

T3-003

Study of the Efficiency Droop Phenomena in GaN based LEDs with Different Substrate

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Currently GaN based LED is known to show high internal or external efficiency at low current range. However, this LED operation occurs at high current range and in this range, a significant performance degradation known as 'efficiency droop' occurs. Auger process, carrier leakage process, field effect due to lattice mismatch and thermal effects have been discussed as the causes of loss of efficiency, and these phenomena are major hindrance in LED performance. In order to investigate the main effects of efficiency loss and overcome such effects, it is essential to obtain relative proportion of measurements of internal quantum efficiency (IQE) and various radiative and non-radiative recombination processes. Also, it is very important to obtain radiative and non-radiative recombination times in LEDs.

In this research, we measured the IQE of InGaN/GaN multiple quantum wells (MQWs) LEDs with PSS and Planar substrate using modified ABC equation, and investigated the physical mechanism behind by analyzing the emission energy, full-width half maximum (FWHM) of the emission spectra, and carrier recombination dynamic by time-resolved electroluminescence (TREL) measurement using pulse current generator. The LED layer structures were grown on a c-plane sapphire substrate and the active region consists of five 30 Å thick In_{0.15}Ga_{0.85}N QWs. The dimension of the fabricated LED chip was 800 um×300 um. Fig. 1. is shown external quantum efficiency (EQE) of both samples. Peak efficiency of LED with PSS is 92% and peak efficiency of LED with planar substrate is 82%. We also confirm that droop of PSS sample is slightly larger than planar substrate sample. Fig. 2 is shown that analysis of relation between IQE and decay time with increasing current using TREL method.

Keywords: Light Emitting Diodes, External Quantum Efficiency, Decay time

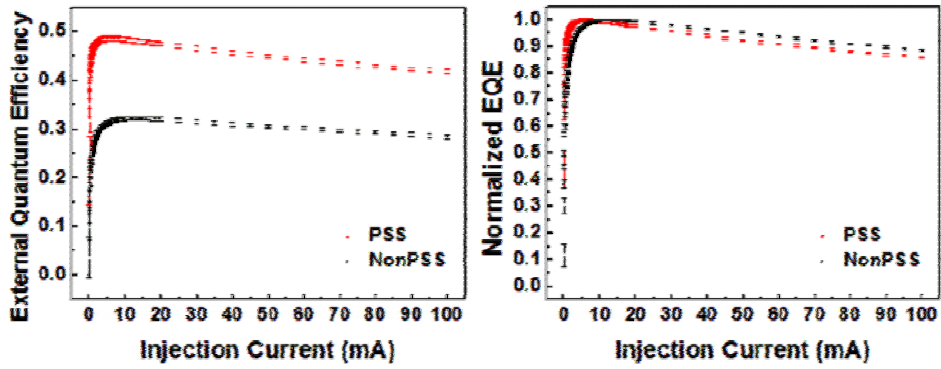


Fig. 1. EQE and normalized EQE comparison of PSS and planar substrate sample with increasing current.

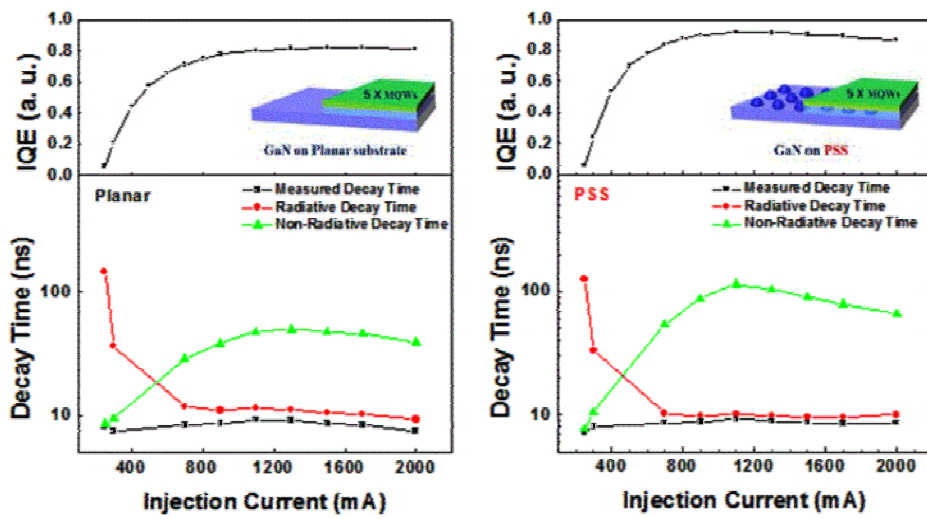


Fig. 2. Analysis of relation between IQE and decay time with increasing current. Inset: schematic of LED with planar substrate and PSS.