Spectroscopic Ellipsometry Optical Critical Dimension Measurements of Template and Imprint Resist for Patterned Magnetic Media Applications

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To use nanoimprint lithography [1,2] for patterned magnetic media[3] fabrication, template and imprinted resist profile parameters such as critical dimension (CD), sidewall angle (SWA) and feature height (FH) are crucial information for process control. However, high pattern density, small feature size (~10nm), and unique imprint resist material properties involved in this application pose significant metrology challenges for traditional techniques such as SEM and AFM.

Being highly sensitive and nondestructive, spectroscopic ellipsometry optical critical dimension (SE-OCD) measurement is especially suited for patterned media because they are mostly composed of periodic structures. SE-OCD collects and analyses the light signal reflected from periodic structures and it can be used to extract detailed sidewall profile information (FIG.1).

However, the implementation of SE-OCD is difficult because the meaning of (Ψ,Δ) obtained from ellipsometry is not straightforward, and its data analysis involves the construction of an appropriate optical model to match the measured spectra. The regression procedure can be rather challenging due to problems such as parameter correlation.[4]

In this paper we present the successful implementation of SE-OCD to detect CD and grating profiles for quartz templates and imprint resist features with a pitch as small as 72.6nm. Variations in grating line-width cause changes in detected optical spectra, which can be modeled to extract pattern CD information (FIG.2). Since the imprint pattern is a replica from the template, template and the corresponding resist pattern should show complementary trends in CD variation, which can be clearly detected in our SE-OCD measurements (FIG.3).

In addition, comparison of SE-OCD measured template and corresponding imprinted resist profiles provides a useful way to study imprint pattern fidelity. FIG.4 shows the measured spectra and the best fit models of a template with a grating pitch of 72.6nm and of the corresponding imprinted resist pattern. For the template, the best fit OCD model shows a 69nm feature height, a 44.4 nm bottom CD and a 78° SWA, which are in good correlation with TEM measurement. For the corresponding resist pattern, the best fit model indicates a resist profile with a slightly shallower pattern (~61nm feature height) and a more vertical sidewall (SWA~ 86°) compared to the original template.

Previously, these features are difficult to detect using conventional techniques such as cross-sectional SEM or AFM due to their limited sensitivity, damages from ebeam irradiation, and AFM tip effect. Our study demonstrates that with appropriate optical modeling, SE-OCD has the sensitivity to provide the critical profile information for the unique metrology needs in patterned media applications.

[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).
[3] Thomas R. Albrecht, 52nd EIPBN conference, May (2008).
[4] H. Fujirawa, "Spectroscopic Ellipsometry: Principles and Applications", John Wiley & Sons (2008).

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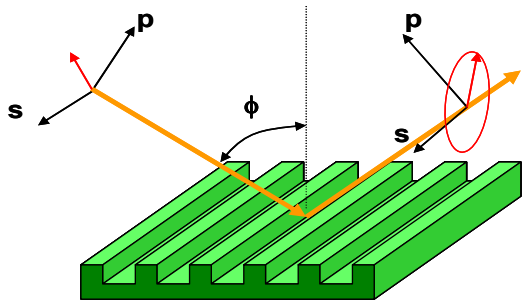

FIG.1 Schematic of the SE-OCD measurement, gratings are perpendicular to the plane of incidence.

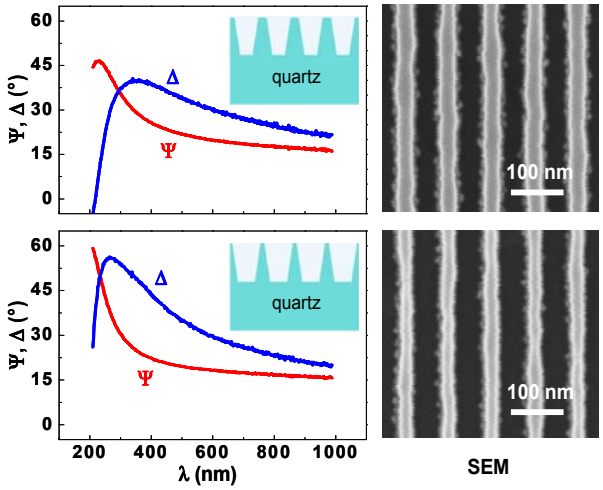

FIG.2 Varying line-width on a quartz template causes a change in measured spectra, which can be fitted through modeling to track the CD variation.

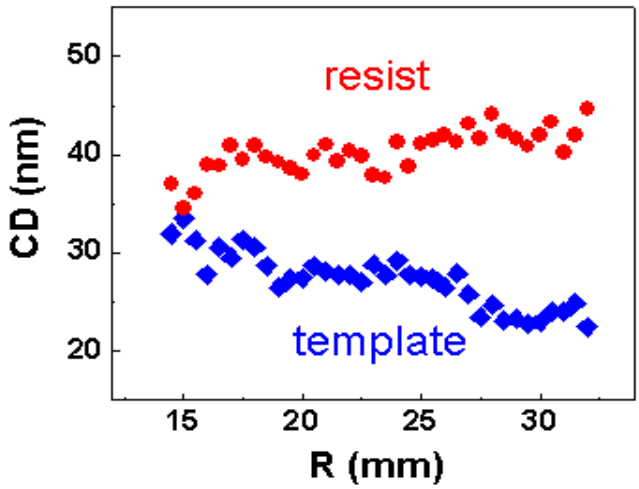

FIG.3 SE-OCD measurement clearly shows the opposite trends in CD variation at different radii of a template and the corresponding imprinted resist pattern.

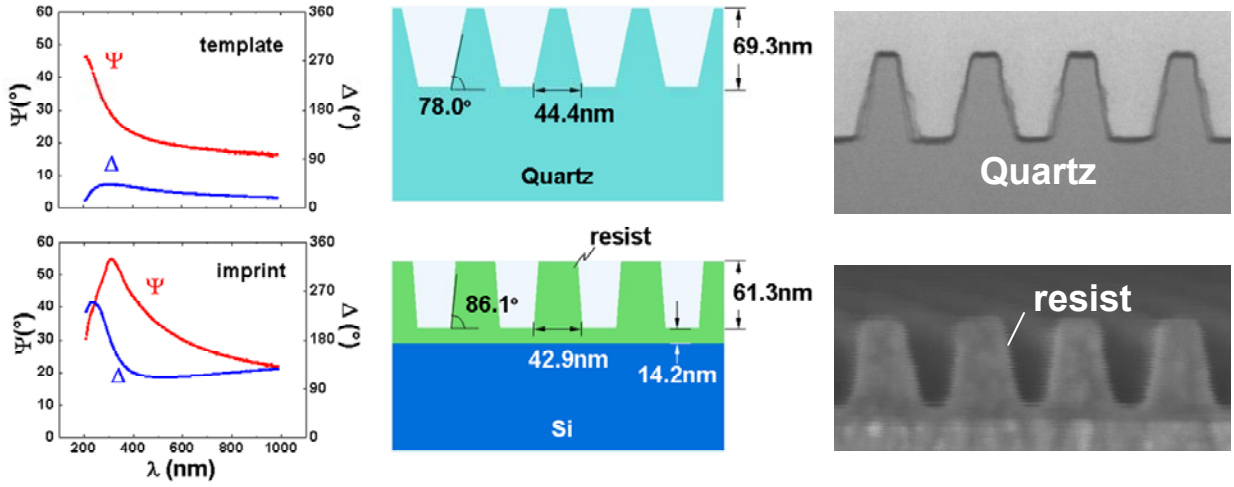

FIG.4 Measured spectra (left) and the best fit models (center) of a template with a track pitch of 72.6nm and of the corresponding imprinted resist pattern. For the template, the best fit OCD model shows good correlation with TEM (top right). For the resist pattern, the best fit model indicates a resist profile with a slightly shallower pattern (~61nm feature height) and a more vertical sidewall angle (SWA) of 86° compared to the template (~69nm feature and 78° SWA).