Phase transitions at enhanced temperatures in Mo/Si multilayers

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Mo/Si multilayers, with layer thicknesses of 3-5 nm, are currently being developed as reflective coatings for the optics of Extreme Ultraviolet Lithography (EUVL) systems. Such optics require high thermal stability to resist structural changes under extremely high photon fluxes. The stability of Mo/Si multilayers was investigated by sequential annealing treatment. The changes at Mo/Si interfaces were determined by grazing angle and wide angle X-ray diffraction (XRD). A detailed analysis of structural changes at Mo/Si interfaces is presented for multilayers with Mo ratios in a period in the range 0.1-0.8. The multilayer thickness decreases during annealing due to additional intermixing of bulk constituents at interfaces. For all multilayers that still contain bulk Mo and Si, a phase transition occurs at temperatures higher than 330°C. The activation energy and interdiffusion coefficient at this temperature indicate the diffusion of Si into a Mo_xSi_y compound[1]. We present results that clearly identify the recrystallization of the multilayer during the phase transition.
The thermal stability can be improved by using diffusion barriers at Mo/Si interfaces. Using carbon as a diffusion barrier, we show that the phase transition can be postponed towards much higher temperatures, increasing the thermal stability.

1. Rosen et al, Applied Optics, 32, no. 34, 6975-6980 (1993):

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