An ellipsometric thickness monitor with layer-by-layer analysis for EUV multilayer optics fabrication

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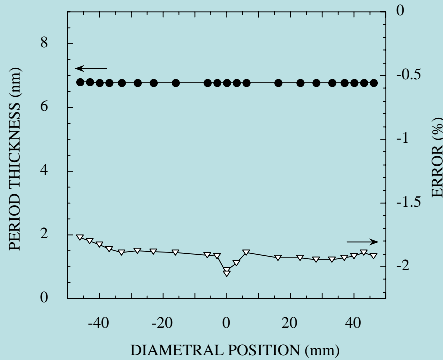
Motivations



T. Hatano, S. Kubota, Y. Adachi, T. Tsuru and M.Yamamoto,

Proc. 8th International Conference on Synchrotron Radiation Instrumentation, San Francisco, USA, 25-29 August 2003, AIP, 2004, p. 839

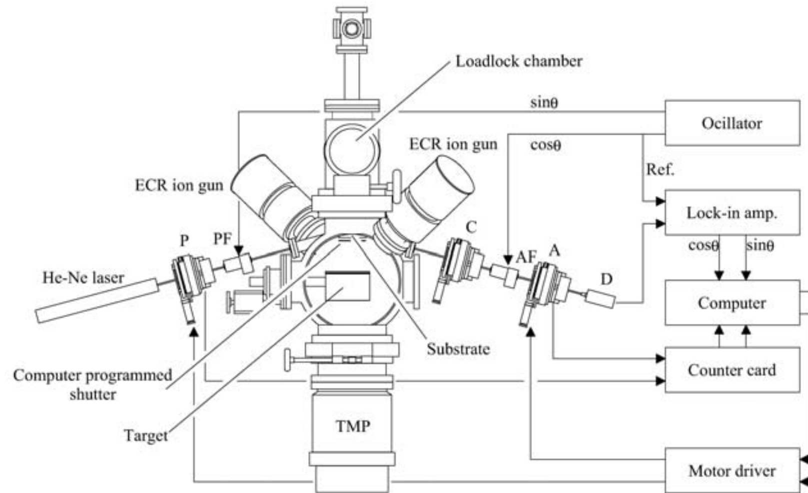
・ Our ion beam sputtering (IBS) system with a computer programmed shutter enables to control period thickness for wavelength matching.

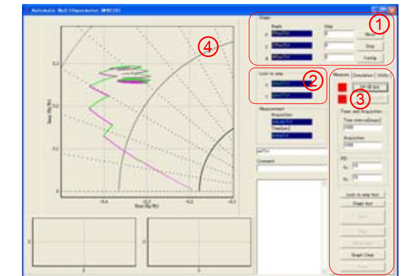
Uniformity; **within a P-V error of 0.3 %**

Difference from designed thickness; **within an error of 2 %**

・ **A sputtering rate monitor** of sufficiently high sensitivity in thickness is indispensable to **realize high reflectance, high throughput and reflection wavelength matching** for EUV multilayer optics of narrow bandwidth.

Multilayer fabrication system with an ellipsometric thickness monitor





① P, C and A controller and position display

② Lock-in amp. output display

③ Measurement and simulator panel

④ Complex plane display of plot a growth curve

Easy Operation and Measurement!!

・ The Faraday-modulation automatic null ellipsometer [1] enables to measure the null position at a time interval of <150 msec.

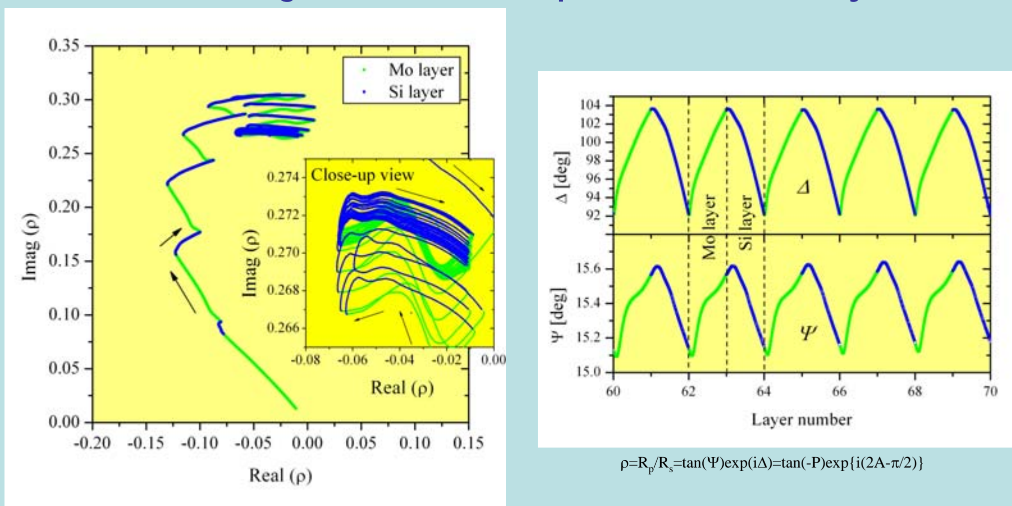
・ By **layer-by-layer analysis** [2] of the complex relative amplitude attenuation ρ, **the optical constant and thickness of individual layer** are obtained.

[1] M. Yamamoto, Y. Hotta and M. Sato, Thin Solid Films **433** (2003) 224

[2] T. Tsuru, T. Tsutou and M. Yamamoto, Thin Solid Films **455-456** (2004) 705

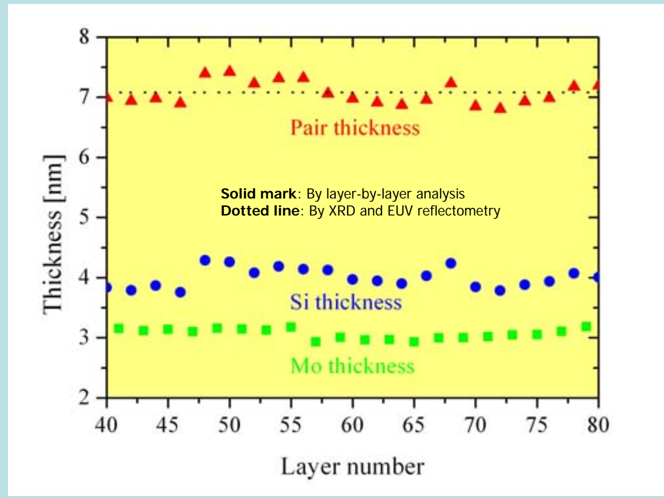
Ellipsometric *in-situ* measurement of Mo/Si multilayer fabrication

Observed growth curve of 40 period Mo/Si multilayer



$\rho = R_p/R_s = \tan(\Psi)\exp(i\Delta) = \tan(-P)\exp\{i(2A-\pi/2)\}$

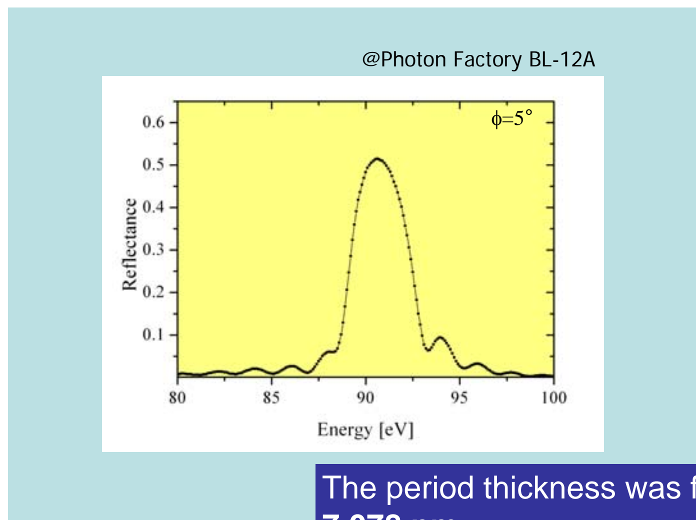
Layer-by-layer analysis



The average period thickness was found to be 7.07 nm.

EUV reflectometry

@Photon Factory BL-12A



The period thickness was found to be **7.078 nm**.

Period thicknesses by three methods

	Ellipsometry	X-ray diffractometry	EUV reflectometry
Period thickness [nm]	**7.07** Mo: 3.07, Si: 4.00	**7.081**	**7.078**

Summary

・ Average thicknesses of Mo and Si layers determined by this ellipsometry were found to be 3.07 nm and 4.00 nm, respectively.

・ An average pair thickness of 7.07 nm is in good agreement within 0.14 % with the results of EUV reflectometry at BL-12A, Photon Factory and X-ray diffractometry.

・ The results prove that **our method makes possible the accurate thickness control sufficient for fabrication of EUV multilayer optics**.