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Nanostructures in the Light of Coherent and Resonant X-ray Scattering. Vincent Favre-Nicolin[a,b]
[a]*CEA, INAC, SP2M, 38054 Grenoble, France,*
[b]*Université Joseph Fourier, Grenoble, France*
E-mail:vincent.favre-nicolin@cea.fr

The last 15 years have seen a massive development of crystalline structures with sub-micrometer sizes, either with a simple miniaturization goal, or in order to exploit quantum confinement effects. The study of these objects is a challenge for crystallographers, as their size implies a weak, diffuse scattering rather than sharp Bragg peaks. Moreover, nano-structures, either due to the synthesis method or by design, are often heterogeneous and therefore present inhomogeneous strain and composition 3D fields.
This presentation will be focused on epitaxial nanostructures (quantum dots, nanowires, silicon-on-insulator lines), grown or deposited on a substrate. For these types of samples several methods have emerged during the last 10 years, allowing accurate structural information at the nanoscale.
In the case of hetero-structures (such as Ge/Si or GaN/AlN quantum dots), Grazing Incidence Multi-wavelength Anomalous Diffraction (GI-MAD) has proven to be a very efficient method to extract the composition and strain in an assembly of objects. GI-MAD can be used by measuring scattering maps with a few (2 to 10) energies around one absorption edge (Ge or Ga in our case). Alternatively, it is possible to measure the full Diffraction Anomalous Fine Structure (GI-DAFS) spectrum in order to analyze the environment (nature and distance of neighbours) of the resonant atom.[1,2,3]
Although grazing incidence X-ray diffraction will often yield quantitative structural information, it is practically limited to samples with a limited dispersion of the structural properties (size, shape, mosaicity) of the objects. If this dispersion is too large, it is however possible to measure the scattering from single objects using Coherent Diffraction Imaging (CDI). This is possible thanks to the availability of coherent and intense X-ray beams (up to ~10^5 ph/s/nm^2) on synchrotron beamlines: CDI is a method where the scattering of a single object is measured, and this 2D or 3D scattering pattern corresponds (in the small angle regime) to the Fourier transform of the object's electronic density. While CDI has considerable applications for single non-crystalline objects [3] such as large macromolecules, it can also be used around Bragg reflections: in that case the 3D scattering pattern is the Fourier transform of a complex 3D field which includes information about both the object's density and its deformation from a perfect lattice, in the case of an inhomogeneous strain.
We will illustrate the use of Bragg CDI on single homogeneous and heterogeneous nanowires [5,6,7] down to less than 100 nm and silicon lines, and discuss the current limits and prospects of the method.

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