Standard Project

Experimental Report template

Proposal title: Resolving strain in core-shell nanowires with µ-Laue diffraction		**Proposal number:** 20121269 32-02-752
Beamline: BM 32	**Date(s) of experiment:** from: June 28, 2013 to: July 2, 2013	**Date of report:** Feb. 19, 2014
Shifts: 9	**Local contact(s): J. S. Micha and O. Robach**	*Date of submission:*

Objective & expected results (less than 10 lines):

The objective of this proposal was to demonstrate the interest of µLaue diffraction to study core-shell GaN-InGaN wires by measuring the strain heterogeneities at the 300 nm scale and to evaluate the tools to analyse the µLaue data.

Results and the conclusions of the study (main part):

We combined optical microscopy measurements to select the objects with orientations compatible with simple scanning directions and fluorescence mapping to localise the beam position. The resolution was about 0.5*0.7 µm^2 (depending on the day of the experiment and focusing adjustment). A Ge crystal has been used to calibrate detector and distances for quantitative analysis.

We studied first GaN tripods and then core-shell heterostructures (multiple quantum wells called MQW).

GaN tripods: An example of the analysis of GaN tripods in epitaxy on c-sapphire is shown in Fig. 1. The orientation matrix between the wires A, B, C and the seed D have been determined subtracting the substrate background. The corresponding angles are given in Fig.2. Error bars have to be determined and the values have to be compared to the angles of regular tetrahedron (109.5 deg for the CH4 molecule!). These results will be compared to ZnO branched structures already observed in the literature, in particular to the occurrence of a cubic seed at the bottom of the branches (see Fig. 2).

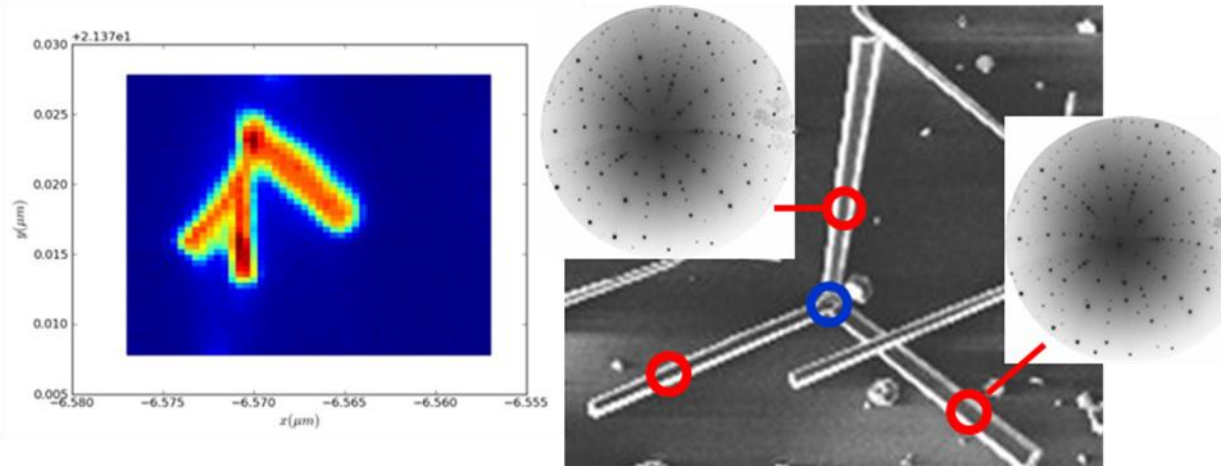

Fig. 1. In the left, fluorescence mapping of GaN tripod wire. The right part shows a scanning electron microscopy image of a tripod with two examples of µLaue patterns. The epitaxial relationship between the tripods and the sapphire substrate is clearly shown.

	A	B	C	D
A	180.0	123.9	111.9	143.9
B	123.9	180.0	124.2	91.7
C	111.9	124.2	180.0	146.8
D	143.9	91.7	146.8	180.0

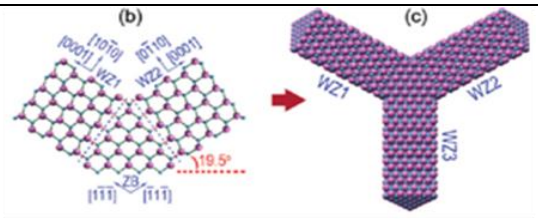

Fig. 2. In the left, angles between the three branches (A, B, C) of the tripod. The right part shows a model proposed in ZnO tripods to explain the formation of this heterostructure. D could be a zinc blend seed and the tree branches are wurtzite.

Core-shell wires: As shown in Fig. 3, an interesting point to report is the XEOL (X-ray Excited Optical Luminescence) signal of this sample. The beam excites the GaN part and gives a visible signal that is strongly enhanced in the MQW part and guided by the wire. This effect has been specifically studied on ID22 with a nanobeam and time resolved analysis (Advanced Materials will be published soon).
We have performed the longitudinal and radial mapping of the wires as shown in Fig. 4 and 5 for samples T1569, T1567, T1529 corresponding to different MQW periods. It appeared also that the number of MQWs is also really important to have a significant signal (5 MQW are not enough to get the signal and we have to use 15 MQWs).
Full movies of these scans (detector image stacking) have been obtained and showed strain fluctuations that are presently under quantitative estimations to be published. A particular stress will be laid on the analysis of the information coming from the different Bragg peaks that have been indexed by the MicroLaue tool (see an example in Fig. 4). Mathematica notebooks have been written to analyse these data.

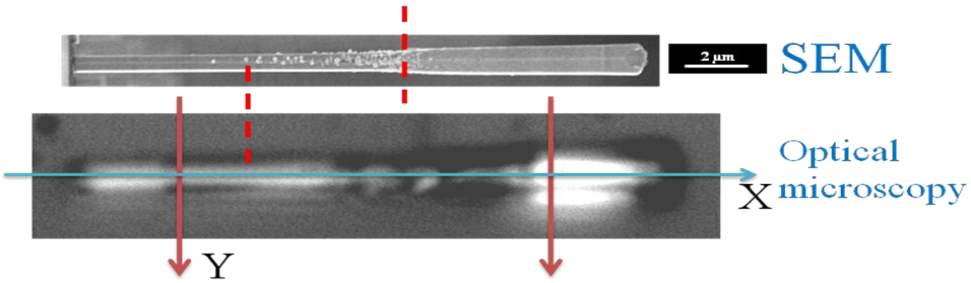

Fig. 3. Scanning electron image of a wire and the respective optical signal with XEOL signal.

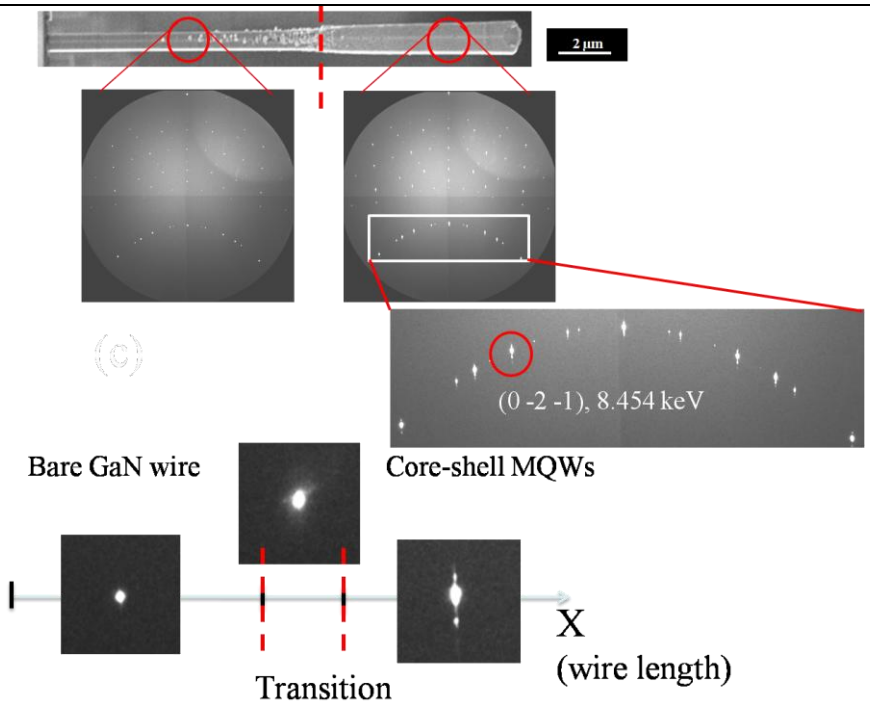

Fig. 4. Example of scanning along the wire length. See the MQW signal in the riht part of the figure.

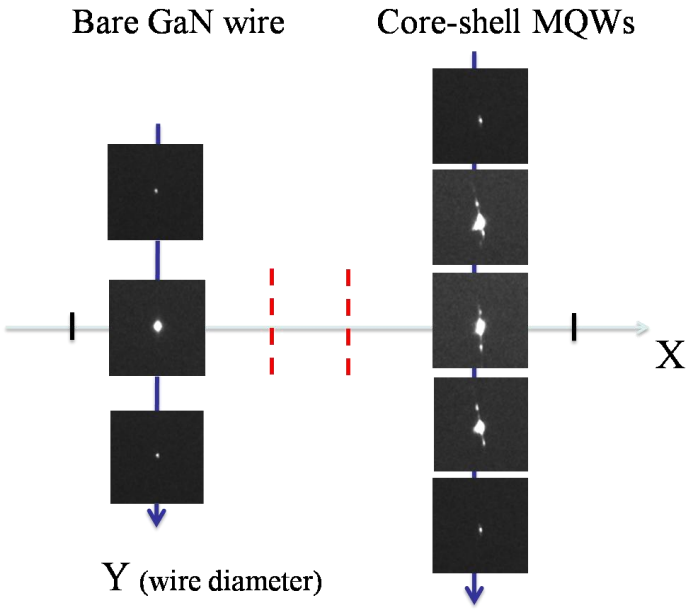

Fig. 5. Example of scanning along the wire diameter. See deformation at the MQW place.

Justification and comments about the use of beam time (5 lines max.):

Very satisfied of this experiment uder continuous improvement.

Publication(s):

The full analysis will be proposed for publication to Applied Physics Letters.