Study of White Light Emission with Three or Two color in Multi Organic Emitting Layers with DCJTB, DPVBi and Coumarin6

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Abstract

Using a blue emitting DPVBi material and red dopant DCJTB, WOLEDs with and without green emitter C6 added in ETL or HTL have been fabricated. The chromaticity color index of WOLEDs without C6 depends strongly on the doping concentration. In addition, manipulating thickness of emitting layer is similar effect such as controlling weight concentration of dopant. While the white color of WOLEDs with C6 added in ETL or HTL depend on position of C6. WOLED of three colors added green dye have been shown turn-on voltage of 3.25V, and EL efficiency 3.05cd/A @9V, 8102 cd/m^2, CIE coordinates (0.30, 0.32).

1. Introduction

White organic Light-emitting device (WOLEDs) have been studied for various application such as lighting, full color displays with color filter and backlights for liquid crystal displays.[1-5] Especially, large area WOLED is of paramount importance for the full-color flat-panel displays. It can be combined with color filter to give red, green and blue light-emitting pixel. Many methods have been introduced to obtain white OLEDs by mixing two complementary colors or three primary colors.[6,7] The small molecular based WOLEDs using vacuum deposition process have shown relatively high efficiency despite their complicated structure with multiple emissive layers.

Kido et al. obtained a white Electroluminescence (EL) emission using a multi-emission layers structures in which the three primary colors were emitted from different organic layers.[8,9] Forrest et al. presented a layer structure.[10] Jiang et al. reported a white organic device with a hole block layer between hole and electron transporting layers.[11]

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In this paper, we will report a WOLED, in which we utilize type of two colors with a blue host DPVBi and a red dopant DCJTB and three colors added C6 layer of green dye. To color balance, devices were controlled by the thickness of emission layer and the position emitting layer.

2. Experimental

Devices of two colors without green emitting layer type reported here have the configuration of ITO/2TNATA/NPB/DPVBi;DCJTB/DPVBI/Alq/LiF/Al in which 2TNATA is 4,4',4"-tris(N-(2-naphthaly)N-phenly-amino)-triphenylamine as a hole injection layer, NPD is N,N-bis-(1naphthyl)-N,N-diphenyl-1,1-biphenyl-4,4-diamine as a hole transporting layer, DPVBi is 4,4'-bis(2,2-diphenyl-ethen-l-yl)diphenyl as a blue emitter and host. DCJTB is 4-(dicyanomethylene)-2-t-butyl-6(1,1,7,7-tetra-methyljulolidyl-9-enyl)-4H-pyran as a red dopant, Alq3 is Tris (8-hydroxy-quionlinolato) aluminium as an electron transport layer.

Devices of three colors are C6 (Coumarin6) added in HTL or ETL as green emitter. Table 1 shows the configurations of all devices presented here.

ITO substrate were pre–patterned with an effective emitting area of 6×4 mm^2. WOLEDs were fabricated by thermal evaporation subsequently in high vacuum chamber under the base pressure of 3×10^{-7} torr.

EL spectra are measured by a MINOLTA CS1000 spectroradiometer. The characteristics of current-voltage are measured with Keithlry 2400 source meter. All measurement is performed at room

TABLE 1. Configurations of all device.

Device No.	Configurations of Organic layers
1	2-TNATA(15nm)/NPD(35nm)/DPVBi:DCJTB(5nm)/DPVBi(30nm)/Alq3(10nm)
2	2-TNATA(15nm)/NPD(35nm)/DPVBi:DCJTB(3nm)/DPVBi(7nm)/Alq3(35nm)
3	2-TNATA(15nm)/NPD(35nm)/DPVBi:DCJTB(3nm)/DPVBi(6nm) /Alq3(36nm)
4	2-TNATA(15nm)/NPD(30nm)/C6(1nm)/NPD(5nm)/DPVBi:DCJTB(3nm)/DPVBi(7nm)/Alq3(35nm)
5	2-TNATA(15nm)/NPD(35nm)/DPVBi:DCJTB(3nm)/DPVBi(7nm)/Alq3(5nm)/C6(1nm)/Alq3(30nm)

temperature in air.

3. Results and discussion

In order to find an optimized DCJTB doping concentration, we studied EL spectra of DCJTB doped by DCJTB with different weight concentration. The structure of the devices was device 1 in Table. 1. It can be obviously seen from Fig. 1 that there are two emission bands in the spectra: the main peak from DPVBi and the second peak from DCJTB. EL spectra of DPVBi doped with 1wt% DCJTB are seen maximum peak of DCJTB at 570nm, a second peak at 440nm. However, EL spectra of DPVBi doped with 0.1wt% DCJTB are seen maximum peek at 560nm, a second peak at 443nm. And second peak of DPVBi doped with0.1wt% DCJTB is relatively higher intensity than DPVBi doped with 1wt% DCJTB. The blue intensity decreases with the increase of DCJTB concentration from 0.1% to 1% by weight. The EL CIE coordinates are summarized in Table 2. It can be found from Table 2 that the white emission was obtained in the sample with 0.1% DCJTB concentration with the CIE coordinates x = 0.31 and y = 0.31.

TABLE 2. EL CIE coordinates of DPVBi doped by DCJTB with different weight concentration in Device 1 at 9V.

	0.1wt%	0.3wt%	1wt%
x	0.31	0.36	0.48
y	0.31	0.36	0.43

In order to balance white light, the device 2 and 3 with different thickness were experimented.

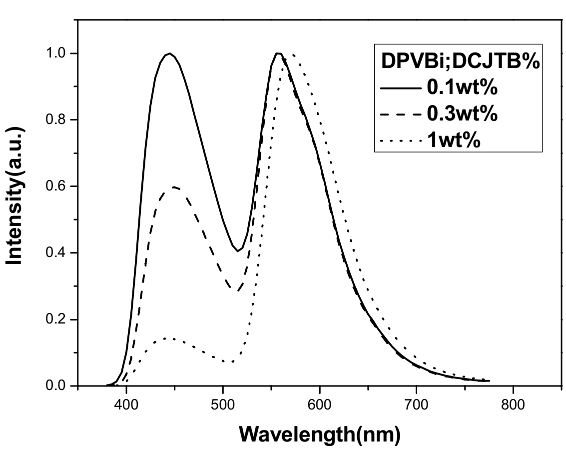

Fig. 1. EL spectra of DPVBi doped with DCJTB with different weigh concentration in Device 1 at 9V.

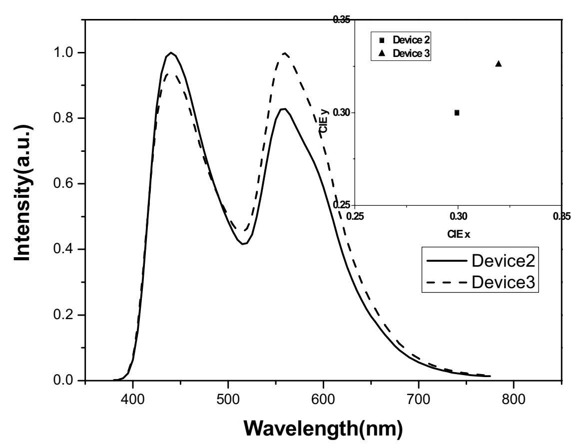

Fig. 2. EL spectra of DPVBi doped with DCJTB with different thickness of emitting layer in Device 2~6 at 9V. Inset shows the CIE color index variation in these devices.

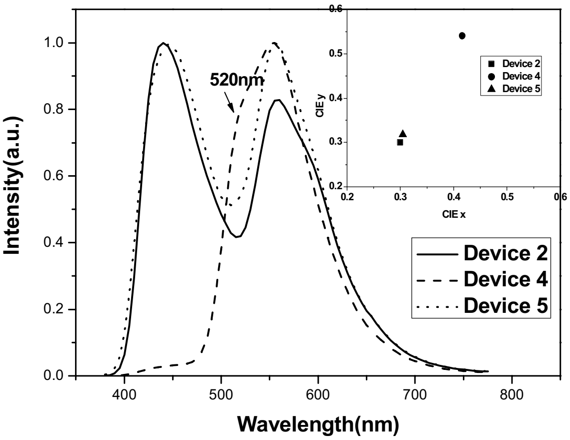

Fig. 3. EL spectra of WOLEDs at 9V.

The DCJTB concentration was fixed at 0.1wt % of the host. Fig. 2 shows the normalized EL spectra using yellow peak intensity at 9V for different fabricated white emitting devices. All devices show blue of 443nm and yellow of 560nm light emitting from the host DPVBi and the dopant DCJTB molecules, respectively, along with a shoulder at 600 nm. Partial energy transfer from DPVBi to DCJTB controls the white balance of the fabricated devices. The EL CIE coordinates which depends on the degree of mixing of a blue and a red light varies with the thicknesses of DCJTB doped and undoped DPVBi as displayed in the inset of Fig. 2. Thus, manipulating thickness of emitting layer has been shown effect such as controlling weight concentration of dopant.

As shown in Fig. 3 device 4 and 5, the emission spectra were found to be quite different in both cases because of position of C6 layer as green emitter. The DCJTB concentration was fixed at 0.1wt % of the host. In case of device 4 added 1nm of C6 in NPD as a HTL, the exciton recombination predominantly occurs in the C6 and DCJTB doped DPVBi of yellow emission region. In case of device 5 added 1nm of C6 in Alq_3 as an ETL, however, the C6 layer prevents holes from being transported across it, so that the exciton recombination takes place in the undoped DPVBi of blue emission region. When device 5 compared with the device 2, these devices were shown differently. A green spectrum of 520nm was increased intensity (0.54 a.b.) of the device 5 than intensity (0.42 a.b.) of the device 2. In addition, the maximum and second peak of the device 5 shifted to a green color. We seem for holes trapping of the C6 layer in the device 4 when electric field is applied, based on the energy band theory. Therefore, undoped DPVBi layer in the device 4 has

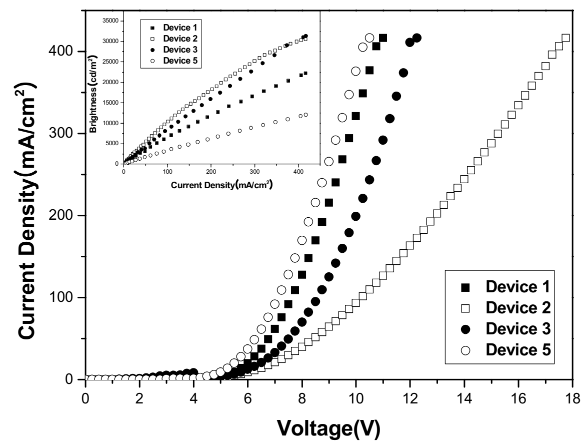

Fig. 4. Current densities of as voltage white emitting OLEDs. Inset shows the brightness variation as fuction current density.

not been generated exciton. While the device 5 has hole-electron recombination zone to DCJTB doped DPVBi layer, DCJTB undoped DPVBi layer and C6 layer. Thus, observed EL spectra of device 4 and 5 such as Fig. 3. Inset of Fig. 3 shows CIE coordinates of device 2, 4 and 5 at applied 9V. The device 2 has been shown CIE coordinates of x = 0.30 and y = 0.30. The CIE coordinates of the device 5 with C6 added in Alq3 layer has been shown x = 0.30 and y = 0.32. Improving the CIE coordinates of the device 5 was occurred by increased green light. The added C6 in Alq3 layer are beneficial to white

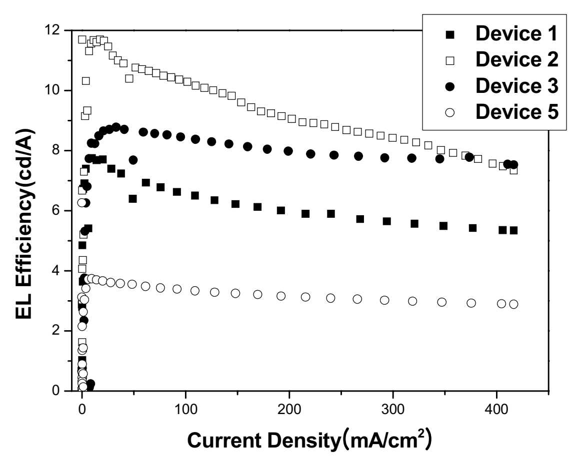

Fig. 5. EL efficiency – Current density curves for the WOLEDs

light emission.

Figure 4 shows the current-voltage characteristics of WOLEDs. The forward resistance of the WOLEDs decreases by manipulating the thicknesses of doped and undoped DPVBi. Higher current flows through the devices 1, 3 and 5 compared with device 2 at the applied voltage. The lowest turn-on voltage of 2.74V is exhibited in the device 4. Inset of Fig. 4 shows the variation of brightness as a function of current density. Luminance is proportional to current density in all WOLEDs. High brightness of 10289cd/m^2 showed in device 2 at 100mA/cm^2, critical factor have a high lifetime and brightness for operating at the lowest possible current density. In generally, the device 1 with thick emitting layer has been shown lower brightness than devices with thin emitting layer. This is decreases quenching along the reduction of emitting layer thickness. Respectively, the device 5 with added C6 has shown the lowest brightness of 3301 cd/m^2 at 100mA/cm^2.

Fig. 5 shows the EL efficiency as a function of current density. WOLEDs with thin emitting layer have been shown high EL efficiency. High efficiency of 11.7cd/A is obtained in device 2 at 6.75V, 17.37mA/cm^2. Almost constant luminous efficiency > 3.0cd/A over the current density of 5~400 mA/cm^2 is noticed in the device 5 While the device 5 with added C6 layer has the lowest EL efficiency. Almost constant luminous efficiency > 3.0cd/A over the current density of 5~400 mA/cm^2 is noticed in the device 5.

4. Summary

We reported on two approaches to obtain white emission from two or three colors. WOLEDs with two colors could be optimized by adjusting the DCJTB concentration and EML thickness. While WOLEDs with green emitter C6 added in HTL or ETL depended on position of C6 layer.

The device 4 with thin emitting layer of two colors achieved showed low turn-on voltage 2.74V, and high EL efficiency 10.3 cd/A, high brightness 10289cd/m^2 @ 100mA/cm^2, CIE coordinates (0.30, 0.30). Also the device 5 enhenced green emission by C6 achieved turn-on voltage of 3.25V, and EL efficiency 3.3cd/A, brightness 3301cd/m^2 @ 100mA/cm^{2,} CIE coordinates (0.30, 0.32).

5. References

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