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:** Diffuse x-ray scattering at linearly ordered SiGe/Si(113) islands	**Experiment number**: HS-2809
Beamline: ID10B	**Date of experiment**: from: 15.02.06 to: 21.02.06	**Date of report**: 28.02.2006
Shifts: 18	**Local contact(s)**: Dr. Oleg Konovalov	*Received at ESRF:*

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Report:

During the time of application for our recent beamtime, nearly one year ago, we hold a close collaboration with the Institute for Crystal Growth, Berlin concerning unidirectional ordering of SiGe dots on homoepitaxial Si(113), and although we have been successfully in the preparation [1], the samples did not fully meet our initial expectations. Since high uniformity shape- and size-vice are essential requirements for the proposed GID and GISAXS measurements we have decided (in advance, and in agreement with the local contact) to focus on a similar, however different system - vertically stacked InGaAs quantum dots embedded in a GaAs(311)B matrix grown by means of MBE. Regardless the actual material, similar questions on the mutual impact of strain energy emerging during dot growth and its partial relief, on the one hand side, and dot morphology and directed self-assembling on the other side have been focused on. Thus, we are interested in the influence of various substrate orientations on the interplay between lateral ordering and vertical inheritance. Previously performed high resolution-ray diffraction measurements along with finite element simulations on the strain field demonstrate a dedicated control of lateral and vertical ordering [2,3].
Here we report on GaAs(311)B based vertical superlattices comprising 16.5 periods of 10 monolayers $In_{0.4}Ga_{0.6}As$, forming quantum dots, and subsequent GaAs layers with spacer thicknesses between 30 and 240 monolayers. During the recent beamtime we have performed grazing incidence diffraction (GID) to probe the impact of various spacer layer thicknesses on the vertical inheritance of the initial dot assembling. Since the strain modulation of an underlying dot should become more decisive for lateral ordering within subsequent dot layers with decreasing spacer thickness [4], one would expect a decreasing angle of inheritance. Surprisingly high resolution x-ray diffraction (performed prior at HASYLAB) indicate that there is no obvious dependence between spacer thickness and the direction of inheritance. This probably hints at an additional effect, presumably related to the particular dot shape, which is – in particular for the buried dot layers – not solved yet.

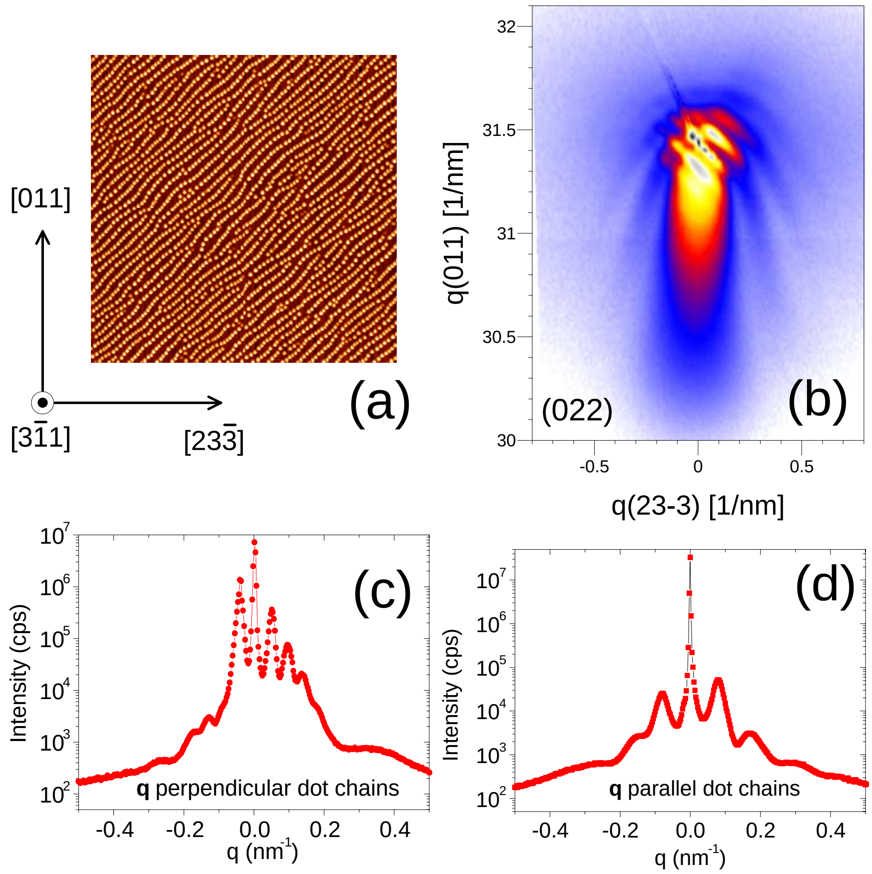

*Fig. 1: Atomic force micrograph (a) of the topmost InGaAs dot layer (180 ML GaAs) and grazing incidence diffraction (b) close to the (022) reflection recorded at an angle of incidence of 0.5°. The pattern depicts an extended diffuse scattering due to strain distribution within the GaAs matrix superimposed by pronounced lateral correlation peaks along the dot chains and perpendicular to them. (c) and (d) show respective line scans through the substrate reflection, wherein the mentioned **q**-vector notates the scattering vector in addition to $\mathbf{q}_{022}$.*

As one example we will briefly discuss a vertical dot stack where the dot layers are separated by 180 ML GaAs, a value which provides extended dot chains running 47° azimutally off the [011] direction, fig.1(a). The lateral dot assembling causes intense modulations close the GaAs (022) substrate reflection, fig.1(b). The satellites distance perpendicular to the chains Δq of 0.045 nm^{-1}, fig.1(c), yields an inter-chain separation of 139 nm (via $2\pi/\Delta q$) which corresponds well with the AFM value of 138 nm. Regardless the obvious asymmetry due to ordering, one may consider the diffuse scattering at $q_{radial} < q_{GaAs(022)}$ is slightly shifted towards negative values of angular momentum transfer, an effect which becomes more pronounced on further samples, even in opposite angular direction. To meet the reader's rather plausibel objection, that sample drift during the scan (which can cause a similar effect) has been omitted: the angular positions of substrate reflection are identical before and after the scan within the goniometer accuracy. To interpret this surprizing result, which is most probably related to (a vertically evolving or asymmetric?) dot shape, we will perform semi-kinematical scattering simulations on the base of finite element calculations which can also provide the established indium profile within the dots.
In parallel with this report we will apply for an additional beamtime at ID 10B considering the described set of samples in order to perform grazing incidence small angle x-ray scattering, an analytical tool which will provide strain-free shape and ordering information.

[1] M.Hanke, T.Boeck, A.-K.Gerlitzke, F.Syrowatka, F.Heyroth, Appl. Phys. Lett. **86**, 223109 (2005)
[2] M. Schmidbauer, Sh. Seydmohamadi, D. Grigoriev, Zh. M. Wang, Yu. I. Mazur, P. Schäfer, M. Hanke, R. Köhler, and G. J. Salamo, Phys. Rev. Lett. **96**, 066108 (2006)
[3] M. Hanke, D. Grigoriev, M. Schmidbauer, P. Schäfer, R. Köhler, R.L. Sellin, U.W. Pohl, D. Bimberg, Appl. Phys. Lett. **85**, 3062 (2004)
[4] G. Springholz, M. Pinczolits, P. Mayer, V. Holy, G. Bauer, H. H. Kang, L. Salamanca-Riba Phys. Rev. Lett. **84**, 4669 (2000)