ESRF	**Experiment title:** **Coherent X-ray Diffraction Imaging of Single InSb/InP and InSb/InAs Nanowires**	**Experiment number**: HS4152
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Abstract:

Coherent X-ray Diffraction Imaging (CDI) technique has been used in order to collect the 3D diffraction pattern of GaAs photonic nanowires (Fig. 1-a,b). These nanowires present an InAs insertion (either a flat layer or a layer of quantum dots). Characterization of this layer would be useful to correlate the photo-emission properties with the InAs layer structure.

The goal of the experiment was to identify this insertion layer despite its small size (1-1.5 nm). This is possible due to the ~7% lattice mismatch, which creates an extended displacement around the InAs insertion, which can be measured using Coherent Diffraction Imaging in Bragg geometry.

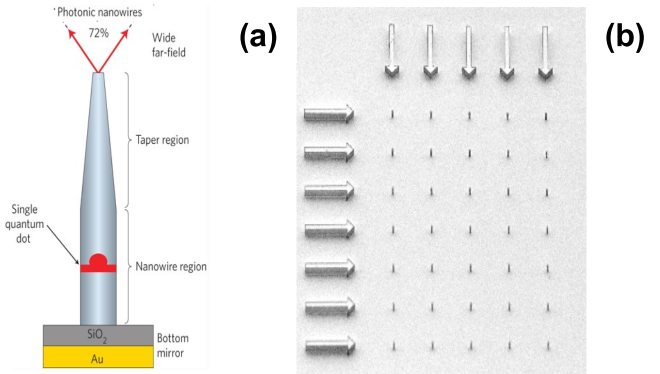

Figure 1: (a) Single-photon source geometry. An InAs insertion (layer of quantum dots: red triangle) is embedded in a GaAs photonic nanowire. (b) Scanning electron microscopy image of one sample – the nanowires can easily be found using the optical microscope available on ID01. The array of 5x7 wires allows to choose from various sizes, with diameters between 100nm to 1 micron.

Experimental set-up:

The new ID01 monochromator has been used in order to achieve less vibrations, a smaller focus spot size and an higher coherence. Energy has been fixed at 8 keV and a Fresnel Zone Plate (FZP) was used to focus the beam at the sample position down to a 300x500 nm² spot size. The opening of the slits in front of our FZP has been chosen equal to 60x20 µm² : such an opening allows to select only the coherent part of the X-ray beam available on ID01.

Diffraction patterns of the investigated Bragg reflection have been collected using a MAXIPIX camera, with a pixel size of 55 micron, to ensure the best resolution and the highest signal/noise ratio.

Preliminary results:

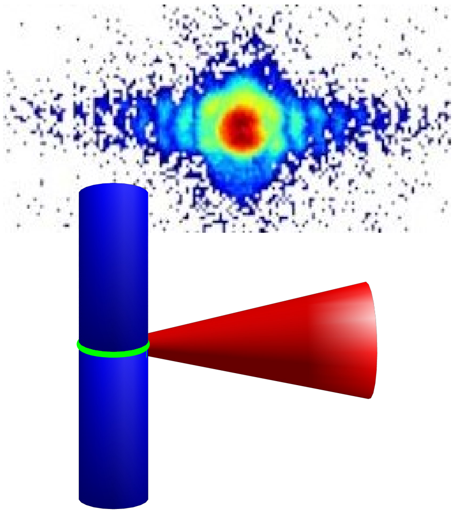

Figure 2 : 2D diffraction image from a vertical scan along a single nanowire: the splitting is visible when the beam illuminates the InAs insertion.

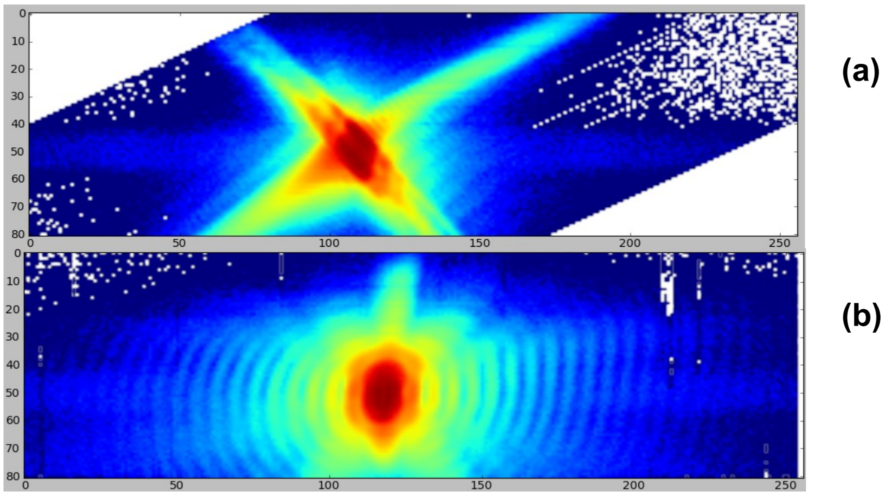

Figure 3 : 3D diffraction pattern of the (004) InAs reflection. (a) Side view: splitting of the peak due to the presence of InAs Quantum dots. (b) View from the top corresponding to the Fourier transformation of nanowire shape.

Thanks to the small transverse beam dimensions it has been possible to select single nanowires on the sample surface. Thanks to the small spot size we have been able to measure the diffraction around the (004) reflection, at different positions along the ~2µm wire. This was repeated for a dozen of different nanowires, with different characteristics (flat InAs layer or with quantum dots, diameters between 100nm and 1µm).

As illustrated in Fig 2, the 2D diffraction image collected at the InAs (004) Bragg reflection shows a split in the scattering intensity, only when the coherent focused beam illuminate the InAs insertion. Simulations (not shown here) indicate that this corresponds to a interplanar distance increase by ~0.05 to 0.1 nm due to the InAs insertion.

We have also succeeded in measuring the full 3D diffraction pattern from the same Bragg reflection (Fig. 3). As expected, the side view of the 3D scattering (Fig. 3-a) shows the same split observed with the vertical scan. The view from the top (Fig. 3-b) corresponds to the Fourier transform of the nanowire shape.

Analysis of our successful data collected during the experiment is already in progress. A resolution of 20 nm is expected to reconstruct a nanowire with a transverse dimension of 400 nm.

From these results we expect to recover:

(1) from the nanowires with an InAs flat insertion, we should be able to reconstruct accurately the deformation introduced by the layer, and therefore its precise thickness

(2) from the nanowires with an InAs insertion featuring a few quantum dots per layer, we hope to be able to reconstruct the 3D strain field, which should allow to localize the quantum dots from the lattice displacement they induce.

While the results from this experiment are very encouraging, the results were still limited by a few factors:

- The nanowires moved (0.5 to 1°) during the 3D data collection, probably due to the heating of the underlying glue by the focused beam. A new gluing procedure is being implemented to avoid this.
- The size of the detector used (256x256 maxipix detector) was a bit too small to fulfill both the over-sampling and resolution requirements of the experiment (need to resolve oscillations and to have a large extent in reciprocal space). This will improve with the new detector with 2x2 chips.
- Sample movement (rotation) for 3D data collection along the sample positions was still difficult, due to the accuracy of the available goniometer. We used energy scans for 3D data collection, combined with the high-precision translations. The new "nano-goniometer" of ID01 should improve this.

An article based on the results of this experiment is in preparation.