The Effect of Cylindrically Inflated Substrate to Improve the Pressure Distribution in UV Nanoimprint

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Even though nanoimprint lithography has made a great advance in the last decade, it is still difficult to transfer patterns of a stamp to a substrate on a large area with high fidelity. In general, nanoimprint process uses hard plates which hold stamps and substrates, and the pressure uniformity over the contact area between a stamp and a substrate is the most important design factor in nanoimprint system. There are many parameters which affect the pressure uniformity like waviness of plates, geometrical imperfections of stamps and substrates, so high load is commonly required to overcome these mechanical constraints and to reach a certain pressure uniformity. The air cushion press suggested by He Gao et al in Princeton university was an innovative method to get conformal pressuring in nanoimprint lithography.[1]

We propose a new method to induce uniform pressure over the imprinting field with low pressure. Figure 1 shows the developed system. The main idea of this system is to use a cylindrically inflated flexible base on which a flexible stamp or a replica is attached. In this configuration, the cylindrically deformed stamp squeezes out the resin on a substrate toward the outside, and the uniform pressure distribution over the contact area is achieved because the contact conditions hold during process. In addition, the demolding process is somewhat easy, and the air bubbles trapped in the resin are removed during squeezing process. Figure 1 (b) shows the inflated polycarbonate film by air pressure of 3kPa, and the PDMS replica attached on it. The total load applied on a 6 inches wafer under this condition is just about 5kgf, and this is very low pressure compared to other nanoimprint processes. A substrate on which resin is coated or dropped is loaded on the chuck, and then moves up toward the replica bonded on the inflated PC film. The initial contact area is a narrow stripe transverses through the center of a substrate, and the contact area expands outside of the substrate without any changes in the previously contacted region. The master pattern was fabricated on a 6 inches silicon wafer, and it is replicated to PDMS material. Figure 2 shows the imprinted pattern on a polyurethane-acrylate (PUA) resin. The size of the dots is 7um in diameter, about 175nm in height, and matches well the original one fabricated on the silicon master. The residual layer is a little thick because the viscosity of the PUA resin is high, but we expect this process will works well in the case of using low viscosity resin to reduce the residual layer of imprinted patterns.

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[1] He Gao, Hua Tan, Wei Zhang, Keith Morton, and Stephen Y. Chou, Nano Lett., **6**, 2438 (2006)

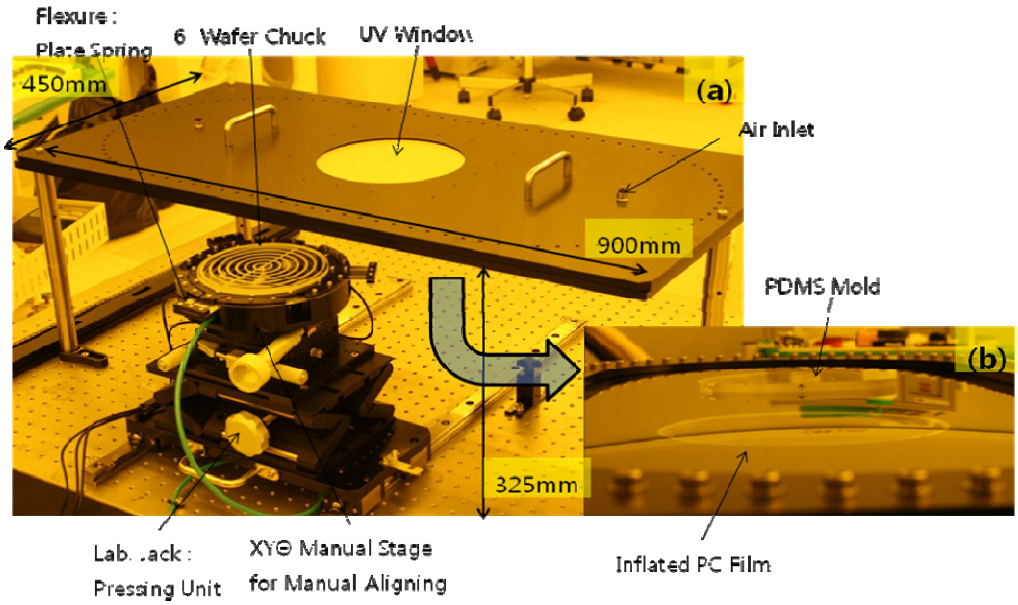

Figure 1: System Configuration: (a) The system is comprised of a wafer chuck unit, XYZθ manual stages, and a head unit which holds inflated PC film. (b) Inflated PC film base and PDMS mold.

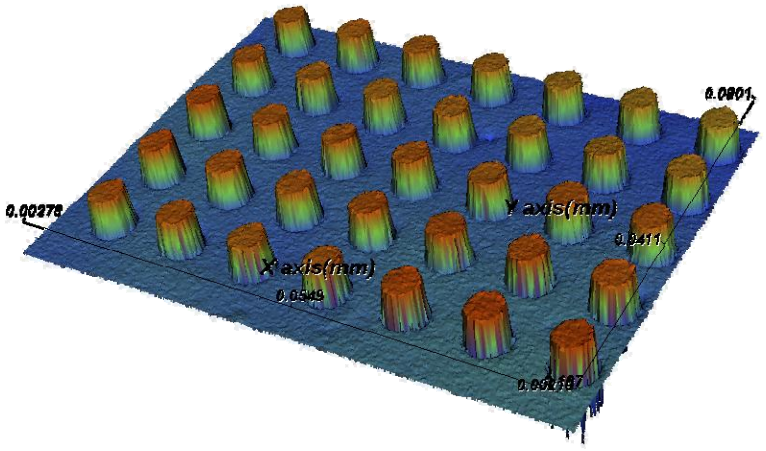

Figure 2: Imprinted PUA Dot Pattern