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: Investigation of strain and Ge/Si interdiffusion in Ge islands MBE-grown on Si (001) through thin oxid layers.**	**Experiment number**: HS 1542
Beamline: ID 01	**Date of experiment**: from: 10/03/2001 to: 10/08/2001	**Date of report**: 27.02.02
Shifts: 18	**Local contact(s)**: T.H. Metzger	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

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Report:

During the last 10 years, semiconductor nanostructures have been investigated extensively in order to study the effect of quantum confinement on the physical properties of semiconducting materials. Group IV (i.e. Si and Ge), nanostructures embedded in a dielectric layer can emit light and store carriers suggesting future applications in optoelectronic and non-volatile memory devices.

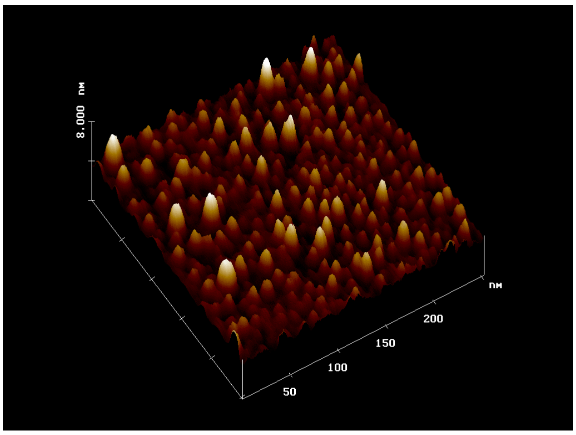

Figure 1 : AFM image in tapping mode of germanium dots grown on a silicon (001) surface covered by a thin nitride layer.

A major difficulty in the fabrication is that nanometric dimensions and high density of dots have to be achieved in order to make the devices operate at room temperature. Recently germanium dots have been grown by Molecular Beam Epitaxy (MBE) on a silicon (001) surface covered by a thin (1.2 nm thick) silicon oxide [1] and/or silicon nitride layer [2]. Growth has been performed on an MBE machine installed on the CRG IF beamline (BM 32). The experimental procedure, which induces the growth of high-density ($4x10^{11}/cm^2$) and nanometric size germanium dots on silicon oxide and silicon nitride has been described previously [1,2]. Despite the presence of a thin dielectric layer germanium dots grown by MBE exhibit an epitaxial relationship with the underlying silicon substrate. In order to optimise the growth procedure a systematic characterisation of the density and shape of dots has been performed by Atomic Force Microscopy (AFM) observations in the Surface Science Laboratory of ESRF (see Figure 1).

Grazing Incidence X-ray Diffraction (GID) experiments have been performed on the ID1 beamline in order to investigate the structural properties of germanium dots (see Figure 2).

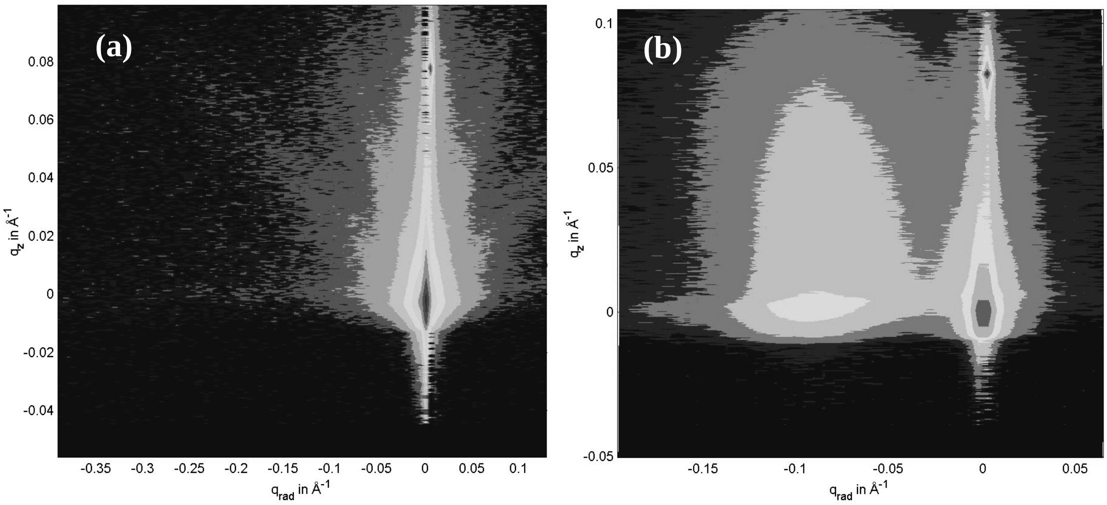

Figure 2 : The radial scans of the germanium dots: (a) few nm, (b) 12 nm size, grown on a silicon (001) surface covered by a thin silicon nitride layer.

Two different set of samples have been investigated: germanium dots grown through a very thin Si_3N_4 layer on the Si (001) surface and the same germanium dots subsequently buried by a thick Si_3N_4 capping layer. From the GID measurements at the (220) surface reflection the strain distribution inside the dots has been determined. The radial scans from (220) germanium to the (220) silicon Bragg peak for two different samples are shown in Figure 2. For small dots (few nanometers diameter) only a small asymmetry can be detected close to the silicon Bragg peak (Fig 2(a)) indicating a high degree of pseudomorphic strain inside the dots. Larger dots (~12 nm) exhibit a large distribution of in-plane lattice parameter induced by an elastic strain relaxation (Fig 2(b)). For all samples, the Grazing Incidence Small Angle X-ray Scattering (GISAXS) measurements were also performed in order to determine the size and shape of the germanium dots.

References

[1] A. Barski, M. Derivaz, P. Noe, J. L. Rouvière, D. Buttard, D. Sotta, Appl. Phys. Lett. 77, 3541 (2000)
[2] M. Derivaz, P. Noe, J.L. Rouvière, D. Buttard, D. Sotta, P. Gentile and A. Barski, Mat. Sci. and Eng. B 89, 191 (2002)

Papers published as a result of measurements performed during this experiment :

١) STRAIN DISTRIBUTION IN GERMANIUM DOTS GROWN THROUGH A VERY THIN DIELECTRIC LAYER ON SILICON (001) SURFACE, M.Derivaz, P.Noe, J.L.Rouviere, P.Gentile, A.Barski, Département de Recherche Fondamentale sur la Matière Condensée, CEA/Grenoble, SP2M 38054 Grenoble, Cedex 9, France and T.H.Metzger, O.Plantevin, T.Schulli, ESRF, BP 220, 38043 Grenoble cedex, France, send to EMRS., Strasbourg, France 2002

٢) STRAIN DISTRIBUTION IN GERMANIUM DOTS GROWN THROUGH A VERY THIN DIELECTRIC LAYER ON SILICON (001) SURFACE, M.Derivaz, P.Noe, R.Dianoux, P.Gentile and A.Barski, Département de Recherche Fondamentale sur la Matière Condensée, CEA/Grenoble, SP2M 38054 Grenoble, Cedex 9, France and T.H.Metzger, O.Plantevin, T.Schulli, ESRF, BP 220, 38043 Grenoble cedex, France, send to NANO7/ECOSS21, Malmö , Sweden 2002