Stress Evolution in Mo/a-Si Multilayers for High-reflectivity EUV Mirrors

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Abstract

The continued shrinking of microelectronic device size requires advances in lithography, including possibly using extreme ultra-violet (EUV) light. This requires advances in the level of surface finish and shape precision for optical elements and development of high reflective coatings for this wavelength ($\sim$ 130 Å). The Mo/a-Si multilayer system is a promising candidate for this application due to its large electron density contrast and flat, smooth layering. However, these multilayers exhibit high stresses when deposited to optimize EUV reflectivity causing unaccceptable distorsion of the optical element. Stresses in these multilayers may develop due to interfacial alloying, atomic peening, and the effects of surface and interfacial energies.

As a first step towards understanding and possibly eliminating the stress we monitor the stress evolution during and after growth. Stress evolution during growth is obtained from in-situ substrate curvature measurements using a multiple parallel laser beam technique. Our preliminary results show well-defined stress modulation during deposition. Large changes in substrate curvature were measured during the early stages of deposition of the individual layers, with Mo exhibiting apparent tension and Si exhibiting apparent compression. These curvature changes were of approximately equal magnitude, resulting in near-cancellation of the apparent stress. The effects of deposition rates and parameters such as sputtering pressure and carrier gas species will be discussed. Values for interfacial roughness and interdiffusion are obtained by fitting a numerical model to superlattice diffraction patterns obtained by small angle x-ray scattering.