High efficiency neutral-beam-etched nanodisk of InGaN/GaN MQWs buried with regrown GaN

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Directional micro-LED (μLED) based on the evanescent wave coupling effect in a micron-sized truncated cone has great potential in developing high-brightness, high-resolution, and low-power-consumption μLED display [1]. The top-down approach is a promising process to realize the directional μLED. In this process, the nanodisk of InGaN/GaN multiple quantum wells (MQWs) is first fabricated by dry etching and then buried by regrown GaN. Finally, truncated cones are fabricated to realize directional emission. In our previous work, we have reported the successful fabrication of high-quality nanodisk of InGaN/GaN MQWs by using neutral beam etching (NBE) [2]. Compared with conventional inductively coupled plasma (ICP) etching, the nanodisk produced by NBE presented a much higher internal quantum efficiency (IQE), due to the removal of plasma damage and UV photons radiation during the etching process. In this work, we report a successful regrowth of GaN with thickness of 100 nm on the nanodisk fabricated by NBE toward the implementation of the nanodisk into the directional micro-LED. Scanning electron microscope (SEM) proves that the regrown GaN covers the nanodisk completely and start to coalesce laterally (Fig.1(a) and Fig.1(b)), which may mitigate the sidewall defects and behave as a barrier to enhance the localization of carriers in MQWs. The excitation-power-dependent photoluminescence (PL) peak of nanodisk after regrowth shows smaller blueshift at 5 K as compared with that before regrowth, due to the reduced stress-related quantum confined Stark effect (QCSE) in MQWs (Fig.2(a)). With suppressed QCSE, mitigated defects and effective carrier localization by undoped GaN regrown on the nanodisk, enhanced and stable IQE of ~50 % over a wide PL excitation range was realized (Fig.2(b)).

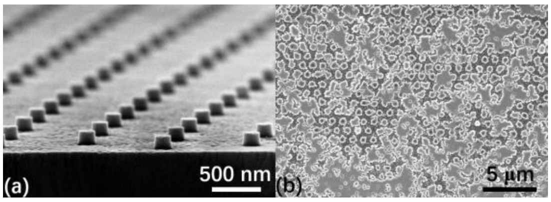

Fig.1. SEM of nanodisk before (a) and after (b) regrowth.

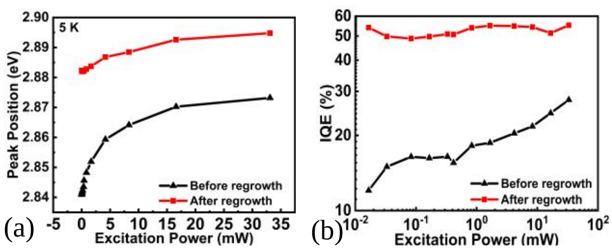

Fig.2. PL peak position as function of excitation-power (a) and IQE (b) of nanodisk before and after regrowth.

Reference: [1] Xuelun Wang et al., Applied Physics Letters 107.13 (2015): 131112.
[2] Kexiong Zhang et al., JSAP 2019 spring meeting.