Solid State Science and Technology, Vol. 19, No2 (2011) 200-206
ISSN 0128-7389

THE DEVICE PERFORMANCE DUE TO VARIATION OF PVK CONCENTRATION ACTED AS THE HOLE TRANSPORT LAYER THROUGH BLUE ORGANIC LIGHT EMITTING DIODE BY USING EMISSIVE LAYER DPVBI.

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ABSTRACT

Bi-layer devices of the structure ITO/PVK/DPVBi/Al with the thickness of 4,4'bis(2, 2'-diphenyl vinyl)-1,1' biphenyl (DPVBi) 56 nm were fabricated. In this study the performance of the device has been observed through variation in the Poly(9-vinylcarbazole) (PVK) concentration as the hole transport layer (HTL). The relation between PVK concentration and the threshold voltage, maximum voltage, and maximum current as well as luminance has been identified. The device performance was analyzed in the perspective of current voltage curved (I-V) and light intensity characteristic. From the result, the device with PVK concentration 0.7% showed the optimum performance at the threshold voltage 13.0 V and the maximum current achieved was 12.7 mV. The device is found to emit blue light spectrum centred at peak 371.92 nm with the maximum voltage 14 V, whereas the maximum luminous intensity with optimum luminance are 1.04×10^6 candela and 0.212 cd/m^2. DPVBi acted as the emissive EL layer was embedded by thermal evaporation while PVK film was prepared by spin coated technique.

Keywords: PVK concentration; thickness; threshold voltage; luminance; light spectrum;

INTRODUCTION

Organic light-emitting diodes (OLEDs) have been extensively studied due to their possible applications for flat panel colour displays and also their colour tunability, low operating voltages and ease of fabrication.[1,2] Meanwhile, OLEDs with high efficiency and long lifetime have been fabricated and small-size display screens made of OLEDs have been used in electronic gadget by the pioneer electronics industries. It is vital to studies on the basic problems in order to have a good understanding of the mechanisms in the devices and improve the performance of the OLEDs [1].

The basic OLED structure consists of one or two organic films between two electrodes, one of which must be transparent. In conventional OLEDs, to maintain a balance between electron and hole concentrations, one has to use a composite structure of two polymers, one as hole transporting layer (HTL) and the other as electron transporting layer (ETL) [4]. High brightness and efficiency depend on efficient and balanced recombination [5,6]. For the target of raising luminance efficiency, many technologies have been proposed such as, the usage of multi and mixed transport layers as well as optimizing the thickness of the ETL or HTL [7]. These bi-layer structure could reduce the voltage across the device, thus extend OLED life time.

The previous studies indicate that by changing the solution concentration used for spin-coating fabrication of conducting polymer improves the overall performance of devices by mean of the injection efficiency and mobility of the carriers [8]. These results are made possible by optimizing the structures and improving the materials. In this paper we report on the LED characteristics of a sandwich junction whose polymer layer HTL or PVK is changing in concentration, and thus the influence on threshold voltage and the luminous intensity of fabricated device. PVK or molecule formula of $C_{14}H_{11}N$ is due to carbazole derivatives have attracted much attention in OLED device fabrication due to their fine hole transporting capability, high charge carrier mobility and high photochemical stability [9]. Use of PVK provides an economy option since this material is well-known hole-transport material as well as an accommodating polymer host [10].

EXPERIMENTAL DETAILS

In this study a device which is due to variation of PVK concentration acted as the hole transport layer through blue organic light emitting diode by using emissive layer DPVBi has been well fabricated. 5 types of device were fabricated for comparison and analysis: Device 1: ITO/PVK (0.4%)/DPVBi/Al, Device 2: ITO/PVK (0.5%)/DPVBi/Al, Device 3: ITO/PVK (0.6%)/DPVBi/Al, Device 4: ITO/PVK (0.7%)/DPVBi/Al, and Device 5 ITO/PVK (0.8%)/DPVBi/Al.

The device as shown in Figure 1 consists of glass substrate coated with ITO. PVK layer is then deposited on that substrate by using spin coating technique at equivalent 2000 rpm at ambient temperature. The organic layer DPVBi and cathode Al with fixed thickness 56 nm and 130 nm were sequentially deposited by conventional vacuum vapour deposition on PVK layer respectively. The deposition rates for DPVBi are 0.5-1.0 A/s with the chamber pressure at 1×10^{-6} Torr. In addition, PVK concentration parameter is manipulated in the structure of these particular devices. The sources of light area for the fabricated devices are 4.9×10^{-6} m^2.

This study provides understanding of the effect of PVK concentration as the hole transport layer (HTL) on the luminescent performance of devices. The device performance was analyzed in the perspective of current voltage curved (I-V) and light intensity characteristic. The electroluminescent (EL) spectrum and the Commission International d'Eclairage (CIE) coordinates were measured by Photometer/ Radiometer

OL 730 CV, the current voltages luminance measurements were conducted by using Keithley System Model 238.

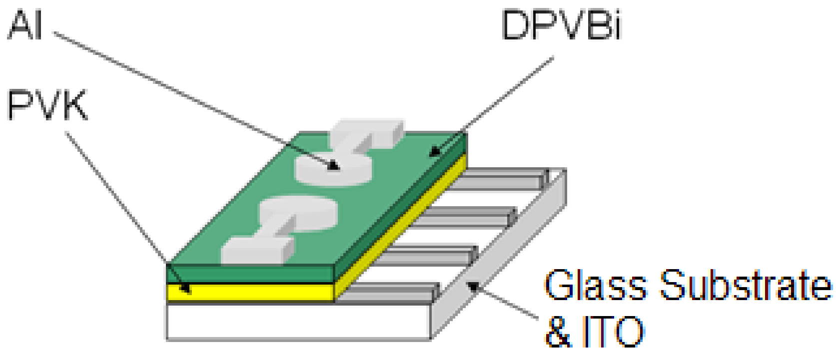


Figure 1: Device fabricated structure

RESULTS AND DISCUSSION

The fabricated devices with different PVK concentration (between 0.4% to 0.7%) show typical diode or rectifier behaviour. The ideal PVK concentration was identified to obtain optimum OLED performance via this particular characterization. The good rectifier characterization is based on unsymmetrical of I-V curve graph in forward bias condition and from the result the output current is increased dramatically with respect to the voltage values. Persist diode characteristic is violated when PVK concentration exceeds 0.8% through the observation of unstable formation of I-V curve graph.

Horst Vestweber (1997) reported that the significant decrease of current density and an increase in efficiency with increasing HTL thickness. Increment in PVK thickness is due to increasing of PVK concentration. This also contributes to raise the PVK layer density attributed from the formation of vast number of PVK molecules on ITO. The increase in efficiency with increasing PVK thickness implies an increase in charge balance factor which probably reduced hole injection efficiency [11]. Base on the result shown in Figure 2, increasing in PVK concentration acted as hole transporting layer will reduce the maximum current density thus proven that the PVK film concentration ranging from 0.4% to 0.7 % are good hole transport layer.

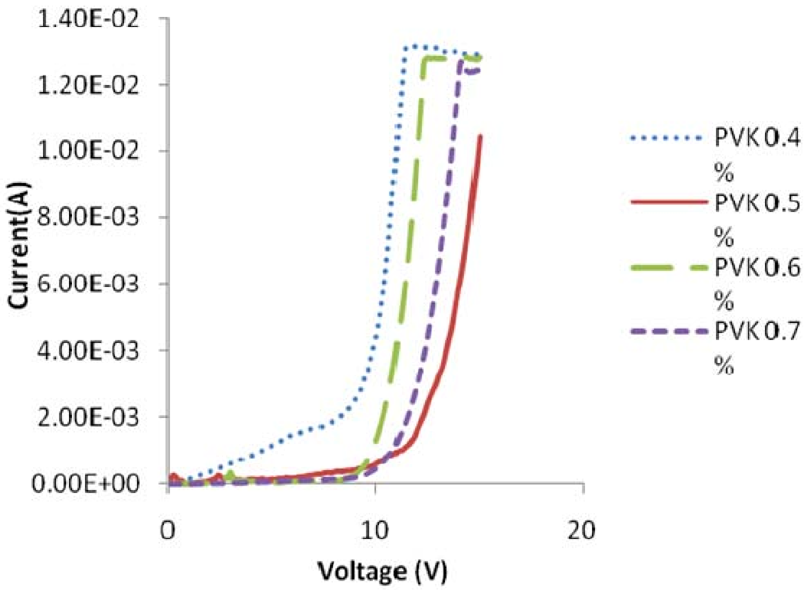


Figure 2: I-V curve graph varies to PVK layer concentration

The performances for the whole devices are attributed from several parameters due to threshold voltage, voltage at maximum luminance and maximum luminance value. Base on the Fowler-Nordheim tunnelling theory and data observation, the threshold voltage for the devices is increasing proportionally to the PVK concentration value as mention in Table 1. Increasing in PVK concentration in each device directly affected the increment of PVK thickness layer in the bi-layer structured device. This condition require the large amount of energy for the hole injection through the thicker PVK layer acted as HTL and consequently increase the turn on voltage value for the devices. For good OLED, it must be operated with minimum voltage [12]. The minimum threshold voltage recorded from the experiment is device 1 with value 10 V at luminance value of 0.018cd/m^2.

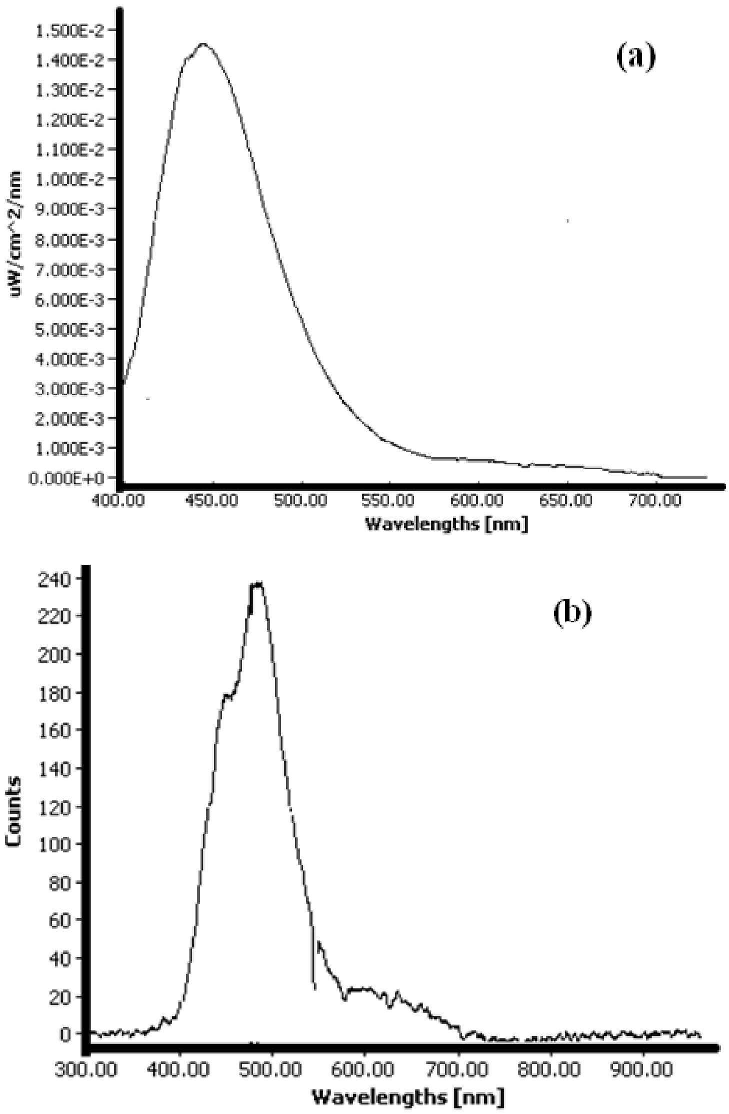
In comparison to other devices, PVK layer concentration at 0.7 % showed the optimum performance through threshold voltage 13 V at maximum current archive at 12.7 mA, whereas at the maximum voltage of 14 V, the luminance is generated in the blue spectrum at 371.92 nm. The maximum luminance produced from this device is 0.212 cd/m^2. Base on the current efficiency perspective, the ratio of luminous intensity to current density for the devices is increased continuously with respect to PVK concentration. Instead of reduction in current density and threshold voltage, increasing in luminous intensity is more dominant and apparent proportion to the increment of PVK concentration. The characterization implies to all five devices in this particular experiment signifies the incoming of vast number of PVK molecules in the HTL layer which increase the injection of large number of holes towards emissive layer. Recombination between several numbers of holes and electrons can be maximized to produce electroluminescent. This situation directly induce the rising in

Solid State Science and Technology, Vol. 19, No2 (2011) 200-206
ISSN 0128-7389

electroluminescent intensity due to increasing in PVK layer concentration acted as hole transporting layer and finally increase the device efficiency.

Table 1: PVK concentration effect on characterization parameters

PVK Concentration (%Wt)	Threshold Voltage (V)	Voltage at Maximum luminous, Vmax (V)	Maximum current Imax (A)	Maximum Luminance, Bmax (cd/m^2)	Wave Length (nm)	CIE Coordinate
0.4 %	10.0	11.40	0.0129	0.018	444.07	(0.144,0.094)
0.5 %	12.0	15.00	0.0104	0.061	482.84	(0.162,0.116)
0.6 %	12.0	12.45	0.0128	0.158	371.92	(0.167,0.117)
0.7 %	13.0	14.00	0.0127	0.212	371.92	(0.163,0.117)
0.8 %	-	-	-	-	-	-



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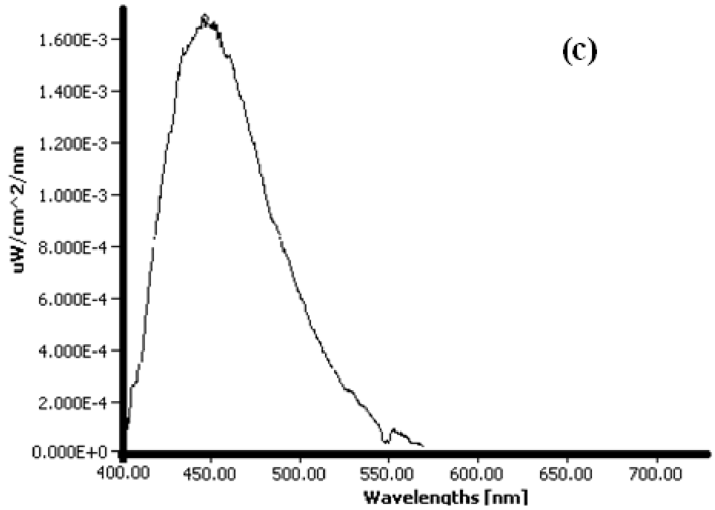

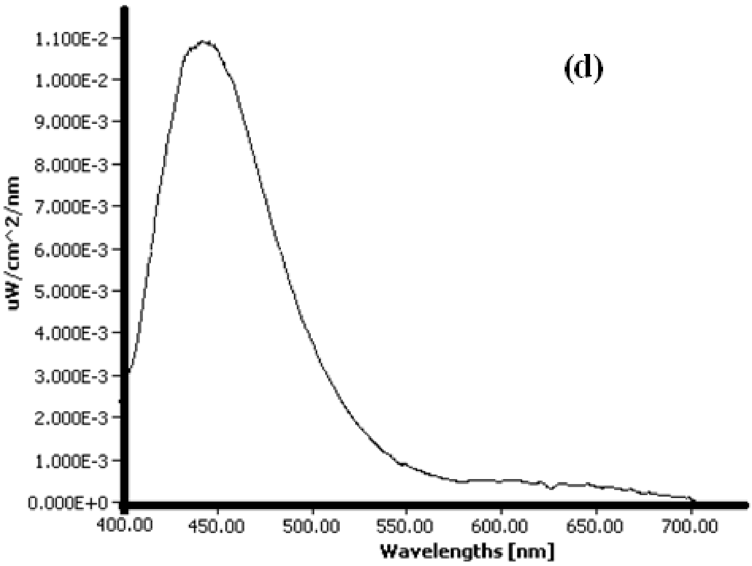

Figure 3: Light intensity vs. wave length at PVK concentration (a) 0.4%, (b) 0.5%, (c) 0.6%, (d) 0.7%

CONCLUSION

The result shows that by changing the sample concentration in the solution use for spin-coating fabrication of PVK will induce the thickness of the hole transporting layer. Increasing in PVK thickness attributed to the increase in the maximum and threshold voltage of the devices. The large amount of energy for the hole injection through the thicker PVK layer acted as HTL is required and consequently increase the voltage value across the devices. Increasing in PVK concentration prevail the reduction in maximum

ISSN 0128-7389

current density of the samples but generates significant luminance base on the direct proportion to luminance of the particular device. This condition indicates the presence of substantial amounts of PVK molecule that consequent a lot of holes to be transported and optimize the hole injection to emissive layer to produce optimum electroluminescent. Increasing of PVK thickness will lessen the maximum current density across the samples and thus reduced hole injection efficiency but at the same time increase the device luminance. The balance factor from this contradict situation causes the device 4 where the PVK layer concentration of 0.7% to be selected as the optimum performance device based on conducted characterization mention in the experiment.

ACKNOWLEDGEMENT

This work was funded by the School of Applied Physics, Faculty Science and Technology, Universiti Kebangsaan Malaysia.

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