Fabricating Nano-scale Gratings with Multiple Imprinting

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The need for low-cost and high-throughput nanopatterning has stimulated the fast development in nanoimprint lithography (NIL). In conventional NIL, a pattern is physically imprinted into thermal plastic polymer film by a hard mold at elevated temperature and pressure [1]. But for the extremely small physical size, a mold for imprint lithography typically has a high density of nanoscale protrusion features on its surface, which leading to a strong adhesion of the imprinted polymer to the mold. Another issue is the cost; fabrication of this high density of nanoscale feature mold relies on very dedicated and expensive equipment. In this paper, an improved lithography is introduced to produce sub-100nm gratings by using 300nm gratings mold.

In this process, silicon wafer was spin-coated with 20mg/ml Poly(3-hexylthiophere-2,5-diyi) (P3HT) in 1,2-Dichlorobenzenetion，and the polymer thickness is 80nm. The grating mold had a 600nm period and 50% duty circle was used to imprint the P3HT thin film.

First step, the 300nm with 160 depth polymer gratings was fabricated by imprinting at 150^{o}C with a pressure of 100N/cm^{2} [Figure 1]. Second, another mold was used to imprint the prepared polymer gratings, which mold had an 80um period and 50% duty circle with 50nm depth. The ability to perform second nanoimprint process is due to the structural stability enhanced by P3HT chain stretching and alignment in semicrystalline polymers [2]. The 1:2 width ratio gratings was fabricated, showed in figure 2, which proved the gratings can be narrowed by multiple imprinting. Another sample with 90nm depth and 1:4 width ratio gratings showed in figure 3, the width change is around 200nm. With this multiple nanoimprinting lithography, we may pattern sub-10nm gratings in the future.

[1] Chou S Y, Krauss P R. Imprint lithography with sub-10 nm feature size and high throughput]. Microelectronic Engineering, 1997, 35(1): 237-240.
[2] Dehu Cui and Xing Cheng. “Step-and-Repeat Solid-Phase Nanoimprint for High-Throughput Functional Polymer Patterning,” EIPBN 2010.

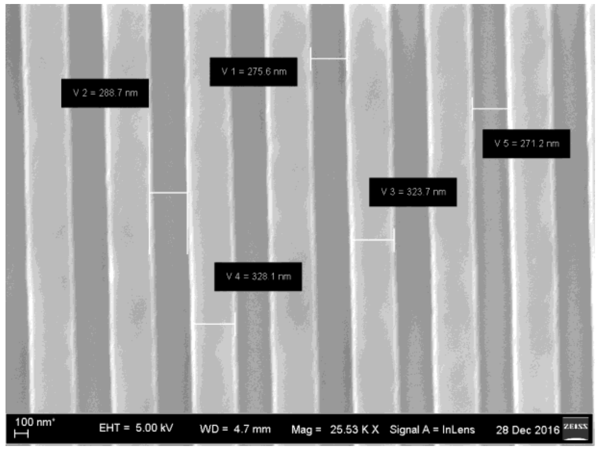

Figure 1: The initial gratings of 80nm thickness: The ratio is 1:1 of 600nm period.

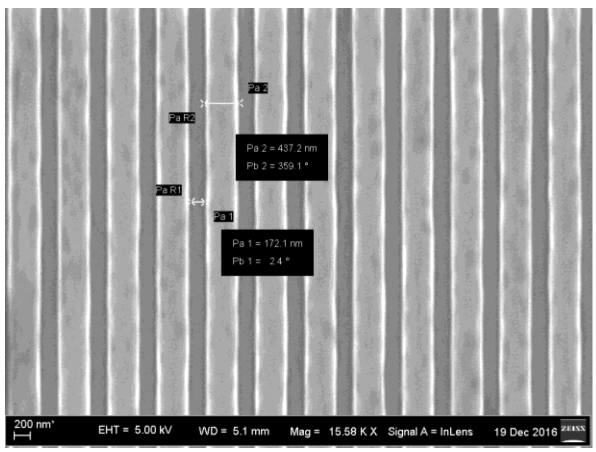

Figure 2: The polymer gratings of 80nm thickness: The ratio is 1:2 of 600nm period.

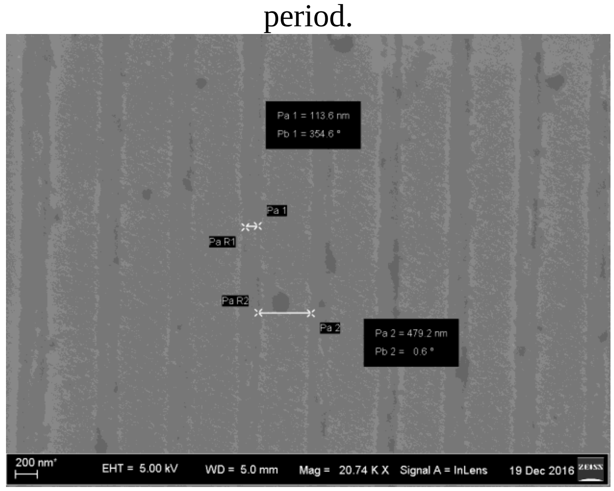

Figure 3: The polymer gratings of 90nm thickness: The ratio is 1:4 of 600nm period.