EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

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:** X-ray diffraction on small ensembles and on single Ge islands	**Experiment number**: SI-1156
Beamline: ID10B	**Date of experiment**: from: 27.04.2005 to: 03.05.2005	**Date of report**: 22.11.2005
Shifts: 15	**Local contact(s)**: Dr. Bernd Struth	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

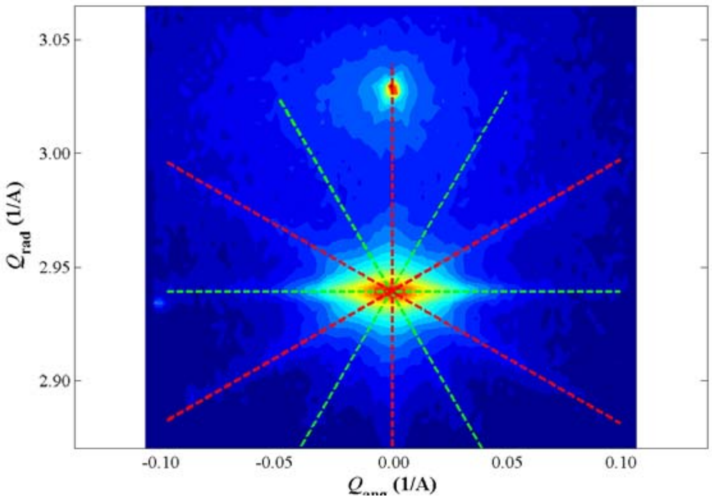
Prof. G. Bauer, J. Stangl (*), Inst. for Semiconductor and Solid State Physics, Johannes Kepler University, Linz, Austria

Prof. V. Holý, Department of Electronic Structures, Charles University Prague, Czech Republic

Prof. Werner Seifert, B. Mandl (*), A. Mikkelsen(*), J. Erikson(*), Solid State Physics Division, Lund University, Lund, Sweden

Report:

We have investigated a series of InAs wire samples grown on InP(111) B at a substrate temperature of 620°C and different deposition times. The wires grow along the [111]B direction, have diameters in the range from 30 to 250 nm, and are typically several µm long, depending on deposition time. It is expected that the wires consist of completely elastically relaxed material, but some alloying with InP could be present. In order to prove an epitaxial relationship between wires and substrate, we recorded reciprocal space maps in GID geometry around the (20-2) Bragg reflection of InP, as shown in Fig. 1 for a sample with 60 s deposition time. The reflections from the InP substrate (at about Q_{rad}=3.035 Å) and InAs (at about Q_{rad}=2.94 Å) are clearly visible. Evaluating the position of the reflections we obtain an in-plane lattice parameter $a_{||}$ of the InAs of 6.046 Å, close to but not exactly that of pure bulk InAs (6.058 Å).



Streaks are running in various direction from the InAs Bragg peak: they are due to the side facets of the wires, reflecting the hexagonal wire shape also seen in SEM images. The streaks marked by the red lines in Fig. 1 correspond to ⟨1-10⟩

directions, as expected from previous SEM investigations. However, a second subset of streaks (marked by green lines) is present, which unexpectedly run in ⟨11-2⟩ directions. They could corresponds to hexagonal wires roated by 30°, but no such wires have ever been observed in SEM. The origin of these streaks remains unclear at the moment.

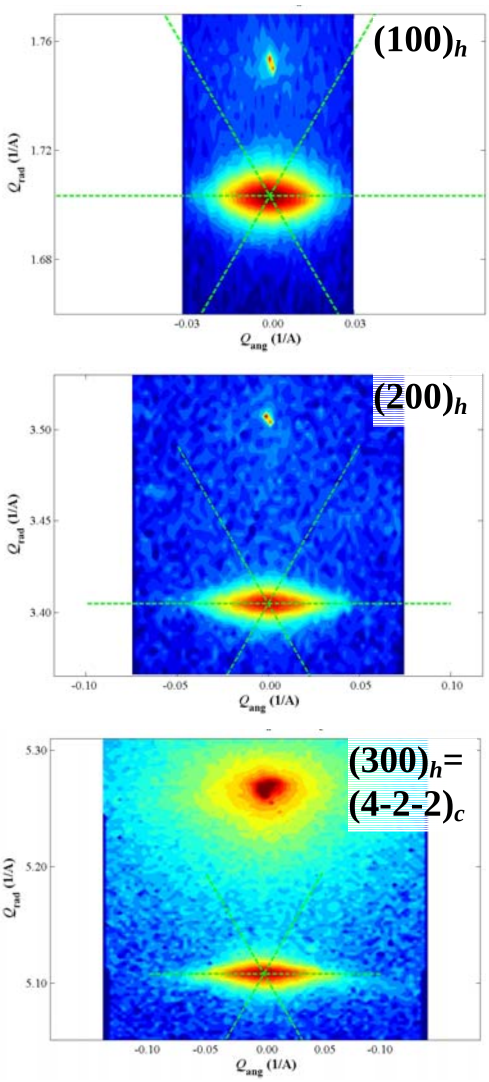


Fig. 2. in-plane maps for wurtzite and zincblende-allowed reflections.

In order to obtain information on the InAs content, we measured also the lattice parameter perpendicular to the substrate $a_\perp$ surface from maps around the (111) reflection. We obtain $a_\perp$=6.076 Å, slightly above the value of pure InAs. Considering $a_{||}$ and the elastic constants of bulk InAs a value of $a_\perp$=6.065 Å would follow; hence the measured $a_\perp$ is too large. Alloying with InP would decrease the lattice parameter, so this cannot be the reason for the deviation. However, there are hints from high-resolution TEM that the wires contain a large number of stacking faults, and a part of the wires might eventually grow in the wurtzite rather than the zincblende structure, which is the stable structure for bulk InAs and was also found for epitaxial layers and quantum dots. However, for the wires grown along [111], the transition from zincblende to wurtzite only means a change of the stacking sequence from ABCABC to ABAB.

In order to check the existence of wurtzite InAs, we recorded in-plane maps in GID geometry which are allowed for wurtzite, but forbidden for zincblende. The difference being (in first order) only the stacking sequence leads to a situation where in reciprocal lattice several reflections are identical. With the cubic [111] direction parallel to the hexagonal [001] direction, the wurtzite lattice has in-plane reflections $(100)_h$, $(200)_h$, and $(300)_h$, with the $(300)_h$ equivalent to the $(4\text{-}2\text{-}2)_c$ (the subscripts "c" and "h" stand for "cubic" and "hexagonal"). We recorded reciprocal space maps around these reflections, shown in Fig. 2. One can see only extremely weak reflections from zincblende InP in the first two maps, while very strong Bragg peaks appear from InAs. In the cubic-allowed reflection, scattering from InP is by far stronger than scattering from InAs. This clearly proves that a significant portion of InAs grows in the wurtzite rather than the zincblence lattice structure. Assuming wurtzite structure, from the measured reflections we arrive at lattice parameters a=4.26 Å and c=6.985 Å, which agrees very well with values found in literature for wurtzite InAs [1], suggesting that the majority of wires grows in the wurtzite structure.

[1] K. Takahashi, T. Moriizumi, Jap. J. Appl. Phys. **5**, 657 (1966).