

Effects of Buffer Layer in Organic Light-Emitting Diodes Using Poly(N-vinylcarbazole)

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Abstract : We have seen the effects of buffer layer in organic light-emitting diodes using poly(N-vinylcarbazole)(PVK). Polymer PVK buffer layer was made using static spin-casting method. Two device structures were made; one is ITO/TPD/Alq3/Al as a reference and the other is ITO/PVK/TPD/Alq3/Al to see the effects of buffer layer in organic light-emitting diodes. Current-voltage characteristics, luminance-voltage characteristics and luminous efficiency were measured with a variation of spin-casting speeds. We have obtained an improvement of luminous efficiency by a factor of two and half when the PVK buffer layer is used.

Keywords : *buffer layer, poly(N-vinylcarbazole), luminous efficiency, organic light-emitting diodes.*

1. Introduction

Organic light-emitting diodes have received attention because of potential application to full color flat-panel display. They are attractive because of low-driving voltage and capability of multicolor emission by the selection of emissive materials [1-5]. In 1987, Tang et al., reported a stacked electroluminescent(EL) cell structure, which has a luminous efficiency of 1.5 lm/W and a luminance of 1,000 cd/m² for green light under the low-operating voltage below 10V[6].

In order to enhance the performance of organic light-emitting diodes, some organic materials are adopted for hole-injection buffer

layer inserted between indium-tin oxide(ITO) anode and the emissive layer. Copper phthalocyanine(CuPc), PEDOT, starburst amines and polyaniline(PANI) are the common hole-injection buffer layer materials[4]. The buffer layer is used to improve the performance of organic light-emitting diodes in several aspects, such as a good mechanical contact, energy band adjustment, suppressing noisy leakage current, reducing the operating voltage, and enhancing the thermal stability and quantum efficiency. However, a unique buffer layer that can efficiently provides all the above mentioned functions is yet to be found.

There is a report that the CuPc buffer layer in OLEDs improves the electrical

stability of the organic light-emitting diodes based on Alq3 thin films[7]. The CuPc layer prevents the organic light-emitting diodes from deteriorating of the organics as well as the electrode layers[8]. Not many studies have been done regarding on the effects of poly(N-vinylcarbazole)(PVK) buffer layer in organic light-emitting diodes.

In this paper, we have studied the effects of PVK buffer layer in organic light-emitting diodes based on Alq3 thin films by investigating current-voltage characteristics, luminance-voltage characteristics and luminous efficiency.

2. Experimental

We have fabricated the organic light-emitting diodes with a use of well-known emissive material, 8-hydroxyquinoline aluminum(Alq3). Indium-tin-oxide(ITO) glass, having a sheet resistance of 15/ and 170nm thick, was received from Samsung Corning Co.

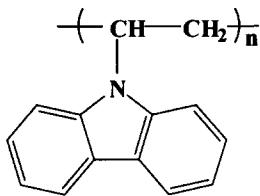


Fig. 1. Molecular structure of organic material PVK which is used as a buffer layer.

Fig. 1 shows a structure of PVK molecule. Polymer PVK buffer layer has been fabricated by static spin-casting method in the range of 1000 ~ 5000 rpm. And then the organic materials were successively evaporated onto pre-cleaned ITO at 10⁻⁶ torr, and Al cathode was deposited at 1.010⁻⁵ torr. Light-emitting area was defined by using a shadow mask to be 0.30.5 cm². Two device structures were made; one is ITO/TPD/Alq3/Al as a

reference and the other is ITO/PVK/TPD/Alq3/Al to investigate the effects of buffer layer. A 0.1 wt% PVK solution was made with a solvent of dichloro ethane. Current-voltage characteristics, luminance-voltage characteristics, and luminous efficiency of organic light-emitting diodes were measured using Keithley 236 SMU electrometer and Minolta CS-100 chroma meter. Luminous efficiency was calculated based on the luminance, electroluminescent spectra and current densities.

3. Results and Discussion

Fig. 2(a) shows typical nonlinear current-voltage characteristics of ITO/TPD/Alq3/Al (reference) and ITO/PVK/TPD/Alq3/Al devices with several different spin-casting speeds for PVK layer. The spin-casting speed refers to the thickness of PVK layer. As the spin-casting speed increases, the thickness of the film decreases due to a centripetal force acting on the film. Fig. 2(b) is a luminance of device depending on the applied voltage. As the voltage increases above 5V, the current density starts to increase rapidly and there occurs a green-light emission.

Using Fig. 2(a) and (b), luminous efficiency was calculated. As is seen in Fig. 3, the luminous efficiency starts to increase from 5V and becomes a maximum near 10 ~12V. As the thickness of PVK layer becomes thicker, the luminous efficiency becomes higher. This reflects that the PVK buffer layer affects on the hole injection from the ITO. While the maximum efficiency of reference device(without PVK layer) is close to 0.1 lm/W, the maximum efficiency of device with PVK layer is about 0.25 lm/W. That is, there is an improvement of efficiency by factor two and half. Thus, the PVK buffer layer is a useful hole-injection buffer to enhance the device performance.

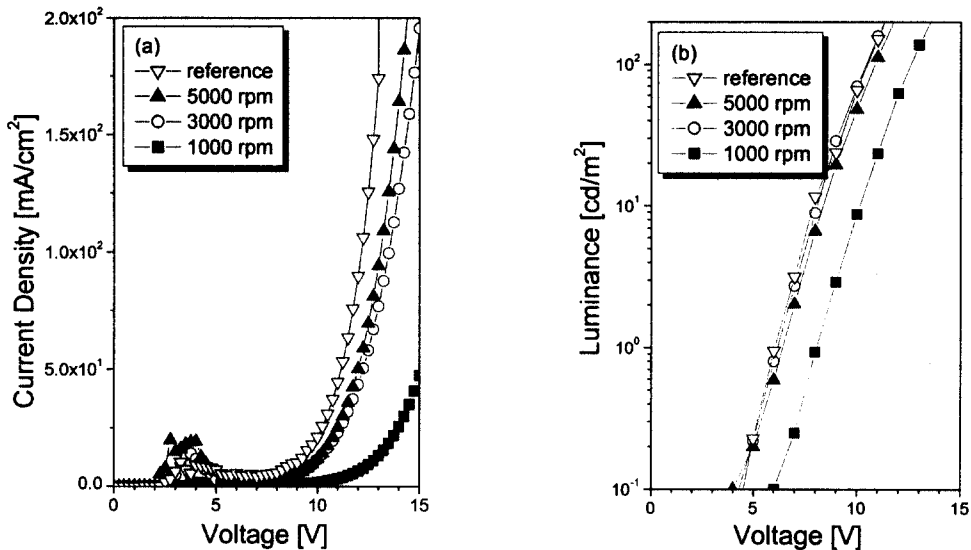


Fig. 2. (a) Current-voltage characteristics and (b) luminance-voltage characteristics of ITO/PVK/TPD/Alq₃/Al devices.

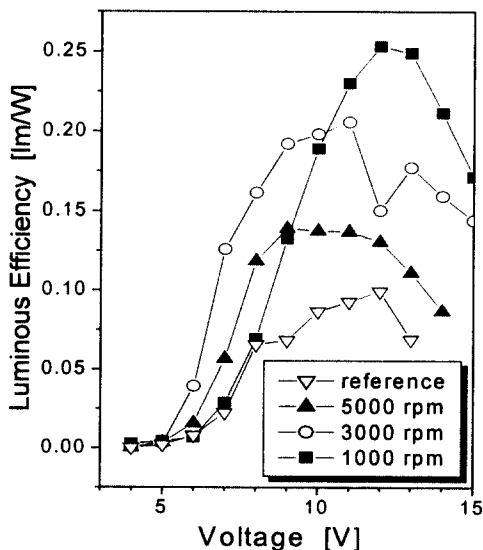


Fig. 3. Luminous efficiency-voltage characteristics of ITO/PVK/TPD/Alq₃/Al devices.

4. Conclusion

We have fabricated the efficient OLEDs using the PVK hole-injection buffer layer in a device structure of ITO/PVK/TPD/Alq₃/Al. By using the PVK buffer layer, the luminous efficiency of device has improved by factor of two and half. We are going to study further how the buffer layer affects on the stability of the device.

Acknowledgments

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