Numerical method using modified squeeze model for NIL

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Nanoimprint lithography (NIL) is a simple process for fabricating nano-structures with low cost, and high throughput in the semiconductor industry. There remain several technical issues in improving NIL process such as material deformations, air bubble and insufficient filling. Many researchers[1-4] have studied to solve those using numerical method with a squeeze model. The established equation (Stefan's equation[5]) has been used for predicting an imprinting velocity and time. However, the imprinting velocity calculated by its equation becomes overestimated, as the ratio of indenter width to polymer thickness (polymer supply ratio) is close to 1. Thus, presenting modified squeeze model is critical to improve this problem.

In this study, modified squeeze model was presented and used for investigating the effect of a stamp geometry, polymer thickness, and temperature. It was confirmed this model can take advantage of prevention of the overestimated calculation of the imprinting velocity. NIL experiment was also conducted in order to obtain filling shapes and ratios with the measurement of scanning electron microscope (SEM). Figure 1 showed the comparison between numerical and experimental results according to the ratio of cavity width to tool width (dimensionless cavity size) and pressure variation rate. The results were demonstrated that a filling ratio increased with the increase dimensionless cavity size due to a fluidic resistance. The similar tendency to the previous study[6], where the filling ratio was reduced with the augment of the pressure variation rate, was indicated. It was confirmed that the presented model was in good agreement with the experimental data, indicating the maximum difference between numerical and experimental filling ratios were less than 10%. Figure 2 showed the polymer filling behaviors with dimensionless cavity size. Both of results showed a concave shape due to the low contact angle and disturbed air.

In the future work, additional investigation will be carried out with various polymer thickness and temperature based on modified squeeze model. It is expected that the results of this study can be applied to optimize the operating conditions of NIL with the analysis of the polymer flow field characteristics.

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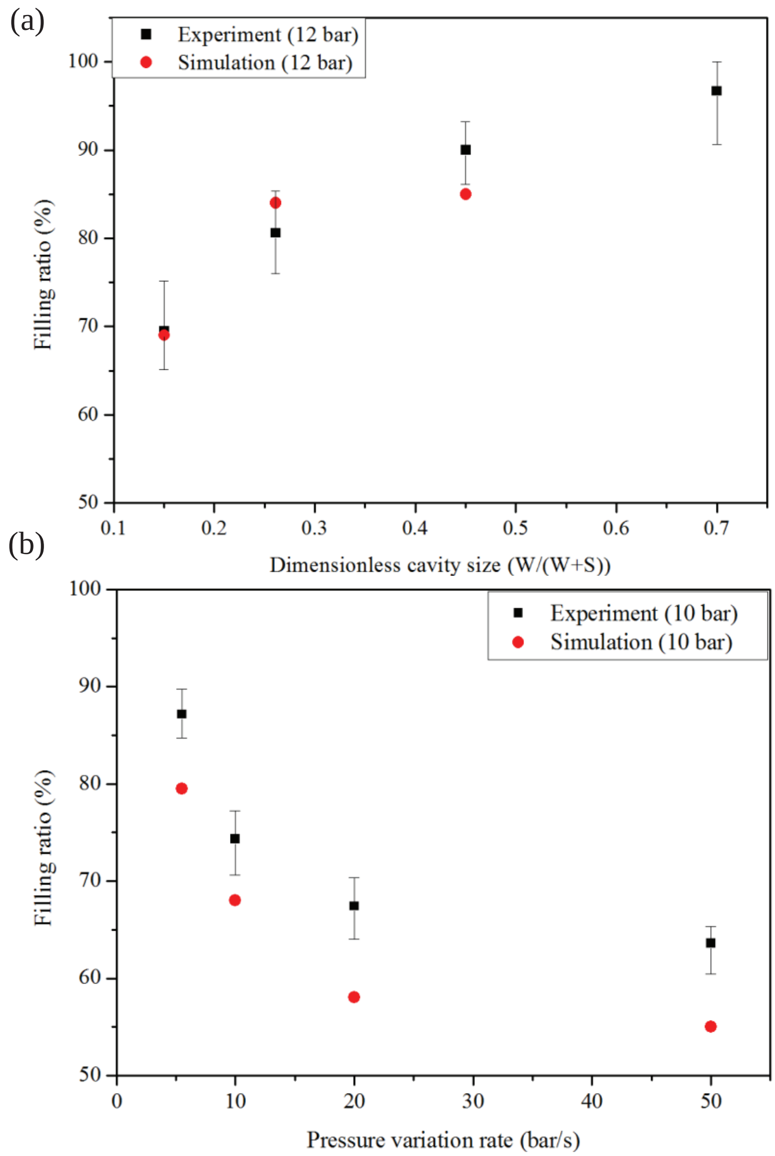

Figure 1: Filling ratio with (a) dimensionless cavity size and (b) pressure variation rate in 165 °C.

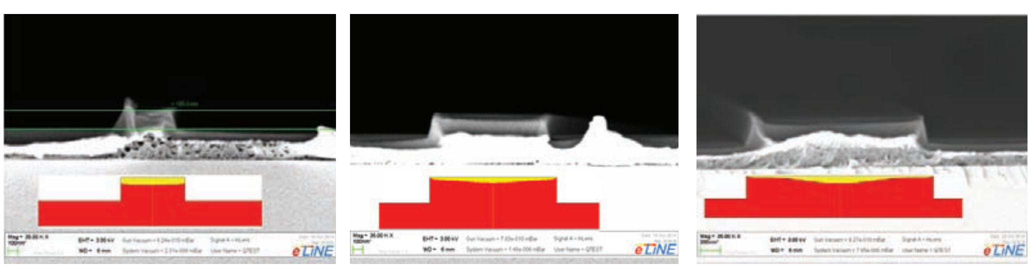

Figure 2: Polymer filling behaviors with dimensionless cavity size with 10 bar/s at 12.5 bar in 165 °C.