In situ Analysis in the Annealing of Multilayers

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The different possible pairs of materials that could make a x-ray multilayer are more often chosen not only for the maximum theoretical reflectivity but also take into account a number of other factors such as the ease of deposition, the roughness of the layers deposited, the extent of their chemical compatibility/interface, and particularly in the case of high heat loads from synchrotron radiation, their thermal stability. In situ grazing incidence dispersive x-ray reflectometry and optical ellipsometry have been used to study the structural changes occurring during the annealing of x-ray multilayers. In particular, tests on W/Si, W/SiC and Ta/Si multilayers were carried out at specific temperatures below 700^0C; multilayers of both thin ($\sim$30Å) and thick ($\sim$160Å) d-spacings were studied. The samples analysed were deposited using a method based on microwave-generated Distributed Electron Cyclotron Resonance (DECR) plasma sputtering; the physical properties of the layers closely resembled those of the bulk.

The reflectometer used in these experiments has been previously described in its use as a study of the growth of multilayers. It consisted of a copper anode tube with a Si220 Johansson crystal in a Rowland circle configuration to focus Cu-K_α x-rays on to the sample. A position sensitive detector comprising a phosphor plate/image intensifier and a CCD sensor enabled a grazing incidence x-ray measurement of the sample to be continuously made (without any scanning motion) over an angular range of $0 - 2.5^0$. Measurements were simultaneously performed using a commercially-available optical ellipsometer with an energy range from $2 - 5$eV; information regarding the surface characteristics of the multilayers was revealed.

The studies on the thin period multilayers were particularly sensitive to variations of the first Bragg peak. In general, it was found that the thermal stability of the W/SiC was vastly superior to that of the W/Si and Ta/Si multilayers besides exhibiting a smaller shift in period. Moreover, whilst an overall drop in peak reflectivity was observed for the W/Si and Ta/Si multilayers, the reflectivity of the W/SiC was found to increase slightly at higher temperatures. In the case of the larger period samples, the possibility of observing upto six Bragg peaks with the reflectometer allowed the interdiffusion of the layers at the interface to be precisely measured at each temperature. The corresponding rate of diffusion between the layers is discussed with respect to the physical and chemical properties of the materials.

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