Stress and Intermixing in Mo/Si Multilayers

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Abstract

Mo/Si multilayers are promising candidates as mirrors for extreme ultraviolet (EUV) lithography. One of the technological hurdles presented by this system is the large residual compressive stress, $\sim$ -350 MPa, which causes undesirable distortion of the precise optical figures in the underlying substrates. *In-situ* stress monitoring during growth of sputtered Mo/Si multilayers shows large tensile and compressive curvature transients in the initial stages of growth of Mo on Si and Si on Mo, respectively. Intermixing at the interfaces by an asymmetric diffusion mechanism in which Si is the active diffusion species may be responsible for this observed behavior. Evidence to this effect was obtained by measuring a correlation between the degree of intermixing (determined by x-ray diffraction) and the size of the curvature transients in a series of Mo/Si multilayers grown with different sputtering pressures. Although it is possible to deposit multilayers with low residual stress by increasing the sputtering pressure, in applications such as EUV mirrors, Mo/Si multilayers must be deposited with the lowest possible working pressure to ensure low roughness and high reflectivity. Preliminary results show a marked reduction of residual stress in multilayers sputtered with low-pressure Kr compared to conventional Ar sputtering; while high reflectivity is retained for small-angle scattering using Cu K_α radiation, multilayers sputtered with Kr exhibit a suppression of the compressive curvature transient that is associated with deposition of Si on Mo. The average stress in the multilayer is therefore more tensile. The microstructure and interface nature of Kr-sputtered Mo/Si multilayers will be discussed in the context of intermixing as the source of the curvature transients.