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Enhancement of luminance yield of blue light organic light emitting diode

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Abstract—In this study N,N'-diphenyl-N,N'-bis(1-naphthyl) -(1,1'-biphenyl)-4, 4'-diamine (NPB), polytetrafluoroethylene (Teflon) and 4,4'- bis(9-ethyl-3-carbazovinylene)-1,1'-biphenyl (ADS080) were used to improve the light emitting efficiency. The thickness of NPB, Teflon and ADS080 were varied to obtain higher luminance yield. The dopant concentration was also studied. The results show that all of them effectively influence the luminance efficiency of blue organic light emitting diodes. A double doped structure with optimum separation between two doped layers shows apparent improvement on the luminance yield.

1. Introduction

C. W. Tang et al. proposed the effect of doping on organic light emitting diode (OLED) in 1989 [1] [2]. For the blue OLED, Xue-Yin et. al used perylene to be doped in DPVBi and JBEM [3]. Aminul Islam et al. used DAD and TDAD as dopants in CBP and TPBI [4]. Yong Qiu et al. studied the effects of hole injection layer and found that the hole injection layer can decrease the turn-on voltage [5] [6]. In the paper, NPB, Teflon and ADS080 were used to improve the luminance efficiency of blue OLED with optimum parameters.

2. Experiments

ITO glass with sheet resistance of 10 Ω/sq was used as substrate, and luminance area was set at 1 cm^2 with lithography. ITO substrate was first cleaned with acetone, methanol and pure water, and then cleaned with Arogn plasma before being placed into a vacuum evaporation chamber. When chamber pressures reached 2.5×10^{-6} torr, the deposition of organic material began, we evaporated Teflon, NPB or TPD, 4,4'-bis(diphenylvinylenyl)-biphenyl (ADS082), ADS080 and tris(8-hydroxy-quinoline) aluminum (AlQ_3) respectively, next the device was moved to another vacuum chamber for deposition of LiF and Al.

This study used Teflon as hole injection layer, NPB or TPD as hole transport layer, AlQ_3 as electron transport layer, ADS082 as a blue host emitting layer, ADS080 as a blue dopant, LiF as buffer layer and Al as metal cathode. This study also employed SpectraScan PR650 for automatic measurement of luminance as well as electroluminescence, and Keithley 2400 for automatic measurement of voltage-current curves.

3. Results and Discussion

In this study the effects of three materials, NPB, Teflon and ADS080, with different experimental parameters on the luminance efficiency were studied. At first, we introduce the effects of hole transport layer. At this time, the host blue emission material, ADS082, was used without any dopant. The device structure is shown in Fig. 1 where V=X=Y=Z=0 nm. For TPD and NPB having the same thickness of 45 nm, it can be seen from Fig. 2 that the device using NPB as hole transport layer has better luminous efficiency than TPD. If NPB thickness was 90 nm, the luminance intensity can increase to as high as 1600 cd/m^2 as shown in the insert of Fig. 2.

The effects of Teflon layer are shown in Fig. 3, using NPB=45 nm in undoped devices. It can be seen that the Teflon layer (V=1 nm) can avoid the luminance yield decay and maintain it as high as 2.2 cd/A even at high injection current of 80 mA/cm^2. Because Teflon material is an insulator, too thick layer (V=2 nm) will decrease the luminance yield, as shown in Fig. 3.

Next we will discuss the effects of thickness and concentration of dopant material, ADS080. The doped devices shown in Fig. 4 for comparison used single-doped structure whose doped layer was located at the NPB/ADS082 interface. For the group devices no matter NPB=90nm or NPB=45nm, the doped devices almost have higher luminance yield than the undoped ones. Form the comparison of doped concentration in NPB=90nm group devices, 2.91% has higher luminance yield than that of 14.3%. (the same doped thickness of X=1nm). From the comparison of doped thickness in NPB=45nm group devices, doped thickness X=0.3nm has better luminance yield than X=0.5nm (with the same doped concentration of 2.91%).

Finally, multi-doped layer structures are discussed. It is found that the double-doped structure can balance the electron and hole injection number and increase the luminance efficiency. The double doped structure is shown in Fig. 1 with X=Z=0.3nm and Y=2nm. The double doped structure has better efficiency than single doped, as shown in Fig. 5.

4. Conclusion

In this study the NPB thickness (90nm), Teflon thickness (1nm), and ADS080 doping concentration (2.91%) and thickness (0.3nm) are optimum device parameters for blue OLED. The luminance yield as high as 4 cd/A can be achieved. It is found that the double-doped structure with

2nm separation between two doped-layers can improve the luminance efficiency apparently.

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Al	**(100 nm)**
LiF	**(0.3 nm)**
AlQ_3	**(15nm)**
ADS082	**(35-X-Y-Znm)**
ADS080:ADS082	**(Znm)**
ADS082	**(Ynm)**
ADS080:ADS082	**(Xnm)**
NPB or TPD	**(Wnm)**
Teflon	**(Vnm)**
ITO	
Glass	

Fig. 1 Diagram of double-doped structure with thickness noted.

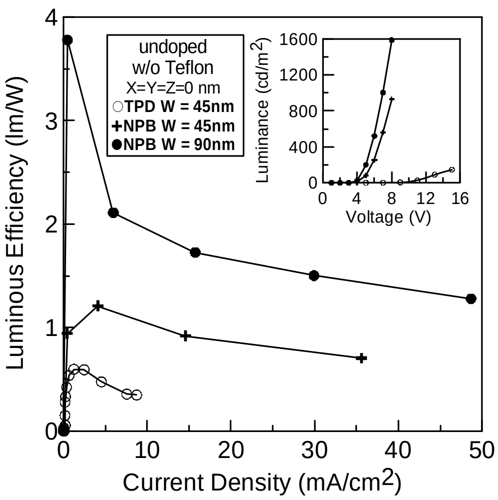

Fig. 2 Luminous efficiency versus current density for undoped devices.

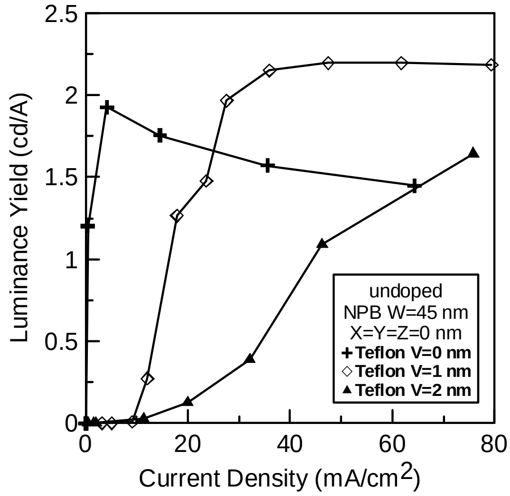

Fig. 3 Luminance yield versus current density for devices with Teflon layer.

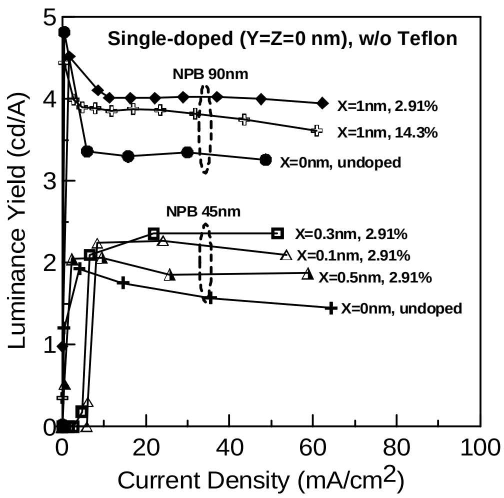

Fig. 4 Luminance yield versus current density for devices with NPB=45 and 90 nm, respectively.

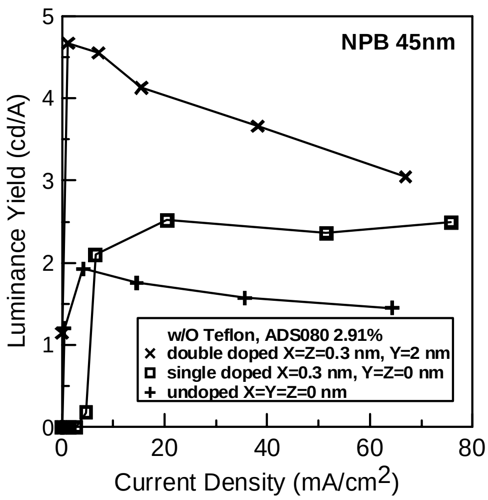

Fig. 5 Luminance yield versus current density for single and double doped structures, respectively.