

Pyromellitic dianhydride as a cathode interfacial layer in the organic light emitting diodes: thickness optimization and its electroluminescent characteristics

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Abstract

In this work, pyromellitic dianhydride (PMDA) was used as a cathode interfacial layer in the organic light emitting diodes (OLEDs) and its thickness was optimized. Various electrical and optical characterizations of the OLEDs having various thicknesses of the PMDA cathode interfacial layer revealed that the best OLED performance could be achieved by using 0.5 nm-thick PMDA layer compared to the control device without any interfacial layer.

1. Introduction

The organic light emitting diode (OLED) is one of the most promising display devices in the future flat panel application.¹ Its major advantages can be emphasized to be low-power consumption, excellent emission quality with a wide-view angle, and color tuning capability. However, its electroluminescent efficiency still needs further improvement and balancing the numbers of electrons and holes injected into the organic light emitting layer is the most important parameter to be engineered. Up to now, the most significant improvement of the OLED performance was achieved by using an ultra-thin LiF as an interfacial layer between the cathode and the organic layer.²

In this presentation, as an alternative cathode interfacial layer, we used pyromellitic dianhydride (PMDA) film with various thicknesses (0.3 – 1.3 nm) between the tris-(8-hydroxyquinoline) aluminum (Alq₃) and Al cathode, and tried to find the most optimum thickness showing the best OLED performance.

2. Experimental

The OLED devices with various PMDA thicknesses as a cathode interfacial layer were fabricated on the ITO-coated glass. After cleaning the substrates, N,N'-diphenyl-N,N'-bis(3-methylphenyl)-1,1'-diphenyl-4,4'-diamine (TPD) and tris-(8-hydroxyquinoline) aluminum (Alq₃) were deposited as a hole transport layer (HTL) and an emitting material layer (EML), respectively. In order to find the optimum OLED configuration, the PMDA cathode interfacial layers having a thickness ranged from 0.3 to 1.3 nm were deposited and the Al was used as a cathode electrode. All the layers used in our OLED fabrication were deposited by using a thermal evaporation method.

Fig.1 shows the schematic cross-sectional device configuration and the molecular structure of PMDA.

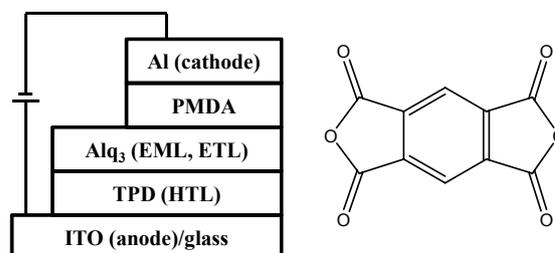
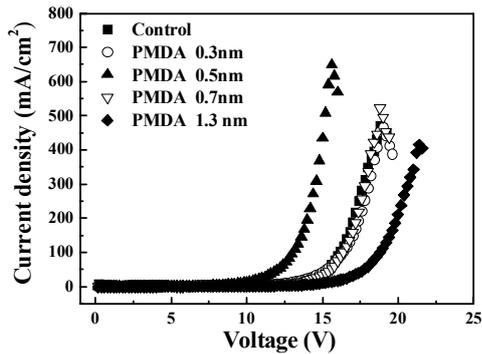


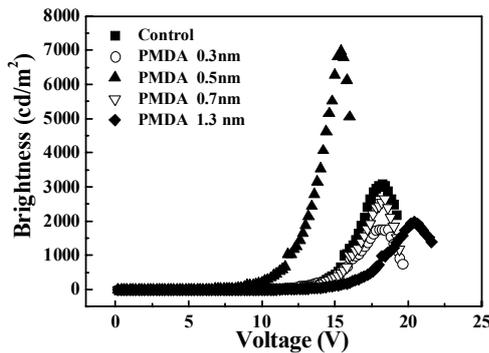
Figure 1. The OLED structure used in this experiment and the molecular structure of PMDA.

After the fabrication of the OLED devices with different thicknesses of the PMDA interfacial layer, various electroluminescent characteristics were measured to find the optimum process condition.

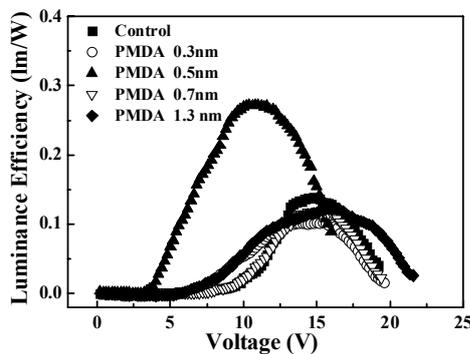
3. Results and discussion



(a) J-V



(b) B-V



(c) LE-V

Figure 2. (a) J-V, (b) B-V, and (c) LE-V characteristics of the fabricated OLED devices as a function of the PMDA thickness

Figs. 2(a), (b) and (c) show the current density, brightness, and luminance efficiency characteristics of the OLED devices having the PMDA cathode interfacial layer with various thicknesses. Compared to the control sample without any cathode interfacial layer, the OLED performance was systematically improved by increasing the thickness of the PMDA layer. The best performance was achieved by using a 0.5 nm-thick PMDA layer; the turn-on voltage was reduced by ~ 6 V and the maximum brightness was increased by $\sim 4,000$ cd/m^2 . Especially, the maximum luminance efficiency was almost doubled by using a PMDA layer with an optimum thickness. However, when the thickness of the PMDA layer was increased over 0.5 nm, the electrical and optical characteristics of the OLEDs were significantly deteriorated because the PMDA layer started to act as an insulating layer.

4. Summary

In summary, we investigated the electrical and optical characteristics of the OLEDs as a function of the thickness of the PMDA cathode interfacial layer. The OLEDs with the 0.5 nm-thick PMDA cathode interfacial layer exhibited the most performance improvement compared to the control device without any interfacial layer.

5. References

1. S. Y. Park, C. H. Lee, W.J. Song, C. Seoul, *Current Applied Physics*, **1**, 116 (2001).
2. X. J. Wang, J. M. Zhao, Y. C. Zhou, X. Z. Wang, S. T. Zhang, Y. Q. Zhan, Z. Xu, H. J. Ding, G. Y. Zhong, H. Z. Shi, Z. H. Xiong, Y. Liu, Z. J. Wang, E. G. Obbard, X. M. Ding, W. Huang, X. Y. Hou, *J. Appl. Phys.*, **95**, 3828 (2004).