Han, Keping, “Fabrication of Micro-Filtration Membranes Using Ion Beam Aperture Array Lithography”

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In this dissertation, we studied the fabrication of freestanding microfiltration membrane filters using ion beam aperture array lithography (AAL). The work involved the development of an in-house stencil mask fabrication process, where both silicon and silicon nitride membranes were explored, the fabrication of free-standing polyimide filtration membranes, the measurement of the statistical pore-size distribution for the manufacturing process, and the experimental measurement of water permeability for membranes with varying pore densities.

In the AAL manufacturing process, a stencil mask, containing a periodic array of circular openings (the aperture array), is irradiated by a broad beam of energetic (~50keV) helium ions. The ions are either stopped in the opaque region of the mask or pass through the openings to expose the resist on a substrate that is placed in close proximity and thus replicate the mask pattern. Each mask opening can be used to “write” an arbitrary pattern in a massively parallel fashion by either inclining the beam relative to the mask or by moving the substrate underneath the mask. By taking advantage of this flexibility, we were able to fabricate filters with 200 and 350nm diameter pores, 0.25cm2 area and with a pore density that varied from 2.5x107 to 4x108 pores/cm2. The filters had uniform equally spaced pores without any pore overlap for any given pore size and pore density. The pores size varied less than ±3.5% of the nominal size for over one hundred samples. In addition, the standard deviation of the pore size was less than 7% of the mean for any given pore density. The permeability of clean water through these membranes was measured and was five times larger than the commercial membrane permeability with similar pore size and density.