

Hard X-ray reflectivity and scattering study of supersmooth surfaces and thin films in Moscow X-Ray Optics Group.

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X-ray reflectometry and scatterometry are widely recognized methods to inspect and characterize thin film parameters and smoothness of interfaces in single and multi layer structures. Two approaches and two types of instruments have been developed and used for this purpose in Moscow X-Ray Optics Group. The first is based on a conventional two crystal scheme of a diffractometer with monochromatization of the CuK_α beam incident onto a sample. The reflected and scattered intensity are recorded to extract the thin film characteristics and PSD functions of surfaces and interfaces. The software uses the perturbation theory in respect to the height of microroughness applied to isolated interface or to a film on a substrate. Supersmooth substrates provided by more than ten manufacturers have been certified with this instrument. The sensitivity allows to measure microroughness down to 1Å height. The results are compared with those of other groups obtained by AFM and scattering at 345 nm and 4.4 nm.

The second approach is probing of a sample and recording the reflected and scattered signals at two wavelengths CuK_α and CuK_β simultaneously. The key element of the measurement scheme is a thin pyrolytic graphite plate working as a semitransparent beam splitter. The two-wavelength mode provides larger amount of experimental data, increases reliability of results and also offers new measurement opportunities. The ratio of CuK_α and CuK_β intensities is very helpful to characterize small area samples and the samples with complex or irregular shape. Parts of samples' area modified chemically or by ion implantation can also be characterized. The possibility to measure the PSD function of curved surfaces is revealed. The two-wavelength instrument is designed and constructed as an upgrade to a commercial diffractometer. The results of application to multilayers and nanostructures used in X-ray optics and solid state physics are presented.