Characteristics of residual layer thickness on liquid transfer imprint lithography and roll press method

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Nanoimprint lithography (NIL) is a unique and cost-effective method for the fabrication of nanoscale patterns. However, controlling the thickness of the residual layer is difficult because the NIL transfer mechanism is based on pressing a thin-film polymer between a hard mold and a substrate. Liquid transfer imprint lithography[1] (LTIL) is one candidate for solving this problem, as excess resin is removed by splitting the mold from the resin in the liquid phase. This method also allows for transfer onto warped, undulated, and spherical surfaces because soft replica molds can be used. Polydimethylsiloxane molds are typically used, but other polymer molds can be employed. Thus, we examined the characteristics between the replica mold materials and residual layer thickness on roll press motion in LTIL. In this study, holes patterns (diameter: 260 nm; pitch: 500 nm; height: 430 nm) were used for the master mold. The replica mold was prepared using a UV-curable resins, PAK-01-CL (Toyo Gosei Co., Ltd.) (Pencil hardness: B), PARQIT OEX-028-X433-3[2] (Autex Co., Ltd.) (6H) and ETAX-003XC (Autex Co., Ltd.) (4B) on a polyethylene terephthalate (PET) film substrate (Cosmoshine A4300; Toyobo Co., Ltd.) and using parallel-plate UV-NIL equipment. These replica molds were subjected to two kinds of surface treatment. Some were depositing platinum, the others were depositing platinum and release treatment. Fig. 1 outlines the experimental procedure. The replica mold was brought into contact with the liquid resist layer (PAK-01-CL) dropped onto the PET film. The replica mold was then carefully peeled off from the liquid resist layer, splitting the liquid resist layer into two layers. The liquid resist layer remaining on the replica mold was then brought into contact with a Si substrate under roll pressure and UV curing. The UV source was set up on the right-hand side of the roller in our apparatus. The sample was irradiated by UV obliquely from the upper right-hand corner of the roller through the transparent vinyl sheet. Therefore, the resin was cured by UV irradiation through the transparent vinyl sheet while under the roll pressure. The replica mold was released from the Si substrate. Fig. 2 shows cross-sectional (75° tilted view) SEM images of the transfer result using each replica mold (roll pressure: 6 MPa). Holes patterns are transferred residual layer less onto Si substrate by roll press and LTIL. As a result, hard replica mold (X433-3) did not deform by roll pressure, so X433-3 is suitable for LTIL mold material.

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2. Y. Otsuka, S. Hiwasa, and J. Taniguchi, Microelectron. Eng. 123 (2014) 192.

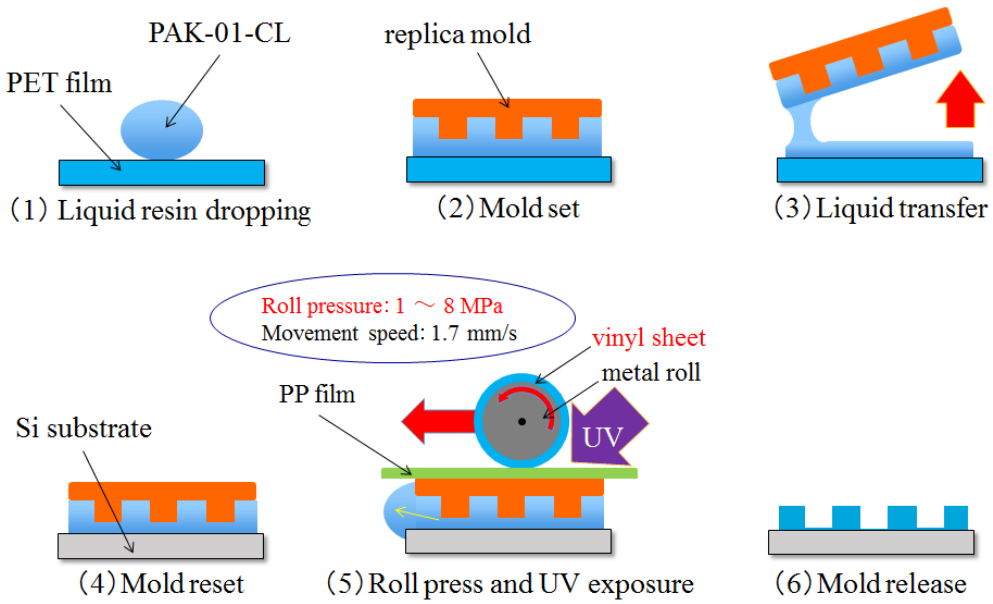

Figure 1: Experimental procedure.

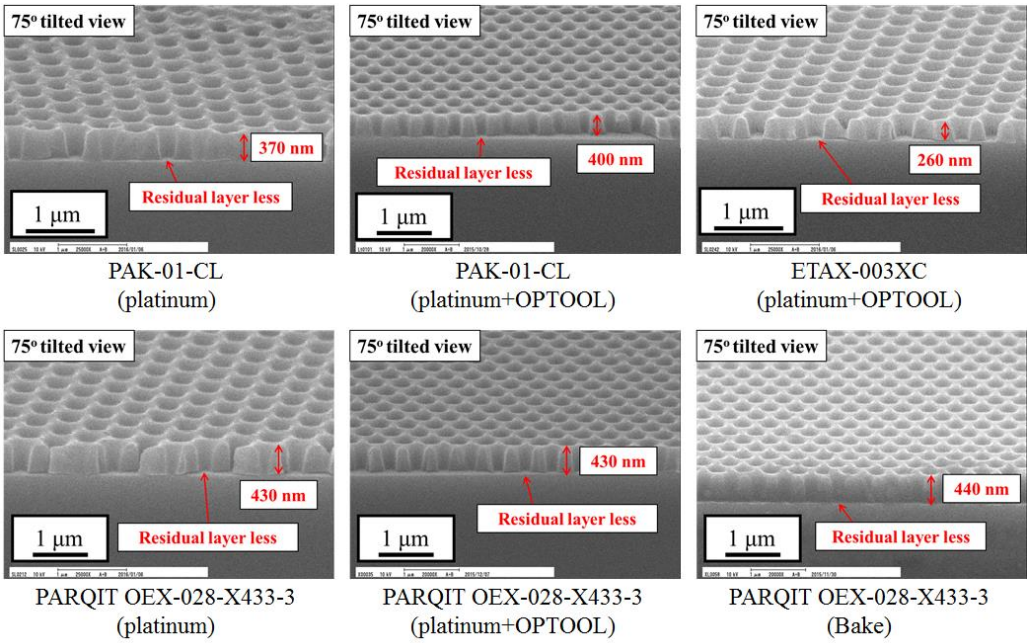

Figure 2: cross-sectional (75° tilted view) SEM images of the transfer result using each replica mold (roll pressure: 6 MPa).