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Characteristics and Stability of Organic EL Device using a Polymer Hole Transport Material Doped by Fluorescent Dye

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We fabricated a novel organic electroluminescent (EL) device using a poly[*N*-(*p*-diphenylamine)phenyl methacrylamide]], PDPMA doped by nile red as a polymer hole transport material. The fluorescent dye was used as a guest emitting material. The ITO/nile red doped PDPMA/Alq_3/Al device emitted red light with high brightness of 1000 cd/m^2 and showed considerable stability over long duration. The optoelectrical properties and EL characteristics of the organic multilayered device were investigated. Especially, we have examined the feasibility of application as an organic EL device with color tuning function.

Keywords: PDPMA; fluorescent dye; optoelectric properties; EL characteristics; color tuning

INTRODUCTION

Organic electroluminescent(EL) devices have attracted great attention due to their potential application as full-color flat panel display. Especially, extensive studies on color tuning organic EL device using fluorescent dye as a guest emitting material have been reported [1]. However, the EL device composed of host-guest type has some

significant problems such as low stability and short life time in operation, because fluorescent dye is very sensitive to light, heat, humidity and oxygen [2].

Recently, we reported on the optoelectrical properties of organic EL device using a PDPMA as a polymer hole transport material [3]. In this study, the effects of dye dopant content on EL characteristics in the organic EL device consisted of ITO/nile red doped PDPMA/Alq_3/Al have been investigated.

MATERIALS AND EXPERIMENTAL

PDPMA as a polymer hole transport material was synthesized by solution polymerization with an AIBN initiator. The chemical structure of PDPMA was shown in Figure 1 (a).

ITO substrate with sheet resistance less than 20 Ω was cleaned ultrasonically with a series of organic solvents prior to use. The PDPMA film was spin-cast from a monochlorobenzene solution containing PDPMA and nile red(0.8 wt.%). The speed of spin casting was about 2000 rpm. Alq_3 and Al were deposited by a ULVAC VPC-200F evaporator at a pressure below 1×10^{-5} Torr. The photoluminescence and electroluminescence spectra were obtained from the measurements of an Acton 300i spectrofluorometer. The morphology of dye-doped PDPMA was observed with an Auto Probe PSI AFM.

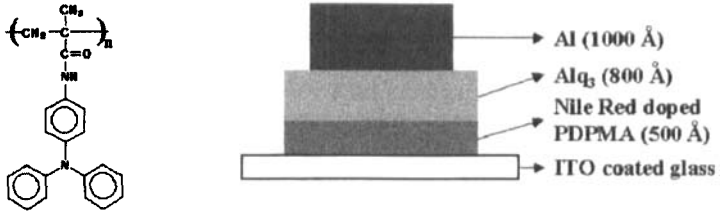

FIGURE 1 The chemical structure of PDPMA (a) and the schematic diagram of organic EL device (b).

RESULTS AND DISCUSSION

The schematic diagram of organic EL device fabricated in the present study was shown in Figure 1 (b). Figure 2 showed the fluorescence and emission spectra of the cells with different doping ratios. For the 0.5 wt.% doped cell, the fluorescence peak at 600 nm originated from nile red. It is the reason why excitation energy transfer from Alq_3 to nile red occurred. Along with the decrease in fluorescence intensity with higher concentration, a gradual blue shift in the maximum fluorescence peak occurred due to the strong dipolar interaction between nile red molecules. The EL spectra of the cells have a dependence on the dopant concentration similar to the PL spectra as shown in Figure 2. It is concluded that the optimal concentration is about 0.8 wt.% for EL efficiency. Especially, it should be noted that the color of the cell could be easily tuned by changing dopant concentration or applied voltage.

I-V characteristics of the cells with different doping ratios were shown in Figure 3. As the concentration of nile red molecules increases, turn-on voltage increases, indicating that the dye dopant behaves as a hole-blocking material, reducing charge transport of majority carrier.

Figure 4 showed three-dimensional AFM images of nile red doped PDPMA and Alq_3 doped with nile red. The surface morphology of nile red doped PDPMA was not changed upon the exposure to atmosphere for 12 hours.

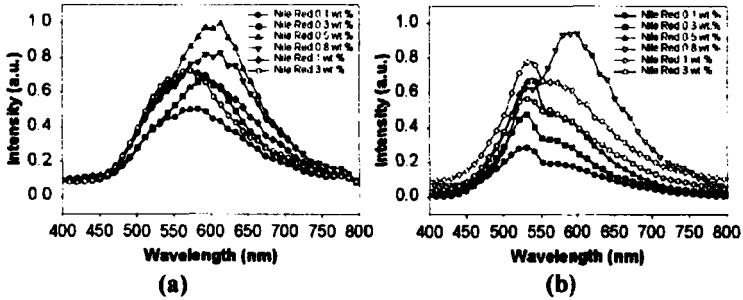

FIGURE 2 The PL spectra of PDPMA doped with nile red (a) and the EL spectra of ITO/ nile red doped PDPMA/Alq_3/Al (b).

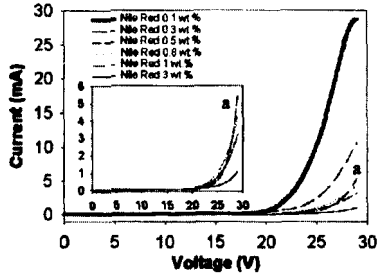

FIGURE 3 I-V characteristics of ITO/nile red doped PDPMA /Alq_3/Al device.

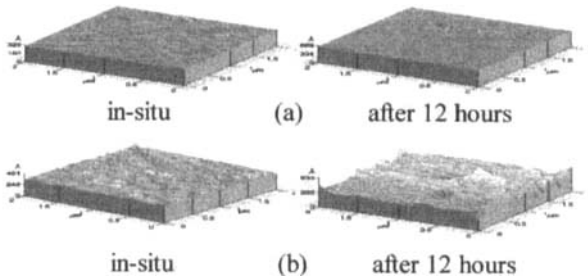

FIGURE 4 AFM images of nile red doped PDPMA (a) and Alq_3 doped with nile red (b).

ACKNOWLEDGMENTS

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