Interface Engineering of Short- and Ultrashort Period W-Based Multilayers for Soft X-Rays

Authors : A. E. Yakshin, D. Ijpes, J. M. Sturm, I. A. Makhotkin, M. D. Ackermann

Abstract : Applications like synchrotron optics, soft X-ray microscopy, X-ray astronomy, and wavelength dispersive X-ray fluorescence (WD-XRF) rely heavily on short- and ultra-short-period multilayer (ML) structures. In WD-XRF, ML serves as an analyzer crystal to disperse emission lines of light elements. The key requirement for the ML is to be highly reflective while also providing sufficient angular dispersion to resolve specific XRF lines. For these reasons, MLs with periods ranging from 1.0 to 2.5 nm are of great interest in this field. Due to the short period, the reflectance of such MLs is extremely sensitive to interface imperfections such as roughness and interdiffusion. Moreover, the thickness of the individual layers is only a few angstroms, which is close to the limit of materials to grow a continuous film. MLs with a period between 2.5 nm and 1.0 nm, combining tungsten (W) reflector with B_4C, Si, and Al spacers, were created and examined. These combinations show high theoretical reflectance in the full range from C-Kα (4.48nm) down to S-Kα (0.54nm). However, the formation of optically unfavorable compounds, intermixing, and interface roughness result in limited reflectance. A variety of techniques, including diffusion barriers, seed layers, and ion polishing for sputter-deposited MLs, were used to address these issues. Diffuse scattering measurements, photo-electron spectroscopy analysis, and X-ray reflectivity measurements showed a noticeable reduction of compound formation, intermixing, and interface roughness. This also resulted in a substantial increase in soft X-ray reflectance for W/Si, W/B4C, and W/Al MLs. In particular, the reflectivity of 1 nm period W/Si multilayers at the wavelength of 0.84 nm increased more than 3-fold – propelling forward the applicability of such multilayers for shorter wavelengths.

Keywords : interface engineering, reflectance, short period multilayer structures, x-ray optics
Conference Title : ICTFTA 2024 : International Conference on Thin Film Technology and Applications
Conference Location : Amsterdam, Netherlands
Conference Dates : November 04-05, 2024