Impact of resist shrinkages on de-molding process in thermal and UV NIL

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1. Introduction

De-molding process in nanoimprint lithography (NIL) is essential not only for successful yield but also cost-efficiency for production usages. There have been published several reports on the de-molding issues such as de-molding force measurement[1-3].

In this paper, we simulate the resist shrinkage process in thermal and UV NIL process on the contact force with the side walls of the mold patterns, which may strongly related to the friction or adhesion phenomena in mold releasing process.

2. Simulation model

Figure 1 shows schematic diagram of the simulation system. The resist is fixed on the rigid substrate and the mold pattern is transferred to the resist. In our first approach, the resist is assumed to be a simple elastic body and uniform shrinking occurs as demonstrated in Fig.2, where the liner shrinkage rate is fixed to be 1.0 %. Due to the shrinkage, the resist pushes the side wall of the mold pattern, which we call it a contact force. The contact force affects to the friction and adhesion phenomena between the resist and the mold. The mold and the substrate are the material and assumed to be rigid body. The contact forces are evaluated in various configurations of the system in NIL process using finite element method (FEM).

3. Result and discussion

Figure 3 demonstrates the simulation result of the contact force in variation with the rates of the resist width Mr per the mold width Mm. Long flange space releases the contact force, because the resist is fixed on the substrate and the shrinkage force does not influence to the contact force near the center area of the mold.

Figure 4 shows the dependence on residual layer thickness. As the thickness of the resist increases, the contact force enlarges, however the contact force is saturated when the thickness of the resist exceeds the half width of the mold. On the other hand, the dependence of the contact force on the mold width is shown in Fig.5. The contact force increases as the mold width becomes long, however it is saturated. This is because that the contact force arises near the mold edge as shown in Fig. 2 and it almost constant when the mold width increases. On the contrary, the contact force hardly arises inside pattern area in the mold.

4. Conclusion

Impact of the resist shrinkage on the contact force to the mold side wall is simulated in various configurations of NIL systems. The contact force arises near the mold edge area and the amount depends on the residual thickness, additional free space of the resist flange and the width of the mold. These knowledge are indispensable for designing of the pattern layout, process conditions and system configuration in NIL process for successful de-moldings.

References

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[3] J. Ishihara, et al., *Extended abstract of MNC07*, 7B-7-6 (*Kyoto*, 2007)450.

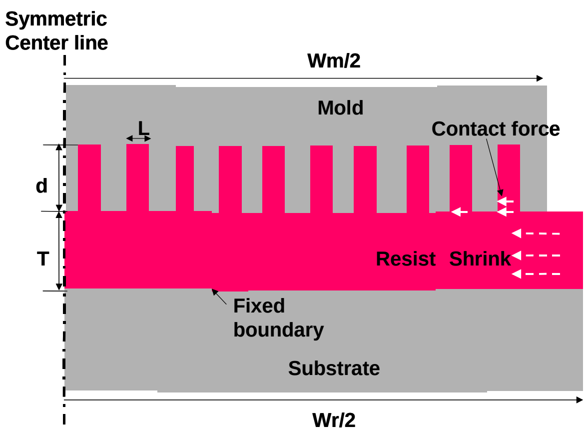

Fig.1 Schematic diagram of the simulation. The resist with Wr in width is put on substrate including residual thickness T and the mold with width in Wm is processed. The resist is shrieked and pushed the side wall of the mold pattern.

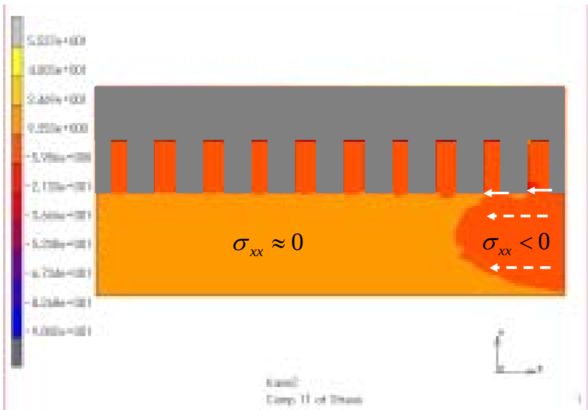

Fig.2 Typical result of the stress distribution σ_{xx} .

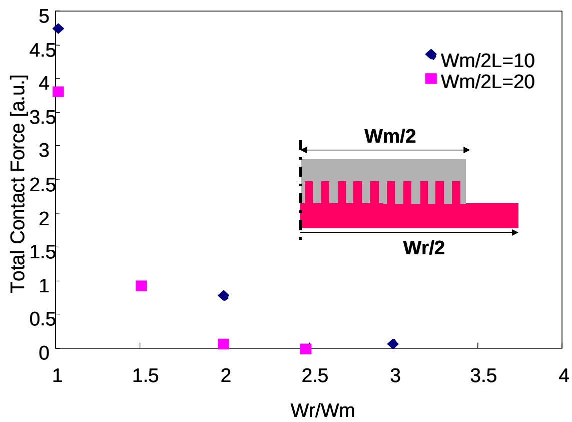

Fig.3 Contact force vs. ratio of the rest width Wr per the mold width Wm. Long flange space releases the contact force (Wr/Wm>>1).

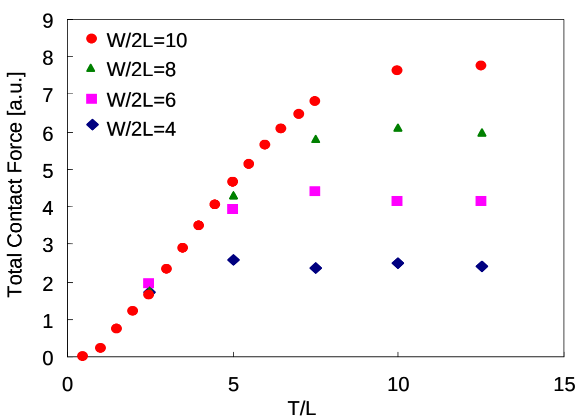

Fig.4 Dependence on the residual layer thickness. Thick resist enhances the contact force.

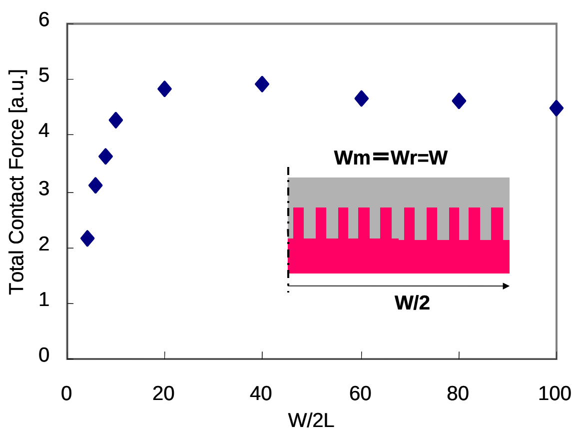

Fig.5 Dependence on the mold width. (Wm=Wr, T=d=2.5L)