ESRF	**Experiment title:**	**Experiment number**:
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Shifts: 18	**Local contact(s)**: Dr Nils Blanc	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

G. Saint-Girons*, B. Gobaut* (PhD student), A. Chettaoui* (PhD student), J. Penuelas

INL-ECL, Lyon

V. Favre-Nicolin*, G. Renaud*

CEA – Grenoble

N. Blanc*

ESRF-BM32

Report:

First of all the Ge evaporator was degased prior to the beamtine on the SUV setup. The Ge flux was calibrated at 1.6A/minute via a quartz microbalance, which correspond to an evaporation temperature of 1190°C. This flux is low enough to be able to follow the growth at each step of the growth (typically few seconds of deposition and then GIXD + GISAXS measurements). The temperature was double checked via a thermocouple and a pyrometer.

$SrTiO_3$ substrates were degased, and the surface reconstruction observed via RHEED and GIXD in order to obtain a clean surface. However we were not completely satisfied of the commercial substrate quality (XPS measurements performed after the experiment have shown lots of impurity SrTiO3). However a clean 2x1 surface was obtained after annealing at 550°C.

The substrate temperature during the deposition was calibrated. At high temperature (>550°C Ge re-evaporate and we cannot grow the layer, the only way to avoid this re-evaporation is to grow a Ge thick layer. The substrate temperature was then changed to 430°C, a successful growth was then performed corresponding to 370s of Ge deposition.

A mapping of the reciprocal space was performed in order to identify each contribution (“bulk like” SrTiO3 , SrTiO3 surface reconstruction, 111 oriented Ge and 001 oriented Ge).

On this mapping we identify, the Ge Bragg peak corresponding to two different orientations. We decided to follow the evolution of these peaks during the growth. At each step GISAXS measurements were performed for three different azimuth corresponding to different sample orientations, in order to observe any effect of the surface anisotropy (step, surface reconstruction domain)

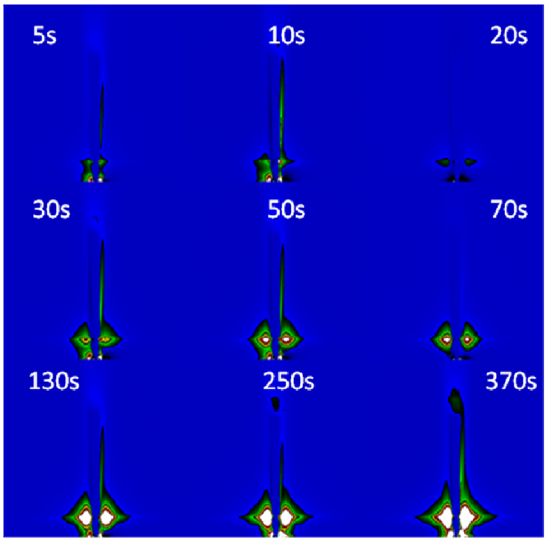

Figure 1 : GISAXS pattern (background substracted) during the Ge deposition.

The evolution of the GISAXS pattern shows the formation of two lobes which is the signature of nucleation and subsequent growth of Ge islands on the surface. No island facetting is visible, the patterns corresponding to the three azimuthal angles show no clear differences, which means no surface anisotropy is detected via GISAXS.

DWBA simulations are in progress with the IsGISAXS software [1] in order to extract the islands morphology (diameter, height, and shape), the evolution of the islands density will be also determined.

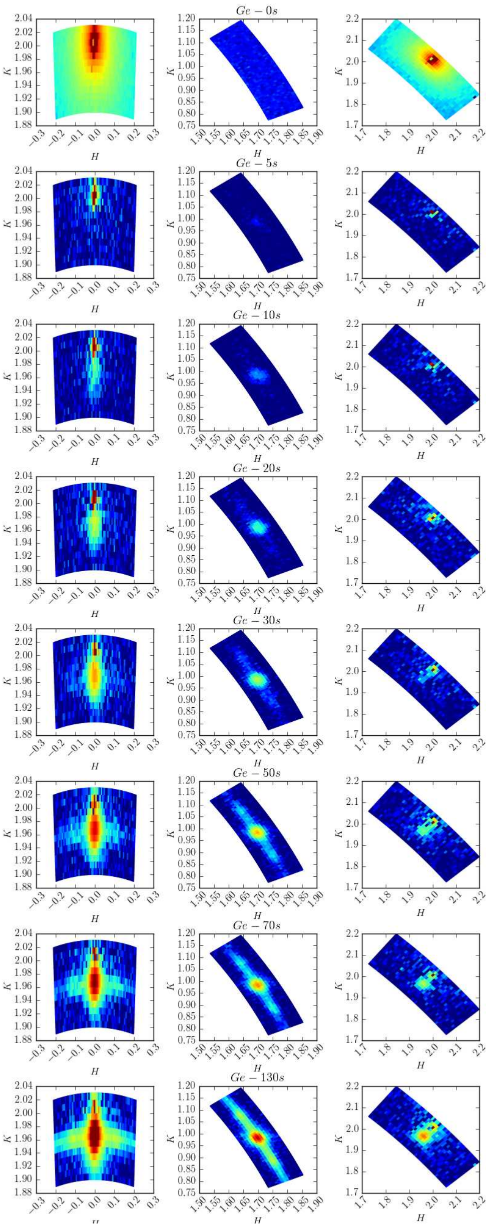

Figure 2: Evolution of the reciprocal space map during the Ge deposition

Mappings of the Bragg peaks located around h=2, k=0 (first column); h=1.7, k=1 (second column) and h=2, k=2 (third column) are shown on figure 2 in SrTiO3 reciprocal space units. The first and second columns are related to 220 Ge Bragg peaks and the third to the 400 Ge Bragg peak.

Each line corresponds to different Ge deposition time. Figure at 0s correspond to the substrate, then the data are corrected of the substrate contribution.

From these data we extracted the Ge Bragg peak (first column) which was fitted with voigt function. The position and the width of the peak was determined and plotted with the deposition time (figure 3).

At the very beginning of the growth we observed that the lattice parameter of Ge is slightly different from the bulk which could be the signature of interfacial dislocation. However due to important substrate contribution, the fit is difficult and error bars are important. By performing l-scans we could measure the Ge lattice parameter and avoid the substrate contribution.

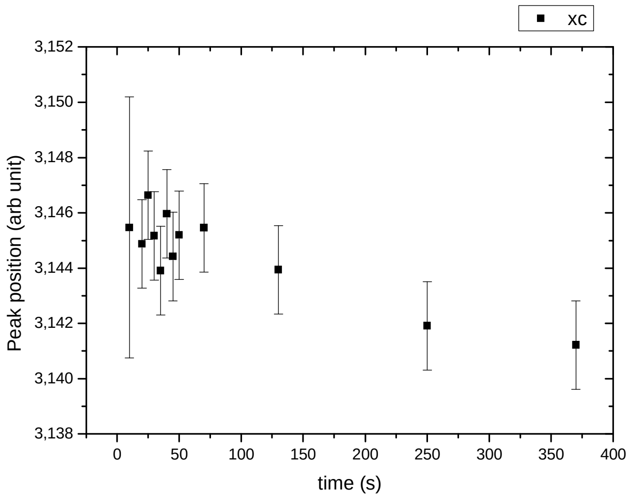

Figure 3: Evolution of the position of Ge 220 peak with time

This contraction of the Ge lattice parameter could be the signature of strains at the very beginning of the growth, during the formation of the dislocation network at the Ge/SrTiO3 interface. Analysis are still in progress.

Two kinds of islands were observed, corresponding to two different epitaxial relationships. The first one, is related to a cube on cube epitaxy leading to 001 out of plane oriented Ge islands, the other one is related to triangle on square epitaxy leading to 111 out of plane oriented Ge islands. The mapping of figure 2 are related to these islands: first column to 001 + 111 islands, second column to 111 islands, third column to 001 islands. The volume of each peak is being analyzed in order to obtain the proportion of these two kinds of islands during the growth. Interestingly 111 oriented islands correspond to incommensurate epitaxy. However several orientations seem to be favorable as displayed on figure 4 which represents azimuthal scans around the 220 Ge Bragg peak. This effect was already observed for InP on SrTiO3, and was explain by a simple model [2], however the measurements were performed at a fixed amount of InP. Our results show the evolution of these preferential orientations with the particles size. Calculation are in progress to fit our data.

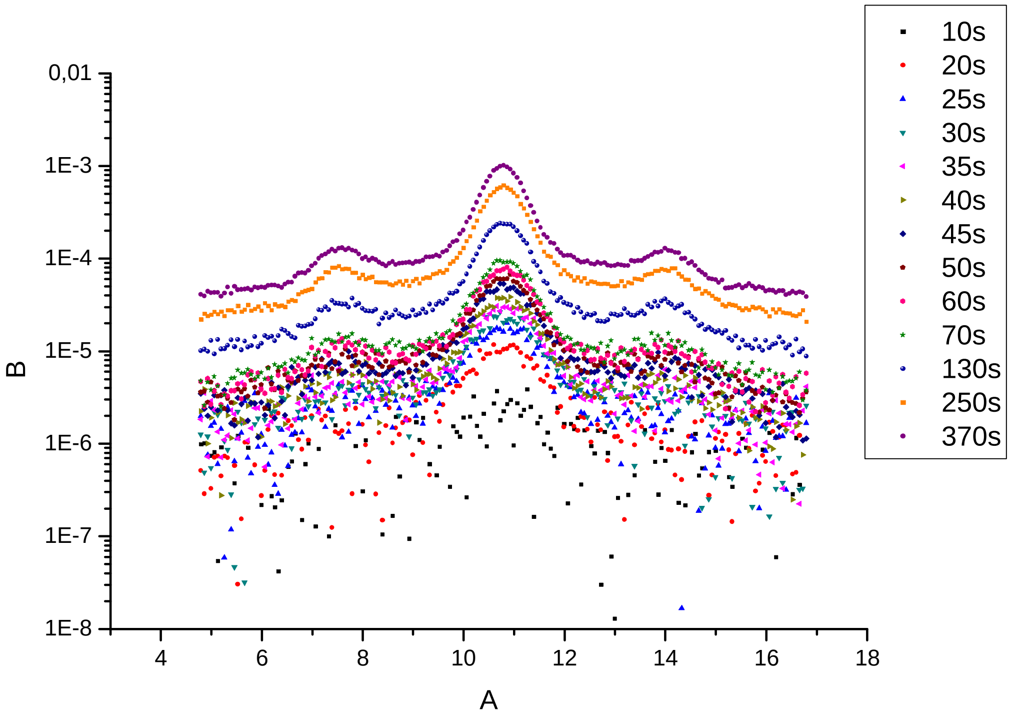

Figure 4: Azimuthal scans for a Ge(220) reflection corresponding to 111 oriented islands.

References:

[1] R. Lazzari, Journal of Applied Crystallography **35**, 406 (2002)
[2] G. Saint-Girons et al. Applied Physics Letters **92**, 241907 (2008)