

## Colloque IVA : Imagerie et diffraction nanométrique

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### X-Ray Microdiffraction Analysis of Nanostructures : from Ensemble Average to Single Object Properties

X-ray diffraction is a versatile tool to determine the structural properties of nanostructures (size, spatial distribution, chemical composition and strain state), and it can be applied to buried as well as uncapped objects. So far, in most x-ray studies, ensembles of nanostructures have been investigated. Consequently, the obtained parameters are those of an average structure, thus meaningful only if the ensemble is monodisperse.

We present here local probe x-ray diffraction experiments on inhomogeneous systems : focused x-ray beams are used to localize nanostructures and analyze their strain and composition, identifying and probing individual objects one by one. In a scanning mode, an image of the sample surface is recorded (similar to a point probe microscope), which allows the reproducible alignment of a specific nanostructure for analysis.

Some examples will be shown :

- i) SiGe (sub-)micron sized islands, epitaxially grown on Si(001). The structural properties of specific islands are measured in diffraction (chemical composition and strain) and compared to the results of (scanning) electron microscopy on precisely the very same object.
- ii) Semiconductor Rolled Up NanoTubes [1]. I will show microdiffraction results on a single particular nano-tube on a macroscopic sample. The lattice parameter distribution and strain were measured non-destructively and modeled using elastic theory.
- iii) Metal-oxide tunnel junctions [2]. The effect of the optical lithography patterning on the crystalline structure of tunnel junctions will be shown : tilts (up to several degrees) of the crystalline planes in the vicinity of the junctions' edges (and propagate over several microns towards the center of the junction) are evidenced. They are attributed to the release of the elastic strain in the individual layers of the junction during the lithographical process.

By addressing shape, strain and composition at the nanoscale, the non-destructive spatially resolved microdiffraction from low-dimensional systems is expected to play an important role in the understanding of the structure of nanomaterials, and provide a better control on their fabrication and functionality. In the outlook it will be shown that this approach can be complemented by coherent (diffraction) imaging methods and phase retrieval, allowing for a model-free direct reconstruction of the nanostructure in real space.

[1] B. Krause et al., Phys. Rev. Lett. 96, 165502 (2006). [2] C. Mocuta et al., Appl. Phys. Lett. 91, 241917 (2007).