Decrease nanoimprint lift-off force by poly(ethylene glycol) doping

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Nanoimprint lithography is a high throughput technique for sub-micron and nano-patterns replication [1]. In the nanoimprint process, a patterned mold is pressed into the polymer substrate; leading to a strong adhesion of the imprinted polymer to the mold. After that, the lift-off force was reacquired to separate the mold and the substrate. One of the key issues of successful NIL technology is to avoid adhesion of the polymer to the stamp, because the larger force may severely decrease the quality and replicability of the patterns transfer.

In this paper, We chose methoxypolyethylene glycol azide (mPEG-Azide) as dopant in the poly(methyl methacrylate (PMMA) matrix for thermal nanoimprint lithography. PMMA was pretreated by solving in toluene with 7% in weight, stirring at 90℃ for over 5 hours. Meanwhile, the 7%wt mPEG-Azide solution was prepared in toluene for further usage. The final PMMA and mPEG-Azide solution were mixed to prepare six concentration gradient, and the weight ratio of mPEG-Azide to PMMA were 0, 0.1%, 0.2%, 0.3%, 0.4% and 0.5%, respectively. The standard sample of mold and substrate on wafer was cut into 16 mm × 20 mm and was first heated to 150℃, pressed under 0.3 MPa. After keeping the pressure for 5 min, turn up the temperature to 175℃, the mPEG-Azide will decompose into small molecules, like CO_2, H_2O et al. The finished sample was tested by universal tensile tester (MTS Criterion) to obtain the lift-off force. It should be noticed that the weight of mold and wafer could be neglect comparing to the demoding force in Fig 1. The degree of decrease was as high as 77.97% as shown in Table 1, the SEM pictures of the gratings were shown in Fig 2

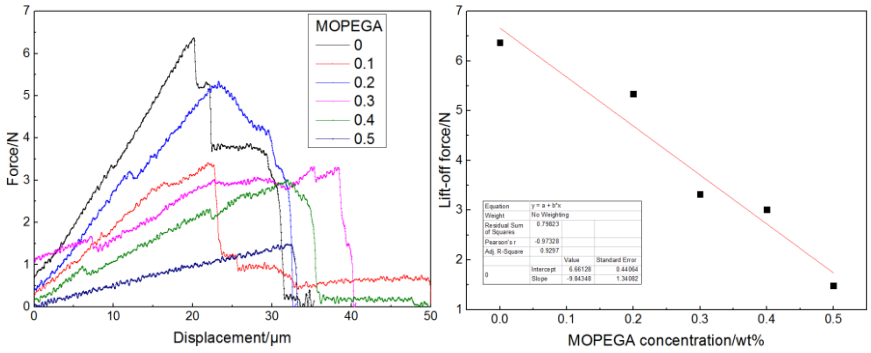

Figure 1. The characterization of lift-off force. (A) The force-displacement curve of different concentration of mPEG-Azide in wt%. (B) The peak force as lift-off force vs. the concentration of mPEG-Azide.

Table 1*.

Wt%	Peak force/N
0	6.731
0.1	3.411
0.2	5.338
0.3	3.323
0.4	3.011
0.5	1.483

The peak force of demoding among different concentration of mPEG-Azide
mPEG-Azide concentration/wt%

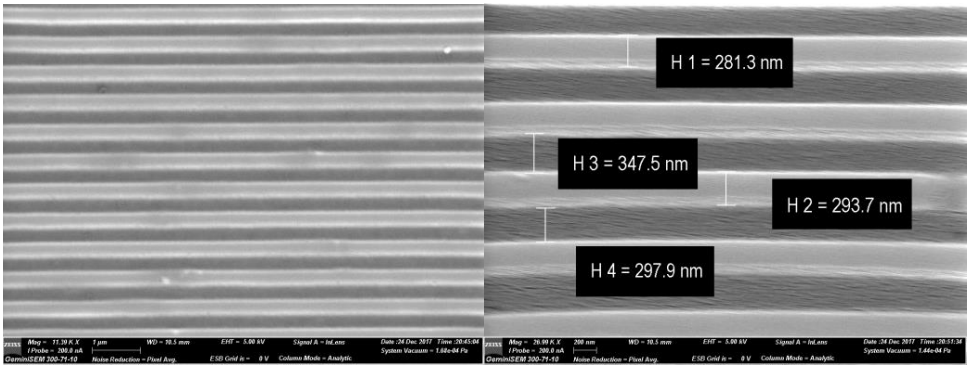

Figure 2.The SEM pictures of the gratings.

[1] S. Y. Chou, P. R. Krauss, and P. J. Renstrom, "Imprint lithography with 25-nanometer resolution," Science (Washington, D. C.), 10.1126/science.272.5258.85 vol. 272, no. 5258, pp. 85-7, // 1996.