Transforming Conductive GaN:Si Epitaxial Layers into Nanoporous GaN and Insulating GaOx Layers for III-nitride Photonic Devices

Chia-Feng Lin[1], Wen-Che Lee[1], and Yuan-Chang Jhang[1]
[1]Department of Materials Science and Engineering, National Chung Hsing University, Taichung, 250 Kuo Kuang Road, Taichung, 402, Taiwan
Tel.:+886-4-22840500 ext 706, E-mail: cflin@dragon.nchu.edu.tw

We report a simple and robust process to convert embedded conductive GaN epilayers into insulating GaOx. The fabrication processes consist of laser scribing, electrochemical (EC) wet-etching, photoelectrochemical (PEC) oxidation, and thermal oxidization of a sacrificial n^+-GaN:Si layer. The conversion of GaN is made possible through an intermediate stage of porosification where the standard n-type GaN epilayers can be laterally and selectively anodized into a nanoporous (NP) texture while keeping the rest of the layers intact. A schematic of the treated LED structure with a current confined aperture region fabricated through laser scribing, EC lateral wet etching, and oxidation processes is shown in Figure 1. The light intensity profiles of the LED chips as analyzed by a beam profiler. The EL emission intensity is localized to the central mesa region indicating that the current did not flow into the mesa edge region with the bottom insulating GaO_x layer. The dimensions of the central aperture region were reduced after the PEC oxidation process. The fibrous texture of NP GaN with an average wall thickness of less than 100 nm dramatically increases the surface-to-volume ratio and facilitates a rapid oxidation process of GaN into GaO_x. The GaO_x aperture was formed on the n-side of the LED between the active region and the n-type GaN layer. The wavelength blueshift phenomena of electroluminescence spectra is observed in the treated aperture-emission LED structure (441.5nm) when compared to non-treated LED structure (443.7nm) at 0.1mA. The observation of aperture-confined electroluminescence from an InGaN LED structure suggests that the NP GaN based oxidation will play an enabling role in the fabrication of nitride photonic devices.

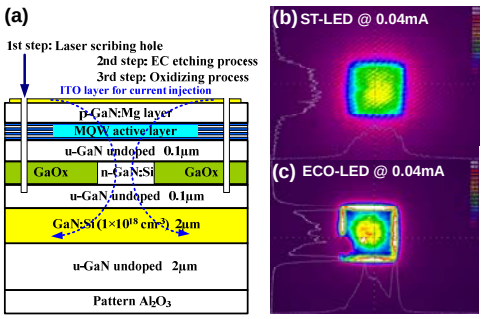

Fig. 1. (a)Schematic of the ECO-LED structure that fabricated through laser scribing process, EC lateral wet etching process, and oxidation process to current-confined aperture region. The light intensity profiles of (b) the ST-LED and (c) the EC-LED were analyzed by a beam profiler under 0.04mA operation current.

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