ESRF	**Experiment title: Relation between electrical and structural properties of individual GaAs/InGaAs/GaAs core-shell quantum well nanowires**	**Experiment number**: ma2631
Beamline:	**Date of experiment**: from: 10.11.2015 to: 15.11.2015	**Date of report**: 01.03.2016
Shifts:	**Local contact(s)**: Steven Leake	*Received at ESRF:*

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Report: The aim of the experiment was to find a correlation between crystallographic structure and electrical properties of single NWs. To do this we used single GaAs (fig.2) grown exclusively in wurtzite phase and single GaAs/$In_{15}GaAs_{85}$/GaAs (fig. 3) core multi shell nanowires grown by MBE onto silicon(111) substrate. We measured so called speckle scans along the (331) and (224) asymmetric truncation rods of the nanowires and wires using a coherent beam with size of 150x250nm² (FWHM) and x-ray energy of 9keV.

First we report on results taken from single WZ nanowires. Prior to the coherent x-ray diffraction experiments we removed the parasitic islands (see fig.1 a) from the sample using focused ion beam (FIB) in order to isolate nanowires of interest (see fig. 1 b). Fig. 2 a shows the speckled structure throughout the (10-15) WZ Bragg peak. Surprizingly we found three parallel rods with two of them almost same speckle structure separated by Δq_x = 0.05nm^{-1} (fig.2 a) around the q_x=-18.2nm^{-1} and tilted 3rd speckle close to q_x=-18.1nm^{-1} . This behaviour we explain by the FIB impact. Due to recrystallization of sputtered Ga and As atoms at the nanowires side planes during the FIB treatment the wire thickness has been increased from 700nm to 1120nm (see fig. 1 (a) and (c)) forming a shell layer with slighly increased lattice parameter (see fig. 1 d). The recrystallized content of GaAs becomes visible as a shell created under the influence of the FIB. Due to the small beam size it was possible to scan different regions of the wire and find a region where the scattering from the GaAs shell is not presesent in the speckle pattern (fig. 2 b) revealing that the shell thickness might be nonuniform along the growth axis. Smilar behaviour was found at a second single nanaowire. In order to study this effect further speckle rods were measured (not shown here) for the wires which were not treated by FIB and region on the sample surface containing parasitic islands only where the effect was not visible. Analysis based on the measurements as well as I-V characterization is under way.

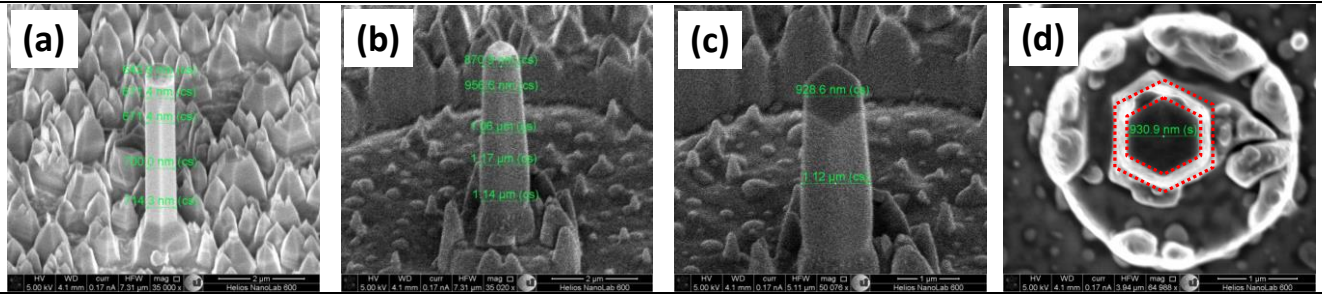

Fig. 1 Preparation of GaAs wires for CXDI experiment. SEM pictures of the wire before (a) and after the FIB treatment (b-d).

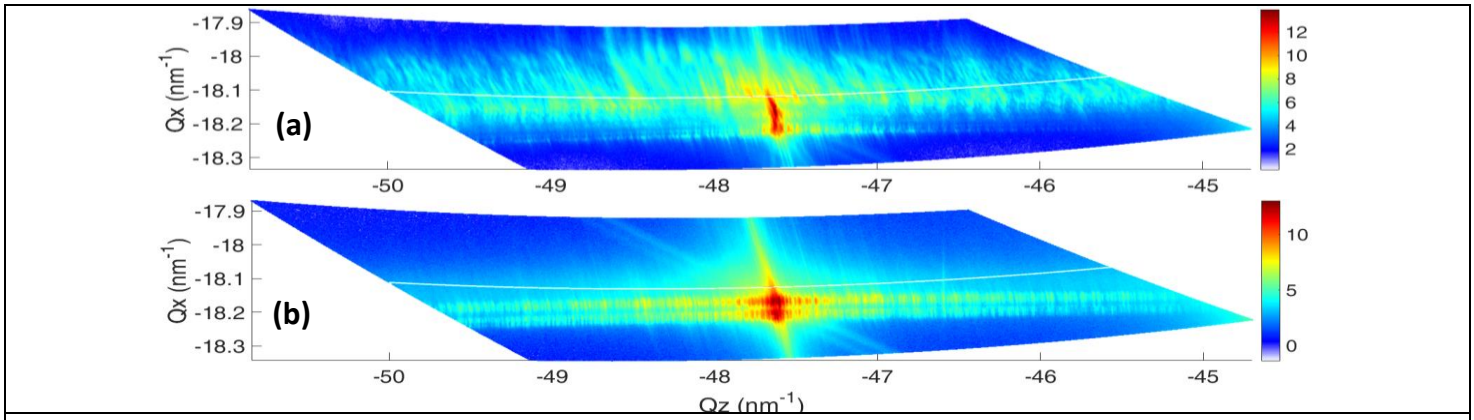

Fig. 2 Speckle pattern around (10-15) WZ reflection of GaAs measured at different positions (a) and (b) on the nanowire.

The investiagted GaAs/$In_{15}GaAs_{85}$/GaAs nanowires wires with 140/10/30nm thicknesses of the core (GaAs), quantum well (InGaAs) and outer shell (GaAs) were grown onto prepatterned substrate with lateral separation of 5-10 microns. The segments of several single wires were measured in asymmetric scattering geometry (fig. 3). It appears that wires from same array, grown under the same conditions, have different phase composition along the growth axis. Particularly wires having no WZ and TZB segments (fig. 3 a) can exist near the others having WZ and TZB segments (fig. b-c). Moreover some of the wires show complex double speckle rod pattern in between TZB and WZ reflections (see fig. 3 b). For some of the wires speckle pattern around the WZ reflections shows clearly appearance of signal corresponding to 2 (or more) different periodicity along the [111] growth direction (fig. 3 d). The data now will be analysed in order to determine the number of phase sgements using the methods published recently [1] Due to the very different structure these wires may show different electrical properties. Because of growth onto prepatterned substrate the same nanowires we have characterized by X-rays will be selected for measurement of the I-V characteristics.

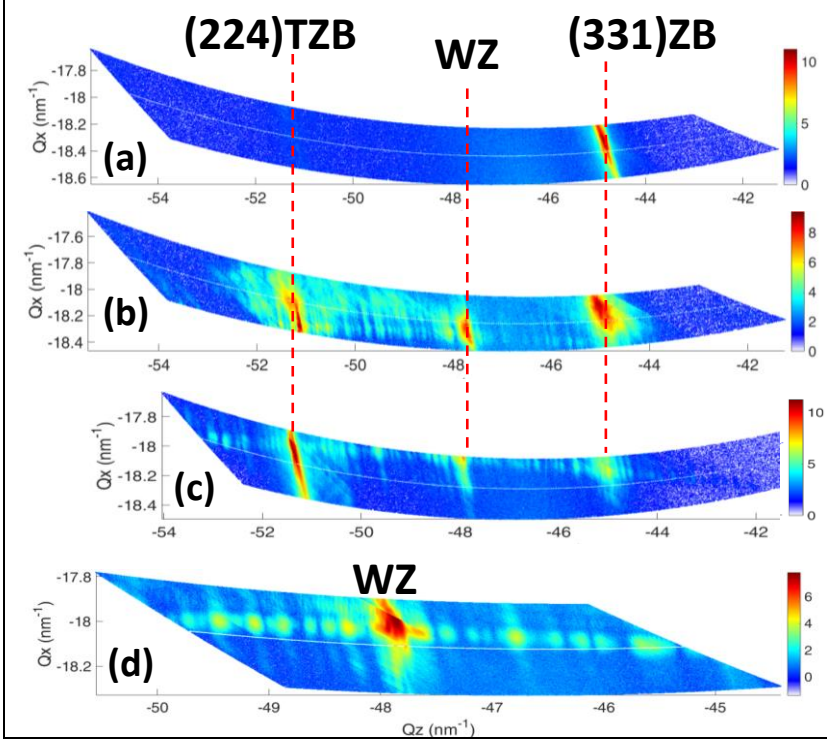

Fig.3 Speckle patterns of 4 different core-shell nanowires (a)-(d).

- **(a) Speckle pattern show no WZ and TZB structures.**
- **(b) Speckle pattern shows WZ and TZB structures with second rod between WZ and TZB reflections**
- **(c) Single rod recorded between (331)ZB and (224)TZB**
- **(d) Speckle near WZ reflection**

References

1. Bussone G. et al., Nano Letters 2015, **15**, 981–989