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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:** **Proposal title:** Coherent Diffraction Imaging of Antiphase Domains in GaP Nanolayers for Low Cost Photonic Applications	**Experiment number**: MA-2243
Beamline: ID01	**Date of experiment**: from: February 4, 2015 to: February 9, 2015	**Date of report**: Sept 13, 2023
Shifts: 15	**Local contact(s)**: T. Schulli, Gilbert A. Chahine, S. Leake	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

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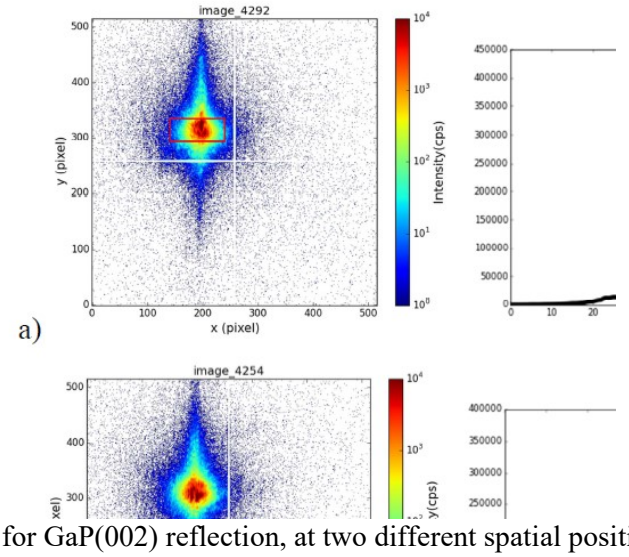
Report:

This experiment is in the context of coherent integration of III-V semiconductors on silicon for integrated photonics on Si and also for high performance&low cost photovoltaic on Si applications. Si buffer and III-V growth are performed in our laboratory. The main objective of this experiment was to use coherent diffraction for imaging of antiphase domains on GaP/Si nanolayers. Development of such a non destructive imaging technique is crucial for comprehension and elimination of these crystalline defects, detrimental for optical properties.

ity (small APD size compared to the scattering volun



a)

Fig. 1 2D images of the scattered spot for GaP(002) reflection, at two different spatial positions and corresponding cutlines in the horizontal direction.

Coherent diffraction has been carried on different samples with different thicknesses,bellow the criticial thikness (ie <90nm and without misfit dislocations) and above this treshold. As shown figure 1, a clear contrast appears from different areas on the sample. Coherent Ptychographic imaging process has been performed, however, correct phase retrievel could not be obtained for coherent Bragg imaging on any sample. We have lated on focused on K-map on a 140nm GaP layer grown on Si miscut substrate (6° in the [110] direction).

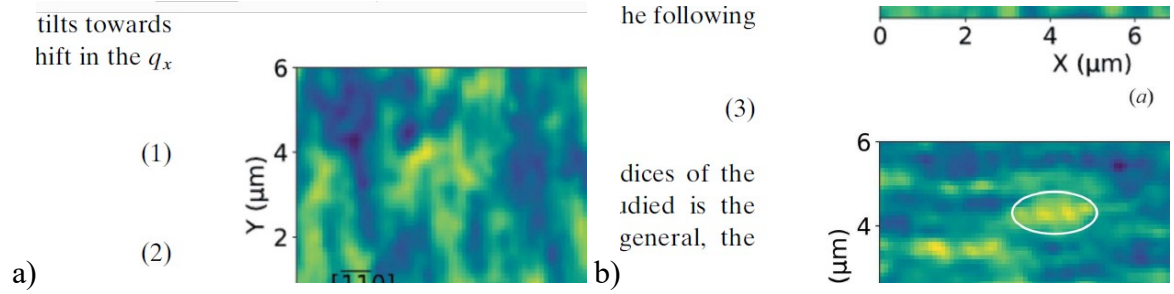


Fig. 2 Mapping of the tilt value along [-1-10] (a) and [1-10] (b) recorded on GaP (004) reflection.

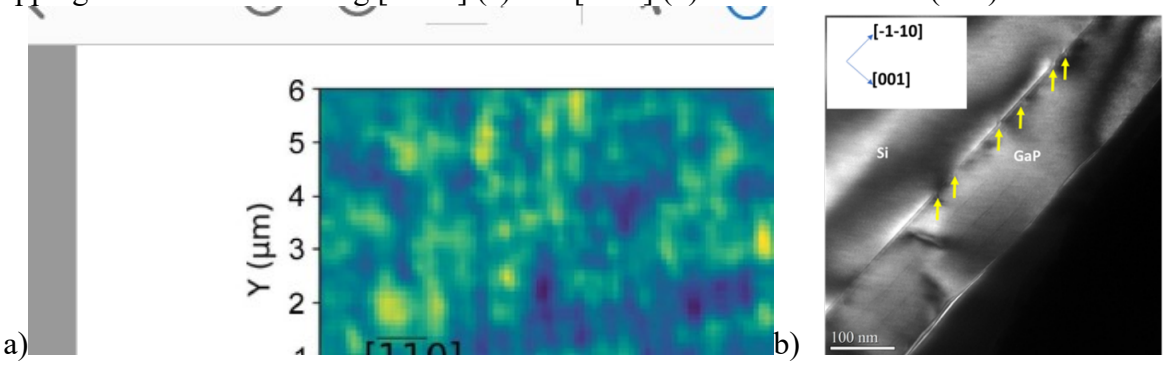


Fig. 3 a: Mapping of the in plane strain recored on GaP (004) reflection, b: TEM cross section showing misfit dislocations.

This later part of the experiment allowed us to study strain related to misfit dislocations. The complex 5D dataset (3D in reciprocal space+2D in space) provides rich local structural information, such as the lattice tilt and the strain. Cross-hatch like patterns parallel to the [-1-10] and [-1-10] can be evidence local tilt and strain mappings. The anisotropy of the distribution of strain is however shown fig. 3a. It should be related to the Si miscut. Combined with TEM measurements, the relaxation rate measured by K-map on the (004) Bragg reflection shows that 60° dislocations seem to be the main mechanism in the strain relief process, and the distribution of the dislocations is not homogeneous. We suggest that the cross-hatch pattern at the GaP/Si interface influences the free surface roughness, as demonstrated by a strong correlation between the K-Map strain mapping and the surface roughness mapping measured by AFM.

References:

[1] Y. Ping Wang, A. Létoublon, T. Nguyen Thanh, M. Bahri, et al. J. Appl. Cryst. **45** (2015) 702-709
[2] A. Zhou, Y. P. Wang, C. Cornet et al.. J. Appl. Cryst. (2019). 52, 809–815.
[3] Y. Wang et al.. X-ray Coherent Scattering on GaP/Si for III-V Monolithic Integration on Silicon. International Workshop on Phase retrieval and Coherent Scattering (COHERENCE 2016), Jun 2016, Saint-Malo, France. 2016.
[4] A. Zhou et al. *EMRS - Spring Meeting* Jun 2018, Strasbourg, France

Justification and comments about the use of beam time (5 lines max.):

15 shifts combined with the use of an efficient 2D detector allowed us to study 4 samples of different thicknesses.

Publication(s):

- 1 paper published in Applied Crystallograhy [2], 2 contribution in international conferences [3-4].