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 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:** Individual stacking faults in GaAs nanorods studied by coherent diffraction and Patterson analysis	**Experiment number**: HC-1745
Beamline: ID01	**Date of experiment**: from: 23.07.2015 to: 29.07.2015	**Date of report**: 03.09.2015
Shifts: 18	**Local contact(s)**: Steven Leake	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

*Václav Holý, Charles University in Prague, Czech Republic,

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*Ullrich Pietsch, University of Siegen, Germany.

Report:

The aim of the beamtime was to develop and test a new method for a direct determination of the positions of individual stacking faults in a single wurtizte (WZ) [0001]-oriented GaAs nanowire, based on diffraction of a very narrow coherent x-ray beam. The method suggest to measure the reciprocal-space distribution of diffracted intensity along an asymmetric crystal truncation rod (CTR) comprising the maxima 224 of the cubic zincblende lattice (ZB), 01-15 of the WZ lattice and 331 of the twinned ZB (TWZB) lattice; Fig. 1 shows a sketch of the maxima positions in reciprocal space, ZB, TWZB and WZ maxima are denoted by black, blue and red symbols, respectively. From numerical simulations it follows that the Fourier transformation of the measured intensity distribution (the Patterson function) calculated along the section of this CTR between the maxima exhibits peaks, the positions of which directly correspond to the positions of individual fault planes. Therefore, this method could allow for a direct determination of the positions of the fault planes without complicated and time consuming phase-retrieval.

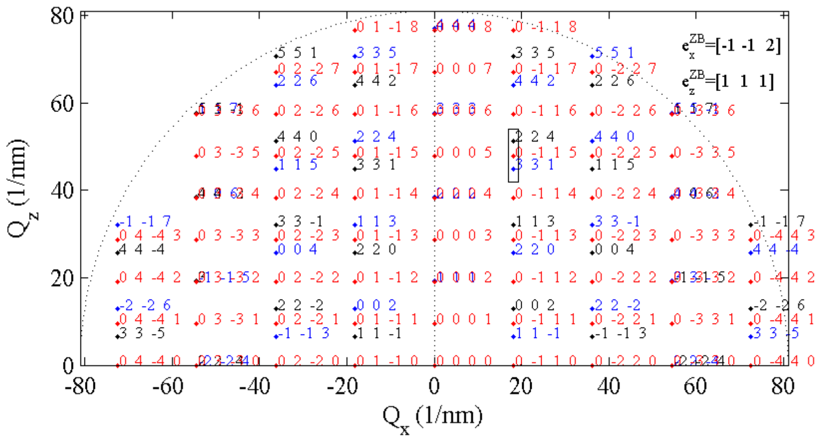

Fig.1. Diffraction maxima in reciprocal space; black, blue, and red symbols denote the ZB, twinned ZB, and WZ maxima, respectively. The small rectangle indicates the measured area.

We have investigated a GaAs sample with $(111)_{ZB}$ oriented surface, on which epitaxial nanowires have been grown by the self-assisted MBE growth [1], Fig. 2 shows a typical SEM image of the sample.

From the figure it is obvious that few tens of nm thin and approx. 1 μm long nanowires grow from facetted islands lying directly on the substrate surface. According to the growth parameters and preliminary laboratory x-ray diffraction investigations we expected that the wire structure is predominantly WZ, while the islands underneath have the cubic ZB lattice.

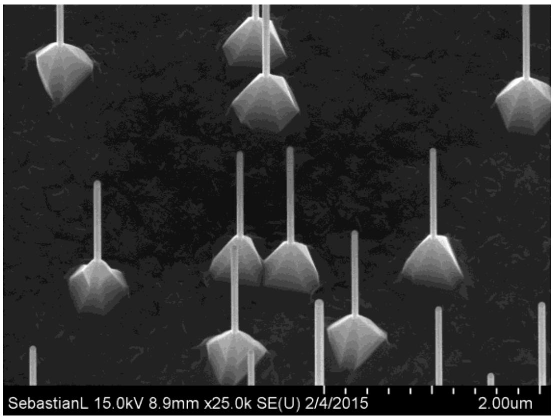

Fig. 2. Typical SEM image of the investigated sample.

The synchrotron measurements have been carried out at the ID01 beamline, using the primary beam with the energy of 8 keV. The fully coherent beam was focused down to 200 nm by a Fresnel zone plate, the form of the wavefront of the primary beam was determined by a sequence of images taken at various FZP-detector distances.

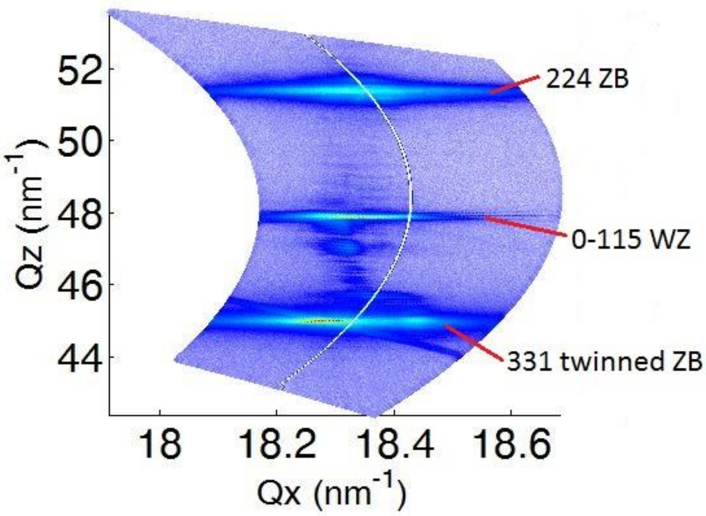

Fig.3 Example of the measured data

Using a fast K-mapping procedure [2] we found a suitable isolated nanowire, from which we have measured a large three-dimensional reciprocal-space distribution of diffracted intensity, using an offset omega-2theta scan and a large two-dimensional detector. During the scan we have checked the stability of the sample and performed a xy optimization of the sample position if necessary. The measurement procedure has been carried out on several nanowires; we tried to identify the particular nanowires by comparing the K-mapping image of the sample with optical micrographs.

In Fig. 3 we show an example of the obtained data integrated in the Q_y direction perpendicular to the scattering plane. All three types of maxima are present; the 224ZB peaks stems mainly from the substrate; this peak cannot be avoided. The 331TWZB and 0-115WZ originate in the nanowire and in the island underneath. From the data it follows that in contrast to our previous expectations the island is predominantly wurtzite similarly to the nanowire, since the wurtzite peak exhibits oblique streaks perpendicular to the facets of the island. This finding makes the direct application of the suggested method complicated, however we tried to discriminate the nanowire and the island contributions by changing the sample z position;

The next step will consist in extracting the contribution of the irradiated nanowire from the measured three-dimensional distribution and in calculating the corresponding Patterson function.

[1] C. Colombo et al., Phys. Rev. B **77**, 155326 (2008).
[2] G. A. Cahine et al., J. Appl. Cryst. **47**, 762−769 (2014).