# 3D contact stencil masks for lift-off process on extremely uneven surface

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Lift-off process is a popular method for transferring micro-/nano-patterns to various thin film materials. The process starts with generating stencil mask patterns in a layer of intermediate material coated on the substrate surface using lithography techniques, followed by physical vapor deposition (PVD) of desired thin film material and intermediate material removal. However, traditional lithography process is incompatible with substrates with surface unevenness as large as several tens of microns or beyond due to two factors, the lack of methods to evenly coat resist on uneven surface, and the limited depth of field (DOF) (for projective lithography optics) or the requirement of small gap between photomask and substrate (for contact photolithography to reduce the pattern blurring).

We report a new lift-off method which is capable of handling substrate surface with unevenness far beyond the DOF of most lithography system (hundreds of microns, for example) using 3D contact stencil masks. The bottom of each stencil mask fits the surface profile of the substrate which greatly reduces the gap between the bottom of the mask and the substrate surface, and therefore the pattern blurring. The thickness of the mask in the aperture surrounding area is designed to be comparable to or smaller than the critical size of the apertures, which mitigates the clogging problem during PVD step. The stencil masks are fabricated in a 3D laser nanolithography system (Nanoscribe Photonic Professional GT). The two-photon-polymerization based technique used on this tool makes it possible to create stencil masks with sub-micron resolution, which is not available with stencil masks made by the traditional laser cutting technique. The native undercutting profile on the mask surface increases the chance of successful mask-substrate separation.

Detailed mask design and fabrication strategies will be discussed for solving problems such as aperture distortion, thin film thickness variation, and special aperture handling, etc. As an example of the application of this lift-off process, a micro-heater fabricated on the etched side of a silicon nitride window (200-micron-uneveness) will be demonstrated.

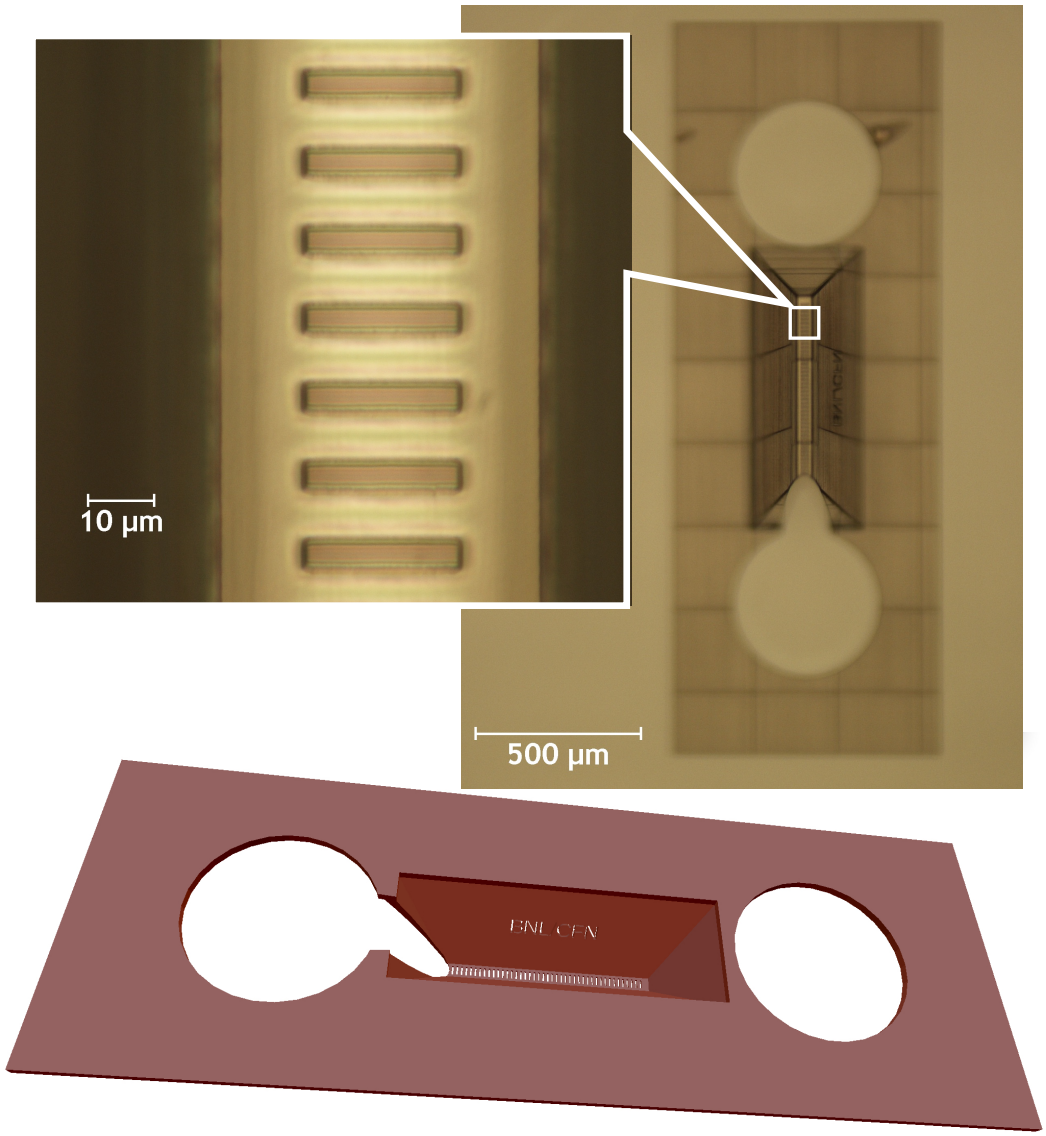


*Figure 1: Upper: micrography of a 3D contact stencil mask (back side); Insert: magnified picture of high-resolution apertures; Lower: 3D model of a contact stencil mask in perspective view (front side).*

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