PECCP LB 박막을 이용한 유기 발광 다이오드의 제작과 이의 특성

Fabrication and Properties of OLEDs using PECCP Langmuir-Blodgett(LB) Films

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Abstract

Characteristics of organic light-emitting diodes(OLEDs) were studied with devices made by PECCP[poly(*3,6-N-2*-ethylhexyl carbazolyl cyanoterephthalidene)] Langmuir-Blodgett(LB) films. The emissive organic material was synthesized and named PECCP, which has a strong electron donor group and an electron acceptor group in main chain repeated unit. The LB technique was employed to investigate the identification of the recombination zone in the ITO/PECCP LB films/Alq_3/Al structure by varying the LB film thickness. PECCP was considered as an emissive layer and Alq_3 was used as an electron-transport layer. We measured current-voltage(*I-V*) characteristics, UV/visible absorption, PL spectrum, and EL spectrum of those devices.

Key Words : Electroluminescence(EL) devices, Langmuir-Blodgett(LB) method, PECCP

1. Introduction

Most of semiconductor devices are normally based on inorganic materials such as silicon. A typical size of device is of the order of ㎛(10^{-6}m). This size is still big compared to that of molecular level. It is being recognized a limitation of miniaturization of the inorganic devices[1]. It is expected in the near future that the size of device could be reduced to the molecular level. This is called the molecular-electronic devices. First of all, ultra-thin films have to be manufactured for these devices to be developed.

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There are several ways of producing the ultra-thin films. Among these methods, Langmuir-Blodgett(LB) technique has recently drawn much attention[2]. Basic concept of the LB method is to make the ultra-thin films by transferring monolayer which is formed at the air-water interface to a solid substrate. With this technique, we can easily control a thickness and orientation of the molecules. There are some advantages in the LB technique compared to other methods such as chemical-vapor deposition(CVD) and physical-vapor deposition(PVD). One of the merits of LB method is that the LB films can be deposited in a monolayer structure[3) 4)].

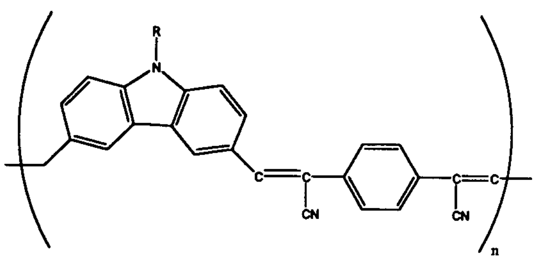
In organic light-emitting diodes(OLEDs), light generation is the consequence of the recombination of holes and electrons injected from the electrodes. Such carrier recombination in the organic emitter layer excites the emitting centers.

In order to investigate the recombination zone, a new method such as the LB technique is needed, in which the barrier layer does not play the role of a transmitting carrier[5) 6)].

In this paper, PECCP was synthesized for LB device. We fabricated EL device using LB technique and observed the optical, electrical and electroluminescent properties. Also we confirmed the recombination zone from the OLEDs using the PECCP LB films.

2. Experimental

Figure 1 shows a molecular structure of poly (*3,6-N-2*-ethylhexyl carbazolyl cyanoterephthalidene)(PECCP). This material has a donor group and an acceptor group and an ethylhexyl group. This material is a good solubility in common organic solvents such as a chloroform, THF, and etc.



R = ethylhexyl group

Fig. 1. Molecular structure of PECCP.

3. Results and discussions

The π-A isotherm varies with a change of environments, it was studied by using different conditions of barrier moving speed[3)]. We have performed the π-A isotherms by varying the moving speeds of the barrier from 50 to 200 cm^2/min. After performing these experiments, 10 mN/m at room temperature was selected as the appropriate surface pressure for making the LB film.

Figure 2 shows the π-A isotherms of the PECCP molecules obtained at room temperature with 50*ul* spreading solution and various barrier moving speeds.

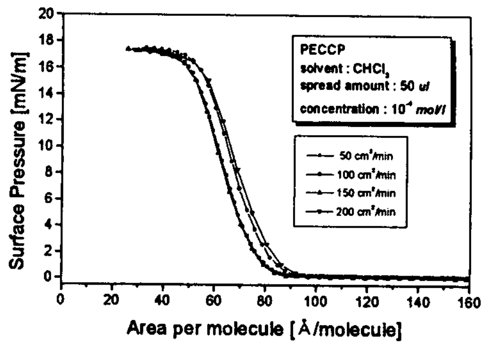


Fig. 2. π-A isotherms of PECCP by varying barrier moving speeds.

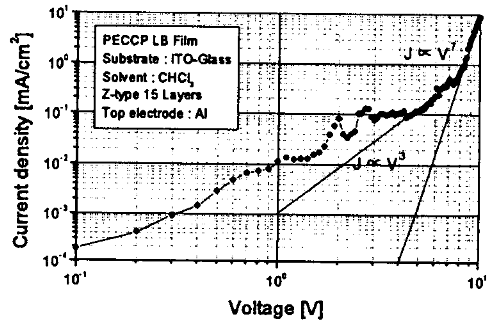


Fig. 3. Current density-voltage characteristics in ITO/PECCP LB film/Al device.

Figure 3 shows current-voltage characteristics of the PECCP LB films measured along the vertical direction. We observed the turn-on voltage is 6V.

Figure 4 shows the UV/visible spectrum and PL of PECCP LB film. In the UV/visible, the exhibits broad absorption band at 410nm which is due to conjugated double bond. This LB thin film shows PL around λ_{max}=530nm(excited source, 430nm) and green EL around λ_{max}= 530nm in the ITO/PECCP LB film/Al device.

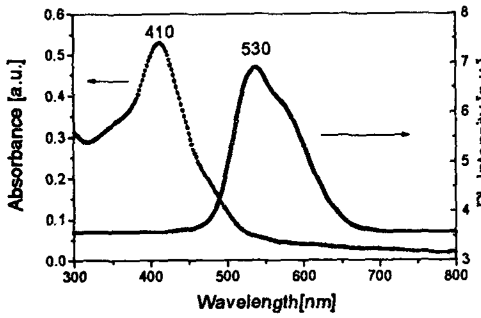


Fig. 4. UV/visible absorption and PL spectra of the PECCP LB film.

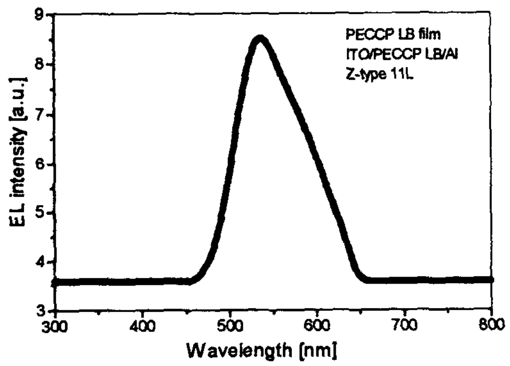


Fig. 5. EL spectrum of the ITO/PECCP LB film/Al structure.

Figure 5 shows the EL spectrum from the ITO/PECCP LB film/Al structure. We observed the EL peak at 530nm, and the peak is almost same the PL peak of the PELLC LB film. So we thought that the light emitting was from the PECCP LB film in our EL cell. But we observed the very weak luminescence from the EL cell. So, we adopted the electron transporting layer(ETL) with an Alq_3, and the EL structure is ITO/PECCP LB films/Alq_3/Al. PECCP as an emitting layer is fabricated by LB method and Alq_3 as an electron transporting layer is deposited by thermal evaporation method.

Figure 6 shows that the current-voltage characteristics of the ITO/PECCP LB films/Alq_3/Al structure. We observed the turn-on voltage is 6V and observed the more intensity luminescence from the EL cell. This result is good efficiency more than ITO/PECCP LB film/Al structure because we adopted electron transport layer.

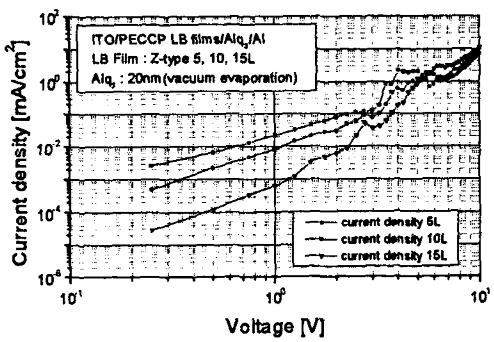


Fig. 6. Current density-voltage characteristics of ITO/PECCP LB film/Alq_3/Al.

Figure 7 shows that EL spectrum from the ITO/PECCP LB films/Alq_3/Al structure. This result is the emission is from the PECCP LB films increasing the LB films layers.

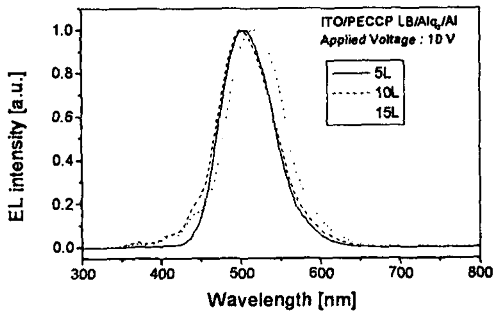


Fig. 7. EL spectrum of the ITO/PECCP LB films/Alq_3/Al structure.

So, we thought that the LB technique is a good as a confirm method of the recombination zone. Figure 8 shows that the energy band diagram of the each materials. From the Al electrode to the Alq_3 as an ETL the electron is injected and from the ITO electrode to the PECCP as a HTL and EML the hole is injected. Electron and hole were injected almost same speed, because the reason is same difference of the potential barrier. Alq_3 is the electron affinity is good more than PECCP. So, we thought that our El cell as the ITO/PECCP LB films/Alq_3/Al structure was light emitting from the PECCP region.

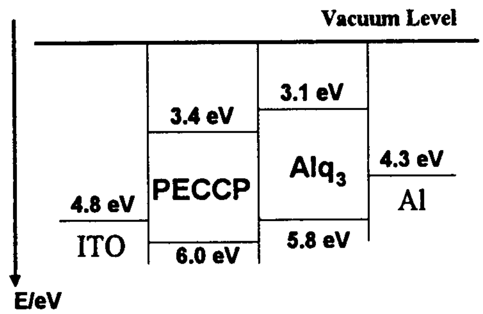


Fig. 8. Energy band diagram of the EL cell.

4. Conclusions

We observed the optical and electrical properties of the OLEDs in the ITO/PECCP LB film/Al and ITO/PECCP LB films/Alq_3/Al structures. The following conclusions can be drawn.

1. PECCP ultra thin films were made by LB technique.
2. These films show PL and EL(λ_{max}= 530nm) spectra in the ITO/PECCP LB film/Al structure.
3. We observed the low turn-on voltage at around 6V.
4. We confirmed the recombination zone from the LB method.
5. We also observed rectifying diode characteristics in OLEDs using LB films as an emitting layer.

Acknowledgments

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