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Study on the Work Function of Various ITO Substrates Using Electrochemical Analysis

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We have measured the work function for various indium-tin oxide (ITO) substrates using cyclic voltammetric method, where the cyclic voltammetric system was constructed using a three-electrode compartment electrochemical cell consisted of a ITO and Al as the working electrode, a platinum wire as the counter electrode, and Ag/Ag^+ (0.1M $AgNO_3$) as the reference electrode. And we have investigated the relation ship between the work function and the power efficiency of the OELD having a structure of glass substrate/ITO/TPD/$BeBq_2$/Li:Al. The work functions of the ITO substrates with a sheet resistance of 7, 10, 15, and 30ohm/cm^2 were 4.70, 4.78, 4.81, and 4.77eV, respectively. It was also found that the ionization potential (IP) and electron affinity (EA) of $BeBq_2$ were 5.5eV, and 2.9eV, respectively.

Keywords: organic electroluminescence; ITO, Al, CV, CCPSA, TPD, work function, $BeBq_2$

INTRODUCTION

Organic electroluminescent devices (OELDs) have attracted much interest since Tang and VanSlyke first demonstrated the stable, and bright bilayer cell structure[1-3]. Especially the role of ITO substrate in this OELDs is very important since the work function of ITO infuenced the carrier injection

characteristics to hole transporting layer (HTL). In this study, we have investigated the work function of various ITO substrate using electrochemical analysis and the relation between the work function and the power efficiency using OELD with a cell structure of ITO/TPD/Bebq$_2$/Li:Al. We used cyclic voltammtery(CV) and constant current potentiometry analysis (CCPSA) as electrochemical analysis.

EXPERIMENTAL

(a) The ITO treatment: In this study, the various ITO substrates were cleaned under the following condition: (1) treatment with an 80°C NH_4OH : H_2O_2 solution (1:1:5) for 15 min, followed by rinsing with distilled H_2O. And the ITO substartes were also cleaned with aceton and distilled water for 15min. (b) OELD fabrication: In order to study the effect of the work function of ITO substrate on the power efficiency of OELDs, the double-layered OELDs with a structure of ITO/TPD(40nm)/Bebq$_2$(60nm)/Li:Al(100nm) using vacuum-deposition method were fabricated, where TPD was used as a hole transport material and $BeBq_2$ was used as emitting material. The emitting area was 3 x 3 mm^2. The vacuum pressure was maintained in the range of 10^{-7} Torr during the whole sublimation process and the deposition rate was maintained within 0.4 Å/s. We have measured the work function of ITO and HOME-LUMO levels of EL material with Phimacs EL analysis system 300. The molecular structures of TPD, and $BeBq_2$ were shown in FIGURE 1.

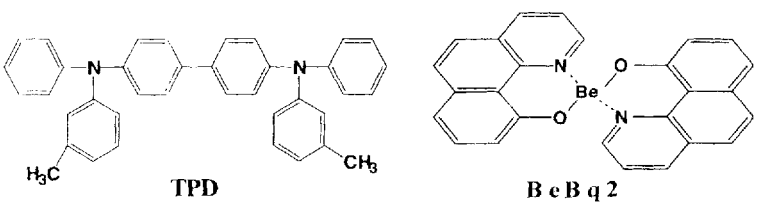
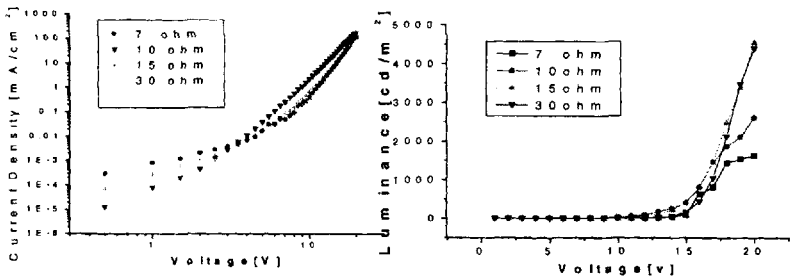


FIGURE 1. Molecular structures of the $BeBq_2$ and TPD used in this study.

RESULTS AND DISCUSSION

The current(I)-voltage(V), and luminance(L)-voltage(V) characteristics of OELDs having various ITO substrates are shown in FIGURE.2, the OELD having ITO(15 ohm/cm^2) exhibited higher current density than that of 30 ohm/cm^2. However, the OELD having ITO(15 ohm/cm^2) exhibited the higher luminance than any other OELD.



(a) (b)

FIGURE 2. (a) Current density vs. voltage, and (b) Luminance vs. voltage characteristics of OELDs with a cell structure of ITO/TPD(40nm) /Bebq$_2$(60nm)/Li:Al(100nm).

FIGURE 3 shows cyclic voltammogram of the ITO substrate with a sheet resistance of 15 ohm/cm^2 for the measurement of work function work function.

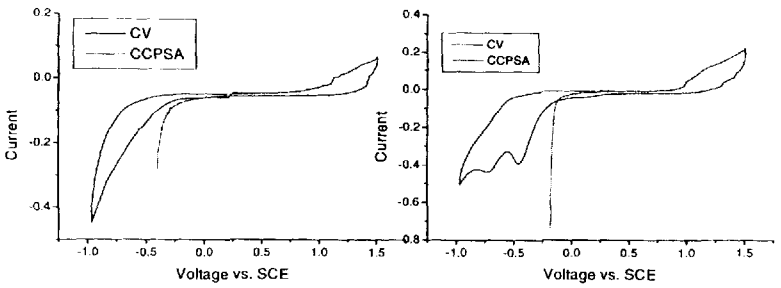


FIGURE 3. Cyclic voltammogram of the ITO substrate with a sheet resistance of 15 ohm/cm^2 for the measurement of work function (a) before treatment, and (b) after treatment.

ITO	Untreated		Treated		Power
	Onset V	eV	onset V	eV	Efficiency[cd/m^2]
7Ω	-0.31	4.49	-0.10	4.70	0.44
10Ω	-0.29	4.51	-0.02	4.78	0.37
15Ω	-0.15	4.65	0.01	4.81	0.70
30Ω	-0.27	4.53	-0.03	4.77	1.05

TABLE 1. The relation between the work function of the ITO and the power efficiency of OELDs

Table 1 shows the relation between the work function of the ITO and the power efficiency of OELDs having the treated ITO. It was found that after the treatment, the work function of ITO generally increases and ITO having higher work function does not show higher efficiency.

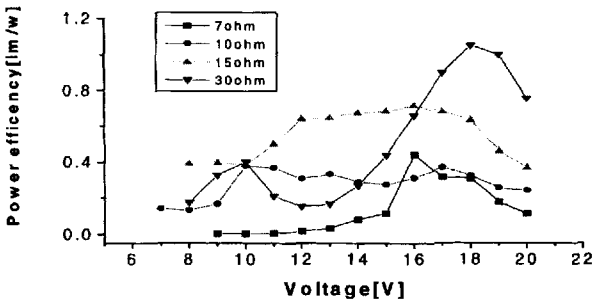


FIGURE 4. The power efficiency of OELDs having various ITO substrate as a function of driving voltage.

FIGURE 4 shows the power efficiency of OELDs having various ITO substrate as a function of driving voltage. It was found that the ITO substrate of 30 ohm/cm^2 exhibited the higher power efficiency at 18 voltage than any other ITO substrate. However, the ITO substrate of 15ohm/cm^2 has a higher average power efficiency than any other ITO substrate.

SUMMARY

In this study, we have investigated new electrochemical method for the measurement of ITO work function. It was found that there is a close relation between the work function of various ITO substrates and the power efficiency of OELD using various ITO substrates.

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