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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

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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.

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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:** In-situ GISAXS and GID investigations of the growth of Ge-islands on Si(001)	**Experiment number**: Si-1047
Beamline: BM32	**Date of experiment**: from: 13.04.2004 to: 21.04.2004	**Date of report**: 29.08.2004
Shifts: 21	**Local contact(s)**: Tobias U. Schülli, Gilles Renaud	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

T. U. Schülli*[1], M.-I. Richard*[1], E. Wintersberger*[2], G. Renaud*[1], R. Dujardin*[1], A. Letoublon*[1], M. Ducruet*[1], A. Barski*[1], G. Bauer[2], V. Holy[2]

[1] *Commissariat à l'Energie Atomique, 17 avenue des Martyrs, 38054 Grenoble, France*

[2] *Johannes Kepler Universität Linz, Institut für Halbleiterphysik, 4040 Linz, Austria*

Report:

Grazing incidence samll angle scattering (GISAXS) and diffraction (GID) measurements have been performed during the deposition of Ge on Si(001). The experimental setup allowed for a combined measurement in diffraction and small angle scattering geometry within only a few minutes. The monlayerwise deposition could thus be followed on an atomistic scale (evolution of the surface reconstruction and strain relaxation) as well as on the mesoscale (surface roughening during island nucleation, island morphology and faceting).

Under GID conditions, the 2x1 surface reconstruction was monitored and in-plane reciprocal space maps were recorded in the vicinity of the Si(220) and Si(400) reflections were recorded. GISAXS images were registered with a 2D CCD detector.

In Fig. 1 (a) a radial scan along <110> is presented, containing the half order peaks of the 2x1 surface reconstruction. Figure 1 (b) shows the (½ ½ 0) reflection as a function of Ge deposit. The intensity significantly decreases significantly with the deposit bewteen 1 and 3 monolayers (ML) of Ge and the reconstruction signal has completely dissappeared for 4 ML.

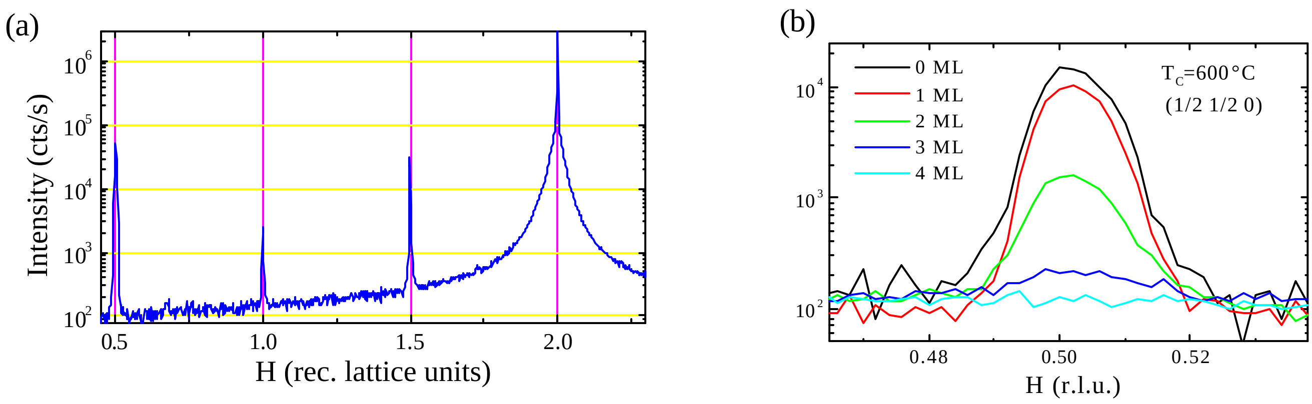

Fig.1: (a) radial scan along <110> of a 2x1 reconstructed Si(001) surface. (b) (½ ½ 0) reflection as a function of Ge deposit.

The vanishsing of the 2x1 surface reconstruction coincides with the beginning nucleation of islands. The latter can be monitored by the lattice relaxation that is visible in the vicinity of the Bragg peaks. The appearance of the (220) diffraction signal from nucleated islands as a function of the Ge deposit is shown in Fig. 2(a). It can be seen, that up to 3 deposited MLs, the diffraction signal ressembles to the one of a clean Si-surface indicating pseudomorphic strain in a 2D layer of Ge on Si. At 4 ML, a "shoulder" appears to the left side of the Si(220) Bragg peak. For continuing deposition, this shoulder evolves towards more relaxed positions in reciprocal space. At the same time, a rise of the scattered intensity around the Si peak proves that an induced distortion of the Substrate takes place with the island nucleation. The change of the relaxation behaviour between 4 and 5 ML deposited can be atttributed to a change of the island morphology. For a deposit of up to 4 ML, the GISAXS pattern shows no change. The islands that nucleate at 4 ML are thus very flat objects. At 5 ML, first streaks from facets of type {113} appear. For increasing deposition, these streaks get narrower, indicating an increase in size of these facets (see Fig. 2 (b)). GISAXS images for a variety of azimuts were recorded. The most pronounced facets were found for {113} and {15 3 23} orientations as shown in Fig. 2 (c), confirming STM results published recently [2].

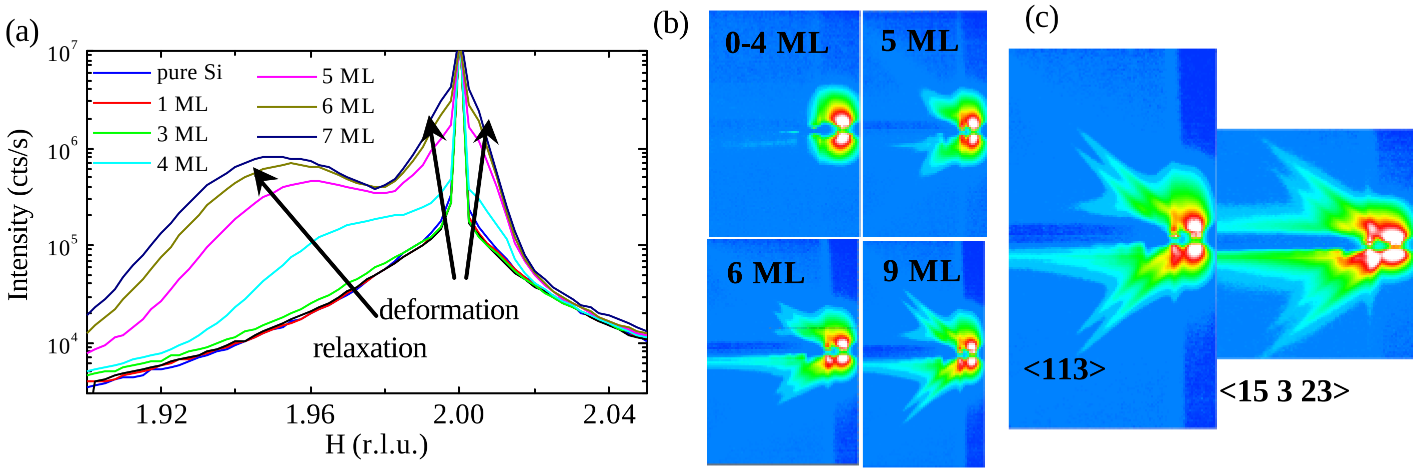

Fig. 2: (a): radial scan in the vicinity of the Si(220) reflection for different deposits of Ge. (b): GISAXS images in the <110> azimut showing the appearance of {113} facets. (c): The facet orientations {113} and {15 3 23} are dominatina terminations of facetted domes .

Quantitative analysis of the GISAXS images and the reciprocal space maps (not shown in this report) is in progress and will allow us to track the evolution of island size and interdiffusion during the growth.

References

[1] G. Renaud, R. Lazzari, C. Revenant, Science **300**, 1416 (2003).
[2] A. Rastelli, H. von Känel, Surf. Sci. **515**, L493 (2002).