A Tri-layer Method to Fabricate Wafer Scale Nanoimprint Mold by Copolymer Lithography

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Copolymer lithography has been used to pattern highly dense dots and lines with tunable periodicity and pattern size. The configuration of copolymer phase separation depends on molecular weight, volume ratio of each block and film thickness. The film thickness is usually as thin as a few tens of nanometers, which makes the lift-off of copolymer template very difficult. Previously, there were mainly two methods for the lift-off: (1) wet etching that applied organic solvents in ultra-sonication bath and (2) ion beam etching. Here, we report a tri-layer method (figure 1) that offers excellent lift-off of copolymer and pattern transfer on wafer scale. We successfully applied this method to fabricate a 4 inch full wafer nanoimprint mold.

The tri-layer substrate consists of (from top to bottom) a 20 nm evaporated SiO_2, a 100 nm thermally cross-linked polymer layer and an oxidized silicon wafer. The PS-PMMA block copolymer template was formed as described in [1] on the tri-layer substrate (figure 2 (a)). Reactive ion etching (RIE) transferred the pattern of template into tri-layer substrate (figure 2 (b)). Finally, Cr dots were deposited on oxidized silicon wafer after a lift-off (figure 2 (c)). The Cr dots arrays were also used as RIE etching mask to fabricate imprint mold (figure 2 (d)).

Our results have shown that the tri-layer method greatly facilitated the lift-off from copolymer templates. We achieved 34 nm pitch, ~17 nm diameter metal dots over entire wafer after lift-off. In addition, a wafer scale nanoimprint mold of 0.6 T/in^2, 50 nm high pillars has been obtained. Although it can be observed from figure 2 (d) that there were approximately 4% vacancy defects in fabricated mold which was caused by the irregularly small openings of copolymer templates (figure 2 (a)), the defects can be largely reduced by improving the quality of copolymer phase separation. Finally, due to the chemically inert cross-linked polymer layer, the tri-layer method should accommodate to copolymer materials in a variety of solvents.

[1] Shuaigang Xiao, XiaoMin Yang, Erik W Edwards, Young-Hye La and Paul F Nealey 2005 Nanotechnology 16 S324

Figure 1

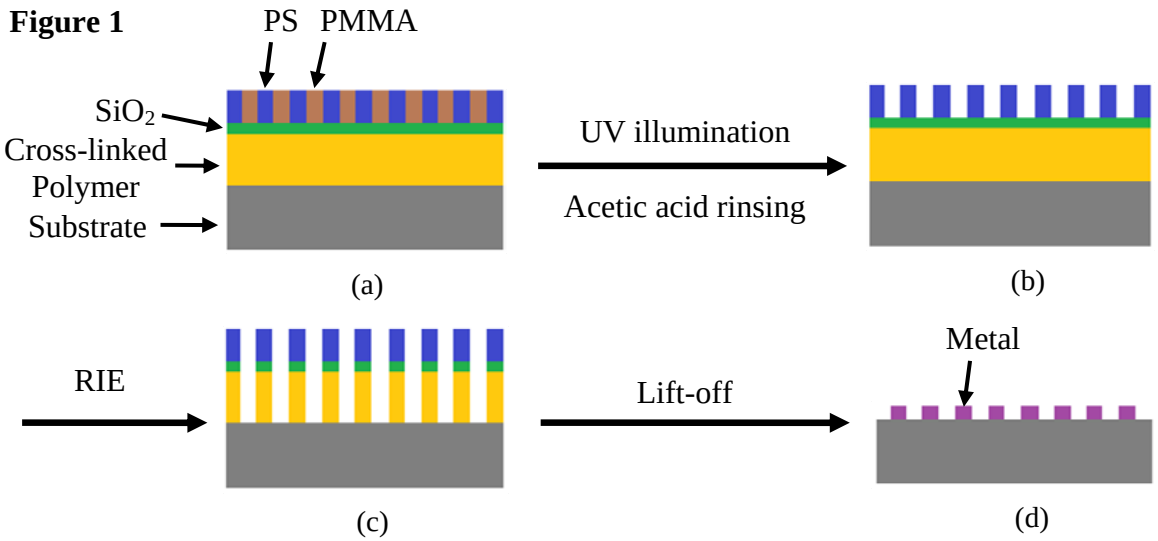

Figure 1. Schemes fabrication process of the tri-layer method to fabricate wafer scale nanoimprint mold by copolymer lithography

Figure 2

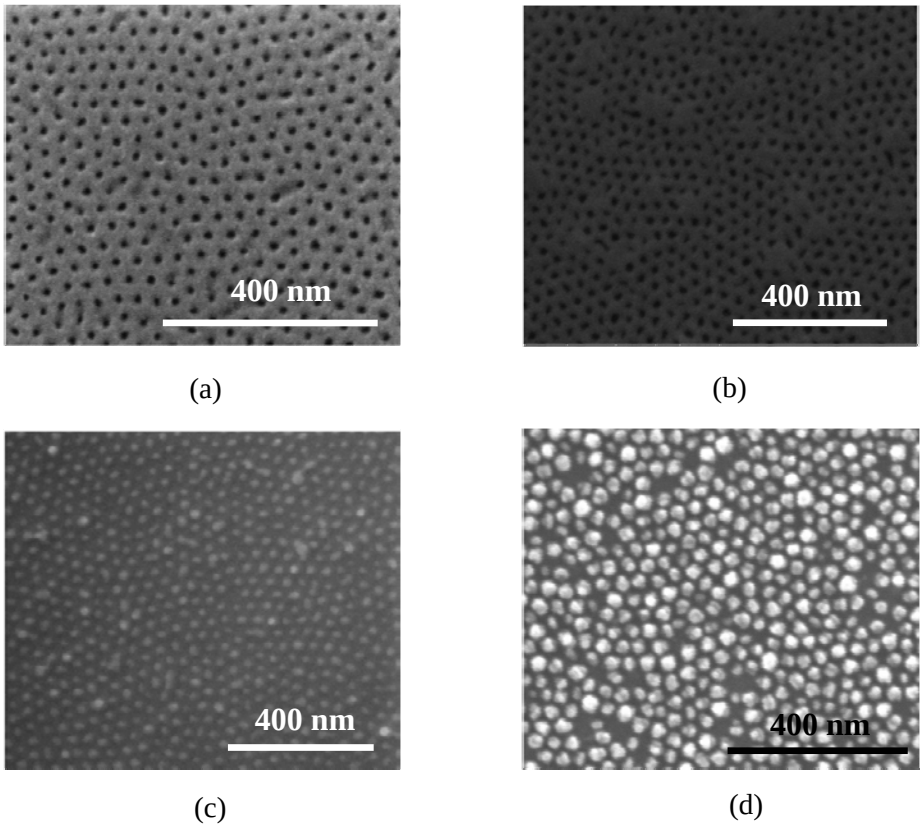

Figure 2. (a) PS-PMMA copolymer template after selective removal of PMMA by UV illumination; (b) Pattern transfer into tri-layer substrate; (c) Cr dots after lift-off (d) Nanoimprint mold made by RIE with Cr dots as etching mask.