ESRF	**Experiment title:** Coherent x-ray scattering at individual SiGe/Si islands	**Experiment number**: SI-1605
Beamline: ID13	**Date of experiment**: from: 27.02.2008 to: 04.03.2008	**Date of report**: 10.03.2008
Shifts: 15	**Local contact(s)**: Dr. Sebastian Schoeder, Dr. Manfred Burghammer	*Received at ESRF:*

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Report:

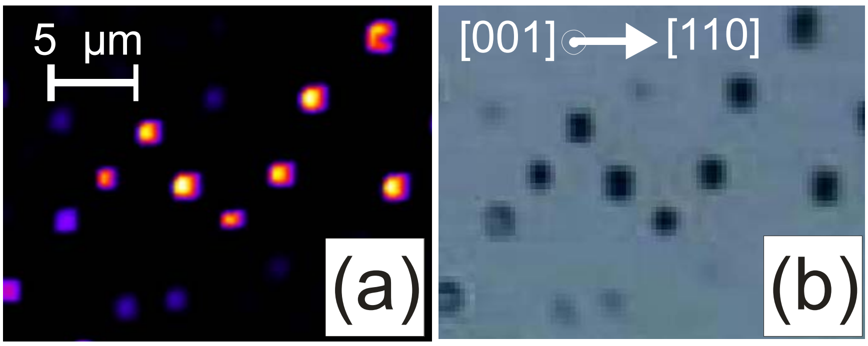

Fig.1: (a) Ge-Kα fluorescence signal of SiGe/Si(001) islands as probed with a scanning x-ray beam (200 nm diameter at 15.4 keV, refractive lenses [C.Schroer, Dresden]) compared with (b) an optical micrograph taken at the same position on the sample.

X-ray diffraction serves a powerful tool to probe the three-dimensional strain distribution in nanoscale objects. With the availability of monochromatic nano-focused x-ray beams at ID13 (ESRF), investigations of individual nanoscale objects became accessible and will be reported here. In summary, we have focused on single SiGe/Si islands, and reciprocal space maps were recorded with a local resolution of about 200 nm.

The islands were grown in the so-called Stranski-Krastanow mode by liquid phase epitaxy from a liquid bismuth solution. Such an approach ensures a growth rather close to thermodynamic equilibrium, and the islands consequently tend do establish their equilibrium shape [1], which consists of truncated pyramids with four adjacent {111} facets and a single (001) top facet. Depending on the applied germanium content one can accurately adjust the final islands size between e.g. 3 µm base width (at 5% germanium) and about 50 nm (about 80% germanium) [2]. While varying the growth time subsequent growth stages are found, e.g. flat islands with side facets

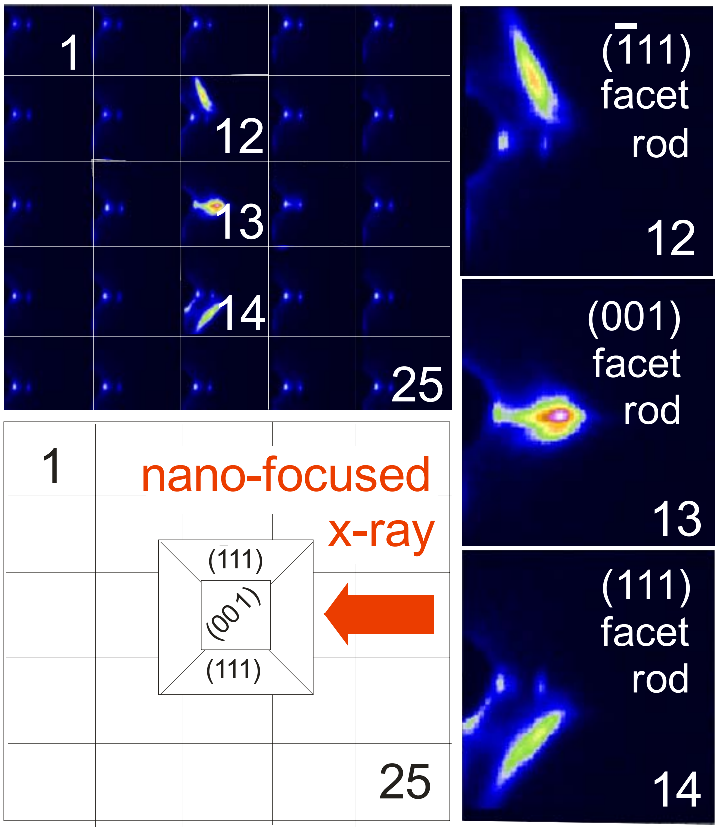

Fig.2: locally resolved diffuse scattering patterns (as measured by a CCD detector) at different positions of the x-ray spot on the sample (1-25).

less step than {111} and final objects with an aspect ratio base vs. height of about two. Recent x-ray scattering investigations on ensembles of similar islands revealed a non-uniform germanium (which results in an even more complex elastic strain) profile inside.

Fig.1a briefly illustrates the Ge-Kα fluorescence, which coincides quite well with a corresponding image of an optical microscope (b). It nicely shows the ability to use x-ray fluorescence instead of optical microscopy, which turns to be an essential adjustment tool while approaching dimensions smaller than the optical wavelength (which is planned in a continuation of experiment SI-1605). The initial x-ray beam with an energy of 15.4 keV was focused by refractive x-ray lenses installed by the group of Prof. Dr. Christian Schroer (TU Dresden). X-ray foci of 200 nm, and in a few cases 100 nm (combined however with an about ten-fold reduced intensity) has been used to locally probe the SiGe/Si islands and their close vicinity at the substrate.

As a first, however promising example an area close to a SiGe/Si(001) island with 1 µm base width was divided into a grid of 5×5 measuring points, fig.2. Please note that each image exhibits a characteristic scattering pattern, indicating that individual regions inside the island are probed. For example, we were able to spatially resolve different scattering features depending on the particularly illuminated {111} facet (there are four), which excites different facet rods (12,13,14). Obviously the nano-focused x-ray probes each part of the island as a kind of semi-infinite crystal and hence excites just particular facet rods.

Further on we have mapped at each position an entire three-dimensional reciprocal space map (not shown here) near the (004) reflection. Thereby we have locally probed the strain distribution within different islands areas. Respective scattering simulations in order to receive quantitative information are under way.

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References:

[1] M.Hanke et al., Appl. Phys. Lett. 84, 5228 (2004)

[2] W.Dorsch et al., Appl. Phys. Lett. 72, 179 (1998)