Techniques for achieving zero stress in thin films of iridium, chromium, and nickel

[a]David M. Broadway, [a]Stephen L. O'Dell, [a]Brian D. Ramsey, and [b]Jeffrey Weimer.
[a]NASA Marshall Space Flight Center, Huntsville, AL 35812, USA
[b]University of Alabama in Huntsville, Department of Material Science, Huntsville, AL 35899, USA

ABSTRACT

We examine techniques for achieving zero intrinsic stress in thin films of iridium, chromium, and nickel deposited by magnetron sputter deposition. The intrinsic stress is further correlated to the microstructural features and physical properties such as surface roughness and optical density at a scale appropriate to soft X-ray wavelengths. The examination of the stress in these materials is motivated by efforts to advance the optical performance of light-weight X-ray space telescopes into the regime of sub-arcsecond resolution through various deposition techniques that rely on control of the film stress to values within 10-100 MPa. A characteristic feature of the intrinsic stress behavior in chromium and nickel is their sensitivity to the magnitude and sign of the intrinsic stress with argon gas pressure and deposition rate, including the existence of a critical argon process pressure that results in zero film stress which scales linearly with the atomic mass of the sputtered species. While the effect of stress reversal with argon pressure has been previously reported by Hoffman and others for nickel and chromium, we report this effect for iridium. In addition to stress reversal, we identify zero stress in the optical functioning iridium layer shortly after island coalescence for low process pressures at a film thickness of approximately 35nm. The measurement of the low values of stress during deposition was achieved with the aid of a sensitive in-situ instrument capable of a minimum detectable level of stress, assuming a 35nm thick film, in the range of 0.40-6.0 MPa for <111> oriented crystalline silicon substrate thicknesses of 70-280 microns, respectively.

Key words: X-ray space telescopes**,** soft X-ray optical coatings, in-situ measurement of film stress, thin film characterization

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