Fabrication of simple bi-layered structure red and green PHOLEDs

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Abstract

Highly efficient red and green phosphorescent devices comprising a simple bilayer structure are reported. The driving voltage to reach 1000 cd/m^2 is 4.5 V in $Bebq_2$: $Ir(piq)_3$ red phosphorescent device. Current and power efficiency values of 9.66 cd/A and 6.90 lm/W in this bi-layered simple structure PHOLEDs are obtained, respectively. While in $Bepp_2$:$Ir(ppy)_3$ green phosphorescent device, the operating voltage value of 3.3V and current and power efficiencies of 37.89 cd/A and 35.02 lm/W to obtain a luminance of 1000 cd/m^2 are noticed, respectively.

1. Introduction

Organic light emitting devices (OLEDs) have generated considerable interest in recent days, owing to their use in general illumination applications. [1-3] High current and power efficiencies and superior lifetime are essential requirements of these applications. Good charge balance in emitting layers and low barrier to charge carriers injection in p-i-n devices demonstrate a low operating voltage and high efficiency.[1] An upper limit on the external quantum efficiency of 5 % in fluorescent small molecule organic devices has been overcome in phosphorescent OLEDs (PHOLEDs) by harvesting the singlet and triplet excitons to emission of photons.[2, 3] Iridium (III) complexes have been shown to be the most efficient triplet dopants employed in highly efficient organic light-emitting devices (OLEDs). [4, 5] However, the turn-on voltage of PHOLEDs is relatively high about 1 ~ 2 V compared to that of fluorescent OLEDs. [6, 7] Therefore, the selection of suitable (i) host materials for PHOLEDs, (ii) HTL to avoid leakage of electrons and excition quenching, (iii) phosphorescent dopant materials are very imperative to achieve the high efficiency in bi-layered PHOLEDs. In the present investigation, highly efficient simple bi-layered structure for red and green emitting PHOLEDs are reported.

2. Experiment

To fabricate OLED devices, a clean glass substrate precoated with a 150-nm ITO layer with a sheet resistance of 10 ~ 12 Ω/□ was used and the substrate size was 2 cm Χ 2 cm. The patterns of 2 Χ 2 mm^2 were formed by photolithography and wet etching processes and used as an anode. The glass substrate was cleaned by sonification in an isopropyl alcohol, acetone, and methanol, rinsed in deionized water, and finally irradiated in a UV-ozone chamber. All organic materials were deposited by the vacuum evaporation technique under a pressure of ~ 3.0×10^{-7} Torr. Doping is carried out by co-evaporation from independent sources and effusion rates were monitored using a quartz crystal microbalance (QCM). Subsequently, Al with a deposition rate of ~ 5 Å/s was deposited in vacuum chamber without breaking the vacuum and used as a cathode. The current density-voltage (J-V) and luminance-voltage (L-V) data of PHOLEDs were measured with a Keithley SMU 238 and Minolta CS-100A, respectively. Electroluminescence (EL) spectra and CIE color coordinate were obtained using a Photo-research PR-650 spectroradiometer.

Following simple bilayer PHOLEDs were fabricated. Fig.1 shows the structures of three red PHOLEDs devices fabricated using different host Materials.

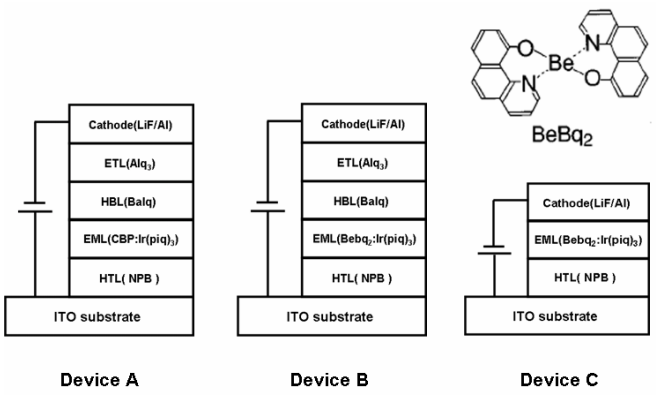

Fig. 1. Structures of fabricated three PHOLEDs: device A - CBP: Ir(piq)$_3$, device B- Bebq$_2$: Ir(piq)$_3$, device C - Bebq$_2$: Ir(piq)$_3$ without HBL and ETL.

Fig.2 shows the structures of PHOLED devices fabricated for the present study using various HTL Materials.

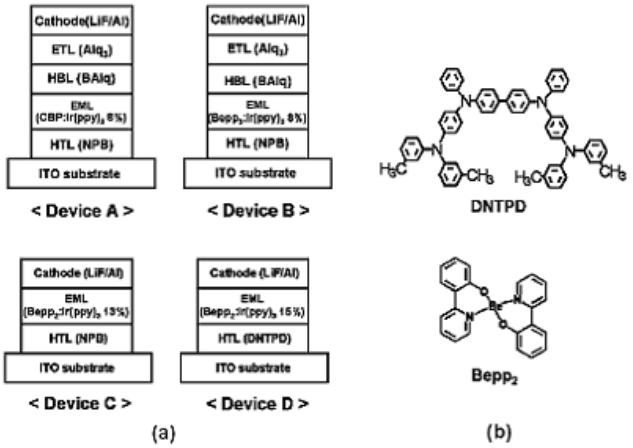

Fig. 2 Fabricated device structures of four PHOLEDs using different HTL materials.

3. Results and discussion

Figure 3 shows the I-V-L characteristics of fabricated red phosphorescent devices. The driving voltage for the device A to reach 1000 cd/m^2 is 8.8 V, 6.8 V for the device B, and 4.5 V for the device C. A narrow band-gap host material, Bebq$_2$, for red PHOLEDs has a very small exchange energy value of 0.2 eV between singlet and triplet states. High current and power efficiency values of 9.66 cd/A and 6.90 lm/W in bi-layered simple structure PHOLEDs are obtained, respectively.

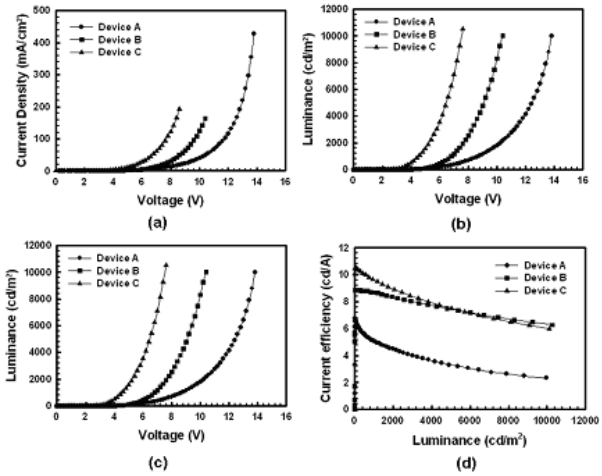

Fig. 3. I-V-L characteristics of fabricated three PHOLEDs ; (a) current-voltage characteristics (b) luminance-voltage characteristics (c) current efficiency-luminance (d) power efficiency-luminance.

Figure 4 displays the I-V-L characteristics of green PHOLEDs devices with different HTL materials, measured until 10,000 cd/m^2 brightness value. The turn voltage value of 9.5 V to attain a luminance of 1000 cd/m^2 in Devices A (CBP host) is reported (Fig. 2(a). The current and power efficiencies to reach the luminance of 1000 cd/m^2 are 19.92 cd/A and 6.52 lm/W, respectively. In Device D, the operating voltage value of 3.3V and current and power efficiencies of 37.89 cd/A and 35.02 lm/W to obtain a luminance of 1000 cd/m^2 are noticed, respectively.

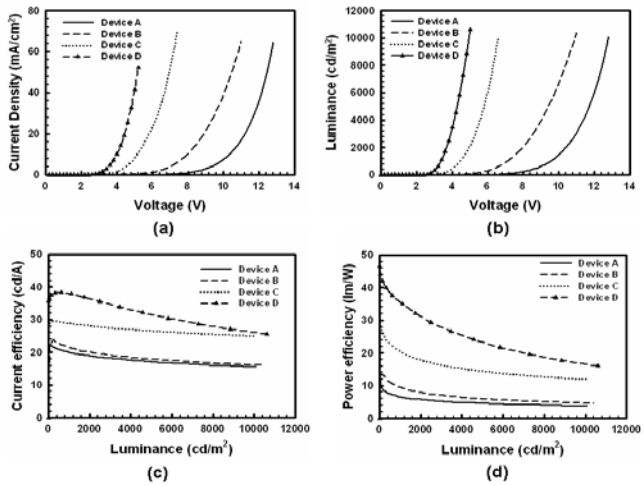

Figure 4. I-V-L and efficiency characteristics of green PHOLEDs. (a) current-voltage characteristics (b) luminance-voltage characteristics(c) current efficiency-luminance (d)

power efficiency-luminance

Figure 5 show the EL spectra at a brightness of 1000 cd/m^2 of fabricated green and red PHOLEDs. In case of green PHOLEDs with NPB HTL (device C) very weak NPB emission is observed around 450 nm. Device D with DNTPD HTL indicates that the issue of exciton diffusion into HTL is totally suppressed.

Clean red light emission at 632 nm observed in red PHOLEDs devices. Results reveal confinement of excitions in the emissive zone and no leakage of electrons into HTL in these red PHOLEDs.

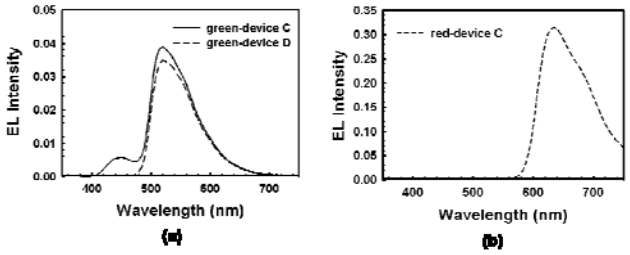

Figure 5. EL spectra of green and red PHOLEDs device at luminescence of 1000 cd/m^2. (a) green devices of bi-layered structure (b) red devices of bi-layered structure

4. Summary

In Bebq$_2$: Ir(piq)$_3$ red phosphorescent bi-layered simple structure, the driving voltage value of 4.5 V to reach 1000 cd/m^2, current and power efficiency values of 9.66 cd/A and 6.90 lm/W PHOLEDs are reported, respectively. Whereas in Bepp$_2$:Ir(ppy)$_3$ green phosphorescent device, the operating voltage value of 3.3V and current and power efficiencies of 37.89 cd/A and 35.02 lm/W to obtain a luminance of 1000 cd/m^2 are noticed, respectively.

In conclusion, we have demonstrated highly efficient simple bi-layered structure for red and green emitting PHOLEDs.

Acknowledgements

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5. References

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