Microstructure and Electronic Properties of InGaN Quantum Wells

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$In_xGa_{1-x}N$ quantum wells are the core of high-efficiency light emitting diodes operating in the green to violet region of the visible spectrum. There are many interesting features that make these materials especially useful for efficient emitters. It has been conjectured that the combination of piezoelectric fields and local composition inhomogeneities may be responsible for the high emission efficiencies that are observed; in spite of the high dislocation densities typical of these materials. This presentation reviews the properties of InGaN quantum wells. Composition uniformity (Fig. 1) strongly depend on growth methods and parameters, and vary significantly even within the same wafer. The electrostatic potential and electrostatic charge distribution have been profiled across quantum wells and dislocations using electron holography (Fig. 2) [1-5].

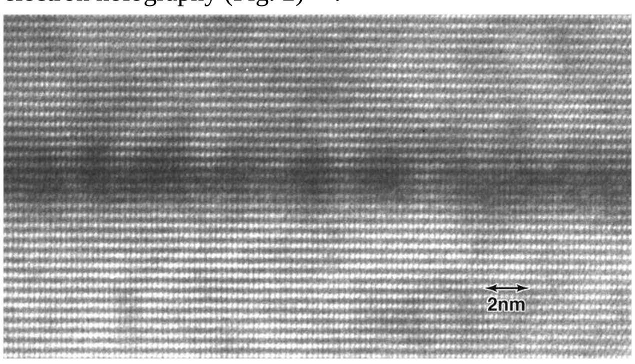

Fig. 1 *Lattice image of an InGaN quantum well along [1-100] projection of the wurtzite lattice. Quantum well appears to be an array of spheroids.*

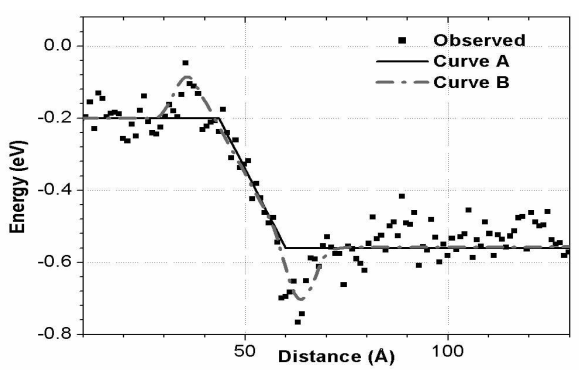

Fig. 2 *Variation of the electrostatic potential energy across an InGaN quantum well. This profile was obtained by electron holography in the TEM.*

Optical absorption and cathodoluminescence have been used to determine the emission characteristics and close correlation with dislocations and compositional inhomogeneities has been obtained [2-5]. However, one of the most difficult aspects that we face is the control of the strain associated with epitaxial growth. In the absence of lattice-matched substrates, large mechanical distortion at the interface leads to the onset of huge piezoelectric fields that should have significant impact on the structural and electronic nature of the epilayers. This is observed when comparing layers grown under different strain conditions such as between direct growth on GaN/sapphire and growth on ELOG GaN/sapphire. It has been observed that under tensile conditions, misfit dislocations can generate early in the growth, leading to epilayers with substantially different properties. The accurate measurements of the composition uniformity and the electrostatic fields are important in order to understand the light-matter coupling in InGaN layers.

References

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This research was supported by Nichia Corporation.