Reduction of stress and roughness by reactive sputtering in W/B_4C X-ray multilayer films

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ABSTRACT

We have investigated the stress and roughness in W/B_4C X-ray multilayer films grown by reactive DC magnetron sputtering in a nitrogen-argon gas mixture. We have also studied the properties of single-layer W and B_4C films, in order to understand specifically how the stress, roughness, chemical composition and microstructure in these materials depends on the sputter gas composition. We find that the stress and roughness in both single-layer and multilayer films deposited reactively is reduced substantially; we find a corresponding improvement in X-ray performance in the case of multilayer films designed to operate at X-ray energies for which the incorporation of nitrogen will not adversely affect the optical properties of these coatings. Furthermore, the observed reduction in film stress in these coatings will mitigate stress-driven adhesion failures. In the case of single-layer W films, the observed reduction in stress and roughness is correlated with a change in microstructure: the W film is amorphous when deposited reactively (and contains ~12–25% incorporated N, depending on the sputter gas composition), versus polycrystalline when deposited in pure argon gas. Finally, we find extremely low surface roughness in reactively-sputtered films of amorphous B_4CN_x; thus, in addition to their use in X-ray multilayer reflective coatings, these films can be used as smoothing layers to reduce the surface roughness of X-ray mirror substrates, thereby leading to reduced scattering and higher specular reflectance.