ESRF	**Experiment title:** Ordering of self-assembled SiGe islands studied by grazing incidence x-ray small angle scattering and x-ray diffraction	**Experiment number:** SI-427
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Names and affiliations of applicants (* indicates experimentalists):

Prof. Dr. Rolf Köhler (Humboldt-Universität zu Berlin, Institut für Physik, AG Röntgenbeugung, Hausvogteiplatz 5-7, 10117 Berlin)

Dr. Martin Schmidbauer* (same address)
Thomas Wiebach* (same address)
Michael Hanke* (same address)

We have investigated coherent $Si_{1-x}Ge_x$ layers grown on Si (001) by means of liquid phase epitaxy (LPE). The layers have been grown in Stranski-Krastanov growth mode and consist of coherent {111}-faceted truncated pyramids exhibiting unique shape and a narrow size distribution. We report here on our preliminary data evaluation and give an overview of the most important and relevant results. All measurements were performed at E = 8000 eV. Typical values for the Ge content x, the island base width w and the island height h are x = 25 %, w = 140 nm, h = 80 nm, respectively. The experiments mainly consist of two parts. Briefly, these are (i) the investigation of lateral correlation effects, and, (ii) the characterisation of the strain field inside the pyramids.

1. Correlation effects as measured with GISAXS

We performed triple crystal grazing incidence small angle scattering (GISAXS) with the use of a linear position sensitive detector (PSD) oriented along the surface normal **n**. In this scheme we were able to measure reciprocal space maps representing vertical cuts through the 000 reciprocal lattice point with high resolution. Along q_x it is determined by the analyser crystal ($\Delta q_x = 2.5\ 10^{-4}$ Å^{-1}) whereas along q_z it is given by the vertical beam size and the spatial resolution of the PSD ($\Delta q_z = 5.6\ 10^{-4}$ Å^{-1}).

We have investigated two samples exhibiting low and high island coverage. As an example for the latter case a characteristic cut through the 110 plane (i.e. incoming beam oriented along the island base line) is displayed in Fig.1a. The following features are of relevance: (i) there are strong correlation satellite peaks (rods) at $\Delta q_x = \pm 3.4\cdot 10^{-3}$ Å^{-1}, and, (ii) these peaks are superimposed by a strong contribution from the island shape function which is manifested as two broad rods (CTR) tilted at an angle of about 54° ({111} facets of the pyramids). Moreover, these two rods show pronounced thickness fringes. Since there is a complex interplay of shape and correlation effects one important result is that a complete understanding of GISAXS can be only obtained by measuring 2D-reciprocal space maps instead of the usual technique of 1D transversal scans. Due to the use of an analyser crystal the measurements are, however, rather time consuming. For that reason only a small choice of samples could be investigated. For a more detailed understanding a larger amount of different samples have to be investigated at different scattering conditions. A possible solution is the use of a CCD camera instead of the combination: crystal analyser + PSD.

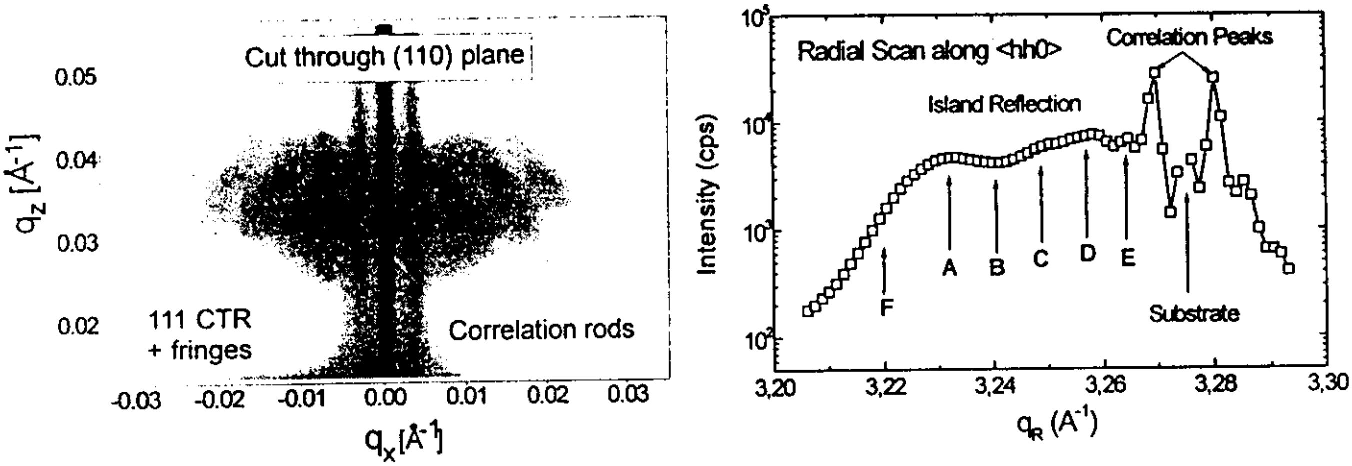

Fig.1: *(a) Reciprocal space map of GISAXS intensity distribution at high island coverage, (b) radial scan of grazing incidence diffraction (220).*

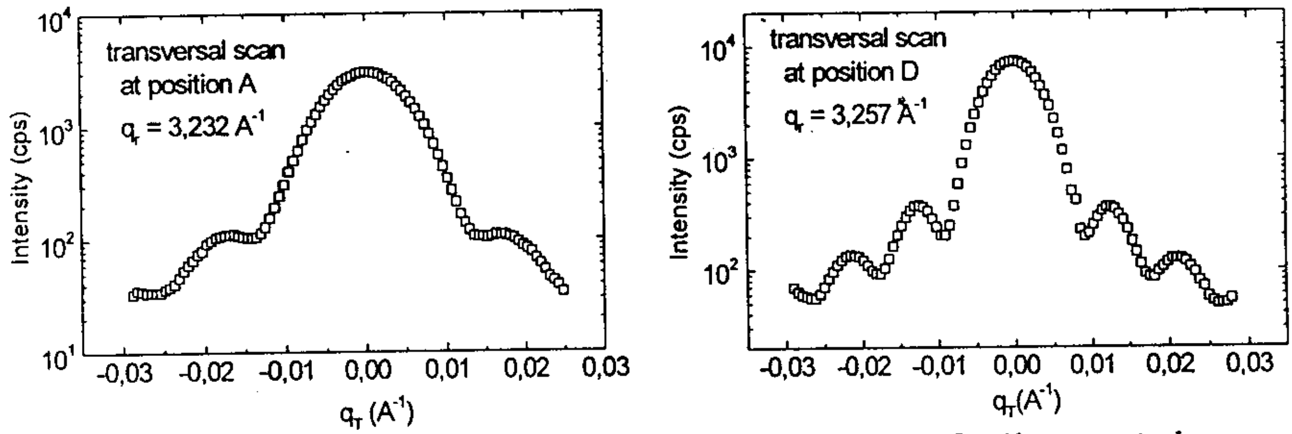

Fig.2: *Transversal scans through radial scan at points A and D in Fig.1b, respectively.*

2. The Strain Field as measured with GID

In order to investigate the strain field inside the islands we have performed grazing incidence x-ray diffraction (GID) using basically the same scattering scheme as described above at. We can then perform scans along all three directions of reciprocal space.

In Fig.1b an example of a radial scan along hh0 in the proximity of the 220 substrate reflection is shown. Due to the high intensity the substrate peak appearing at q_R = 3.275 Å^{-1} is not shown. The two sharp peaks are - as already observed with GISAXS - due to lateral correlation whereas the broad underlying feature can be attributed to diffraction from single islands. Note that the island reflection shows structure with broad peaks at q_R = 3.232 Å^{-1} and q_R = 3.257 Å^{-1}, respectively. This behaviour is characteristic for the intrinsic strain field of the pyramid since FEM calculations show that the top part of the pyramid is nearly totally relaxed whereas regions close to the substrate-island interface are strongly strained.

At fixed values of q_R (see arrows in Fig.1b) we have performed transversal scans. In these scans (Fig.2) we observe extended fringes that are due to the island shape function. It is interesting to note that the wavelength of the fringes depends on q_r. This is a hint that each data point of the radial scan can be assigned to a distinct spatial part of the island. These parts are related to areas showing identical lateral strain. A similar behaviour for InAs islands on GaAs has been found by Kegel et al [1]. The model used here has, however, to be improved. Currently, x-ray diffraction simulations which include finite element calculations for the strain field are performed.

More extended investigations are needed to understand the diffraction process in more detail.

[1] I. Kegel et al. Europhysics Lett. **45**, 222 (1999).