2.5D-Patterning of photonic structures by electron beam and i-line stepper based grayscale lithography processes

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There is a high demand for patterning technologies for 2.5D structures like micro lens arrays (MLAs), photonic integrated circuits (PICs), and MEMS [1]. MLAs are particularly important for integrating micro LED arrays [2]. Another application is adjusting the slope of sidewalls in modern MEMS. Grayscale lithography, which can be achieved by maskless patterning technologies like electron beam (e-beam) or direct laser writing, is used to create these 2.5D structures [1,3]. While these technologies offer high resolution, their low writing speeds hinder scalability to high volume production [1]. To overcome this limitation and enable higher volume manufacturing, i-line stepper lithography is used. Specialized reticles and photoresists are required for grayscale lithography with i-line tools.

This paper showcases process developments that enable the fabrication of 2.5D structures using e-beam (VISTEC SB254, high resolution but low writing speed) and i-line wafer stepper (NIKON NSR2205i11D, medium resolution of 350 nm but high writing speed) grayscale lithography processes for various applications such as micro lenses, photonic integrated structures, and MEMS-related topography integration. Positive and negative tone resists are investigated on different topologies using e-beam and i-line lithography, considering their process possibilities for the addressed applications, resulting in micro scaled lenses, photonic integrated structures, and MEMS-related topography. The investigations are conducted using full wafer processes, and the fabrication process is made scalable with CD-AFM and CD-SEM characterization techniques.

Figure 1 shows SEM images of 1.8 µm wide frustum structures with a defined sidewall angle and plateau width etched in a 600 nm $Si0_2$ layer. In Figure 2, a Fresnel lens with a diameter of 3 mm is presented. Next to the SEM image in (a) a 3D confocal microscope image of the outer area of the lens (b) is shown. A SEM image of an array of frustums is shown in figure 3 (c).

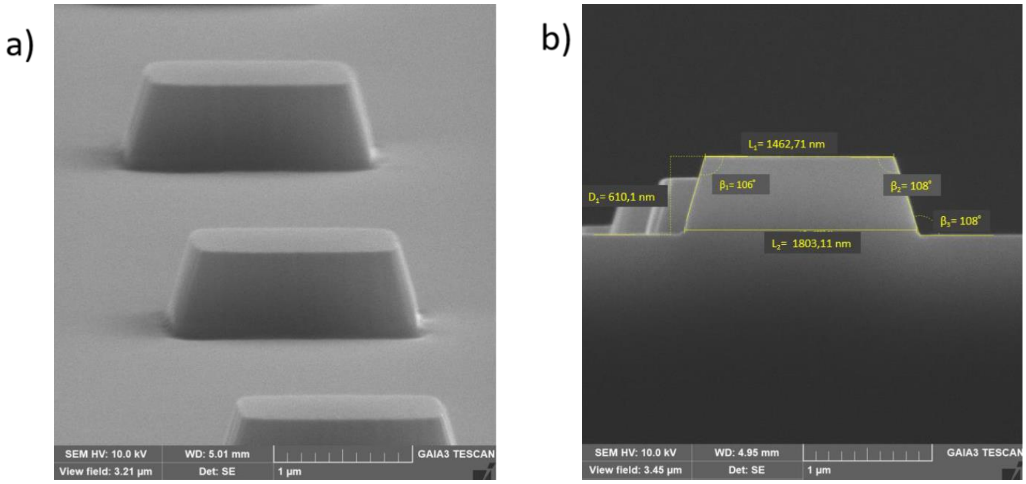

Figure 1: SEM images of 1.8 µm wide frustum structures with a defined sidewall angle and plateau width etched in a 600 nm $Si0_2$ layer as a) overview and b) cross-section.

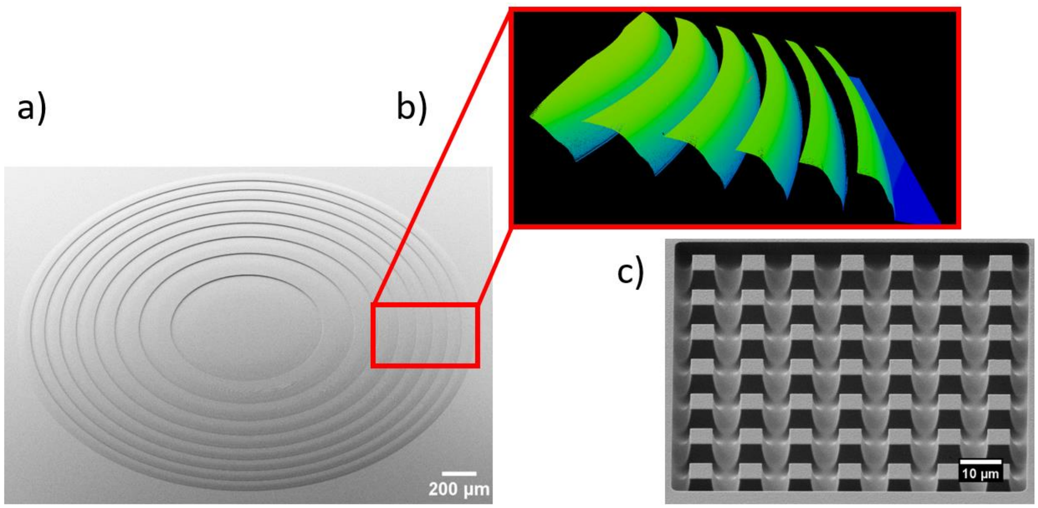

Figure 2: Different structures, exposed by i-line in 8 µm resist ma-P 1275G; a) SEM image of a Fresnel lens with 3 mm diameter, b) 3D image obtained with confocal microscope Confovis AOI 305 and c) SEM image of an array of frustums.