Thin-film passivation of the polymer EL device using parylene and its application to the passive matrix PELD system

Cheon An Lee, Sung Hun Jin, Keum Dong Jung, Jong Duk Lee, and Byung-Gook Park
Inter-University Semiconductor Research Center (ISRC) and School of Electrical Engineering,
Seoul National University, San 56-1, Shinlim-dong, Kwanak-gu, Seoul 151-742, KOREA
Phone: +82-2-880-7279, E-mail: peld2000@hanmail.net

Abstract

The thin-film passivation technology using the poly-para-xylylene (parylene) was applied to polymer electroluminescent devices. The fabricated device shows a good luminescent characteristic of maximum 11640 cd/m^2. The measured lifetime was reached up to 28 hours, which means the effectiveness of the passivation. Applying the parylene thin-film passivation technique, 10×10 passive matrix display system was implemented and obtained some still images.

1. Introduction

Organic electroluminescent (EL) display is one of the promising candidates of the current and future flat panel display because it has many advantages such as simple structure, large viewing angle, high resolution, thin panel, and low driving voltage. Polymer EL display is potentially more attractive due to very simple fabrication process [1].

However, the moisture and oxygen in the atmosphere degrades the emission characteristic. Therefore, passivation technology is one of the key factors for the practical application [2-3]. Recently, the passivation technology using the thin film becomes an important issue because it makes possible to realize quite thin display panel [4-6].

Parylene (poly-para-xylylene) is a versatile polymer because it can be used as dielectrics for capacitors with a low dielectric constant or an electrical insulator with high breakdown voltage [7], a buffer layer for the photolithographic patterning of the active material in the organic thin-film transistor [8], and a thin buffer layer at the anode-organic interface of organic EL device for the performance improvement [9].

Especially, the low permeability against gas and H_2O increases its utility as a moisture barrier [7]. Furthermore, the conformal and pinhole free thin-film can be obtained with a relatively simple and cost effective process. Therefore, it is possible to apply the parylene layer to the passivation of the organic EL device.

In this paper, we studied the thin-film passivation of polymer EL device using the poly-para-xylylene (parylene) and implemented passive matrix polymer EL display systems by applying it.

2. Polymer EL device

2.1 Fabrication process

A bilayer polymer EL device that is composed of hole transport layer (HTL) and emitting layer (EML) was fabricated through the following process steps. Figure 1 shows the structure of the fabricated device. The ITO anode with 8.3 Ω/□ of sheet resistance was patterned by the photolithographic method. It was cleaned in the ultrasonic baths of acetone, methanol, and IPA (Isopropyl Alcohol) for 5 minutes, respectively. Then, it was dried in a stream of nitrogen.

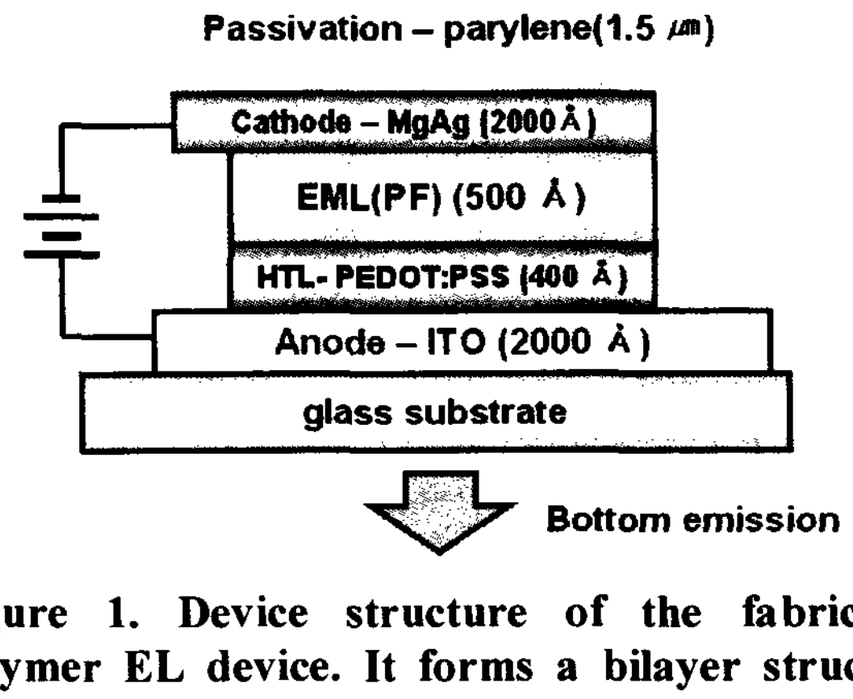


Figure 1. Device structure of the fabricated polymer EL device. It forms a bilayer structure that is composed of the PEDOT:PSS as a hole transport layer and PF derivative polymer as a green light-emitting layer. 1.5 ㎛ of parylene film was used as a passivation layer.

PEDOT:PSS (poly-(3,4-ethylene dioxythiophene) doped with poly (strene sulfonate)) was spin-coated as a hole transport layer. The thickness of HTL was measured about 400 Å using an alpha step. Next, 500 Å of poly fluorine (PF) derivative polymer resolved in chloroform was spin-coated as a green light emitting layer. All fabrication process was carried out in the atmosphere. As a metal cathode, Mg/Ag alloy was e-gun evaporated through the shadow mask with the base pressure of 5×10^{-6} Torr. The emitting size is 3 mm× 3 mm.

Finally, 1.5 ㎛ of poly-para-xylylene (parylene) thin film was evaporated with the PDS (parylene deposition system) equipment as a passivation layer.

2.2 Electrical and Optical characteristics

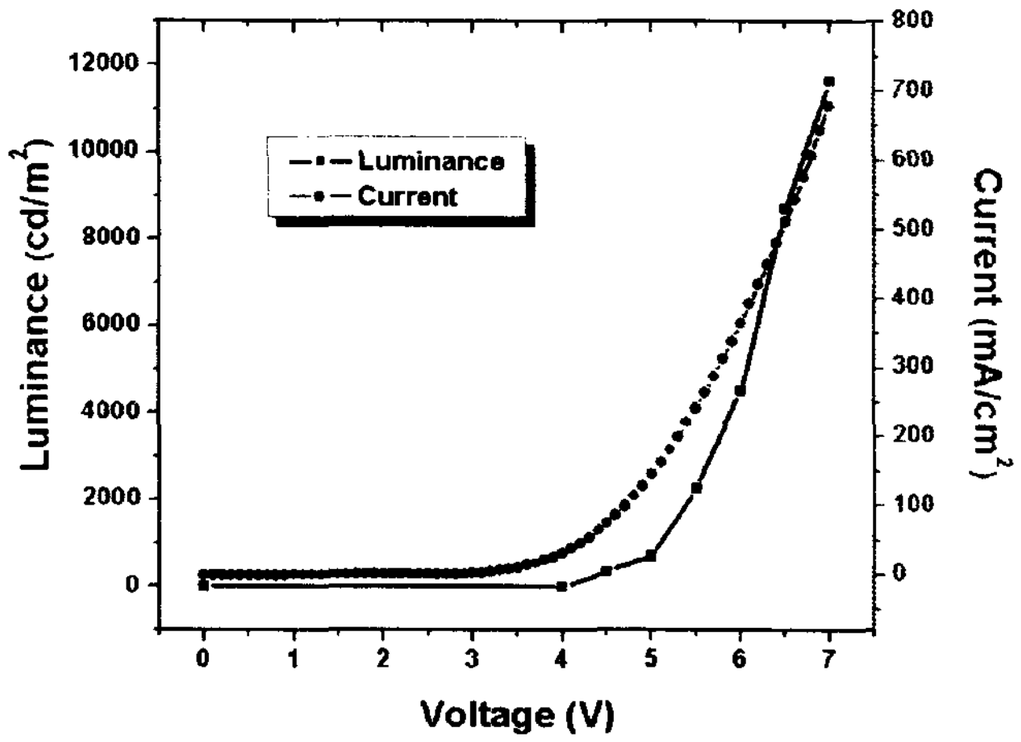
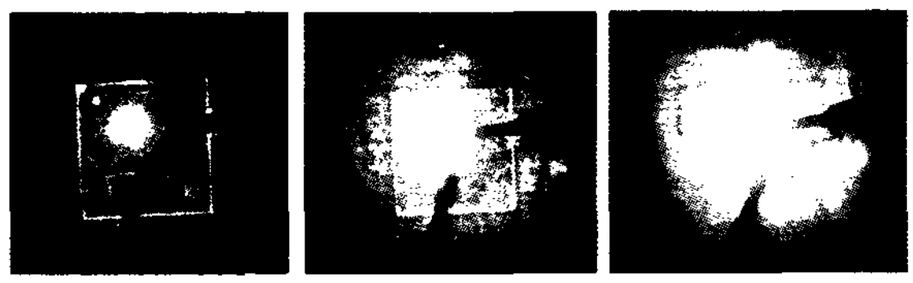


Figure 2. Measured luminance-current-voltage characteristic. The turn-on voltage was about 3 V and the peak luminance was 11640 cd/m² at 7 V. The maximum current efficiency and power efficiency are calculated to 3.7 cd/A and 2.3 lm/W at 5V, respectively.

The current-voltage curves of the completed device were characterized using an HP4156C semiconductor parameter analyzer and optical characteristics were measured using BM-7 luminance colorimeter in the atmosphere. Figure 2 depicts the measured luminance-current-voltage characteristics. The turn-on voltage was about 3 V and the peak luminance was 11640 cd/m² at 7 V. From the measurement, the maximum current efficiency and power efficiency are calculated to 3.7 cd/A and 2.3 lm/W at 5V, respectively. These results are comparatively good considering all fabrication and characterization processes were performed in the atmospheric ambient. The color coordinate is (0.35, 0.62), which is scarcely varied at the various anode voltages. Table 1 summarizes the electrical and optical characteristics of the fabricated polymer EL device. Figure 3 illustrates some photographic emission images at several anode voltages.

Table 1. Measured characteristics of the fabricated polymer EL device

Turn-on voltage	~3 V
Maximum brightness	11640 cd/m² @ 7V
Maximum current efficiency	3.7 cd/A @ 5V
Maximum power efficiency	2.3 lm/W @ 5V
CIE coordinate	(0.35, 0.62)



(a) (b) (c)

Figure 2. Photographic emission images of the fabricated polymer EL device at (a) 5V, (b) 6V, and (c) 7V. The luminance is 705 cd/m², 4518 cd/m², and 11640 cd/m², respectively.

2.3 Lifetime characteristic

To confirm the passivation effect, the lifetime characteristics were carried out for a passivated polymer EL device with a parylene layer and non-passivated one. The initial brightness was adjusted to about 138 cd/m² for the both samples. Then, the brightness of the emitting light was continuously monitored under the constant DC bias applied.

Figure 4 describes the measured lifetime test results. The brightness of the non-passivated sample was decreased half after 64 sec. On the contrary, the luminance of the passivated sample with the parylene film was sustained for about 28 hours. The lifetime of both samples was far from the specification for the practical application yet. It is thought that this short lifetime was resulted from the fact that the device was

exposed to the oxygen or moisture during the fabrication process because it was performed in the atmosphere. However, it is clearly shown that the parylene film can be used an effective passivation layer because the passivated device shows an extended lifetime characteristic about 1500 times.

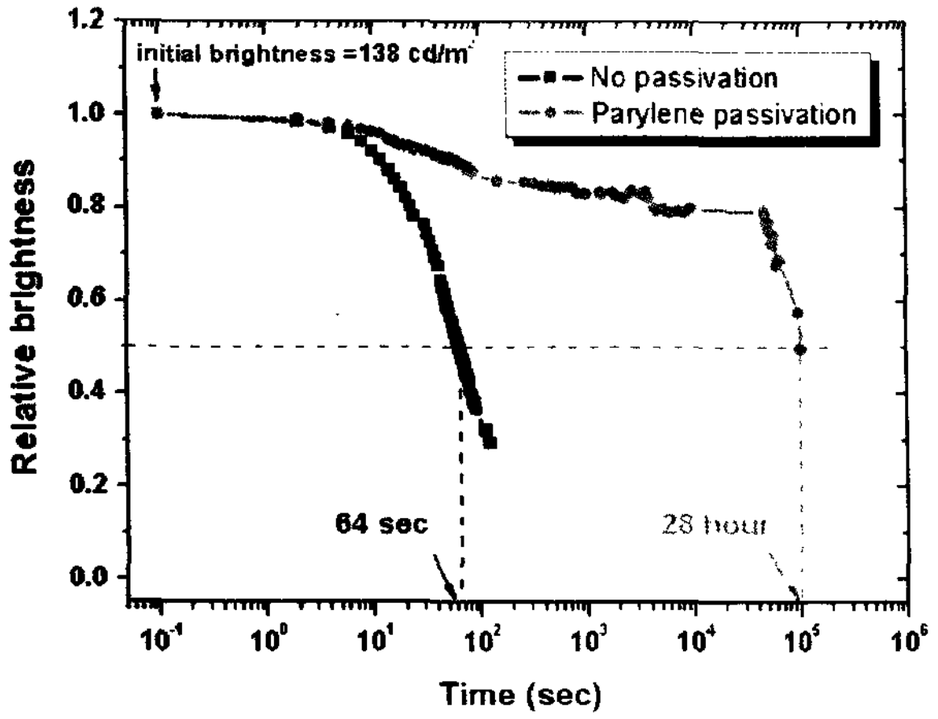


Figure 3. Lifetime test result of the passivated device with parylene thin film and non-passivated device. The lifetime of the passivated polymer EL device was improved about 1500 times, in comparison with the non-passivated sample. It shows that the parylene film can be used an effective passivation layer.

3. Application to the passive matrix display panel

Applying the passivation process using parylene thin film to the display panel, the 10×10 passive matrix array was fabricated through the similar process to that of the polymer EL device. The whole pixel size is 300 ㎛×300 ㎛, and the emissive area is 200 ㎛×200 ㎛.

The driving circuit was designed by using the Altera CPLD (complex programmable logic device) logic. It is composed of three parts: control circuit, row driver, and column driving part. The control circuit includes the video signal generation part and the memory for each pixel data. The pixel data memory was synthesized from the HDL (hardware description language) source code and implemented using CPLD logic. The pixel data is 4 bits, which means the driving circuit supports 16 gray scales. The control logic generates some synchronizing signals and pixel data signals that are read from the data memory.

The row driving circuit generates each row selection signals, sequentially. Voltage level-shifters were connected at the end of each row line because the output voltage level of the CPLD logic does not compatible to the driving voltage of polymer EL devices. The column driving circuit was designed using PWM (pulse width modulation) method with 16 gray levels. It makes data signals corresponding to the pixel data that is supplied from the control logic part. All of these driving circuits except the level shifting circuit were implemented by using only 2 CPLD chips. Figure 5 shows the complete display system and Figure 6 is the emission images of 'SMDL' pattern.

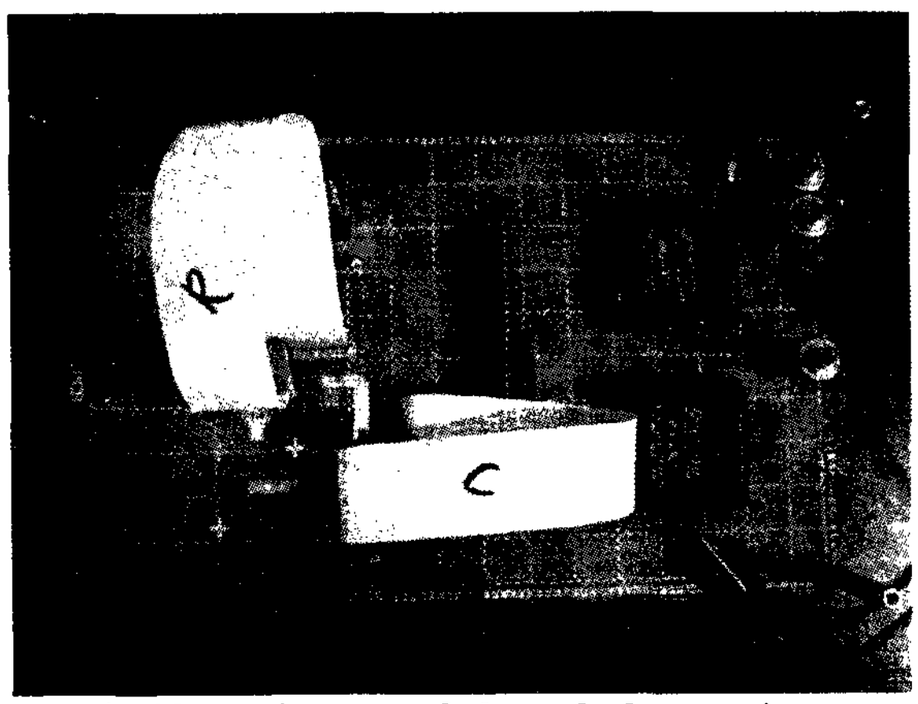


Figure 4. Photo image of the whole passive matrix display system. The driving circuit was designed by using CPLD logic and additional voltage level-shifting circuit was connected at the end of the row driving circuit.

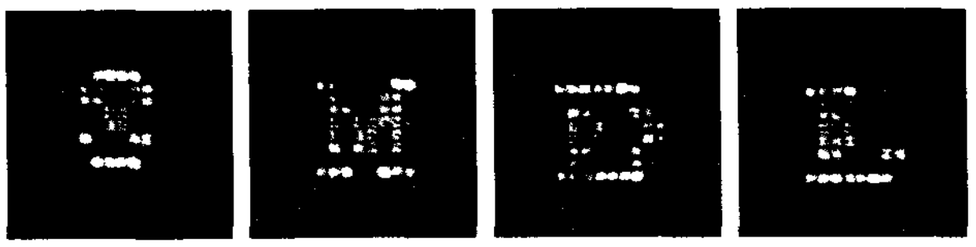


Figure 5. Emission image of 'SMDL' pattern

4. Summary

A thin film passivation technology using parylene thin film was applied to the polymer EL device. The passivated device shows the good luminescent characteristic that the brightness reaches up to 11640 cd/m^2 at 7 V, and the comparatively high efficiency. Furthermore, the lifetime of the passivated device was prolonged about 1500 times compared with the non-passivated sample. It means that the parylene layer

can be used an effective passivation layer for the polymer EL device.

Applying the passivation technique, 10×10 passive matrix array was fabricated. The circuit to drive the panel was designed and implemented using a programmable logic chip. A simple image pattern was obtained by the completion of the display system.

5. Acknowledgement

This work was supported by the contract of ISRC (Inter-University Semiconductor Center) 2003-X-5512 to ETRI (Electronics and Telecommunications Research Institute) and MIC (Ministry of Information and Communication) to carry out the Advanced Technology Project. Also, this work was supported by the Brain Korea 21 program.

6. References

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