

Bi-layer Gravure Printed Organic Light Emitting Layers with MEH-PPV and Rubrene

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Abstract

In this work, we have compared OLED devices made of blended MEH-PPV/Rubrene mixture and MEH-PPV/Rubrene bi-layer structure devices. The emission layers were made with two different ways – one with gravure printed single layer of blended mixture of MEH-PPV and rubrene, the other with gravure printed bi-layers of MEH-PPV and rubrene. Both brightness and efficiency with gravure printed bi-layer devices were higher than blended devices. In this work, we demonstrated that organic bi-layers can be formed with gravure printing technology and higher efficiency can be achieved with bi-layer structure than with blended single layer structure.

1. Introduction

Organic light emitting diodes (OLEDs) are considered attractive next generation flat panel displays. In OLED fabrication, printing technologies are getting attention due to their high productivity. Especially, gravure printing technology shows high throughput and relatively better resolution. Typically polymer light emitting materials are spin-coated with blended mixture. When polymer and small-molecule layer are combined together, typically polymer are spin-coated and small-molecule layers are evaporated.

In this work, we applied the gravure printing technology to organic light emitting diodes fabrications with MEH-PPV/rubrene. The comparison between blended layer and bi-layer type was carried out. Typically PLED with MEH-PPV is realized with single layer structure. Rubrene is often blended to improve properties of the carrier recombination and hole blocking. In this work we improved device characteristics of MEH-PPV/rubrene OLED devices with gravure printed bi-layer structure type.

2. Experimental

An OLED fabricated in this work has the layer structure of ITO/PEDOT:PSS/MEH-PPV/Rubrene (blended single layer or separate bi-layer)/LiF/Al. For the active layer formation, MEH-PPV (poly [2-methoxy-5-(2-ethylhexyloxy)-1,4-phenyleneinylene], Aldrich) and rubrene ((5,6,11,12)-Tetraphenyl-naphthacene, Gracel) were used in this work. MEH-PPV and rubrene was dissolved in a optimized solvent mixture. PEDOT:PSS ([Poly(3,4-ethylenedioxythiophene)-poly(styrene sulfonate)]) was spin-coated on the plasma treated ITO and baked. The MEH-PPV/rubrene layers were printed by gravure printing process. In this work, a lab-scale gravure printer was operated. The ink is supplied to the gravure roll and the ink in the gravure roll was directly transferred when the engraved gravure roll contact with the substrate or organic layer. And the thickness can be controlled by controlling viscosity or by multiple printing techniques. The active layers were printed with two different ways – one with gravure printed organic layer made of blended mixture of MEH-PPV and rubrene, the other with gravure printed rubrene on the top of gravure printed MEH-PPV. After the gravure printing of organic layers, thermal annealing treatment was carried out. 1nm thick LiF and 100nm thick Al layers were deposited respectively by the thermal evaporation process. The luminescence and current characteristics were measured with Spectro radio Meter (Model: CS-1000A).

3. Results and discussion

As the first step we measured the thickness of the various combinations of single- and bi-layers of

MEH-PPV and rubrene. With the solvent printing, the thickness of the layer is typically decreased little and roughness is reduced. This result shows that rubrene was successfully printed on the MEH-PPV layer without affecting MEM-PPV layer thickness much. Consequently, rubrene ink does not dissolve the under MEH-PPV layer in use the proper mix-solvent. Therefore, we have formed rubrene layers on the top of MEH-PPV. The thickness of the gravure printed rubrene layer on the top of MEH-PPV was increased with increased concentration of rubrene in the solution.

To compare the single and bi-layer structure similar thickness of devices were fabricated in 55nm and 77nm of organic layer thickness. For the 55nm thick layers, rubrene concentration was 0.10wt% and 0.33wt% rubrene solution was used for the 77nm thick devices. Overall the higher brightness and efficiency were obtained with 77nm thick devices. They were improved with increased concentration of rubrene. In both cases of 55nm and 77nm devices, bi-layer structure showed higher brightness as shown in Fig. 1. Lower current density was also observed with bi-layer structure devices.

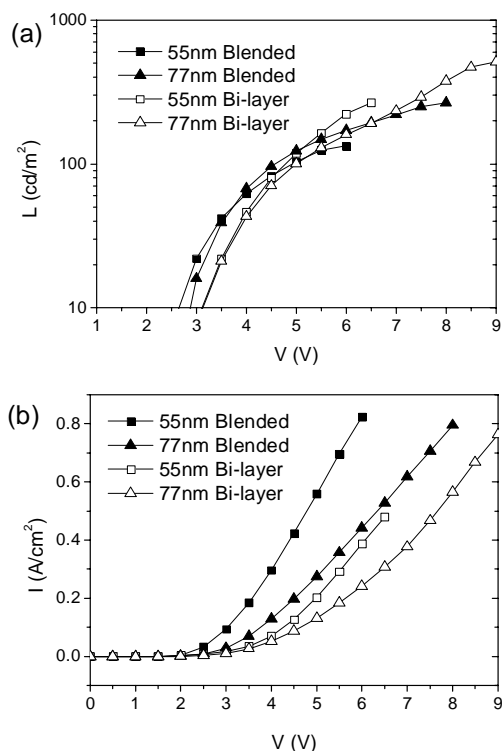


Fig. 1. The (a) luminescence and (b) current density characteristics of MEH-PPV and rubrene devices

The efficiency improvement was achieved by a factor of 3.2 with 55nm devices and by a factor of 1.6 with 77 nm as shown in Fig. 2. The electroluminescence spectrum of MEH-PPV layer overlaps the absorption spectrum of rubrene. The improvement of luminescence and efficiency was reported in bi-layer forming process with the combination of polymer spin-coating and small molecule evaporation processes. In this work we established bi-layers with gravure printing processes.

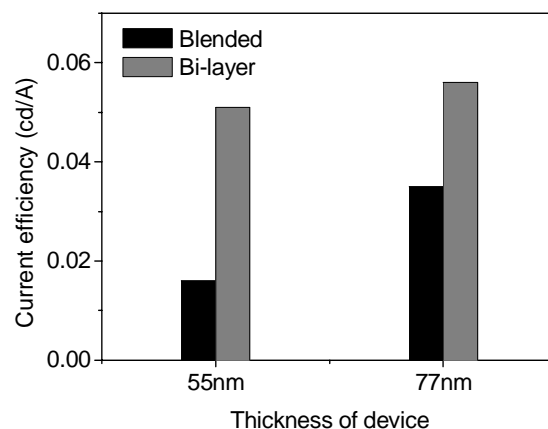


Fig. 2. The efficiency of bi-layer OLED and blended single layer OLED with 77nm and 50nm of thickness

4. Summary

This work shows that multi-layer organic structure can be formed with gravure printing. Small-molecule rubrene layer was also successfully printed on polymer layer. The OLED devices made of gravure printed bi-layered MEH-PPV/rubrene shows higher brightness and efficiency than blended single layer MEH-PPV/Rubrene structure. And this multi-layer structure can be applied various device fabrication scheme of polymer based organic light emitting diode displays.

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5. References

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