Narrow Band Mo/Si EUV Multilayers with Thick Si Structures

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Narrow band Mo/Si multilayers as a high throughput monochromator are needed in our EUV and soft x-ray interferometer composed of multilayer mirror optics with a laser produced plasma laboratory source [1]. The observable number of interference fringes depends on temporal coherence length $\lambda^2/2\pi\Delta\lambda$. The FWHM of spectral reflectance of standard Mo/Si multilayers at the wavelength 13.5 nm is about 0.5 nm, which is insufficient for our interferometer. This is the reason why narrowing the bandwidth of the multilayer reflection is necessary. There have been narrow bandwidth designs of the Si/B_4C [2] and the Si/Si_3N_4 [3] multilayers. In these multilayers, the pair materials have low contrasts at the optical constants. The basic design idea for narrow band multilayers is to make the total thickness of effective layers in reflection thicker than the temporal coherence length needed, because the reflections at the layer interfaces interfere with coherent component of themselves. We designed Mo/Si multilayers using higher order Bragg reflection with thick Si layers and constant Mo layer thicknesses because Si has a low absorption coefficient and too thin Mo layer causes island structure.

d_{Mo} = 2.5 nm

m	d_{Si} (nm)	R (%)	$\Delta\lambda$ (nm)	L/λ (nm)
1	4.4	60	0.47	5
2	11.3	45	0.24	9
3	18.2	32	0.17	13
4	25.1	10	0.13	17
8	52.7	11	0.09	24

Table 1. The Si layer thickness, the p-reflectance, the reflection bandwidth and the temporal coherence length of each m-th Bragg multilayer mirrors.

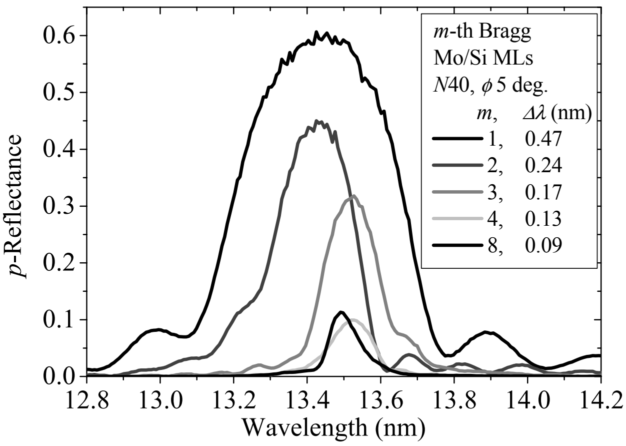

Fig. 1. The p-reflectances of m-th Bragg multilayer mirrors measured at PF BL-12A.

Mo/Si multilayers shown in Table 1 were designed and fabricated by an ion beam sputtering system. The integer m is the order number of Bragg reflection, which equals to one for the standard first Bragg reflection. With the Mo layer thicknesses d_{Mo} fixed at 2.5 nm, the multilayers of the period thicknesses $m \times 6.9$ nm were fabricated to 40 periods with m = 1, 2, 3, 4 and 8. The reflection spectrum in Fig. 1 were measured at PF BL-12A with SR of p-polarized light set at an angle of incidence of 5°. As shown in the table, the bandwidth and the reflectance of m = 3 multilayer mirror were 0.17 nm and 32%, respectively, which realized the temporal coherence length of much longer 13λ.

[1] M. Yamamoto, H. Hatano and M. Furudate, Opt. Precis. Eng. **9** (2001) 405.
[2] J. M. Slaughter, *et al.*, Optics Letters **19** (1994) 1786.
[3] P. Hoher, *et al.*, Opt. Eng. **30** (1991) 1049.