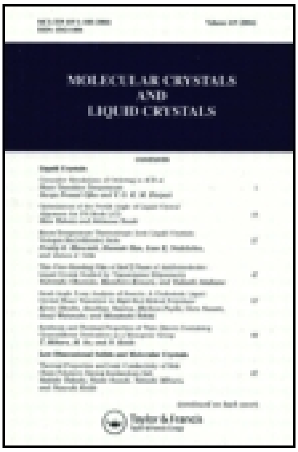

Molecular Crystals and Liquid Crystals
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl20

P-Deciphenylene Electroluminescent Device with a Carbon Nanotube Cathode

Chang Seoul [a] & Yong-Tae Kim [a]

[a] Department of Textile Engineering, Inha University, 253 Yonghyun-dong, Nam-gu, Incheon, 402-751, Korea

Version of record first published: 29 Oct 2010

To cite this article: Chang Seoul & Yong-Tae Kim (2002): P-Deciphenylene Electroluminescent Device with a Carbon Nanotube Cathode, Molecular Crystals and Liquid Crystals, 377:1, 89-92

To link to this article: http://dx.doi.org/10.1080/713738557

Mol. Cryst. Liq. Cryst., Vol. 377, pp. 89-92

1058-725X/02 $12.00 + .00
DOI: 10.1080/10587250290088618

P-Deciphenylene Electroluminescent Device with a Carbon Nanotube Cathode

CHANG SEOUL and YONG-TAE KIM

Department of Textile Engineering, Inha University, 253 Yonghyun-dong, Nam-gu, Incheon 402-751, Korea

Abstract

Carbon nanotube(CN) layer was formed as a cathode next to the p-deciphenylene emitting layer in the ITO/p-deciphenylene(P10)/Al electroluminescent device (ELD). The two devices have the same blue EL emission peak at about 450nm. The current density-voltage-luminance (J-V-L) characteristics were measured for the two devices and compared each other.

The ITO/P10/CN/Al ELD has higher luminance than ITO/P10/Al ELD at lower current densities. The quantum efficiency (QE) behavior for the two ELDs are nearly the same. CN cathode layer induces easy electron injection by lowing the barrier height due to its low work function.

Keywords: p-deciphenylene; carbon nanotubes; cathode; J-V-L characteristics

1. Introduction

The molar mass effect of p-phenylene oligomers was studied and the p-deciphenylene (designated as P10) was found to be the most efficient emitting oligomer in the p-phenylene homolog series. Thus we choose p-deciphenylene (P10) as the emitting material in this work.[1,2]

Romero et al.[3] fabricated multiwalled carbon nanotube(MWCN)/poly(phenylene vinylene)/Al device. They used MWCN as an anode and observed no light from the device but easy injection of holes at the MWCN anode.

Fournet et al.[4] reported that using a composite fabricated from carbon nanotube(CN)s with poly(m-phenylene-vinylene-co-2,5-dioctyloxy-p-phenylene-vinylene)(PmPV) as an electron transporting layer next to poly(2,5-dimethoxy-1,4-phenylene-vinylene-2-methoxy-5(2'-ethylhexyloxy)-1,4-phenylene-vinylene) (M3EH-PPV) layer enhanced the external quantum efficiency by 4 times the original efficiency of ITO/M3EH-PPV/Al electroluminescent device.

In this work, we report the effect of CN cathode on the performance of ITO/P10/Al ELD. The current density-voltage-luminance (J-V-L) characteristics of ITO/P10/CN/Al device were compared with that of ITO/P10/Al ELD. We also measured the electrical conductivities and EL spectra.

2. Experimental

2.1 Syntheses of Poly(p-deciphenylene) (P10)

Poly(p-deciphenylene) (P10) were synthesized by Yamamoto method.[1].

2.2 Single walled carbon nanotube (SWCN) and ELD fabrication

In this paper, we used SWCN. It was purchased from the CNI (Carbon Nanotechnologies Incorporated). SWCN layer (thickness of 10 micrometers) was formed by spraying the acetone solution on P10 layer and dried thoroughly. Then Al was deposited on CN layer for the secure attachment of CN layer and better electrical contact of CN layer.

2.3 EL spectra and J-V-L curves

The EL spectra was measured with a Shimadzu Spectrofluorophotometer(RF-540).

The device was mounted in a cryostat under room temperature. The J-V characteristics were measured with a Keithley 236 SourceMeter. The intensity of the EL emission from a device was simultaneously measured with a Keithley 2000 multimeter equipped with a calibrated Si photodiode(Hamamatsu Photonics) or an ARC P2 PMT through an ARC 275 monochromator.

3. Results and discussion

As a control, the ITO/P10/Al device was fabricated simultaneously and compared with ELD with CN cathode. The device area was 2mm x 2mm. In the beginning of the experiment, we intended to develop an ELD with CN emitting layer. They show near metallic conductivity. We changed the plan to develop the ELD with CN cathode. The conductivity for ITO/P10/Al and ITO/P10/CN/Al were $5.95*10^{-10}$ and $3.85*10^{-9}$ S/cm, respectively. Thus, device with SWCN cathode exhibited better electric conductivity.

Fig.1 shows the current-voltage (I-V) relation of the control and P10 ELD with SWCN cathode. The current of SWCN ELD rises at low voltages. The turn-on voltages of ITO/P10/CN/Al and ITO/P10/Al device are 8 and 10 volts, respectively. 2 volts difference was seen easily. The thickness of P10 layer and SWCN layer were about 150nm, 10μm, respectively.

The luminance-voltage (L-V) characteristics of ITO/P10/CN/Al and ITO/P10/CN/Al devices are shown in Fig.2. ITO/P10/CN/Al device has higher luminance at low voltages. But the voltage difference at the steep rising in luminance is less than 2 volts. The luminance evolution seems to be relatively easy for the ITO/P10/Al device.

In Fig.3, EL spectra for the two different devices measured at 3 mA are shown. They show the maximum EL peak at 450nm but only the maximum intensities differ. This means that CN cathode does not alter the emitting mechanism and only assists to easy injection of electrons through the low barrier height between the P10 and CN interface.ITO/P10/CN/Al emits brighter

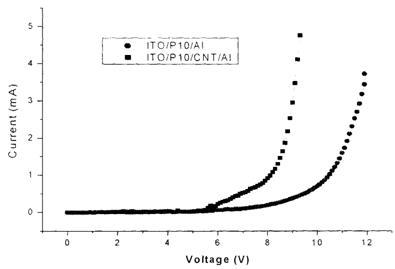

Figure. 1. The current-voltage characteristics of ITO/P10/Al (circle), ITO/P10/SWCN/Al (square) devices measured at room temperature.

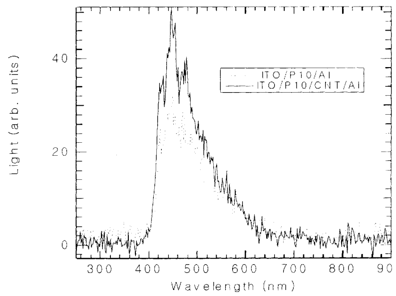

Figure. 3. The EL spectra of the ITO/P10/Al device (dotted line) and ITO/P10/SWCN/Al device (solid line) at room temperature.

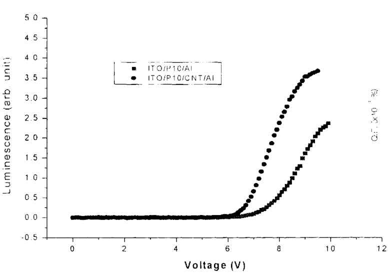

Figure. 2. The luminecence-voltage characteristics of ITO/P10/Al (square), ITO/P10/SWCN/Al (circle) devices measured at room temperature.

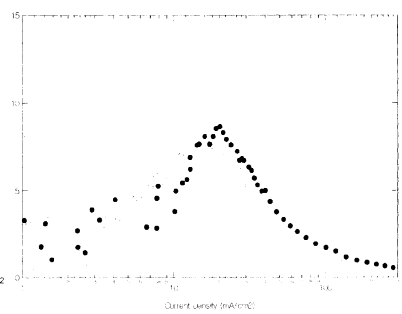

Figure. 4. The Quantum efficiency (QE) of the EL devices ITO/P10/Al (open circle), ITO/P10/SWCN/Al (filled circle).

blue light than ITO/P10/Al device at lower current densities.

The measured work function for MWCN is 4.9 +/- 0.3 eV and SWCN 3.7+/- 0.3 eV. This difference can be attributed to a size dependent reduction of the work function at the tube apex(tip, end).[5] The work function of Al was known to be 4.3 eV. Easy injection of electrons at CN cathode comes from the sole cause of low work function for SWCN. The 2[nd] possible cause is due to the large interface area between P10 and SWCN layer.

The external QE as a function of current density is shown in Fig. 4. They show the same trend, initial increase and then slow burn-out, The luminance was higher for CN cathode device at low current densities. But the Q.E. behavior as a function of current density has the same trend. The emitting surface has location in P10 layer and the CN cathode only assists to easy injection of electrons by lowering the barrier height between CN layer and P10 layer.

4. Conclusions

Carbon nanotube(CN) layer was used as a cathode and the effect of SWCN layer on the EL devices were studied. SWCN cathode layer only induce easy injection of electrons by lowering the barrier height between the SWCN layer and P10 emitting layer.

ITO/P10/SWCN/Al ELD emits brighter blue light than ITO/P10/Al device at lower current densities. The external QEs for the two devices are nearly the same. This means the emitting behavior does not altered by the incorporation of SWCN layer. SWCN layer only induces easy injection of electrons due to its low work function.

Acknowledgment

This research was supported by the 2000 year interdisciplinary program of the Inha University research funding.

References

1. W.J.Song, C.Seoul, G.W.Kang, C.H.Lee; *Syn.Met.* **114**, 355 (2000)

2. Chang Seoul, Won-Jun Song, Gi-Wook Kang, Changhee Lee, Proceedings of the 1[st] International Meeting on Information Display, Aug.29-31,2001, EXCO in Daegu, Korea, 633

3. D.B.Romero, M.Carrard,W.A.de Heer,L.Zuppiroli, *Adv. Mater.*,**8**,899(1996)

4. P. Fournet, D.F. O'Brien, J.N. Coleman, H.-H. Hoerhold, W.J. Blau, *Syn. Met.* **121**, 1683 (2001)

5. O.Groening,P.Groening,O.M.Kuettel, and L.Schlapbach, The abstracts of the sixth Foresight Conference on Molecular Nanotechnology, Nov.12-15,1998, Westin Hotel in Santa Clara,CA. [http://www.snf.ch/nfp/nfp36/progress/schlapbach.html]