Improvement of electroluminescent efficiency by using interfacial exciton blocking layer in blue emitting electrophosphorescent organic light emitting diodes

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Abstract

We report improved efficiency in blue electrophosphorescent organic light emitting diodes by introducing an interfacial exciton blocking layer between light emitting layer (EML) and hole transport layer (HTL). Iridium(III) bis [(4,6-di-fluorophenyl)-pyridinato-N,C2']picolinate (FIrpic) was used as blue phosphorescent dopant and JHK6-3 with carbazole and electron transporting group as host and also as the interfacial layer, resulting in drastic increase in quantum efficiency.

1. Introduction

Phosphorescent organic light emitting diodes (OLEDs) have been spotlighted for the possibility of achieving nearly 100% internal efficiency and it was proved in green emitting devices [1]. The quantum efficiency of blue phosphorescent OLED, however, is lower than green. One of the reason is the not-adequate confinement of triplet exciton in the emitting dye due to the lower triplet energy of host and hole transporting layer (HTL) than the phosphorescent dye.

In this presentation, we report on the improved quantum efficiency of blue electrophosphorescent OLED by inserting an interfacial exciton blocking layer, where iridium(III)bis[(4,6-di-fluorophen-yl)-pyridinato-N,$C^{2'}$]picolinate (FIrpic) was as the blue phosphorescent electro-luminescent dye. A newly synthesized bipolar material, JHK6-3, was used as the interfacial layer and also as the host for the dye.

2. Experiment

The phosphorescence spectra of JHK6-3, α-NPD and FIrpic were recorded with a JASCO FP6500 spectrofluorometer at 77K using dilute solutions (~ 10^{-5} M) in methyl-tetrahydrofuran. The gate delay was 20 ms. The OLEDs were fabricated as follows. The α-NPD, JHK doped with 6% FIrpic, and BAlq layer were successively deposited on a precleaned ITO coated glass substrates under high vacuum condition (~1×10^{-6} Torr) as the HTL, light emitting layer (EML), and hole blocking and electron transporting layer with the thickness of 40, 20 and 40 nm, respectively. 1-nm-thick LiF and 100 nm aluminum were evaporated through a shadow mask to form 1-mm-square cathode. For comparison, devices with the interfacial exciton blocking layer (IEBL) inserted between HTL and EML were also fabricated. 10 nm thick JHK6-3 without doping was used as the interfacial layer. Current density - voltage characteristics were measured with a source meter

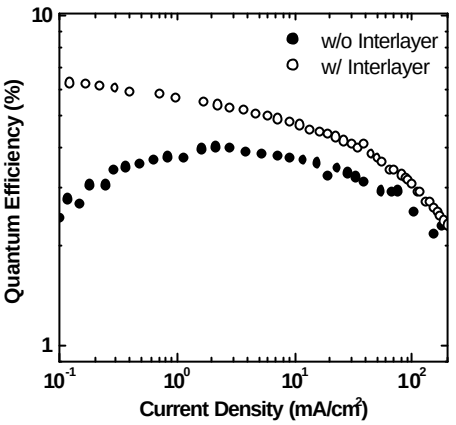

Figure 0 External quantum efficiency vs current density for OLED devices. Device structure I : ITO/a-NPD(40nm)/ 8%-FIrpic:JHK6-3(20nm)/BAlq(40nm)/ LiF(1nm)/Al(100nm). Device Structure II: ITO/a-NPD(40nm)/JHK6-3(10nm)/ 8%-FIrpic:JHK6-3(20nm)/BAlq(40nm)/ LiF(1nm)/Al(100nm)

(Keithley 2400) and luminance(L) with an optical power meter (Newport, Model 1835-C).

3. Results

Figure 1 shows the phosphorescence spectra of α-NPD, JHK6-3, and FIrpic. The triplet energy levels of JHK6-3, α-NPD and FIrpic, taken at the highest energy peak in the phosphorescence spectra are 3.01, 2.41 and 2.65eV, respectively. The higher energy level of JHK6-3 than FIrpic implies that triplet energy

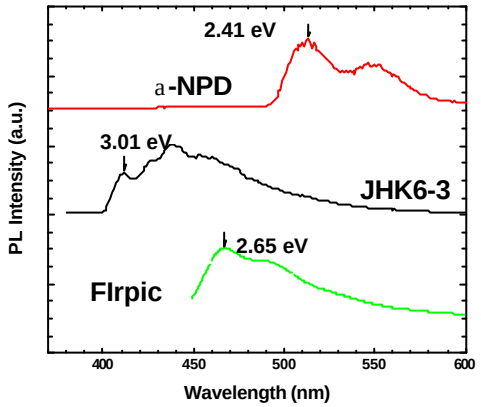

Figure 0. Phosphorescence spectra of a-NPD, JHK6-3, and FIrpic in solution (10^{-5} M methyl-tetrahydrofuran) at 77K.

transfer from JHK6-3 to FIrpic is energetically favorable. In contrast the energy level of α-NPD is lower than FIrpic so that the excitons near the HTL are expected to diffuse and transfer energy to α-NPD inducing nonradiative decay and lower efficiency.[2]

External quantum efficiencies of the OLEDs with and without the interlayer are displayed in Figure 2. The device with the interlayer shows maximum quantum efficiency of 6.5% with monotonic decrease in efficiency with increasing current. In contrast, the efficiency increases first to reach the peak efficiency of 4% with decrease in efficiency with further increase of current. The device with the interlayer shows higher quantum efficiency than the device without the interlayer. The difference is especially large at lower current density. The higher quantum efficiency and different efficiency - current characteristics can be interpreted based on the exciton blocking effect of the interlayer, triplet exciton quenching by α-NPD, and charge balance and exciton formation zone in the devices.

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4. Acknowledgements

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5. References

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