Super-flat high-reflectivity semitransparent multilayer mirrors

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There has been a large interest in using semi-transparent multilayers in interferometric, polarization and lasing experiments in the soft x-ray region of the spectrum. Nevertheless, the difficult issue of fabricating large active area multilayer membranes has restricted its use for several applications. In the present work, we address mainly two issues for the fabrication of this important x-ray optical element. First we describe the study of the relation between the film stress and the magnetron sputtering deposition parameters. Subsequently, we describe the evaluation of the influence of the supporting membranes on the reflectivity of the multilayers. As a result of this study, large area semi-transparent multilayer films with good flatness and high reflectivities were fabricated.

The presence of intrinsic stress in sputter deposited multilayers complicates the fabrication of free-standing multilayers with the required figure quality. We verified that the multilayer stress depends strongly on the RF power applied to the RF magnetron plasma. We demonstrated that the multilayer stress can be controlled varying only the RF power and keeping the optimized Γ for high-reflectivity [1]. Multilayer films of Mo/Si (N= 20.5, d= 10nm, Γ = 0.36) were deposited on 200 nm thick supporting membranes. Figure 1 shows the surface profile of a 11 mm-square semi-transparent multilayer measured with an optical interferometer. The central 7.5-mm square has a flatness of 1.1 nm (rms). There is no influence of the supporting membrane materials on the figure quality.

The performance of the semi-transparent multilayers was determined using a soft x-ray reflectometer at the NTT SR facility. We compared the reflectivity of multilayers deposited on SiC, polished SiN and as-deposited SiN membranes. The reflectivity for SiC and polished SiN was over 40%, while the reflectivity for as-deposited SiN was 4%. The difference in reflectivities can be explained by the surface roughness of these different supporting membranes. Using an AFM, the measured roughness of the SiC, polished SiN and as-deposited SiN supporting membranes are 1.0, 1.1 and 3.2 nm, respectively.

Using the present approach, large-area semi-transparent Mo/Si multilayers with flatness in the nanometer range and reflectivities around 40% can be easily fabricated.

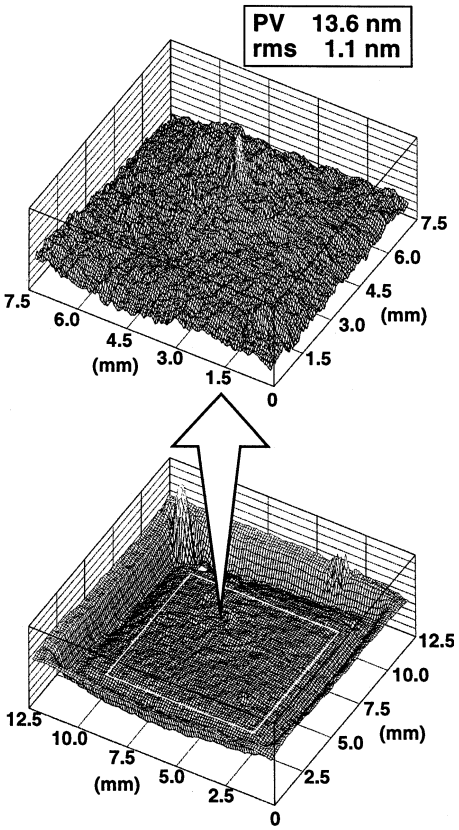

Figure 1. Surface oblique profile of a 11-mm square SiC membrane coated with 20.5 layer pairs of Mo/Si. The central 7.5-mm square has a flatness of 1.1 nm (rms).

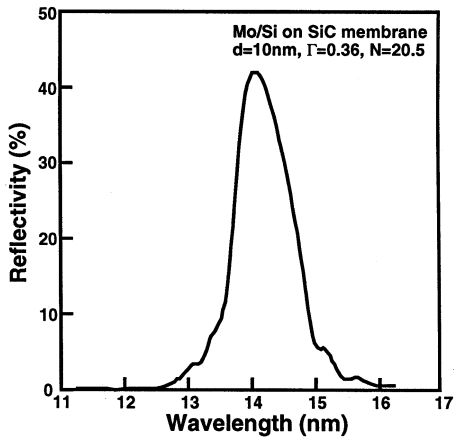

Figure 2. Reflectivity curve of the multilayer shown in Fig. 1. The reflectivity was measured at 45° from the surface.

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