FABRICATION OF WHITE ORGANIC LIGHT-EMITTING DEVICES WITH MULTI-EMISSIVE-LAYER STRUCTURE

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White organic light emitting devices were fabricated using phosphorescent materials. The device structure was ITO/ NPB (20 nm/ DPVBi(x nm)/CDBP:5% Ir(btp)2acac(35 nm)/Alq3(y nm)/BCP(5 nm)/CsF(1 nm)/Al (150 nm), where NPB is a N,N'-bis-(1-naphthyl)-N,N'–biphenyl-1,1'-biphenyl-4,4'-diamine as a hole transporting layer, DPVBi is 4,4 '-bis(2,2 -diphenylvinyl)-1,1 '-biphenyl as blue fluorescent dye, CDBP is 4,4'-bis(9-carbazolyl)-2,2'-dimethylbiphenyl, Ir(btp)2acac is a bis[2-(4-tert-butylphenyl)benzothiazolato-N,C2_]iridium (acetylacetonate) [(*t*-bt)2Ir(acac)], BCP is 2,9-dimethyl-4,7-diphenyl-1,10-phenanthroline as electron-transporting and hole-blocking layer, Alq3 is tris(8-hydroxyquinoline) aluminum as an green emitting layer. CsF layer inserted is used as a buffer layer to increase the electron injection efficiency. The thickness of DPVBi and Alq3 were 20nm and 25 nm and maximum luminance about 2453 cd/m^2 .

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1. Introduction

Organic light emitting diodes(OLEDs) have attracted more and more attention for their various potential applications such as full color display, backlight for liquid crystal display(LCD) or next generation light sources, since Tang and Van Slyke demonstrated brighnt green OLEDs with a sandwiched structure[1-6].

In order to generate the desired white light, WOLEDs with various configurations have been proposed, such as (a) a multilayer device with blue, green, and red emission layers, (b) a doped device with a host material and blue, green, and red fluorescence dyes, (c) a single emission layer device with white emission materials, (d) excimer and exciplex emission, and (f) tandem structure (7-12). Among these approaches, WOLEDs employing multi-emissive layer structure has advantages over other architectures in terms of efficiency and color controllability because the recombination current, singlet and triplet energy transfer and performance of each layer can be controlled by layer thickness, doping concentration and charge blocking layers.[13-21] In this study, we demonstrate a efficient white organic light emitting devices fabricated by the phosphorescent organic material Ir(btp)2acac doped in host material CDBP as a red emitting layer, green-emitting (Alq3) and blue-emitting 4,4'-bis(2,2'-diphenylvinyl)-1,1'-biphenyl(DPVBi) layers were fabricated. Luminance-voltage and luminance-current density, and EL spectra characteristics of the devices with different thickness have been investigated.

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2. Experimental

The chemical structures of organic materials (NPB, DPVBi, CDBP, Ir(btp)2acac, Alq3, BCP) used in this work and the structures of the device are show in figure 1.The configuration of the devices is ITO/ N,N'-bis-(1-naphthyl)-N,N'–biphenyl-1,1'-biphenyl-4,4'-diamine (NPB) (20 nm/ DPVBi(x nm)/CDBP:5% Ir(btp)2acac(35 nm)/Alq3(y nm)/BCP(5 nm)/CsF(1 nm)/Al (150 nm), DPVBi as blue emitting layer, CDBP:Ir(btp)2acac as red emitting layer, Alq3 as green emitting layer, NPB acted as hole transporting layer(HTL), BCP as electron transporting layer, hole blocking layer(ETL/HBL) . All devices were grown onto a pre-cleaned ITO coated glass substrate with resistance of 20 Ohm/sq. The ITO coated substrates were routinely cleaned with detergent, distilled water, acetone, and 2-propanol and subsequently in ultrasonic bath. The substrates were dried in an oven at 100 ^{o}C, before treatment with UV-Ozone. After treatment UV-Ozone for 25 minutes, all organic layers were deposited in succession without breakingvaccum (10^{-6} Pa). Thermal deposition rates for organic materials, CsF and Al were 2 A^{o}/S, 1 A^{o}/S and 10 A^{o}/S respectively. EL spectra and CIE coordination of the devices were measured by PR650 spectra scan spectrometer and the current-voltage-brightness characteristics were simultaneously measured by a Keithley 2400 programmable voltage-current source. All the measurements were carried out at room temperature under ambient conditions.

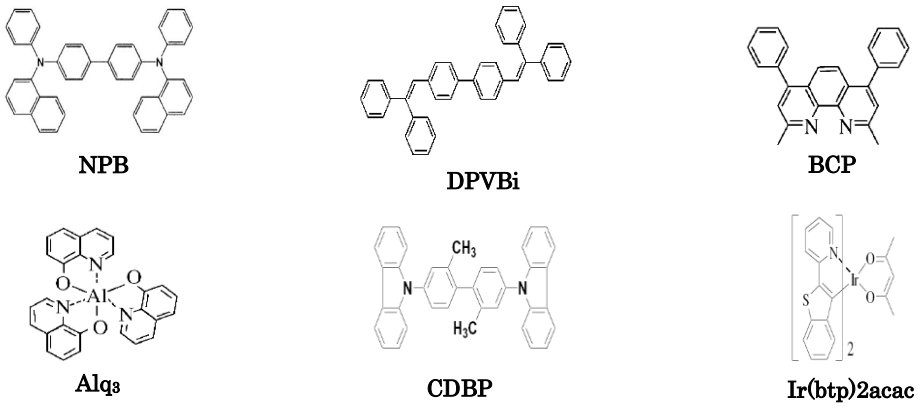

Fig. 1. Chemical structure of the NPB, DPVBi, BCP, Alq3, CDBP and Ir(btp)2acac materials

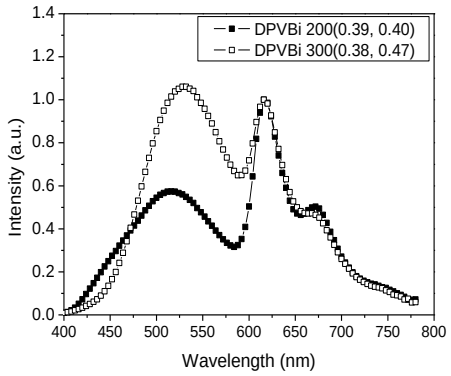

Fig.2 Normalized EL spectrum of the device
ITO/(NPB) (20 nm/ DPVBi(x nm)/CDBP:5% Ir(btp)2acac(35 nm)/Alq3(nm)/BCP(5 nm)/CsF(1 nm)/Al (150 nm)

3. Results and Discussion

Fig.2 shows the EL spectra with two different thickness of DPVBi. The dependence of thickness was observed with the blue color increasing related to the red light at increasing the

thickness of DPVBi. The EL spectra peaks at 508 nm, due to DPVBi, peak at 618 nm, due to CDBP-Ir(btp)2acac. In the structure of ITO/(NPB) (20 nm/ DPVBi(xnm)/CDBP:5%Ir(btp)2acac(35nm)/Alq3(nm)/BCP(5 nm)/CsF(1 nm)/Al (150 nm), x= 20 nm and 30 nm, the CIE coordinates (0.39, 0.40) and (0.38, 0.47) were observed respectively.

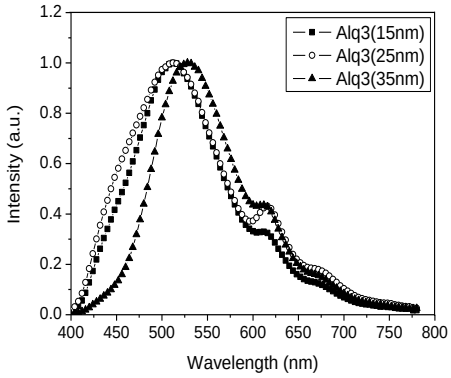

Fig.3 Normalized EL spectrum of the device of ITO/(NPB) (20 nm/ DPVBi(20 nm)/CDBP:5% Ir(btp)2acac(35 nm)/Alq3(y nm)/BCP(5 nm)/CsF(1 nm)/Al (150 nm)

Fig.3 shows the EL spectra with different thickness of Alq3. The device structure ITO/(NPB) (20 nm/ DPVBi(20 nm)/CDBP:5% Ir(btp)2acac(35 nm)/Alq3(y nm)/BCP(5 nm)/CsF(1 nm)/Al (150 nm), we can observed that the red shifted with increasing Alq3, the CIE coordinates was observed (0.30, 0.36), its closet to the absolute white (0.33, 0.33) with the thickness of 25nm. Luminance-voltage characteristics are shown in Fig.4. The maximum luminance was 2453 cd/m2 at 14V and 1662 cd/m2 at 13V respectively. When the CIE coordinates (0.30, 0.36) was close to the absolute white at 12V, its luminance was 2453 cd/m2. We also observed that different thickness of Alq3 layer makes different efficiency and the optimum thickness is 25 nm.

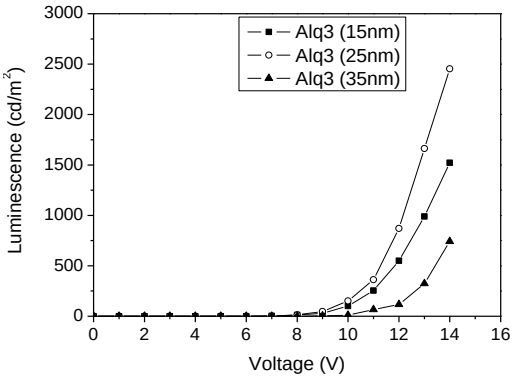

Fig.4. Luminance versus Voltage (L-V) characteristics of device of ITO/(NPB) (20 nm/ DPVBi(20 nm)/CDBP:5% Ir(btp)2acac(35 nm)/Alq3(y nm)/BCP(5 nm)/CsF(1 nm)/Al (150 nm)

4. Conclusions

In summary, we have demonstrated bright white organic light emitting devices with maximum luminance about 2453cd/m2. A blue emitter, DPVBi was used to provide strong blue emission, red emitting Ir(btp)2acac doped CDBP and green emitting Alq3 to emit white light. The thickness of DPVBi and Alq3 were 20nm and 25 nm. The optimum device structure was ITO/NPB(20 nm)//DPVBi(20nm)/CDBP:5%Ir(btp)2acac(10nm)/Alq3(25nm)/BCP(5nm)/CsF(1nm)/Al(150 nm).

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