A Bilayer Resist Method for Creating Silica Microfluidics

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Abstract:

In support of a growing collection of lab-on-a-chip applications utilizing inexpensively formed microfluidics [1-2], we have demonstrated a new method for creating silica microfluidic networks. Unlike some existing bilayer resist processes involving hydrogen silsesquioxane (HSQ) [3-4], this process utilizes a single photolithographic step. The resulting silica microfluidics offer several advantageous material properties over polydimethylsiloxane (PDMS).

Summary of Research:

We formed microfluidics using various thicknesses of HSQ, which were spun and exposed to oxygen plasma to cross-link a 10 nm thin barrier layer. This barrier was robust against photoresist solvents, allowing a bilayer stack to be formed without altering the underlying HSQ bulk. Photoresist was then spun, patterned with optical lithography, and used as a mask layer. A wet-chemical etch was used to transfer the pattern into the barrier layer, followed by development to isotropically dissolve the HSQ bulk. Microfluidic networks formed with this developer-based transfer are self-terminated on the underlying substrate without inducing surface damage. Cross-sectional electron micrographs of these channels revealed a sponge-like film composition, which was compacted into a dense silica film during a subsequent high-temperature anneal (Figure 1).

This annealed film had excellent chemical solvent resistance. The resulting microfluidic channels have widths 1.5-3.1 µm and heights of 80-520 nm, respectively (Figure 2).

The microfluidic networks were sealed and used to directly observed flow of fluorophore-labeled deoxyribonucleic-acid (DNA) using fluorescence videomicroscopy. Future applications of this fabrication method may include integration with other components such as MEMS/NEMS or nanowire sensors.

References:


Figure 1: (LEFT) Cross-sectional electron micrograph of HSQ film prior to annealing, exhibiting porous structure. (RIGHT) HSQ film structure following a high temperature anneal. The previously porous structure is collapsed into a dense, amorphous film.

Figure 2: Electron micrograph of a microfluidic channel constriction formed in HSQ with cross sectional dimensions 1.5 (w) by 0.08 (h) micrometers.