Fabrication of High-aspect-ratio Grids Using SU-8 as a Mold

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Introduction

Various optical, x-ray, and gamma-ray applications require antiscatter grids or collimators. Collimators with higher resolution and more optimized sensitivity than those that are currently available can improve the imaging for γ-cameras used in planar scintigraphy of small animals for single-photon-emission computed tomography. We are applying deep x-ray lithography and electroforming techniques to fabricate high-resolution collimators [1-5]. The use of SU-8 photoresist [6] instead of polymethyl methacrylate (PMMA) will significantly reduce the cost of the process because of the much shorter exposure time.

To be efficient, collimators for γ-cameras used to image 140-keV gamma rays should be over 1-cm thick. Here we discuss a thickness enhancement method for the fabrication of very tall metal microstructures without the use of stacking.

Methods and Materials

Commercially available negative-tone photoresist SU-8 50 (MicroChem) and rigid graphite sheets (Goodfellow) were used for sample fabrication. A schematic of the method is shown in Fig. 1. The deep x-ray exposures were performed at the APS bending magnet beamline 2-BM [7].

An x-ray mask used for patterning was fabricated on the graphite sheet by standard optical lithography using photoresist SU-8 25. Process parameters have been described elsewhere [8]. The SU-8 resist coated onto rigid graphite was exposed to x-rays by using an x-ray mask; then it was developed and copper-electroformed, as schematically shown in Fig. 1(a) through 1(e). After electroforming was complete, the overplated copper was lapped and polished flat, and the surface was cleaned with isopropyl alcohol (IPA). Then the second layer of the resist was applied [Fig. 1(f)]. The sample was exposed to x-rays again, but the exposure was performed from the backside, and a copper grid that had been electroformed in SU-8 mold served as a mask [Fig. 1(g)]. After developing [Fig. 1(i)], the second electroforming was performed [Fig. 1(j)]. Subsequently, a new layer of the resist could be applied, and the process could be repeated.

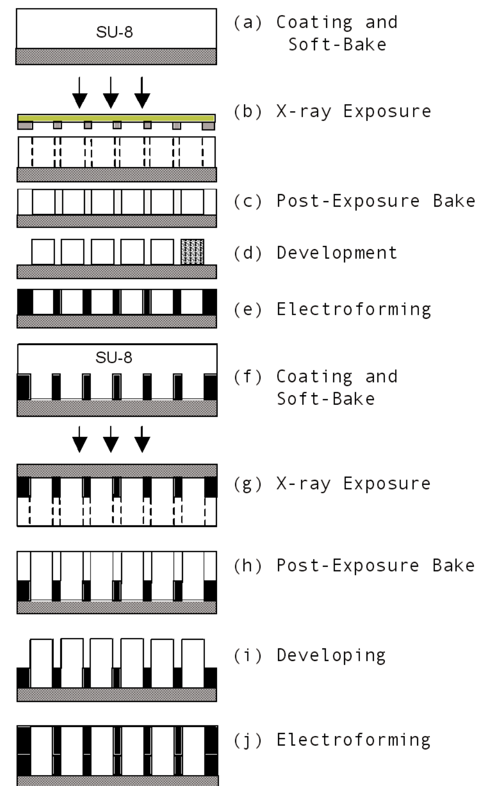

FIG. 1. Schematic of the preparation method.

Results

We optimized the process parameters [6] and obtained high-aspect-ratio channels in a continuous 1-mm-thick SU-8 layer by a single-coating method [steps (a)-(e) in Fig. 1]. The channels have good vertical walls, as seen in the scanning electron microscope (SEM) image in Fig. 2.

It is very difficult to clear very deep and narrow trenches in a continuous SU-8 layer, even with ultrasonic assistance. For this particular application, we had fabricate collimators over 1-cm tall with a septa wall width of 39 µm. To achieve the desired height of the structure, an appropriate number of layers can be stacked together, as was demonstrated previously [1, 2]. Very tall structures can also be obtained by the so-called thickness enhancement method [9], which we applied here to the thick SU-8 layer. A SEM image of the edge of a 1-mm-tall grid fabricated by this method is shown in Fig. 3. This method allows the total thickness of the structure to be increased without requiring the stacking of numerous thinner structures, while allowing a

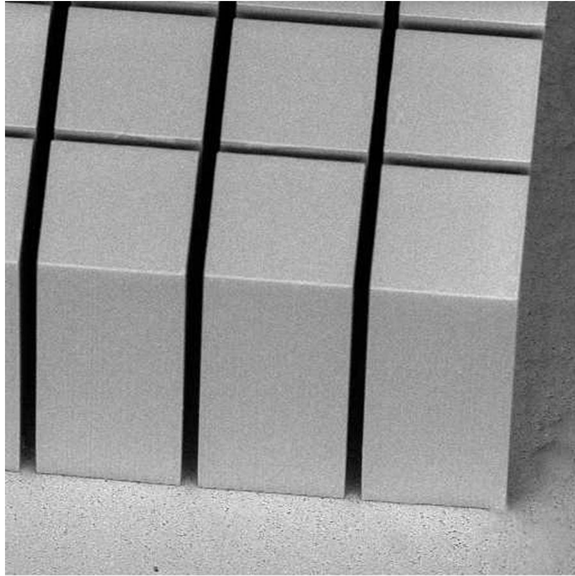

FIG. 2. A SEM image of the microchannels in the SU-8 50 mold: 1-mm deep, 39-µm wide, and 24-mm long.

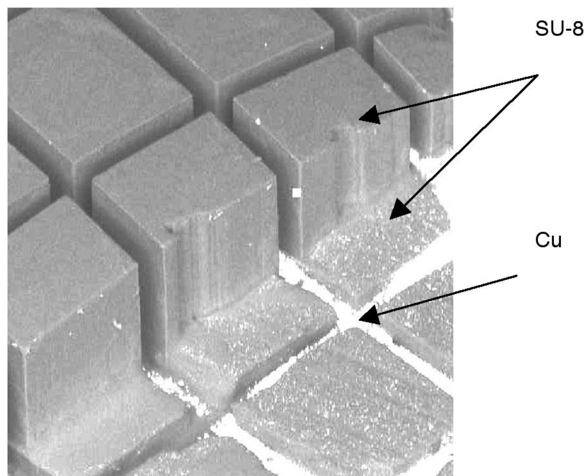

FIG. 3. Microchannels 500-µm deep and 39-µm wide in an SU-8 mold on top of another 500-µm-thick SU-8 mold with copper-electroformed microchannels.

relatively thin resist layer, which is easy to work with. We used copper electroforming to prove the viability of the method, but, for collimator fabrication, lead/tin and gold electroforming is required.

This is a promising approach for obtaining high-aspect-ratio structures greater then 1-cm thick without the stacking of many layers.

Acknowledgments

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