Nanoimprint for Illumination Module to Control the Emitted Light using Flexibility Enhanced SCIL Mold

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Large-area and nano-scale are the key words in nanoimprint lithography process which shows its competitiveness compare to other lithographic tools. In this respect, optical components used in flat panel display business are good targets for the nanoimprint process. For a decade, many researchers have developed techniques to manufacture diffusion film, polarizer film, dual brightness enhancement film, and anti-reflection film. However, it is the undeniable reality that there are still many drawbacks such as process uniformity, residual layer problem, difficulty of master and its replica fabrication.
Recently, an interesting issue related to illumination module for display which controls the emitting light direction using nano-scale grating draws concerns of researchers[1]. The principle of this illumination module uses first-order lights which are diffracted from small pixel-size gratings fabricated on a display panel. It is an attractive application in nanoimprint process because the pattern scale is a few hundred nanometer and the patterning area is a few tens of centimeter which is a difficult size covered by conventional lithographic tools. In addition, the patterning size is not as large as flat panel TV applications, so the patterning uniformity which is one of the key issues becomes a relatively possible target.
We used the SCIL[2] which is one of the advanced nanoimprint process to get the large-area process uniformity for this application. Figure 1 shows a replica mold, and we glued a 50 micron thick polycarbonate film on the backside of a 50 or 70 micron thick glass substrate. The PC film enhances the flexibility of the mold while maintaining the strength of the mold in planar direction. We followed general process conditions with AMO NIL MMS4 resin. Figure 2 shows the nanoimprinting result on a 6 inch wafer. The pitch difference results in the color variation shown in the image, and the SEM images show the cross sectional view of the fabricated on the wafer. In the future, we will optimize the index of resin and the design of the gratings to maximize the optical effect in display application.

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[1] D. Fattal, Z. Peng, T. Tran, S. Vo, M. Fiorentino, J. Brug, and R. Beausoleil, Nature 495 (2013) 348-351.

[2] R. Ji, M. Hornung, M. A. Verschuuren, R. van de Laar, J. van Eekelen, U. Plachetka, M. Moeller, and C. Moormann, Microelectron. Eng. 87 (2010) 963-967.

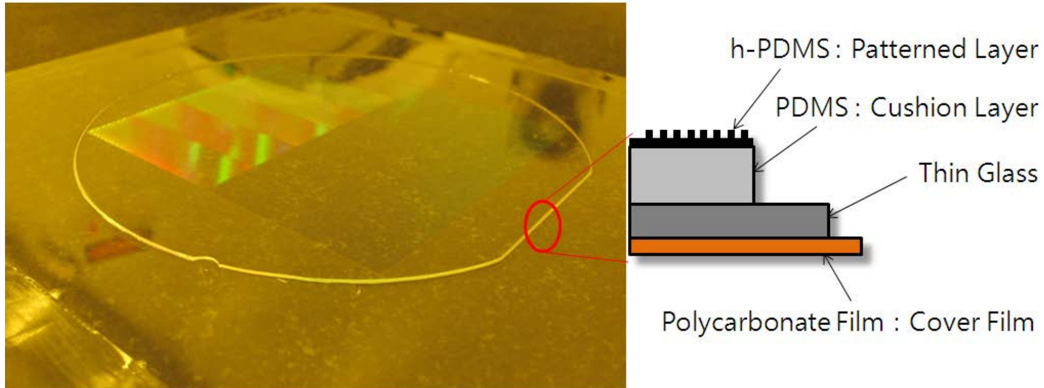

Figure 1. Flexibility enhanced SCIL mold with polycarbonate film which is glued on the backside of a glass substrate. The size of the replica is 240mm x 240mm.

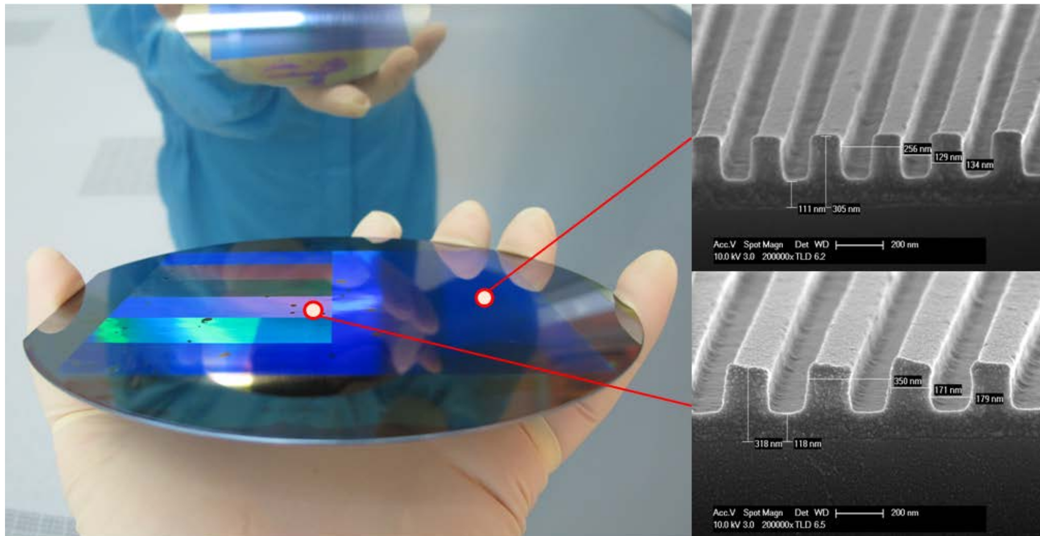

Figure 2. Imprinting results for nanometer scale grating patterns. The silicon wafer has 6 inch size and linear gratings which have different pitch scale are fabricated on it. The smallest grating shown in the upper image has 260nm pitch size and the pitch of the lower one is 350nm.