Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

Polymer Light-Emitting Diode with Ionic Material as an Electron Injecting and Hole Blocking Layer

Hyang-Mok Lee [a], Kang-Hoon Choi [a], Do-Hoon Hwang [a], Lee-Mi Do [a] & Taehyoung Zyung [a]

[a] Electronics and Telecommunications Research Institute, P. O. Box 106, Yusong, Taejon, 305-600, Korea

Version of record first published: 04 Oct 2006

To cite this article: Hyang-Mok Lee, Kang-Hoon Choi, Do-Hoon Hwang, Lee-Mi Do & Taehyoung Zyung (1998): Polymer Light-Emitting Diode with Ionic Material as an Electron Injecting and Hole Blocking Layer, Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals, 316:1, 277-280

To link to this article: http://dx.doi.org/10.1080/10587259808044508

Mol. Cryst. Liq. Cryst., 1998, Vol. 316, pp. 277–280
Reprints available directly from the publisher
Photocopying permitted by license only

Polymer Light-emitting Diode with Ionic Material as an Electron Injecting and Hole Blocking Layer

HYANG-MOK LEE, KANG-HOON CHOI, DO-HOON HWANG, LEE-MI DO, and TAEHYOUNG ZYUNG
Electronics and Telecommunications Research Institute, P. O. Box 106, Yusong, Taejon 305-600, KOREA

Light-emitting diodes (LEDs) of poly[2-methoxy-5-(2'-ethyl-hexyloxy)-1,4-phenylene vinylene] (MEH-PPV) were fabricated using sodium sulfonated polystyrene (SSPS) ionomer containing 10 mol% ionic groups as an electron injecting and hole blocking material. When a device was structured as ITO/MEH-PPV/SSPS/Al, the operating voltage was reduced by ~60 % and the relative quantum efficiency was thousand-fold enhanced compared with the corresponding single-layer MEH-PPV device.

Keywords: polymer LED; ionomer; electron injection; hole blocking

INTRODUCTION

Polymer electroluminescence (EL) devices have been developed for the application of flat panel display in the last several years[1], [2]. For the effective EL device, the hole and the electron should be combined with balanced injection and transport in the emissive layer. Unfortunately, most of the emissive polymers have low electron affinity and hence preferential hole-transporting property. There are two ways to solve the problem, where one is to use the cathode with low work function such as Li, Ca and Mg[3], and

the other to introduce the novel charge transporting material with high electron affinity[4]. As far as the stability of the device is concerned, the latter is likely more practical method. In this work, an ionomer was selected for the electron injecting and hole blocking material in the EL devices.

EXPERIMENTAL

A sodium sulfonated polystyrene (SSPS) ionomer containing 10 mol% ionic groups was prepared[5] and used as an electron injecting and hole blocking material. Four different polymer light-emitting devices of poly [2-methoxy-5-(2'-ethyl-hexyloxy)-1,4-phenylene vinylene] (MEH-PPV) were fabricated on indium-tin oxide (ITO) coated glass substrates; a single layer structure of (i) ITO/MEH-PPV/Al, and three two-layer structures of (ii) ITO/MEH-PPV/SSPS/Al, (iii) ITO/SSPS/MEH-PPV/Al and (iv) ITO/MEH-PPV/SSPS/Au. Thicknesses of MEH-PPV and SSPS were 60 nm and 15 nm, respectively.

RESULTS AND DISCUSSION

In order to figure out the role of SSPS ionomer layer in the device, I-V characteristics of all the devices were measured and shown in Fig. 1. It is seen that the ITO/MEH-PPV/SSPS/Al device turns on at a lower field compared with the corresponding single layer of MEH-PPV device. Threshold voltage of the ITO/MEH-PPV/SSPS/Al device for turn on was about 2 V. Increase of the current density is observed at the entire range of electric field indicating that the ionomer does indeed lead to a more electron injecting. This fact is strongly supported by I-V characteristics of ITO/MEH-PPV/SSPS/Au device, in which the relatively low work function Al cathode (4.3 eV) has been replaced by higher work function metal Au (5.2 eV). It is

observed that the ITO/MEH-PPV/SSPS/Au device has more current than the MEH-PPV single-layer device with Al cathode and ITO/MEH-PPV/Au device does not emit the light. This must be caused by more electron injecting through the ionomer layer. As a result, SSPS in the devices dramatically influence the device behavior and performance through enhanced recombination of the oppositely charged carriers to form excitons in MEH-PPV layer. Fig. 2 exhibits this obviously. On the other hand, it should be noted that the apparent electric field for appreciable current injection in ITO/SSPS/MEH-PPV/Al device is higher than any other devices. Since the SSPS ionomer has very high band gap of ~5 eV, it may be very difficult for the hole to be injected into the ionomer.

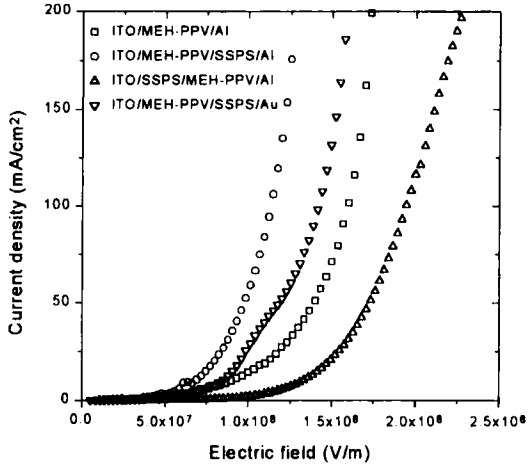

FIGURE 1. Current density vs. electric field characteristics for the devices with ionomer.

Figure 2 shows the variation of luminous power with current density for three devices. At low (~5 mA/cm^2) and high (~200 mA/cm^2) current densities, the light emission from the ITO/MEH-PPV/SSPS/Al is approximately 1000 and 100 times more efficient, respectively, than the corresponding single layer MEH-PPV device. In the inset, threshold voltage for detection of

visible light emission is as low as ~2 V for the ITO/MEH-PPV/SSPS/Al device, which is reduced by ~60 % compared with the ITO/MEH-PPV/Al.

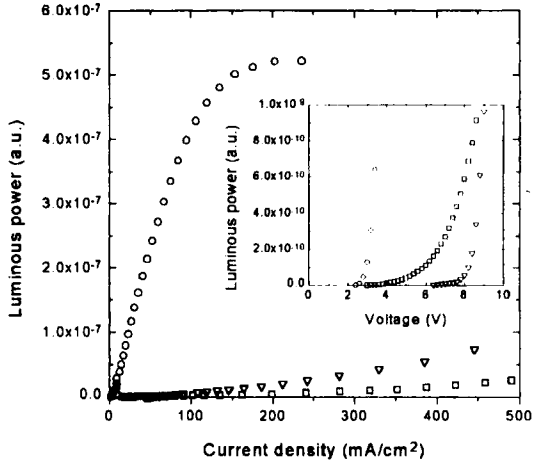

FIGURE 2. Luminous power vs. current density characteristics for the devices with ionomers; (□) ITO/MEH-PPV/Al, (○) ITO/MEH-PPV/SSPS/Al, (▽) ITO/MEH-PPV/SSPS/Au. The inset shows the luminous power-operated voltage characteristics for the corresponding devices.

In summary, we have investigated the polymer LED with SSPS ionomer used as an electron injecting and hole blocking layer. The performance of the ITO/MEH-PPV/SSPS/Al device was significantly enhanced due to the excellent electron injection and hole blocking of the ionomer.

References

[1.] J. H. Burroughes, D. D. C. Bradley, A. R. Brown, R. N. Marks, K. Mackay, R. H. Friend, P. L. Burn, and A. B. Holmes, Nature **347**, 539 (1990).
[2.] T. Zyung, and S.-D. Jung, ETRI journal **18**, 181 (1996).
[3.] I. D. Parker, J. Appl. Phys. **75**, 1659 (1994).
[4.] D. O'Brien, M. S. Weaver, D. G. Sidzey, and D. D. C. Bradely, Appl. Phys. Lett. **69**, 881 (1996).
[5.] J.-K. Park, B.-K. Park, and R. Ryoo, Polym. Eng. Sci. **31**, 873 (1991).