



Efficient fluorescent white organic light-emitting devices based on a ultrathin 5,6,11,12-tetraphenylanthracene layer

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ABSTRACT

White organic light-emitting devices (OLEDs) were fabricated using a ultrathin layer 5,6,11,12-tetraphenylanthracene as the yellow light-emitting layer and *p*-bis(*p*-*N,N*-diphenyl-aminostyryl)benzene (DSA-ph) doped in 2-methyl-9,10-di(2-naphthyl)anthracene (MADN) matrix as the blue light-emitting layer. The thickness of rubrene ultrathin layer will seriously affect the device performance, and the device with 1 nm rubrene achieves the best performance, with the maximum luminance of 33,152 cd/m² at 11 V and the maximum current efficiency of 8.69 cd/A at 7 V.

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1. Introduction

The development of white organic light-emitting devices (WOLEDs) generated lots of interests in this area, as these devices can be employed not only as illumination light source but also as back-light source candidate for next generation flat-panel displays. To achieve white emission from OLEDs, various methods have been attempted such as excimer/exciplex emission, mixing of three colors (red, blue and green) or two (complementary) colors in single host matrix or in physically separate layers [1–3]. For the application in solid-state lighting sources, high efficiency and long operation lifetime are essential. Phosphorescent WOLEDs generally are more efficient due to its demonstrated potential for achieving 100% internal emission efficiency by utilizing both the singlet and triplet excitons [4–10]. However, in comparison with fluorescent WOLEDs, phosphorescent WOLEDs typically have shorter operational lifetime [10]. Furthermore, the color stability of all-phosphor-doped WOLEDs is generally limited, as the blue electrophosphorescent devices have especially short operational lifetime. Therefore, the development of all-fluorescent WOLEDs with high efficiency and long lifetime is indispensable.

As one of the most efficient blue dopants, *p*-bis(*p*-*N,N*-diphenyl-aminostyryl) benzene (DSA-ph) has been used to fabricate efficient blue and white devices [11–13]. In this study, WOLEDs based on

DSA-ph doped in host material 2-methyl-9,10-di(2-naphthyl)anthracene (MADN) as a blue-emitting layer and a ultrathin 5,6,11,12-tetraphenylanthracene (rubrene) layer as a yellow-emitting layer were fabricated. We have investigated the influence of rubrene layer thickness on the device performance, and the reasons for the Commission International de L'Eclairage (CIE) coordinate change.

2. Experiments

The molecular structure of organic materials used in this work and the structure of devices are depicted in Fig. 1. We used 4,4',4''-tris(3-methylphenylphenylamino)-tri-phenylamine (m-MTDATA) and *N,N*'-bis-(1-naphthyl)-*N,N*'-diphenyl-1,1'-biphenyl-4,4'-diamine (NPB) as hole-transporting layers, ultrathin rubrene for the yellow-emitting layer, 5 wt.% DSA-ph doped MADN for the blue-emitting layer and 4,7-diphenyl-1,10-phenanthroline (Bphen) for the electron-transport layer. A bilayer cathode of LiF/Al was subsequently vapor-deposited onto the organic films. The devices were prepared by vacuum deposition onto indium tin oxide coated glass substrates. Prior to the deposition of organic layers, ITO-coated glass was cleaned by scrubbing and sonication. The organic layers were deposited by high-vacuum (10⁻⁶ Torr) thermal evaporation with a rate of 0.1–0.2 nm/s. The layer thickness and the deposition rate of the organic and inorganic materials were monitored *in situ* by an oscillating quartz thickness monitor. Electroluminescent (EL) spectra and Commission International de L'Eclairage (CIE)

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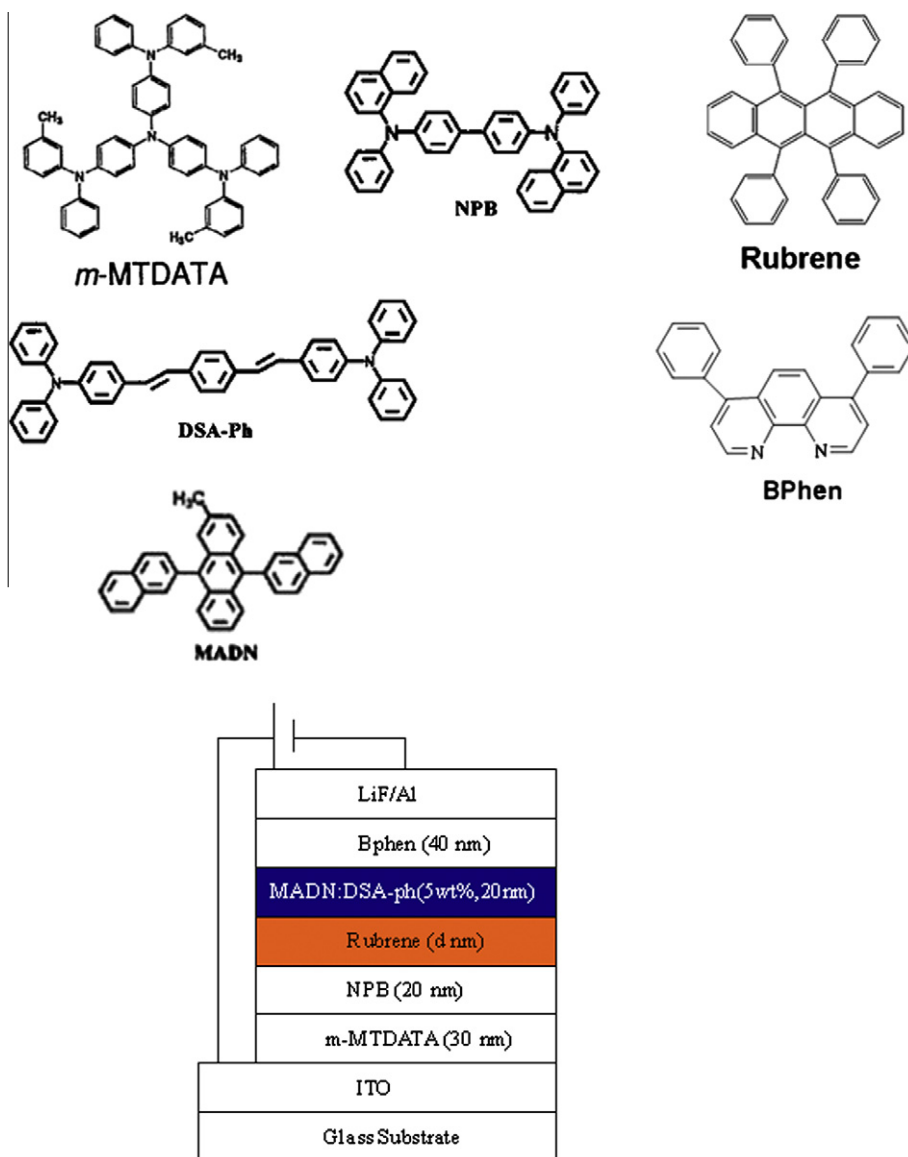


Fig. 1. The molecular structure of the materials used in this work and the device structure.

coordinates of the devices were measured by a PR650 spectra scan spectrometer and the current–voltage–brightness characteristics were measured simultaneously with a programmable Keithley 2400 voltage–current source. All measurements were carried out at room temperature under ambient conditions.

3. Results and discussion

Fig. 2 shows the EL spectrum for device *m*-MTDATA/NPB/rubrene (1 nm)/MADN:DSA-ph/Bphen/LiF/Al at 9 V. The device exhibits its two-peak EL spectrum: 465 and 560 nm peaks from DSA-ph and rubrene, respectively.

Table 1 lists the performance of the devices with different thicknesses of rubrene. The device with 1 nm rubrene can achieve higher EL efficiency than those with 2 and 3 nm rubrene. This may be ascribed to that concentration-quenching became serious with 2 and 3 nm rubrene.

Fig. 3 displays the voltage dependence of (a), the current density (J) and the brightness (L) and (b) the EL and power efficiency of the device with 1 nm rubrene. The turn-on voltage of this device is ~ 3 V. Bright white light, over 10,000 cd/m^2 , was successfully obtained at ~ 8 V. The maximum luminance reached 33,152 cd/m^2 at 11 V.

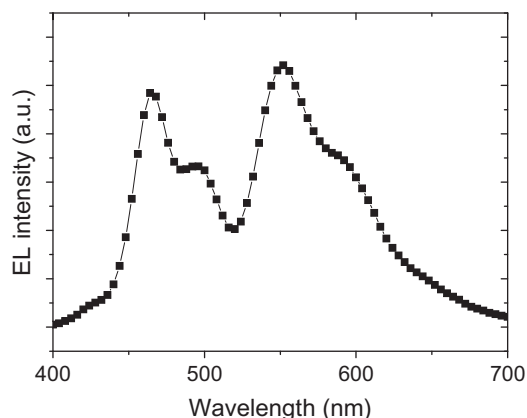


Fig. 2. EL spectrum for the device at 9 V.

The maximum EL efficiency and power efficiency are 8.69 cd/A at 7 V and 5.5 lm/W at 4 V.

The CIE coordinates change of the device with 1 nm rubrene from 3 V to 10 V is shown in Fig. 4a. The inset is the magnified

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