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# Interfacial Characteristics of Organic Electroluminescent Devices (OELDs) Using Impedance Technique

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# Interfacial Characteristics of Organic Electroluminescent Devices (OELDs) Using Impedance Technique

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We studied the effect of bias voltage on the impedance spectra of a double-layered cell. When bias-voltage was applied, bulk resistance was reduced due to the increased number of carriers but total capacitances increased very much due to more polarization at interfaces. When compared with single-layered cell, double-layered cell resulted in the lower turn-on voltage, which may be related to the increased interfacial impedance.

Keyword OELD; impedance spectroscopy; Randle's equivalent circuit; electrical double layer; $C_{dl}$

## INTRODUCTION

Double-layered cell including a hole transport layer (HTL) has an advantages of lowering energy barrier of ITO interface and blocking electrons from emitter, so that the probability of exciton formation can be seriously enhanced by the presence of HTL [1].

To understand the effect of HTL on the cell performance we employed AC impedance spectroscopy [2]. Especially by obtaining the cell impedance under bias-voltage [3] we tried to correlate the effect of

HTL to the cell parameters, which were obtained by fitting to Randle's equivalent circuit.

## EXPERIMENTAL

Tris(8-quinolinolato)aluminum ($Alq_3$, Aldrich) and N,N'-diphenyl-N,N'-(3-methylphenyl)-1,1'-biphenyl-4,4'-diamine (TPD, Aldrich) were used as an emitting material (EML) and a hole transporting material (HTL), respectively. ITO coated glass substrate (20 Ω/□) was cleaned ultrasonically by a detergent and deionized water.

TPD and $Alq_3$ were sequentially evaporated on the ITO glass at the rate of 3 Å/s under $5 \times 10^{-6}$ Torr. Impedance spectra were obtained for the cells from IM6 (Zahner Electrik). To study the effect of bias voltage impedance spectra were obtained under voltage. Frequency ranged from 0.1 to 1M Hz at amplitude of 100 mV and I-V curves were measured by Keithely 236.

## RESULTS AND DISCUSSION

FIGURE 1 shows the thickness effect on the impedance spectra of the double-layered cells and the thickness of TPD was maintained at 30 nm. Total impedance increased with increasing thickness of the emitting material.

FIGURE 2 shows the effect of bias voltage on the impedance spectra of the double-layered cell. The radius of semicircle decreased very rapidly

with increasing bias voltage and became too small to be seen at 8 V where light was emitted. When voltage was applied, we expect that resistance of the cell diminished due to the increased charge carriers

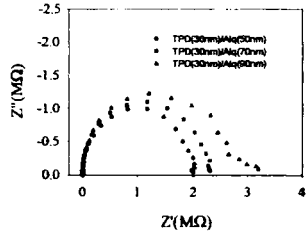


FIGURE 1 Impedance spectra of ITO/TPD/$Alq_3$/Al with various thickness of $Alq_3$.

and that total capacitance of the cell increased due to more charge at the interfaces. Cell parameters were obtained by fitting to the simplified Randle's equivalent circuit. As shown in TABLE 1 capacitance of bulk materials did not change much but interfacial capacitance ($C_{dl}$) increased very rapidly with increasing voltage. In this study we did not differentiate two types of interfaces and more detailed study is required to differentiate the contribution of each interface.

TABLE 1 Cell Parameters Fitted by Randle's Equivalent Circuit

| DC bias | $R_B$ | $C_B$ | $C_{dl}$ |
|---|---|---|---|
| 0 V | 3.87 MΩ | 6.87 nF | 4.13 μF |
| 3 V | 376 KΩ | 6.60 nF | 50.2 μF |
| 6 V | 36.7KΩ | 6.54 nF | 630 μF |
| 8 V | 4.99 KΩ | 6.13 nF | 6.3 mF |

FIGURE 3 compares I-V curve of ITO/$Alq_3$/Al with that of ITO/TPD/$Alq_3$/Al. For both cells the thickness of $Alq_3$ kept the same. Double-layered cell resulted in higher current density and its turn-on

voltage was 4 V, which was 2 V lower than that of single-layered cell. The lower turn-on voltage may be related to interfacial impedance.

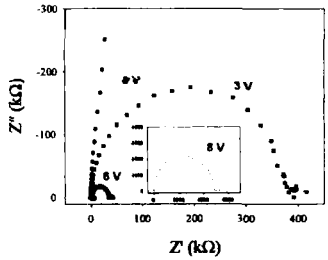


FIGURE 2 Impedance spectra of ITO/TPD/$Alq_3$/Al with bias voltage.

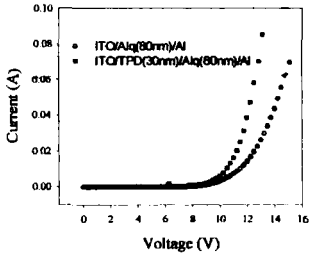


FIGURE 3 I-V Curves of ITO/$Alq_3$/Al and ITO/TPD/$Alq_3$

## CONCLUSIONS

Double-layered cell (ITO/TPD/$Alq_3$/Al) showed higher impedance with increasing thickness of the emitting material as in the single cell. When bias-voltage was applied, total cell impedance diminished very rapidly due to lower bulk resistances and interfacial impedances. Lower turn-on voltage of double-layered cell may be related to the interfacial impedance.

## ACKNOWLEDGEMENT

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## REFERENCES

[1] H. Suzuki and S. Hoshino, J. Appl. Phys., **79**, (1996) 858.
[2] C. Jonda and A. B. R. Mayer, Chem. Mater. **11** (1999) 2429.
[3] H. W. Rhee, K. S. Chin, S. Y. Oh, J. W. Choi, Thin Solid Films **363** (2000) 236.