

Impact of Mold-Resist Roughness on Friction and Adhesion Properties by Nano Tribological Inspection

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1. Introduction

Tribology between polymer and mold surface is one of the most critical issues for successful de-molding in nanoimprint lithography^{1,2}. The roughness on side wall of the mold is essential to investigate the mold releasing, however few investigations had been reported on mold roughness matter^{3,4}. In this report, friction and adhesion force are measured between roughed polymer surface and Si materials using AFM system.

2. Sample preparation and Measurement System

To model the resist and mold side wall interfaces, roughed PMMA surfaces are prepared. The schematic of the sample preparation is shown in Fig.1. The Si surface is roughed by conventional dry etching and the roughed Si substrate is replicated to PMMA surface by thermal nanoimprint and roughed PMMA surface is obtained. Figure 2 shows examples of the roughed Si substrate and replicated PMMA surfaces. Nano scale roughness is successfully obtained.

The friction and adhesion between the roughed PMMA and SiO₂ is evaluated using SiO₂ ball probe on AFM cantilever. The probe radius is 5 μm. The AFM system is in-house equipment.

3. Result and discussion

Figure 3-a) shows relations between the coefficient of friction and the roughness in Ra (root mean square roughness) of the PMMA surface. The friction has local minimum at around Ra=1.0 nm. On the other hand, the adhesion force is almost constant in various surface roughnesses as shown in Fig.3-b). These results suggest that the side wall roughness affects the de-molding process in nanoimprint lithography.

References

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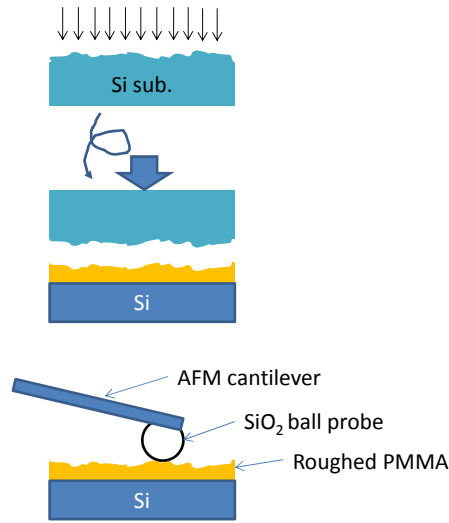


Fig.1. Schematics of sample preparation.

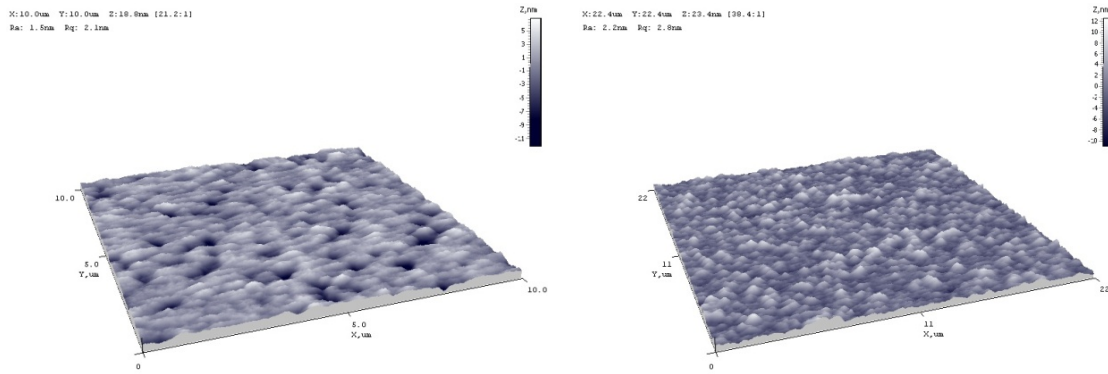


Fig. 2 a) As etched Si surface b) Replicated PMMA surface
Roughed Si surface by plasma etching and replicated PMMA by nanoimprint.

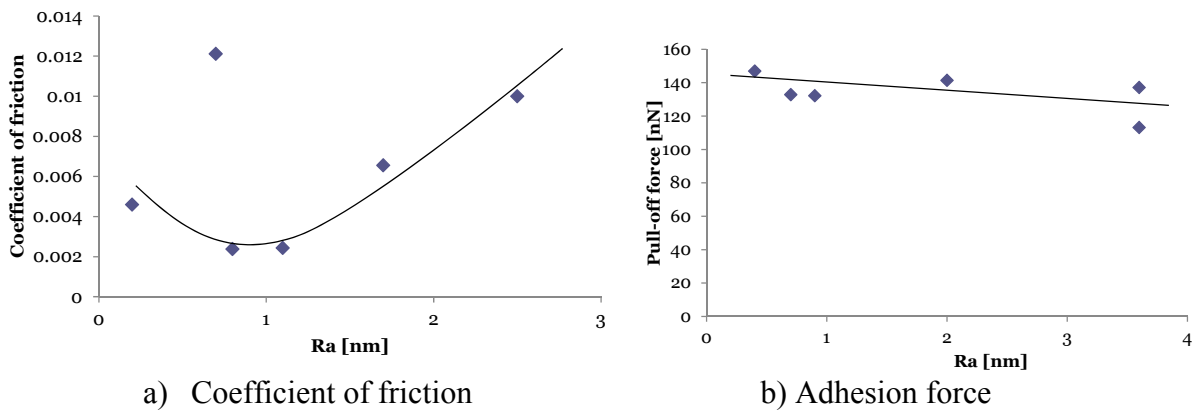


Fig.3. Tribological inspection results by SiO₂ probe