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Color Stability Enhancement of White Organic Light-Emitting Diodes Using a Charge Control Layer

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Abstract

Blue phosphorescent iridium complexes iridium (III) bis [(4,6-di-fluorophenyl)-pyridinato-N,C2'] (FIrpic) and yellow phosphorescent iridium complexes Iridium(III) bis (4-phenylthieno [3,2-c] pyridinato-N,C2′) acetylacetonate (PO-01) was doped into the small molecular phosphorescent host N, N_-dicarbazolyl-3, 5-benzene (mCP) to fabricate white phosphorescent organic light-emitting diodes (white PHOLEDs). Device current efficiency is enhanced by inserting a charge control layer (CCL) into the emitting layer.

The peaks of PHOLED electroluminescent (EL) spectrum locate at 472 nm (FIrpic) and 560 nm (PO-01). A high current efficiency white PHOLED has been fabricated by the use of FIrpic and Po-01 as the double emitting layer (EML), in which the mCP is used as the CCL inserted. The doping concentration of PO-01 is optimized and the carrier transport mechanism of CCL is discussed. The optimized current efficiency is 30.06 cd/A. The CIE coordinates locate at (0.33, 0.41) and vary within (±0.01, ±0.01) under driving voltage of 5-15V.

Keywords: OLED, charge control layer (CCL)

1. Introduction

Organic light-emitting diodes (OLEDs) have attracted much interest over the past few years because of their properties of self-emission, fast response time, high luminance, low cost, and ease of fabrication, among other characteristics.[1,2] White organic light-emitting diodes (OLEDs) are one of the most promising technologies which will likely replace the existing liquid crystal display (LCD). In particular, white OLEDs (WOLEDs) have drawn particular attention because of their use in full-color displays combined with red-green-blue (RGB) color filters, liquid crystal display (LCD) backlights, and next-generation light sources.[3-9] White light emission can be obtained by mixing light of two complementary colors (such as red/bluish green, blue/orange, or green/magenta) or the three primary colors (red, green, and blue) from small molecules and/or polymers. To obtain high luminance of a typical layered OLED, the light-emitting layer is generally doped with various fluorescent or phosphorescent dyes.

In this paper, iridium (III) bis [(4, 6-di-fluorophenyl)-pyridinato-N, C2’] (FIrpic) and Iridium (III) bis (4-phenylthieno [3,2-c] pyridinato-N,C2′)acetylacetonate (PO-01) are used as blue and yellow dopants. Doping concentrations are optimized and the carrier transporting mechanism of CCL is discussed.

2. Experiment

The structures of WOLED devices used in this study were ITO/m-MTDATA/α-NPB/ mCP/mCP:FIrpic/mCP:PO-01/TPBi/LiF/Al. A thin charge control layer (CCL) layer of mCP is sandwiched between mCP:FIrpic and mCP:PO-01 EML to study the optoelectronic performance of WOLED devices. Devices were fabricated on glass substrates that had been precoated with a 150-nm-thick layer of indium-tin-oxide (ITO) with a sheet resistance of 10 Ω/square. Cleaned and UV-ozone-treated ITO substrates were loaded into an evaporation system at a base pressure of under 10^{-6} Torr. The WOLEDs were formed such that the intersections between the ITO anode and the cathode stripes each had an area of 0.24 cm^2.

The current density-voltage (*J*-*V*), luminance-current density-luminous efficiency (L-J-η_L) and power efficiency-current density-external quantum efficiency (η_p-J-η_{ext}) characteristics were measured using a PR650 spectroscan spectrometer and a Keithley 2400 pro-

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grammable voltage-current source. The EL spectra and the Commission Internationale d'Eclairage (CIE) coordinates of these devices were also obtained using a PR650 spectroscan spectrometer.

3. Results and Discussion

An OLED device without a CCL has the structure of ITO/m-MTDATA/α-NPB/mCP/ mCP:FIrpic/mCP:PO-01/TPBi/LiF/Al. The optimized current efficiency (CE) is 20.1 cd/A and luminance (L) is 16200 cd/m^2. A thin CCL layer of mCP sandwiched between mCP:FIrpic and mCP:PO-01 EML increase the CE to 24.1 cd/A. The thickness of each emitting layer is modified to observe the luminous characteristics. The optimized current efficiency of 30.06 cd/A and luminance of 17000 cd/m^2 have been achieved. Its CIE coordinates locate at (0.33, 0.41) and vary within (±0.01, ±0.01) under driving voltage of 5-15V. Fig. 1 shows the triplet exciton transfer mechanism in white PHOLED.

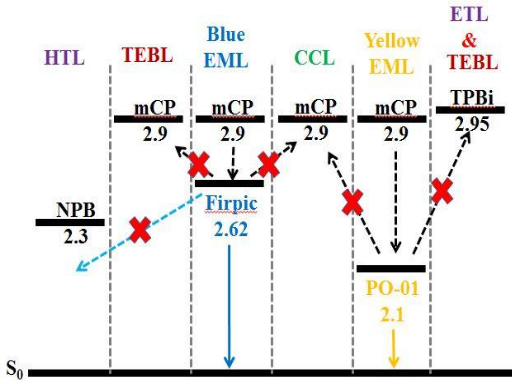

Fig. 1 The triplet states of TEBL, CCL and EMLs. The triplet exciton transfer mechanism in white PHOLED

4. Conclusions

In this paper, the fabrication of high color stability WOLEDs with mCP as a CCL layer is demonstrated. The CIE coordinates locate at (0.33, 0.41) and vary within (±0.01, ±0.01) under driving voltage of 5-15V. The optimized current efficiency reaches 30.06 cd/A. Experimental results reveal that we have successfully fabricated high efficiency and color stability WOLED by optimizing the doping concentration of PO-01 and the thickness of CCL.

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