Techniques for Three Dimensional and Molecular Scale Fabrication

John A. Rogers
Department of Materials Science and Engineering
University of Illinois at Urbana-Champaign
1304 W. Green St., Urbana, IL 61802

Soft lithography, nanoimprint lithography and related techniques have important roles in many areas of research, and some are being explored for certain commercial applications in microfluidics, photonics, large area electronics and other areas. This talk describes some of our recent work in the development of soft lithographic techniques that enable 2D molecular scale, and 3D nanoscale patterning capabilities. The former relies on advanced soft lithographic nanoimprinting techniques with templates derived from individual single walled carbon nanotubes. Figure 1 illustrates, as an example, the ability replicate features with dimensions down to ~1-2 nm using this approach with optimized polymer chemistries. Systematic studies suggest that the average distances between crosslinks in the polymer mold material define the resolution limits. The 3D methods use soft, conformable phase masks and contact mode photolithographic exposures to create structures in thick, transparent layers of photoresist. Control over the mask geometries, the wavelengths and coherence of the exposure light and the nature of the interactions of photons with the resist layers provide significant flexibility in the choice of 3D structure designs. These techniques and the fundamental science behind them form the focus of this talk. We also highlight work on representative applications in laser fusion, liquid crystals, plasmonics and photonic bandgap materials that take advantage of the large area, low cost nature of these experimentally simple methods. The references below describe some recent past work in these areas.

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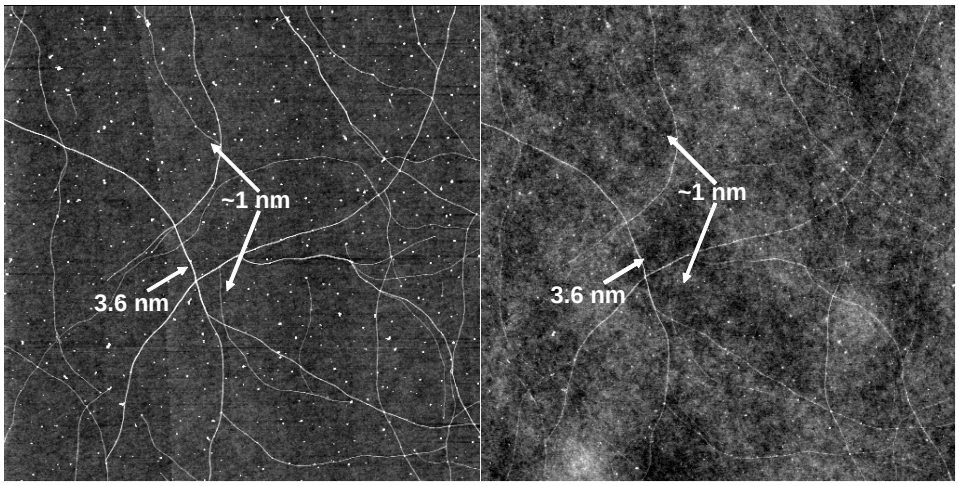

Master, 10x10 µm **Polymer Imprint, 10x10 µm**

Fig 1: Molecular scale fabrication: Atomic force micrographs of single walled carbon nnotubes grown by chemical vapor deposition on a silicon wafer (left frame), and a surface relief replica of these tubes imprinted onto a thin polymer film (right frame) using a soft mold generated by casting and curing against the nanotube 'master'.

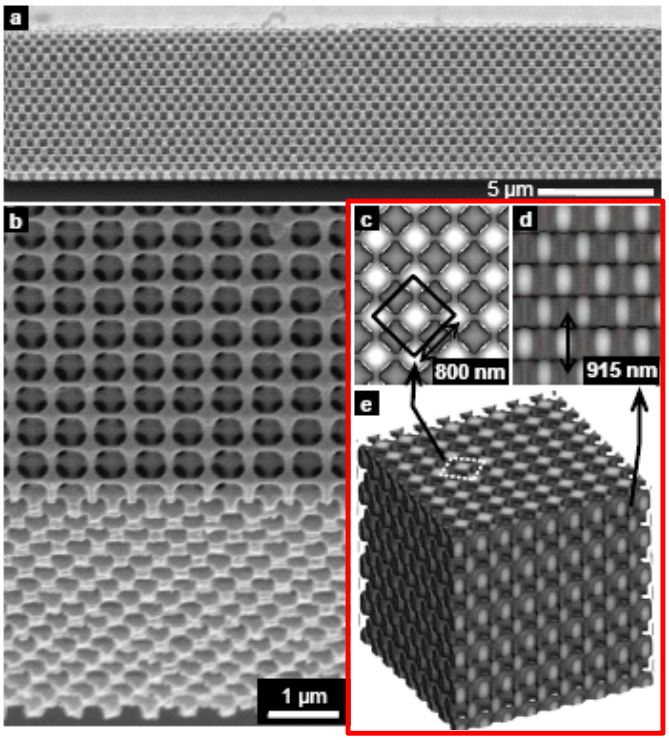

Fig 2: Three dimensional fabrication: Scanning electron micrographs (frames a, b) of a three dimensional polymer structures formed by contact mode exposure through a conformable, elastomeric subwavelength phase mask. Rigorous coupled wave analysis predictions of the expected structure geometries (frames c-e).