MS24 3D electron diffraction

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3D ED on epitaxial thin films

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Abstract

Using strain engineering, metastable phases can be stabilized in the form of epitaxial thin films. Besides their intrinsically small diffracting volume, these films are clamped onto a thick crystalline substrate that significantly complicate their analysis by X-ray diffraction methods and usually prevents any structure determination of unknown complex phases stabilized in the form of thin films. Over the past decade, 3D Electron Diffraction (3D ED) [1] and, in particular, precession-assisted electron diffraction tomography (PEDT) has proven to be a powerful tool to address this challenge. To introduce the topic and the method, some results obtained on a series of Bismuth-based films [2,3] will be briefly outlined.

While challenging, the determination of unknown structures does actually not represent the primary need for epitaxial thin films. In most cases, the deposited materials have a known structure. The question is not to solve the structure but to know how it differs from a reference structure (bulk). In a second part, we will address the accurate structure refinement of our film based on the dynamical diffraction theory. Although this type of refinement is now well established for PEDT [4], we will be confronted here with a complication related to the microstructure of epitaxial thin films which generally resemble more polycrystalline samples with a strong texture than single crystals. The influence of the presence of oriented domains (twinned domains) on our ability to obtain relevant information about the structure of a film will be illustrated with results obtained on tilted perovskite films [5].

In the last part, we will present a 3D ED protocol adapted for a systematic analysis of epitaxial thin films with the use of scanning precession-assisted electron diffraction tomography (see 3D SPED approach already used for nanocrystalline microstructures analysis [6]). In this approach, a parallel electron nanobeam (typically less than 10nm) is scanned along the film growth direction in order to collect series of PEDT data as a function of film thickness for different tilt angles of the sample holder. This can be a line scan or an area scan which will allow us to extract relevant crystallographic information from a specific part of the film. This will be illustrated with our most recent results obtained on 35 nm thick PrVO3 films deposited on SrTiO3 [7].

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References

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