	Experiment title: "Coherent X-ray diffraction of individual GaAs nanorods grown by seed-free MOVPE onto GaAs[111]"	Experiment number: SI-1738
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U. Pietsch, A. Biermanns, A. Davydok, H. Pätzelt, V. Gottschalch <i>1. Solid State Physics, University of Siegen, D- 57068 Siegen, Germany</i> <i>2. Semiconductor Chemistry Group, University of Leipzig, D- 04103 Leipzig, Germany</i>		

The aim of this proposal was to measure and compare structural features of individual GaAs nanorods (NRs) grown in a periodic array by seed-free metal organic vapour phase epitaxy (MOVPE) through a pre-patterned SiN_x mask. In particular we have measured GaAs NRs grown on GaAs[111]B. Patterning of the SiN_x mask with lateral spacing of $1\text{ }\mu\text{m} < D < 3\text{ }\mu\text{m}$ was performed within an area up of $600 \times 600\text{ }\mu\text{m}^2$. Fig.1 shows a respective SEM picture of the sample. The hexagonal shape of NR and the square arrangement of the pattern are clearly visible.

Besides the unknown influence of the SiN_x mask on the growth process, it is assumed that the mutual interaction of neighbouring nanorods during growth affect the final shape and size of individual rods. Therefore we selected individual NRs grown in the centre or at the border of the array measured the coherent diffraction patterns at these selected positions.

The experiment at ID1 was performed using the novel nanofocus setup installed at the beamline. The 8keV X-ray beam was focussed down to a spot size of $220 \times 600\text{ nm}^2$ (FWHM vertical and horizontal, respectively) using a Fresnel zone plate (FZP) placed 130mm in front of the sample. A central beamstop and an order-sorting aperture were placed in front and behind the FZP, respectively, to block all but the first diffraction orders produced by the FZP. In order to achieve an almost fully coherent illumination of the sample, the incoming X-ray beam was reduced to a size matching the transverse coherence length.

Under this conditions, the final spot size on the sample surface matches well the size of individual nanorods (fig.1), allowing to efficiently use the coherent flux.

In order to identify individual NRs, we utilized the fact that the NRs are slightly strained with respect to the substrate, giving rise to a diffracted signal at a slightly smaller Bragg angle compared to the substrate. By adjusting to the NR position and scanning the beam across the surface (scanning X-ray micro-diffraction, SXMD), the spatial distribution of intensity maxima displays the positions of individual NRs as shown in fig. 2 for a certain area inside the pattern. Note that, in agreement with the SEM image in fig. 1, some rods are missing due to incomplete removal of the SiN mask. The elongation of the peaks along the vertical direction is caused by the different beam size in the horizontal and vertical direction.

After identification of individual rods in the centre and at the border of the NR array, we recorded 3D, coherent diffraction patterns in the surrounding of the GaAs (111) reflection. Measurements were performed using the 2 dimensional MAXIPIX pixel detector with a pixel size of $55 \times 55\text{ }\mu\text{m}^2$. This setup allows to record the full reciprocal space by only rotating the sample around the Bragg angle, taking images at each position.

Figure 3 shows vertical and horizontal slices through the 3D diffraction pattern recorded at rod indicated by (1) in fig. 2 inside the array. The q_z direction in the RSM is parallel to the surface normal. Due to the coherent

illumination of a single NR only, the diffraction pattern is the Fourier transform of the shape of the selected NR and shows characteristic oscillations due to the the rod's finite size and its almost perfect hexagonal symmetry in the plane parallel to the surface (fig. 3, right). In fact, the size measured by the interference fringes in fig. 3 corresponds well with the size of a single NR.

Similar measurements were taken at NRs at the border of the patterned array. Our preliminary analysis indicates that the size of rods at the border is smaller and the hexagonal shape of this rods is less perfect compared to rods in the centre due to the reduced number of next neighbours.

The data reveals promising for upcoming phase retrieval analysis, allowing a detailed comparison of different nanorods.

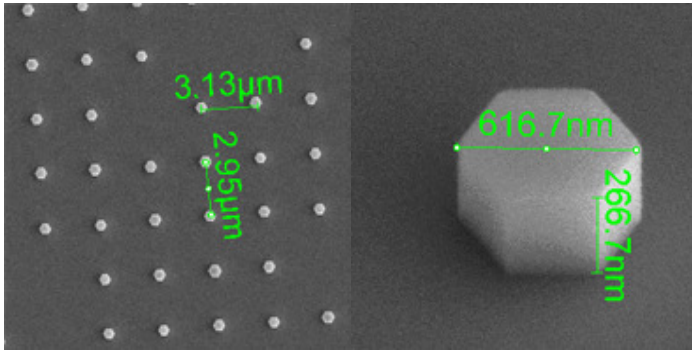


Figure 1 The SEM pictures display the regular square arrangement and hexagonal shape of NRs.

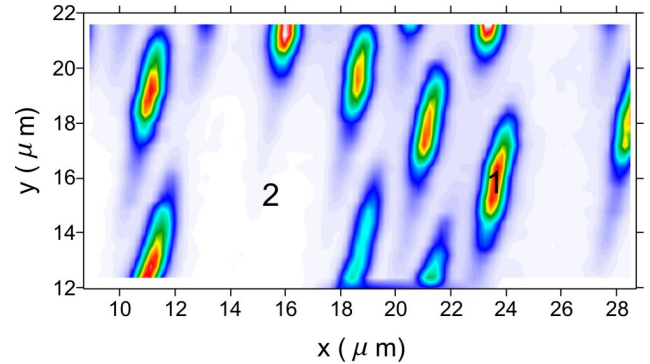


Figure 2: Intensity pattern of diffuse scattering recorded inside the NR pattern.

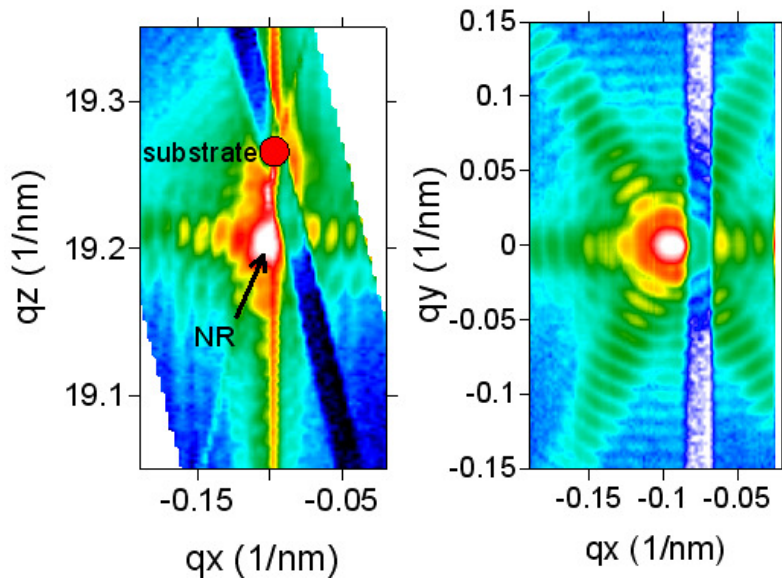


Figure 3 RSM taken from a rod in the centre of the array (1 in fig. 2).