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Effect of $SnDP(HPB)_2$ as a Hole Blocking Layer in OLED

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1. Introduction

Organic light-emitting diodes (OLED) based on organic thin layers are of interest because their possible application as flat panel displays which are operative at low drive voltage. Generation of light in these systems is the results of recombination of hole and electrons which injected from the electrodes. Such recombination in the emitting layer, then, excites the emitter material [1].

A number of organic materials have been synthesized and made to obtain high performance OLED [2]. The method to improve the properties of OLED by using a hole blocking material between the emitting layer and the cathode is being studied to allow more recombination in the emitting layer [3]. We synthesized $SnDP(HPB)_2$ which used as a hole blocking material. Because its electronic structure is suitable as a hole blocking layer due to its large highest occupied molecular orbital (HOMO = 6.7 eV) [4]. As a result, we obtained to enhance the performance of OLED.

2. Experimental

The structure of devices were ITO/NPB (40 nm)/Alq_3 (60 nm)/$SnDP(HPB)_2$/LiF (0.5 nm)/Al (100 nm). The thicknesses of $SnDP(HPB)_2$ were 2 nm, 3 nm, and 4 nm. The organic materials were successively evaporated on top of the ITO substrate under 5×10^{-6} torr with a deposition rate of about 1.0 Å/s. A metal cathode was deposited under 5×10^{-6} torr with a deposition rate of about 10 Å/s. Table 1 shows the structures of OLED.

Table 1. The structures of OLED

Device	Structure
Device 1	ITO/NPB/Alq_3/LiF/Al
Device 2	ITO/NPB/Alq_3/$SnDP(HPB)_2$(2 nm)/LiF/Al
Device 3	ITO/NPB/Alq_3/$SnDP(HPB)_2$(3 nm)/LiF/Al
Device 4	ITO/NPB/Alq_3/$SnDP(HPB)_2$(4 nm)/LiF/Al

Fig. 1 shows the molecular structure of $SnDP(HPB)_2$. We investigated the PL spectrum of $SnDP(HPB)_2$ as shown in Fig. 2. The PL peak of $SnDP(HPB)_2$ was observed at 447 nm. $SnDP(HPB)_2$ showed blue emission. We measured the ionization potential(IP) and electron affinity(EA) of $SnDP(HPB)_2$ using cyclic-voltammetry.

The IP and EA of $SnDP(HPB)_2$ were measured to be 6.7 eV, 3.0 eV, respectively[5-6]. The $SnDP(HPB)_2$ is used as a hole blocking layer between the emitting layer and the cathode. We measured current density-voltage-luminance characteristics at room temperature.

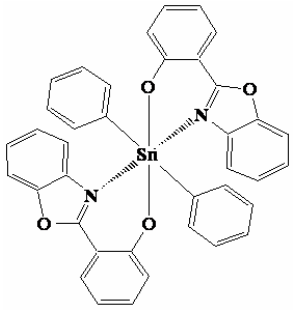


Fig. 1 Molecular structure of $SnDP(HPB)_2$.

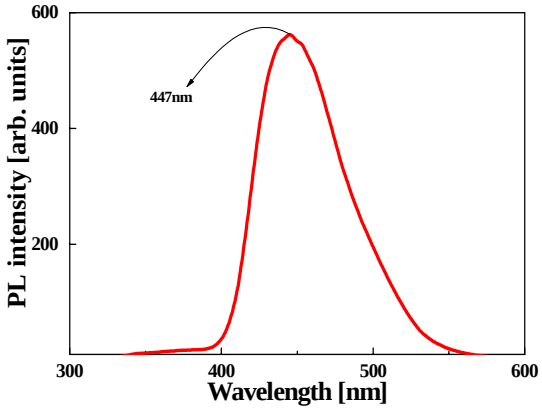
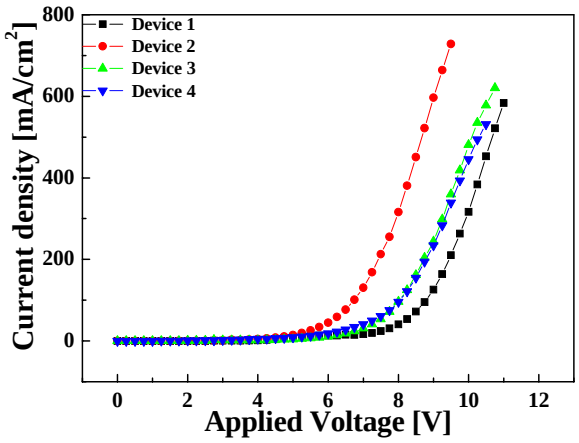


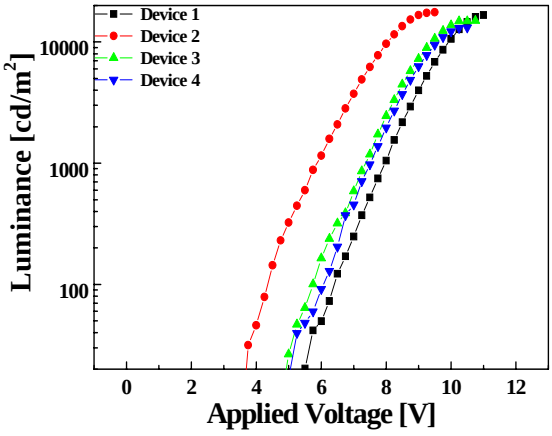
Fig. 2 PL spectrum of $SnDP(HPB)_2$.

3. Results and Discussion

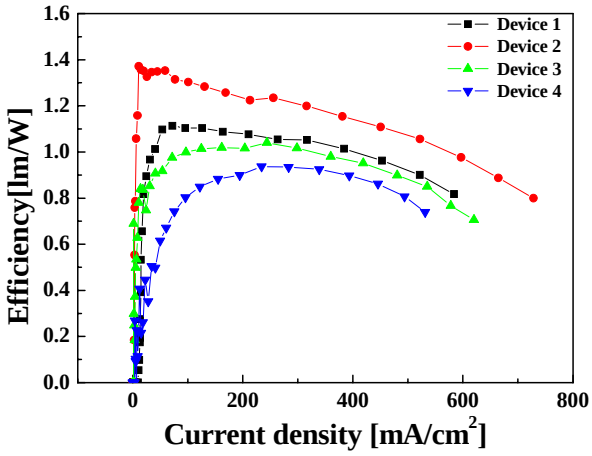
Fig. 3 (a) and (b) show the current density and luminance, respectively, with varying applied voltage; (c) shows the efficiency with varying current density. As shown in Fig. 3 (a) and (b), all the four devices are of similar good performances.



(a)



(b)



(c)

Fig. 3 (a) Current density-voltage, (b) Luminance-voltage, and (c) Efficiency-current density characteristics for devices.

Fig. 3 (b) and (c) have shown that, not only the luminance, but also the efficiency of the devices with suitable thicknesses of $SnDP(HPB)_2$ material is better than those without $SnDP(HPB)_2$. In comparison with the devices without $SnDP(HPB)_2$, the efficiency is obviously increased even its operating voltage decreased. This phenomenon can be explained is as follows: The HOMO of $SnDP(HPB)_2$ is 6.7 eV, which is far more than the HOMO of Alq_3(5.7 eV). Therefore, $SnDP(HPB)_2$ layer blocks the hole from transporting toward cathode, which decreased the leakage the carriers, resulting the improvement of the efficiency.

4. Conclusion

We have synthesized $SnDP(HPB)_2$ and used in OLED. In the cyclic voltammetry experiment, the HOMO and LUMO levels of $SnDP(HPB)_2$ have been measured to be 6.7 eV and 3.0 eV. The presented EL devices with hole blocking material of $SnDP(HPB)_2$ have demonstrated high luminance and efficiency. As the hole blocking layer, the optimal thickness of the $SnDP(HPB)_2$ layer is about 2 nm. This improvement of the OLED performance can be attributed to the hole blocking effect of the $SnDP(HPB)_2$ layer.

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