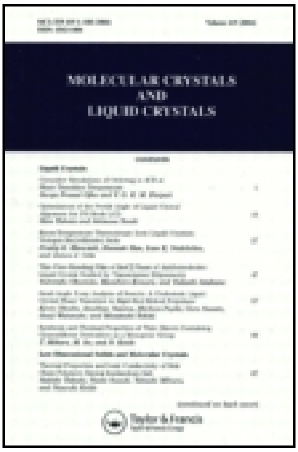

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Effects of Buffer Layer in Organic Light-Emitting Diodes

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Effects of Buffer Layer in Organic Light-Emitting Diodes

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We have seen the effects of buffer layer in organic light-emitting diodes using poly(vinyl carbazole)(PVK), copper phthalocyanine(CuPc) and poly(3,4-ethylenedioxythiophene):poly(styrene sulfonate)(PEDOT:PSS) in a device structure of ITO/buffer/TPD/Alq_3/Al. We have obtained an improvement of external quantum efficiency by a factor of four when the PVK layer is used. The PEDOT:PSS layer not only gives an improvement of efficiency by a factor two, but reduces an operating voltage as well.

Keywords; External quantum efficiency; Buffer layer; OLEDs

INTRODUCTION

In 1987, Tang and VanSlyke reported a bilayer organic electroluminescent (EL) cell structure, which has a quantum efficiency of about 1 % and a luminance of 1,000 cd/m^2 for green light under the low-operating voltage below 10V[1]. An intensive research is going on to improve the device efficiency using the buffer layer, different electrodes, and etc. By using the buffer layer, the charge-injection can be controlled and the stability could be improved[2-3]. In this paper, we report the effects of PVK, CuPc, and PEDOT:PSS layer in organic light-emitting diodes(OLEDs) based on TPD/Alq_3 thin film by investigating current-voltage, luminance-voltage characteristics and external quantum efficiency.

EXPERIMENTALS

We have used N,N′-diphenyl-N,N′-bis(3-methylphenyl)-1,1′-biphenyl-4,4′-diamine(TPD) as a hole-transport and 8-hydroxyquinoline aluminum(Alq_3) as an electron transport and emissive material. Two device structures were made to investigate the effects of buffer layer; one is ITO/TPD/Alq_3/Al as a reference and the other is ITO/buffer/ TPD/Alq_3/Al.

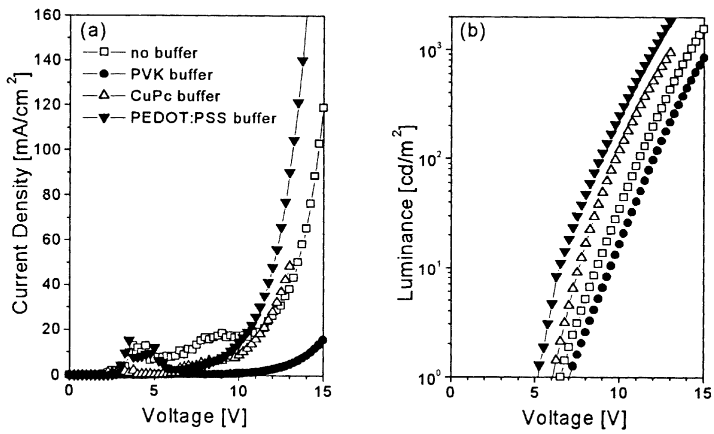

FIGURE 1 (a) Current-voltage characteristics and (b) luminance voltage characteristics of ITO/buffer/TPD/Alq_3/Al devices.

Polymer PVK and PEDOT:PSS buffer layer was fabricated onto pre-cleaned ITO by static spin-casting method in the range of 2000 ~ 6000 rpm using photo-resist spinner of Headway Research Inc. The film thickness of CuPc was made to be 5, 15, 25, 35nm, and that of TPD and Alq_3 was 40nm and 60nm, respectively. Current-voltage and luminance-voltage characteristics of OLEDs were measured using Keithley 236 source-measure unit, 617 electrometer and Si-photodiode. The external quantum efficiency was calculated based on the luminance, EL spectrum and current densities.

RESULTS AND DISCUSSION

Figure 1 shows a current-voltage and luminance-voltage characteristics of ITO/TPD/Alq_3/Al (reference) and ITO/buffer/TPD/Alq_3/Al devices. All devices show green light emission with a peak at 506nm, characteristic of Alq_3. As the voltage increases above 5V, the current density and the luminance start to increase rapidly and there occurs a light emission.

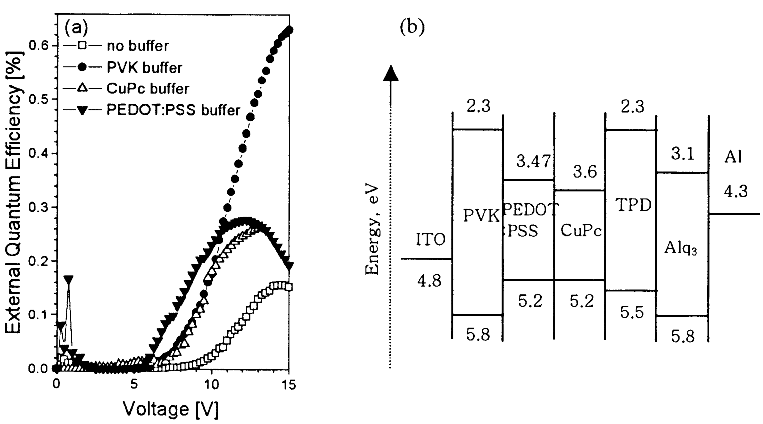

FIGURE 2 (a) External quantum efficiency-voltage characteristics and (b) schematic energy-level diagram of the OLEDs.

The external quantum efficiency of device was calculated using Figure 1. As shown in Fig. 2(a) for PVK buffer layer, the external quantum efficiency starts to increase from 5V and reaches a maximum near 15V. While the maximum efficiency of reference device(without buffer layer) is close to 0.15 %, the maximum efficiency of device with PVK layer is about 0.6 %. That is, there is a significant enhancement of efficiency by a factor of four. For devices with CuPc and PEDOT:PSS buffer layer when compared to reference device, there is an improvement of efficiency by a factor of two. These improvements could be understood by energy-level diagram drawn in Fig. 2(b). By adjusting the barrier-height in anode, we were able to control the luminance and the efficiency of OLEDs. The device with PEDOT:PSS layer not only gives an improvement of efficiency but also reduces the operating voltage as well.

CONCLUSION

We have fabricated the efficient OLEDs using the PVK, CuPc, and PEDOT:PSS buffer layer in a device structure of ITO/buffer/TPD/Alq_3/Al. We have obtained an improvement of luminance and the external quantum efficiency by using those buffer layers. This improvement of performance could be achieved by using the buffer layer which works as either hole-blocking or hole-injection supportive layer.

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