Simple Fabrication of UV Nanoimprint Templates using Critical Energy Electron Beam Lithography

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Ultraviolet Nanoimprint Lithography (UV-NIL) is a promising nanoscale patterning method suitable for nanoelectronics, photonics, and biology. UV-NIL can fabricate smaller dimension resolution features than optical lithography because the pattern is defined by physical template size, not by diffraction limit. The transparency of the UV-NIL templates also enables the multilayer processes with alignment unlike traditional Nanoimprint Lithography. However, UV-NIL template fabrication processes are expensive and time consuming because a chrome layer is necessary both as a charge dissipation layer to minimize pattern distortion during electron beam patterning and as a physical mask during subtractive quartz etching (Figure 1(a).)

In this paper, we propose a simple UV-NIL template fabrication scheme using Critical Energy Electron Beam Lithography (CE-EBL) [1] with Hydrogen Silsesquioxane (HSQ) resist. In CE-EBL, e-beam patterning at the critical energy (E_2) practically eliminates charge induced pattern distortion seen on insulators such as quartz or glass. This template fabrication process eliminates conventional deposition and etching of charge dissipation layers.[2]

The schematic of the template fabrication is shown in Figure 1(b). After spin coating HSQ on pre-cleaned glass, the HSQ resist was prebaked at 170℃ for 5 min. Using a variable magnification scanning method,[1,3] the critical beam energy was found to be 1.6 keV for 60 nm HSQ on glass. HSQ resist was then directly patterned with electron beam operated at E_2, followed by development with 1.91 wt% tetramethyl ammoniumhydroxide (TMAH) for 1 min. This patterned HSQ on quartz or glass can be directly used as a UV-NIL template after post heat treatment.

The pattern distortion generated by surface charging on glass is demonstrated in Figure 2. There was no apparent distortion when the beam energy was 1.6 keV, which is E_2, but line mismatches were prominent when operating at 5 keV. Figure 3 shows SEM images of 55 nm line width templates with a 200nm pitch, as well as a nanofluidic prototype template. As demonstrated from the result, this simple template fabrication approach may lead to the development of new biological devices, nanoelectronics, and optoelectronics.

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2 D. P. Mancini, K. A. Gehoski, E. Ainley et al., J. Vac. Sci. Technol. B 20, 2896 (2002).

3 D. C. Joy and C. S. Joy, Micron 27, 247 (1996).

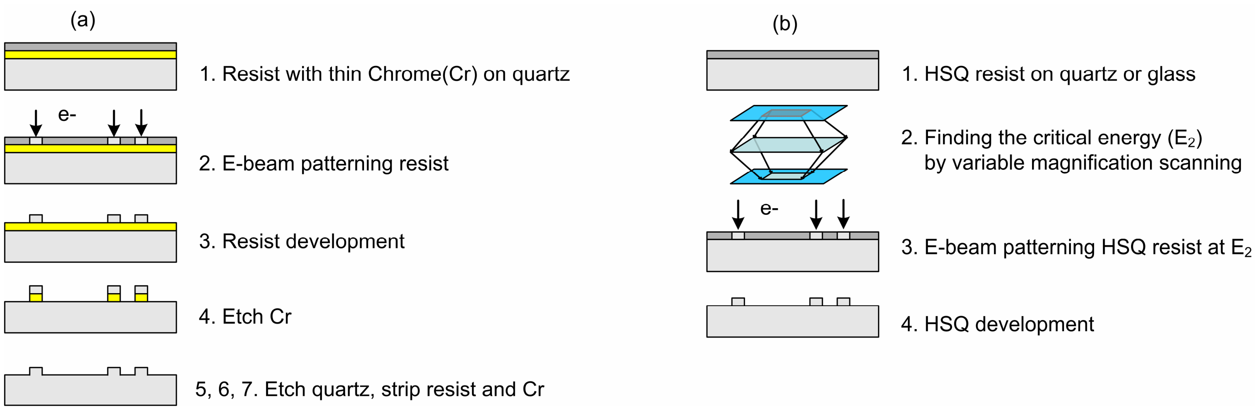

Figure 1. Comparison of process flows between a conventional chrome based template (a) and a CE-EBL based template (b). The template fabrication process is simplified using CE-EBL method combined with HSQ additive processing.

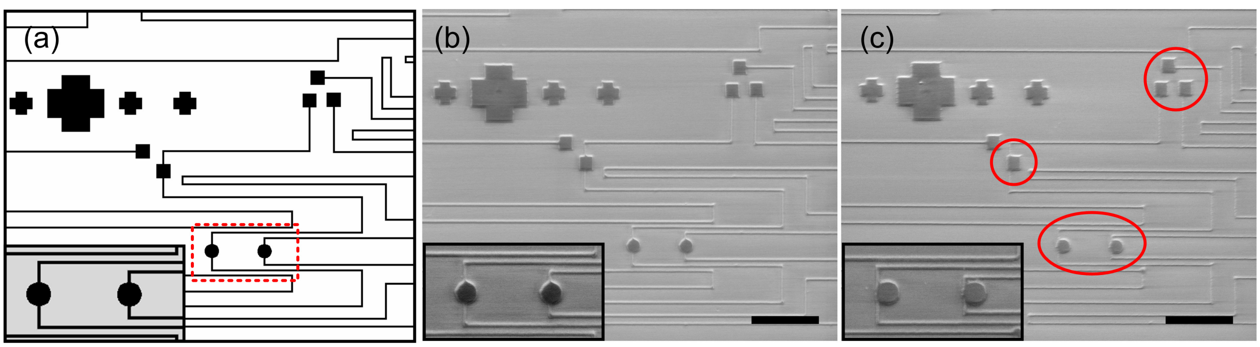

Figure 2. Pattern distortion in electron beam lithography on insulators as a result of surface charging. (a) Design of the desired pattern. SEM images of 60 nm thick HSQ on glass after development, patterned at (b) 1.6 keV (E_2) and (c) 5 keV. Charge induced pattern distortions are prominent at 5 keV (circled, inset figures). Scale bar = 5 µm.

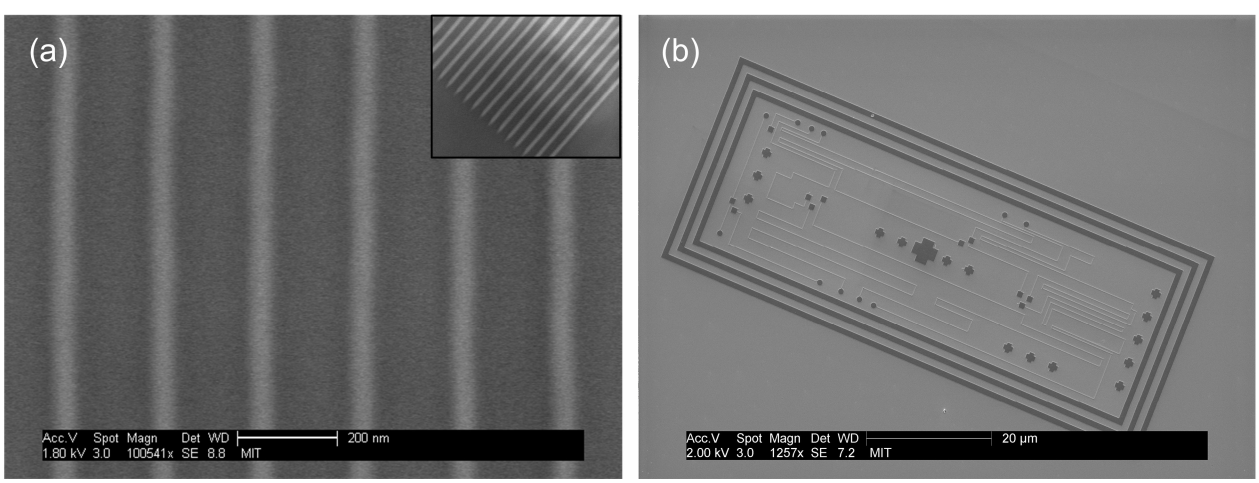

Figure 3. LVSEM images of UV Nanoimprint Lithography templates fabricated by CE-EBL. High density lines with 55nm line width and 200nm pitch (a), and a nanofluidic prototype template (b).