Fabrication of WOLED with orange and blue emissive layers using two complementary color method

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Keywords : white organic light-emitting diodes, two complementary color

Abstract

WOLED devices were fabricated using two complementary color method with two emissive layers of blue and orange color respectively. WOLED's color purity was optimized as changing thickness of blue emissive DPVBi layer with most efficient red emissive layer doped with 0.2% DCJTB in Alq_3 and obtained better white color coordinates of (0.36, 0.33) at 9V.

1. Introduction

WOLEDs have been increasing attention in various applications including solid light source such as backlight for LCD and planar lighting as well as full color OLED with color filter. The structures and materials for WOLEDs have been studied extensively by many research groups worldwide.[1-4] There are a number of methods to achieve white emission in OLED and two complementary color method has been highlighted recently according to high emission efficiency, more practical color mixing, simple process and lower shift of exciton-recombination zone. White emission usually can be obtained by mixture of two complementary colors such as sky blue and deep red or deep blue and orange. In this paper, we pursued to achieve WOLED through optimization of two complementary colors using blue and orange emissions as changing thickness of blue emitting layer and concentration of orange color dye. The WOLED devices with optimum layer structure showed proper color coordinates of white emission, (0.36, 0.33) at 9V for white light source.

2. Experiment

Indium tin oxide (ITO)-coated glass was cleaned in an ultrasonic bath by the following sequence: in acetone, distilled water and isopropyl alcohol. WOLEDs were fabricated by using the high vacuum (6.0×10^{-7} Torr) thermal evaporation of organic materials onto the surface of the ITO-coated glass substrate. The deposition rates were 1.0~ 1.1 Å/sec for organic materials and 0.1 Å/sec for lithium quinolate (Liq), respectively. After the deposition of the organic layers, the aluminum (Al) cathode was deposited at a rate of 5 Å/sec without a vacuum break. The doping concentrations of the dopants were optimized between 0.2 – 1.0%. With the DC voltage bias, the optical and electrical properties of WOLEDs such as the current density, luminance, luminous efficiency, electroluminescence (EL) spectra and CIEx,y coordinates characteristics were measured with Keithley 238 and PR 650 instruments. All measurements were carried out under ambient conditions at room temperature.

3. Results and discussion

The device structure of orange color OLED using Alq_3 as host material and DCJTB as orange emitting dopant material is ITO/NPB(500Å)/Alq3:DCJTB (0.2~1.0%, 150Å)/Alq3(300Å)/Liq(20Å)/Al(1000 Å) and it shows highest efficiency with 0.2% of DCJTB concentration as summarized in Table 1.

Table 1 Color coordinates and efficiency of orange OLED with various dopant concentration at 9V.

Doping concentration	CIE x,y	luminous efficiency
0.2%	(0.52, 0.44)	5.26 cd/A
0.5%	(0.54, 0.42)	5.08 cd/A
1.0%	(0.56, 0.41)	4.60 cd/A

Current efficiency of orange color emission was decreased as increasing dopant concentration because highly concentrated dopant took a role as impurity in emissive layer to make quenching happened. Alq_3 was selected best host material for orange color OLED because it is capable of transferring absorption energy to dopant, DCJTB more efficiently for emission as demonstrating reasonably high overlapping between Alq_3's absorption peak and DCJTB's emission peak as shown in Figure 1.

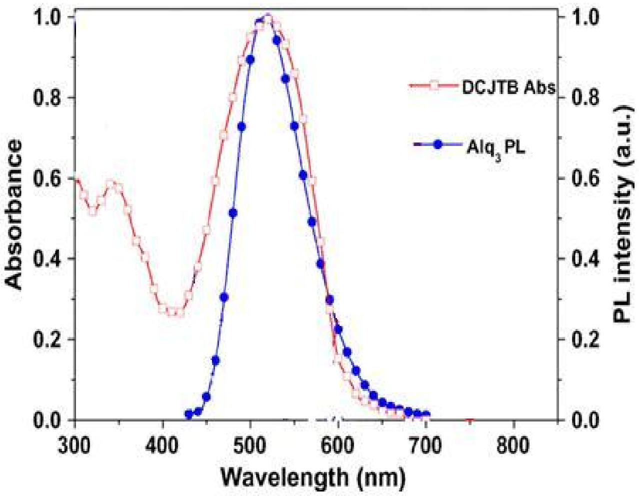

Figure 1. Absorption and photoluminescence spectra of Alq_3 and DCJTB.

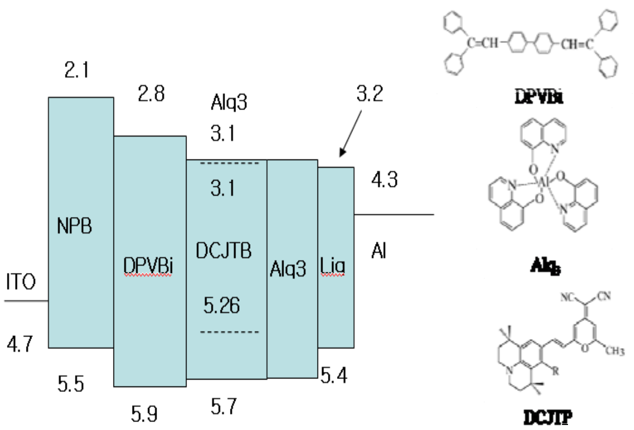

Figure 2. WOLED's energy diagram and molecular structures of emitting materials.

WOLED's band gap diagram including host:dopant orange emitting layer and molecular structures of emitting layer materials are described in Figure 2. WOLED's optimum device structure is ITO/NPB(500 Å)/DPVBi(120, 170, 200 Å)/Alq3:DCJTB(0.2%,115 Å)/Alq3(300 Å)/Liq(20 Å)/Al(1000 Å) and it shows best white color coordinate of (0.36, 0.33) when thickness of blue emitting layer, DPVBi is 170 Å as described in Figure 3. Recombination of hole and electron in blue emission is effected by thickness of DPVBi layer and this results in a shift of color coordinate due to unbalanced color mixture of deep blue and orange. As increasing thickness of DPVBi, color coordinates of white OLED was shifted to blue while it was stayed in orange color at 120 Å of DPVBi thickness since hole mobility faster than electron generates exciton in orange emissive layer more than in blue DPVBi layer. To adjust region of hole-electron recombination, thickness of DPVBi was increased to obtain higher chance of exciton generation in DPVBi layer and it helped to achieve better white color coordinates.

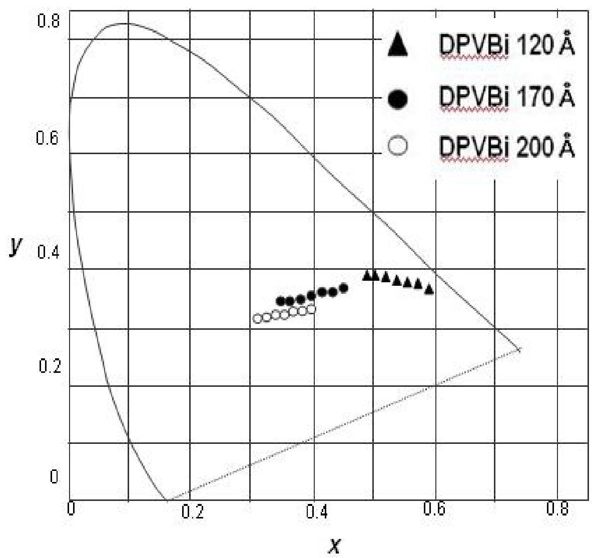

Figure 3. Color coordinates of white emission different thickness of DPVBi layer in WOLED.

Figure 4 shows current efficiency of WOLED with various thickness of DCJTB layer and highest efficiency was achieved with 170 Å of DPVBi thickness in white OLED. WOLED with 170 Å of DPVBi has higher efficiency of 3.0 cd/A than WOLEDs with 120 Å and 200 Å of DPVBi thickness, 2.5 and 2.0 cd/A respectively.

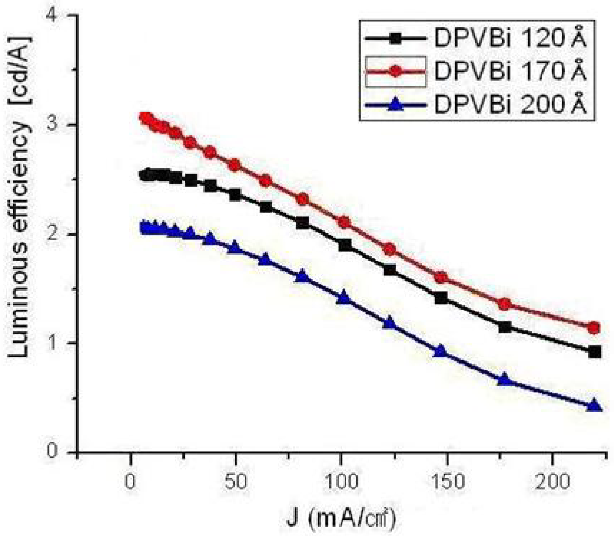

Figure 4. Current efficiency of WOLED with different thickness of DPVBi layer in WOLED.

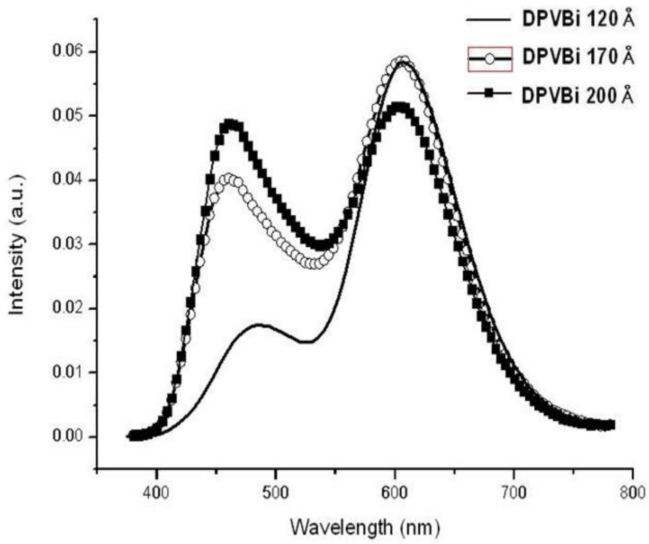

Figure 5. EL spectra of WOLED with different thickness of DPVBi layer in WOLED.

Figure 5 showed that EL spectra of WOLED with different thickness of DPVBi layer in WOLED. Optimum white emission is obtained with DPVBi thickness of 170Å as performing blue, green and red emission while WOLED with DPVBi thickness of 200Å a little bule shifted due to strong blue emission and weak orange emission and also that with DPVBi thickness of 120Å builds up more extion in orange layer to be resulted in weaker blue emission.

4. Summary

WOLED using two complementary color method provides best solution for solid light sources with technical advantages such as higher efficiency, simple manufacturing process and lower production cost. White OLED using blue emissive layer with DPVBi and orange emissive layer with DCJTB doped Alq_3 shows highest luminous efficiency of 3.0 cd/A at 11.5 mA/cm^2 with major peaks of RGB emission in EL spectrum as well as reasonably acceptable CIEx,y coordinates of (x=0.36, y=0.33) at 9V.

5. References

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