Nanometer dimension control on silicon imprint mold using atomic layer deposition for large-area nanofabrication

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The ability to fabricate nanostructures over large areas in the centimeter range is critical for a wide range of scientific and technological applications, ranging from optical devices, sensors, solar cells to bio-medical devices. However, the complex processes and costs associated with the generation of large area nanostructures are always a hindrance to large area fabrication. Nanoimprint technique[1] is a viable approach to create nanostructures over large areas using a mold or a template. In this work, the features on the imprint mold are reduced in size by 30-50 % to generate nanostructures in the sub-100 nm range using atomic layer deposition, without the need to fabricate a new mold using expensive electron-beam lithography technique and extensive process development. The atomic layer deposition (ALD) is used to coat a 20 nm-thick layer of Al_2O_3 on the silicon mold consisting of periodic gratings (200 nm pitch, 100 nm wide trench). The conformal nature of the ALD ensures that the grating profile is preserved while generating an imprint mold consisting of smaller nanostructures. There have been previous reports[2,3] on the application of area-selective ALD technique as a viable nanopatterning technique, which however, includes an electron-beam induced deposition step that can result in a complex process flow. In this work, an additional coating step such as ALD on a pre-fabricated imprint mold is used to 're-size' the nanostructures according to the device requirement. Moreover, the same approach can be used to deliver sub-50 nm or smaller features patterned using spot electron-beam lithography technique[4], thereby, avoiding the need to carry extensive process development. Figure (1) below show the atomic microscopy images of (a) the silicon mold before the ALD coating, (b) the silicon mold coated with a 20 nm-thick Al_2O_3 using ALD. As shown in the figures, the 100 nm nanostructures in Figure 1 (a) is reduced in size to 60 nm while preserving the grating profile. The width of trenches in the periodic gratings changed by at least 40 % as shown by the dotted lines (vertical) in Figures 1 (a) and (b). The 're-sized' mold can now be used to imprint a new set of periodic gratings with sub-100 nm features. In the work, details of the process development involved and imprint results using the ALD-coated silicon mold will be presented.

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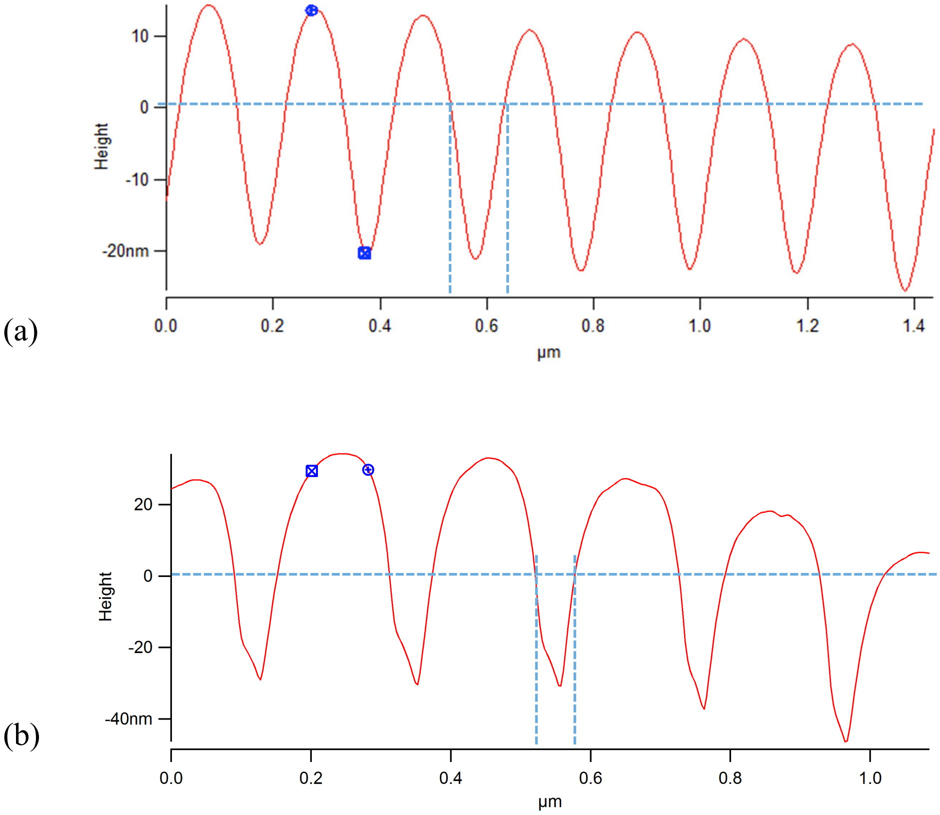

Figure 1: Atomic force microscopy scans of (a) uncoated silicon mold with periodic nanostructures, (b) silicon mold with the 20 nm ALD-coated Al_2O_3