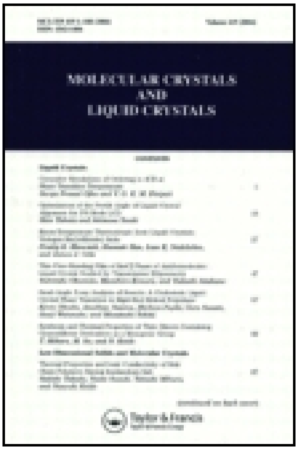

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Organic Light Emitting Diodes(OLEDs) with Oligothiophene and Silicon Monoxide

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Organic Light Emitting Diodes(OLEDs) with Oligothiophene and Silicon Monoxide

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The improved device performance of organic light emitting diodes(OLEDs) and hole-blocking effect of SiO layer are presented. The interface between the organic layer and metallic anode of an OLED is crucial to the stability and performance of the device. A uniform and thin film of the α-septithiophene(α-7T) has been used as a buffer layer at the interface between the ITO electrode and hole transport layer(HTL). The insertion of α-7T layer has decreased the operating voltage and improved the external power efficiency. The Maximum EL intensity was over 17000cd/m^2 and the maximum external power efficiency at 2000cd/m^2 is 6.41m/W and that at 100cd/m^2 is 9.34lm/W. Using the SiO layered in front of HTL as a hole-blocking layer, the sensitivity of the device efficiency on current density is investigated.

Keywords; buffer layer; oligothiophene; organic light .emitting diode(OLED); SiO

INTRODUCTION

Organic light emitting diodes(OLEDs) have shown great potential for information display applications. Several methods have been proposed in the past to improve the device performance efficiency. Insertion of a buffer layer between the metallic anode and hole transport layer(HTL) is one of the methods. It has been reported that OLEDs using oligothiophene as a buffer material show improved device performance.[1] Oligothiophene has relatively low ionization potential(IP)(5.0 – 5.2eV) and higher mobility(as high as $0.03cm^2/Vs$) [2]. Silicon monoxide(SiO) has been frequently used to improve the performances of OLEDs. The effects of a SiO layer, at the interface between the organic layer and the aluminum electrode, were investigated and a strong dependence of the diode efficiency on the thickness of SiO layer was observed.[3] In this work, α-septithiophene was used to act as a buffer material. The effect of SiO layer on the device performance efficiency was investigated.

EXPERIMENTAL

Three kinds of OLEDs were fabricated to investigate the performance of the buffer layer and SiO layer. Figure 1 shows the molecular structure of the organic materials used in the device. ITO-coated glass with sheet resistance of 10Ω/□ was used as the substrate. N,N'-diphenyl-N,N'-(3-methylphenyl)-1-1'-biphenyl-4,4'-diamine (TPD) was used as HTL and 8-Hydroxyquinoline aluminum(Alq_3) was used a emitting layer(EML) and electron transport layer(ETL). Aluminum was used as cathode. Device structures are as follows; device I has a structure of ITO/TPD(400Å)/Alq_3(600Å)/LiF/Al; device II ITO/α-7T(30Å)/TPD(400Å)/Alq_3(600Å)/LiF/Al; device III ITO/α-7T(30Å)/SiO(50Å)TPD(400Å)/Alq_3(600Å)/LiF/Al respectively. All the OLEDs were fabricated via conventional thermal evaporation under the pressure of 10^{-5} Torr. All the electrical properties and the emission spectra were measured at room temperature under ambient atmosphere.

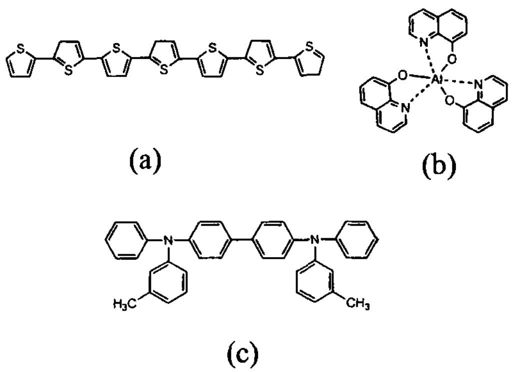
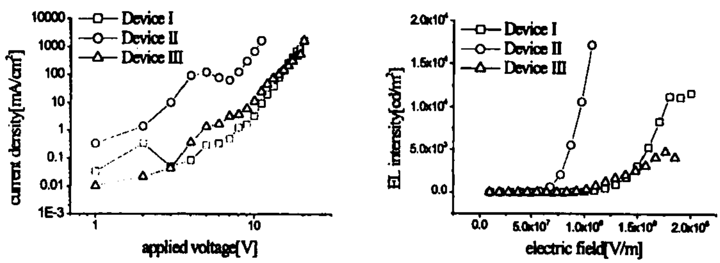


FIGURE 1. Molecular structure of (a) α-7T; (b) TPD; (c) Alq_3

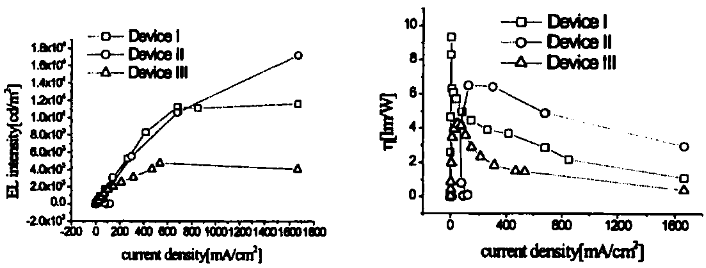
RESULTS AND DISCUSSION

As shown in FIGURE 2.(a), device I and device III showed similar current density-applied voltage(J-V) characteristics. The Maximum EL intensity from device I was two times than that from device III(FIGURE 2. (b)). With device II, we observed the highest maximum EL intensity. Moreover device II showed the highest current density at the same applied voltages. The EL intensity-current density(lm-J and external power efficiency –current density(η-J) characteristics are shown in FIGURE 3. With the same current density, the EL intensity of device I compares with that of device III. This may indicate that the current density is not the dominant factor for the improved device performance of OLEDs. J. Staudigel and his co-workers have performed simulation numerically, and the results suggested that the spatial distribution of singlet exciton



(a) (b)

FIGURE 2. Device performance of OLEDs (a) current density(J) vs. applied voltage(J-V); (b) Electroluminescence(EL) intensity vs. applied electric field(lm-F)



(a) (b)

FIGURE 3. Device performance characteristics (a) EL intensity-current density(lm-J); (b) external power efficiency-current density(η-J)

density in EML is extended to the ETL/cathode interface in two-layer system(HTL/ETL) but not in three layer system[4]. In three-layer system the excitons formed in EML were distributed only in narrow region from the HTL/ETL interface in their report. Moreover, the excitons in EML outnumber in three-layer system than two-layer system. C.W.Tang and co-workers have reported that the recombination region of carriers extended to 200Å from the HTL/ELT interface. As a result, the three-layer system has showed enhanced device performance in J. Staudigel's experiments. The device III has very high energy barrier fromed by SiO layer(FIGURE 4.). The high energy barrier induces the built-in electric field formed by accumulated positive charge a the interface between α-7T and SiO. The built-in electric field causes broad distribution of exciton over the device. The decreased number of exciton near the HTL/ETL interface, 200Å from TPD layer, leads to lower the EL intensity of device III.

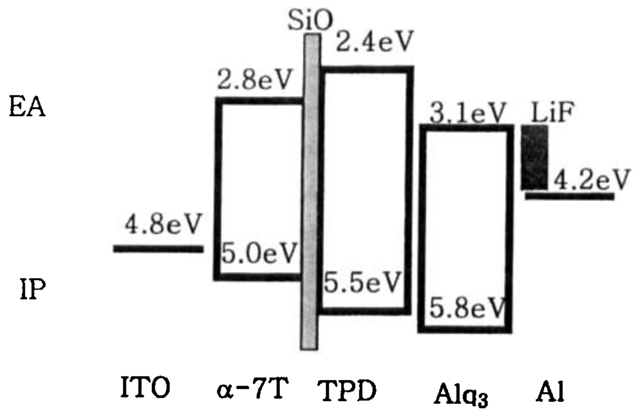
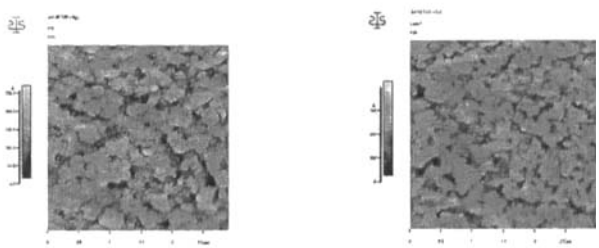


FIGURE 4. Energy band diagram of materials. Ionization potentials(IP) and electron affinities(EA) are literature values for TPD, Alq_3[6] IP and EA of α-7T were measured via cyclovoltametry(CV) technique.

In conclusion, the use of α-7T as a buffer material has induced the current density and external power efficiency of OLEDs to increase. But the increased current density is not the dominant factor to improve device performance. The energetic barrier for the hole injection at the interface of hole injecting layer/HTL is one of the important factor to dominate the device performance of OLEDs. And the improved surface morphology of hole injecting layer, α-7T layer can contribute to the improvement of device performance.(FIGURE 5.)



(a) (b)

FIGURE 5. AFM images of (a) ITO surface on glass substrate (b) α-7T on ITO(30Å)

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REFERENCES

[1] D.M.Shin, S.T.Lim, J.S.Choi, J.S.Kim, Thin Solid Films, **363**(2000)

[2] A.Ddabalapur, L.Torsi,H.E.Katz, Science, **268**(1995).

[3] Y.Ohmori, Y.Kurosaka, N.Tada, A.Fujii, K.Yoshino, Jpn.J.Appl.Phys., **36**(1997).

[4] J.Staudigel, M.Stobel, F.Steuber, J.Simmerer, J. Appl. Phys., 86(1999).

[5] C.W. Tang, S.A. VanSlyke, and C.H. Chen, J. Appl. Phys., **65**, 3610-3616(1989).