Morphology and Oxidation of U/Al, UN/Al, Al/Si, and B4C/Si Multilayer Thin Films

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Recently we found that the reflectivity of a U/Al multilayer EUV mirror constructed for normal incidence reflectance of the He+ line (304 Ang) was less than 50% of that calculated. The three main causes for loss of reflectance are: non-uniformity in multilayer thickness, interfacial and surface roughness, and the changing of optical constants because of oxidation. Using TEM, AFM, and AES we examined the uniformity, roughness, and oxidation of multilayer stacks of U/Al, UN/Al, Al/Si, and B4C/Si and monolayers of U and UN. It was found that multilayers of U/Al were totally oxidized to a depth of about 100 angstroms after a few weeks in air. It was also found that approximately 10-20 angstroms of Al_2O_3 was present at the U-Al interfaces. These are serious problems for those portions of the spectra where oxygen is highly absorbing. The majority of our loss in reflectivity of the U/Al stack can be attributed to the oxygen present in the film. Uranium nitride was chosen as a potential multilayer material because it is less susceptible to oxygen than pure uranium, and has a higher melting point (2900 K vs 1400 K). However, it was found that UN/Al stacks were about three times as rough. Using TEM we were able to see that the UN exhibited a ordered polycrystalline growth, while U was mostly amorphous. The crystalline structure of the UN is a probably cause for its greater roughness.