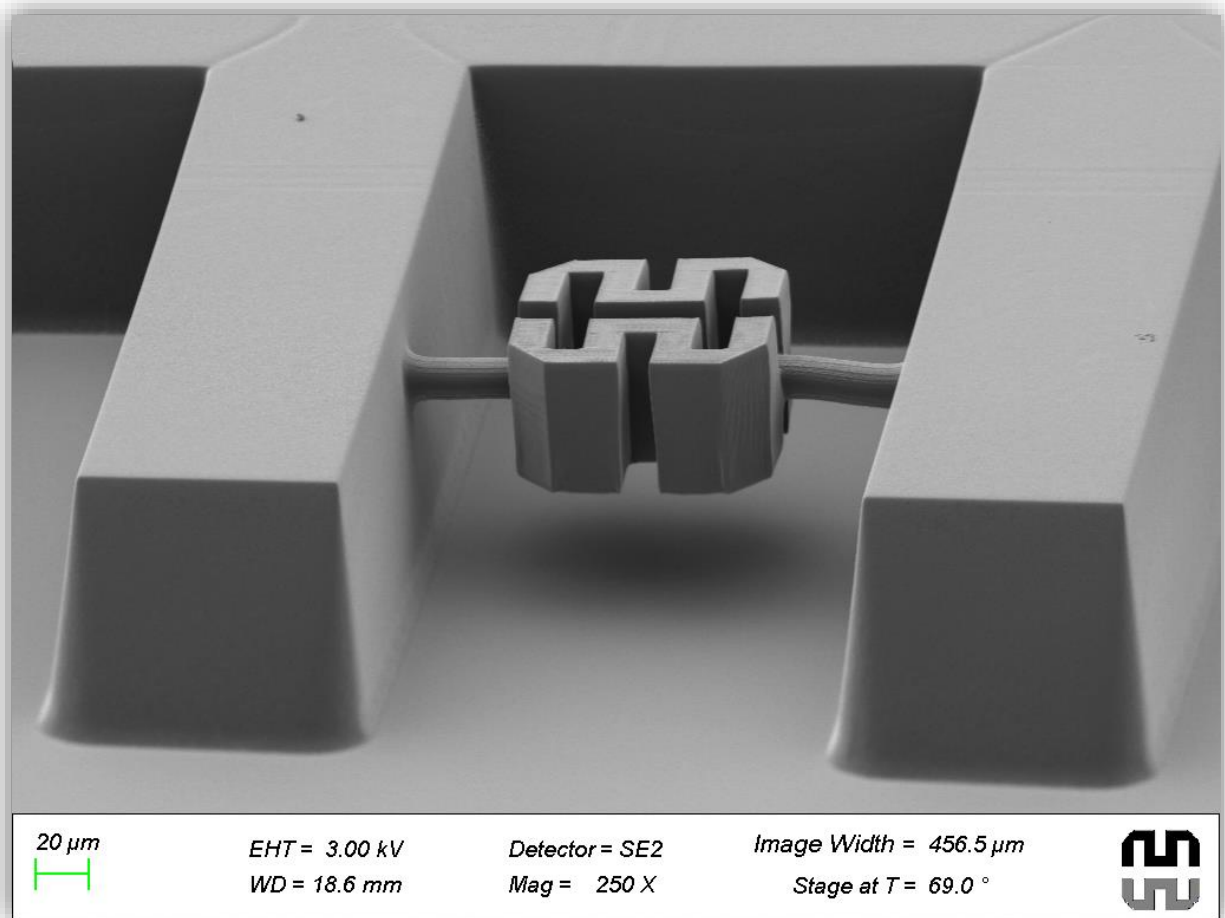
- “High aspect ratio 2D” structures are written with maskless UV lithography. Those elements will have the same height as the resist thickness.
- “3D” structures are written with 2PP

A system that integrated both technologies would expose those two sub-designs in one single process cycle.

As 2PP is generally used with negative photoresist we selected a standard negative resist that works with both technologies: SU-8.

We demonstrated that it is possible to expose structures in a layer of negative resist using two different technologies “Maskless UV Lithography” and “Two-Photon Polymerization”. The advantage of mixing the technologies becomes obvious when supporting structures are required to hold fine resolution free-standing 3D shapes, e.g. in the application of microfluidics where the channels themselves represent the supporting structure. These can be written several orders of magnitude faster using maskless lithography. The combination of high throughput maskless lithography with the versatility of 2PP literally offers the best of both worlds.

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*Suspended logo made with Two-photon polymerization
between walls made with maskless UV lithography.*