Abstract:

The fabrication of highly efficient green-yellow light emitting diodes is challenging as it requires the growth of high quality $In_xGa_{1-x}N$ quantum wells (QWs) with large indium composition. The goal of this work was to study the structural and optical properties of $In_xGa_{1-x}N$/(Al)GaN multiple QWs grown by metal organic chemical vapor deposition. Different approaches have been implemented to achieve green-yellow emission: high indium concentration (≥ 20%) with low InGaN quantum well thickness (< 3.0 nm) or low indium concentration (< 20%) with high InGaN quantum well thickness (> 3.0 nm). Moreover, the effect of a capping layer on top of the QWs has also been investigated. Atomic force microscopy, X-ray diffraction, room temperature photoluminescence and mainly transmission electron microscopy (TEM) techniques have been used to characterize these structures. The QW thicknesses and indium compositions have been determined by digital processing of lattice fringes in cross-sectional high resolution TEM images. An original treatment has been developed to analyze quantitatively $In_xGa_{1-x}N$ QW thickness fluctuations. The structural analysis of multiple QWs with high indium composition has shown that structural defects are created in the QWs. The nature and the density of these defects have been determined and different mechanisms for their formation have been proposed. It has also been shown that a few monolayers of AlGaN or GaN capping layers deposited at the InGaN QW growth temperature prohibited indium evaporation and/or diffusion. As a consequence, using such process, thicker InGaN QWs with less thickness fluctuation can be obtained. It therefore helps to extend the emission wavelength with a reduced degradation of the room temperature photoluminescence efficiency. The conclusion of my study is that there is no ideal solution to design efficient green-yellow emitting QWs as the involved parameters play contradictory roles on the internal quantum efficiency. My thesis work proposes a few tracks in order to obtain a good compromise between these parameters.