X-Ray Studies of the Roughness of Thin Films

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In the present work we are performed X-ray investigations (at the wavelength of 0.154 nm) of individual thin films of materials widely used in fabrication of soft X-ray and UV multilayer mirrors (carbon, tungsten, barium fluoride, aluminium oxide) in order to determine the law of variation of the external surface microrelief as well as its interrelation with the substrate roughness during film growth.

Our approach to the study of thin film roughness consists in the direct determination of all three power spectral density functions (which are Fourier transformation of correlation functions) from a set of X-ray scattering diagrams measured at different grazing angles of the probe beam without any assumptions about the film growth. The results of X-ray scattering measurements are confirmed by independent measurements of roughness of uncoated substrate and external film surface with the use of atomic force microscopy.

The X-ray scattering method is demonstrated to enable the quantitative determination of the correlation between the substrate and film roughnesses as well as parameters of additional roughness arising during the deposition process. The obtained results show that the low-frequency Fourier harmonics of the substrate microrelief transfer with the coefficient close to 1 during the film growth, while the high-frequency harmonics are conditioned only by the stochastic nature of the film deposition process. In other words, the long-period microroughness of the film and the substrate are in correlation with each other, and the short-period ones are statistically independent.