Dynamic Scaling at Initial Stage of a Film Growth

The main aim of the experiments proposed was to try to understand what is important for further development of the scaling concept and determination of the boundary of its universality. With this purpose the dependence of scaling exponents on the substrate roughness; substrate material and deposition technology were investigated. Reflectivity of Al_2O_3 films were measured at the BM5 beamline of the ESRF. The particular experimental diagnostic based on grazing incidence X-ray reflectometry available at the BM5 beamline of the ESRF as well as computer software specially developed for the roughness analysis at the BM5 were used. The XRS measurements was done at an energy of 17.5 keV using a double-crystal Si (111) monochromator. To monitor the total intensity of the reflected beam a scintillator was used and a 2D detector was used to collect the scattered beam. In the case of the in-situ experiment both the reflectivity variation as a function of deposition time and the XRS diagrams were recorded to infer the Al_2O_3 deposition rate and the film density.

To study the film structure depending on deposition technology, the experiment was done for Al_2O_3 films grown by two different technologies. We compared the Al_2O_3 films synthesized by Atomic Layer Deposition (ALD) and grown using magnetron sputtering. The following experiments have been carried out: 1) post-situ study of roughness evolution of a film fabricated on Si substrate by ALD method; 2) in-situ study of roughness evolution of a sputtered film. Al_2O_3 layers were grown at room temperature using rf magnetron sputtering in pure Ar gas on the Si substrate that was used in film fabricated by ALD method. In both cases the estimated thickness of the films was ~28 nm. In the case of in-situ experiment the film thickness was controlled by monitoring the X-ray reflectivity versus time. To get an additional information about subsurface layers structure of the Al_2O_3 film fabricated by ALD method, we carried out ion etching of the film. The analysis of the reflectivity measured before and after ion etching shows differences between curves in the range of small angles that indicates the existence of adhesion layer consisting of molecules of water, hydrocarbons, oxygen, etc. on the sample surface.

To observe the difference in growth dynamic in dependence of substrate roughness and of substrate material, the films were deposited by magnetron sputtering on the Si substrates of different roughness and on glass substrate. All substrates were investigated carefully (both the reflectivity and the scattering were measured) before sputtering process. To infer the Al_2O_3 deposition rate and the film density the reflectivity variation as a function of deposition time and the XRS diagrams were recorded. The scattering diagram at the 0.25^o grazing angle of a probe beam was recorded by 2D detector. The grazing angle of the probe beam was set to 0.25^o, i.e., out of the range of total external reflection of Al_2O_3 film and substrate material. In this case the PSD-function of external film surface and the PSD-function describing vertical correlation (conformity) of the film and the substrate roughness can be extracted from a single scattering diagram.

Today quantitative analysis of the whole set of experimental data are performed to determine a structure of films studied.