Abstract submitted to EIPBN 2007, Denver, CO

Nano-Scale Mechanics of Drop-On-Demand UV Imprinting

S.V. Sreenivasan, Xiaoming Lu, Anshu Cherala, Phil Schumaker, Jin Choi, Ian McMackin
Molecular Imprints, Inc., Austin, TX 78758

Researchers have demonstrated that imprint lithography techniques have remarkable replication resolution and can pattern sub-5nm structures [1]. However, a fully capable lithography approach needs to address several challenges in order to be useful in nano-manufacturing applications. This presentation will focus on drop-on-demand UV imprint process and its ability to address key manufacturing challenges such as process repeatability, low defectivity, and the ability to handle pattern density variations.

This article will discuss the basic mechanics of drop-on-demand UV imprinting and its applicability to both large area and step and repeat processes. The work builds on previous research reported in the literature [2]. The mechanics of the template-liquid-substrate stack prior to UV curing will be discussed. The relationship between residual layer control, throughput, and defects in the presence of arbitrary pattern density variations will be discussed. The ability to operate the process using very low viscosity liquids (< 5 cps) will also be discussed. It is believed that these low viscosity processes are essential for achieving high throughput for template designs of arbitrary pattern density variations; and to achieve low pressure processes that are suitable for low defectivity.

Two key attributes of the drop-on-demand UV imprinting process will be discussed: (i) The ability to automatically target drops of UV curable monomer based on local volume requirements dictated by the GDS-II data for a template as illustrated in Figure 1, and (ii) Contact geometry modulation at the template substrate interface to create a continuous film from discrete drops without trapping voids between the discrete drops (as shown in Figure 2). Table 1 shows that the use of these two techniques of “GDS-based drop targeting” and “contact geometry modulation” results in significant improvements in throughput.

The paper will also provide a comparison with spin-on UV imprint process [3] to point out the key differences in performance and versatility. The process tuning capability uniquely offered by drop-on-demand dispense will also be discussed. Specific emphasis will be placed on process robustness to investigate the viability of this process for manufacturing in areas such as magnetic storage, photonic devices and IC applications.

References:

1. F. Hua, Y. Sun, A. Gaur, M. A. Meitl, L. Bilhaut, L. Rotkina, J. Wang, P. Geil, M. Shim, J. A. Rogers, and A. Shim, “Polymer imprint lithography with molecular-scale resolution,” Nano Lett. **4**(12), 2467–2471 (2004).
2. D. J. Resnick, S. V. Sreenivasan, and C. G. Willson, “Step & flash imprint lithography,” Materials Today **8**(2), 34–42 (2005).
3. M. Otto, M. Bender, F. Richter, B. Hadam , T. Kliem, R. Jede, B. Spangenberg, H. Kurz, “Reproducibility and homogeneity in step and repeat UV-nanoimprint lithography,” Microelectronic Engineering, Volume 73-74 , Issue 1, June 2004

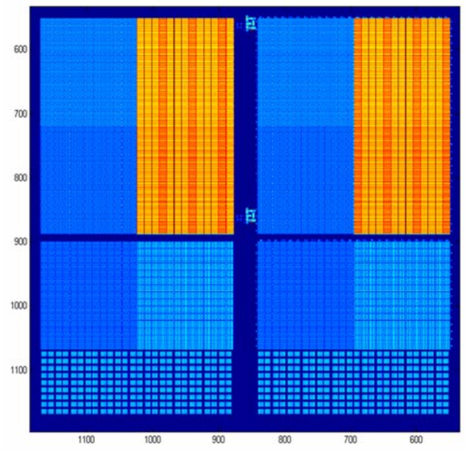

Figure 1: A volume map for a template based on GDS-II data showing highly varying pattern density regions in the template. Here 'blue' represents low pattern density regions and 'orange' represents high pattern density regions.

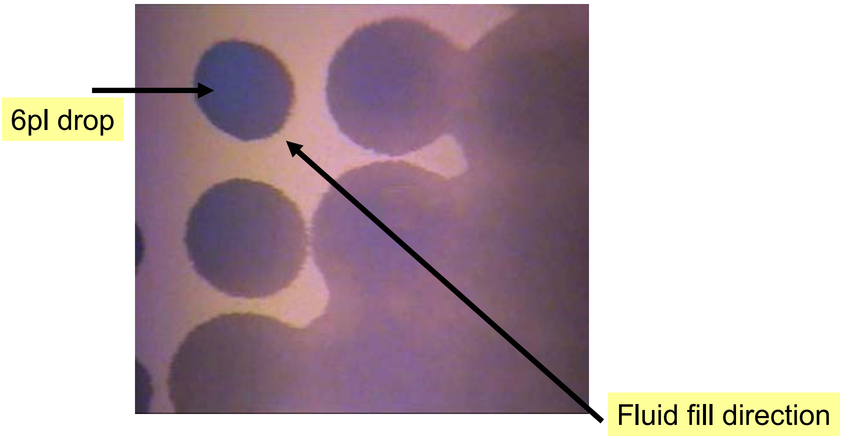

Figure 2: Contact geometry modulation leads to lateral merging of drops (orthogonal to the fluid fill direction) to create a continuous film without trapping voids between the discrete drops

Table 1: GDS based volume compensation combined with contact geometry modulation leads to significantly improved throughput. Here the minimum monomer drop volume used was 6 pl and the mean value of the residual layer used in the imprint process was 25nm.

	No Contact Geometry Modulation		Contact Geometry Modulation	
Drop Pattern	Uniform Grid	GDS Based	Uniform Grid	GDS Based
Fluid Fill Time for Contacts through Pitch	30 secs	15 secs	10 secs	3 secs