Nanocolumns of InGaN/GaN MQWs Fabricated by Neutral Beam Etching for Directional Micro-LEDs

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GaN-based directional micro-LED (μLED) is highly desired for high-brightness and high-resolution full-color μLED display which is a promising display device for next generation wearable electronics. We recently proposed a novel directional μLED based on the evanescent wave coupling effect in a micron-sized truncated cone [1]. In this device, a small active region with a lateral dimension on the 100-nm-order is buried at the center of the micron-sized truncated cone. The top-down etching of an MQW sample is a promising approach to fabricate the small active region. However, the plasma discharge during the process of dry etching brings in damages and defects, which greatly degrades the performance of the device. To solve these issues, neutral beam etching (NBE) has been considered as an effective way [2].

In this work, two nanocolumns of InGaN/GaN MQWs with diameters of about 150 nm were fabricated by NBE and inductively coupled plasma (ICP) etching, respectively, where SiO_2 dot patterns prepared by electron-beam lithography were used as a mask. In comparison of ICP nanocolumns, scanning electron microscope (SEM) images of NBE nanocolumns presented smooth sidewall surface (Fig.1(a)). Photoluminescence (PL) measurements of NBE nanocolumns revealed a higher emission intensity from InGaN/GaN MQWs than that of an unetched reference sample, suggesting an extremely low etching damage induced by the NBE process. The high-quality nanocolumns of InGaN/GaN MQWs fabricated by NBE shows its great potential in scalable realization of high performance directional μLED.

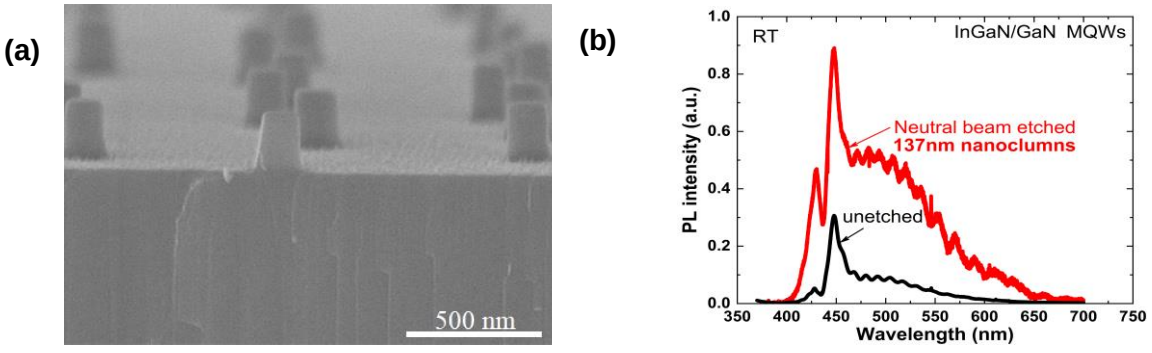

Figure 1(a) SEM image and (b) PL spectra of nanocolumns of InGaN/GaN MQWs fabricated by NBE. The intensities of PL spectra of the NEB etched and unetched samples were normalized to the same emission area.

[1] Xuelun Wang *et al.*, Applied Physics Letters 107.13 (2015): 131112.

[2] Yafeng Chen *et al.*, Journal of Applied Physics 123.20 (2018): 204305.