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**MS-1-P-2252 3D STEM of highly anisotropic insertions in nitride nanorods: a challenge to FIB preparation techniques and transmission electron tomography**

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The ongoing request for innovative semiconductor devices for opto-electronics motivates the growth of low-dimensional objects such as nanowires or nanorods. The realization of designed heterostructures based on axial or radial symmetry depends on the nanorod's shape, i.e. on its surface facets, and growth conditions. The understanding of the physical properties of the resulting low-dimensional heterostructures necessitates the detailed three-dimensional (3D) microstructure information. Consequently, there is a demand to further establish transmission electron tomography as a feasible tool in materials science - especially for nanoscale semiconductor heterostructures - along with the challenging site specific preparation of adequate samples.

The investigation of inclined GaN nanowires grown on a non-polar (11-22) GaN template with (In,Ga)N insertions at the top by scanning transmission electron microscopy (STEM) tomography is presented in this work. The objects' geometrical arrangement (Fig. 1b) requires a sophisticated sample preparation technique in a dual-beam device comprising a scanning electron microscope (SEM) and a focused ion beam (FIB). On the one hand, the technique allows to isolate the target within an electron transparent lamella (Fig. 1a). On the other hand, the positioning of the lamella realized by the incorporated micromanipulator and the versatile sample stage enables the chemical sensitive high-angle annular dark field (HAADF) STEM imaging along a <11-20> direction (Fig. 1c) that is not straight forwardly available in conventionally prepared samples. The mounting of the sample with its [0001] orientation along the tilt axis will be discussed.

To access the complex morphology (facets, layer thickness, In content) of (In,Ga)N insertions in the GaN based objects, a HAADF STEM tilt series has been acquired over a tilt range of 165°. The 3D reconstruction reveals the shape (Fig. 2a) and the anisotropic occurrence of (In,Ga)N insertions in layers parallel to the facets of the object (Fig. 2b). The isosurface rendered volume shows that the object is limited by the hexagonal m- and r-planes as well as a rough cap parallel to the c-plane. The r-planes close to the substrate normal are only weakly developed whereas the other four are clearly formed. The cross-sections through the reconstructed 3D volume show high abundance of In in red color whereas the parts dominated by green belong to the GaN core and shell.

This study demonstrates the unique access to complex three-dimensional morphological and chemical information of nanoscale semiconductor heterostructures by HAADF STEM tomography. The requirement of a sophisticated sample preparation technique has to be underlined.

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Fig. 1: (a) The SEM image represents the target object within the lamella suitable for tomography. (b) The schematic of the target object illustrates its special geometry which challenges TEM sample preparation. (c) The HAADF STEM image exhibits the lamella in cross-section. The white arrow in image (a) and (c) marks the object that is presented in Fig. 2.

Fig. 2: (a) Isosurface representation of the three-dimensionally reconstructed object along the direction perpendicular to the substrate and the view onto a (1-100) side facet. (b) The cutaway of a cube from the object (schematic) offers the view onto three ortho-slices parallel to low indexed lattice planes providing chemical information.