FORSCHUNGSZENTRUM ROSSENDORF
ROBL CRG at the ESRF

ROBL-CRG

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 beamtime for measurements on ROBL (BM 20) at the ESRF. This double-page report will be reduced to a one page, A4 format, and will be published in the Annex to the ROBL Bi-Annual Report. The report may be put on the Web-pages of the FZR. If necessary, you may ask for an appropriate delay between report submission and publication.

Should you wish to make more general comments on the experiment, enclose these on a separate sheet, and send both the Report and comments to the FZR or ROBL team.

Published papers

All users must give proper credit to ROBL 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 ROBL (will be submitted to the Joint ESRF/ ILL library) the complete reference and the abstract of all papers appearing in print, and resulting from the use of ROBL.

Deadlines for submission of Experimental Report

Normally, reports should be submitted not later than 6 month after the experiment.

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 / experiment 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.
- bear in mind that the double-page report will be reduced to 71% of its original size, A4 format. A type-face such as “Times” or “Arial” , 14 points, with a 1.5 line spacing between lines for the text produces a report which can be read easily.

Note that requests for further beam time must always be accompanied by a report on previous measurements.

Postal address: FZR, Postfach 510119, D-01314 Dresden; Germany
Telephone: (0351) 260 3122; Fax: (0351) 260 3438.
ROBL-CRG at the ESRF, B.P. 220, F-38043 Grenoble Cedex, France
Telephone: (33) 476 88 -2339/2367; Fax: (33) 476 88 -2505

ROBL-CRG	**Experiment title:** PLEASE FILL IN	**Experiment number**: 20-02-58
Beamline: BM 20	**Date of experiment**: from: 12.06.2002 to:18.06.2002	**Date of report**: 29.10.2002
Shifts: 18	**Local contact(s)**:Andreas Bauer	*Received at ROBL:*
Names and affiliations of applicants (* indicates experimentalists): Laurent Diehl * Selcuk Mentese * Julian Stangl *		

Report:

Aim of the experiment was the investigation of plastic relaxation via the formation of dislocations in Si/SiGe multilayer structures. The samples have been grown at the PSI Villingen (Switzerland) and are so-called quantum cascade structures. A series of strained SiGe layers forms quantum wells for holes in the valence band. For especially designed quantum well widths and depths (the latter are determined by the Ge content of the wells and their strain status) minibands are formed under an applied bias, and electroluminescence can be observed. A particular problem of such structures in the SiGe system is the required large number of strained layers with a very high total thickness, which may lead to plastic relaxation. In order to enhance the design freedom for such structures, instead of growing them directly onto Si (001) wafers, they are grown onto a virtual substrate with a different lattice parameter than Si. For this purpose, Si wafers with a strain-relaxed SiGe buffer layer have been used.

For the investigated samples, the plastic relaxation of the remaining strain via formation or multiplication of dislocations during thermal treatment has been investigated, in order to obtain a measure for the thermal budget the structures may undergo during device processing without deterioration. It was planned to use a small furnance available at ROBL beamline to perform this annealing study in-situ, recording reciprocal space maps around selected reflections during annealing at temperatures between 450°C and 850°C. Due to a problem with the furnance, the annealing had to be carried out ex-situ, and the samples have been measured after subsequent annealing steps. Figure 1 shows several

reciprocal space maps of sample J014 in the as-grown state as well as after annealing at 850°C for 30 minutes. As is obvious from the maps, the shape of the diffusely scattered intensity from the SiGe buffer as well as from the cascade multilayer shows small differences. Also, the average position with respect to the Si substrate is slightly changed, which might hint at a different strain state. It is, however, not clear, whether this is already an effect of annealing and a difference in the dislocation distribution in the samples, or whether the differences rather result from different measurement spots at the samples: as the annealing was ex-situ and the sampels had to be aligned after each annealing step, it is likely that slightly different spots are illuminated.

As the samples are grown on a relaxed buffer containing already a high density of dislocations, the threading segments of dislocations penetrate the SiGe cascade structure already in the as-grown sample, leading to a peak broadening in reciprocal space maps. Hence small differences in the relaxation state are difficult to detect in the case of an ex-situ annealing study for samples exhibiting lateral inhomogeneities, as is the case here.

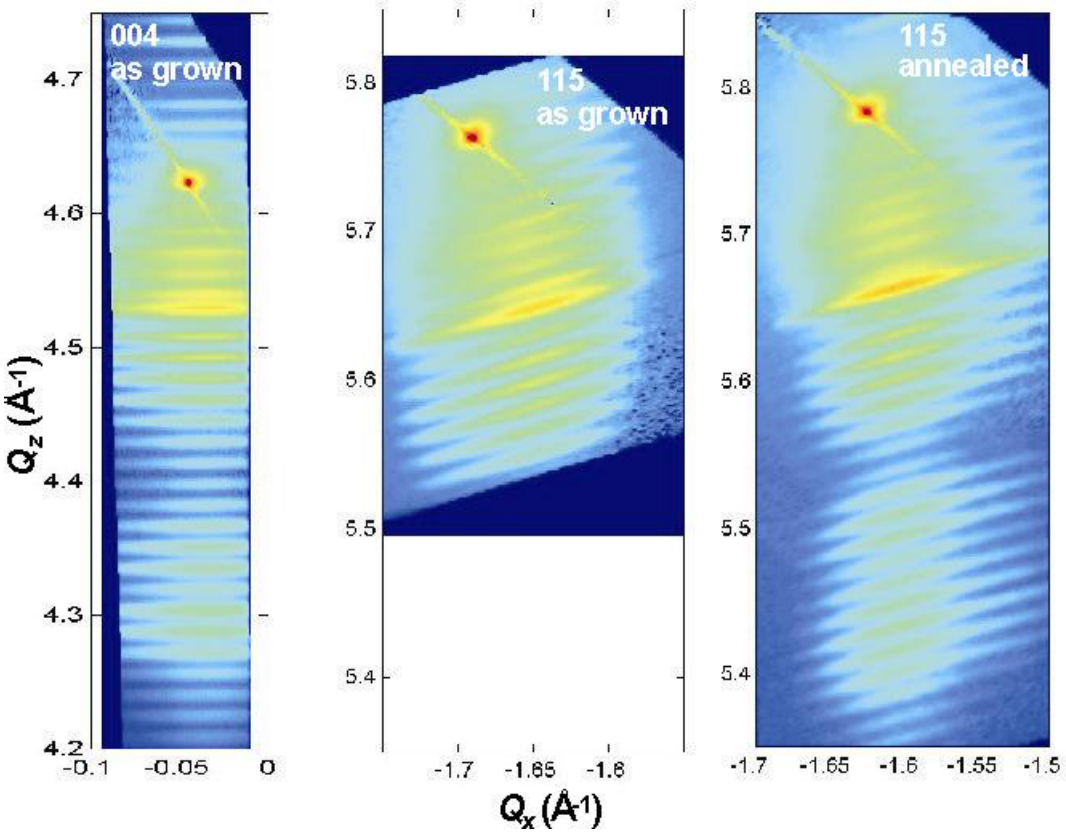

Fig. 1: Reciprocal space maps around (004) and (115) of sample J014 as grown and after annealing at 850°C for 30 min.