FABRICATION PROCESS FOR POLYMER PHOTONIC CRYSTALS USING NANOIMPRINT LITHOGRAPHY

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Nanoimprint Lithography (NIL) is considered as a low-cost fabrication process for photonic devices. By embossing a two-dimensional periodic pattern into a thin polymer layer, a photonic bandgap (PBG) device can be generated. A waveguide can be generated by removing single rows of pillars or holes in the PGB structures. This implies that by engineering a grating structure by a lithographic means, the light propagation can be controlled and even be tuned. Because of their low propagation loss at telecommunication wavelengths, polymer waveguides with two-dimensional periodic patterns are attractive candidates for platforms implementing low loss PBG photonic crystals [1].

We present a fabrication process for producing dense two-dimensional periodic patterns in polymers, with defined fill factor (the ratio pillar diameter to gap) and aspect ratio. A stamp copying process (figure 1) was developed, which had significant advantages over a one-step stamp manufacturing process. It allows us to vary and optimize both fill factor and aspect ratio independently. Because of the reversal of the pattern polarity by etching, the stamp copying process must be repeated with the inverse pattern to get a stamp with the original pattern [2].

The hexagonal periodic pattern of holes with a period of 400nm was exposed by superimposing three linear gratings with 60° inclination (figure 2). By using the continuous path control mode of our Leica LION LV1 e-beam writer, a large grating with no stitching error can be obtained in PMMA resist, which is the negative pattern of the final hexagonal hole array. This structure is transferred into silicon and used as a 0st generation stamp. After two copying steps, the 2nd generation stamp with a high aspect ratio pillar array is obtained which can be used to fabricate the final polymer structure with a periodic hole array. In figure 3 a stamp structure with an aspect ratio of 2 is shown. By embossing into 25k PMMA, 400nm deep holes could be generated and the stamp be demolded without damage. The structures fabricated this way demonstrate the feasibility of the fabication of PBG photonic crystals via NIL [1].

References:

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[2] H. Schift, S. Park, J. Gobrecht, *Nano-Imprint - Molding Resists for Lithography*, J. Photopolym. Sci. Technol. (Japan), 16(3), 435-438 (2003).

Figures:

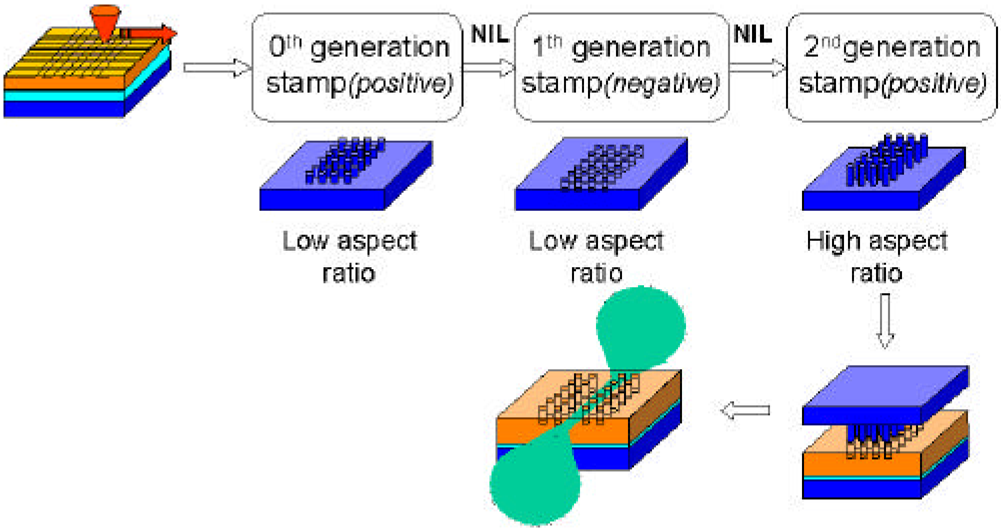

Fig. 1. Fabrication sequence for PC devices using a repeated stamp copying process.

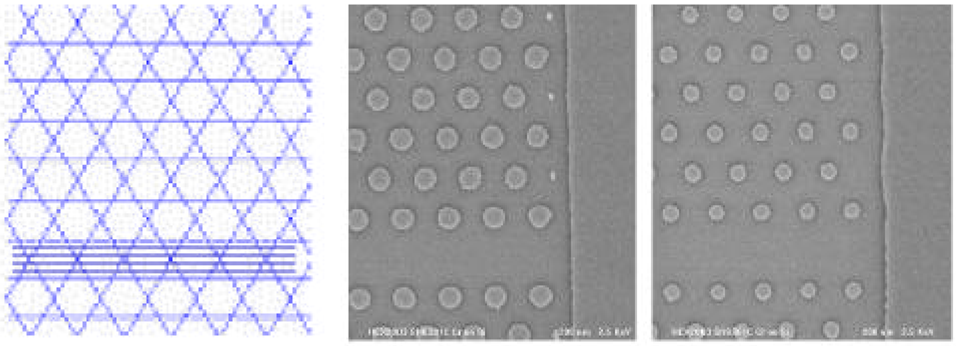

Fig. 2. Superposed exposure of three inclined gratings into PMMA using a bezier exposure mode (schematic view left side, exposed and etched pattern center and right). The fill factor of the arrays can be modified by varying the line dose.

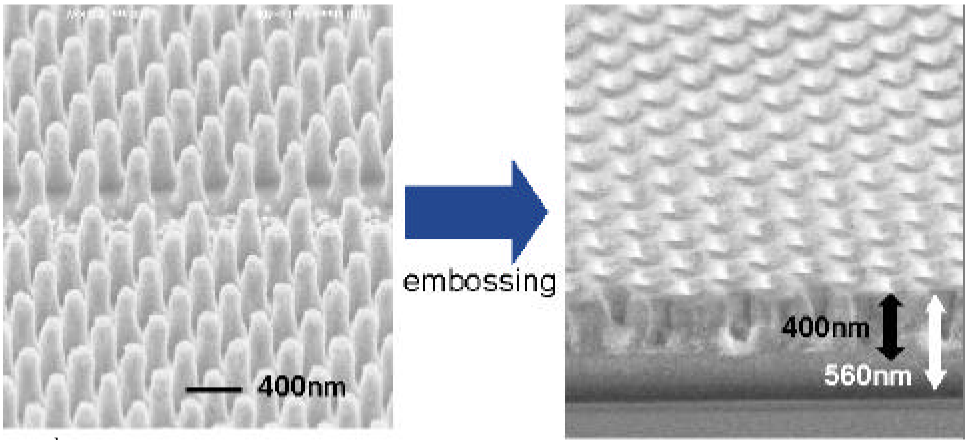

Fig. 3. 2nd generation silicon stamp and embossed PMMA film on silicon substrate.