

High efficiency fluorescent organic light-emitting devices utilizing a phosphorescent sensitizer

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1. Introduction

Organic light-emitting devices (OLEDs) based on small organic molecules have been attracting much attention ever since C. W. Tang firstly demonstrated a high efficient OLEDs [1]. Much effort has been focused on the improvement of the emission efficiency by developing either high efficiency materials or efficient device structure [2-6]. However, the efficiency for OLEDs have been limited by the use of fluorescent emission materials, since fluorescence only involves singlet relaxation, thus eliminating the participation of the triplet exciton population. Given a statistical limit of 1:3 for the singlet to triple exciton ratio in molecular organic fluorescent materials [7], the maximum internal quantum efficiency for fluorescent OLEDs is limited to 25% of the efficiency from the thin film. An effective method to solve this problem is to employ a phosphorescent-sensitizer [8, 9] to transfer all the excitons, both singlets and triplets, from the host to singlets and triplets on the phosphorescent intermediary. The singlets on the intermediary intersystem cross to triplets. The triplets on the intermediary are efficiently transferred to singlets in the fluorescent dye. Therefore phosphor sensitization can lead the efficiency of the fluorescent OLEDs similar to those of electrophosphorescent devices.

In this letter, we report high-efficiency OLEDs using a phosphorescent sensitizer approach. The host material is 1,3,5-tris(N-phenylbenzimidazol-2-yl)benzene (TPBi) and the dopants are the phosphor sensitizer fac tris(2-phenylpyridine) iridium (Ir(ppy)_3) and the red fluorescent dye 4-(dicyanomethylene)-2-t-butyl-6-(1,1,7,7-tetramethyljulolidyl-9-enyl)-4H-pyran (DCJTB). We obtain highly efficient yellow to red light emission at different concentration of DCJTB.

2. Experiments

Organic layer were deposited by high-vacuum (10^{-6} Torr) thermal evaporation onto a precleaned glass substrate precoated with an indium-tin-oxide (ITO) anode. A 50-nm-thick film of N,N'-diphenyl-N,N'-bis(1-naphthyl)-(1,1'-biphenyl)-4,4'-diamine (NPB) served as the hole-transport layer (HTL). Next, a 20-nm-thick light-emitting layer (EML) consisting of the TPBi host was deposited while being simultaneously

doped with 10 wt % Ir(ppy)_3 and 0.5-2 wt % DCJTB via thermal co-deposition from three independent source boats. A 10-nm-thick layer of bathocuproine (BCP) was used to confine excitons in the EML. A 30-nm-thick layer of tris-(8-hydroxyquinoline)aluminum (Alq) was used to transport and inject electrons into the EML. Finally, a double layer of LiF/Al was thermally evaporated to finish device construction.

3. Results and discussion

Fig.1 shows the optical absorption and PL spectra of the materials used in this work. Good spectra overlap between TPBi and Ir(ppy)_3 , and Ir(ppy)_3 and DCJTB are observed. Therefore, we can expect the energy transfer from TPBi to Ir(ppy)_3 and then from Ir(ppy)_3 to DCJTB.

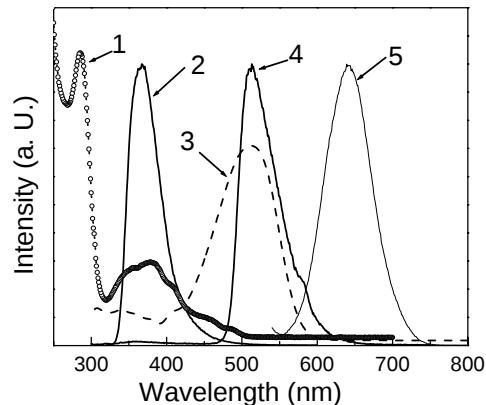


Fig.1 Absorption of Ir(ppy)_3 (1); PL of TPBi (2); Absorption of DCJTB (3); PL of Ir(ppy)_3 (4); PL of DCJTB (5) in solution

Figure. 2 shows the electroluminescence (EL) of the devices with 10 wt % Ir(ppy)_3 and different DCJTB concentration (0.5 wt %- 3 wt %). EL is only observed from Ir(ppy)_3 and DCJTB in all double-doped devices, indicating efficient transfer of excitons from the TPBi host to the dopants, in addition to direct formation of excitons on Ir(ppy)_3 . For the devices with the emitting layer doped with 10% Ir(ppy)_3 , when the concentration of DCJTB is 0.5%, there is an emission peak of Ir(ppy)_3 in addition to the red peak of DCJTB, and results in yellow emission. The

emission intensity of Ir(ppy)_3 is decreased with an increasing concentration of DCJTB, and in addition, a red spectra shift of the DCJTB peak is observed with increasing DCJTB concentration. When the concentration of DCJTB increases to 2%, the emission peak of Ir(ppy)_3 disappears, results in red emission.

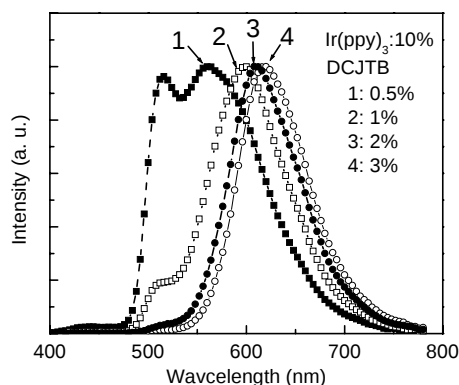


Fig.2 EL spectra of the devices with 10% Ir(ppy)_3 and different concentration of DCJTB

Fig. 3 and Fig. 4 shows the EL efficiency and luminance-voltage characteristics of the devices with 10 wt % Ir(ppy)_3 and different DCJTB concentration (0.5 wt %- 3 wt %). The devices at the concentration of 10:0.5 with yellow emission have the maximum brightness and luminance efficiency of 24000cd/m^2 (at 18V) and 10.6cd/A (at 5V). As can be seen, the efficiency of the double-doped devices decreases with the increasing concentration of DCJTB, which is due to a substantial increase in aggregate-induced quenching. The devices at the concentration of 10:2 with red emission have the maximum brightness and luminance efficiency of 10000cd/m^2 (at 19V) and 3.5cd/A (at 5V).

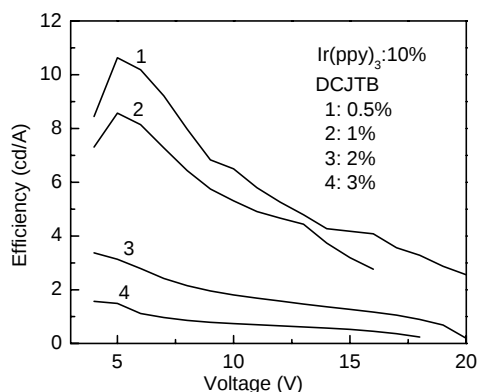


Fig. 3 EL efficiency (cd/A) of the devices with 10% Ir(ppy)_3 and different concentration of DCJTB

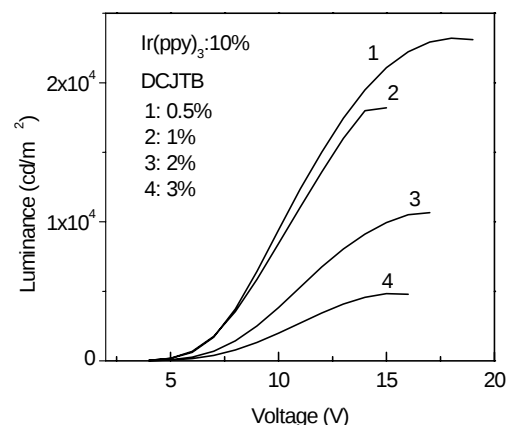


Fig.4 luminance-voltage characteristics of double-doped devices

Acknowledgements

This work is supported by National Natural Science Foundation of China under Grant Nos. 60077014 and 50073008.

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