Fabrication and Testing of Flexible Cyclic Olefin Copolymer Stamps by Nanoimprint Lithography

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Nanoimprint Lithography (NIL) is a promising technology that can fabricate high resolution nanostructures beyond the limitation set by light diffraction or beam scattering that are faced in other conventional lithographic practices [1]. It has the capability to fabricate nanostructures on large area of rigid or flexible substrates. Its unique advantages of low cost and high throughput are particularly desired by many emerging applications in the field of photonics, biotechnology, photovoltaics, just to name a few. In these emerging applications, plastic films are widely explored as both nanoimprint template material and device substrate materials. In our work, we experimentally demonstrate the capability of fabricating nanostructures on cyclic olefin copolymer (COC) through a hot embossing process, and further transferring the structures into nanoimprint resist through a UV nanoimprint process using this nanostructured COC film as a template.

COC is a relatively new plastic material but increasingly getting popular. Its unique combination of a number of favorable properties such as low water absorption, good optical transparency in near UV range, high strength, and high chemical resistance to acids and alkalis [2,3] make it a superior material for optical devices and microfluidic devices. Its low surface energy, good optical transparency and decent mechanical strength also make it a suitable candidate material for NIL templates.

In this paper, fabrication and testing of CoC flexible stamps by NIL technique is presented. The schematic of the complete process is shown in Fig. 1. First, COC (8007) stamps having gratings of different periods (700 nm, 420 nm, 280 nm, 140 nm) are successfully fabricated by thermal NIL process using silicon molds. For each grating mold, series of experiments were performed and analyzed in order to get optimal experimental parameters for perfect replication. Then, the prototype COC stamps are tested by successfully imprinting nanostructures on a UV-curable epoxy using UV curing. AFM images of master silicon mold, fabricated COC stamp and nanostructures on the UV-cured epoxy having gratings of 140 nm period and 70 nm line width are shown in Fig. 2a, 2b and 2c, respectively. The well replicated results on the UV-cured epoxy demonstrate the feasibility of COC material for NIL polymer stamps. These flexible polymer stamps have many potential applications such as molds for Roll-to-Roll NIL process.

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[2] T. Nielsen, D. Nilsson, and F. Bundgaard, P. Shi, P. Szabo, O. Geschke and A. Kristensen, Nanoimprint lithography in the cyclic olefin copolymer, Topas, a highly ultraviolet-transparent and chemically resistant thermoplast, Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures, 22, 1770 (2004).

[3] P. S. Nunes, P. D. Ohlsson, O. Ordeig and J. P. Kutter, Cyclic olefin polymers: emerging materials for lab-on-a-chip applications, Microfluidics and Nanofluidics, 09, 145 (2010)

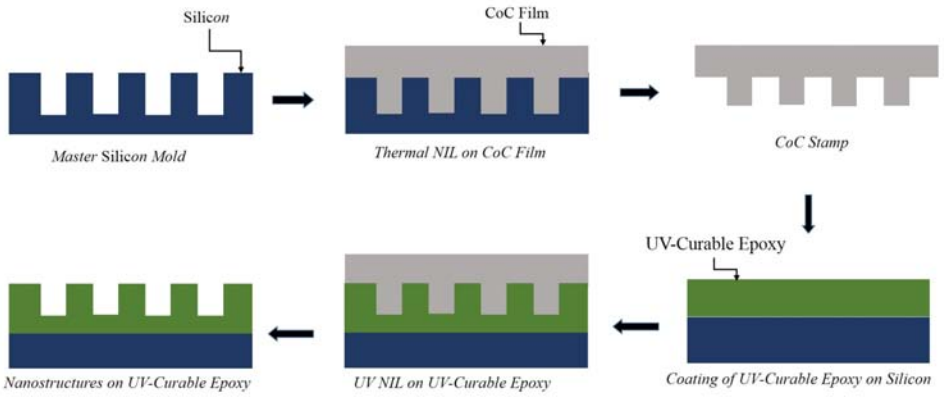
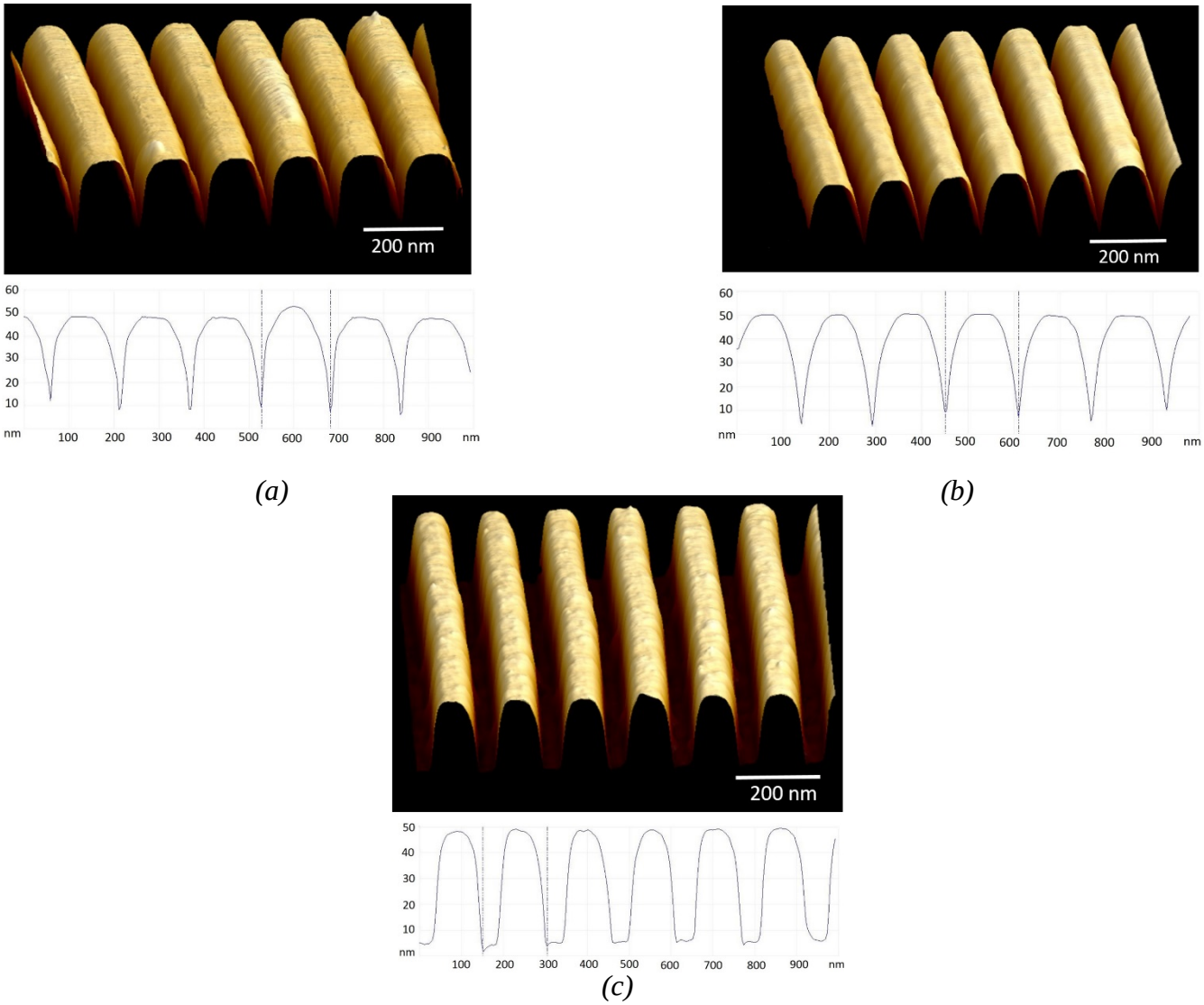


Figure 1: Schematic illustration of the Process:



(a) *(b)* *(c)*

Figure 2: AFM micrographs of gratings having 140 nm period and 70 nm line width: (a) Silicon master mold (b) CoC (8007) stamp (c) Nanostructures on UV-cured epoxy.