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Measurement of EUV scattering from Mo/Si multilayer mirrors

Noriaki KANDAKA*, Teruki KOBAYASHI, Masayuki SHIRAISHI,
Takaharu KOMIYA, Tetsuya OSHINO, Katsuhiko MURAKAMI
Nikon Corp. Sagamihara, Kanagawa 228-0828, Japan

Introduction

EUVL (Extreme Ultraviolet lithography) is the most promising NGL (next generation lithography) technology. Numerous EUV multilayer reflective optics will be employed in EUVL systems, and they will be required to have high reflectivity to achieve high system throughput.

Because EUV light has much shorter wavelength than visible or UV light, scattering affects the performance in EUV multilayer-coated reflective optics significantly. This means that an evaluation of scattering caused by roughness is necessary[1].

Samples

We prepared three polished fused silica substrates (Samples A, B and C) that have different surface roughness each other, and deposited 50 pairs of Mo/Si multilayers on all sample substrates by ion beam sputtering in a batch. Periodic length was 7.2 nm (Mo: 2.5 nm, Si: 4.7 nm). Table 1 shows surface roughness of multilayers deposited on samples A, B and C measured with AFM. We measured for two measurement areas 1μm x 1μm and 10μm x 10μm. By these measurements, roughness in the structure size region of 30 nm – 300 nm and 100 nm – 3μm were evaluated respectively.

Measurements and results

Figure 1 shows EUV angular scattering distributions measured at BL-12A. The angle of incidence was 14 degrees and the wavelength of the incidence beam was 13.4 nm. The scattering intensities of samples B and C were higher than that of sample A at less than 3 degrees and 8 degrees in scattering angle respectively. These scattering angles correspond to 300 nm and 100 nm in structure size of surface roughness. These results agree with AFM measurements.

Figure 2 shows EUV reflectivity of samples A, B and C. Sample A has the highest reflectivity. The reflectivities of samples B and C were 0.6% and 2% lower than that of sample A. Because these multilayers were deposited simultaneously, we expected that these differences were caused by difference of surface roughness. The scattering loss of samples A, B and C calculated by integration with the measured scattering intensity throughout the whole range of solid angles were 0.3%, 1.1% and 2.7%, respectively. Difference of these values of scattering loss was corresponded to the difference of reflectivity.

Table 1: Surface roughness of multilayers deposited on samples A, B and C.

	area size	roughness (nmRMS)
Sample A	1x1μm	0.112
	10x10μm	0.108
Sample B	1x1μm	0.117
	10x10μm	0.232
Sample C	1x1μm	0.161
	10x10μm	0.273

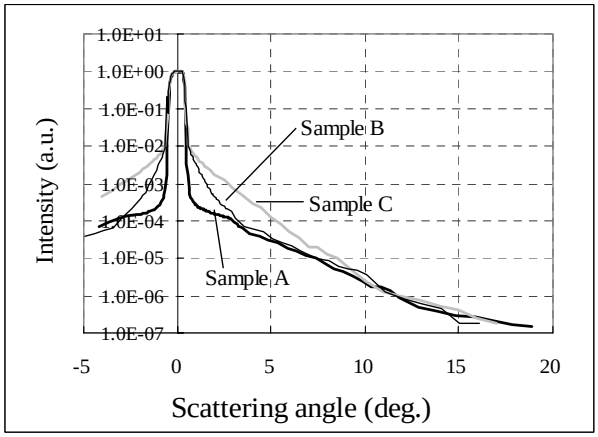

Figure 1: EUV angular scattering distributions from samples A, B and C.

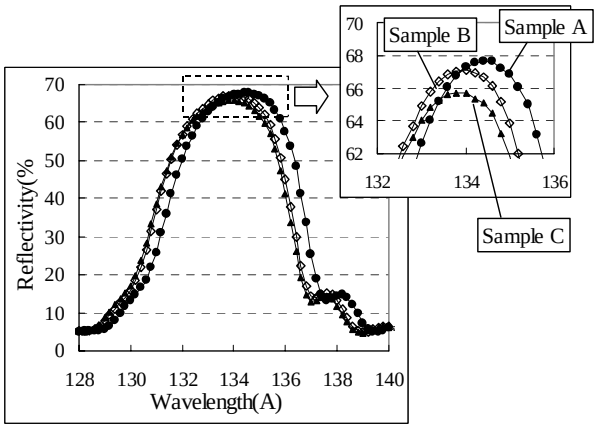

Figure 2: EUV reflectivity of samples A, B and C.

Reference

[1] E. M. Gullikson, SPIE Proc. **3331**, 72-80 (1998).

*kandaka.n@nikon.co.jp