Investigation of the Morphology of Surface Nanostructures by Means of the Synchrotron Radiation Based High-Resolution GEXRF Technique

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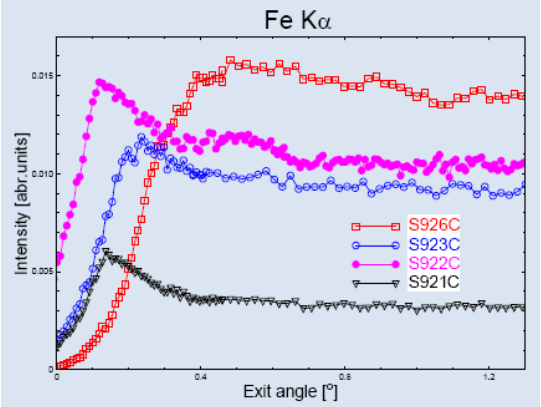
Surface nanostructures are recognized as promising objects for fabrication of semiconductor devices having desired optical, electronic and magnetic properties [1]. Investigation of nanostructures' surface morphology is of great importance for semiconductor nanotechnology, in particular, when it can be combined with the measurements of the lateraland depth- distribution of atoms deposited on the surface. In this respect, the synchrotron radiation based high-resolution grazing emission x-ray fluorescence (GEXRF) technique [2-5] offers new perspectives. Indeed, the novel high-resolution GEXRF method was found to be highly-sensitive to low-level surface impurities on silicon wafers including their lateral 2D mapping and depth profiling [2,3].

We report on the application of the high-resolution grazing emission x-ray fluorescence technique to the surface morphology study of ultra-thin layers deposited on silicon wafers. A set of deposited on Si substrates thin films (1-20 nm) of MgO, Al, Cr and Fe of different morphologies, namely, from well separated islands to a fully covering layer was investigated. The experiment was performed at the ESRF beam line ID21 using the von Hamos Bragg-type bent crystal spectrometer for the high-resolution x-ray fluorescence detection [6]. The Kα x-ray fluorescence lines of Mg, Al, Cr and Fe were measured as a function of the grazing emission angle around the critical angles φ_c (~1°). For such grazing emission angles the fluorescence from the substrate is limited to a very shallow (few tens of nm) near surface layer and is therefore significantly reduced [4,7]. This results in a high-sensitivity detection of the deposited layer. Since φc is well defined only for flat surfaces, the intensity of the x-ray fluorescence lines observed in its vicinity is strongly dependent on the surface morphology. The information on the surface morphology and element distribution was obtained by comparing the measured GEXRF angular distributions to calculations following Ref. [4]. The potential of the synchrotron radiation based high-resolution GEXRF method to study the morphology of surface nanostructures could be demonstrated.



Measured intensities of the Fe-Kα fluorescence line versus the grazing emission angle for the deposited on Si substrates thin films of Fe of different morphologies.

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