EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

ESRF

Experiment Report Form

The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF.

Once completed, the report should be submitted electronically to the User Office using the **Electronic Report Submission Application:**

http://193.49.43.2:8080/smis/servlet/UserUtils?start

Reports supporting requests for additional beam time

Reports can now be submitted independently of new proposals – it is necessary simply to indicate the number of the report(s) supporting a new proposal on the proposal form.

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

Reports on experiments relating to long term projects

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

Published papers

All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

Deadlines for submission of Experimental Reports

- 1st March for experiments carried out up until June of the previous year;
- 1st September for experiments carried out up until January of the same year.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report, in English.
- include the reference number of the proposal to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

ESRF	**Experiment title: Study of strain and composition fluctuation in InGaN/GaN nanowires (NWs) heterostructures by MAD and DAFS**	**Experiment number**: **HS-4168**
Beamline: BM2	**Date of experiment**: from: 27 oct. 2010 to: 02 nov. 2010	**Date of report**:
Shifts: 18	**Local contact(s)**: H. Renevier	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Dr B Daudin, INAC, CEA, Grenoble

Pr. Hubert Renevier, LMGP, Grenoble INP

PhD Cedric Leclere, LMGP, Grenoble INP

PhD Gabriel Tourbot, INAC, CEA, Grenoble

Dr. Maria Grazia Proietti, Univ. Zaragoza, Spain.

Report:

Since very recently we have succeeded, at INAC/SP2M/Nanophysique and Semiconductors laboratory, in collaboration with LETI DOPT, CEA-Grenoble, in growing state-of-the-art GaN/InGaN/GaN NWs heterostructures, which exhibit strong electroluminescence in the visible range. The growth is performed on Si(111) substrates by using radio frequency plasma-assisted MBE under N-rich atmosphere. A typical sample is shown in Fig.1. Despite the observation of good electroluminescence yield, the control of wavelength emission is still far from being optimized.

We collected scattered intensity 2D maps nearby the bulk GaN 11-22, 30-32, 10-15 and 0004 Bragg reflections for 2 different samples, with and without the core-shell morphology. Fig. 2 show the diffraction 2D maps nearby the bulk GaN 11-22 reflection, for the core-shell sample that shows to be matched to GaN along the c axis. Indium composition fluctuations lead to the spreading of x-ray scattering (diffuse scattering). Fig 3 also shows a grazing incidence line scan along the reciprocal space direction *h* marked in the map (dashed line). The formation of a core-shell region is clearly shown by the line scan, at constant *l*, by two well separated in plane contributions.

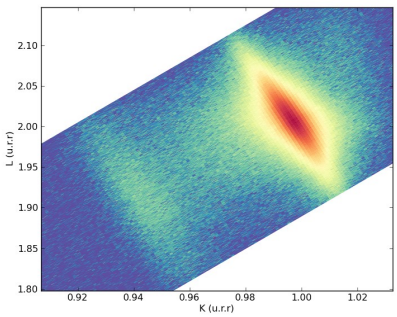

Figure 1: Reciprocal Space Map in the [11-22] direction close the GaN 11-22 reflection. Sample 1424

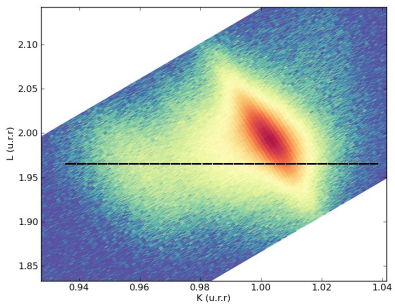

Figure 2: Reciprocal Space Map in the [11-22] direction close the GaN 11-22 reflection. Sample 1354

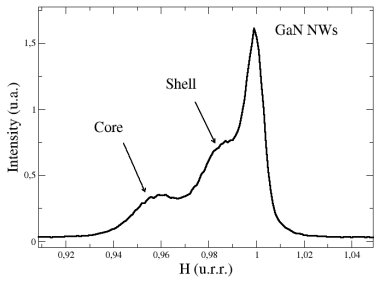

Figure 3: Grazing Incidence (α_i=0.12°) X-Ray diffraction intensity along the [11-20] direction. Energy=10200eV.

In concentrations in the core and shell regions have been obtained by fitting the cusps (lineshape) of the Diffraction Anomalous Fine Structure spectra measured at the Ga-Kedge (≡ MAD data analysis). The fit are shown in figures 4 and 5, the results show a very low In concentration in the shell (about 5% or less) and a rather high In concentration in the core (35%).

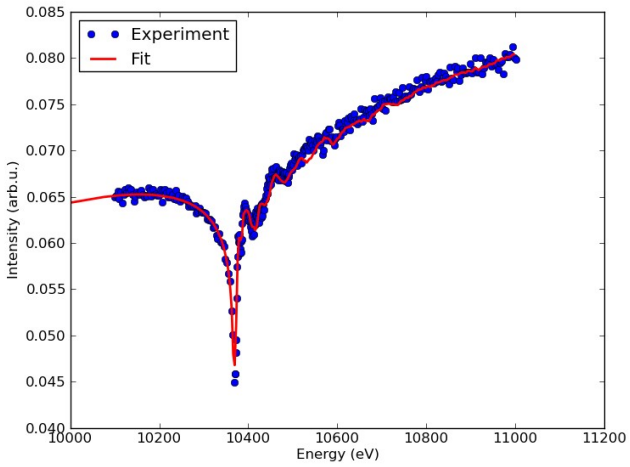

Figure 4: DAFS spectrum measured at hkl = 0.952 0.959 1.953 (core region). Multiwavelength Anomalous Diffraction analysis. Composition refinement lead to an In content of about 35%. Sample 1354

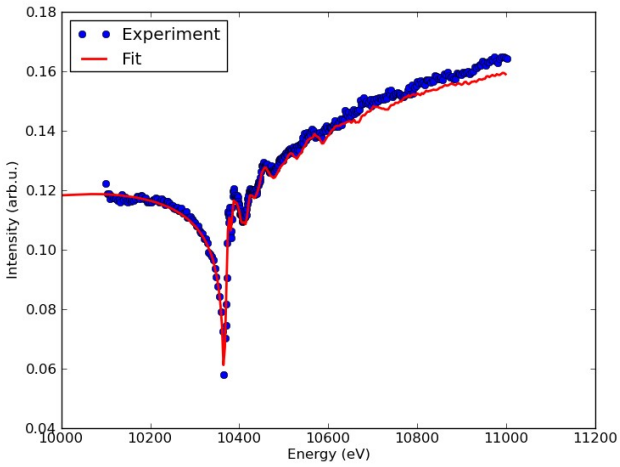

Figure 5: DAFS spectrum measured at hkl = 0.977 0.985 1.973 (shell region). Multiwavelength Anomalous Diffraction analysis. Composition refinement lead to an In content of about 5%. Sample 1354 (hkl = .977 .985 1.973)

Fig. 6 shows the extracted oscillations from the raw EDAFS data, collected at beamline BM2, and their FT transform amplitudes Fig. 7 for the same core-shell sample but for different **Q** values, i.e. selecting either the core or shell region of the wires as in Fig. 4 and Fig. 5. We can clearly see around 1.9Å the contribution of 4 nitrogen as first neighbors around Ga absorbers. What is more interesting is that we can observe around 3Å a radical change in the Ga environment. This is due to the substitution of In to Ga as scatterers in the Next Nearest Neighbors (NNN) of Ga atoms and confirm the In rich composition of the Core.

We could obtain composition, in an independent way from EDAFS oscillations but it is clear that EDAFS data quality is not good enough to perform a quantitative analysis. In the next experiment, we expect to collect spectra with a higher S/N ratio and a wider *k* range to give reliable values on In concentration and also to determine interatomic distances. Indeed, NNN distances are splitted out by composition for Ga-Ga and Ga-In pairs and by strain and for in-plane and out of plane neighbors. They are crucial for determining local strain and the presence of clustering but a better S/N ratio is mandatory to distinguish the different Ga environments.

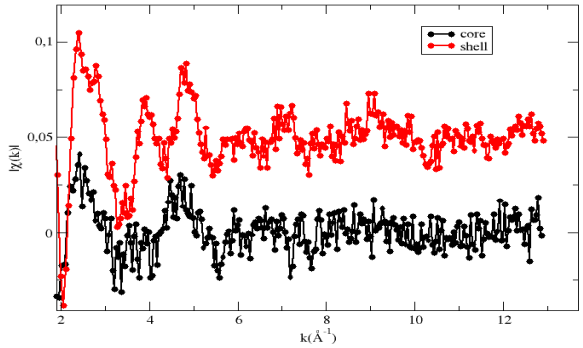

Illustration 6: EDAFS spectra for the core and the shell EDAFS oscillations

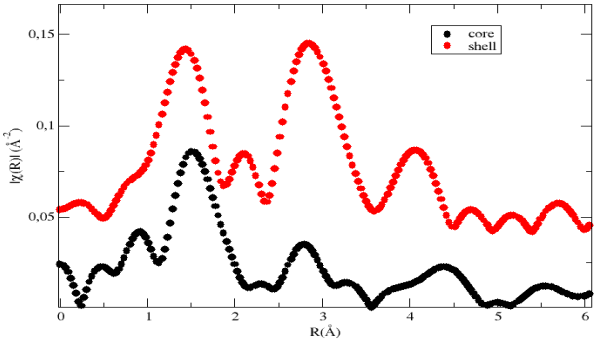

Illustration 7: FT of the EDAFS oscillations