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Surface Induced Alteration of Nanosized Amorphous Alumina

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Abstract : Various nanosized amorphous alumina thin films in the range of (2.4 - 63.1) nm were deposited onto amorphous carbon and amorphous Si3N4 membrane grids. Transmission electron microscopy (TEM), electron energy loss spectroscopy (EELS), X-ray photoelectron spectroscopy (XPS) and differential scanning calorimetry (DSC) techniques were used to probe the size effect on the short range order and the amorphous to crystalline phase transition temperature. It was found that the short-range order changes as a function of size: the fraction of tetrahedral Al sites is greater in thinner amorphous films. This result correlates with the change of amorphous alumina density with the film thickness demonstrated by the reflectivity experiments: the thinner amorphous films have the less density. These effects are discussed in terms of surface reconstruction of the amorphous alumina films. The average atomic binding energy in the thin film layer decreases with decease of the thickness, while the average O-Al interatomic distance increases. The reconstruction of amorphous alumina is induced by the surface reconstruction, and the short range order changes being dependent on the density. Decrease of the surface energy during reconstruction is the driving force of the alumina reconstruction (density change) followed by relaxation process (short range order change). The amorphous to crystalline phase transition temperature measured by DSC rises with the decrease in thickness from 997.6°C for 13.9 nm to 1020.4 °C for 2.7 nm thick. This effect was attributed to the different film densities: formation of nanovoids preceding and accompanying crystallization process influences the crystallization rate, and by these means, the temperature of crystallization peak.

Keywords : amorphous alumina, density, short range order, size effect
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