X-ray reflectometry of thin films: possibilities and perspectives

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The X-ray reflectometry technique considered here consists of measuring and analyzing the reflectance of a thin film versus grazing angle and the angular distribution of radiation scattered by roughness. This is a unique method for studying matter both in depth (stratified inhomogeneities) and in the lateral direction (roughness) with sub-nanometer resolution.

Current possibilities and future perspectives of X-ray reflectometry for studying the 3D structure of thin films are examined. In particular, the following topics are discussed:

- Relation between the Distorted Wave Born Approximation method and the perturbation theory on the roughness height [1]. Discussion on the suitability of these methods for the analysis of roughness.
- Unique determination from a single scattering diagram of the two Power Spectral Density functions (PSD_{ff} and PSD_{sf}) characterizing the topology of a thin film deposited on a substrate [2, 3].
- In situ X-ray reflectometry of a growing/eroded film: determination of the scaling exponents, experimental determination of data collapse for the PSD-functions, establishment of a (nonlinear) differential equation describing the process of film growth/erosion derived directly from experimental data, variation of the roughness conformity with film growth/erosion, exact solution of the phase problem [2-8].
- Inverse problem of X-ray reflectometry, i.e., reconstruction of the dielectric constant profile from reflectivity curve measurements [9]. Discussion on the possibility to determine, from reflectivity measurements, the depth-distribution of the atomic concentration of chemical elements composing a structure.
- Self-consistent approach to study the 3D morphology of a thin film, i.e., determination of the roughness parameters and reconstruction of the depth-distribution of the dielectric constant at once [10].

The results presented are based on a series of experiments performed at the BM5 beamline of the ESRF.

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