Recently focusing optics (as, e.g., Fresnel zone plates and refractive lenses), for hard x-ray synchrotron radiation have been developed, which may provide x-ray beam foci of down to 50 nm. A central aim of the discussed studies is the application of those nanofocused hard x-rays to high resolution x-ray diffraction, a method which typically uses extended x-ray foci and thus averages over large ensembles. As a consequence measurements have been performed by using the nanofocus setups at ID01 and ID13 of the European Synchrotron Radiation Source, Grenoble/France, and P06 at PETRAIII, Hamburg/Germany, with x-ray beams that were typically between 100 nm and 250 nm in size.

We will briefly discuss a reference experiment, in which individual parts of a single SiGe/Si(001) island (samples were grown by liquid phase epitaxy) have been excited. Whereas the main part part of the contribution will focus on isolated core-shell (In,Ga)N/GaN rods. The incorporation of indium atoms into a GaN matrix offers the possibility to tune the wavelength of the emitted light. This makes the ternary (In,Ga)N alloy embedded into a GaN matrix interesting for a variety of optoelectronic applications. For example, 3D core-shell rods are discussed as promising candidates for next generation light emitting diodes. We have used nanofocus x-ray diffraction to investigate the structure and the local strain field of an isolated GaN micro-rod with a shell, which comprises of a GaN spacer, (In,Ga)N/GaN double quantum well (QW) and a p-doped GaN cap. Due to the high spatial resolution of the x-ray beam, we are able to investigate several distinct volumes of one individual side-facet. Here, we find a drastic increase in thickness of the outer GaN shell along the rod height.

The related diffraction patterns were interpreted and simulated using an approach dedicated to scanning nanodiffraction which combines finite-element method and kinematical scattering. Information about shape, positional correlation and chemical composition of the low-dimensional structures was obtained, which demonstrates the feasibility of the method of nanofocus high-resolution x-ray diffraction.

Structural and compositional analysis of isolated core-shell (In,Ga)N/GaN rods based on nanofocus x-ray diffraction, reflectivity and transmission electron microscopy

Spatially resolved strain and luminescence analysis of individual core-shell (In,Ga)N/GaN rod light emitting diodes


Keywords: nanofocus x-ray diffraction, low-dimensional objects, finite element method