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Multilayer Reflectance Loss after Ion Milling

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1 Introduction

For accurate reflection wavefront error correction of diffraction-limited imaging VUV multilayer mirrors, a period-by-period ion milling system was developed [1]. A cut-off view of the work chamber is shown in Fig. 1. A multilayer sample is irradiated by a 150 mmΦ Ar ion beam accelerated at 500 V, through a homogenizer mask plate realizing a constant milling rate over the whole area of a mirror, and through a template having openings for the areas of milling. A multilayer mirror up to 100 mmΦ, together with the template, is mounted on a holder rotating at 200 rpm. To study damage of the multilayer surface, reflectances of milled Mo/Si multilayers were measured.

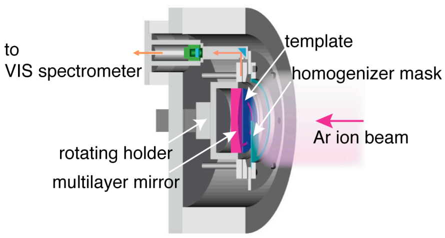

Fig. 1: Cut-off view of the work chamber of the multilayer ion milling system.

2 Experiments and Results

Three 40-period Mo/Si multilayers were fabricated by ion beam sputtering deposition. The period thicknesses were all about 7 nm. They were milled by 10 bilayers in a selected area of 10×10 mm^2. Homogenizer mask plates and area selecting templates, both made of Si and Mo, had been prepared. A photoresist contact mask could be used instead of a template. Area-selected ion millings were carried out with Si-template&homogenizer, Mo-template&homogenizer, and photoresist with Mo-homogenizer.

Reflectance measurements were performed using a reflectometer at BL-12A [2]. The beam size was narrowed to 0.5 mmΦ for the spatial resolution. The angle of incidence was 5°. Reflection peaks were found around 90 eV. With the photon energy fixed at the reflectance peak of each sample, the sample x-stage was scanned across the milled area. Fig. 2 shows the results. The milled areas exist between x = 15 mm and x = 25 mm for all samples.

In samples of milling area selection with a Si-template and a Mo-template, unexpected reflectance decrease was found outside the milled area. In the sample of milling area selection with photoresist contact mask, no reflectance decrease was found outside the milled area, which supports the reflectance decreases in other samples were caused by some contamination. After reflectance measurements, XPS analysis was performed and Si, Mo and Fe contaminations were detected from both samples locally milled with Si- and Mo-templates. Si-Mo and Fe contaminations could come from the removed surface multilayer materials and the ion gun, respectively.

As for the milled area, reflectance loss was kept under 15% whereas the Ar ion beam bombarded multilayers during milling. The reflectance spectral shape of top-10-bilayer-removed multilayers were similar to that of a 30 period multilayer. The reflectance loss would be attributed by compound formation in top few layers.

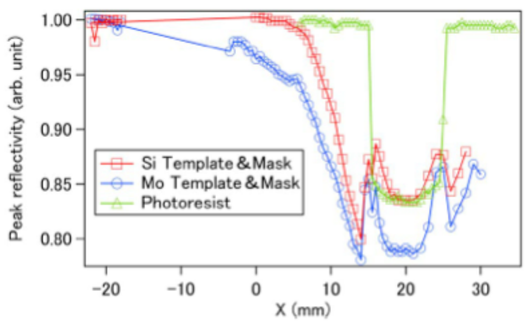

Fig. 2: Normalized peak reflectances of Mo/Si multilayers locally milled with Si-template&homogenizer, Mo-template&homogenizer and photoresist&Mo-homogenizer.

3 Conclusion

Ion milling with a photoresist contact mask for area selection shows a good feasibility of precise wavefront error correction of VUV multilayer mirrors, although further optimization of milling conditions and characterization are required to minimize the reflectance loss.

References

[1] T. Tsuru *et al.*, IOP Conf. Series. **186** (2009) 012077.
[2] S. Mitani *et al.*, Rev. Sci. Instrum., **60**, (1989) 2216.

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