

**Study on Charge-Transfer Exciton Using  
Solid State Cathodoluminescence Based on MEH-PPV  
(Poly[2-methoxy-5-(2-ethylhexyloxy)-1,4-phenylenevinylene])**

JIN-ZHAO HUANG\*, SHI-SHUAI LI, XIU-PENG FENG, PEI-JI WANG and ZHONG ZHANG  
School of Science, University of Jinan, Jinan-250022, Shandong Province, P.R. China  
E-mail: jzhuangjz@hotmail.com

In this paper, the solid state cathodoluminescence (SSCL) is applied to investigate the charge-transfer exciton (CTE). The solid state cathodoluminescence is a brand new luminescence mechanism in organic-inorganic electroluminescence system and it is characterized by the two emission peak, 405 and 580 nm. After the thickness of emission layer MEH-PPV (poly[2-methoxy-5-(2-ethylhexyloxy)-1,4-phenylenevinylene]) is decreased to 80 nm from 120 nm and the third emission peak (480 nm) is observed, which is located between the two traditional solid state cathodoluminescence peaks. It is believed that it is from charge transfer exciton emission.

**Key Words:** Solid state cathodoluminescence, Charge-transfer exciton.

### INTRODUCTION

It is well known that the charge-transfer exciton (CTE) occurs in the course of recombination of electron and hole, but it is difficult to identify in the experiment<sup>1-3</sup>. The solid-state cathodoluminescence (SSCL) is a kind of luminescence mechanism in organic-inorganic heterostructure light emitting diodes. Compared with traditional cathodoluminescence ray tube (CRT), the process of electron acceleration is in SiO<sub>2</sub> layer rather than in vacuum<sup>4-6</sup>. The luminescence mechanism of SSCL is identified in the references<sup>7,8</sup>. It is confirmed that the origin of the long wavelength is exciton luminescence and the exciton is from the impact excitation. The short wavelength emission comes from the direct radiative recombination of electron and hole caused from exciton dissociation. So, in this paper, the solid state cathodoluminescence is utilized to study the charge-transfer exciton.

The thickness of emission layer is important in investigating luminescence properties. In this paper, the thickness of emission layer is decreased and the luminescence properties of the solid state cathodoluminescence device were studied further.

### EXPERIMENTAL

The device ITO/SiO<sub>2</sub> (200 nm)/MEH-PPV (80 nm)/SiO<sub>2</sub> (200 nm)/Al has been fabricated. The SiO<sub>2</sub> layer was prepared by electron beam evaporation (EVA450, Alliance Concept Co. Ltd., France). In this process, the substrate temperature was kept at 160 °C, the vacuum was  $2 \times 10^{-6}$  Torr and the growth rate was 0.3 nm/s and

the thickness was controlled by a quartz crystal thickness monitor. The MEH-PPV was dissolved in chloroform and then it was fabricated by spin-coating method. The top Al electrode was prepared by thermal evaporation under the vacuum  $10^{-6}$  Torr. The electroluminescence was measured by SPEX fluorolog-3 spectrometer.

## RESULTS AND DISCUSSION

The electroluminescence spectrum of the device which is driven by AC voltage of 500 Hz is shown in Fig. 1. Under the condition of different voltage, the spectrum consists of three emission peaks located at 405, 480 and 580 nm, respectively. The spectrum is characterized by the appearance of short wavelength emission (405 nm) and middle wavelength emission (480 nm) when the applied voltage is over a certain value.

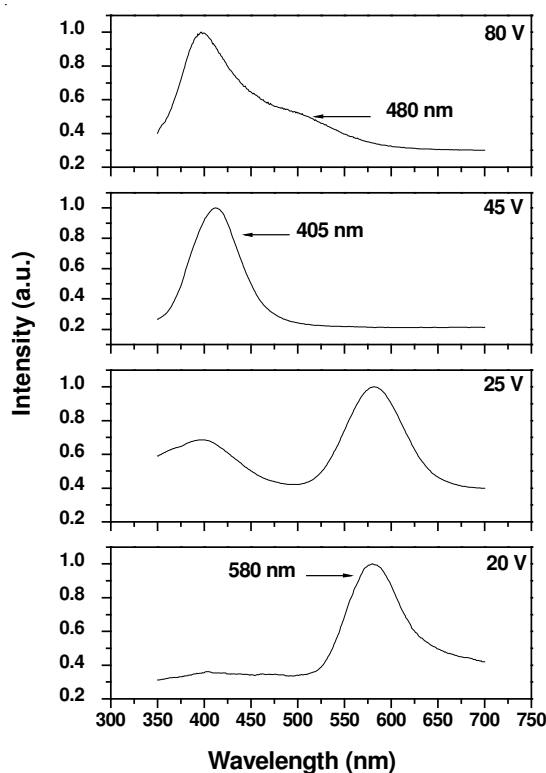


Fig. 1. Electroluminescence spectrum of device ITO/SiO<sub>2</sub> (200 nm)/MEH-PPV (80 nm)/SiO<sub>2</sub> (200 nm)/Al under different voltage

The intensity of long wavelength, short wavelength and middle wavelength *versus* voltage are illustrated in Fig. 2. It shows that there is only the long wavelength emission when the voltage is low. With increasing applied voltage, we obtain both long and short wavelength emission and then the long wavelength peak disappears

completely and the short wavelength and the middle wavelength are observed. The four voltage region can be identified in the spectrum. The first range (A) is from 18-20 V, the second range (B) is from 20-30 V, the third range (C) is from 30-45 V and the fourth range (D) is from 45-80 V.

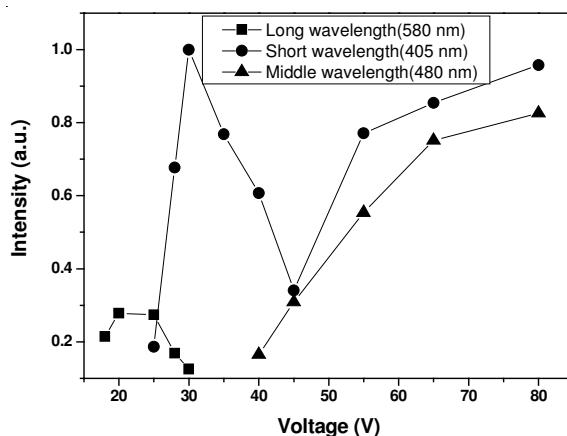


Fig. 2. Electroluminescence intensity of wavelength *versus* voltage

The origin of the 405 and 580 nm emission is identified<sup>7,8</sup>. Here, the origin of the 480 nm emission is investigated.

In this paper, it is proposed that the 480 nm emission comes from the charge-transfer exciton recombination. The charge-transfer exciton occurs in the course of recombination of electron and hole<sup>1,2</sup> and the 480 nm emission occurs in the course of 405 nm emission which is the radiative recombination of electron and hole. So it can satisfy the occurrence condition of charge-transfer exciton. In addition, the charge-transfer exciton exists in the organic material. According the two points mentioned above, the 480 nm emission is from the charge-transfer exciton and the charge-transfer exciton is identified in the experiment.

The formation of charge transfer exciton makes the number of electron dissociated from exciton decrease. So the intensity of 405 nm emission decreases and then the 480 nm emission occurs in the range C. After the voltage is increased, the exciton dissociation is enhanced and the formation of charge transfer exciton is enhanced also, so the intensity of 405 nm emission and 480 nm are all increased sharply (in the range D).

### Conclusion

The charge-transfer exciton (CTE) is identified by means of solid state cathodoluminescence (SSCL). Based on traditional SSCL device, the thickness of emission layer is decreased and a new 480 nm emission peak is observed. The emission is from charge transfer exciton. In this paper, a method is provided to investigate the charge transfer exciton.

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