Growth and Microstructure of GaN Nanowires and Quantum dots

L. Yan, K. Grossklaus, J. M. Millunchick
A.Banerjee, S.Jahangir, and P.Bhattacharya

The performance of InGaN/GaN nanostructures depends critically on their crystalline perfection. In this work, we have examined the initial nucleation and growth of self-catalyzed GaN nanowires growth on Si(111). Despite the fact that the substrate develops some texture and an amorphous Si_xN_{1-x} layer as a result of exposure to the N plasma, very uniform nanowires nucleate with diameters on the order of 20 nm. We find that the growth conditions, namely the Ga growth rate, determine the density of nanowires. As the nanowires grow, however, they coalesce into bundles. Defects formed between the individual nuclei due to variations in the orientation typically annihilate as the nanowires increase in length.

The morphology and microstructure of InGaN/GaN Quantum Dots superlattices were also studied to determine the effect of growth parameters on the microstructure and optical properties. All of the samples in this study exhibited room temperature luminescence, despite the fact that the interfaces were rough according to X-ray Diffraction. Atomic Force Microscopy reveals rough surfaces upon which 3D islands are nucleated, and analysis shows that the correlation length (a measure of the nanostructure size) is inversely related to the PL emission energy, and RMS roughness has a weak inverse dependence on the PL intensity. Initial Atom Probe Tomography on samples that contain a thin quantum well of InGaN in GaN shows that the In distribution in this layer is nonuniform, varying by ±4% over approximately 10nm.