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 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:** Anti-phase and twin domains detection in GaP nanolayers on Si vicinal surfaces	**Experiment number**: **32-02-727**
Beamline:	**Date of experiment**: from: 02/04/2010 to: 06/04/2010	**Date of report**: 29/09/2010 *Received at ESRF:*
Shifts:	**Local contact(s)**: Jean-Sébastien MICHA	
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Introduction

Our laboratory is skilled in MBE growth of III-V quantum structures on InP, for laser devices with potential applications telecommunication. In order to extend these applications III-V growth on silicon is studied. For this purpose GaP and related quaternary (GaAsPN) materials lattice matched to Si are studied. The best optical properties can be obtained with GaP as starting layer. But, the structural properties of this interface are of primary importance.

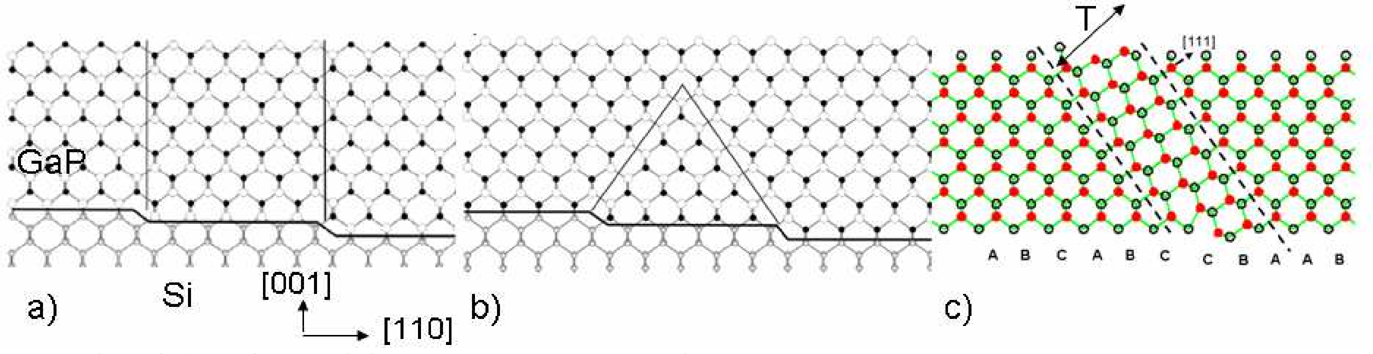

Fig. 1 Typical defects in GaP/Si nanolayers. a: E-APD, b: SA-APD c: MT.

Several types of defects are observed on such layers: point defects, misfit dislocations, microtwin (MT), stacking faults (SF) and anti phase boundaries (APB). These defects are detrimental for optical properties and must be eliminated or at least confined near the Si interface. Amongst them APB and thus anti-phase domains (APD) are difficult to avoid since they are due to the intrinsic nature of the interface. The fig. 1 presents 2 typical APD in a GaP layer on a vicinal Si(001) substrate with a: an emerging APD (E-APD) and b: a self annihilating APD (SA-APD). A MT is aslo shown (c). In this type of material, APD have been characterized using mainly transmission electron microscopy (TEM) [1]. But XRD is very powerfull (no sample preparation, more statistical meaning…) [2].

20nm GaP layers samples have been grown in our laboratory on 4° miscut samples, at the laboratory using a solid source MBE. The 4° miscut should favor the formation of Si bisteps in order to limit the formation of APD [3]. Different growth conditions are employed (growth temperature, post growth annealing, continuous MBE or alternative deposition of Ga/P) in order to minimise the defect density and the roughness of GaP surface. XRD has been employed on a laboratory setup for the GaP layer characterisation. High overall crystal perfection has been observed when looking at strong reflections, (004) and (224). Howether transverse scans through (002), (004) and (006) exhibit a specific broadening part on the weak reflections (002) and (006). This has been interpreted by the presence of APD that are probably emerging at the surface (E-APD). This interpretation is also supported by a comparative XRD/TEM study performed on a different sample [4].

Experimental results

Due to lack of time and technical problems only one sample has been studied. Grazing incidence condition has been used to emphasise the contribution of the GaP layer. Broadening of weak reflections ((200) and (222) types) confirm observed features on our lab setup for the same sample: high density of emerging APD with a characteristic lateral size of the order of 15nm. But as shown on figure 2, diffuse streaks also show up around some GaP reflections. When following these streaks, new reflections (fig. 2b) are found at positions in agreement with the presence of microtwins (MT) which correspond to a 180° rotation of the GaP main phase around a [111] axis [5]. The 4 possible types of MT were identified by carrying out transverse RSM around (222) and (2-22) reflections. The thickness T (fig. 1c) of the MT has been also evaluated by taking the correlation length as the inverse of the integral breadth of the peak. For fig. 2b a correlation length of about 6nm is found across the MT reflection at (1.66, 2.33, 1.66). A larger correlation length is found in the 2 perpendicular directions for the same peak. These observations are also confirmed by TEM observations carried on a different sample elaborated in the same conditions. These new reflections type could not be observed on our lab setup. This shows the necessity of synchrotron radiation for characterisation of such defects in nanolayers. As shown also on these RSM the contribution of the emerging APD can be clearly evidenced, with a broadening along the lateral direction, i.e. perpendicular to the (110) oriented APB.

Conclusion and perspectives

This experiments showed the high sensitivity of synchrotron XRD for detection of GaP defects. A complementary experiment should be carried out on a another sample higher of structural quality (i.e. which presents weak broadened contribution on all peaks) for a better comprehension of APD anihilation. For this purpose, SR is absolutely required for detection of SA-APD.

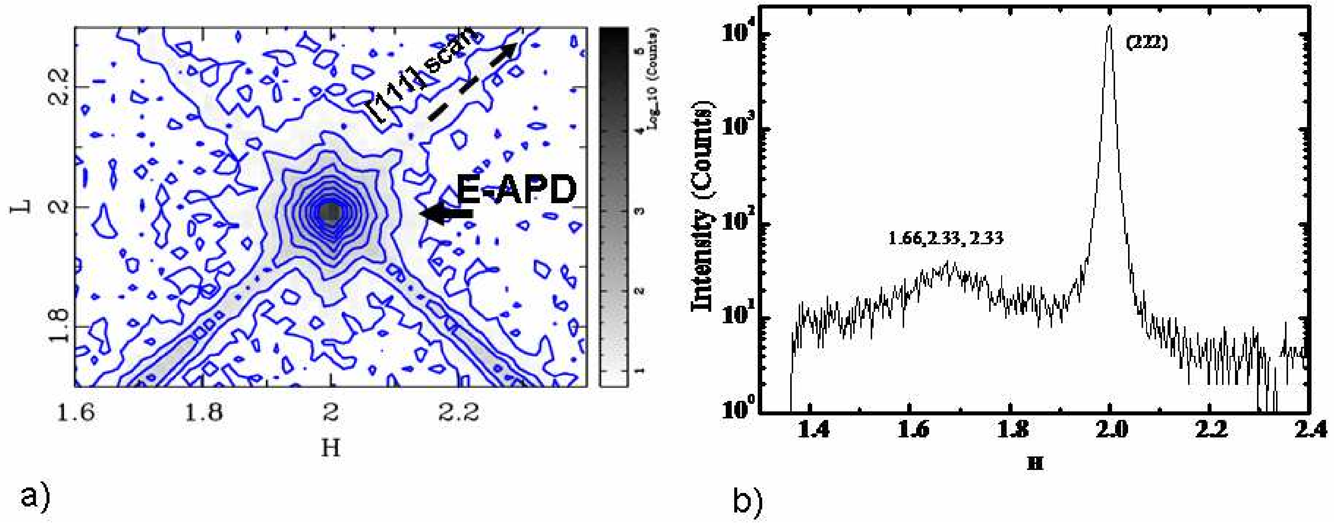

Fig. 2 a: Transverse RSM around (2-22) showing MT streaks along 3 fold axis direction and E-APD.

References :

[1] I. Németh, B. Kunert, W. Stolz, K. Volz, J. Cryst. Growth 310 (2008) 1595.

[2] D. A. Neuman, H. Zabel, R. Fischer, H. Morkoç, J. Appl. Phys. 61 (1987) 1023.

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[5] K. Hiruma et al. Journ. of Appl. Phys. 77 (1995) 447.