Electro-optical Performance of OLED with MEH-PPV Fabricated by Solution Process

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ABSTRACT

We investigated the effects of solvents and concentration on the electro-optical performance of the organic light emitting diode (OLED) fabricated by the solution process. From the experimental results, we optimized the fabrication method of it and we figure out the underlying mechanism of carrier flow by the trap state.

1 INTRODUCTION

From the material viewpoint, organic light emitting diode (OLED) can be divided into two group: low molecular weight and high molecular weight. Generally, for OLED devices with the low molecular weight, they are fabricated by the vacuum process. On the other hand, for OLED devices with high molecular weight, the solution processes can be used to fabricate devices. The solution process has many advantages comparing to the vacuum processes, such as, mass production, low cost, and less time for the fabrication. However, the device efficiency by solution process is lower than that of by the vacuum process. [1] There are various attempts to increase the efficiency of the OLED device fabricated by the solution process. Many researches have been conducted on solution processes using low molecular weight, new materials, conjugation of low molecular weight and high molecular weight, molecular weight control, inverted structure, and all solution. [2]

(a) Space Charge Limited Current

The current density can be expressed by an electric potential difference, namely, an applied bias voltage, such as

$$J = g(V)V = g_l V^{l+1} \quad and \quad g_{l=} \frac{\sigma_0}{d}\left(\frac{l}{E_t d}\right)^l \quad (1)$$

Here, we define $g(V) = g_l V^l$ as an effective conductance per unit area with a dimension of A/(Vm^2). [3]
The flow of charge carriers are affected by the trap state. The trap charge concentration can be expressed by the Eq. 1.

$$n_t = N_t \exp(\frac{E_F}{k_B T_c}), (T_c = lT) \quad (2)$$

Here l is dimensionless quantity. When l=0, it reduces to the Ohm's law, when l=1, space charge limited current with no trap state. When l>1, it indicated the trap limited space charge limited currents. The value is also related to the temperature. According to the Eq. (1), because the temperature (T) is related to the concentration (n), the concentration of electrons and holes in the SCLC in the trap state can be influenced.

2 EXPERIMENT

In this study, we using MEH-PPV, Poly[2-methoxy-5-(2-ethylhexyloxy)-1,4-phenylenevinylene]. MEH-PPV was mixed into the three different solvents of toluene, chloroform, chlorobenzene with various concentration of 0.1, 0.5, and 1wt% by using a stirrer at 1200 rpm for 2 days. solution was coated on the substrates by the spin coating methods at 2000 rpm for 30 seconds and bar coating using 30 μm size. The coated device was put in a glove box anti-chamber, and the solvent was dried in a vacuum state for 12 hours. The coated layer on the electrode was removed by wiping with solvent. and dried at 50℃ for 30 minutes. we compared the electro-optical performance of the OLED by fabricated various conditions and optimized the best solvent and its concentration. The device performance was tested. In addition, we have optimized the efficiency of the device by the proposed coating method of the bar coating.

3 RESULTS

J-V curve of the fabricated device were measured. By fitting the measured date with the Eq. (1), we can find the effective conductance per unit area of each device. From the J-V curves in Figs.1 and 2, the fitting parameter of an effective conductance per unit area, g and parameter, l are summarized. The optimal concentration was confirmed to be 0.5 wt%, toluene was the best among the solvents. The effective conductance per unit area is 0.0835 and the parameter l is 3.20733. Although chloroform has a high effective conductance per unit area (g), but the error sigma value is too high in that the J-V characteristics does not show the diode

Table 1 Comparison of properties between spin coating and bar coating

Sample	V_{on}	J_{max}	L_{max}
Spin coating	4.5	1400	34.74
Bar coating	4	1400	35.95

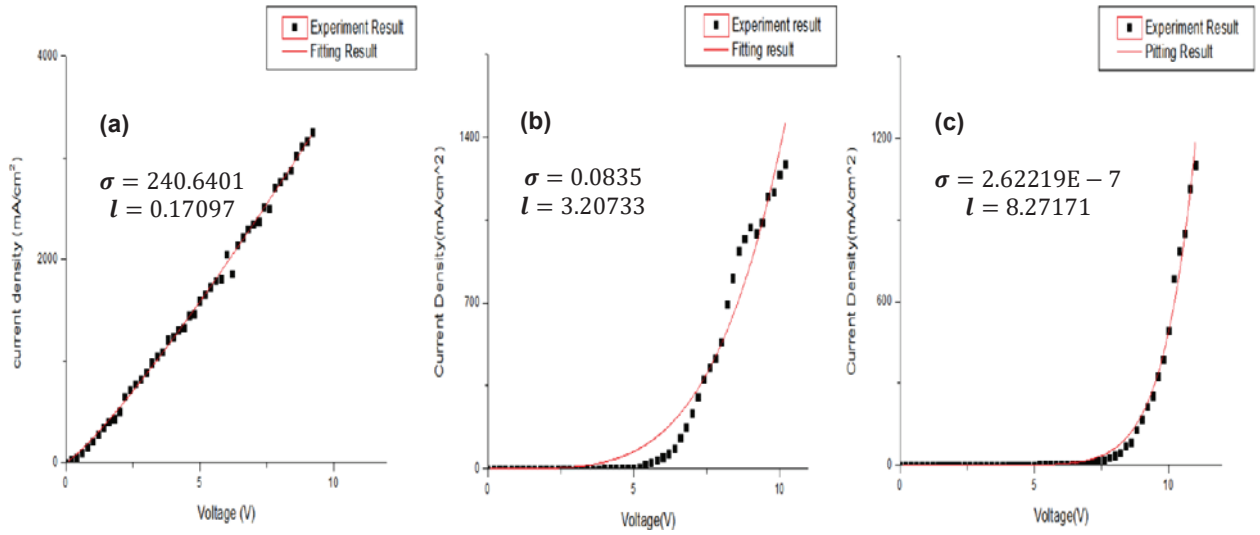

Fig. 1. J-V characteristics according to solvent concentrations of (a) 0.1wt% (b) 0.5wt% (c) 1wt%

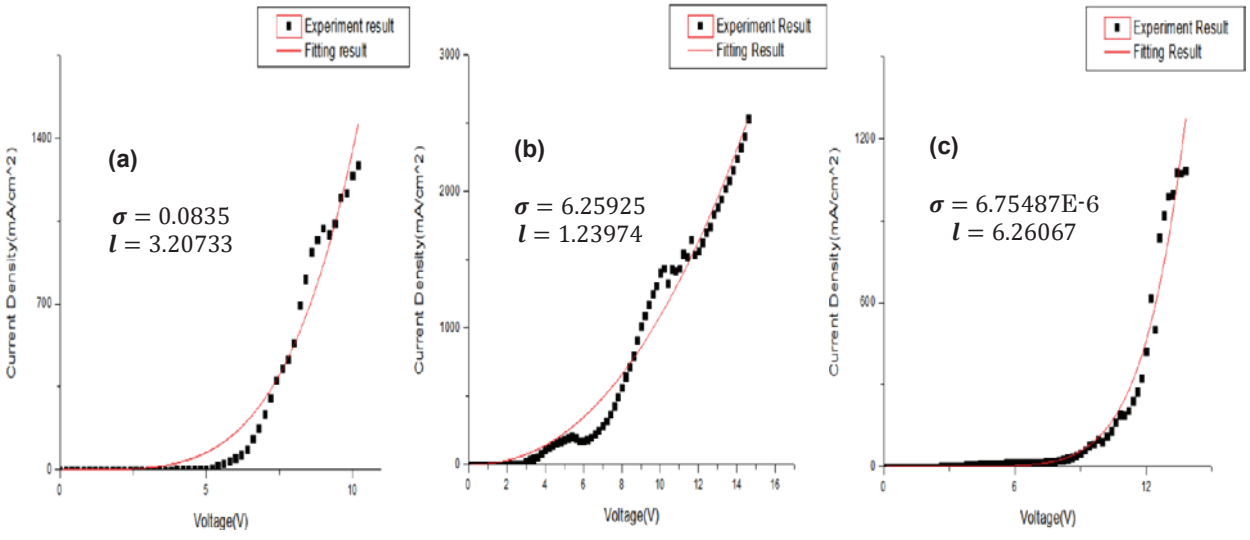

Fig. 2. J-V characteristics according to various solvents of (a) Toluene, (b) Chloroform, (c) Chlorobenzene

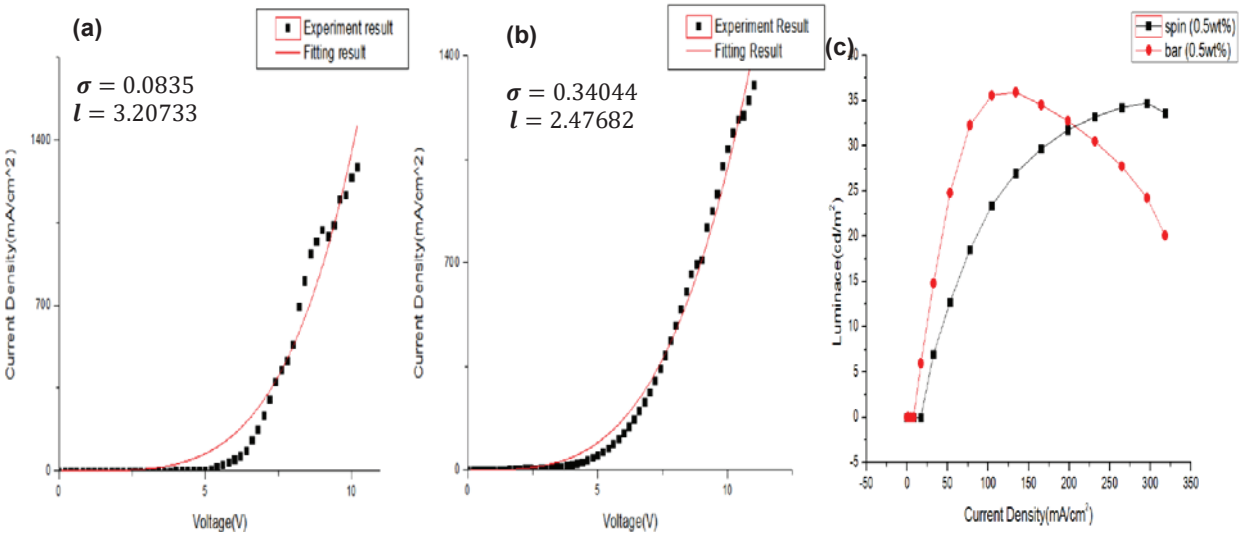

Fig. 3. Comparison of electrical and optical properties of spin coating and bar coating; J-V curve of (a) spin coating and (b) bar coating, (c) luminance by the spin and bar coating

characteristics. It would cause by inhomogeneous mixture. For chlorobenzene, the parameter of l value is high, but the effective conductance per unit area (g) is very low, and the operating voltage is high.

For the various concentrations of toluene, the best electrical performance was obtained with 0.5wt%. For the concentration of 0.1 wt%, the J-V curve does not represent diode characteristics as shown Fig. 2 (a). With the concentration of 1 wt%, the parameter, l value is high and the effective conductance per unit area (g) is very low, and the operating voltage is high as shown Fig.2 (c).

Table 1 summarizes the properties of the bar coating and spin coating conditions. In order to analyze the state of the optimum conditions of the bar coating and the spin coating, Figure 3 shows the electro-optical performance of the spin coating and bar coating conditions. The bar coating e operating voltage is fast, and better conductivity than the spin coating.

4 DISCUSSION

First, 0.5 wt% was identified as the optimal concentration. The reason is that the J-V characteristic is not confirmed in the case of 0.1 wt%, the parameter(l) value is high in the case of 1 wt% but the electric conductivity (g) is very low, and the operating voltage is high.

Second, toluene was identified as the optimal solvent. Trichloromethane has a high electrical conductivity(g) but is not reliable data because the error sigma value is too high. That is, it can be interpreted as not being mixed well. The parameter(l) value is high in the case of chlorobenzene but the electric conductivity(g) is very low, and the operating voltage is high.

Generally, in the solution process, an organic material is dissolved in a solvent and manufactured using a spin coater. We coated emission layer (EML) using bar coater. By using bar coating method, the molecules can be arranged in one direction. In general, the organic device is in the amorphous state, and the conductivity is improved through the arrangement of the molecules, and the device characteristics are improved.

5 CONCLUSIONS

By comparing the fabrication condition and the measured J-V characteristics, we optimized the solvents and the concentration for the solution process of the organic light emitting diode with MEH-PPV. It was possible to optimize the J-V characteristics by finding the effective conductance per unit area and parameters in SCLC.

We compared the properties of spin coating and bar coating under optimized coating conditions. As a result, the efficiency of the bar coating had a good data more than spin coating, we conclude that the reason is due to the orientation of the molecules.

6 ACKNOWLEDGMENTS

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