

Variety of Emission Color Control for Coating and Self-Aligned Ink-jet Printed Small Molecules Organic Light-Emitting Diodes

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1. Introduction

One of the most interesting display devices is organic light-emitting devices (OLEDs) that show excellent properties of self-emission, ultra-thin, high response, low driving voltage and bright emission. To achieve emission color control using OLEDs, an additive color mixture technique of the three primary colors relation is necessary. For example, following types of devices are considered: a multilayer structure device with RGB emission layers [1], a color conversion technique [2], and a color mixture technique using fine mesh as an evaporation mask [3]. We have been reported self-aligned (SA) bank formation technique using ink-jet printing (IJP) on insulating polymer layer [4]. We have also investigated a color conversion materials placed on a peripheral of the ink-jet printed emission dots [5] and pigment dispersion structure [6].

In this study, we have examined variety of emission color control for coating and self-aligned ink-jet printed small molecules organic light-emitting diodes.

2. Experiments

After ultraviolet (UV) ozone cleaning, the conducting polymer poly(ethylene dioxythiophene)/ poly(styrene sulfonate) (PEDOT:PSS) was spin-coated on an indium tin oxide (ITO)-coated glass substrate. Then, baking at 200°C in atmosphere for 5 min was carried out. Next, the phosphorescent small molecule was spin-coated on the substrate. Then, an ink with another phosphorescent small molecule was ink-jet printed on the substrate. *N,N'*-di-[(1-naphthyl)-*N,N'*-diphenyl]-1,1'-biphenyl-4,4'-diamine (α -NPD) was used for the hole transport material and 4,4'-bis (*N*-carbazolyl)-1,1'-biphenyl (CBP) was used for host material. Bis(2-(2'-benzo [4,5- α] thienyl) pyridinato-*N,C3'*) iridium (acetylacetonate) ($\text{btp}_2\text{Ir}(\text{acac})$), bis[2-(4,6-difluorophenyl) pyridinato- C^2 , *N*](picolinato) iridium (III) (Flrpic) and *fac*-tris(2-(*p*-tolyl)-pyridine)iridium ($\text{Ir}(\text{tpy})_3$) was used for phosphorescent materials. The ink solution was 0.8 wt% chloroform: toluene with a mixing ratio of 95: 5 as spin-coating layer and 0.8 wt% (Red, Green), 1.5 wt% (Blue) chloroform as IJP region. The ink was α -NPD: CBP: $\text{btp}_2\text{Ir}(\text{acac})$ or $\text{Ir}(\text{tpy})_3$ with a mixing ratio of 5: 95: 5 and CBP: Flrpic with a mixing ratio of 120: 20. Next, the substrate was baked in vacuum for 2 h. Finally, a hole blocking layer of bathocuproine (BCP), *tris*(8-hydroxyquinoline) aluminum(Alq_3) and a stacking layer

of LiF/ Al cathode were evaporated. The structure of OLEDs was ITO (160 nm)/ PEDOT: PSS (50 nm)/ Emission layer (60 nm) Ink/ BCP (15 nm)/ Alq_3 (10 nm)/ LiF (0.8 nm)/ Al (70 nm). Figure 1 shows the structure of OLEDs using spin-coating and IJP. Characteristics of current density versus voltage (*J-V*) and luminance versus current density (*L-J*) were measured using a semiconductor parameter analyzer and a luminance meter, respectively. The electroluminescence (EL) spectrum was measured with a spectrometer and CIE chromaticity coordinates calculated wavelength of the emission measured spectrum and the luminescence intensity.

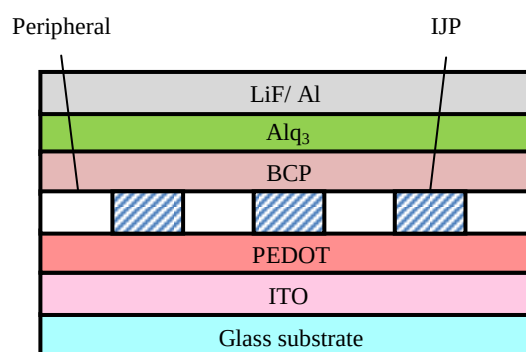


Fig.1 Device structure of coating/IJP device.

3. Results and Discussion

Figures 2 and 3 show *J-V* and *L-J* characteristics of devices for all of combination of emission materials, respectively. Figures 4 and 5 show emission spectrum and CIE chromaticity coordinates when using red peripheral region and green IJP region. Figure 5 and 6 also show an emission spectrum and CIE chromaticity coordinates using red peripheral region and blue IJP region. From the *J-V* and *L-J* characteristics, device characteristics were almost identical. By increasing the voltage, green emission at IJP region was observed. At chromaticity coordinates, it is confirmed that chromaticity approached white color emission. However, it is also observed that both of peripheral region and IJP region were emitted green color. This is due to the mixing of solvent after IJP was occurred at all over the region. The luminance of 643 cd/m^2 was achieved at current density of 319 mA/cm^2 and voltage of 11 V.

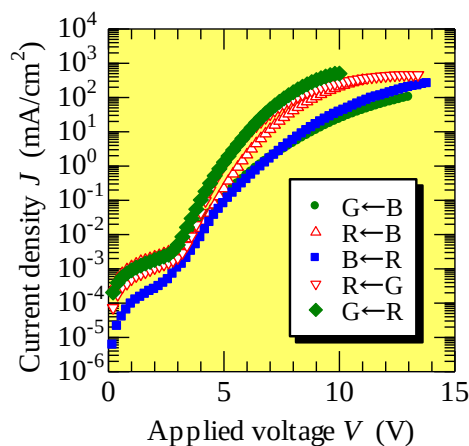


Fig.2 J-V characteristics.

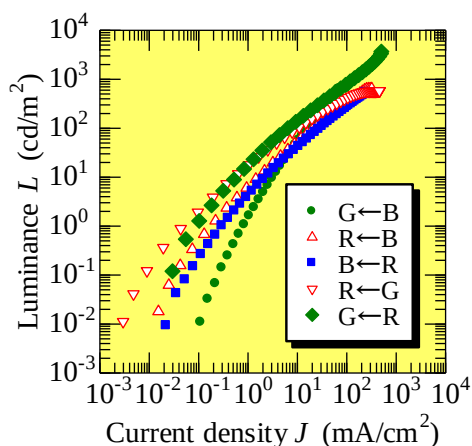


Fig.3 L-J characteristics.

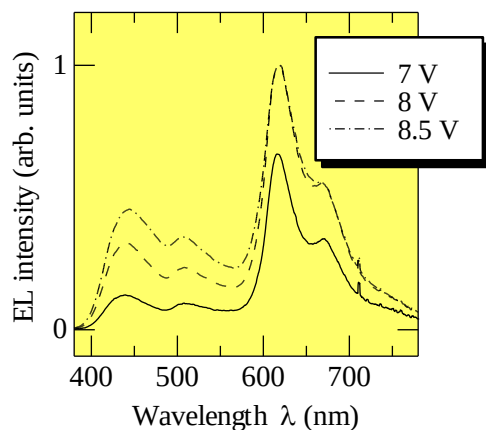


Fig.4 Emission spectrum (RG).

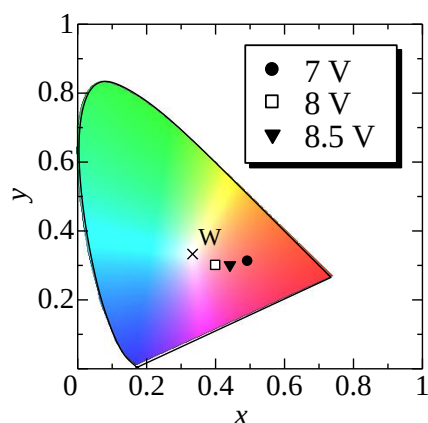


Fig.5 CIE chromaticity coordinates (RG).

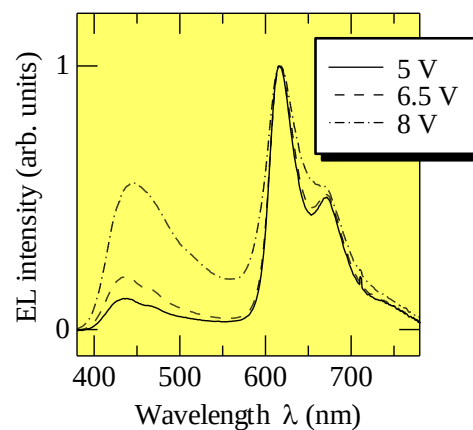


Fig.6 Emission spectrum (RB).

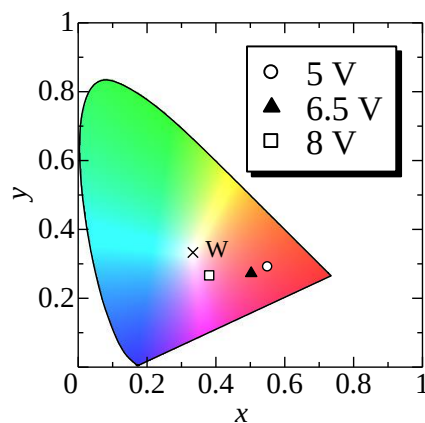


Fig.7 CIE chromaticity coordinates (RB).

4. Conclusions

We had investigated variety of emission color control for coating and self-aligned ink-jet printed small molecules organic light-emitting diodes. Different color emission was confirmed periphery and IJP region gradually as it increased voltage. It is confirmed that color approached white color from CIE chromaticity coordinates. Brightest device characteristics are that current density and luminance were 643 cd/m^2 at 319 mA/cm^2 and 11 V.

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