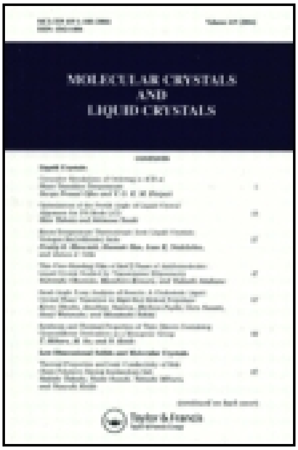

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Red Color Enhancement of White Light Emitting Diode by Doping Alq_3 Layer with DCM

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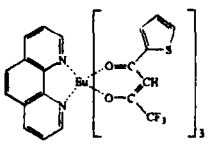
Several lanthanide complexes such as $Eu(TTA)_3(Phen)$, $Tb(ACAC)_3(Cl\text{-}Phen)$, and $Tb(ACAC)_3(Phen)$ were synthesized and the photoluminescent (PL) and electroluminescent (EL) characteristics of their thin films were investigated by fabricating the devices having the structures of ITO/TPD/$Tb(ACAC)_3(Cl\text{-}Phen)$/$Eu(TTA)_3(Phen)$/$Alq_3$/Li:Al and ITO/TPD/$Tb(ACAC)_3(Phen)$/$Eu(TTA)_3(Phen)$/DCM doped Alq_3/ Alq_3/Li:Al. The role of DCM in Alq_3 layer was explained using energy band diagrams of these OELD structures.

INTRODUCTION

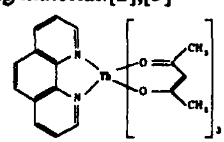
Organic light-emitting diodes(OLEDs) have attracted much attention because of their possible application as large-area light-emitting displays.[1],[2] Especially, the need for white light emitting diodes and back-lights has spurred interest in the preparation of white light emitting devices so that red, green and blue would be conveniently available from one device. However, a major disadvantage of OLEDs is related to their instability under normal operating conditions and a lack of long lifetime reliability remains.[2] In this study, we prepared white OLEDs by incorporating several organic layers with aluminum-tris(8-hydroxy-quinoline)(Alq_3) doped with 4-(dicyanomethylene)-2metyl-6-(p-dimethyl-laminostyryl)-4H-pyran(DCM) as the red emitting layer, which allow simultaneous emissions of red, green and blue lights to give a white light. The electroluminescent characteristics of the OLEDs with multi-layer structures was investigated and explained using the energy band structures of electroluminescent devices, which were measured using cyclic voltammetry.[3],[4]

EXPERIMNTAL

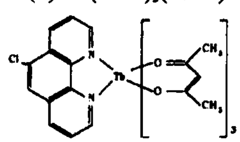
In this study, glass substrate/ITO/TPD(30nm)/Tb(ACAC)$_3$(Cl-Phen)(30 nm)/Eu(TTA)$_3$(Phen)(5nm)/non-doped Alq$_3$(10nm)/Alq$_3$(20nm)/Li:Al and glass substrate/ITO/TPD(30nm)/Tb(ACAC)$_3$(Phen)(30nm)/Eu (TTA)$_3$(Phen)(5nm)/DCM doped Alq$_3$(10nm)/Alq$_3$(20nm)/Li:Al structures were fabricated by vapor deposition method, where the N,N'-diphenyl-N,N'-bis(3-methylphenyl)-1,1'-biphenyl-4,4'-diamine(TPD) was used as a hole transporting and also blue-light emitting material, Tb(ACAC)$_3$(Cl-Phen) and Tb(ACAC)$_3$(Phen) as a green-light emitting materials, Eu(TTA)$_3$(Phen) and Alq$_3$ doped DCM as a red-light emitting materials and Alq$_3$ as an electron transporting material.[2],[5]



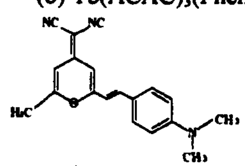
(a) Eu(TTA)$_3$(Phen)



(b) Tb(ACAC)$_3$(Phen)



(c) Tb(ACAC)$_3$(Cl-Phen)



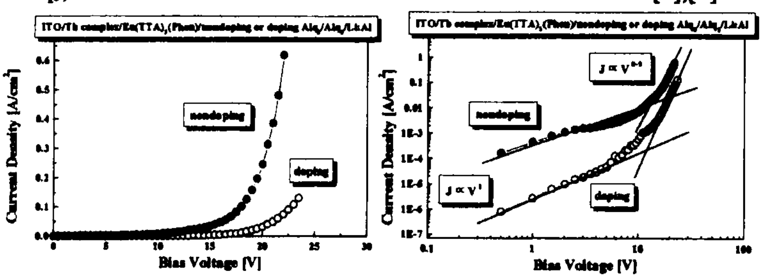
(d) DCM

FIGURE 1. The molecular structures of Tb(ACAC)$_3$(Phen), Tb(ACAC)$_3$(Cl-Phen) Eu(TTA)$_3$(Phen) and DCM used as an emitting material of the OLED fabricated in this study.

The layers of various organic films were deposited by vapor deposition on the patterned ITO-coated glass substrates, where the details on the cleaning and deposition conditions were published elsewhere[1],[5] and the ITO coated glass substrates with a sheet resistance of 30 Ω /□ was donated by Samsung Corning Co., Ltd.. The light emitting area of the devices was 8 ㎟(4 ㎜× 2 ㎜). The UV/Visible absorption spectra of the TPD, Eu(TTA)$_3$(Phen), DCM, Tb(ACAC)$_3$(Cl-Phen), Tb(ACAC)$_3$(Phen) and Alq$_3$ films on the quartz glass slide were measured with HP 8425 diode array spectrophotometer. Current-voltage (I-V) characteristics of the film along the direction perpendicular to the substrate were measured using Keithley 238 electrometer.

RESULTS AND DISCUSSION

The spectral behavior of the organic materials used has been studied in a form of thin films and the UV/visible absorption and photoluminescent (PL) spectra of Tb(ACAC)$_3$(Phen), Tb(ACAC)$_3$(Cl-Phen), Eu(TTA)$_3$(Phen), Alq$_3$, DCM and TPD were the same as shown in the literatures.[2],[5]

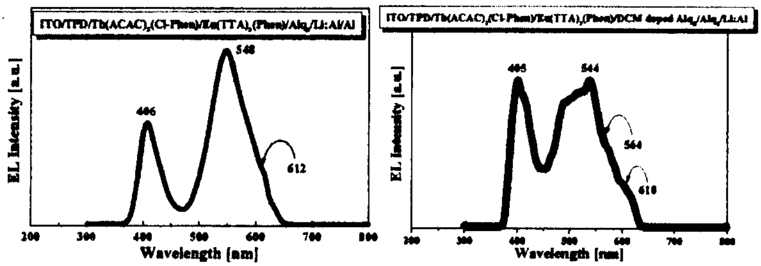


(a) (b)

FIGURE 2. The current density-bias voltage (J-V) and the log(J)-log(V) characteristics of OLEDs with the structures of ITO/TPD/Tb complex/ Eu(TTA)$_3$(Phen)/non-doped or doped Alq$_3$/Alq$_3$/Li:Al.

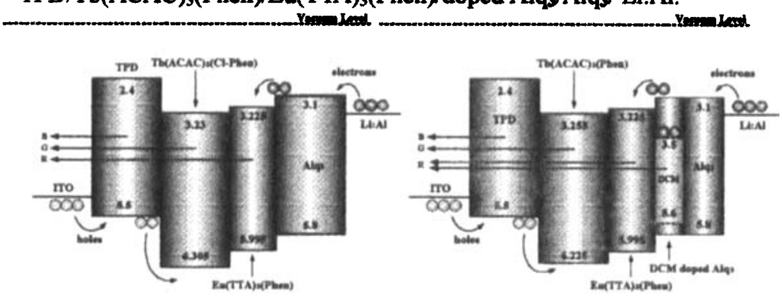
Fig. 2 (a) shows the current density-bias voltage (J-V) characteristics of OLEDs with the structures of ITO/TPD/Tb complex/Eu(TTA)$_3$(Phen)/

non-doped or doped Alq_3/Alq_3/Li:Al. It was found in Fig. 2 (a) that the OLED using non-doped Alq_3 as an electron transporting layer has a higher current density at the same driving voltage. This seems to be due to the difference in charge carrier injection and transport characteristics between the undoped Alq_3 and the DCM doped Alq_3. Fig. 2 (b) shows the logJ-logV characteristics of the OLEDs with the structure of ITO/TPD/Tb complex/Eu(TTA)$_3$(Phen)/non-doped or doped Alq_3/Alq_3/ Li:Al/Al. The current density (J) is proportional to $V^{8\sim9}$ over eight decades of the current for the OLEDs with non-doped and doped Alq_3, which can be explained by the proposed trapped-charge-limited current (TCLC) and space-charge-limited-current (SCLC).[5]



(a) (b)

FIGURE 3. The EL spectra of the OLEDs with the structures of (a) ITO/ TPD/Tb(ACAC)$_3$(Cl-Phen)/Eu(TTA)$_3$(Phen)/Alq_3/Li:Al and (b) ITO/ TPD/Tb(ACAC)$_3$(Phen)/Eu(TTA)$_3$(Phen)/doped Alq_3/Alq_3/ Li:Al.



(a) (b)

FIGURE 4. Schematic energy band diagrams of the OLEDs with the

structures of (a) ITO/TPD/Tb(ACAC)$_3$(Cl-Phen)/Eu(TTA)$_3$(Phen)/Alq$_3$/ Li:Al and (b) ITO/TPD/Tb(ACAC)$_3$(Phen)/Eu(TTA)$_3$(Phen)/DCM doped Alq$_3$/Alq$_3$/Li:Al obtained by using cyclic voltametric method.

It was shown in Fig. 3 (a) and (b) that both EL spectra show the three peaks at the wavelength of 405~406 nm, 544~548 nm, and 610~611 nm, which seem to be due to the emission from the TPD, Tb ion, and Eu ion, respectively. These phenomena can be explained in the energy band diagrams of these devices shown in Fig. 4, where electrons and holes are trapped in DCM doped Alq$_3$.

CONCLUSION

In this study, it was found that the turn-on voltage of the device with non-doped Alq$_3$ was lower than that of the devices with doped Alq$_3$ and the blue and red light emission peaks due to TPD and Eu(TTA)$_3$(Phen) with non-doped Alq$_3$ were lower than those with DCM doped Alq$_3$.

ACKNOWLEDGMENTS

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