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:** Grazing-incidence diffraction from a three-dimensionally ordered Ge dot-crystal	**Experiment number**:
Beamline: ID10B	**Date of experiment**: from: 12.Feb.2004 to: 17.Feb.2004	**Date of report**: 29.Mar.2004
Shifts: 15	**Local contact(s)**: Bernd Struth	*Received at ESRF:*

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Report:

We have investigated Ge/Si multilayer samples, where in each Ge layer about 6ML of Ge have been deposited, leading to the self-organized formation of SiGe islands. In contrast to previous studies on similar samples grown on flat Si(001) substrates, these multilayers have been deposited onto prepatterned Si(001) substrates: the substrates are coated with photo resist, and using holographic lithography a periodic stripe pattern with a period of about 300 nm is generated. Rotating the substrates by 90° and repeating the procedure, a two-dimensional pattern is produced, which is transferred into the Si substrates. After prepatterning, the substrates are inserted into an molecular beam epitaxy system, and the surface is cleaned by a high-temperature step, which (together with the subsequent growth of a Si buffer layer) alters the surface pattern: the etched pits transform into facetted pits. The Ge islands consequently grow within these pits on facetted surfaces different from the (001) substrate surface, which changes the growth conditions. As a result, perfectly two-dimensionally ordered SiGe islands with a very narrow size distribution are produced [1]. Growing multilayers, the vertical stacking of islands in subsequent layers leads to three-dimensionally ordered island multilayers. The aim of our experiments is to characterize the parameters of the resulting islands, and compare the results with islands grown under identical conditions onto flat substrates. Furthermore, the statistical properties of the island ordering is investigated.

In order to obtain information on the strain distribution within the growth plane and along growth direction, reciprocal space maps around asymmetrical reciprocal lattice points have

been recorded in co-planar gemoetry, i.e., with the incident and diffracted beams and the surface normal lying in a common plane. An example is shown in Fig. 1 (sample CG037). In addition to the intensity modulation along Q_z, which is due to the multilayer structure, many orders of satellite maxima also along Q_x are found. The latter reflect the highly perfect lateral ordering of the SiGe islands.

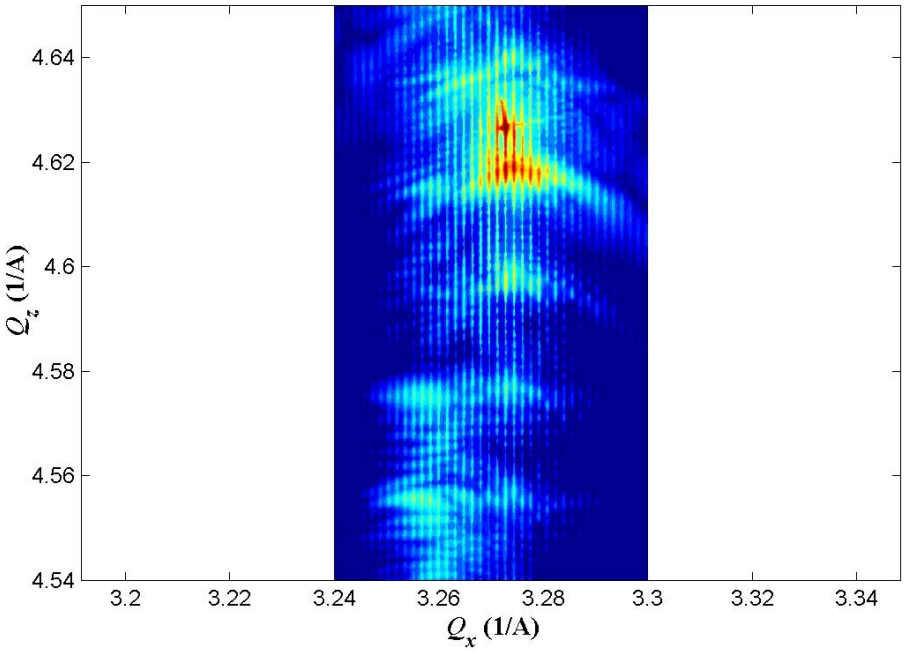

Figure 1: Reciprocal space map around the (224) Bragg reflection of sample CG037, showing lateral satellites due to the lateral SiGe island ordering.

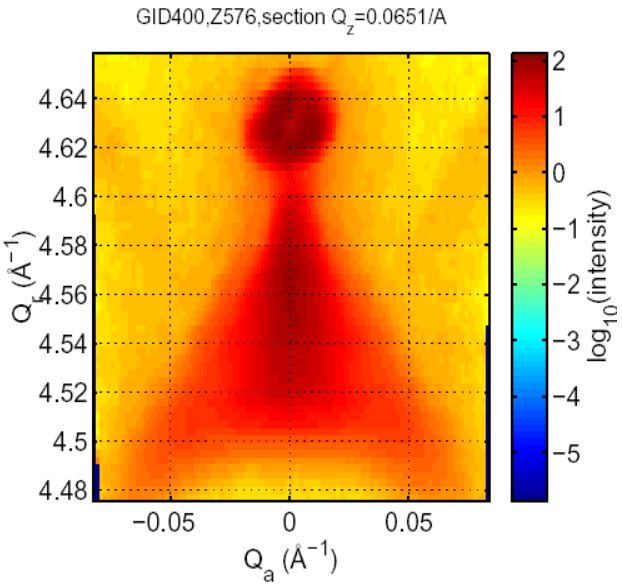

Figure 2: In-plane GID map around the (220) reflection of sample Z576.

The Ge composition of the individual islands can in principle be obtained from the envelope of the satellite peaks. However, the scattering pattern is rather complicated, and first attempts to obtain a good fit have not been fully satisfactory. In order to obtain additional information on the Ge content, i.e., on the Si-Ge intermixing, we performed grazing incidence diffraction around the (220) inplane Bragg reflection. Figure 2 shows the diffracted intensity for sample Z576 for a certain Q_z value, i.e., a slice parallel to the sample surface through the three-simensional intensity distribution. From the lower intensity maximum, the average in-plane relaxation can be estimated. Furthermore, from the complete data set, streaks from the different facets of the grooves and the pits can be observed.

[1] Z. Zhong, A. Halilovic, T. Fromherz, F. Schäffler, G. Bauer, Appl. Phys. Lett. **82**, 4779-4781 (2003).