Nanofabrication of SERS Device by an Integrated Block-Copolymer and Nanoimprint Lithography Method

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The integration of block-copolymers (BCP) and nanoimprint lithography (NIL) presents a novel and cost-effective approach to achieving nanoscale patterning capabilities. The method utilizes a PS-PMMA cylindrical-forming diblock copolymer as a masking material to create a large array of posts on a Si substrate[1]. After self-assembly, the minority PMMA component of the BCP is removed, forming an etch mask for NIL template formation. Pattern transfer is achieved with plasma etching and a standard lift-off technique. NIL enables the creation of features that supersede the diffraction limitations of optical lithography[2]. Our BCP-NIL integrated technique results in sub-50 nm templates that are reusable and relatively inexpensive and fast to make in contrast to conventional methods such as e-beam lithography.

We demonstrate the fabrication of a surface enhanced Raman scattering (SERS) device using templates created by the BCP-NIL integrated method. A template of close-packed posts, with dimensions of 20 nm in diameter, 40 nm in height, and 35 nm in pitch was realized. This template was then used to perform the thermal imprint of a 50 nm-thick PMMA layer on a Si substrate. Au with a Cr adhesion layer was evaporated onto the patterned PMMA and subsequent lift-off resulted in an array of nanodots. Scanning electron microscope images are shown in Figure 1. The nanoscale dimensions and close proximities of the dots act as plasmonic “hot spots” that enhance Raman scattering signals. A solution of 10^{-5} M Rhodamine 6G (R6G) in methanol was drop-casted onto the substrate and allowed to dry to demonstrate the plasmonic enhancement.

Raman spectra were collected for samples of R6G on Si substrates with and without patterned nanodots. The samples were excited by the 532 nm line of a Nd:YAG laser. As shown in Figure 2, the peaks associated with R6G Raman scattering (as indicated by the arrows) were enhanced on the R6G-coated Au nanodot pattern. Spectra are also shown for R6G on unpatterned areas of the test device and a bare Si control chip. No R6G related peaks were observed in either case. The demonstrated BCP-NIL fabrication method shows promise for cost-effective nanoscale fabrication including plasmonic and nanoelectronic devices.

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[2] H.J. Park, M-G. Kang, L.J. Guo, ACS Nano **3**, 2601 (2009).

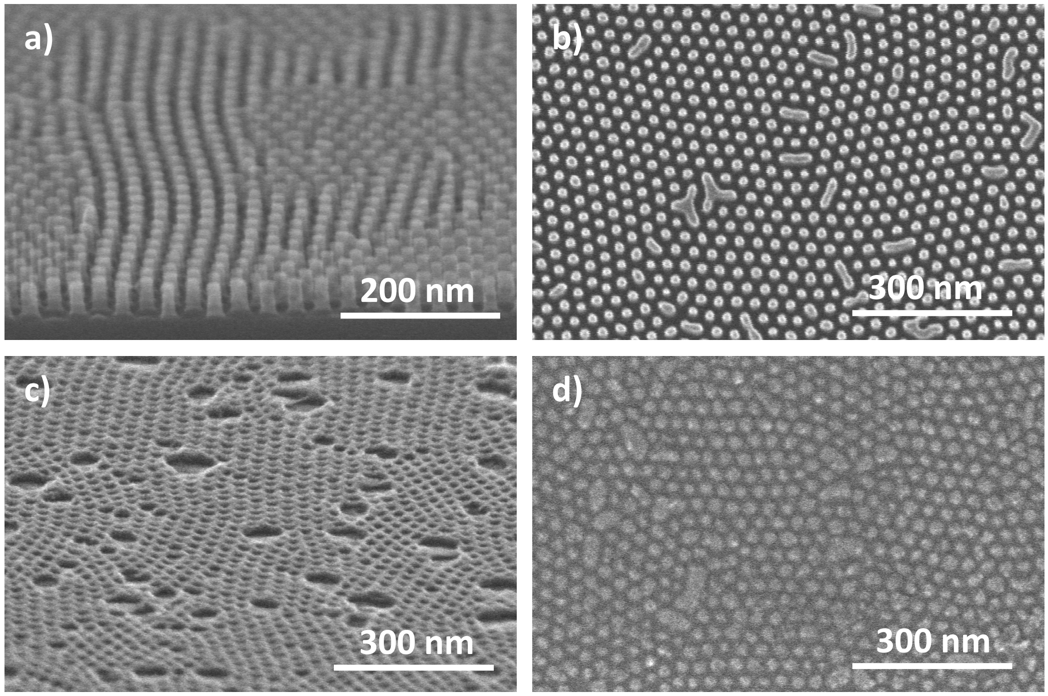

Figure 1: Scanning electron microscope images of the a) Si template tilted view, b) Si template top view, c) nanoimprinted substrate tilted view, and d) metal dots on nanoimprinted substrate top view after evaporation and liftoff.

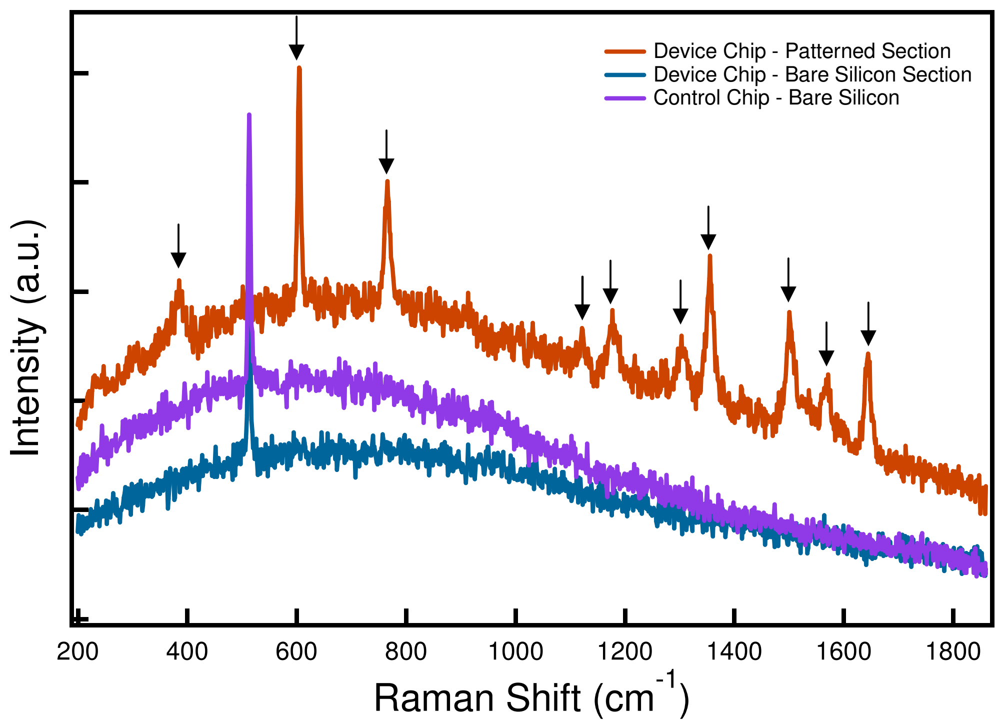

Figure 2: Raman spectrum of Si substrates with and without gold nanodots, blanketed with Rhodamine 6G. The amplification of R6G peaks (denoted by black arrrows) in the sample with dots indicates a plasmonic enhancement.