Characterization of EUV-Deposited Carboneous Contamination

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The contaminations on EUV masks deteriorate the throughput, the CD variation[1], the exposure latitude etc. in EUV lithography. These are dependent not only on the thickness of the contamination layers but also on their weight densities.[1] The information about their compositions and structures are useful in understanding the deposition processes and they are also useful in devising a better cleaning technology.[2] In this study, carboneous contaminations on EUV mask blanks exposed by EUV light from synchrotron radiation have been investigated by various analytical techniques.

Using GIXR the thickness and the weight density of the layer was estimated. And the thickness distribution of the layer was evaluated from spectroscopic ellipsometry. The most reliable thickness was obtained from the cross sectional TEM image. The chemical and elemental compositions were analyzed with XPS, HR-RBS, and HR-ERDA. The result from HR-RBS/HR-ERDA is shown in Fig. 1. It was found that the contamination layer mainly consisted of carbon atoms but it also contained hydrogen atoms with half the number of carbon atom thus making hydrogen to carbon ratio as 1:2. In addition, the ratio of hydrogen to carbon decreases with the depth. This suggests that the photo-chemical reaction caused by EUV light proceeds after the contamination is deposited. The density of the film was calculated by combining the result of HR-RBS with the thickness obtained from TEM.

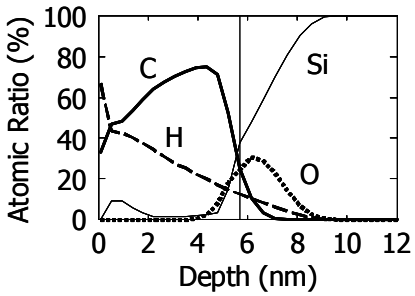

Fig 1: Elemental composition variation of carboneous contamination determined with HR-RBS/HR-ERDA.

The thickness and density values measured with the above mentioned techniques are summarized in Table 1.

Table 1: Summary of Thicknesses and Densities measured with various techniques.

	Thickness	Density
Ellipsometry	6.7 nm	n/a
GIXR	9.0 nm	1.5 g/cm^3
TEM	5.7 nm	1.9 g/cm^3
RBS	n/a	

Other results including the chemical bonding nature of carbon atoms analyzed with reflective EELS, surface roughness by AFM etc. will also be presented.

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[1] Y. Nishiyama et al., Proc. SPIE Vol. 6921-41 (2008).
[2] T. Anazawa et al., EIPBN2008 5B-3 (will be submitted).