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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 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:** Local Atomic Structure in InGaP Surface Undulations	**Experiment number:** HS4147
Beamline: BM 26A	**Date of experiment:** from: 21 June to: 25 June 2010	**Date of report:**
Shifts: 9	**Local contact(s):** Sergey Nikitenko, Miguel Silveira	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

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Report:

In the experiment HS4147 we have investigated the local structure of well ordered (In,Ga)P/GaAs(001) surface undulations (Figure 1a). The surface undulations which are aligned along the [-110] direction appear on a $In_{0.48}Ga_{0.52}P$ layer grown lattice-matched on GaAs. They are observed when the molecular beam epitaxial (MBE) growth is performed at elevated temperature (470°C) while at lower temperature a smooth and isotropic surface morphology shows up. This phenomenon is of high scientific and technological relevance since the surface undulations can be used as a natural template for subsequent well defined MBE growth of InP quantum dots (QDs) (Figure 1b) [1]. The microscopic mechanisms leading to the (In,Ga)P surface undulations are not yet understood.. Lateral compositional modulation (LCM) and $CuPt_B$ like long range atomic ordering (LRO) are the most frequently discussed mechanisms causing the surface undulations as observed in Figure 1a and polarization dependent photoluminescence experiments (not shown here) indicate the presence of both mechanisms.

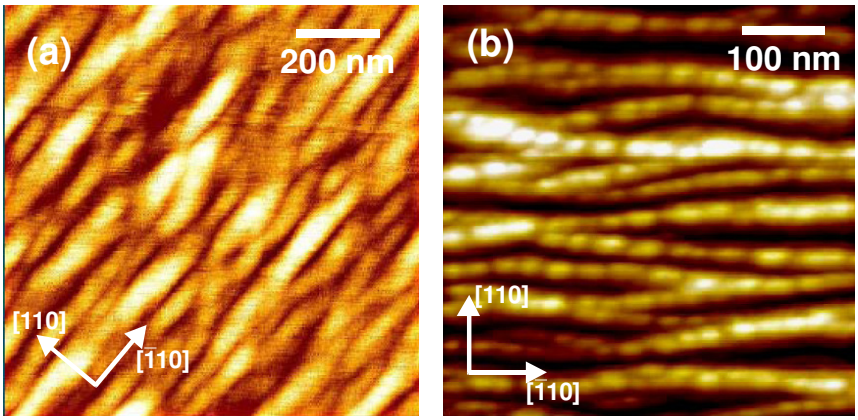


Fig.1: Surface morphology (AFM) of (a) 250 nm thick $In_{0.48}Ga_{0.52}P$ grown on GaAs (001) by gas source MBE at T = 470°C and, (b) InP quantum dots grown on undulated $In_{0.48}Ga_{0.52}P$ layer.

To examine the atomic arrangement by Ga and In K-edge fluorescent EXAFS, we prepared different types of samples (i) with and (ii) without

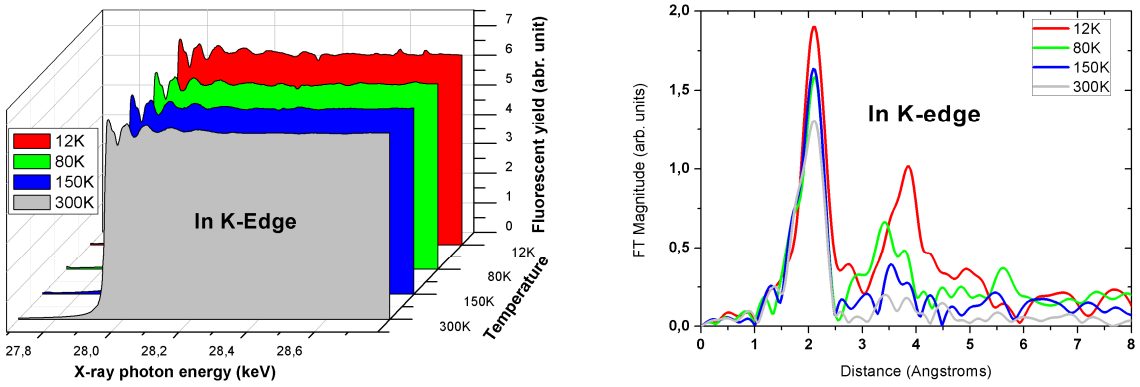
surface undulations and (iii) with InP QDs. An EXAFS experiment has been already performed at BM26A (DUBBLE beamline) at ESRF (see report HS 4147). Here, the In K-edge was measured on different samples in the temperature range from 12K to 300K. Figure 2a displays the EXAFS signal in the vicinity of the In K-edge for one of our $In_{0.48}Ga_{0.52}P$/GaAs structures and Figure 2b shows the corresponding Fourier transformation. These investigations at BM26A have been very useful since they demonstrate that our structure has a significant dependency on temperature. This could be an indication of atomic SRO which is expected to depend on temperature. However, just a part of the suggested scientific programm could be covered in the experiment, since severe experimental restrictions were present during this beam time:

- At BM26A the signal was detected by measuring the x-ray fluorescence yield. For working at the In K-edge this – in principle – should work since Indium is expected to appear in the $In_{0.48}Ga_{0.52}P$ layer only, and it does not appear in the GaAs substrate. However, we are interested in the local atomic structure in the very-near-surface region in the proximity of the surface undulations. However, owing to the large energy of In K-fluorescence the EXAFS signal is dominated from volume of the entire $In_{0.48}Ga_{0.52}P$ layer (250 nm thickness) and not from the surface region which is about 3 nm thick. For that reason the interpretation of Figure 2b is difficult.

- For similar reasons EXAFS close to the Ga K-edge could not be investigated since the signal from the $In_{0.48}Ga_{0.52}P$ layer cannot be distinguished from the strong signal caused by the GaAs substrate. Again, a suppression of the signal from the GaAs substrate could have be achieved by using e.g. secondary electrons which exhibit a small information depth. For technical reasons, the detection of secondary electrons was, however, not possible at BM26A.

- The P K-edge was not accessible in this experiment.

- A limited number of just 9 shifts have been allocated. Unfortunately a further reduction of experimental time (about 2 shifts) appeared due to experimental problems (long beam loss, problems with interlock system).



(a) (b)

Fig.2: (a) EXAFS at the In K-edge at various temperatures and (b) corresponding Fourier-transformation.