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High Resolution Mo/Si Multilayer Bandpass Filters

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Introduction

We are developing an EUV interferometer composed of multilayer mirror optics with a laser produced plasma laboratory source. The spectral continuum of the plasma will be monochromatized into a bandwidth of the multilayer reflection for flexible selection of the wavelength, where the resolving power up to $\lambda/\Delta\lambda$ ~ 100 is necessary to observe enough number of interference fringes. Usually a Mo/Si multilayer of a Mo layer thickness d_{Mo} ~ 2.5 nm, a Si layer thickness d_{Si} ~ 4.4 nm and $\lambda/\Delta\lambda$ ~ 30 is used as a high reflectance normal incidence mirror for a 92 eV photon energy. For use in bandpass filtering, layer thickness structures enabling high reflectance and high resolving power were studied.

Multilayer Design

First we designed low absorption loss multilayers under the Si *L* absorption edge with thin d_{Mo} and thick d_{Si} structures where the period thickness $D = d_{Si} + d_{Mo}$ is constant. Design parameters are listed in Table 1. *N* is the number of layer pair. The sample #1 is a standard high reflectance mirror.

Table 1: Design parameters of Mo/Si multilayers of constant *D*.

No.	d_{Mo} (nm)	d_{Si} (nm)	*D* (nm)	*N*
#1	2.5	4.4	6.9	40
#2	1.4	5.5	6.9	60
#3	1.0	5.9	6.9	80
#4	0.6	6.3	6.9	100
#5	0.2	6.7	6.9	120

Second we designed low “reflection loss” structures reducing the number of interfaces. If every other Mo layer is replaced by Si, two interfaces disappear in every two Mo/Si layer pairs and they make one layer pair of very thick d_{Si} structure satisfying the second order Bragg condition. Design parameters are listed in Table 2. The sample #1 is identical to that in Table 1.

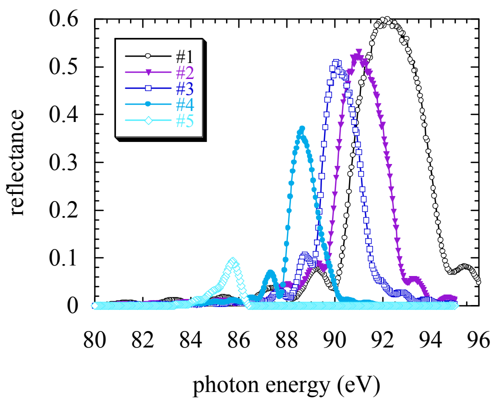
Table 2: Design parameters of Mo/Si multilayers of constant d_{Mo}.

No.	d_{Mo} (nm)	d_{Si} (nm)	*D* (nm)	*N*
#1	2.5	4.4	6.9	40
#6	2.5	11.3	2×6.9	40
#7	2.5	18.2	3×6.9	40
#8	2.5	25.1	4×6.9	40
#9	2.5	51.7	8×6.9	40

Multilayer Performances

All samples were deposited on a Si wafer by our ion beam sputtering system.

The spectral reflectances were measured at BL-12A, the Photon Factory using *p*-polarized light. The angle of incidence was fixed at 5°. The resolving power of the monochromator was 800. The experimental results are plotted in Fig. 1. The reflection peak unexpectedly shifted toward low energy in very thin d_{Mo} samples, plausibly because of interface compound formation. The peak reflectance and $\lambda/\Delta\lambda$ of sample #7 were 32% and 79, respectively, which would be convenient enough for the interferometry use. The sample #9 shows a reflection peak at 81 eV under the 7th order Bragg condition as well as at 92 eV under the 8th order. However unwanted spectral components would be filtered out by an interferometry test mirror coated with a standard multilayer.



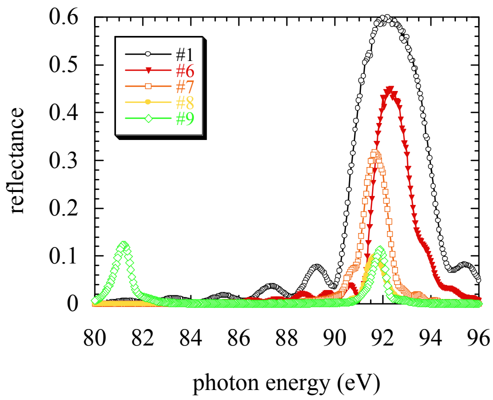


Fig. 1 Spectral reflectances of constant *D* multilayers (top) and constant d_{Mo} multilayers (bottom).

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