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Improvements in the Characteristics of Blue Polymer Light-emitting Diodes by Polymer Hole Transport Layer

Jian Li, Takeshi Sano, Yasuko Hirayama, Taiji Tomita, Hiroyuki Fujii and Kenichiro Wakisaka

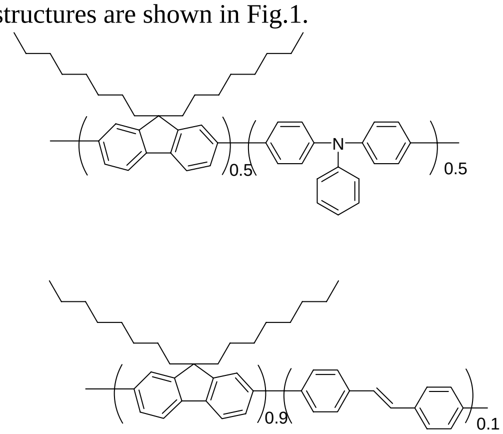
Photonics Devices Department ,Frontier Devices Research Center, SANYO Electric Co., Ltd., 1-18-13, Hashiridani, Hirakata-City, Osaka 573-8534 Japan
Phone: +81-72-841-1261 E-mail: lijian@rd.sanyo.co.jp

1. Introduction

One of the effective methods to improve the characteristics of organic light emitting diodes (OLED) such as the efficiency and life time is to make multilayer structure devices.[1,2] But in the polymer light emitting diodes(PLED) case, due to the good solubility in common solvents of the polymers, such as the fluorene copolymers, it is difficult to form multilayer structures without crosslinking the polymers. Although the post-reaction method [2] or the different solvents method [3] are the methods to make multilayer devices, the number of different polymers suitable for these methods are very limited . In this paper, by using UV crosslinking method, we have successfully made the multilayer blue PLED device with greatly improvements in the characteristics.

2. Experimental

The hole transporting material [4,5], fluorene-triphenyl amine copolymer[PF8-TPA(50%)]; the blue polymer, fluorene-stilbene copolymer, [PF8-SB(10%)] were synthesized according to the Suzuki coupling procedure. The chemical structures are shown in Fig.1.



PF8-TPA(50%)

PF8-SB(10%)

Fig.1. The chemical structures of the copolymers.

Fig.2 shows the device structures of the single layer and multilayer devices. The crosslinked hole transporting layer(HTL)was obtained by crosslinking the PF8-TPA(50%) through UV irradiation. The detailed crosslinking method will be published elsewhere. The PF8-SB(10%)(described as blue polymer) was used as blue emitting layer. This blue emitting layer was spin coated on the top of the crosslinked hole transporting layer to form a multilayer structure film. The thicknesses of the two layers were controlled to be about 25nm and 70nm, respectively. The devices were then made following common procedures. All the measurements were carried out in air at room temperature.

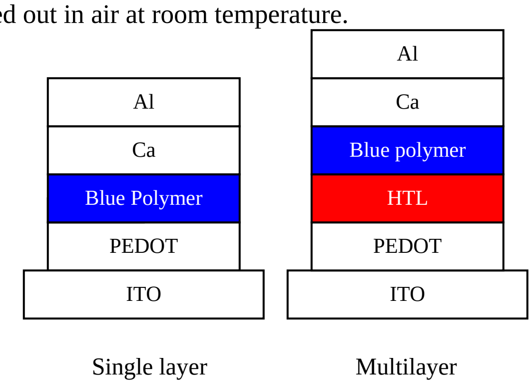


Fig.2 Device structures of the single-layer and multilayer devices.

3. Results and discussions

The photoluminescencee spectra of single layer and multilayer blue polymer film

Fig.3 is the photoluminescence spectra of the blue polymer films. It is found that both the single layer film and multilayer film which the blue polymer film was spincoated on the HTL have the same PL spectrum. This means that the crosslinked hole transporting layer does not affect the photo emission of the blue polymer.

The properties of the single layer and multilayer blue polymer devices

Although the hole transporting layer was crosslinked by the UV irradiation, it seems that the hole mobility in this layer was not greatly reduced and the hole can still go into the emitting layer. The emitting area is in the fluorene-stilbene copolymer layer not in the fluorene-TPA copolymer layer. Both the devices emitted blue light.

From Fig.4 and 5, it is found that the efficiency and luminance have been greatly increased by introducing the hole transport layer. This means that the hole transport layer makes the hole transporting from the PEDOT layer to the emitting layer more easily. The carrier balance in the emitting layer is improved. The efficiency and luminance are then greatly increased. Another possible reason is that the HTL can also block the electrons and thus increase the recombination ratio of electron and holes in the emitting layer.

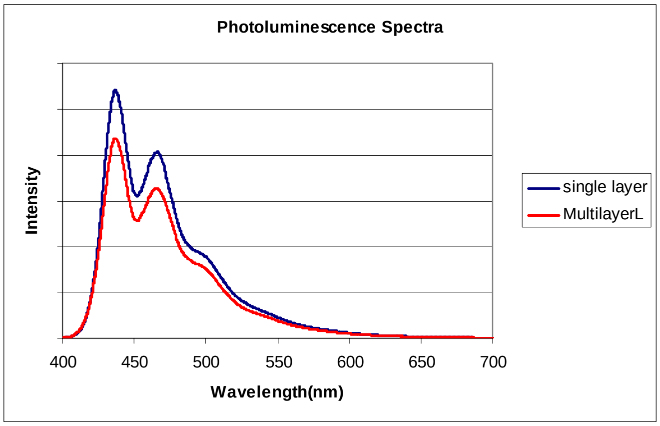


Fig.3 Photoluminescence spectra of the single layer film and multilayer film of blue polymer

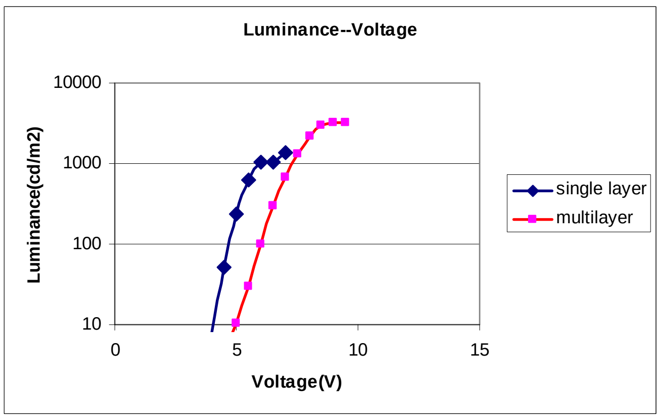


Fig.4 Luminance-voltage characteristics of the single-layer and multilayer devices.

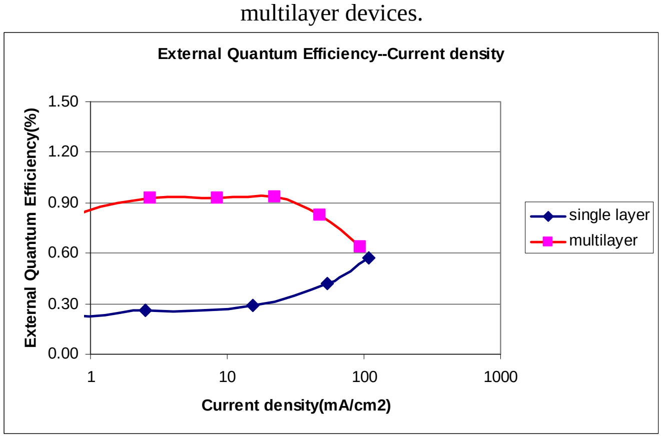


Fig.5 External quantum efficiency-current density characteristics of the single-layer and multilayer devices.

Llifetime test results of the single layer and the multilayer blue polymer devices

The lifetime of the blue multilayer device was given in Fig.6, together with that of single layer device as a reference.

From this Fig., we can find that the lifetime of the multilayer device is much longer than that of the single device although not as long as expected. We also found that by introducing the HTL, the life times of green and red devices can also be greatly increased. The reasons for the improvement of the lifetime by introducing the hole transport layer are like follows. Because of the hole transport layer, it increases the hole transporting into the emitting layer and the carrier balance in the emitting layer is improved. This better carrier balance reduces the degradation of the emitting polymer and increases the lifetime. Another possible reason may be because of the hole transporting layer, it prevent the impurities from PEDOT entering the emitting layer and increase the lifetime.

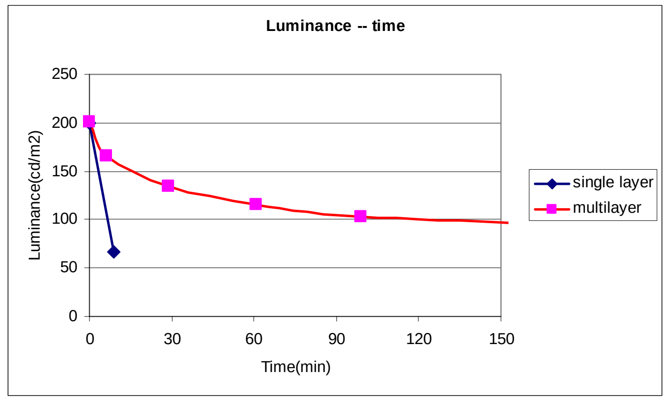


Fig.6 The life time test of the blue devices

4. Conclusion

UV irradiation crosslink method is found as an effective way to make the insoluble hole transporting layer. By introducing the hole transporting layer, the luminance, efficiency and life time of the blue device have been greatly increased because of the improvements of the carrier balance in the emitting layer.

Acknowledgments

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