ESRF	**Experiment title:** Nano-diffraction at individual SiGe/Si island clusters and InGaAs/GaAs quantum dot molecules	**Experiment number**: SI-1784
Beamline: ID13	**Date of experiment**: from: 11.03.2009 to: 18.03.2009	**Date of report**: 30.07.2009
Shifts: 15	**Local contact(s)**: Dr. Manfred Burghammer	*Received at ESRF:*

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Report:

This experiment was an addition to experiment SI-1605 performed in March 2008 where an individual SiGe/Si(001) island has been examined with a nano-focussed X-ray beam at beamline ID13. At that time several facets of an pyramid-like SiGe island with base length of 1 μm could be illuminated with a spot size of 200 nm. Nano-fluorescence maps of the islands and reciprocal space maps with facet rods of individual side facets has been demonstrated [1].

The aim of experiment SI-1784 was to go to smaller and more complex samples especially of the SiGe system. We examined island clusters of up to four SiGe pyramids grown in the direct surrounding of holes during a self-assembling process (see fig. 1). These islands now were around 50 nm in height and have a base length of about 100 nm. Measurements of the diffuse scattered intensity around the Si (004) reflex has been performed. The beam size was 250x250 nm² with a resulting vertical footprint at the sample surface of around 350 nm in size. Hence, if a cluster of pyramids has been hit directly the whole cluster was illuminated.

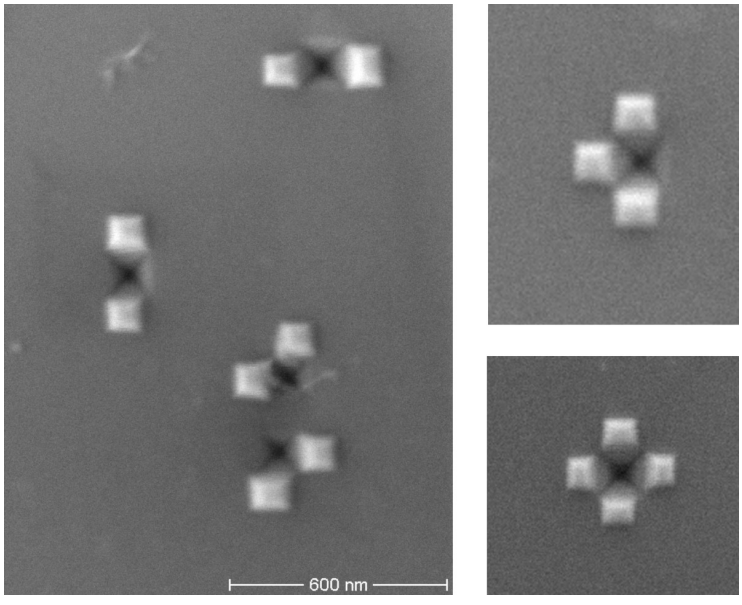

Fig. 1: Scanning electron micrographs of SiGe/Si(001) islands

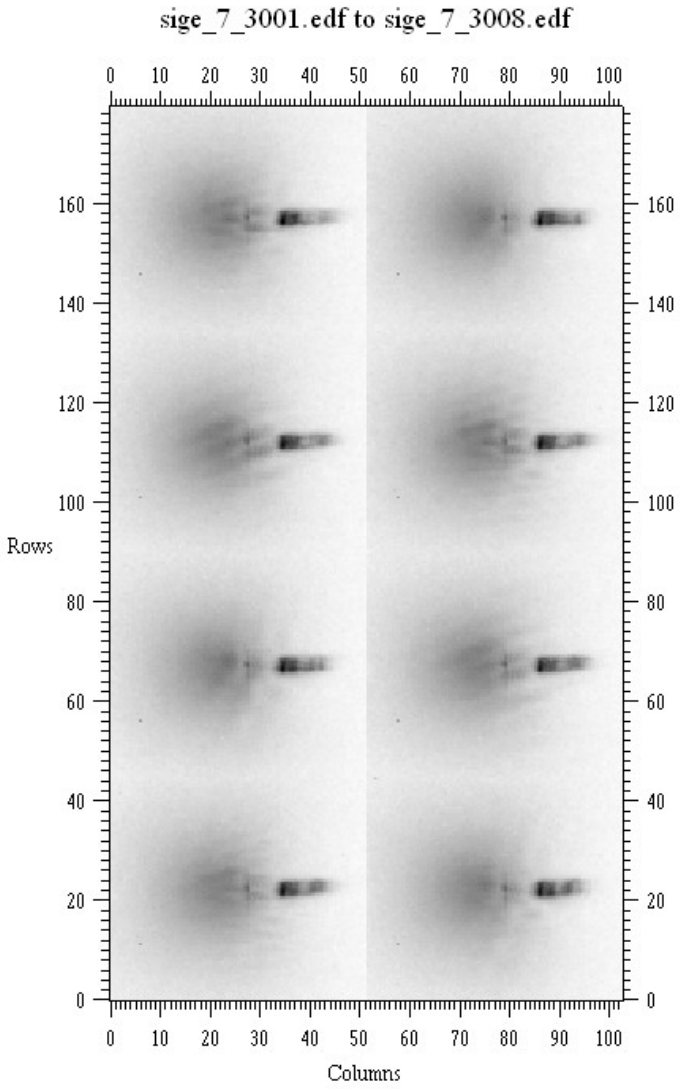

Fig. 2: Sequence of reciprocal space maps around Si (004) reflex of different local positions on the sample.

We have already performed FEM calculations with models of all variations of clusters (one single pyramid, clusters of two, three or four pyramids).
Fig. 3 depicts two examples of deformation profiles from models with two SiGe islands each, as discribed more in detail in the image description. Black lines in fig. 3 indicate the bordering edges beween the side facets of the pyramids and holes. Comparing the FEM results of the individual islands of each model one can see clear asymmetries in the deformation fields. This will also effect X-ray scattering simulations. Further steps of data treatment and subsequent X-ray scattering simulations are in preparation.

In fig. 2 an example of the recorded reciprocal space maps of different sequential positions on the sample surface is shown. The sample surface has been moved horizontally or vertically in steps of 300 nm after each exposing process. If the beam hits a structure on the surface a complex diffraction pattern is visible. The uppermost map on the right and the lowermost on the right show almost no fine structures like the majority of positions on the sample surface does whereas all other maps of fig. 2 have fine structured diffraction pattern that has to be interpretated.

The method of high resolution X-ray diffraction is very sensitive to the strain distribution inside the quantum dot objects, shape and positional ordering of the objects. With the finite element method (FEM) one can calculate the deformation profile in three-dimensional models of the grown nano-objects and can use this as input data for X-ray scattering simulations. A comparison between simulations and the experimental data will be used to confirm our interpretations.

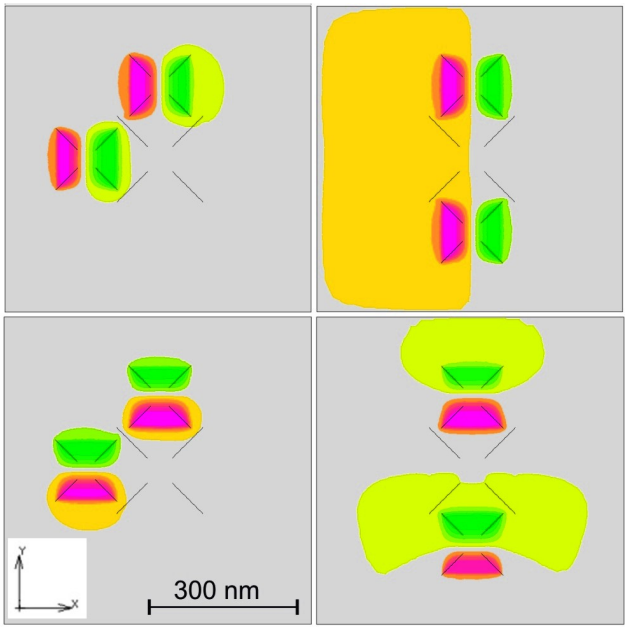

Fig. 3: FEM calculations of two different clusters of two islands each. The upper two pictures show the deformation field in x direction (on the left one model with two pyramids and an on the right an other model with two opposed pyramids). The lower two pictures show the deformation field of each model in y direction.

[1] "Scanning X-ray diffraction with 200 nm spatial resolution" Hanke, M.; Dubslaff, M.; et al; Appl. Phys. Lett. 92, 193109 (2008) and ESRF spotlight http://www.esrf.eu/news/spotlight/spotlight64/spotlight64/