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White Light Emission from a Single-Layer Electroluminescent Device Using Exciplex Formed between Organic Materials

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White Light Emission from a Single-Layer Electroluminescent Device Using Exciplex Formed between Organic Materials

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We fabricated a single-layer white light electroluminescent (EL) device consisted of emitting layer contains molecularly doped poly(N-vinylcabazole) (PVK) with 30 wt% of 2,5-bis(5-tert-bytyl-2-benzoxazolyl)thiophen (BBOT), 2.17 mol% of N,N'-diphenyl-N,N'-bis(3-metylphenyl)-1, 1'-biphenyl-4,4'-diamine (TPD) and 0.039 mol% of poly(3-hexylthiophene) (P3HT). In the photoluminescence (PL) spectra, we observed the exciplex formed between PVK and BBOT, TPD and BBOT, respectively. Sequential energy transfer occurred in a mixed emitting layer. Consequently, we achieved white light emission corresponds to Commission Internationale de L'Ëclairage (CIE) coordinate of x = 0.295, y = 0.32.

Keywords : electroluminescent device; white light emission; exciplex

INTRODUCTION

Recently, many researchers interested in white light EL device because it can be use for various applications such as backlight and light source. To achieve the white light, emitting materials of blue, green and red emission are used and many different types of device were designed. For example, multilayer devices consist with blue, green and red emission layer, devices using host-guest system and single or multilayer devices with white emission material. Kido *et al.*[1] reported white emission from dye-dispersed polymer and Jordan *et al.*[2] reported

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white emission from multilayer EL devices. An exciplex is known as a transient donor-acceptor complex between the excited state of the donor and the ground state of the acceptor. Exciplex formation has been observed between PVK and BBOT, BBOT and TPD, respectively. [1]
In this paper, we fabricated a white light EL device with molecularly doped polymer emitting layer forming an exciplex between organic materials. Moreover, we investigated the energy transfer phenomenon in a mixed emitting layer by monitoring of time-resolved PL.

EXPERIMENTAL

We formed molecularly doped polymer films on indium-tin-oxide (ITO) substrate by spin coating from a chloroform solution of PVK molecularly doped with 30 wt% of BBOT, 2.17 mol% of TPD and 0.039 mol% of P3HT. On the top of the emitting layer, LiF insulating layer of 1.5 nm thickness and Al layer of 250 nm thickness were deposited at about 1×10^{-6} Torr. The EL spectrum was measured using a spectrograph and a Si photodiode array. The PL spectra were measured using a double spectrometer and a PMT. Excitation light at 325 nm from a He-Cd laser used for the photoluminescence measurement. PL decay was recorded by the time-correlated single-photon counting method with excitation light source of 270 nm.

RESULT AND DISCUSSION

The maximum peaks of PL spectra of PVK, BBOT, TPD and P3HT were 420, 480, 420 and 620nm, respectively. To investigate of an exciplex formation between emitting materials, we measured PL spectra of mixed material: PVK+BBOT, PVK+TPD and BBOT+TPD. Figure 1 shows the PL spectra of mixed emitting materials. In the spectrum (a), the peaks observed at 450, 470 and 500nm. The peaks at 450, 470nm are originated from BBOT and 500nm may originate from the exciplex formed between PVK and BBOT.[1] The peak at 420nm from PVK was not observed that it implies the energy transfer occurred from PVK to BBOT. In the spectrum (b), the peaks obtained at 400, 420nm. In this case, the energy transfer also occurred from PVK to TPD, but the exciplex was not observed. In the spectrum (c), the peaks are obtained at 450, 530 and 555nm. The peak seen at 450nm originated from BBOT and peaks at 530 and 555nm assumed that correspond to complex formation between TPD and BBOT.

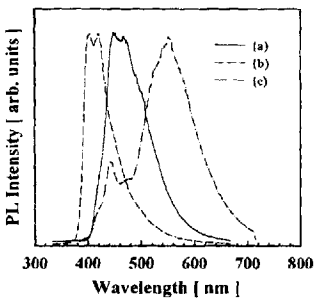

FIGURE 1 PL spectra of mixed organic materials; (a) PVK+BBOT, (b) PVK+TPD, (c) TPD+BBOT.

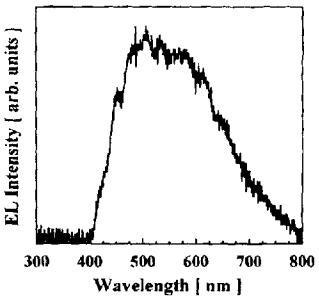

FIGURE 2 EL spectrum of ITO/ PVK+BBOT+TPD+P3HT/LiF/Al EL device.

EL spectrum of an emitting light from ITO/PVK+BBOT+TPD+P3HT /LiF/Al device showed in Figure 2. EL spectrum was measured operating voltage at 16V and the observed color of EL device is white. As can be seen in Figure 2, the peaks appeared at around 450, 500, 535, 555, 620 and 650nm, respectively. Among these peaks, the emission peak at 450nm caused by BBOT and the peaks at 620 and 650nm were originated from P3HT. This implies that P3HT with organic compound not formed any type of an exciplex. From the previous PL spectra, we assumed that the peak showed at 500 nm originated from an exciplex formation between PVK and BBOT and the peaks that showed at 535 and 555 nm originated from an exciplex between BBOT and TPD. The intensity of peaks of 535 and 555 nm increased with increasing concentration of TPD, whereas the peak intensity of 450 nm was decreased. This implies that the increment of concentration of TPD leads to increase the exciplex formation between TPD and BBOT. Therefore, we can control the blue and green emission color with changing the molar ratio of TPD and BBOT.

Figure 3 shows the nanosecond time-resolved PL decays of a mixed emitting layer pumped by 270 nm pulses at room temperature. The decay dynamics were observed at 450, 500, 550 and 650 nm, which correspond to the BBOT emission, the exciplex generated from PVK+BBOT, the exciplex generated from BBOT+TPD and P3HT emission, respectively. The decay lifetimes of BBOT and P3HT in a mixed materials became longer due to the sequential energy transfer between emitting materials.[3]

Figure 4 shows the voltage-current-luminance characteristics of the EL device. The current and light output increased with increasing forward applied voltage. The turn-on voltage of the device was about 8V and

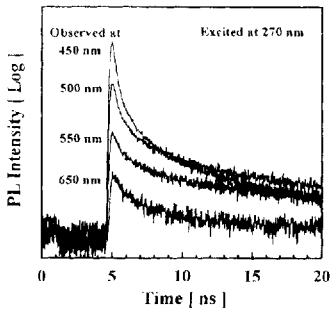

FIGURE 3 Time-resolved PL decays of PVK+BBOT+TPD+P3HT mixed emitting materials.

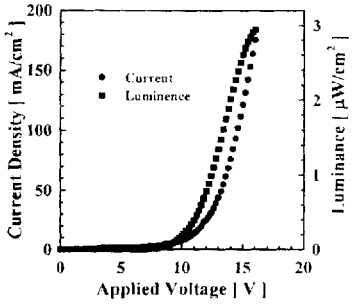

FIGURE 4 Voltage-current-luminance characteristics of ITO/PVK+BBOT +TPD+P3HT/LiF/Al EL device.

emission started at same voltage. However, the emission intensity of device was relatively low because it was affected by the exciplex formation between an organic compounds and low quantum efficiency of P3HT. The maximum luminance of 3 μW/cm^2 obtained at the driving voltage of 16 V and it is equal to 26 cd/m^2. The generated a white emission color of EL device corresponds to CIE coordinates of x = 0.295 and y = 0.32.

CONCLUSION

We successfully produced a white light emission from organic EL devices using an exciplex generated between organic materials. The luminance of white light emission obtained as great as 26 cd/m^2 at 16 V and it corresponds to CIE coordinate of x = 0.295, y = 0.32.

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