Fabrication of High-Aspect-Ratio Nanopores by Interference Lithography

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Optical interference lithography (IL) has been successfully applied to manufacture periodic structures. Although this technique offers the advantage of submicron resolution over large sample areas and through the entire resist thickness, most papers on this subject report aspect-ratios below four[1-2] resulting in thin, fragile samples requiring structural support often provided by silicon frames.

Here we present our results on fabrication nanofilters with high-aspect-ratio pores in approximately 10-μm-thick resist thus providing structural strength without the need of a subframe. SU-8 - a biocompatible polymer with excellent chemical and mechanical properties was used as a resist. Comparing with commercial nanopore polymer filters produced by track etch (6-25 μm thick), our filters have uniform straight pores and much higher pore density. Commercial filters with high pore density obtained by aluminum anodizing (60 μm thick) have wider distribution of pore sizes and are not bio-compatible. The high porosity and uniform pore size produced by IL will enable a new line of nanofilters.

A three-beam Lloyd's mirror interferometer[3] was used to create a nanohole array pattern with hexagonal symmetry after a single exposure. A HeCd laser (λ = 325 nm, 30 mW) was used for illumination, and the patterned area is about 4 cm^2. To obtain high-aspect-ratio holes the resist was coated onto a quartz substrate and back-side exposure was performed. This approach prevents problems associated with non-flat surface of thick resist layer. A freestanding film with ~ 250-nm-diameter holes has been obtained. Figures 1 and 2 show SEM images of pores in the SU-8 resist. The surface of the resist was coated with 10 nm of gold for SEM imaging. We performed focused ion beam cross-sectioning with an FEI Nova NanoLab microscope to determine the depth of the developed channels.

Use of the Center for Nanoscale Materials, Argonne National Laboratory was supported by the U. S. Department of Energy, Office of Science, Office of Basic Energy Sciences, under Contract No. DE-AC02-06CH11357.

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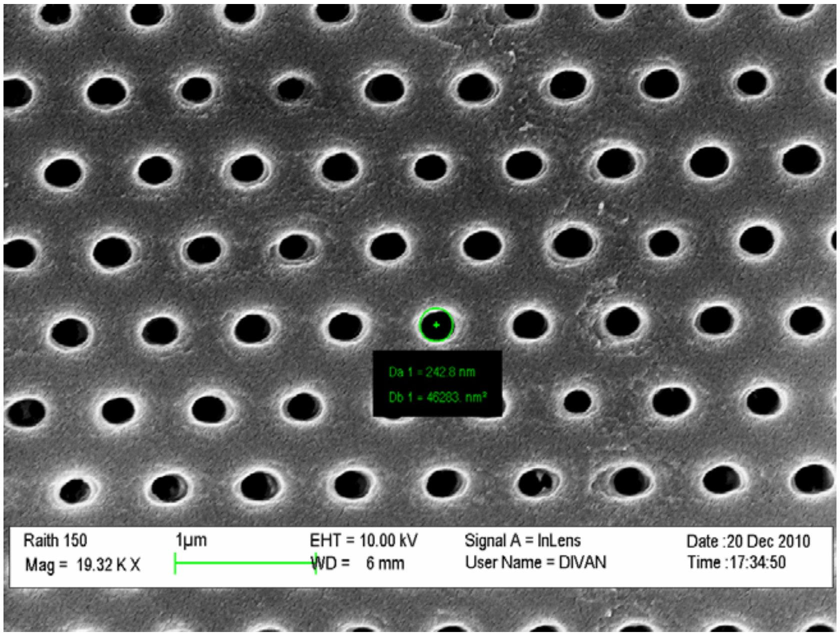

Figure 1. ~250 nm-diameter pores observed at the front side of 10-µm-thick resist layer exposed from the back side.

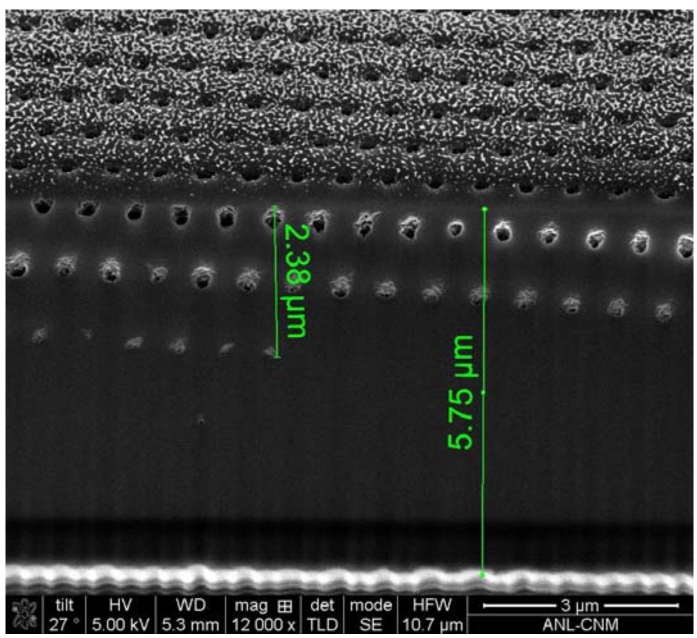

Figure 2. Cross-sectional image of a processed resist. Focused ion beam milling was used to cut the film at the 25^{o} angle from normal. The geometry factor is 1.15; the pore depth is 2.7 µm. About half thickness of the film was developed. Freestanding film is developing from both sides, and a membrane with holes through the entire resist thickness could be obtained.