Refractive Index, Absorbance and Thickness Measurement of Underlayer Materials for the EUV Lithography at 13.5-nm

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1. INTRODUCTION

According to the Rayleigh's equation for resolution of optical lithography, the feature size of photoresists that can be patterned is governed by the wavelength of the exposure radiation. Following the evolution of the lithographic light-source wavelength from 365-nm, 248-nm, 193-nm, to 193-nm immersion, a light source at 13.5-nm in the extreme ultraviolet (EUV) region will probably be used for the next generation lithography. To pattern photoresist with a good latent image, the optical properties of refractive index (n) and absorbance (k) at the wavelength along with thickness (T) of the resist stack have to be optimized. However, there are only limited 13.5-nm light sources and equipments worldwide available to conduct research and development of EUV photoresists.[1-2] In this study, we measured the above mentioned optical properties of photoresist and Underlayer materials using a newly built EUV at National Synchrotron Radiation Research Center (NSRRC).

2. EXPERIMENTAL

The reflectivity measurement was performed at the 08A1 BM-LSGM beamline, which provides the EUV light source at 13.5 nm. This work examined the reflectivity curves of thin-film samples on silicon substrate specularly by an EUV reflectometer of NSRRC. The optical properties derived from analysis and presented in Sec. 3, were derived by X'Pert SW of Panalytical.

In this study, samples include nine underlayer materials, "round robin" resist, and PMMA resists.

3. RESULTS

The performance of the reflectometer is illustrated in Fig. 1 for the precision of both θ and 2θ goniometers. The angle resolution of the newly-built reflectometer has a θ and 2θ precision of ±0.05°, which is sufficient to resolve the reflectivity period as will be shown in the later figures.

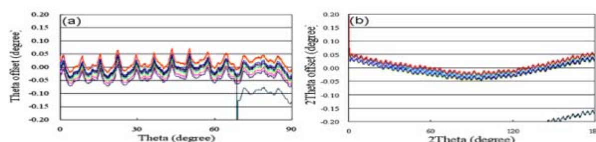

Fig. 1: The precision of the θ-2θ goniometers is about ±0.05° .

Figure 2 (a) and (b) show the measured and fitted reflectivity curves of PMMA and S_{001}, respectively; and Table 1 lists the derived n, k and T values of both materials. Note that measurements were not carried out under an optimal θ -2 θ alignment of reflectometer; therefore, the results of this report are preliminary and yet satisfactory. The optical values of PMMA agree well with literature values as listed in Table 1.

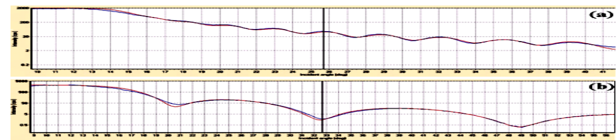

Fig. 2: Reflectivity Curves of (a) PMMA and (b) S001. Red-line, measured; blue-line, fitted.

Sample	Self developed fitting			Commercial SW				Literature value		
	n	k, um-1	T(Å)	n	k, um^{-1}	T(Å)	d(g/cm^3)	n	k, um-1	d(g/cm^3)
PMMA	0.9708	5.17, 5.61	1221	0.9770	4.95	1220	1.12	0.9758	5.19,5.03	1.18
S_{001}	0.9732	5.28, 6.14	293	0.9839	9.46	271	1.31			

Table 1: Preliminary n, k, T results of PMMA and S001

The reflectivity curves of nine underlayer materials, round-robin resist, and PMMA are shown in Fig. 3. For each sample, two consecutive reflectivity curves were acquired. Some samples evidently show an evolution of the reflectivity curve upon EUV exposure.

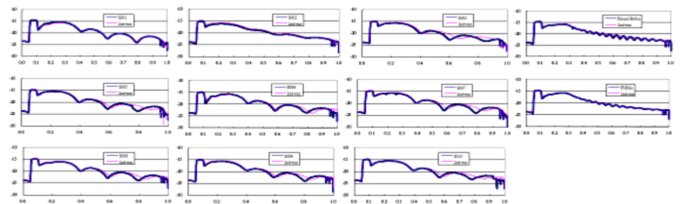

Fig. 3: Reflectivity measurement of nine underlayer materials, round-robin and PMMA resists.

4. SUMMARY

This work used the newly built EUV reflectometer to derive n, k, and T values of EUV thin-film materials. The results of PMMA agree well with literature values. An observation of the evolution of the reflectivity curves upon EUV irradiation will be further investigated.

References

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