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High brightness InGaN/GaN blue LED realized by a 2"×6 MOCVD system

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1. Introduction

GaN-based materials are promising for optical devices operating in the blue and green wavelengths [1,2]. These optical devices are essential for full-color displays and pick-up heads in high definition digital-video-disk. In addition, their wide, direct band gaps and excellent thermal conductivity make them a good candidate for high-temperature field-effect transistors [2,3]. However, quality of GaN-based devices is highly dependent on crystalline purity of epitaxial layers grown by modern reactors utilizing different techniques.

Currently, GaN-based materials can be grown by metal organic chemical vapor deposition (MOCVD), molecular beam epitaxy (MBE), and hydride vapor phase epitaxy (HVPE) techniques, etc. Among them, MOCVD is most widely used in growing III-nitrides due to its high controllability and productivity. MOCVD reactor design is open topic in nitride technology at the moment.

In this paper, we present high brightness blue LED with InGaN/GaN multiple quantum well (MQWs) prepared by newly designed multi-wafer (2”x6) MOCVD reactor with RF heater and vertical showerhead (Marvel260A). The high quality III-nitrides films and LED epitaxial layers were also grown and characterized.

2. Experimental procedure

We have fabricated high brightness blue LED by using newly designed MOCVD reactor. This system consists of RF heater and vertical showerhead, and capable to handle 2"×6 wafers per growth. Figure 1 shows the schematic of the reactor used. Trimethylgallium (TMGa), trimethylindium (TMIn) and ammonia (NH_3) were used as precursors for Ga, In and N, respectively. The LED structure consisted of 20 nm thick GaN buffer layer, 1.2 μm undoped GaN grown at 1060°C, 2 μm Si-doped n-type GaN grown at 1045°C, followed by five pairs of InGaN/GaN MQWs structure, 90 nm thick Mg-doped p-type GaN, and 40 nm p+GaN contact layer at 960°C.

The high brightness LED was characterized by double crystal x-ray diffraction (DCXRD) in order to examine the crystal quality, room temperature photoluminescence (PL) for optical characteristics, PL mapping for measurement of thickness uniformity and emission wavelength, and optical microscope to investigate the surface morphology.

3. Result and discussion

Figure 2 shows DCXRD ω-2θ scans for (0002) reflection from the high brightness LED with InGaN/GaN multiple quantum wells. The full-width at half maximum (FWHM) linewidth of first satellite peak is 325 s.

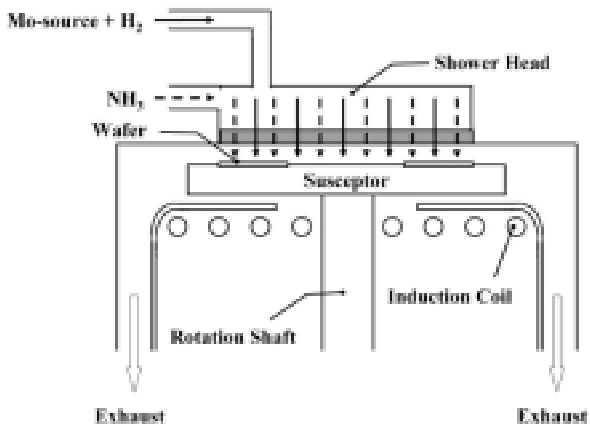

Fig. 1 Schematic of newly designed Marvel260A reactor.

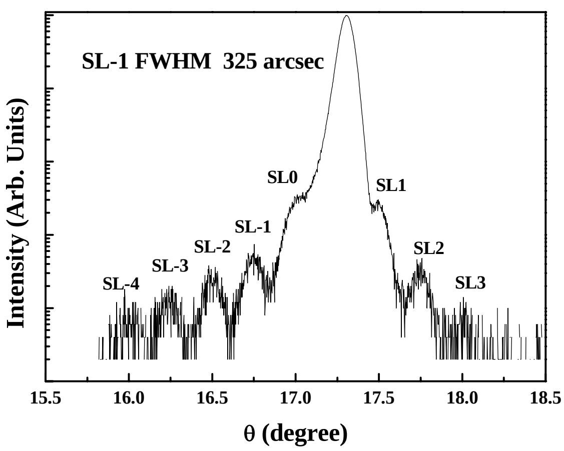

Fig. 2 DCXRD ω-2θ scans for (0002) reflection from the high brightness LED.

Figure 3 shows PL mapping of high brightness blue LED. The uniformity of layer thickness and PL wavelength for the InGaN/GaN MQW wafers in a 2" wafer was better than ±2 % and ±0.25 %, respectively.

The LED wafers were fabricated and epoxy molded to make a lamp (ϕ=5). Figure 4 shows room temperature electroluminescence (EL) of the high brightness LED. The LED exhibits sharp emission at 470 nm with line width of about 25 nm.

Figure 5 shows radiant power and external quantum efficiency (EQE) of the high brightness LED. The radiant power was 4mW at a forward current of 20mA. We note that the power is very high considering such a simple LED structure.

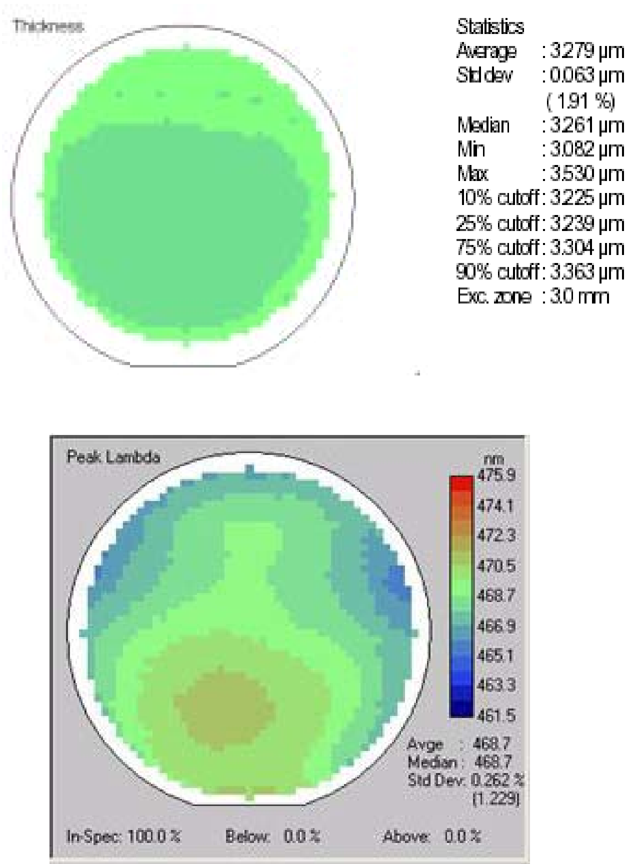

Fig. 3 PL mapping of high brightness LED.

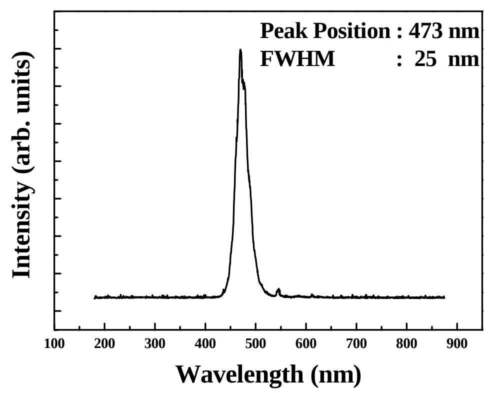

Fig. 4 Room temperature photoluminescence of high brightness LED

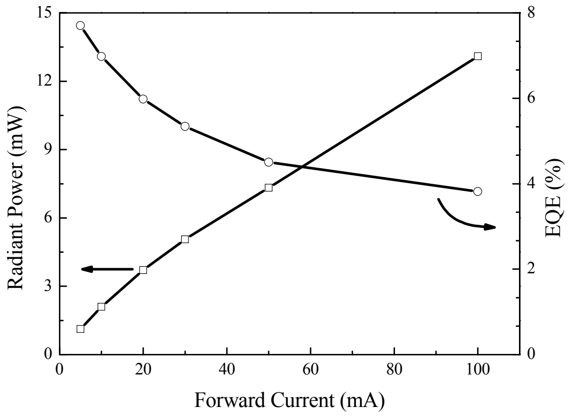

Fig. 5 Radiant power and external quantum efficiency (EQE) of the high brightness LED.

4. Conclusions

We have fabricated high brightness blue LED with InGaN/GaN MQW. The LED epitaxial structure was grown by a newly designed MOCVD reactor. The uniformity of layer thickness and PL wavelength was better than ±2 % and ±0.25 %, respectively. The epoxy molded LED lamp showed radiant power of 4mW at a forward current of 20mA.

References

[1] S. Nakamura, M. Senoh, S. Nagahama, N. Iwasa, T. Yamada, T. Matsushita, H. Kiyoku, Y. Sugimoto, T. Kozaki, H. Umemoto, M. Sano, and K. Chocho, Jpn. J. Appl. Phys. **36** (1997) L1568.

[2] S. Nakamura and G. Fasol, The Blue Laser, Springer, Berlin, 1997.

[3] A. Mills, III-Vs Rev. **9** (1996) 44.