THE FABRICATION OF SHORT PERIOD MULTILAYERS FOR X-RAY MIRROR APPLICATIONS.

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Abstract

The fabrication of short period multilayers for X-ray mirrors with periods in the region of 1 to 2nm still represents a considerable technical challenge. It is known theoretically that few elemental combinations can be envisioned which will give high reflectivities at these wavelengths, particularly at normal incidence. Starting with this poor prospect, the problems of interface roughness and interface mixing both conspire to make the fabrication of ideal multilayers difficult. In this paper the issues associated with these apparently insurmountable problems are addressed and an attempt is made to define routes to further improve the performance of existing multilayers.
As the period of a multilayer is reduced from tens of nanometers to these extra short periods the interface sharpness increasingly becomes important. A compromise must be reached as far as the mutual miscibility of the layers used. One expects the sharpest composition gradients for immiscible layers, however at the extreme such layers are likely to wet one another so poorly that small islands tend to form as one layer is grown on another and this leads to an inherent roughness. If, on the other hand, the elements of the layers are miscible which results to good wetting of one layer on the next, there will also be a tendency for the interface mixing. A second similar compromise is usually made in terms of the energetic atom or ion bombardment which promotes surface mobility and smoothness. High bombardment (or ion polishing) promotes surface smoothness and adatom mobility, however such bombardment is also likely to produce subplantation effects and intermixing of the surface and sub-surface layers.
These issues are discussed in general terms with part reference to our own work on magnetron sputtered multilayers with periods in the 1-3nm range based on the model systems W/Ti, W/Si, W/C and the all amorphous system a-TaIr/a-TiNi. Detailed studies have been made of resputtering phenomena. Speculations will be made for research routes to further improve the reflectivity performance of these multilayers.