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Development of an Automatic Null Ellipsometer for Sputtering Rate Monitoring of EUV Multilayer Fabrication

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Instrumentation

To overcome current difficulty of absolute period control in the EUV multilayer fabrication by sputtering, we have developed an automatic null ellipsometer as a sputtering rate monitor having high enough picometer thickness sensitivity enabling accurate monitoring of the nm period multilayer fabrication [1]. Figure 1 shows schematic drawing of the ellipsometer installed as the sputtering rate monitor of our ion beam sputtering multilayer fabrication system. By the ellipsometer, the complex relative amplitude attenuations are measured and plotted on a complex plane at an every 200 msec time intervals during a periodic multilayer fabrication. A growth curve displayed on the complex plane gives information of the film properties such as the complex refractive indices and thicknesses. The ellipsometric data obtained in a series are used to determine the thicknesses of each layer in every 100 msec [2].

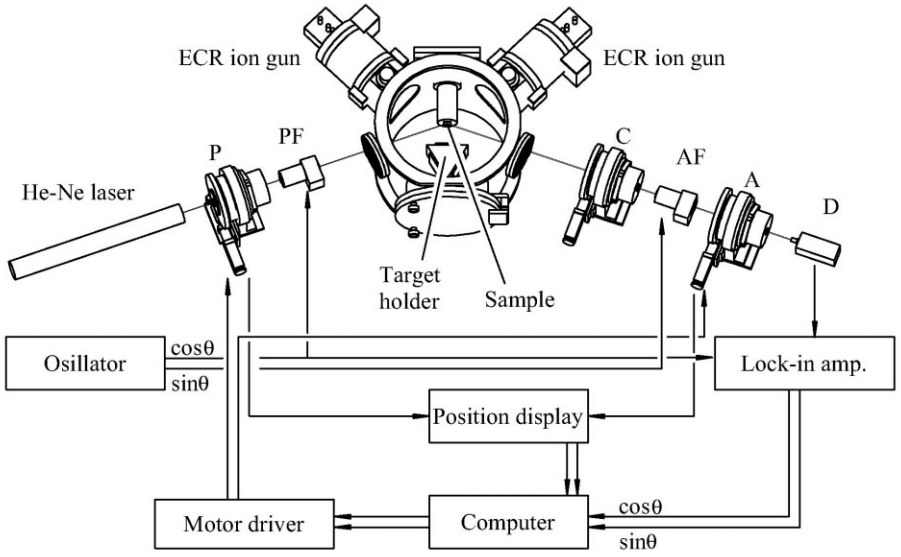

Fig. 1 Schematic drawing of the automatic null ellipsometer. The letters denote P: polarizer, PF: polarizer Faraday rotator, C: compensator, AF: analyzer Faraday rotator, A: analyzer and D: detector, respectively.

Measurements

With real time thickness analysis during Mo/Si multilayer fabrication, the sputtering rates of Mo and Si were observed to be 0.9162 nm/min and 4.752 nm/min, respectively. The period thickness was evaluated to be 6.98 nm by a calculation of the final total thickness divided by the number of periods of 40. EUV spectral reflectance of this multilayer mirror was measured at BL-12A, the Photon Factory. The angle of incidence was 23°. The experimental result is plotted in Fig. 2. The period thickness was evaluated to be 7.22 nm by the spectral shape analysis [3]. This value is compared with the above ellipsometric one. The difference of 3.3% can be attributed by a compound layer formation at every boundary of Mo and Si as observe by ellipsometry. The results proved good possibility of a single wavelength in-situ null ellipsometry for accurate and detailed controlling of the period thickness of EUV multilayer.

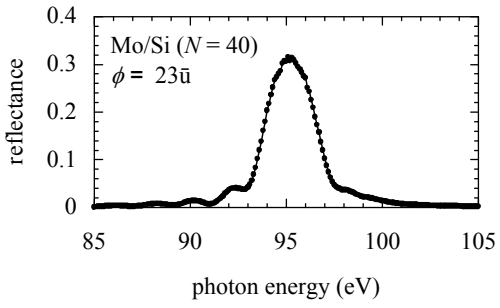

Fig. 2 Measured spectral reflectance of a 40 period Mo/Si multilayer.

References

[1] M. Yamamoto et al., Thin Solid Films **433**, 224 (2003).
[2] T. Tsuru et al., Thin Solid Films **455-456**, 705 (2004).
[3] T. Hatano et al., AIP Proc. **705**, 839 (2004).

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