ROBL-CRG	**Experiment title:** **In-situ annealing studies of SiGe nano-structures: x-ray diffraction and GISAXS studies**	**Experiment number**: 20-02-050 EU-M03
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Report:

The intentions of this beamtime at ROBL were the investigations of SiGe-structures and nanostructures with the help of grazing incident small angle scattering (GISAXS) and conventional high angle diffraction. Si/SiGe cascade emission structures have been developed and manufactured recently, and for the first time with well-resolved electroluminescence in 10 µm wavelength range. The non-radiative lifetime is found to depend strongly on the design of the quantum well structure (layer thickness, Ge concentration and interface roughness). Using GISAXS we want to obtain more detailed information about the interface roughness corellation properties within one interface and from interface to interface. The self-organsitation of pyramidal PbSe islands that spontaneously form during strained-layer epitaxial growth of PbSe/PbEuTe superlattices results in the formation of 3D dot crystals. Lateral and vertical ordering of these PbSe quantum dots have been studied recording reciprocal space maps around (111).

The Si/SiGe cascade structures were investigated using GISAXS geometry with a PSD. This geometry enables us to record a large range of momentum transfer in reciprocal space, i.e. small lateral structures. Thus, we achieved detailed information on the correlation spectrum of the interface morphology.

To obtain information on the vertical and lateral ordering of the PbSe dots, we measured reciprocal space maps (RSMs) in coplanar high-resolution x-ray diffraction geometry. RSMs were measured in three different azimuths [-1-12], [-101] [-211]

within the (111) surface using a position sensitiv detector (PSD). In the RSMs q_z is parallel to the [111] surface normal. A large number of satellite peaks is observed not only along q_z, but also in the q_x direction parallel to the surface (Fig. 1). The appearance of these peaks proves that the dot positions are highly correlated both laterally and vertically. This ordering shows a strong dependence on the PbEuTe spacer layer thickness; thus a whole sample series with the same growth parameters, but with varying spacer layer thicknesses, were investigated. We were able to show that a pronounced hexagonal lateral ordering tendency for vertical aligned dots exists around 160 Å spacer layer thickness (Fig. 1 a). Furthermore, the lateral dot spacing changes linearly with spacer thickness, as can be seen from the spacing of the lateral intensity maxima. As a comparision, we investigated also a sample with a spacer thickness of about 460 Å, revealing a well ordered fcc-like dot stacking (Fig. 1 c).

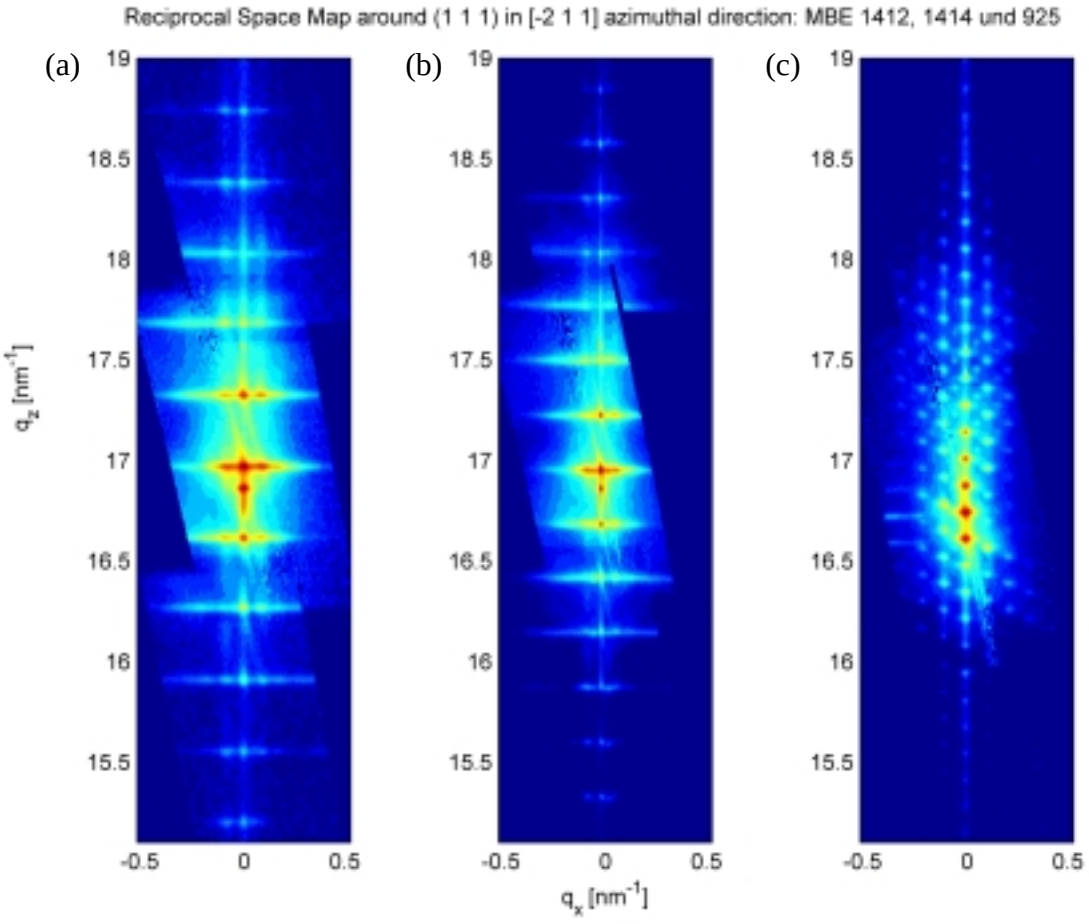

Fig. 1: Reciprocal space maps around (111): PbSe Dots with (a) 160 Å, (b) 200 Å and (c) 460 Å PbEuTe spacer layer thickness.