Cleaning Induced Imprint Template Erosion

Zhaoning Yu,* Nobuo Kurataka, Hieu Tran, Gene Gauzner, Hongying Wang, Henry Yang, Yautzong Hsu, Kim Lee, and David Kuo

[1]*Seagate Technology, 47010 Kato Road, Fremont, CA94538, USA*

To make a UV-imprint-based manufacturing process economical, repeated use of the imprint template is required. In the UV-imprint process, [1] a silica template with the desired pattern is in direct contact with the resist when UV-irradiation is applied to cure the resist. Imprint process failure can cause the cross-linked resist to stick to the template. The resulting contaminants are resistant to solvent attack, thus, their removal requires the use of cleaning processes with aggressive oxidants.[2] Considering that multiple cleaning will be performed on the template during its lifetime, the issue of template damage in such an environment should be carefully addressed.

In this paper we report on the detection of template CD change as a result of template cleaning using spectroscopic ellipsometry optical critical dimension (SE-OCD) measurements (FIG.1).[3] SE spectra of the 72.6nm pitch line-and-space pattern on a silica template were analyzed to extract pattern profile information with good sensitivity (FIG.2). Previously, changes in template features are difficult to characterize using conventional techniques such as cross-sectional SEM or AFM, due to their limited sensitivity, small sampling size, and pattern topography effects. Our study demonstrates that the template damage from wet chemical cleaning can be accurately measured by SE-OCD.

Using these techniques, we have confirmed that the H_2SO_4-H_2O_2 SPM cleaning widely used for substrate organic contaminants removal also etches silica slowly – up to a molecular monolayer is partially removed from the silica surface by each cleaning cycle. Although the rate of silica pattern erosion in SPM is slow, the cumulated effects over the lifetime of an imprint template can be significant (FIG.3). Therefore, to establish a reliable manufacturing process based on nanoimprint lithography, better template cleaning processes that are less damaging to template features need to be developed.

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[2] S. Singh, S. Chen, K. Selinidis, P. Dress, N. Kurataka, G. Gauzner, and U. Dietze, Proc. of SPIE Vol. 7823 (2010).
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* *Email: zhaoning.yu@seagate.com*

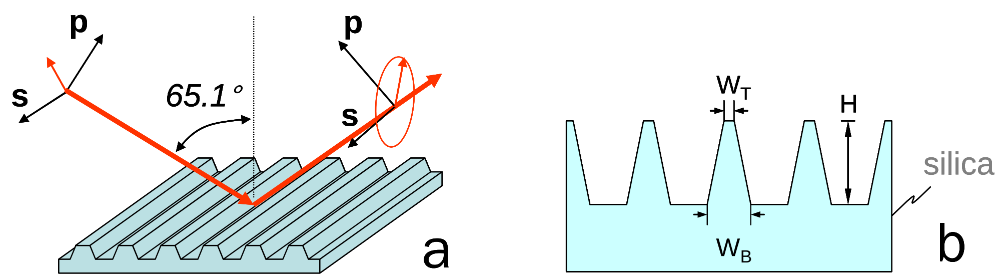

FIG. 1 Schematics of the SE-OCD measurement (a) and the parameters describing the nano-grating line-shape (b). The linearly polarized light beam is incident upon the sample surface at a 65.1° angle of incidence, with the grating lines perpendicular to the plane of incidence. We deduce the silica etch rates by tracing the changes in the nano-grating line-shape over time.

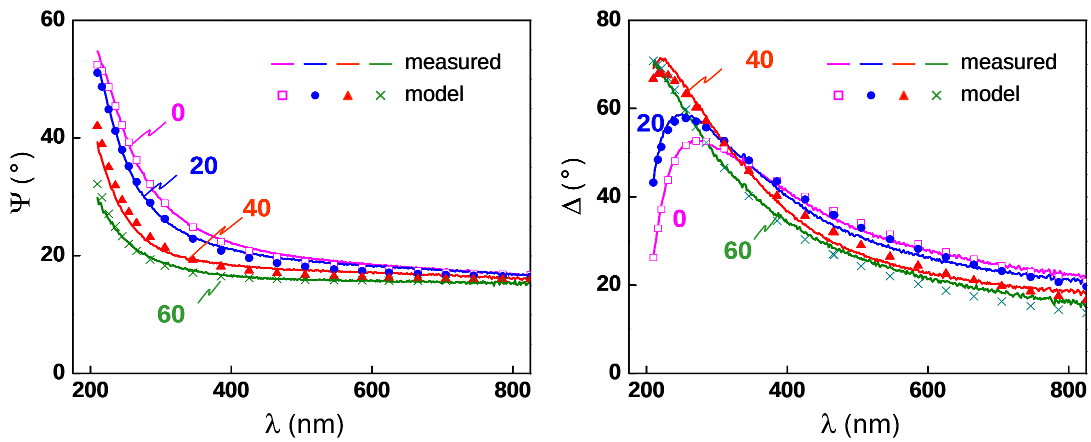

FIG. 2 Measured (lines) and calculated (dots) SE (Ψ,Δ) spectra of the silica template in the initial pre-cleaning state and after 20, 40, 60 SPM (H_2SO_4+H_2O_2) cleaning cycles. Erosion of the grating features resulted in changes of the spectra, which can be fitted to extract the grating line-shape information.

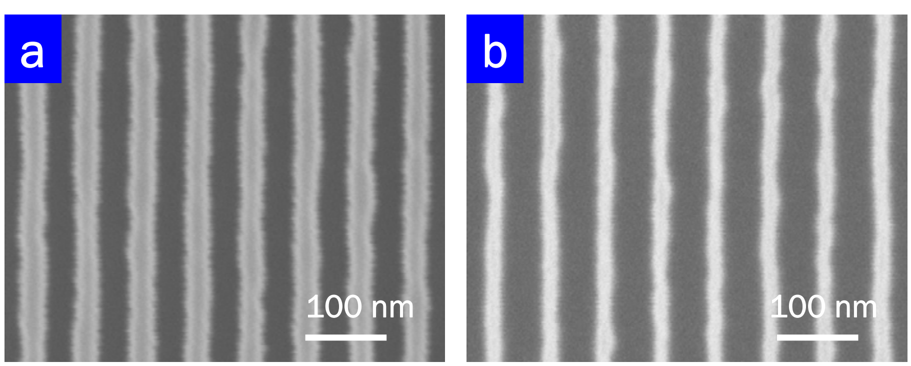

FIG. 3 SEM images of the silica template line-and-space pattern in its pre-cleaning initial state (a) and after 60 SPM (H_2SO_4+H_2O_2) cleaning cycles (b), showing significant erosion of the lines.