Defect-tracking For Nanoimprint Lithography Using Optical Surface Analyzer and Scanning Electron Microscope

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Particle contamination can cause serious issues for contact printing processes such as thermal or UV- nanoimprint lithography.[1,2] To characterize particle-induced defects, high resolution scanning electron microscopes (SEM) are commonly used. However, since these tools have very limited field of view, identifying a particular defect using SEM can be time-consuming and difficult.

In this paper, we discuss a method for effectively tracking defects by combining the functions of an optical surface analyzer with SEM. First, we use the fast optical surface analyzer to identify the defects by their optical scattering signal. The optical analyzer scans the full substrate surface within minutes and it locates the defects with ~10μm resolution. After setting up a reference system for coordinate conversion, the defect coordinates generated by the optical scanner can be used by the SEM stage controller to move the stage to the close vicinity of a particular defect of interest (FIG.1).

By integrating the functions of the optical surface scanner and the scanning electron microscope, we can track specific defects on both the imprinted substrates and the template reliably. For example, the images in FIG.2 show the defect at the same location of several consecutive imprints. During the first imprint, a particle was trapped between the template and the substrate. After separation, the particle stayed on the template, and a void in resist pattern was left on the substrate. During the second imprint, the same particle was removed from the template and transferred to the second substrate. However, SEM images of the subsequent imprints show that, although the particle was no longer on the template, it had already permanently damaged the template during the first imprint, and the damaged pattern was replicated in the subsequent imprints.

Our studies show that the particles found on substrates are predominantly hard particles such as metal oxides. Unlike the relatively soft organic contaminants, the hard particles can cause permanent template damage during imprint (FIG.3). Thus, substrate cleanliness is a critical issue in imprint-based manufacturing and need to be carefully managed. Pre-imprint screening of substrates for particles seems necessary for maintaining imprint quality and for the protection of templates. Optical surface analyzers, when used in combination with high-resolution electron microscopes, provide highly effective means for the study of these defects.

[1] S. Chou, P. Krauss, and P. Renstom, Science 272, 85 (1996).
[2] M. Colburn, I.Suez, B. J. Choi, M. Meissl, T. Bailey, S.V. Sreenivasan, J.G. Ekerdt, and C.G. Wilson, J. Vac. Sci. Technol. B 19, 2685 (2001).

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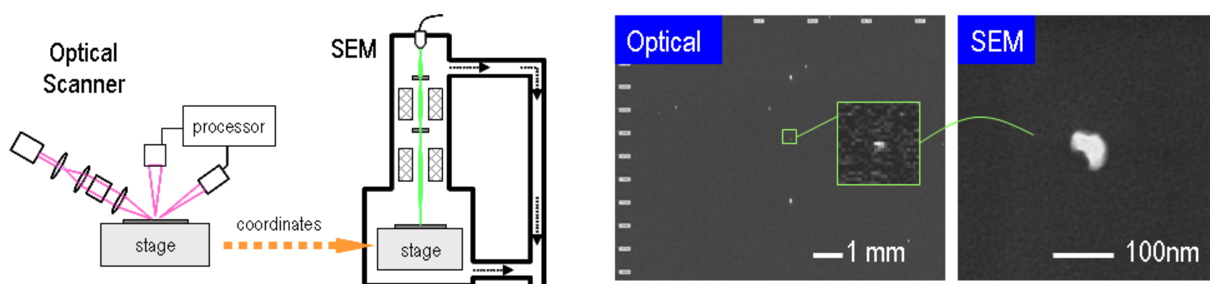

FIG. 1 To track defects, the fast optical scanner is first used for a full surface scan, the coordinates of the defects are sent to the SEM stage controller so the stage can be moved accurately to the location of a particular defect for high-resolution imaging. This method enables us to track specific defects from imprint to imprint and to compare them to the template with relative ease.

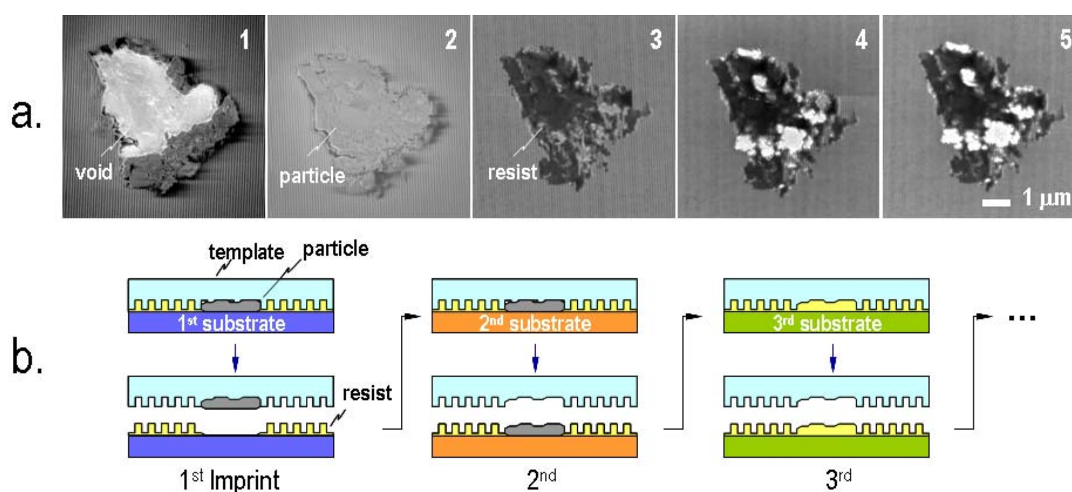

FIG. 2 SEM images of the defect at the same location for 5 consecutive imprints showing the effect of a "hard" particle on imprint. Although the original particle was removed from the template during the second imprint, the template damage from the first imprint remained and caused a series of repeated defects in the subsequent imprints.

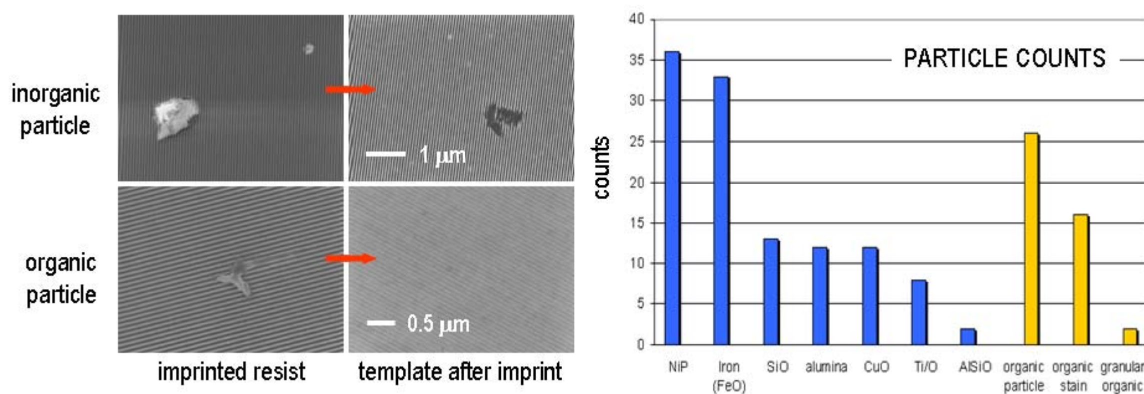

FIG. 3 Our studies indicate inorganic hard particles during imprint tend to cause permanent template damage, while the organic contaminants generally do not cause such damage. Since particles found on substrates are dominated by inorganic metal oxides, contamination control is a critical issue for template protection.