Metal-Assisted Etching of Silicon Molds for Electroforming

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Template based metal-assisted chemical etching enables fabrication of Si nanostructures with controlled diameter, shape, length, and packing density. Ordered arrays of high-aspect-ratio micro/nanostructures in semiconductors stirred a huge scientific interest due to their unique one-dimensional physical morphology and the associated electrical, mechanical, chemical optoelectronic and thermal properties. Recently, a simple, fast, and effective nanostructure formation method, *metal-assisted chemical etching* was reported.[1, 2, 3] The process is based on placing a noble metal (usually gold) in the form of nanoparticles or a pattern onto the surface of Si, then performing a HF:H_2O_2 etch. The noble metal catalyzes the etching reaction of Si at the metal/Si interface through electrochemical effects, causing the metal to sink into the Si, forming a deep, vertical-wall pit. At the end of the etch the remnant metal can be removed chemically if undesired, or used as a plating base to fill the etched pit with a metal by electroforming.

We present the results on Si nanostructure fabrication by metal-assisted chemical etching where the metal patterning was done with e-beam lithography, or interference lithography, and lift-off. The metals investigated for patterning were Au and Pt. The detailed geometries of the resulting Si structures depend mostly on the initial morphology of the noble metal coverage such as in Figure 1. We noticed that, due to gas evolution during the etching, the metal layer delaminates and tends to move along the surface. This problem was resolved by having a thin layer of 4 nm Ti as adhesion layer, resulting in the successful metal-assisted chemical etching of Si (Fig. 2). Figure 3 shows an example of using the remnant metal as a plate base for electroplating.

We are investigating if this process can be extended towards the fabrication of high aspect ratio zone plate configurations (e.g. Fresnel zone plates or photon sieves), which could be etched into Si to form molds and thereafter electroformed with gold.

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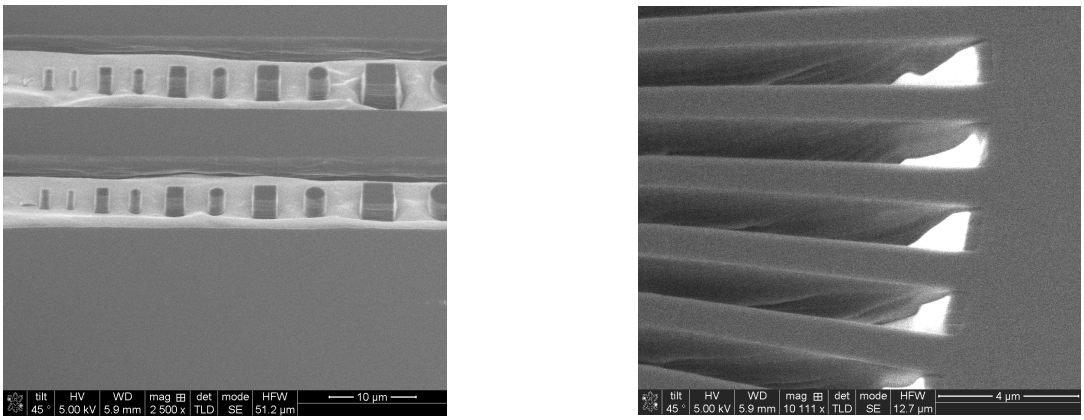


Figure 1: SEM images of different Si structures obtained by gold-assisted chemical etching (no adhesion layer).

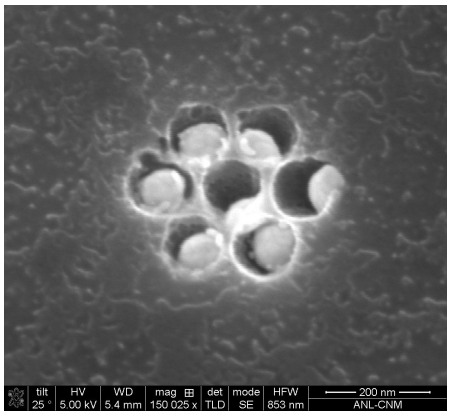
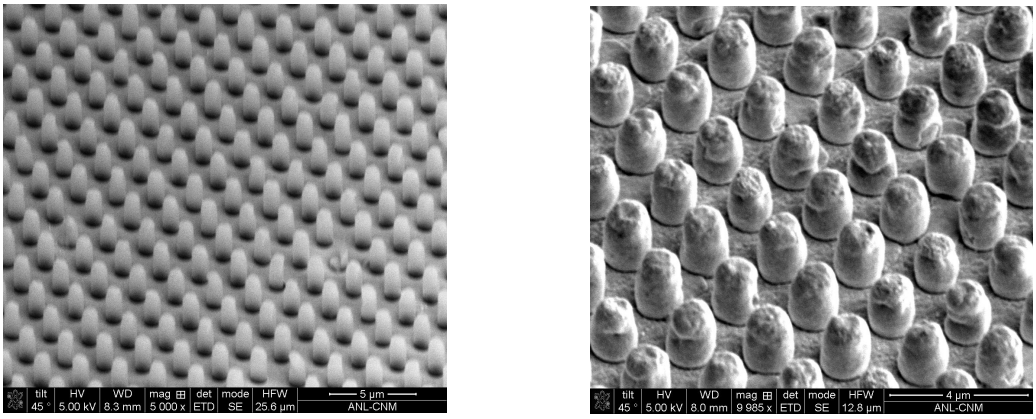


Figure 2: SEM images of Si nanoholes etched by gold-assisted etching (4 nm Ti as adhesion layer).



(a) (b)

Figure 3: SEM images of Si pillars array after gold-assisted etching (a) and after gold electroplating (b).