3D-microfabrication by 2PP sacrificial stencil mask

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Two-photon polymerization (2PP) is a promising technique for fabricating 3D nano-structures without any further processing [1-3]. In case of nano-sensors or actuators, different materials are needed to combine and apply nano-structures on supports. This is normally done by challenging steps such as separate lithography and pattern transfer techniques. For instance, recently, a Subtractive Photoresist Platform for Micro- and Macroscopic 3D Printed Structures has been developed exploiting different chemical properties of photoresists and multiple exposure steps [5]. Here we report about the exploitation of 2PP for building a sacrificial nano-stencil mask together with the 3D support structure for nano-sensors or actuators in one single exposure and development process. This mask was used for generating shadows of different materials by vapor deposition through the stencil. We first spin coated a 20µm thick layer of SU8 for defining the anchoring zones for the permanent and temporal structures resp. After pre-exposure baking and short UV flashing, for conditioning the SU8 top surface, we deposited a droplet of IPL resist [4]. In one single 2PP lithography step, we first exposed the anchoring areas in the SU8 layer, and then the 3D structures on top of them, while the stencil mask was exposed in the volume on top of unexposed SU8 areas. For the current demonstrator experiments, the stencil mask was a plain slit, placed on top of a 50µm high, hollow tower and the 3D structure a plain square pedestal. After the development of the IPL in IPA (which does not develop SU8), Cr was evaporated (Fig. 1 and 2). Then, the stencil mask was lift-off by developing the unexposed SU8.

Figure 3 shows the metal-shadow deposited on the pedestal. The location of this deposit could be shifted by tilting the axis of the tower relative to the line-of-sight with the evaporation source. The red dashed line indicates the normal projection of the stencil. A shift of 3.1 µm (center to center) was measured due to the parallaxes between the position of the sample and the Cr source. The combination of sacrificial polymer structures with permanent ones opens new possibilities in 3D MEMS design.

This technique allows incorporating electronic sensors and switches e.g. piezoresistive or metal-insulator-metal thin film diode elements. Improving the mechanical stability of the stencil and decreasing the divergence of the evaporation beam will further increase the definition of the structures demonstrated in this paper.

References

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Figures

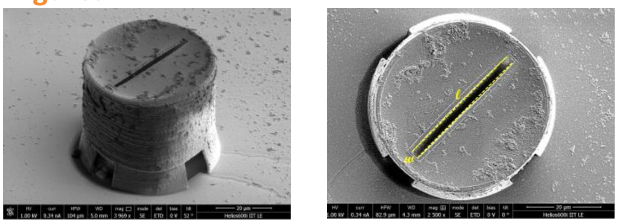

Figure 1. SEM image of the 3D structure with sacrificial stencil mask after the metallization with Cr. The length ℓ was 40µm and the width *w* 3µm. The yellow dashed line reproduces the outline of the stencil.

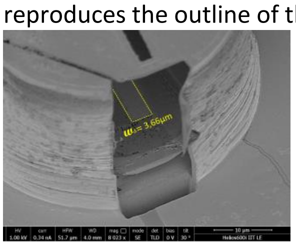

Figure 2. SEM image of a stencil mask opened by Focused Ion Beam milling. It is possible to see the metal structure (yellow dashed line) which has a width of w_s = 3.4µm.

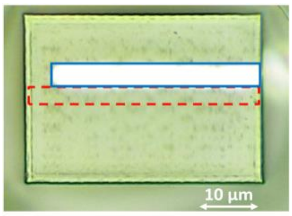

Figure 3. Optical image of the metal structure after lift-off of the stencil mask. The structure (continuous line) has a length of 35.4µm, a width of 3.7µm. It is shifted by 3.1µm relative to the normal projection of the stencil.