The Effect of Improved Hardness using Polyurethane Acrylate in Replica Mold for Substrate Conformal Imprint Lithography

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The substrate conformal imprint lithography (SCIL) [1] which uses a replica mold made of a thin glass, hard and soft polydimethylsiloxane (PDMS) shows great performances in large area patterning. The distinctive features of the SCIL are air supplied pressure system and three-layered replica mold. The air supplied pressure system uses very low air pressure about a few kPa and induces air through many isolated linear grooves which will be switched to vacuum lines to hold the replica mold.

The replica mold is comprised of three layers; thin glass which has 0.2mm thickness, h-PDMS, PDMS. The h-PDMS is a pattern layer and is spin coated on a master wafer. It is usually designed to have 100 microns thickness. The second PDMS is a cushion layer, therefore enhances contact uniformity by compensating surface profile variations. The glass substrate which is backbone of the replica has enough strength in in-plane direction and flexibility in out-of-plane direction.

It is known that hardness of the replica is strongly related to patterning fidelity. In addition, it is better to use hard material to replicate pattern shapes of master accurately. Polyurethane acrylate (PUA) is widely used in nanoimprint research because of its rigidity. Especially, it is useful to replicate deep patterns with over 1 micron depth. However, low bonding force between PDMS and PUA makes it difficult to use PUA as pattern layer.

To overcome this problem, a new approach which controls the curing state of PUA material along its depth was tried to bond the PDMS and the PUA layers. The mechanism of this method is to mix half-cured PUA and liquid PDMS by diffusion. The diffusion is occurred at the boundary between the PUA and the PDMS, and they are cured by heat and ultraviolet light simultaneously.

In this paper, we will show the fabrication procedure for this new replica mold and its patterning fidelity in SCIL process.

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[1] 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.

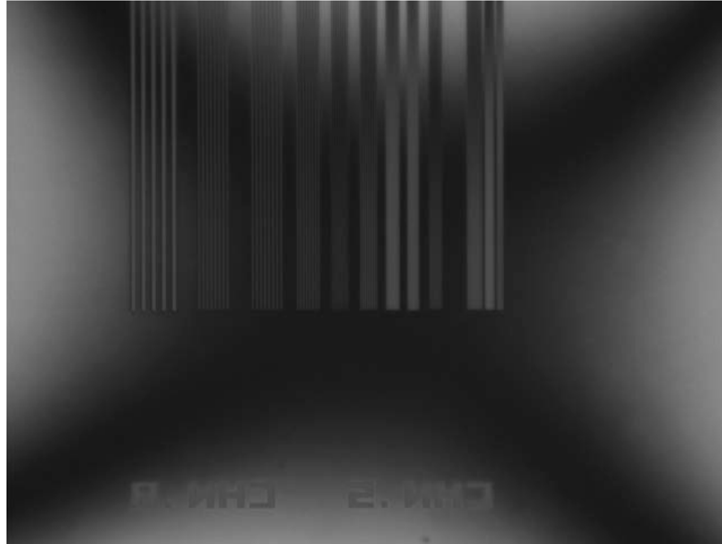

Figure 1: The PUA Replica Mold: Replicated PUA mold. The master pattern is designed for MOSFET application, and it is fabricated to have 1.3 micron depth. This photograph shows how small features can be replicated successfully by PUA material.

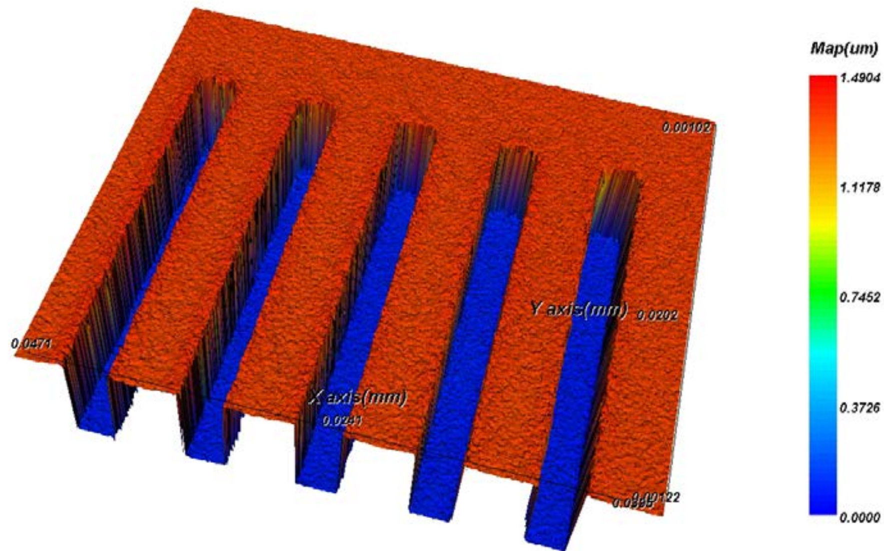

Figure 1: 3-Dimensional Surface Profile of the Replica Mold