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ENHANCEMENT OF EFFICIENCY OF GaN-on-GaN LED BY WET ETCHING ROUGHENING ON N-FACE GaN SUBSTRATE

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ABSTRACT- It is well-known that GaN-on-GaN LEDs have lower dislocation density compared to GaN-on-sapphire LEDs. Nonetheless, the overall efficiency of the GaN-on-GaN LEDs is still lower than the GaN-on-sapphire LEDs. The problem is associated to total internal reflection effect which is higher in the LEDs. The effect decreases light extraction efficiency. Roughening the backside (N-face) of GaN substrate via potassium hydroxide (KOH) etching can reduce the effect. Through the roughening, hexagonal-pyramid structures are formed and they promote multiple light scatterings, thereby increasing the LEE. However, the roughening by KOH etching is difficult to control and results in low density of the hexagonal-pyramid structures . This work proposes to roughen the N-face GaN substrate using a mixed ammonia and hydrogen peroxide solutions. More pyramid structures were formed (with the density of mid-10^8 cm^{-2}) using the solution than using the KOH solution (with the density of mid-10^7 cm^{-2}). By having higher density of the hexagonal-pyramid structures, the external quantum efficiency of the LED on the roughened GaN substrate by the mixed solution increased by 9.5% with respect to the LED on KOH roughened GaN substrate. This result suggests there is a corelation between the pyramid structures density and the efficiency of the LED.

Keywords: Roughening, N-face GaN substrate, Potassium hydroxide (KOH), Ammonia solution (NH_4OH), Hydrogen peroxide (H_2O_2), Hexagonal-pyramid structures.