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$In_{0.05}Ga_{0.95}N/Al_{0.1}Ga_{0.9}N$ LEDs precoated with blue, green and red phosphors

C. H. Kuo[1,3], S. J. Chang[1], Y. K. Su[1], L. W. Wu[1,3], J. K. Sheu[2], J. M. Tsai[3], and R. K. Wu[4]

1)Institute of Microelectronics, Department of Electrical Engineering
National Cheng Kung University Tainan 701, Taiwan
Phone:+886-6-2757575ext62391 Fax:+886-6-2761854
E-mail: changsj@mail.ncku.edu.tw
2) Optical Science Center, National Central University,Chung-Li 320, Taiwan
3)South Epitaxy Corporation, Hsin-shi 744, Tainan County, Taiwan
4) Nantex Industry Corporation, Lin-Yuan 832, Kaohsiung County, Taiwan

Introduction

Recently, tremendous progress has been achieved in GaN-based light emitting diodes (LEDs). This has resulted in a variety of applications such as traffic light, full color display, optical storage and lighting. For the case of lighting, white light can be generated by several different methods [1-4]. The mostly commonly used method is to combine a phosphor wavelength converter with a GaN blue LED chip. The blue light emitted from GaN LED is absorbed by the phosphor and re-emitted as long-wavelength phosphorescence. Thus, white light can be generated by the combination of the two emission bands [1]. White light can also be generated by the combination of two or three different LED chips, if these two or three LED chips emit photons at proper wavelengths with a proper power ratio. However, the driving circuits of these white LEDs are more complex than those phosphor-converted white LEDs. White LEDs can also be achieved by optically exciting phosphor in the ultraviolet (UV) wavelength region, which is similar to the fluorescent light tube. Very recently, Narukawa et al. reported white LEDs using a near-UV LED (400nm) chip to pump blue and yellow phosphors [5]. In this study, we report the fabrication of white LEDs, which consisted of a near-UV LED chip and blue/green/red phosphors. The optical properties of the fabricated white LEDs will be reported.

Experiments

The near-UV $In_{0.05}Ga_{0.95}N/GaN$ multiquantum well (MQW) LEDs were prepared by metalorganic chemical vapor deposition (MOCVD). Detailed of the growth procedure could be found elsewhere. The LED chips were then precoated with blue/green/red phosphors prior to package into LED lamps. Phosphors used in this study were all produced by Nantex Industry Corporation (i.e. NANTEX-RU-B403 as the blue phosphor, NANTEX-RU-G502 as the green phosphor and NANTEX-RU-R603 as the red phosphor).

Results and Discussions

Figure 1 shows RT EL spectra of the $In_{0.05}Ga_{0.95}N/Al_{0.1}Ga_{0.9}N$ UV LED chip with various DC current injection. At 20mA, the peak position and full-widths at half maximum (FWHMs) were estimated to be 397nm and 17nm. When the injection current was smaller than 20mA, a slight EL blue shift with injection current was observed due to band-filling effect. At high injection currents, an EL red shift was observed due to heat generation.

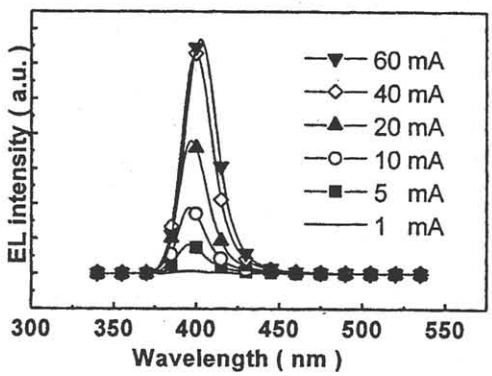

Fig.1 EL spectra of an $In_{0.05}Ga_{0.95}N/GaN$ LED injected with different currents.

Fig.2 shows the EL spectra of $In_{0.05}Ga_{0.95}N/Al_{0.1}Ga_{0.9}N$ LEDs precoated with a blue, green or red phosphor. The injection current was 20mA in all these three spectra. It was found that we could observe the near-UV EL peak from all three samples. It was also

found that the phosphor-related peak was located at 450nm, 500nm and 600nm for the blue, green and red phosphor, respectively. Thus, if we precoat the near-UV LEDs with three phosphors emitting at blue, green and red, we should be able to achieve white LEDs by the three emission bands shown in figure 2.

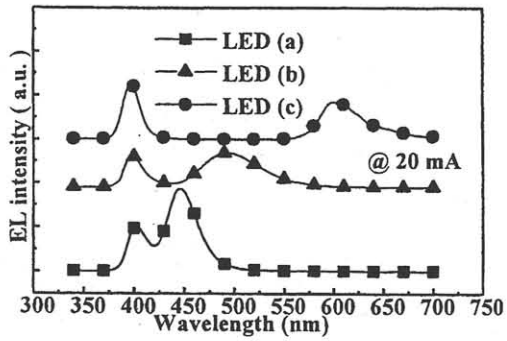

Fig.2 EL spectra of UV LED precoated with three different phosphors.

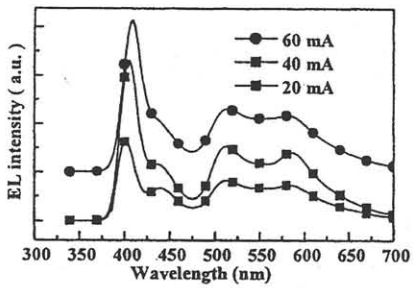

Fig. 3 EL spectra of a white LEDs in which a UV LED was combined with blue/green/red phosphor with various DC injection current.

Figure 3 shows RT EL spectra of the near-UV LED precoated with blue, green and red phosphors at the same time (NANTEX-RU-W650 phosphor). As shown in figure 3, we could indeed observe blue, green and red light at the same time. The combination of these three colors could thus provide us white light. In other words, we could indeed achieve white LEDs by using near-UV LEDs precoated with blue, green and red phosphors at the same time. The optical properties of the fabricated white LEDs were also characterized. With a 20mA injection current, it was found that the color temperature and color rendering index were about 5900K and 71, respectively. It was also found that the color temperature and color rendering index were almost independent of injection current when the injection current was kept in between 20mA and 60mA for our white LEDs. In contrast, the color temperature increases rapidly and the CIE chromaticity coordinates diverge from block-body radiation locus at high injection currents for the conventional white LEDs [5].

Summary

In summary, we reported the fabrication of white LEDs which consisted a near-UV LED chip precoated with blue, green and red phosphors at the same time. It was found that the color temperature and color rendering index were about 5900K and 71, respectively. The color temperature and color rendering index were alfo found to be almost independent of injection current for our white LEDs.

Acknowledgements

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