Accuracy of Wafer Level Alignment with Substrate Conformal Imprint Lithography

R. Fader, M. Rumler, M. Rommel, A.J. Bauer, L. Frey
Fraunhofer Institute for Integrated Systems and Device Technology, Erlangen, 91058, Germany,
robert.fader@iisb.fraunhofer.de

M.A. Verschuuren, R. van de Laar
Philips Research, Eindhoven, 5656 AE, The Netherlands

R. Ji, M. Hornung
SUSS MicroTec Lithography GmbH, Garching, 85748, Germany

Substrate Conformal Imprint Lithography (SCIL) is an innovative nanoimprint technology for large area patterning with nanometer resolution[1]. This soft lithography method uses a three layer PDMS stamp approach for the structure transfer. SUSS MicroTec adapted this SCIL process for their mask aligner[2] and extended the process with a UV option to UV-enhanced SCIL (UV-SCIL). This UV option enabled the usage of fast curing and versatile imprint resists[3,4]. With this, UV-SCIL is a fast and robust technology for the transfer of nano patterns over areas as large as 200mm diameter.

For many device fabrication processes overlay alignment is required. Because of using elastic rubber PDMS stamps the capability of accurate overlay alignment of many soft lithography methods is limited[1]. Since the SCIL process uses a three layer PDMS stamp with a thin glass back plate (200µm thickness), a soft PDMS buffer layer (500µm thickness) and a high modulus PDMS layer (100µm thickness) which contains the structures, absolute distortions caused by shrinkage during thermal curing are minimized[5]. Also, because of the small imprint pressure (20mbar) and the small thickness of the rubber there is only a small relative distortion caused by elastic deformation. Therefore, high overlay accuracy with low stamp distortions should be possible but is not shown so far.

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[1] M.A. Verschuuren, Substrate conformal imprint lithography for nanophotonics, PhD thesis, Utrecht University, 2010.

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

[3] R. Fader, H. Schmitt, M. Rommel, A.J. Bauer, L. Frey, R. Ji, M. Hornung, M. Brehm, M. Vogler, Microelectron. Eng. **98** (2012), 238-241.

[4] H. Schmitt, P. Duempelmann, R. Fader, M. Rommel, A.J. Bauer, L. Frey, M. Brehm, A. Kraft, Microelectron. Eng. **98** (2012), 275-278.

[5] J.A. Rogers, K.E. Paul, G.M. Whitesides, J. Vac. Sci. Technol. B **16** (1998), 88-97.

In this work stamp distortions, local alignment accuracy, and the overlay alignment accuracy of the SCIL process are investigated systematically. The adaption of the SCIL process on SUSS mask aligners also enables the usage of its alignment options for SCIL. With this, the possible alignment accuracy of the SCIL process with box in box alignment marks as well as the alignment accuracy of SCIL with Moiré patterns is determined. Because of the transparency of the PDMS stamps, high contrast alignment patterns are required and were fabricated (see Figure 1 and Figure 2). Next to alignment accuracy, also local and global distortions are evaluated with these patterns. The presented results will allow to properly estimate the alignment accuracy for the SCIL process on SÜSS mask aligners quantitatively.

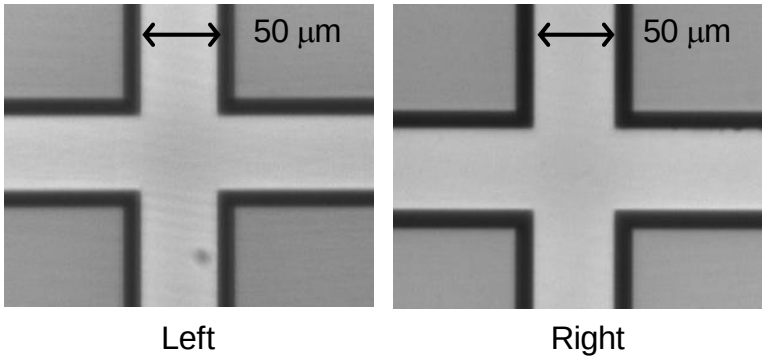

Figure 1: High contrast box in box alignment patterns[1] used for SCIL

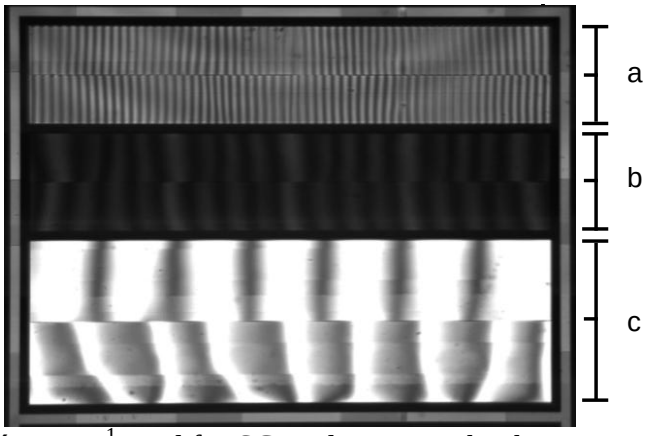

Figure 2: Moiré pattern[1] used for SCIL alignment, the three areas are composed of corresponding grating sets to enhance accuracy and provide 3 resolution regimes (a. 10 μm, b. 2 μm, c. 580 nm)