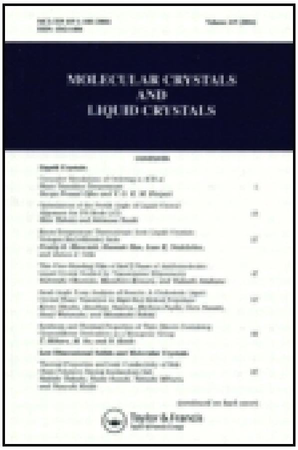

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The Electrical Properties of Europium Complex Thin Film EL Devices Prepared by Vacuum Evaporation Method

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Electroluminescent(EL) and I-V characteristics of $Eu(TTA)_3(phen)$ layers with various thickness were investigated. The red EL spectrum emitted from the $Eu(TTA)_3(phen)$ layer is almost the same as the PL spectrum. Based on the I-V characteristics, it was found that the turn-on voltage is 9V and current density was 0.01 A/cm at a dc operation voltage of 9V. The observed electrical transport phenomena were explained within a trapped-charge-limited current model describing I-V characteristics.

Keywords: Electroluminescence(EL); Photoluminescence(PL); $Eu(TTA)_3(phen)$; Trapped-Charge-Limited-Current(TCLC); Organic light-emitting diodes(OLEDs)

INTRODUCTION

Organic light-emitting diodes(OLEDs) have been expected to find applications as a new type of flat flexible displays since Tang and co-workers reported high-performance OLEDs[1,2,3]. Chelate-metal complexes are often used as a host light-emitting and/or carrier transport material in the OLEDs because they have a good carrier transporting capability and strong fluorescence[4]. In this study, Electroluminescent(EL) and I-V characteristics of $Eu(TTA)_3(phen)$-based multi-layer structures with various thicknesses were investigated. From the measured I-V characteristics it is deduced that the dominant carrier transport mechanism of these structures under the normal operation bias is the trapped-charge-limited current[5].

EXPERIMENTAL DETAILS

The glass substrate/ITO/TPD/$Eu(TTA)_3(phen)$/AlQ_3/Al structures were fabricated by the evaporation method. The aromatic diamine(TPD) was used as a hole transporting material, $Eu(TTA)_3(phen)$ as an emitting material, and tris(8-hydroxyquinoline)Aluminum(AlQ_3) as an electron transporting layer. The molecular structures of the materials being used and a schematic cross-section of the light-emitting diode are shown in Figure 1.

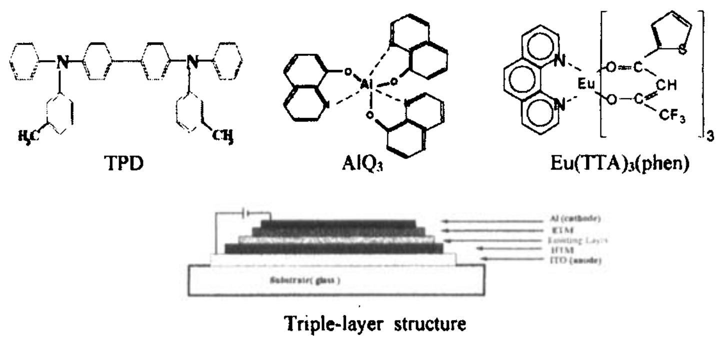

FIGURE 1 Molecular structure of the the TPD, AlQ_3,$Eu(TTA)_3(phen)$ and triple-layer device structure is also shown.

The thicknesses of the TPD, $Eu(TTA)_3(phen)$, and AlQ_3, layers are 30nm, 5~30nm, and 30nm, respectively. The light emitting area of the diode is 4㎟. The UV/Vis absorption spectra of AlQ_3, $Eu(TTA)_3(phen)$, and TPD films on quartz glass slides were measured with a diode array spectrophotometer. Current-voltage (I-V) characteristics of the film along the direction normal to the substrate was measured using an electrometer. The applied voltage was varied from 0 to 20V in a step of 0.5V/s.

RESULTS AND DISCUSSION

Spectral Characteristics

The UV/vis absorption and photoluminescence(PL) spectra of TPD, AlQ_3 and $Eu(TTA)_3(phen)$ films are shown in Table 1. The PL emission peaks from TPD, AlQ_3 and $Eu(TTA)_3(phen)$ occur at around the wavelengths of 400~450nm, 500~550 nm and 600~620nm at room temperature, respectively. The optical absorption spectrum of $Eu(TTA)_3(phen)$ shows a strong absorption band of the wavelengths between 320 and 350nm.

TABLE 1 : Absorbance and PL data.

	Absorbance λ max(nm)	Photoluminescence λ max(nm)
TPD	358	405
AlQ_3	280	520
Eu^{3+}	320~350	612

J-V and logJ-logV Characteristics

The $Eu(TTA)_3(phen)$-based OLED was a triple-layer structure device with TPD a hole transport TPD layer of 30nm thick and an electron transport AlQ_3 layerof 30 nm. Al was chosen for top metal electrode and the thickness of the emitter film was varied from 5 to 30nm. The current density vs. voltage characteristics is shown in Figure 2. Red emission was observed for an emission layer thicker than 5nm The current densities are predominantly dependent of the $Eu(TTA)_3(phen)$ thickness and vary from about 10mA/cm² for 30nm to 240mA/cm² for 5nm emission layer. This indicates that the emission layer has poor carrier transport properties with a high trap density. Furthermore, the recombination is confined to a region of approximately 5nm wide, because no AlQ_3 emission is observed for this emission layer thickness.

Reducing the thickness of the europium complex clearly lowers the operating voltage as shown in Figure 2. The J-V curve characteristics seem to be attributed to the trap-charge-limited-current(TCLC) mechanism.

EL spectra vs. Voltage

Figure 3 shows the EL intensity change with varying the applied voltage. With increasing the voltage applied to the device, the EL intensity became stronger. The maximum EL intensity was obtained at 17V, over which the diode failed to operate. The $Eu(TTA)_3(phen)$-based OLED was made with TPD of 30nm, Eu(TTA)$_3$(phen) of 5nm, and AlQ$_3$ of 30nm thick.

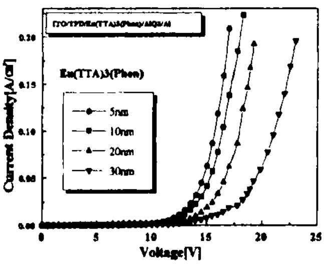

FIGURE 2 Emission layer thickness dependent current density vs. voltage characteristics.

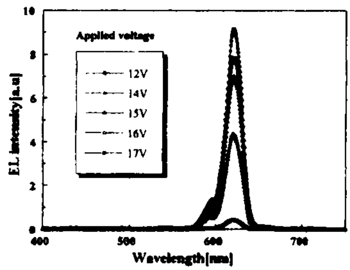

FIGURE 3 EL spectra vs. applied voltage(TPD:30nm, Eu(TTA)$_3$(phen):5nm, AlQ$_3$:30nm).

CONCLUSIONS

The europium complex in an OLED structure was investigated. In the triple-layer EL device, Eu(TTA)$_3$(phen) emits its electroluminescence in the red region with the maximum emission at about 613nm. The current J is proportional to V^9 over seven decades of the current, which might be attributed to the trapped-charge-limited conduction current. The maximum EL intensity was achieved for the Eu(TTA)$_3$(phen) layer of 5nm thick.

Acknowledgments
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