Novel Host materials for Phosphorescent OLEDs with long lifetime

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Abstract

We have developed a novel bipolar host material with both electron and hole transporting characteristics. Since CGH(Cheil Green Host) has some electron transporting characteristics, it shows increased luminance efficiency in device including TCTA and without HBL(hole blocking layer:BAlq). Maximum power efficency of CGH was 27.4lm/W at the device structure ITO/DNTPD(60)/NPB(20)/TCTA(10)/EML(30)/Alq3(20)/LIF(1)/Al . We measured device performance again without HBL. The result of CGH showing 26.0lm/W is outstanding compared to that of CBP showing 19.1lm/W without holeblocking layer. We also measured lifetime and found to be 205hr at 3000nit, that is significant result compared to the life time of CBP device showing 82hr.

CGH shows high device performance with holeblocking layer. Moreover, it shows better device performance and life time than those of CBP without holeblocking

1. Introduction

EL efficiency of organic light-emitting diodes(OLEDs) has advanced rapidly in recent years due to the development of phosphorescent guest molecules containing transition metals, which doped into host materials having charge transporting ability[1-4]. One of the important properties of host materials for PHOLEDs is charge transporting ability[5-6]. CBP has been widely used as a host in PHOLEDs[7]. However, CBP showed better hole transporting capability than electron because of carbazole unit. A novel host material(CGH) having similar carrier transporting abilities of both hole and electron is required to improve EL efficiency of PHOLEDs

Recently, we have developed a novel host material, CGH engineered with both electron and hole transporting units. CGH was fabricated into five device structures and measured device performance of CGH. The five device structures are shown below, the host thickness was 30nm and doping concentration(w/w) of Ir(ppy)3 ranged between 5~7%. As a control device, CBP with 30nm thickness was used as a host material. Dopant concentration is 5% in device structure A/B/C and 7% in device structure D/E.

A : ITO/DNTPD(60)/NPB(30)/EML(30)/BCP(5)/Alq3(20)/LiF(1)/Al
B : ITO/DNTPD(60)/NPB(30)/EML(30)/Alq3(20)/LiF(1)/Al(200)
C : ITO/DNTPD(60)/NPB(20)/TCTA(10)/EML(30)/Alq3(20)/LiF(1)/Al
D : ITO/NPB(70)/TCTA(10)/EML(30)/BAlq(5)/ Alq3(20)/LiQ(1)/Al
E : ITO/NPB(70)/ TCTA(10)/EML(30)/Alq3(25)/LiQ(1)/Al

2. Experimental

The electrochemical property was measured by cyclic voltametry. Photoluminance property was measured by fluorometer. Triplet state(Δ Et) was also obtained from fluorometer with low temperatre method.

The current-Voltage characteristics of the devices were measured using Keithley 2400 electrometer. The brightness was measured using chrometer CS-1000A(Minolta). The lifetime were measured using Polar-Onix M-6000(Mc Science).

3. Results and discussion

As shown in Table 1, there are similar photochemical and electrochemical properties between CBP and CGH but their device performance are different depending on the device structure(A~E).

Table 1. Energy levels of CBP and CGH

	PL(emission)	HOMO(eV)	LUMO(eV)	Δ Et
CBP	386nm	-5.67	-2.24	2.65
CGH	394nm	-5.67	-2.24	2.60

Figure 1. showed the power efficiency of CBP in device structure A, B and C. The power efficiency of CBP was affected by the presence of electron and hole blocking layer.

In device C, CBP showed better performance when TCTA was used as an electron blocking layer, but the turnon voltage was increased.

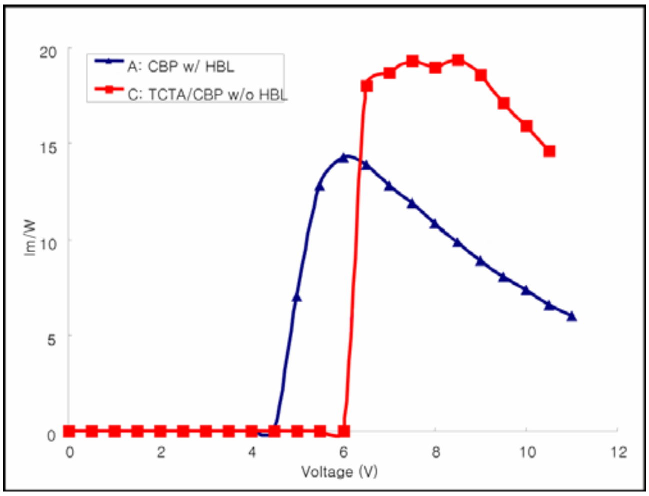

Figure 1. power efficiency of CBP

Figure 2 shows the power efficiency of CGH in device structure A, B, C. CGH also showed better result when TCTA was used as a electron blocking layer. Especially, the maximum power efficiency of CGH in device C was 140% better than that of CBP but the turn on voltage was high.

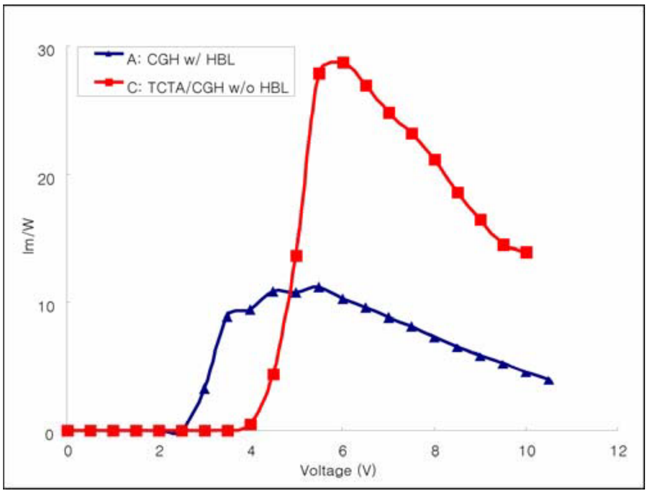

Figure 2. power efficiency of CGH

Table 2 shows device performances of CBP and CGH. Especially, CGH shows dramatically increased power efficiency of 27.4lm/W with electron blocking layer(device C). This result is 330% better than that of device A(8.3lm/W) and 140% better than that of device C(19.1lm/W).

Table 2. Device performance at 1000nit

Host	Device	Turn on (V)	at 1000nit		
			Driving voltage (V)	Luminance efficiency (cd/A)	Power efficiency (lm/W)
CBP	A	5.4	8.1	24.8	10.7
	B	5.4	9.5	25.7	9.4
	C	5.9	7.8	42.9	19.1
CGH	A	3.9	7.4	17.7	8.3
	B	3.7	7.2	20.3	9.7
	C	4.0	6.4	50.2	27.4

We fabricated the device again to measure how much hole blocking layer affects the device performance with CBP or CGH.

In Figure 3 and Figure 4, we fabricated the organic light emitting device with without HBL in order to measure the device performance. In figure 4, CBP shows 50% drop without HBL but CGH shows only 13% drop without HBL. That means CBP was more affected by HBL.

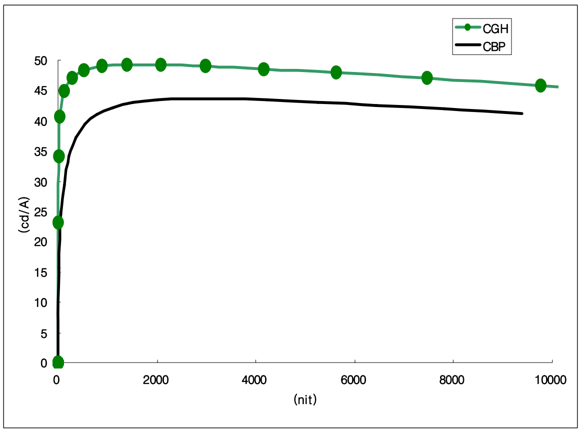

Figure 3. luminance efficiency of device D

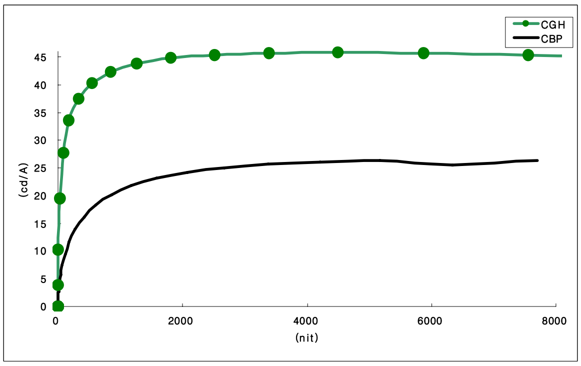

Figure 4. luminance efficiency of device E

As you see in Table 3, HBL affects little in CGH devices. CGH shows 32lm/W and 26lm/W, respectively. This results are better than those of CBP. CGH shows higher luminance than that of CBP. In device E, the power efficiency of CGH is 200% better than that of CBP. Also the luminance efficiency is 200% better than that of CBP. Especially, the device of CGH is stable whether hole blocking layer is used or not. As shown table 3, CGH always shows better performance than CBP does.

Table 3. device performance at 1000nit

Host	Device	Turn on (V)	at 1000nit		
			Driving voltage (V)	Luminance efficiency (cd/A)	Power efficiency (lm/W)
CBP	D	4.8	7.1	42	18
CGH		3.3	4.9	49	32
CBP	E	8.4	8.4	21	13
CGH		5.2	5.2	43	26

We also measured the lifetime of the device E at 3000nit of initial luminance. The lifetime of CGH is 205hr is much longer than that of CBP.

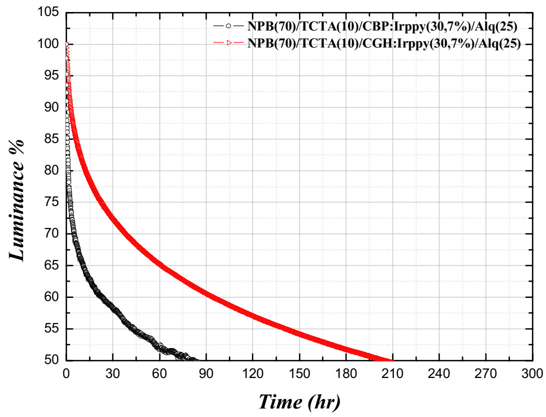

Figure 5. Life time of CBP and CGH at 3000nit

CGH shows high device performance with hole blocking layer. It also shows better device performance and life time than those of CBP without holeblocking layer. The lifetime of the CGH(205hr at 3000nit) is significant result compare to the life time of CBP showing 82hr without holeblocking layer.

3. Summary

We developed high luminance efficiency of green phosphorescent OLEDs using our novel bipolar material as a phosphorescent host. CGH shows some electron carrier properties so that it gives a possibility of removing HBL. Also the current efficiency and the power efficiency of green phosphorescents were increased by our novel host material. we eliminated HBL from the conventional green phosphorescent OLED, however, still obtained OLED with longer lifetime and excellent luminance efficiency.

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