2007년도 대한전기학회 하계학술대회 논문집 2007. 7. 18 - 20

$(POB)_2Ir(pic)$의 doping 비율에 따른 White OLED의 색순도 향상에 관한 연구

김 동 은[1], 김 병 상[1], 박 재 철[2], 장 정 수[3], 권 영 수[1,*]
[1]동아대학교 전기공학과, [2]영진전문대학 인터넷전자정보계열, [3]경일대학교 전기공학과

Significant Improvements in White OLED Color Purity by Doping Ratio of $(POB)_2Ir(pic)$

Dong-Eun Kim[1], Byoung-Sang Kim[1], Jae-Chul Park[2], Jeong-Soo Chang[3], Young-Soo Kwon[1,*]
[1]Department of Electrical Engineering & NTRC, Dong-A University
[2]Internet & Electronic Info-Communication, Yeungjin College
[3]Department of Electrical Engineering, Kyungil, University

Abstract - We has been synthesized $(POB)_2Ir(pic)$ as a red emitting materials and evaluated in the organic light emitting diodes (OLED). The layer of Alq_3 doped with $(POB)_2Ir(pic)$ as emitters has been demonstrated. The structure of the device is ITO/ NPB (40 nm) / $Zn(HPB)_2$ (40 nm)/ Alq_3 : $(POB)_2Ir$ (pic) (30 nm) / LiF / Al. We varied the doped rate of $(POB)_2Ir(pic)$. The doped rate is 0.4 %, 0.6%, 0.8 and 1.2%, respectively. When the doped rate of the Alq_3: $Ir(POB)_2(pic)$ was 0.6%, white emission is achieved. The Commission Internationale de l'Eclairage (CIE) coordinates of the white emission are (0.316, 0.331) at an applied voltage of 10.75V.

1. Introduction

Organic light emitting diodes (OLED) demonstrate a lot of advantages in LCD displays. White light emission with high efficiency and stability is also desirable for applying OLED to illumination light sources and backlight in LCD displays [1]. In multi-layer structures, a white color may result from the combination of two colors (red and blue) or three colors (red, blue and green). They can be used as a backlight in liquid crystal display or as a white light source. In order to realize full color OLED from white light, high efficiency and simple device processing are required [2]. Kido et al. obtained for the first time a white EL emission using a multi-emission layers structure in which the three primary colors were emitted from different organic layers [3]. A white light- emitting device can also be applied as a paper-thin light source. This is very useful for places where lightweight lighting devices are required, such as in aircraft and space shuttles, and as a backlight for liquid crystal displays. There are three methods used to obtain white emitting devices. One method is to dope single host emissive layers with laser dyes that either emit at different ranges from the host material or blend two different emissive polymers. Another is to use a structure that allows for two or three concurrent emissions from one emissive layer. The last method is to use a multilayer structure to get different concurrent emissions from different emissive electron transport layers [4,5]. In this study, we synthesized the red emission materials, $(POB)_2Ir(pic)$ and previous research was synthesized $Zn(HPB)_2$ as blue emitting materials [6]. The ionization potential (IP) and electron affinity (EA) of $(POB)_2Ir(pic)$ were measured by cyclic-voltammetry. We studied white OLED using emitting materials, $Zn(HPB)_2$ layers and Alq_3:$(POB)_2Ir(pic)$. We varied the doped rate of $(POB)_2Ir(pic)$. When the doped rate of the Alq_3 : $(POB)_2Ir(pic)$ was 0.6%, white emission is achieved

2. Experiments

A white OLED was fabricated in which a green light emitting host Alq_3 was doped with a red dye $(POB)_2Ir(pic)$. The $Zn(HPB)_2$ was blue emitting layer. The structure of the devices were NPB (40 nm) / $Zn(HPB)_2$ (40 nm) / Alq_3:$(POB)_2$ Ir(pic) (30 nm) / LiF / Al. The doped rate of the Alq_3:$(POB)_2$ Ir(pic) is 0.4 %, 0.6%, 0.8 and 1.2%, respectively. The organic materials were evaporated on top of the ITO substrate under 5×10^{-6} torr with deposition rate of about 1.0 Å/s. A metal was deposited under 5×10^{-6} torr with a deposition rate of about 10 Å/s. The PL spectrum was measured using a Perkin-Elmer LS45 luminescence spectrometer. The characteristics of the current density-voltage-luminance and the CIE coordinates were measured with an IVL 300 series (JBS Inc.). All measurements were performed at room temperature in air.

3. Results and Discussion

The cyclic voltammetry used to measure the energy gap of $(POB)_2Ir(pic)$. It was found that the films of $(POB)_2Ir(pic)$ could be oxidation and reduction. The oxidation onset potential and the reduction onset potential of $(POB)_2Ir(pic)$ was measured to be +1.1 V and -1.40 V. The EA of $(POB)_2Ir(pic)$ is 3.4 eV and the IP is 5.7 eV. The peaks were observed at the wavelength of 620 nm and $(POB)_2Ir(pic)$ showed red emission. Fig. 1 shows PL spectrum of $(POB)_2Ir(pic)$. Fig. 2 shows the energy level alignment of the devices.

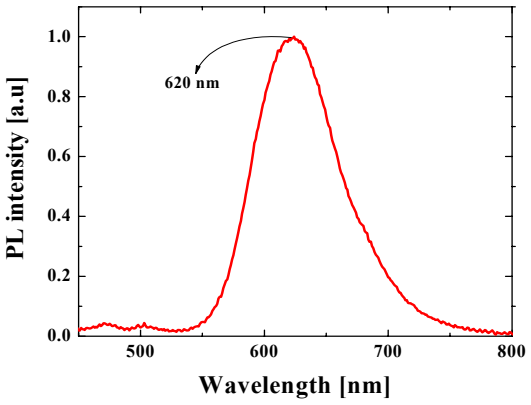

Fig. 1 The PL spectrum of $(POB)_2Ir(pic)$.

Fig. 3 shows the luminanceof devices varying with current density. Fig. 4 shows the efficiency of devices with the varying current density. The maximum of the luminance of device 2 is 14500 cd/m^2 while the voltage is 10.75 V. It is clear that the efficiency of device 2 is higher than that of device 1, 3 and 4. This may due to the thicker emission layer Alq_3:$(POB)_2Ir(pic)$, which also leads improvement of the fluorescence quenching by the cathode.

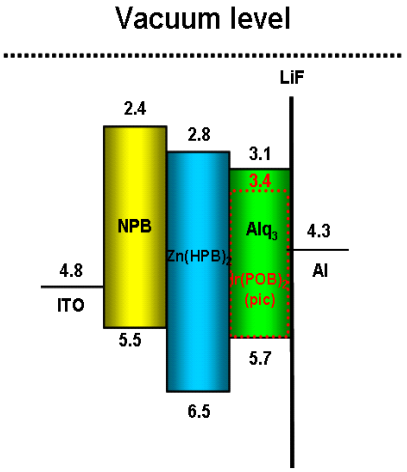

Fig. 2 The energy level alignment of the devices.

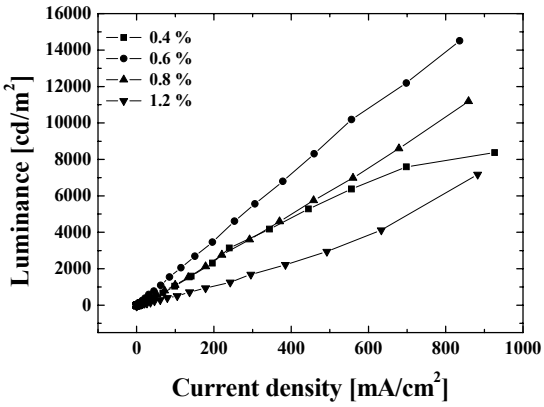

Fig. 3 The luminance of devices varying with current density.

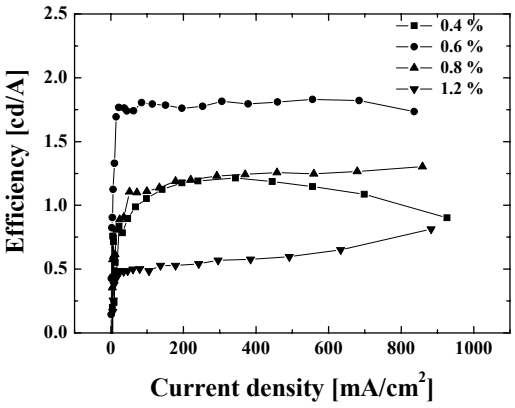

Fig. 4. The efficiency of devices with the varying current density.

Fig. 5 shows the normalized EL spectra and the CIE coordinates of devices 1, 2, 3 and 4. The proportion of red emission increases with the increasing doping rate and blue emission decreasing with increasing doping rate. When the doped rate of the Alq_3:$(POB)_2Ir(pic)$ layer was 0.6%, white emission can be obtained. The CIE coordinates are (0.316, 0.331) at a voltage 10.75 V. This phenomenon might be explained as follows. At increasing the doping rate, red emission was increased because of more electron and hole recombination in Alq_3:$(POB)_2Ir(pic)$ layer than $Zn(HPB)_2$.

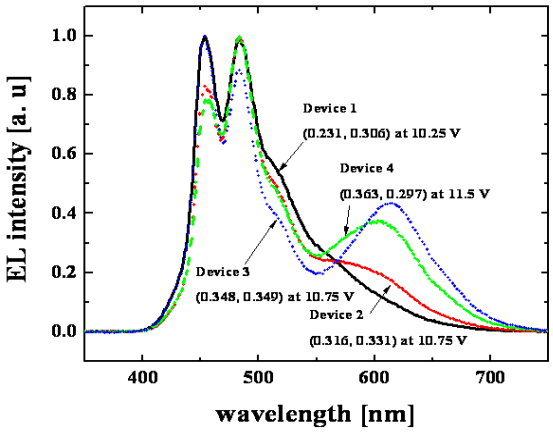

Fig. 5 The normalized EL spectra and the CIE coordinates of devices.

Because in this case, the $Zn(HPB)_2$ is working as a hole blocking layer. In order to understand the relationship between the activation energy for El spectrum and material parameters, in particular IP, an energy diagram of the OLED studied in this letter is presented in Fig. 2. In the mixed layer, holes will be transported by hopping between $Zn(HPB)_2$ molecules, and electrons by hopping between $(POB)_2Ir(pic)$ molecules

4. Conclusion

We synthesized blue emissive materials of $(POB)_2Ir(pic)$. $(POB)_2Ir(pic)$ measured energy level values using cyclic-voltammetry. The IP and EA of $(POB)_2Ir(pic)$ was measured to be 5.7 eV, 3.4 eV. This material was used the red emitting layer in white OLED. We varied the doped rate of $(POB)_2Ir(pic)$. When the increasing of doping rate, the red emission increase with the increase doping rate and the blue emission increase with the increase doping rate. We realized a white emission using $(POB)_2Ir(pic)$. When the doping rate was 0.6% white emission is achieved. The CIE coordinates are (0.316, 0.331) at an applied voltage of 10.75V. We realized a white OLED using the red emitting material of $(POB)_2Ir(pic)$.

[Acknowledgement]

This work was supported by the Korea Science and Engineering Foundation (KOSEF) grant funded by the Korea government (MOST). (No. R01-2006-000-11120-0).

[References]

[1] C. Hosokawa, M. Eida, M. Matsuura, K. Fukuoka, H. Nakamura, T. Kusumoto, Synth. Met., 91, 3, 1997.
[2] T.-W. Lee, O.O. Park, H.N. Cho, Y.C. Kim, Synth. Met., 131, 129, 2002.
[3] J. Kido, K. Hongawa, K. Okuyama and K. Nagai, Appl. Phys. Lett., 64, 815, 1994.
[4] S. Tasch, E.J.W. List, O. Ekstrom, W. Graupner, G. Leising, P. Schlichting, U. Rohr, Y. Geerts, U. Scherf K. Mullen, Appl. Phys. Lett., 71, 2883, 1997.
[5] Y. Wang, F. Tenga, C. Ma, Z. Xu, Y. Hou, S. Yang, Y. Wang, X. Xu, Displays, 25, 237, 2004.
[6] Y. K. Jang, D. E. Kim, W. S. Kim, O. K. Kwon, B. J. Lee, Y. S. Kwon, Jpn. J. Appl. Phys., 45, 3725, 2006.