Optical Properties of GaInN/GaN Multi-Quantum Well Structure Grown by Metalorganic Vapor Phase Epitaxy

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Recent development in GaInN/GaN quantum well based light emitting diodes (LED) have gained much attention in lighting industry due to their potential full color display capability in the entire spectral range including wavelengths in the blue, green, yellow, and red. However, the performance of the GaInN/GaN based green LEDs are far behind that of the blue LEDs due to the difficulties of growth of indium (In) rich GaInN and limited knowledge of light emission processes, especially in green LEDs. Therefore, understanding the optical and structural properties of these materials is vastly benefited for their further development.

This study report on the optical properties of green emission $Ga_{1-x}In_xN$/GaN multi-quantum well (MQW) structure with In composition of ~ 0.2. The MQW structure has been grown by metalorganic vapor phase epitaxy in an Emcore D-180 spectra GaN rotating disc multiwafer system on (0001) plane of sapphire substrate. The MQW consists of five $Ga_{1-x}In_xN$/GaN quantum wells of nominal well width of 3 nm separated by barriers of nominal width 11 nm.

Crystalline qualities of such grown MQW structure were evaluated by XRD measurements. In addition, Raman spectroscopy was utilized to assess structural properties as well as In composition in $Ga_{1-x}In_xN$/GaN/GaN MQW structures.

Optical properties were mainly investigated by photoluminescence (PL) and cathodoluminescence (CL) spectroscopy from 5.2 K to 296 K and photoreflection spectroscopy. Both PL and CL spectra dominated by strong green $Ga_{1-x}In_xN$/GaN/GaN MQW emission centered at ~ 2.38 eV (~ 520 nm) and GaN neutral-donor-bound exciton (D^0X) transition at ~ 3.4 eV. In addition, at low temperature (≤140 K), GaN donor acceptor pair transitions were found to be peaked around 3.2 eV, while they were superimposed with LO phonon replicas of GaN of energy 90 meV similar to the observed Raman results, which consistent with LO phonon energy of GaN.

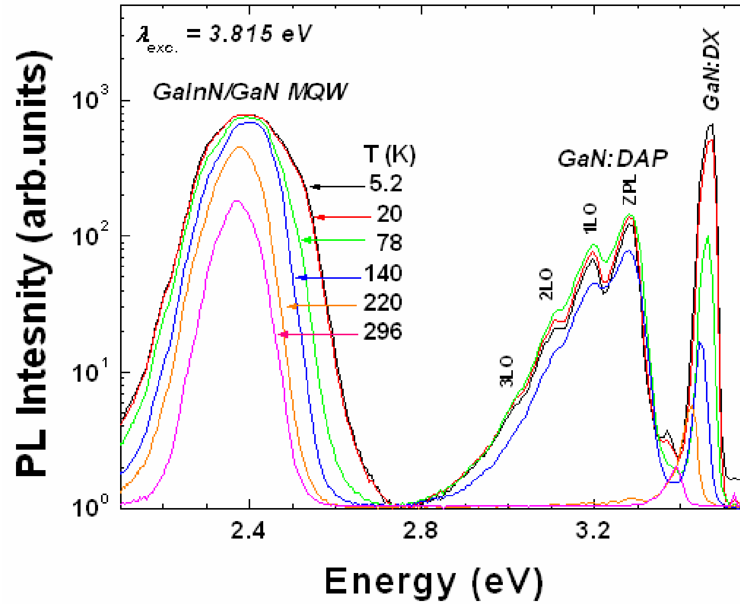

Figure 1. Temperature dependent photoluminescence spectra of GaInN/GaN MQW structure on sapphire substrate.

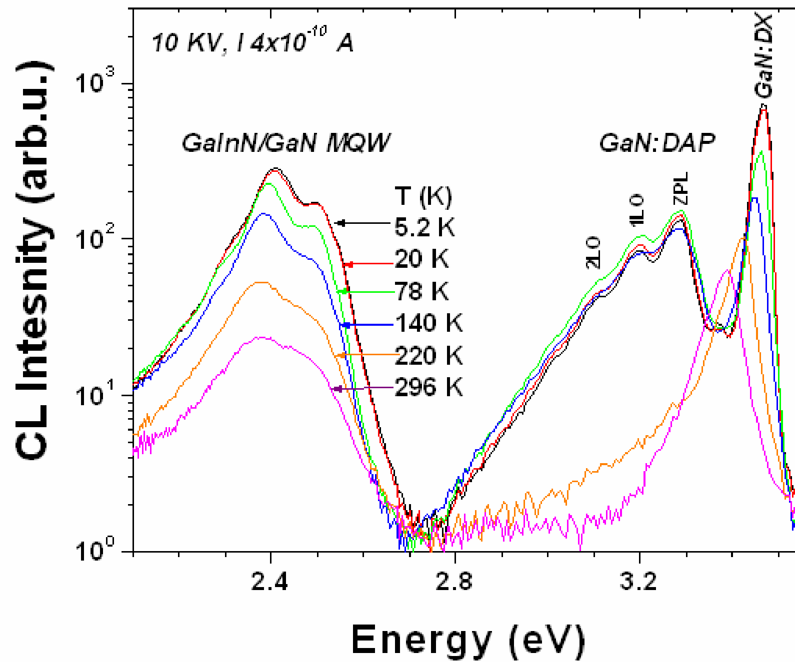

Figure 2. Temperature dependent cathodoluminescence spectra of GaInN/GaN MQW structure on sapphire substrate.