Characterizing Nanoscale Thin-Film Residual Stresses For Stress Mitigation And Engineering in Next Generation X-Ray Optics

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Reflection gratings are critical components to successful X-ray spectroscopes and represent important priorities for future NASA observatories. As such, significant research efforts have been invested to improve mirror and grating fabrication, resulting in increased collecting area and improved mirror performance. However, residual stresses induced by reflective coatings continue to present challenges, causing mirror deformation, degradation of spectral resolution, and decreased scientific performance. Though macro stresses on thicker layers are more easily calculated, localized stress distributions and the stress response of nanoscale layers (5-30nm) are not well understood and can be difficult to measure. This study demonstrates synchrotron XRD methods using the $\sin^2\psi$ technique to better characterize and minimize the stress of single and bi-layered nanoscale reflective layers (5-30 nm) for applications in X-ray optics. Residual stresses are spatially mapped across an optic and analyzed at different deposition conditions. High-Z materials (Pt, Au) have been chosen for this study due to their favorable reflectivity over wavelengths of interest in the soft X-ray regime.