

고분자를 이용한 전계발광소자에 관한 연구

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A Study on Electroluminescence Device with Polymer

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Abstract - Poly(1,4-phenylene(1-methoxyethylene)), organic water soluble PPV precursor was synthesized for polymer electroluminescence(EL) device. To control the molecular array, deposition method of emitter was Langmuir-Blodgett(LB). PPV precursor layer was treated thermally to conversion of PPV. Optical, electrical and EL properties of PPV LB thin film was estimated. Homogeneous light emission of greenish-yellow in PPV LB thin film can be easily confirmed under normal lighting even at low driving voltage. Polymer EL device using PPV LB thin film as emitter materials had a possibility to apply to next generation display device.

1. Introduction

Recently, the advanced microelectronics as well as the supplement of computer, TV and multimedia equipment promotes the request of display device, which can efficiently transfer a lot of information. The predictive change of flat panel display, which has a low power consumption and a possibility of large scaled display is distinct. The electroluminescence (EL) device uses the electroluminescence phenomenon and consists of inorganic and organic devices when the electric field being applied to strongly fluorescent substance. Inorganic EL devices operate on the numerous voltage and so difficult to obtain variable color. Organic EL devices are easily to process, can be possible to variable color tuning by change of functional group in the polymer, and are so economy for low driving voltage. But the quantum efficiency of electroluminescence devices of using the conjugated polymer is less of 6 % from the expect value and life time is short. Above states, the problems are deeply related to array state of molecular chain, conjugation length of polymer, and carrier injection phenomenon from metal electrode to polymer[1][2].

In the midst of next generation display device, organic EL device uses the conducting polymer, which has an energy band gap with semiconductor and metal region[3]. The electrical property of typical representative polymer had been estimated in insulation. Generally polyimide, polyester and polystyrene had been applied in electronic industry as an insulator. The following three types are representative conducting polymer. First, graphite, polysilane and (SN)_x; explosive polymer(polymeric sulfur nitride) have the superconductive property in 0.3K as well as highly conductive property in room temperature. Its processing is hard as a film or fiber and its precursor monomer are unstable in the air. Second, other compound and the charge transfer salt can attach to non-conjugated basic structure, as the pendent group adjoin to organic polymer. The charge transfer salt types have high conductive property just in large crystal type, are weak and are changeable with chemically. Third, the conjugated polymers whose charges carry with the oxidize and deoxidize, has double combination to the main chain alternatively. Representatively the conjugated polymers are following; PPV(p-phenylenevinylene), PA(polyacetylene), Pan (polyaniline), PPP(p-phenylene), PT (polythiophene) and PP(poly-pyrrole).

In this study, poly(1,4-phenylene(1-methoxyethylene)), organic water soluble PPV precursor was synthesized for high performance EL device with conjugated polymer. Generally PPV precursor was coated on ITO using the spin coating but Langmuir-Blodgett(LB) method was used effectively to control molecular array and to be possible the formation of the monomolecular. Thin film of PPV treated thermally were estimated the optical, electrical and EL properties.

2. Experiments

The construction of typical electrode / polymer / electrode device is illustrated in Fig. 1. A high work function metal such as indium tin oxide, ITO(about 4.8eV) served as the hole-injecting contact and was transparent. PPV that consist of 20 Å were deposited as a thin film on the ITO electrode according to LB method and PPV deposited layer was dried at 250 °C for 12 hours in 0.1 torr vacuum. A low work function such as Al(about 4.2eV) was evaporated on to the polymer surface for the metallic electron-injecting contact by vacuum deposition. Thin film of PPV of UV-Visible absorption spectra were monitored by HP 8452A Diode Array Spectroscopy. Active area of the PPV were 100mm². The EL emission spectra and light intensity properties were measured by using Mcpherson 2035 monochromator with a photomultiplier(R928 Hamamatsu Photonics Co. Ltd.). Current-voltage curves measured by Keithley 617 programable electrometer and DC voltage source. All the measurements were performed at room temperature in air under variable DC bias condition.

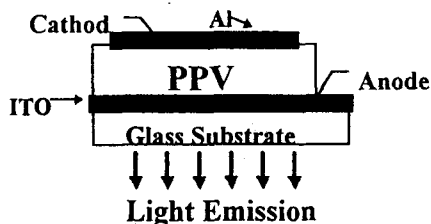


Fig. 1. Structure of polymer EL device

3. Results

Figure 2 indicates the number of layer dependence of UV/Visible absorption spectra when the number of layer of PPV precursor increase. In UV/Visible absorption spectra, it is shown a linear relation with the film thickness of PPV precursor. Generally, optical properties of organic molecular do not depend on the thickness but rely on the conjugation length. Thus as the same theory there were same spectra with increasing of PPV precursor thickness but different absorption values. Thickness control of PPV precursor LB film was proper in molecular level. The peak of absorption spectra were at about 230nm and 324 nm.

To convert from PPV precursor to PPV, thermal treatment be done. After thermal treatment of PPV precursor, UV/Visible absorption spectrum in figure 3 of converted PPV LB film has a shift of peak from 300 to 550nm and extended peak broadly to be due to the conjugation length which means conversion to PPV[1][4].

PPV LB film deposited 20 layers on ITO has current-voltage curve that depends on the electric field in figure 4. In measuring region, PPV LB film showed Ohmic effect. Conductivity was about 10E-8 that was the semiconductor property of similar to insulator.

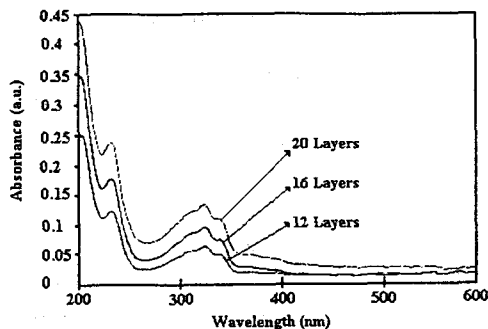


Fig. 2. UV/Visible absorption spectra of poly(p-phenylene(1-methoxyethylene)) LB films

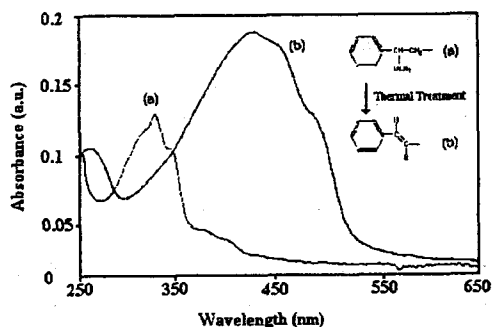


Fig. 3. UV/Visible absorption spectra of (a) poly(p-phenylene(1-methoxyethylene)) LB films, (b) poly(p-phenylenevinylene) LB film by thermal treatment

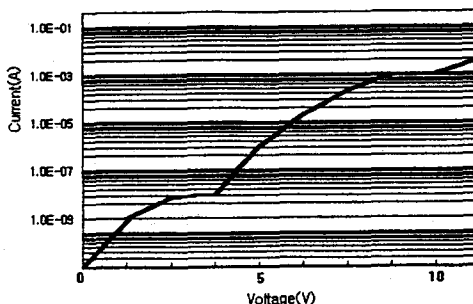


Fig. 4. Current vs. Voltage characteristics to PPV LB film

Photoluminescence in PPV originates from the radiated recombination of the singlet polaron exciton formed by intrachain excitation. The EL emission is generated by recombination of the electrons and holes injected from opposite electrodes of the device[5]. Electrons and holes are injected in conduction and valence bands, and some of them should become negative and positive polarons, respectively, in a very short time. When they collide, polaron excitons will be formed. The EL in these conducting polymers is considered to be due to the radiated recombination of these polaron excitons. Therefore, when positive and negative polaron excitons move out from the excited region and separate, performing recombination, the EL intensity should be increased with increasing driving voltage. Figure 5 notes the emission intensity increases with increasing driving voltage so shows the EL spectra of a PPV thin film at room temperature under various driving voltages. The EL spectrum was very similar to that reported by Burroughes et al.,[6] with a peak near 555nm corresponding to the photon energy of 2.2 eV. PPV EL device emitted light in the greenish-yellow range of the spectrum and could be easily seen under normal lighting, even at low driving voltage.

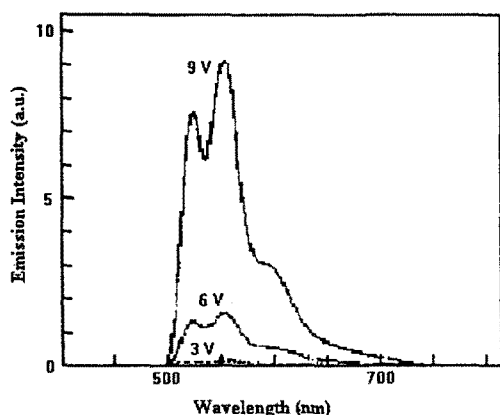


Fig. 5. EL emission spectra of PPV at room temperature under various voltages.

3. Conclusions

In this study, poly(1,4-phenylene(1-methoxyethylene)), organic water soluble PPV precursor was synthesized for visible-light polymer EL device. Deposition method was Langmuir-Blodgett(LB) effectively to control the formation of the molecular array. Thin film of PPV treated thermally was estimated the optical, electrical and EL property. The results of the present experimental study can be summarized as follows.

(1) The device consisted of ITO as substrate, a thin film of PPV as the active electroluminescence layer and an Al electrode as the metallic electron-injecting contact.

(2) In UV/Visible absorption spectra, it was shown a linear relation with the film thickness of PPV. Thus the molecular array of PPV precursor was deposited properly in molecular level by LB method. The EL emission spectra of PPV could be interpreted in terms of radiated recombination of the polaron excitons formed by injection of electrons and holes.

(3) PPV EL device emits greenish-yellow light. Homogeneous light emission from PPV thin-film can be easily confirmed under normal lighting even at low driving voltage in naked eye.

PPV EL device got a possibility of next generation display device. To obtain the high performance, it must consider that defect of polymer in synthesis process, array and length of polymer, properly choice of electrode and multilayer EL device.

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