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X-RAY STRAIN EVALUATION AT INDIVIDUAL SEMICONDUCTOR NANOWIRES

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Semiconductor nanowires (NW's) are of particular interest due to the ability to synthesize single-crystalline 1D epitaxial structures and heterostructures in the nanometer range. One of the most common methods for NW growth is the Vapour-Liquid-Solid mechanism[1]. Using x-ray diffraction we have investigated GaAs NW's on Si[111] substrate where the lattice mismatch is about 4%. Using synchrotron radiation and considering our experience in NW's structure analysis [2,3] we have performed X-ray reciprocal space mapping in vicinity of selected Bragg reflections to analyze the strain release between NW and substrate. For the investigation of strain at the NW to substrate interface we selected samples of different growth time corresponding to different phases of growth: after 60s – the whole surface of the sample is covered by islands; after 150 s – first wires appear; after 300 s – number of NW's is increase and after 1800 s – 3 μm-height NW's cover the whole substrate (Fig. 1).

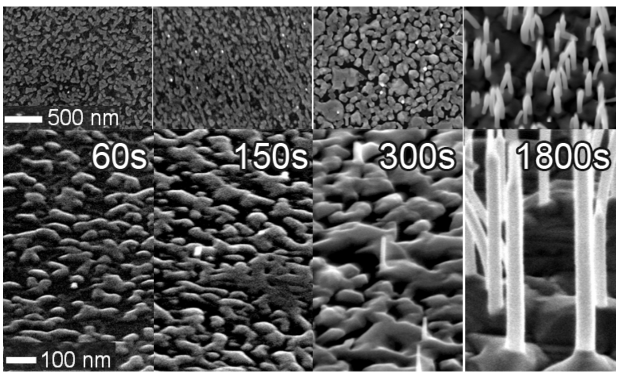

Figure 1. SEM – images of the early stage of GaAs nanowire growth on Si: During the initial stage (60 s to 300 s), the surface is covered with GaAs islands. After 300 s, nanowire growth starts and several micron long wires form (1800 s).

Using symmetric coplanar x-ray diffraction and subsequent rocking curve analysis based on the Tagaki-Taupin approach we could associate the different features seen in SEM to different structure elements appearing during crystal growth. The islands found after 60s are grown in zincblende (ZB) type structure, gradually releasing the lattice mismatch between GaAs and Si. Contrary, the NWs appearing after 150s of growth are of wurtzite (WZ) type structure. Measuring structure type sensitive Bragg reflections, the evolution of the WZ content within the samples could be determined quantitatively from intensity ratio of (331)ZB/(10i5)WZ. Due to the different structure of wires and islands, single wires could be resolved and characterized using a nanometer sized x-ray beam.

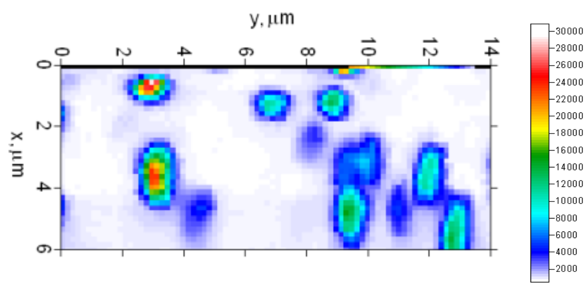

Figure 2. Spatial resolved intensity distribution of the GaAs (10i5) wurtzite reflection. The individual spots represent single nanowires grown in the wurtzite structure.

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