Sub-10 nm nanofabrication

by step-and-repeat UV nanoimprint lithography

S. Dhuey[1], *C. Peroz*[2], *G. Calafiore*[1,2], *N. Alayo*[3], *D. Gosselin*[1], *D Olynick*[1], *S Cabrini*[1]

[1)]The Molecular Foundry, LBNL, Berkeley, CA-94702, USA
[2)]aBeam Technologies, 5286 Dunnigan Ct., Castro Valley, CA 94546, USA
[3)]Centro Nacional de Microelectronica, Barcelona, Spain
e-mail: sddhuey@lbl.gov

Keywords: nanoimprint, nanofabrication, atomic layer deposition, plasma etching

UV Nanoimprint Lithography (UV-NIL) technology is a very attractive technology to reproduce micro/nano-patterns over large area at low cost [1]. The Step&Repeat approach for UV-NIL allows reaching high throughput and is currently in industrial preproduction phase for various applications. Over the last three years, we have developed an attractive method combining the advantages of Step&Repeat technology and the imprinting of spin-coated films. This process enables very high resolution imprinting and easy pattern transfer by having a high control of the residual layer thickness and homogeneity [2].

To demonstrate the ultimate resolution of our imprint process, we have developed new strategy for template fabrication. Atomic layer deposition (ALD) was used for trench filling process to reduce feature sizes, and in a spacer double patterning process. Trenches can be reduced by conformal ALD deposition of aluminum oxide, giving 6 nm features after imprinting and etching (Figure 1). Also, an ALD enabled spacer double patterning technique was used to double the spatial frequency of a set of gratings. First we coat dense photoresist lines with low temperature aluminum oxide. We then do a breakthrough etch of the alumina film and strip the resist to keep the freestanding alumina. We demonstrate 5 to 7 nm alumina lines at pitches from 16 to 20 nm (Figure 2a). Features are then imprinted (Fig. 2b) using our SR-NIL process.

In order to fabricate metallic structures by our SR-NIL, we have developed a novel multi-layer PMMA/SiO_2/mrUVCur resist system in order to overcome the limitation of the NIL resist. Sub-20 nm metallic nanostructures were successfully replicated by imprint and lift-off (Fig. 3) and open the area for fabrication of numerous devices.

These results establish the new state-of-the-art for SR-NIL and demonstrate the unique potential of the process for fabricating nanodevices with sub-10 nm features.

1. J. Haisma, J. Vac. Sci. Technol. B 14 (1996), 4124
2. C. Peroz et al., 2010 Nanotechnology 21, 445301
3. C. Peroz et al., 2012 Nanotechnology 23, 015305

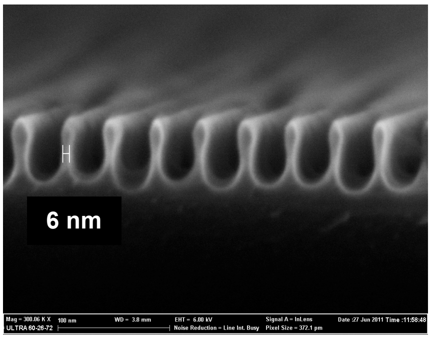
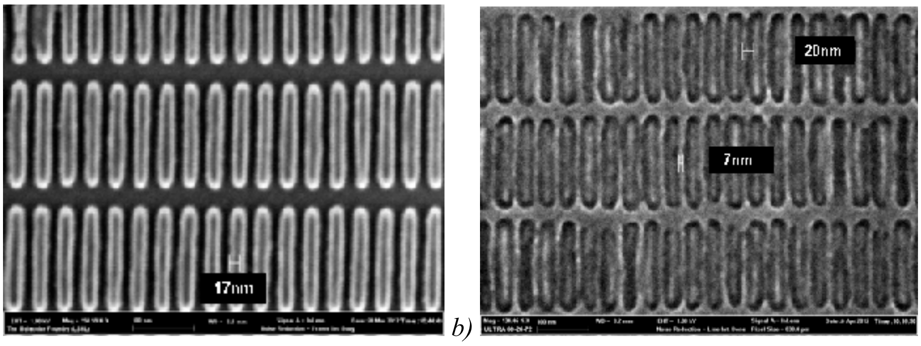


Figure 1: 38 nm pitch, 6 nm wide imprinted lines etched into silicon.



a) b)

Figure 2: Scanning Electron Microscope (SEM) pictures of sub-20 nm pitch grating on the imprint template (a) and imprinted onto the resist (b).

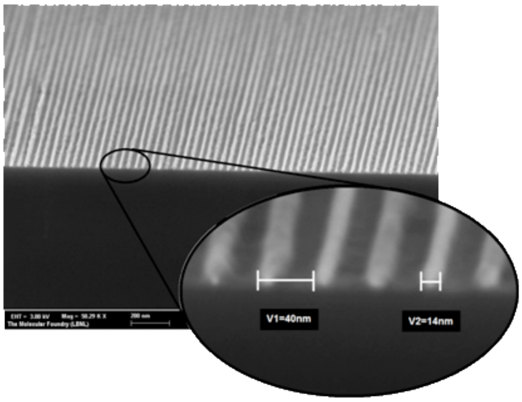


Figure 3: Cross-section SEM of a grating after lift-off of Ti(5 nm)/Au(10 nm) film with 40 nm pitch, 14 nm wide lines.