Thin Films Characterization using Fast Data Acquisition at DiffAbs Beamline (Synchrotron SOLEIL)

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Characterizing the internal (micro)structure and the crystallinity of thin films of nanometric thickness and / or nanostructures is of major importance since a significant part of their properties are tightly related to them. Beyond the film thickness, parameters like the degree of crystallinity and the texture (information on the preferential orientation of crystallites) are meaningful to be addressed and to be quantified, since they (can) have a marked influence on the anisotropic physical properties of materials in general, or thin films (electrical, magnetic and/or mechanical).

Several experimental approaches will be detailed here, making use of the bright x-ray beams available at synchrotrons, the availability of high dynamics low noise fast area detectors, all these coupled with on-the-fly data acquisition. Collecting extended datasets for scattering angles in an angular domain of several 10° can be performed for nm-thick films in times as short as few minutes [1, 2]:

- Film thickness, roughness and density can be inferred from X-ray reflectivity measurements.
- Epitaxial thin films and structures can be characterized in detail by 3D mapping of reciprocal space volumes around Bragg diffraction peaks.
- Texture observation and quantification can be performed by measuring Bragg x-ray diffraction peak(s) intensity as a function of the sample orientation, *i.e.* the so-called pole figures.

The acquired data can also be rapidly converted for visualization and (pre-)analysis, and several 'filtering' procedures can be applied, in order to highlight (during the experimental campaign) the interesting situations for a more detailed investigation (for ex. new crystalline phases, modification or appearing of new / specific textures, …). This optimized experimental approach implemented on DiffAbs beamline (Synchrotron SOLEIL) will be detailed, together with some examples, to illustrate the wealth of information obtained.

Compared to the classical data acquisition schemes, a gain of at least 2 decades in the acquisition time is obtained. The rapidity of the method makes it adapted for systematic studies of a large number of samples, or to build trends by varying one or several characteristic parameters (composition, temperature, actuation, …). Moreover, accessing a broader scattering angle domain, a precise knowledge of the sample crystallinity is not a pre-requisite; studies of new crystalline phases or phase transformation, including the appearing of transitory phases, are thus also feasible. This approach opens thus the path for an in-depth materials characterization, including *in situ* or *operando* studies.

References

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2. E. Solano *et al.*, Thin Solid Films **638**, 105 (2017).

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