Extended Abstracts of the 2005 International Conference on Solid State Devices and Materials, Kobe, 2005, pp.806-807

P10-6

Characteristics of polymer light emitting diodes with the LiF anode interfacial layer

Sunyoung Sohn[1], Jaeyoung Yang[1], Heeyeop Chae[2], Jinhyo Boo[3], and Donggeun Jung[1]*

[1]Department of Physics, Institute of Basic Science, and Brain Korea 21 Physics Research Division, Sungkyunkwan University, Suwon 440-746, South Korea
Phone: +82-31-290-7050 *E-mail: djung@skku.ac.kr
[2]Department of Chemical Engineering, Sungkyunkwan University, Suwon 440-746, South Korea
[3]Department of Chemistry, Institute of Basic Science, and Brain Korea 21 Chemistry Research Division, Sungkyunkwan University, Suwon 440-746, South Korea

1. Introduction

Many efforts have been devoted to the study of the polymer light emitting diodes (PLEDs) in display applications due to the advantages such as simple fabrication methods, high luminous efficiency at low voltage, low cost compared with conventional organic materials.[1,2] One of the most important issues for PLEDs is an improvement of the devices efficiency. The performance of devices was decreased due to the barrier height at interfaces between electrodes and organics.[3] In recent years, it was reported that the insertion of thin insulating layers, such as Si_3N_4[4], SiO_2[5], between the organic layer and ITO in OLEDs can improve the enhancements in brightness and electroluminescence efficiency in device, which was suggested due to the band bending and tunneling effect.[6] Moreover, the use of an ionic insulating lithium fluoride (LiF) between ITO and hole transport layer (HTL) in phenyl-substituted poly(*p*-phenylenevinylene) (Ph-PPV) based PLEDs resulted in a shift of the operating voltage to a lower value, and a higher electroluminescent efficiency.[7]

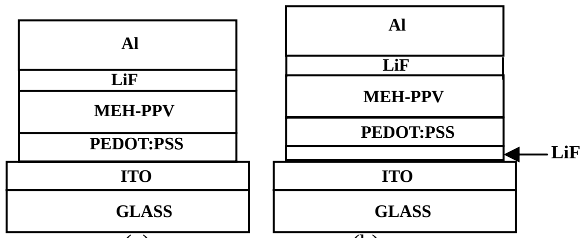
In this work, we report the characteristics of MEH-PPV based PLEDs with the LiF interfacial layer between the anode electrodes and the organic layers.

2. Experiments

The ITO-coated glass with a sheet resistance of 20 Ω/□ was used for anode of PLED fabrication. For the preparation of PLEDs, the ITO glass was cleaned sequentially in ultrasonic bath of trichloroethylene, acetone, and methanol. Finally, the ITO glass was sonicated in deionization water and then blown dry with N_2 gas. The LiF as the anode intermediate layer were deposited to the thickness of 0-2 nm by thermal evaporation. The poly(styrenesulfonate) (PSS)-doped poly(3,4-ethylene-dioxythiophene) (PEDOT) was used as the hole transport layer (HTL). The emitting material layer (EML) used is a 0.6 wt% poly (2-methoxy-5- (2'-ethylhexyloxy)-1,4-phenylenevinylene) (MEH-PPV) solution in chlorobenzene.

The device structures of PLEDs without and with anode interfacial layer were shown in figure 1(a) and 1(b), respectively. The 40-nm-thick PEDOT:PSS and 100-nm-thick MEH-PPV layers were prepared sequentially by spin coating on the substrate. The cathode with 1-nm-thick LiF and 150-nm-thick Al was deposited by thermal evaporation. Thickness of LiF as the cathode interfacial layer was fixed at 1nm, which was optimized to increased electron injection in our experiment.

For electrical measurements, a Keithley 2400 electrometer was used as a voltage source and current measurement equipment. The brightness characteristics of PLEDs were investigated by measuring the photocurrent induced by the light emission from the PLEDs using Keithley 485 picoammeter.

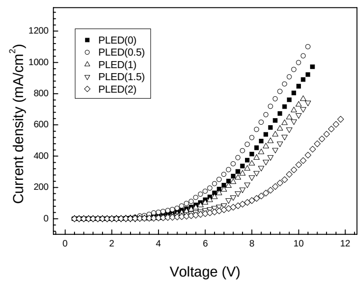


(a) (b)

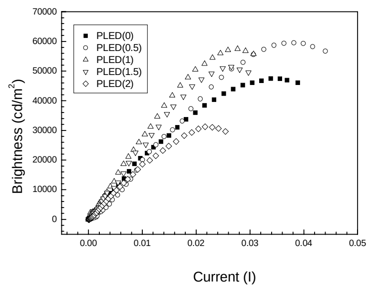
Figure 1. The device structures of PLEDs without (a) and with (b) LiF interfacial layer.

3. Results

Figure 2 (a) and 2 (b) show the current density versus voltage (J-V) and brightness versus current (B-I) characteristics for devices with different thickness of LiF.



(a)

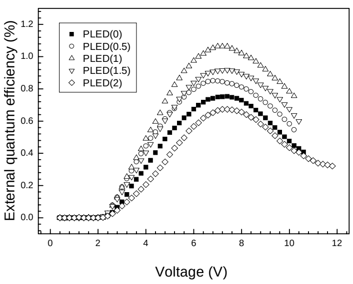


(b)

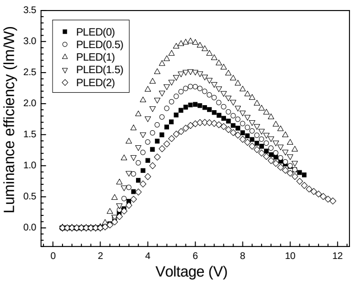
Figure 2. Current density versus voltage (J-V) (a) and brightness versus current (B-I) (b) characteristics of PLEDs as a function of LiF deposition thickness.

When thickness of interfacial layers were over the 1 nm, the turn-on voltage of devices were increased due to the too thick tunneling barrier. The PLED(0.5) and PLED(1) showed better performance than PLED(0), especially in B-I characteristics in high current range.

Figure 3(a) and 3(b) show the external quantum efficiency and luminance efficiency of PLEDs. PLED(0), PLED(0.5), PLED(1), PLED(1.5), and PLED(2) showed the maximum external quantum efficiencies of the 0.75%, 0.84%, 1.06%, 0.91%, 0.67%, respectively, at about 7.2 V.



(a)



(b)

Figure 3. External quantum efficiency (a) and luminance efficiency (b) of PLEDs as a function of LiF deposition thickness.

Also, the maximum luminance efficiencies of PLED(0), PLED(0.5), PLED(1), PLED(1.5), and PLED(2) were 1.97 lm/W, 2.27 lm/W, 3 lm/W, 2.5 lm/W, and 1.7 lm/W at 5.8 V, 5.8 V, 5.8 V, 5.8 V, and 6.4 V, respectively. Especially, PLED(1) showed a higher external quantum efficiency and luminance efficiency than the other PLEDs. By inserting a LiF as the interfacial layer, we thick that excess injected holes from ITO anode can be blocked and hence the recombination ratio of electrons and holes can be increased in the emitting layer to improve device efficiency.

4. Conclusions

In conclusion, we have studied characteristics of PLEDs with the LiF anode interfacial layer of various thickness. The characteristics of the PLEDs were affected significantly by existence of the LiF anode interfacial layer. PLED(1) with optimized thickness improved the external quantum efficiency and luminance efficiency. It is suggested that the insertion of LiF anode interfacial layer with a proper thickness contributed to the increased performance of PLED by enhancing the balance of holes and electrons.

Acknowledgements

This work was supported by Korean Science and Engineering Foundation through Center for Nanotubes and Nanostructured Composites.

References

[1] J. C. Scott, J. H. Kaufman, P.J. Brock, R. Dipietro, J. Salem, and J. A. Goitia, *J. Appl. Phys*., **79**, 2745 (1996).
[2] Tae-Woo Lee and O Ok Park, *Advanced Material*, **12**, 801 (2000).
[3] I. D. Parker, *J. Appl. Phys*., **75**, 1656 (1994).
[4] Hongjin Jiang, Yan Zhou, Boon Siew Ooi, Yuwen Chen, Terence Wee, Yee Loy Lam, Jingsong Huang, and Shiyong Liu, *Thin Solid Films*, **363**, 25 (2000).
[5] Z. B. Deng, X. M. Ding, S. T. Lee, and W. A. Gambling, *Appl. Phys. Lett*., **74**, 2227 (1999).
[6] L. S. Hung, C. W. Tang, and M. G. Mason, *Appl. Phys. Lett*., **70**, 152 (1997).
[7] Furong Zhu, Beeling Low, Keran Zhang, and Soojin Chua, *Appl. Phys. Lett*., **79**, 1205 (2001).