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Ion Beam Polishing of Si in W/Si Multilayer X-Ray Analyzers

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Abstract : Multilayer structures are used as spectroscopic elements in fluorescence analysis. These serve the purpose of analyzing soft x-ray emission spectra of materials upon excitation by x-rays or electrons. The analysis then allows quantitative determination of the x-ray emitting elements in the materials. Shorter wavelength range for this application, below 2.5nm, can be covered by using short period multilayers, with a period of 2.5 nm and lower. Thus the detrimental effect on the reflectivity of morphological roughness between materials of the multilayers becomes increasingly pronounced. Ion beam polishing was previously shown to be effective in reducing roughness in some multilayer systems with Si. In this work, we explored W/Si multilayers with the period of 2.5 nm. Si layers were polishing by Ar ions, employing low energy ions, 100 and 80 eV, with the etched Si thickness being in the range 0.1 to 0.5 nm. CuK X-ray diffuse scattering measurements revealed a significant reduction in the diffused scattering in the polished multilayers. However, Grazing Incidence CuK X-ray showed only a marginal reduction of the overall roughness of the systems. Still, measurements of the structures with Grazing Incidence Small Angle X-ray scattering indicated that the vertical correlation length of roughness was strongly reduced in the polished multilayers. These results together suggest that polishing results in the reduction of the vertical propagation of roughness from layer to layer, while only slightly affecting the overall roughness. This phenomenon can be explained by ion-induced surface roughening inherently present in the ion polishing methods. Alternatively, ion-induced densification of thin Si films should also be considered. Finally, the reflectivity of 40% at 0.84 nm at grazing incidence of 9 degrees has been obtained in this work for W/Si multilayers. Analysis of the obtained results is expected to lead to further progress in reflectance.

Keywords : interface roughness, ion polishing, multilayer structures, W/Si
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