ECSSSD 5P **EFFECT OF Si-DOPING OF THE GaN BARRIER ON THE INTERNAL QUANTUM EFFICIENCY OF InGaN/GaN LIGHT-EMITTING DIODES**

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In the past decade the AlInGaN-based light-emitting diodes (LEDs) have attracted attentions of most researchers as promising candidates to replace conventional lamps in lighting applications including general illuminations, LCD display backlighting, and automobile lighting. However, the efficiency of LEDs is significantly reduced at higher current density, which is known as "efficiency droop" phenomenon. GaN-based materials has a large piezoelectric and spontaneous polarization that lead to reducing radiative recombination probability of LEDs due to the spatial separation of the electron and hole wave functions within InGaN/GaN multiple quantum wells (MQWs). In this paper the heavily Si-doped and Si delta-doped of GaN barrier within InGaN/GaN MQWs are proposed to improve carrier injection, distribution and confinement in the active region. The transport and light emission properties of the LEDs with different structures (Fig. 1a) are investigated numerically using the 1D-DDCC Schroedinger-Poisson drift-diffusion solver software. The parameters for GaN and InGaN materials were taken from Refs. [1, 2]. The structure of the conventional blue InGaN/GaN LED (structure A) consists of a 2 mkm thick Si-doped n-GaN layer (5 x 10^{18} cm^{-3}). The active region consists of six 3 nm thick $In_{0.16}Ga_{0.84}N$ quantum wells (QWs) sandwiched by seven 10 nm thick GaN barriers. On top of the last quantum barrier was a 20 nm thick p-$Al_{0.15}Ga_{0.85}N$ electron blocking layer (EBL) (1 x 10^{19} cm^{-3}) and a 170 nm thick p-GaN cap layer (2 x 10^{19} cm^{-3}). All considered LED devices (labeled as A, B, C) have identical layer structure with different doping of GaN barrier: undoped GaN, heavily Si-doped GaN (1 x 10^{19} cm^{-3}), and Si delta-doped GaN (1 x 10^{19} cm^{-3}), respectively.

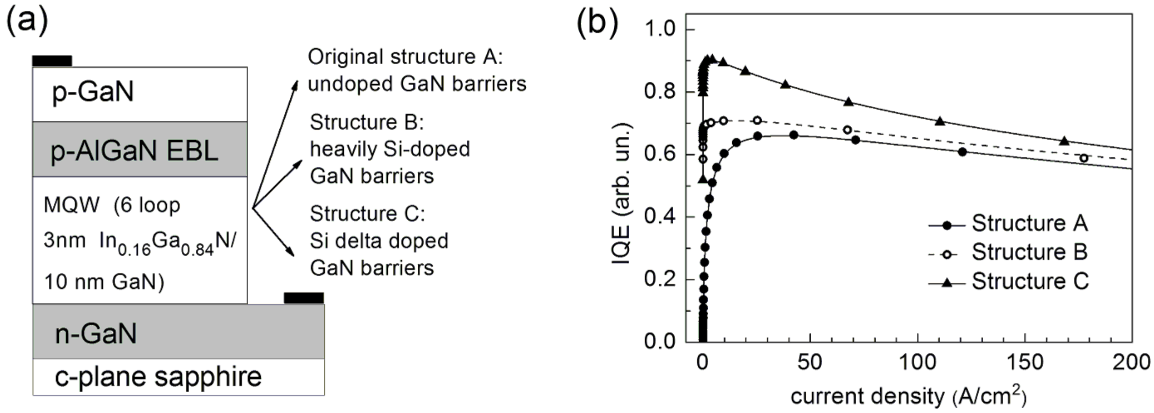

Fig. 1. (a) Schematic structure of InGaN/GaN LEDs with different Si-doped GaN barrier. (b) IQE as function of current density for InGaN/GaN LEDs with structures A, B, and C.

Figure 1(b) demonstrates the internal quantum efficiency (IQE) vs. current density for InGaN/GaN LEDs. It is established that the IQE of Si delta-doped LED (structure C) is the higher among others due to the better carrier confinement in MQW and the relative small polarization field in the active region caused by screening effect. The obtained results are analyzed and mechanisms of reducing of efficiency droop in Si-doped and Si delta-doped LEDs are discussed. Acknowledgments. V.P.S. gratefully acknowledge the financial support from the Alexander von Humboldt Foundation.

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