EUROPEAN SYNCHROTRON RADIATION FACILITY

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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 via the User Portal:

https://wwws.esrf.fr/misapps/SMISWebClient/protected/welcome.do

Reports supporting requests for additional beam time

Reports can 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:** Nano- XRF investigation of the inhomogenous indium distribution in GaAs/InGaAs/GaAs multi core-shell nanowires.	**Experiment number**: MA - 2788
Beamline: ID16b	**Date of experiment**: from: 18.11.2015 to: 23.11.2015	**Date of report**:
Shifts: 12	**Local contact(s)**: Damien Salomon	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

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Report:

Objective:

Due to discrepancy in the lattice parameters of core (GaAs) and shell (InGaAs) materials, the interface properties of the nanowire (NW) side planes are affected by epitaxial strain. As shown for AlGaAs/GaAs multi core-shell NWs, the interfacial strain field is expected to be different along the direction normal to the $(1\bar{1}0)$ side plane and along the $(2\bar{1}\bar{1})$ NW edges of NWs grown along [111] direction. In addition, projection and shadowing effects during shell growth result in in-homogeneities in shell thickness and indium concentration. As any variation in the crystallographic structure may be evaluated by means of x-ray nano-diffraction, both local strain and In-content cannot be separated from each other by XRD. Therefore nano- XRF is a method of choice to overcome this problem.

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

The investigated samples were grown at the Paul-Drude-Institute (Berlin, Germany) by molecular beam epitaxy (MBE) using the Ga-assisted VLS growth mechanism. To compare the effect of different structural parameters, NWs with various shell thicknesses and indium concentrations were probed in this experiment. According to Vegard's law, a higher indium concentration within the InGaAs inner shell will induce an increase of the epitaxial strain between the materials.

In a previous experiment, performed at same BL, we could not spatially resolve the InGaAs shell because of the dominant fluoresence signals originated in the liquid droplet on top of the core-shell nanowires. This droplet always remains in the results of the VLS growth of InGaAs/GaAs nanowires. Therefore, prior to this measurement, a focused ion beam (FIB) was used to remove the droplets and a small segment from the upper part of the NW providing a bare crystalline upper air- to nanowire interface . By the use of optical lenses, the beam used for the XRF experiment was reduced to a spot size of 50nm x 50nm at photon energy of 29.46 keV. While the beam was directed perpendicular to the surface of the sample,

the signal was collected by placing a three element energy dispersive detector at each side of the sample at an angle of 15^0 with respect to the sample surface.
NWs inspected were composed of a 140nm GaAs core covered by an InGaAs shell with 15%, 25% and 40% of indium and capped by a GaAs shell of 30nm. InGaAs shells of 15% and 25% preserved their hexagonal geometry with six well pronounced {110} side facets. Furthermore, independent from any variation in the InGaAs shell thickness (10, 20 and 40nm), the indium distribution at all six side planes was found to be homogeneous (Fig. 1). As the nominal indium concentration increases to 40% within the InGaAs shell , a transition from the hexagonal geometry into the circular one takes place in which the six {110} side-facets are no longer prominent. In addition, XRF measurements showed the appearance of indium-rich 3D aggregates on top of the NW side planes with a noticable larger indium content compared to that within the inner InGaAs shell. Furthermore, NWs with nominally 40% of indium in the InGaAs shell showed an In profile with higher indium within the GaAs core compared to those NWs with lower indium concentration.

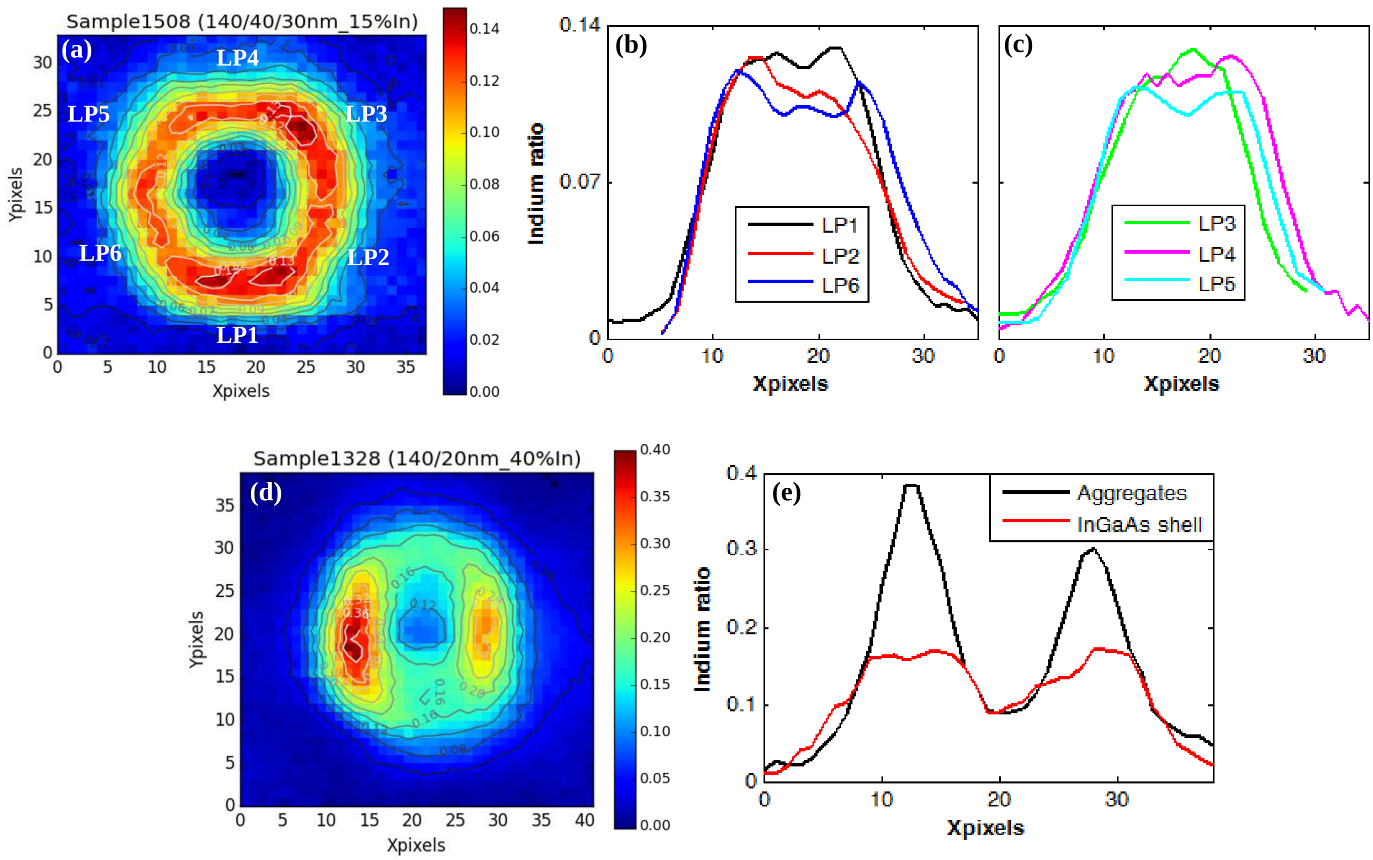

Fig. 1: a) illustrates the homogeneity of the indium distribution within the InGaAs shell for a NW with 15% of indium. b) & c) show line profiles along the six- {110} side facets. Line profiles were divided into two graphs to avoid confusion. d) displays the indium distribution and presence of indium rich aggregates in NWs with 40% of indium. e) presents line profiles through the two indium aggregates (horizontal) and the indium shell (vertical).

In summary, our experiment could demonstrate that the Indium concetration within the InGaAs shells is homonenous as long as the total In content does not exceed 25%. For more quatitative anlysis the measured data will be corrected by the incident beam profile. This analysis is not finsihed so far.

Publication(s): is planned