Complete characterisation of a multilayer coated reflection grating by atomic force microscopy (AFM), X-ray diffraction (XRD) and grazing incidence X-ray fluorescence analysis (GIXRF)

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In order to characterise the profile used in diffraction gratings none-destructively one usually refers to scans being made by use of atomic force microscopes (AFM). By this means, which can register only the surface topography, one will not obtain information about the buried interfaces and the substrate. In order to overcome this shortcomings, we thus subjected a reflection grating none-destructively to an X-ray beam in grazing incidence conditions in order to learn, which additional information can be obtained by combining angularly resolved Grazing Incidence X-ray fluorescence spectroscopy (GIXRF), X-ray reflectivity (XRR) and Grazing incidence X-ray diffraction. The layering in a thin film system can give rise to an X-ray standing wave perpendicular to the surface, by which a depth profiling of the constituents of the film system is possible.

A grating with laminar profile was coated with a single gold layer, which was partly overcoated with a 10 period W/C multilayer. The experiment was run at the X-ray fluorescence beamline at Elettra, where the manipulator in the vacuum diffractometer permits to vary the angle of grazing incidence very precisely, while the reflected signal and the energy-dispersed fluorescence from the layer system can be registered. In addition the grating could also be rotated around its pole, so that the plane of incidence can be oriented freely with respect to the grooves. In the most commonly used configuration this plane of incidence cuts through the grooves, while it can also be oriented parallel to the grooves. In the latter case a laminar grating becomes of system of tiny plane mirrors. In this case, when the trajectory of the probing beam is parallel to the grooves with rectangular profile, nevertheless diffraction will be observed as the structure is periodically disturbing the incident wavefield. Then the diffracted intensity will be found on a cone symmetrically oriented around the plane of incidence. And as one would intuitively expect the totally diffracted intensity should be identical to the reflectivity of a plane mirror with the same coating. And likewise one should not be able to distinguish the angularly resolved GIXRF from that of the plane mirror. This is infact observed and indicates thus the successful realization of the groove profile with the indicated shape.

When now the grating is rotated around its pole such that the beam trajectory is inclined with respect to the grooves, then the fluorescence intensity from buried layers should exhibit significantly different angularly dependent behaviour. This is observed and it will be shown that the now more structured angular dependence is in agreement with predictions employing geometrical ray-tracing calculations. X-ray diffraction data confirm the layering of the system as deduced from the previously described experiments.