Effect of structural design on InGaN based green LEDs with AlGaN cap layer

M.I. Md Taib[1], A.I. Alhassan[2], M.M. Muhammed[3], I.A. Ajia[3], N. Zainal[1,*]

[1]*Institute of Nano Optoelectronics Research and Technology (INOR), Universiti Sains Malaysia, 11800 USM, Penang, Malaysia.*
[2]*Materials Department, University of California, Santa Barbara, California 93106, USA*
[3]*Physical Sciences and Engineering Division, King Abdullah University of Science and Technology (KAUST), Thuwal 23955-6900, Saudi Arabia*

*Corresponding author: norzaini@usm.my

The efficiency of the green light emitting diodes (LEDs) is reported to degrade significantly due to high dislocations density and quantum-confinement Stark effect (QCSE), which results in droop efficiency at higher current. To address this issue, this work proposes the introduction of InGaN layer before the multi-quantum wells (MQWs), and InGaN barrier layer in the MQWs structure. This reduces the dislocations density and QCSE, which then improves the efficiency of the device. Three different structures of green LEDs with AlGaN cap layer have been grown on patterned sapphire substrate (PSS) using MOCVD system, which are 1) standard sample, 2) sample with InGaN barrier and 3) sample with UID InGaN layer. Both symmetric (002) and asymmetric (102) XRD rocking curve scans of sample with UID InGaN layer showed the lowest full-width-half-maximum (FWHM) value of 229 arcsec and 258 arcsec, respectively, as compared to its counterparts. This reveals that the introduction of UID InGaN layer helped in the reduction of dislocations density. Furthermore, AFM results revealed that the lowest surface roughness of 4.56 nm is obtained when UID InGaN layer is introduced. Such results are correlated with the XRD rocking curve results, suggesting the reduction of the defective areas on the surface. A temperature-dependent photoluminescence (TDPL) measurement was performed to obtain the emission wavelength behavior and integrated intensity of the peak energy. A higher MQW internal quantum efficiency (IQE) of 34.36% was obtained in sample with UID InGaN layer than that of 8.13% and 18.17%, for standard sample and sample with InGaN barrier, respectively. Overall, the introduction of UID InGaN layer in the green LEDs structure helped to improve the structural, surface and optical properties of the device.