Self-Organaized Ingan/Gan Multiple Quantum Well Nanocolumn Light Emitting Diodes Grown On (111) Si Substrate

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GaN nanocolumns [1] have superior optical properties due to their dislocation free nature and low surface non-radiative recombination rate. We have demonstrated a strong photoluminescence emission and a low threshold photopump stimulated emission from GaN nanocolumns [2]. The GaN nanocolumns are considered to be an attractive material for high performance light emitting devices. Recently, Kim et al. reported an electro-luminescence (EL) from GaN single-rod p-n junction grown by hydride vapor phase epitaxy [3].

In this study, GaN nanocolumn based visible light emitting diodes (LEDs) with InGaN/GaN multiple quantum well (MQW) active layer were successively fabricated on (111) Si substrates. Yellowish orange to red light EL emissions were observed at room temperature.

GaN based nanocolumns were grown by an rf-plasma assisted molecular beam epitaxy. Figure 1 shows a SEM image of typical GaN nanocolumns grown on (111) Si substrate. The diameter and density of nanocolumns were ~100nm and ~1x10^{10}cm-^{2}, respectively. LED structures were grown on low resistive Sb-doped n-type (111) Si substrates as a sequence of Si doped n-GaN nanocolumns (500nm), undope GaN (10nm), 8 pairs of InGaN(2nm)/GaN(3nm) MQW active, undope GaN (10nm), and Mg doped p-GaN (500nm).

Ni/Au transparent electrodes with a diameter of 400□m were formed on the as-grown surface of the LED structure. Typical current–voltage (I-V) characteristic is shown in Fig.2. Clear rectification characteristic suggests a formation of p-n junction into nanocolumns. Figure 3 shows typical EL image and its optical intensity profile of the InGaN/GaN MQW nanocolumn LED at 5mA. Yellowish orange light emission was observed under the transparent electrode for the forward current injection.

[1] M. Yoshizawa, A. Kikuchi, M. Mori, K. Kishino et al. Jpn. J. Appl. Phys. 36, L459, 1997.
[2] A. Kikuchi and K. Kishino, Int. Symp. on Blue Laser and LED, B3-1, March 2004.
[3] H-M. Kim, T. W. Kang and K. S. Chung, Adv. Mater. 15, 567, 2003.

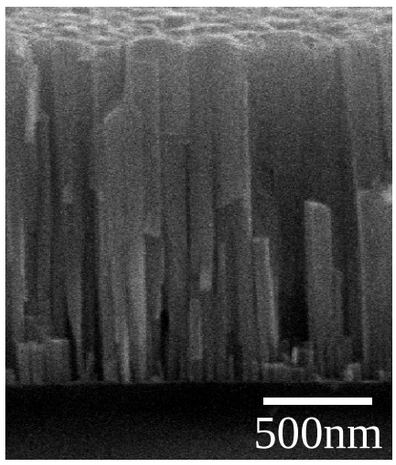

Fig. 1. SEM image of GaN nanocolumns grown on (111) Si substrate.

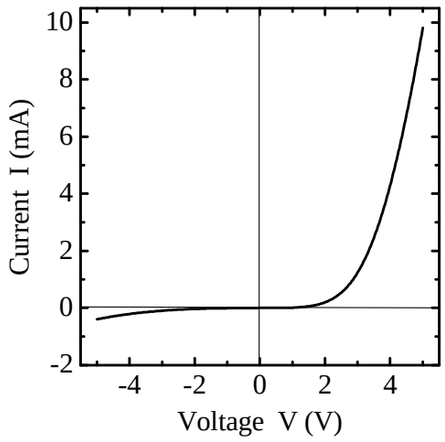

Fig. 2. I-V characteristics of InGaN/GaN MQW nanocolumn LED.

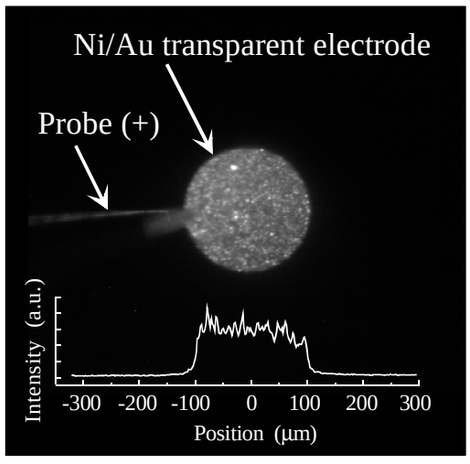

Fig. 3. Electroluminescence image and its intensity profile of InGaN/GaN MQW nanocolumn LED at 5mA.