Reduction of residual stress in EUV Mo/Si multilayer mirrors with post-deposition thermal treatments

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Abstract

The as-deposited stress of typical high-reflectance extreme ultraviolet (EUV) Mo/Si multilayer mirrors was measured to be approximately –410±10 MPa (compressive). These multilayers were deposited by DC-magnetron sputtering and had near-normal incidence (5) reflectances of 67.2±0.1% around 13.2 nm. The effect of both slow and rapid thermal treatments upon multilayer stress and reflectance was measured. For both annealing approaches used, the stress of these multilayers was reduced quasi-linearly with the annealing temperature. Using the slow thermal anneal approach, it is possible to reduce the stress from -410 MPa to zero by heating the sample to ~275 C and the corresponding reflectance drop is ~3.5% (absolute). If preserving the reflectance is critical, it is shown that heating the sample to ~220 C reduces the stress by 85% from -407 MPa to -63 MPa with a reflectance drop of only ~1.5% (absolute). Therefore, it appears possible to "tune" the stress of an EUV Mo/Si multilayer mirrors with this post-deposition annealing technique and predict the cost in reflectance for any given desired final stress. Moreover, it seems that the relationship between the reflectance loss and the stress change does not depend on the type of thermal treatment, i.e., it is the same for both the slow and rapid thermal annealing technique.

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