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Quantitative Transmission Electron Microscopy of Multilayer Coatings for X-ray Optics

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Abstract – Multilayer coatings with optimized properties are essential components in advanced X-ray analytical equipment and in X-ray optics for synchrotron beam lines. Cross-section transmission electron microscopy (TEM) enables analysing the decisive structure parameters and is indispensable for controlling the layer deposition and assessing the X-ray reflectivity properties.

Periodic and aperiodic multilayer systems consisting of ultrathin bilayers on the nanometer scale constitute the basis of advanced X-ray optical components, such as monochromators of small or large spectral bandwidth, components for shaping high-intensity X-ray beams with highest reflectivities, or mirrors for light sources with an active optical length of more than 1 meter. Modern thin film deposition technologies allow to fabricate multilayers with reproducible control of layer thickness and resulting excellent reflectivity properties. High-angle annular dark-field scanning TEM (HAADF-STEM) and high-resolution TEM (HRTEM) imaging of multilayer cross-sections, combined with analyses of image intensity profiles and with the geometric phase analysis (GPA) method, enable to characterise the multilayer interfaces and to locally determine the bilayer and the single layer thickness with high precision. Comparisons with nominal deposition and with thickness values derived from X-ray reflectivity scans show very good agreement.

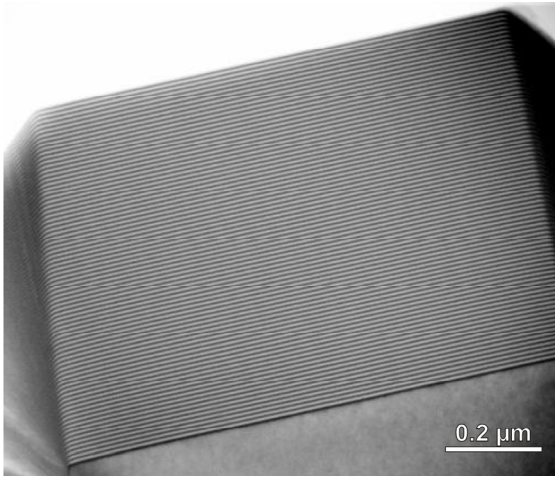

Figure 1: Periodic La/B_4C multilayer coating (80 bilayers) on a silicon grating. Cross-section high-resolution TEM micrograph of the multilayer coating on the Si top region [1].

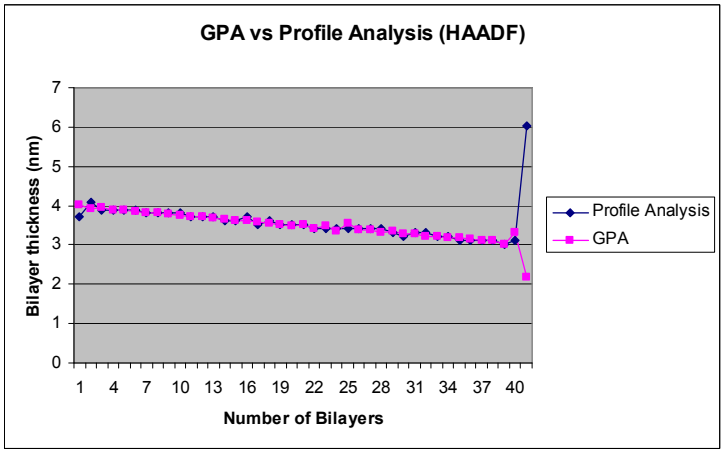

Figure 2: Local bilayer thickness of an aperiodic W/B4C multilayer gradient coating. HAADF-STEM image analyses by GPA method and by image intensity profile method [5].

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