Investigation of GaN regrowth on InGaN/GaN Nanodisks Fabricated by Neutral Beam Etching

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GaN micro-LED (μLED) has great potentials in developing low-power consumption, high-brightness, and high-resolution display for wearable electronics. Usually, highly-directional emission with a small far-field emission angle is a critical factor for high-brightness and high-resolution μLED display, especially those required for VR/AR applications. We recently proposed a novel structure to realize highly-directional LED based on the evanescent wave coupling effect in a micron-sized truncated cone [1]. In this device, high-quality nanodisk array of active region is first needed to be fabricated by dry etching of a planar wafer with multiple quantum wells (MQWs). Next, the nanodisk array is buried in regrown p-GaN by metal organic chemical vapor deposition (MOCVD). Finally, truncated cones of p-GaN surrounding the nanodisk array of active region are fabricated. In our previous work, we have reported the successful fabrication of high-quality nanodisk array of InGaN/GaN MQWs by using neutral beam etching (NBE) [2]. In this work, the influence of regrown GaN thickness on the surface morphology of the regrown sample was investigated. The results of scanning electron microscopy (SEM) present that the nanodisks were completely covered by GaN after regrowth of 100-nm undoped GaN (Fig.1(a)). The shape of the top-facet of the nanodisk transformed from circle to hexagon-like after regrowth. Most of nanodisks start to coalesce laterally with each other, proving that the lateral growth mode is dominated during the regrowth process. With increasing regrown GaN thickness to 300 nm, the regrown GaN totally coalesced to form a smooth and continuous film (Fig.1(b)). However, lots of V pits can be found on the surface, which may be resulted from the dislocations created during the coalescence process. With further increasing the thickness of regrown GaN to 500 nm which is the thickness required for directional μLED, most of the V pits disappeared and the surface become much smoother (Fig.1(c)). Furthermore, the size of remaining V pit became much smaller, proving the improved crystalline quality of the regrown GaN layer.

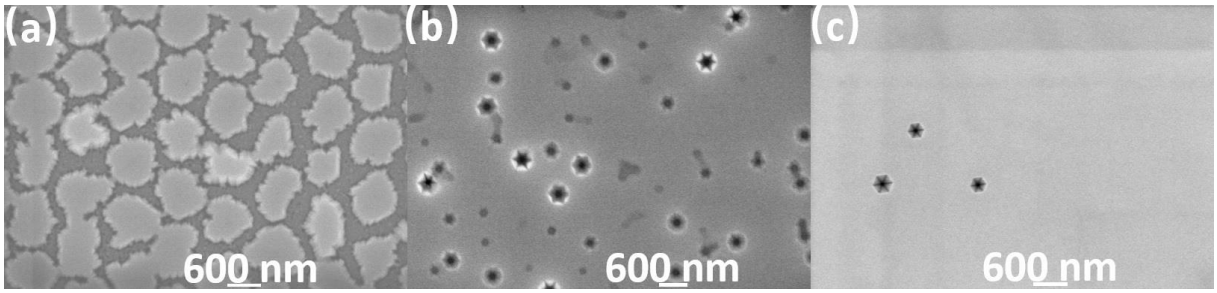

Fig.1. SEM of nanodisk after regrowth of GaN with thickness of 100 nm (a), 300 nm (b), and 500 nm (c).

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

[2] Kexiong Zhang et al.(submitted)