Effect of the location of dye-doped layers on the electroluminescence characteristics of white organic emitting

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Abstract

We fabricated white organic light emitting diodes consisting of three emitting layers of red-emitting DCM2 doped α-NPD, blue-emitting DPVBi and green-emitting C545T doped Alq3. By optimizing the thickness of the hole-transport layer of α-NPD and the electron-transport layer of Alq3, efficient white OLEDs were obtained with a luminous efficiency of 4.40lm/W at luminance of 1000cd/m^2, and a max-imum luminance of 51,939 cd/m^2

1. Introduction

Organic light-emitting diodes (OLEDs) have many attentions as a display technology with superior characteristics. OLEDs have advantages such as thiness and lightness. Wide viewing angle and hight contrast ratio also makes OLEDs one of the promising technologies. The optimization of OLEDs structure is one of important issues for a high efficiency. Careful control of the thickness of device is needed to obtain the high effiency.

White organic light-emitting diodes are very good for their applications to a full-color display, a thin backlight for liguid crystal displays, an illuminator for a good white lightening source, and other solid-state light sources. White light emission can be obtained by several methods. One method is doping a polymer host with red, blue, and greem fluorescent dyes or blending some light-emitting polymers [1-3]. Another method is by mixing two complementary colors or three primary colors from different emitting materials [4-7]. In terms of materials, there are two ways to fabricating OLEDs. White light emitting can be obtained with vapor deposition of several emitting layer for low molecules. Spin-coating high molecules with several dyes is another method for white lightening.

In this paper, we tried to optimize the performance of the white OLED through the systematic study of the effect of the dye doped position on the electrolu-minance (EL) spectra and the luminous efficiency.

2. Results

We fabricated white organic light-emitting diodes using a hole transport layer of 4,4'bis[N-(1-napthyl)-N-phenyl-amino]-biphenyl (α-NPD), α-NPD doped with a red fluorescent dye of 4-dicyanomethylene-2-methyl-6-[2-(2,3,6,7-tetrahydro-1H,5H-benzo[i,j] quinolizin-8-yl) vinyl]-4H-pyran) (DCM2), a blue emitting layer of 1,4-bis(2,2-diphenyl vinyl)benzene (DPVBi), tris(8-hydroxyquinoline) aluminum (Alq3) doped with 10-(2-Benzothiazolyl)-2,3,6,7-tetrahydro-1,1,7,7,-tetramethyl l-1H,5H,11H-[1]benzopyrano [6,7,8-ij]quinolizin-11-one (C545T), and a electron transport layer of Alq3. LiF and PEDOT:PSS were used to improve the carrier injection at cathode and anode, respectively.

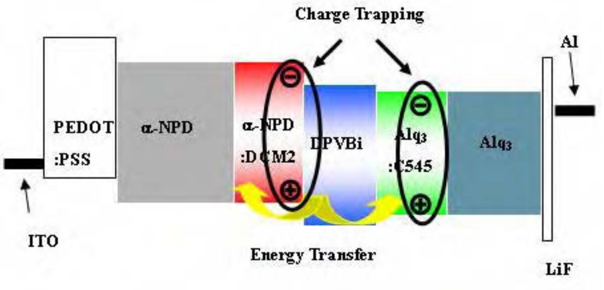

Figure 1. Proposed energy level diagram of white organic light emitting device

Fig. 1 shows the energy level diagram of this device. HTL in front of blue emitting layer is located near the place which gives exciton energy. Electrons from the cathode and holes are deposited HTL and blue emitting layer interface. So, if we doped DCM2 in HTL, Föster energy transfer and charge trapping effect can be enhanced. On the contrary, C545T has more Föster energy transfer than DCM2, and C545T is placed in ETL, which is somewhat far from where gives exciton energy. The specific structure is shown in fig. 2. With this structure, we optimized the device by changing thickness of ETL and HTL.

Figure 2. The device structure of WOLEDs

Fig. 3 indicates the EL spectra in different width of ETL. Assumed that total reflection is occurred at Al cathode, constructive interference took the maximum value at the length between cathode and EML is exactly a quarter of luminance wavelength. From the fact, Constructive interference of green light in the vicinity of 510nm will be higher when the distance between green emitting layer and cathode is about 75nm. That makes the intensity of green light at 510nm higher as ETL is thicker in this experiment.

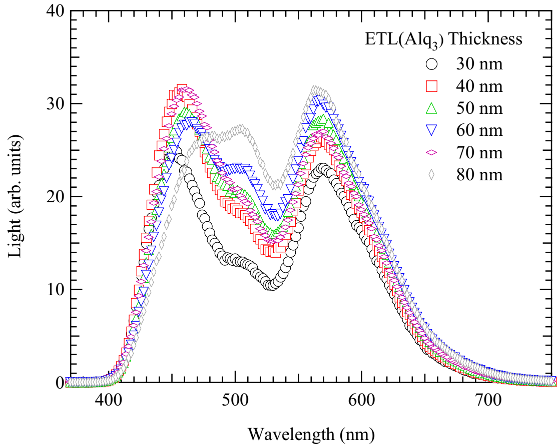

Figure 3. EL spectra with different width of ETL

Fig. 4 and Fig. 5 shows the quantum and power efficiency of different width of ETL. Considering the condition of constructive interference, it is expected that maximum power efficiency can be obtained at the width of ETL about 70nm or 80nm. But, the voltage rise due to increase of width degraded the power efficiency. So we can obtain the maximum power efficiency at the width of ETL about 60nm. The external efficiency and luminance efficiency are 2.53%, and 4.40lm/W, respectively at a luminance of 1000cd/m^2. The maximum luminance is 51,939cd/m2 and CRI(Color Rendering Index) is 73.15.

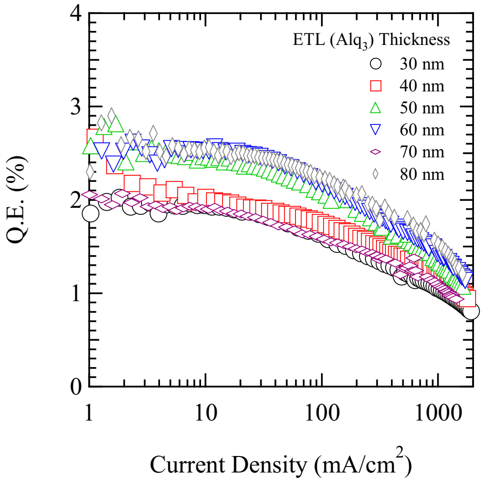

Figure 4. The external efficiency of devices with the different thickness of ETL

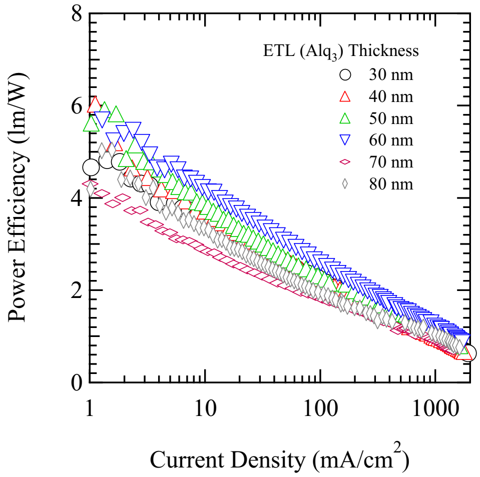

Figure 5. . The power effiency of the devices with different width of ETL

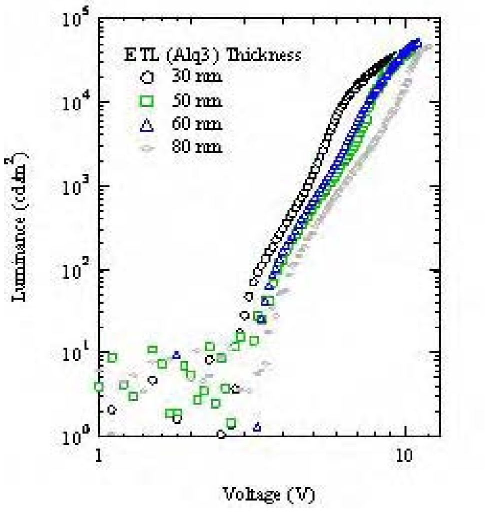

Figure 6. The luminance of devices with different width of ETL

Letting the thickness of ETL 60nm, we ranged the thickness of HTL from 30nm to 80nm for more efficiency. The external efficiency and the power efficiency are shown in fig. 7 and fig. 8. There is no correlation between the thickness of HTL and the distance between the emitting layer and the cathode. Also the thickness of HTL is independent of the constructive interference within the emitting layer. In summary, the luminance efficiency is decreasing while the thickness of HTL is increasing.

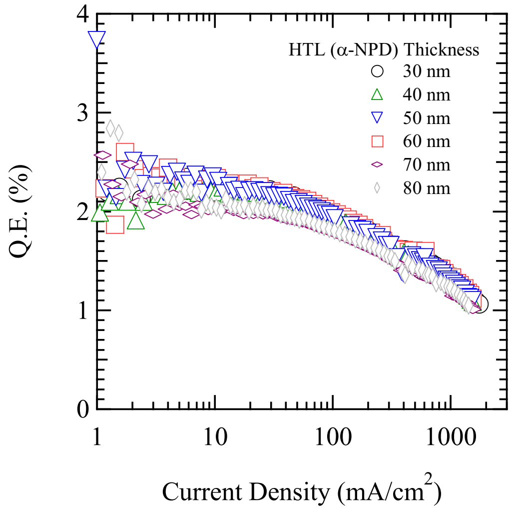

Figure 7. The quantum efficiency of devices with different width of HTL

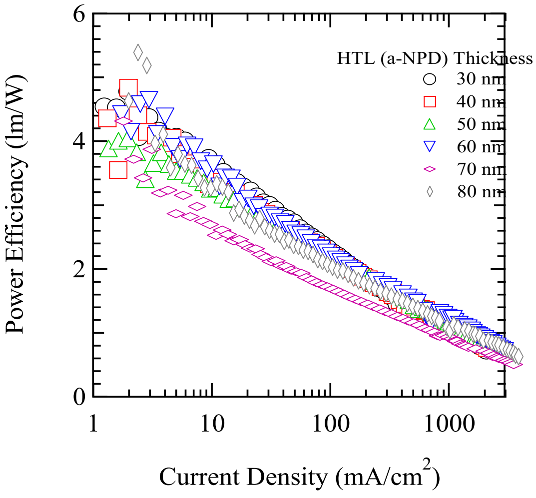

Figure 8. The power efficiency of devices with different width of HTL

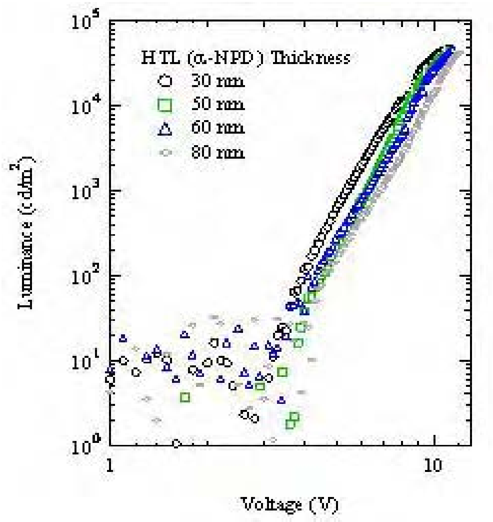

Figure 9. The luminance of devices with different width of HTL

3. Conclusion

In this report, we fabricated the white organic light diodes consisting of three emitting layers doped with DCM2, DPVBi, and C545T. This WOLEDs are optimized the thickness of the hole-transport layer of α-NPD and the electron-transport layer of Alq3 for enhancement of efficiency. It can contribute to fabricate efficient WOLEDs.

4. Acknowledgements

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5. References

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