Characteristics of hybrid mask mold for combined nanoimprint and photolithography technique

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Abstract

We process a novel approach called combined nanoimprint and photolithography (CNP) to greatly simplify the fabrication in conventional nanoimprint lithography (NIL). In this study, a novel HMM with anti-sticking SiO_2 layer is introduced to improve the quality of transferred pattern. The surface property was investigated using contact angle measurement and spectrophotometer. Replicate pattern with CNP using HMM showed complete pattern transfer without defect.

1. Introduction

Nanoimprint lithography has been developed for nano-structure fabrication.[1] The mold plays an important role in nanoimprinting process to get the high-fidelity pattern transfer without structural defect. Combined Nanoimprint and Photolithography(CNP) is a new technique using advantages of both nanoimprint and photolithography. Hybrid Mask Mold(HMM), made of UV-transparent mold material with a UV-blocking metal layer placed on top of the mold protrusions, is the key component for CNP technique. It is possible to transfer patterns without residual layer using CNP technique with HMM.

2. Experimental

2.1 HMM preparation

A typical HMM was fabricated by using e-beam lithography and dry etching of Cr-coated 6x6 inch quartz. After etching process, HMM was deposited with SiO_2 to enhance the anti-adhesive properties for the complete separation between HMM and transfer layer.[2] The

fabrication schematic of HMM is shown in Fig. 1. In addition, the surface of HMM was finally treated with hydrophobic self-assembled monolayer(SAM) to promote the easy detachment between the HMM and transfer layer.

2.2 Property analysis

SiO_2 layer deposited on quartz was analyzed in accordance with thickness variation from 5nm to 20nm. Surface energy and transmittance were calculated from the measured contact angle of water and the absorbance measured by spectrophotometer respectively.

2.3 Pattern transfer

In addition to chemical and optical analysis, imprint test can finally confirm the efficiency of anti-sticking layers in CNP technique. The HMM was pressed into a negative tone photo resist on a Si wafer under the imprint pressure of 30bar, and the pressure was maintained for 300sec while ultra violet light of 2.77mW/cm^2 was irradiated through the mold. Then the mold was released and sample was baked 110/120(℃/sec) and immerged in developer solution at 30sec.

3. Results and discussion

Surface energy of SAM coated surface depends on the underlying substrate, indicative of different nature of the binding of SAM molecules to different oxide thickness. Surface energy calculated from the contact angle of SAM on SiO_2/Cr substrate was smaller than that on Cr substrate.(Fig. 2) By UV spectrophotometer, we confirmed that SiO_2 overcoat has negligible effect on the transmittance.(Fig. 3)

The anti-adhesive ability of the coatings can be confirmed during the demolding process in the imprint tests where a large lacal shear force is exerted on the coated surfaces by the flow of resist. After imprinting without SiO_2 interlayer, the pattern was partially detached from the substrate. However, imprinting pattern transfered from the HMM with SiO_2 layer was completely clean. This enhancement was shown in Fig. 4.

4. Conclusion

We developed a new method of anti-adhesive coating for HMM fabrication in CNP technique. SAM coating on SiO_2/Cr substrate shows lower surface energy and higher hydrophobic property.

Acknowledgment

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Reference

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[2] Sunggook Park, Helmut Schift, Celestino Padeste, Bernhard Schnyder, Rüdiger Kötz and Jens Gobrecht, Microelectronic Engineering, Vol. 73-74, 196-201 (2004)

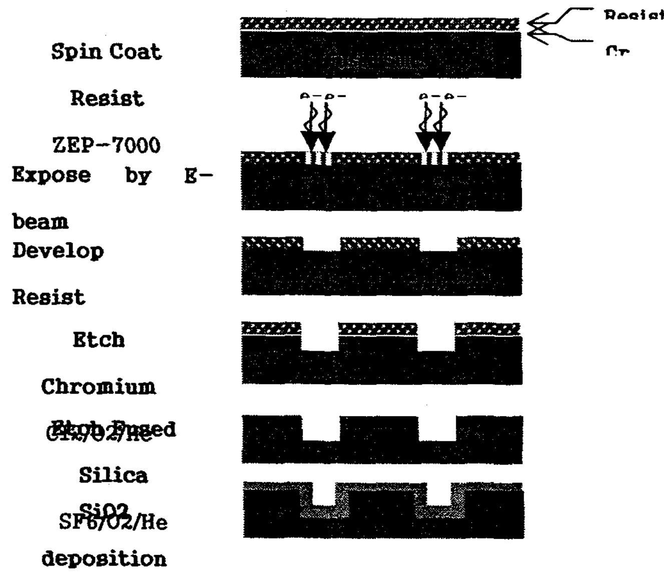

Fig. 1 Schematic of HMM fabrication process

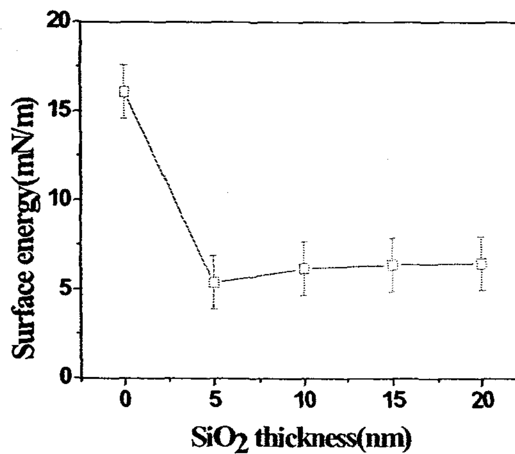

Fig. 2 Surface energy calculated from contact angle as a function of SiO_2 interlayer thickness for SAM coating on SiO_2/Cr substrate.

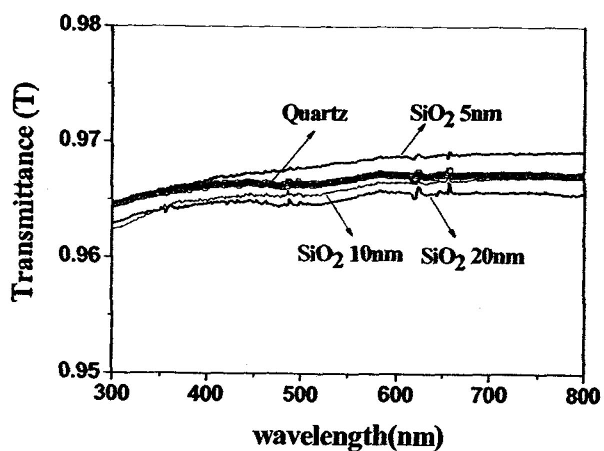

Fig. 3 Transmittance as a variation of SiO_2 thickness by UV spectrophotometer..

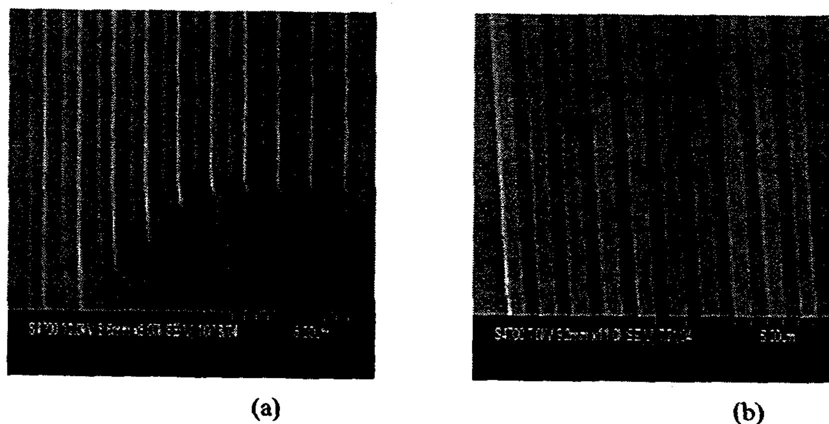

Fig. 4 SEM images of transferred pattern with (a) typical HMM and (b) novel HMM