Current Injection Efficiency in AlGaN-based Deep-Ultraviolet Light-Emitting Diodes

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AlGaN-based light-emitting diodes (LEDs) are attracting considerable interest as deep-ultraviolet (DUV) light sources that could be used to replace toxic mercury lamps in various applications including disinfection, air/water purification, and solar-blind optical communication. We recently demonstrated a DUV-LED with light output power of 90 mW emitting at wavelength of 265 nm by utilizing a novel light-extraction technique, which is the highest light output power reported to date for DUV-LED with emission wavelength shorter than 280 nm.[1] To further improve the performance of DUV-LEDs, a detailed knowledge and reliable evaluation of current injection efficiency (CIE) and internal quantum efficiency (IQE) are of considerable importance. The external quantum efficiency (EQE) is relatively easy to measure quantitatively, but it is difficult to separate the influence of the CIE and IQE from the EQE. There are some works on discussion about the carrier leakage mechanism and its contribution on CIE. However, there is a lack of experimental work on quantitative value of CIE in DUV-LEDs. In calculation or simulation, CIE was always assumed to be unit at low injection current density, but this assumption may be an overestimation for DUV-LEDs. In this report, we discuss the CIE and carrier leakage processes with injection current density by using a high order polynomial fitting of the electroluminescence data. It is shown that the CIE is approximate 51% at low injection current density at room temperature for a DUV-LEDs with an emission of 267 nm. It is much lower than the expected value of 100% and almost independent on the current injection density up to 100 A/cm^2. These phenomena indicate that the current leakage is not due to the spillover of electrons caused by the insufficient barrier height of the electron blocking layers. We speculated that a new *p*-*n* junction was formed at the V-pits/*p*-GaN interface and be added in parallel with the *p*-*n* junction of the DUV-LEDs, which acts as diode-like current leakage paths. These leakage paths are suppressed in InGaN-based LEDs, but could play an important role in AlGaN-based DUV-LEDs due to high operating voltage of DUV-LEDs.

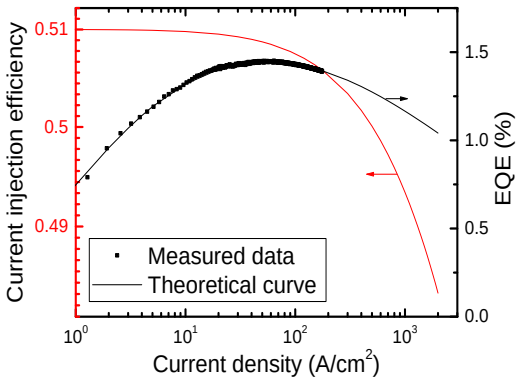

Fig. 1. Current injection efficiency, measured EQE, and calculated EQE as a function of injection current density.

1. S. Inoue, T. Tamari, T. Kinoshita, T. Obata, and H. Yanagi, Appl. Phys. Lett. **106**, 131104 (2015).