Thin film based Optical Elements for Analytical X-ray Applications

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In this contribution we will be giving an overview on current developments of multilayer optics used for diffractometer instrumentation in the home-lab. We will be explaining the manufacturing process of the optics, summarizing the different types of optics and giving some examples of typical applications which benefit from the new possibilities, especially in combination with modern microfocus X-ray sources.

In the home-lab multilayer based Montel Optics are widely used as an essential component in modern X-ray diffractometers. These optics consist of bent substrates with shape tolerances below 100 nm, upon which multilayers are deposited with single layer thicknesses in the nanometer range and up to several hundreds of layer pairs. The multilayers are designed with lateral thickness gradients within ± 1% deviation of the ideal shape. Very low shape tolerances below 100 nm and figure errors below 5 arcsec are required for multilayer mirrors to ensure a superb flux density of up to several 10^{11} photons/s/mm^2 in combination with high-brightness microfocus X-ray sources, such as the air-cooled Incoatec Microfocus Source IµS or novel liquid metal jet X-ray sources. We use magnetron sputtering technology for deposition, optical profilometry in order to characterize the shape and X-ray reflectometry in order to characterize the multilayer thickness distribution both laterally and as in-depth. For X-ray analytics the important beam parameters are monochromaticity, flux, brilliance and divergence. They demonstrate the quality of the combination of suitable X-ray sources with selected multilayer optics.

We will be showing some applications measured by diffractometers equipped with an IµS. The IµS is a low power air cooled X-ray source and is available with Cr, Co, Cu, Mo, and Ag anodes. The implemented multilayer optics form either a highly collimated beam with a low divergence (below 0.5 mrad) or a focusing beam with higher divergence (up to 10 mrad) and very small focal spots (diameter below 100 µm).

Applications realized with an IµS are small-angle X-ray scattering, texture, stress analysis, µ-diffraction, single crystal diffraction to name but a few.
In our presentation we will be presenting how multilayers can be characterized in-situ during their deposition by the method of grazing incidence small-angle X-ray scattering (GISAXS). This kind of experiments was done only at synchrotrons. With an IµS it becomes feasible in the home-lab.