EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

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:** Anomalous x-ray reflectivity study of buried interfaces between Ge and GaAs	**Experiment number**: Si923
Beamline: ID01	**Date of experiment**: from: 05.Sep.2003 to: 12.Sep.2003	**Date of report**: 30.Mar.2004
Shifts: 18	**Local contact(s)**: Bärbel Krause	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):
Prof. Dr. G. Bauer,
E. Wintersberger,*
J. Novak,*
Institut für Halbleiter- und Festkörperphysik
Johannes Kepler Universität Linz
Altenbergerstr. 69
A-4040 Linz
Austria

Report:

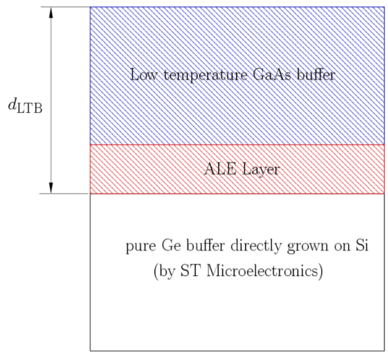

Figure 1: The structure of sample ge121 and ge152. d_{LTB} is the net thicknes of the low temperature buffer layer and the atomic layer epitaxy (ALE) layer.

ST Microelectronics have invented a method for growing thick Ge buffers of constant composition exhibiting a threading dislocation (TD) density of 10^8 cm^{-2} and a root-mean-square roughnes of about 0.5 nm. Therefore, the quality of their Ge buffers is sufficient for devices.

The samples measured during the experiment Si923 can be considered as an application for this ST Microelectronics buffers. Both samples are GaAs buffers grown on a ST Microelectronics Ge buffer deposited on a Si substrate. The GaAs buffers are intended to serve as substrates for future InGaAs/GaAs quantum wells. The samples were grown at the Laboratoire de Photonique et de Nanostructures in Marcoussis. Figure 1 shows the structure of the two samples (namely ge121 and ge152) measured during this experiment. The ALE layer between the Ge and the GaAs buffer layer should avoid the formation of anti phase boundaries.

Our aim was to investigate the buried Ge/GaAs interface being not accessible via atomic force microscopy (AFM) and other surface sensitive methods but via x-ray reflectivity (XRR). First experiments where done at our lab at the university of Linz using a 8 keV x-ray tube as a source. Figure 2 shows a typical result of such a XRR measurement at 8 keV. Obvioulsy there are no fringes from the Ge/GaAs interface visible, and therefore, no information about the buried interface could be obtained from this first measurements. The reason for this is quite simple if one takes the energy dependece of the optical constants of Ge and GaAs into account.

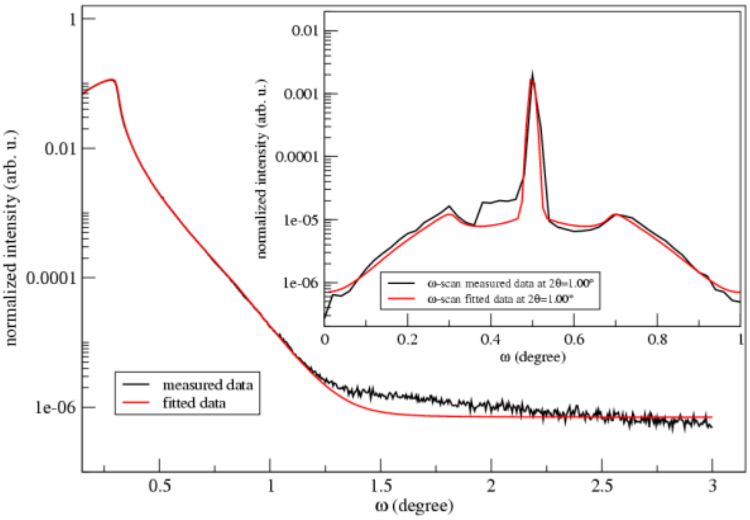

Figure 2: X-ray reflectivity from sample ge152 at an energy of 8 keV.The black line denote the measured and the red one the fitted data. The big picture shows an radial and the small one an angular scan. In the specular scan no fringes from the Ge/GaAs interface are visible.

At an energy of 8 keV these constants are nearly equal for Ga and GaAs and therefore no constrast in the index of refraction could be achieved between the two materials. However, at an energy of 10.3 keV, near the Ga edge, the optical constants of Ge and GaAs differ sufficiently from each other giving rise to a reasonable contrast between GaAs and Ge. Since this energy cannot be achieved by common laboratory souces the measurements have been repeated at the anomalous scattering beamline ID01.

During our experiment we changed the x-ray energy 10.3773 keV being exactly the Ga edge, to obtain maximum contrast. A typical result from the anomalous XRR measurements recorded at ID01 is shown in Fig. 3. The fringes due to the Ge/GaAs interface are clearly visible in the specular intensity. For every sample the x-ray reflectivity was recorded in three 90 degree azimuths to obtain information on the homogenety of the samples. In addition to a radial scan we also performed an angular scan to obtain more information on the distribution of the diffusely scatterd intensity.

A position sensitive detector (PSD) was used for recording the data, providing the complete information needed for data postprocessing (specular and diffuse intensity). The recorded data was corrected with respect to the diffuse background and normalized to the primary beam intensity. After this a fitting program has been used to determine the net thickness of the GaAs layers, i.e., d_{LTB}. It turned out that for one sample (ge152) the specular reflectivity and therefore d_{LTB} depends on the azimuth. We could show that this comes from an inhomogenous thickness distribution over the sample area.

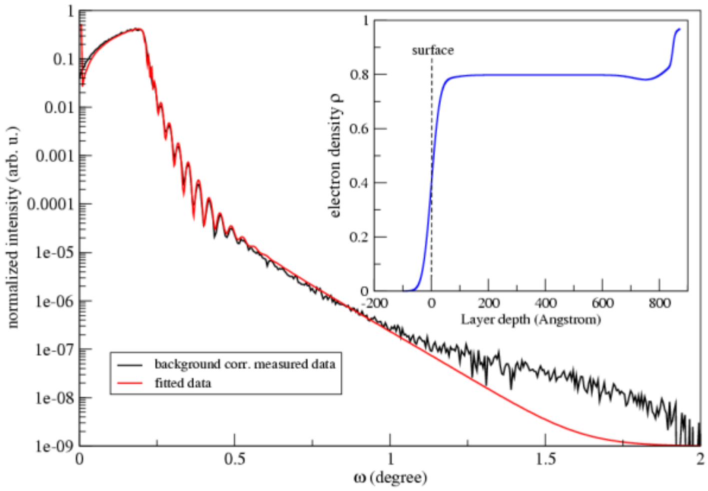

Figure 3: XRR measurement from sample ge121 at an energy of 10.3773 keV. The large picture shows again the specular reflectivity where as the small one the relative electron density. In the specular reflectivity the oscillations from the Ge/GaAs interface are clearly visible.

Finally, we can conclude that anomalous XRR is a powerfull tool for the investigation of burried Ge/GaAs interfaces. It was possible to fit the layer thicknesses of the GaAs layer on top of the Ge buffer. However, further measurements should be made to improve the method and the fitting model has to be further developed for a precise determination of the interface roughness and the relative electron density.