Flow behaviors of a polymer(PMMA) according to the imprint velocity during pressing step in NIL

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Nanoimprint lithography (NIL) is introduced as the one of the next generation lithography to fabricate nano and micro scale patterns[1]. This process could take several advantages such as simple process, low cost and high throughput. However, some defects and reasons are reported[2-4]. Especially, in the case of thermal NIL, damages and deformations of the materials could be appeared due to the conditions of high pressure and high temperature. Thus, to investigate the reason of the defects and to figure out some factors affecting to the defects, it is necessary to understand the deformation mode of polymer from a simulation.

In this study, the simulation is conducted to understand filling behaviors according to the slope of the imprint pressure and the temperature by FLUENT software. The polymer is assumed to be incompressible and non-newtonian squeezed fluid. There are many factors affecting to the imprint velocity. The viscosity of the polymer (PMMA) highly has an effect on the imprint velocity among them since the viscosity of the polymer becomes lower over a hundred times during NIL. Also, the viscosity of the polymer depends on the shear rate induced by the imprint pressure and the temperature. In order to consider these effects in detail, the imprint pressure was defined as a function of the processing time as shown in fig. 1.

Figure. 2 shows the results of flow behaviors according to the various slope of the imprint pressure with the imprint time. As the imprint pressure slowly increases, peaks are observed at the side wall of the stamp due to low imprint velocity enough to be dominated by the capillary force. In contrast, double peaks are formed since squeezed flow is dominant by increased imprint velocity in an instant. In the dominant case of the capillary force, the polymer could not be filled at center of the stamp. On the other hand, when the flow is dominated by the squeezed flow, the air could be trapped at the center or side of the stamp. It is expected to optimize and modify the conditions of NIL by this kind of study. We will also carry on the NIL experiments to compare both results and to verify reasonability of this simulation results.

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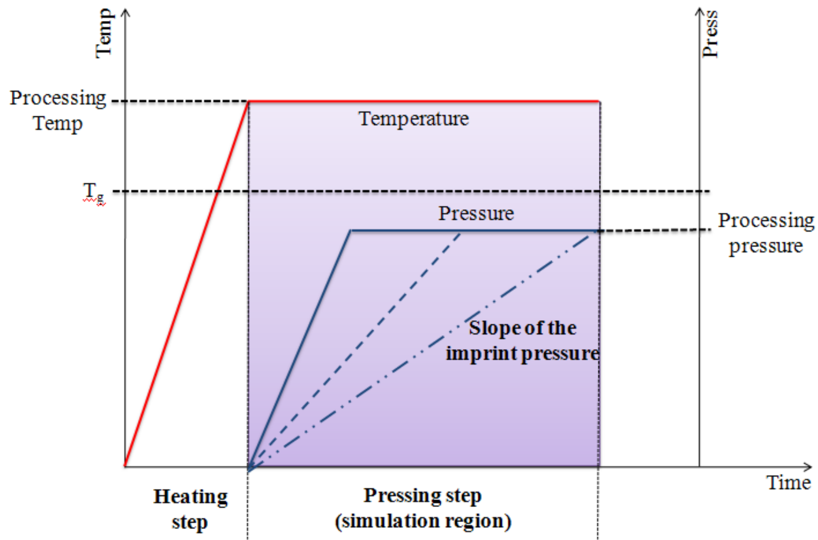

Figure 1. various slope of the imprint pressure during NIL

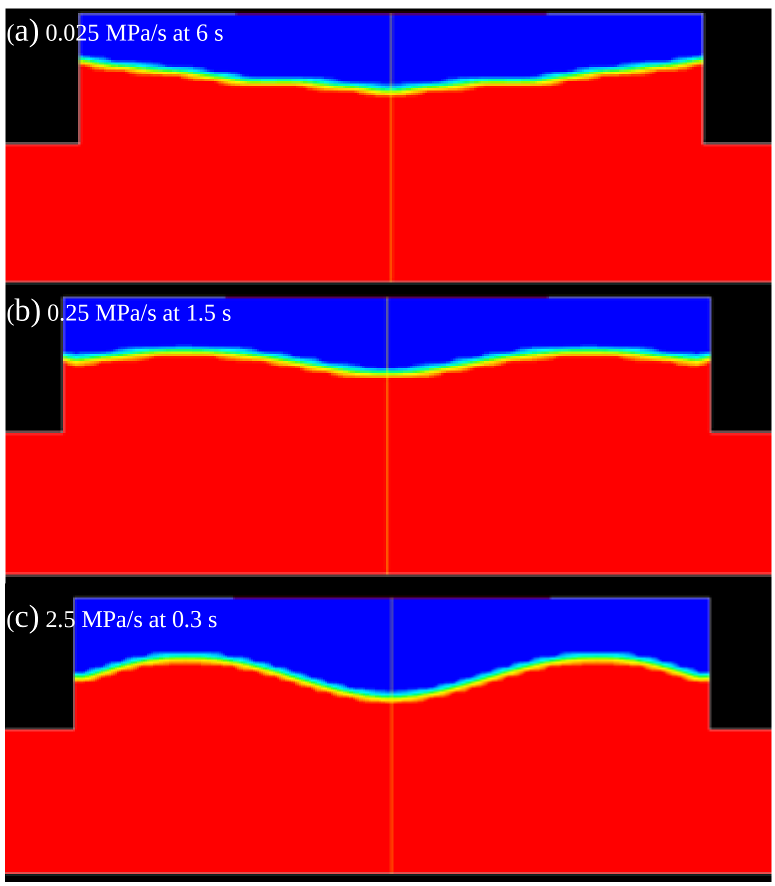

Figure 2. simulation results according to the slope of the imprint pressure (a) 0.025 MPa/s (b) 0.25 MPa/s (c) 2.5 MPa/s at the polymer thickness of 265nm: the stamp depth, width, periodicity and initial polymer thickness are 250 nm, 1200 nm, 4600 nm and 300nm, respectively.