Extended Abstracts of the 2004 International Conference on Solid State Devices and Materials, Tokyo, 2004, pp. 676-677

P13-3

Preparation and Characterization of a Novel Flexible Substrate for OLED

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1. Introduction

Recently, OLEDs have been fabricated on plastic substrates to form flexible organic light-emitting diodes (FOLED) [1,2]. However, one major drawback of plastic substrate to the application of flexible OLEDs is the high permeation rate of water vapor. To achieve an operating lifetime in excess of a few tens of hours, however, isolation of the OLED from atmospheric H2O is necessary [3,4]. In this study we try to use a new amorphous engineering thermoplastic, nominated cyclic olefin copolymer (COC) as a new flexible OLED device.

2. Experimental

COC pellets were melt-pressed into thin films in a hot press. After annealing treatments, ITO was deposited on the COC substrate by plasma in an RF sputtering with Ar gas at a flow rate of 10 sccm (standard cubic centimeter per minute). The OLED with structure consists of a hole transport layer (HTL, ~40Å) of naphthyl phenyl benzidine (NPB), and an electron transport/emitting layer (ETL/EML, ~60Å) of Alq3. The cathode contact deposited on top of the ETL by thermal evaporation was aluminum (Al).

3. Results and discussion

In Fig. 1 shows the H_2O permeation rate curve of OLED with COC substrate. It can be seen that the H_2O permeation rate of the COC substrate is 0.45 (gm/m2-day) at 25°C which is better than that using a commercial PET substrate (15 gm/m^2-day) at 25°C.

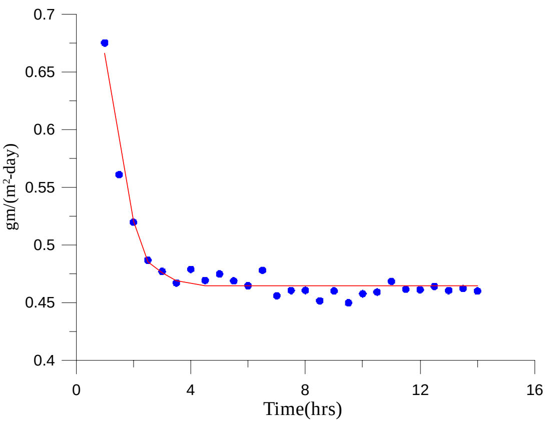
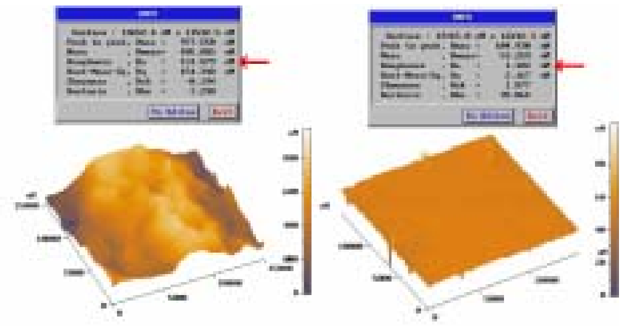


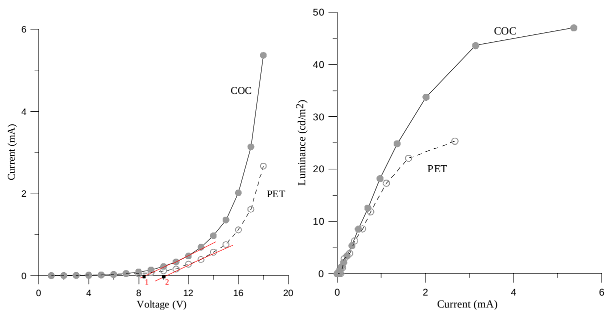
Fig. 1 H_2O permeation rate curve of the COC substrate at 25°C.

Fig. 2 shows AFM images for the three-dimensional view of a COC substrate (a) before annealing and (b) after annealing. Before annealing, the surface roughness of the COC film is around 131 nm, but after annealing the Ra value was reduced to 1.382nm. The difference of R_a values between before and after annealing COC samples is close to two orders. Since the quality of the plastic panel is strongly dependent on the R_a value, the optimum sample preparation conditions can be approached through this study.



(a) (b)

Fig. 2 AFM images for COC substrate (a) before annealing and (b) after annealing.



(a) (b)

Fig. 3(a) Voltage-Current characteristics of an OLED with COC and PET substrate, where 1 and 2 represent the turn-on voltage of the COC (8.4V) and PET (10.0V), respectively; (b) Current-Luminance characteristics of an OLED with COC (45cd/m^2) and PET (23cd/m^2) substrate.

Figs. 3(a) and (b) shows current-voltage (I-V) and current-luminance (I-L) output characteristics of an OLED with a COC substrate and PET substrate. I-V curve shows a typical diode behavior, with current and power output observed only in the forward bias. Under a current of 3mA, the OLED shows a good lighting efficiency (8.4V turn-on voltage) and a luminance of 45 cd/m^2 in average. This is better than those using the commercial PET substrate (10.0 turn-on voltage). It was believed that the lighting efficiency was attributed to the surface roughness and sheet surface electrode resistance of an ITO coated substrate.

The EL spectra of a conventional OLED with COC and PET substrate are shown in Fig. 4. In the COC substrate, the EL intensity peaked at 548nm and exhibited a full width half maximum (FWHM) of 110nm.The PET substrate showed a maximum EL intensity at 548nm with a FWHM of 86nm. However it is relatively narrow as comparing with the COC substrate, which means it has less color purity. The device which was made is our lab emits green light at 548nm with a shoulder of Alq_3 emission, and the Commission Internationale de L'Eclairage (CIE) coordinates are (x=0.3189, y=0.5454), which can be observed in Fig. 5.

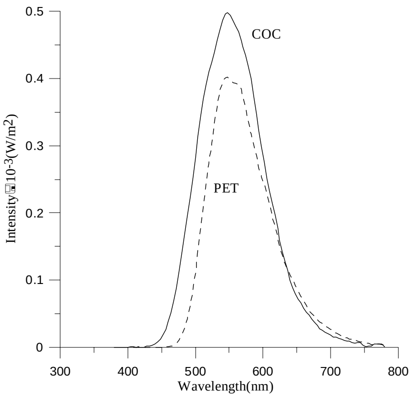


Fig. 4 Electroluminescence spectra of an OLED with COC and PET substrates.

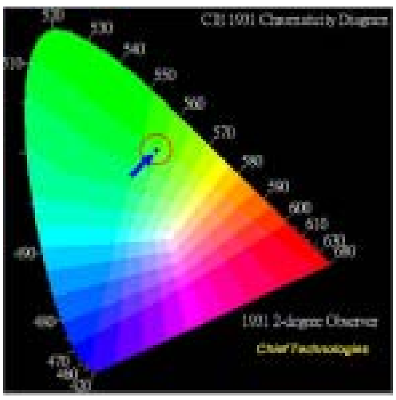


Fig. 5 The CIE color coordinates of an OLED with COC substrate.

Fig. 6 shows a photo image of the real flexible OLED device with a COC substrate. The FOLED was sufficiently flexible to withstand a curvature of over 5/cm as the sample size is approximately 5×5 cm^2.

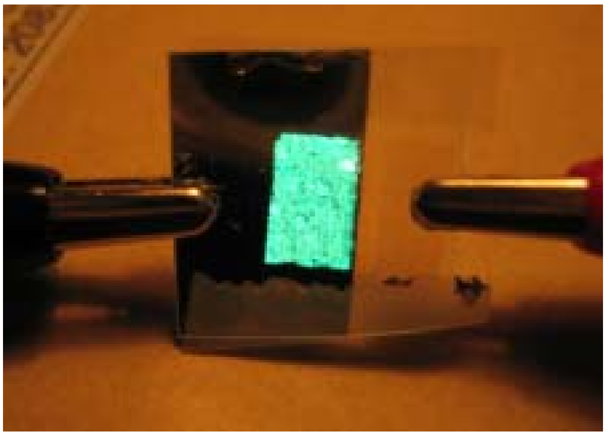


Fig. 6 Photo image of a FOLED in bending with a configuration of COC substrate/ITO/ NPB/Alq3/LiF/Al.

4. Conclusions

In summary, the optical property also improved obviously after thermal treatment, since the COC thin film possesses a very excellent smooth surface, which was evidenced by the visible spectroscopy and AFM observation. The moisture resistant ability of the COC substrate has only 0.45 gm/m2-day, and the OLED with the COC substrate shows better EL performance than that with PET substrate, thus demonstrating the available applications of plastic substrate with COC for a flexible OLED.

Acknowledgements

The authors gratefully acknowledge the funding of the research by the National Science Council of Taiwan. (NSC 93-2622-E-150-007-CC3)

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Appendix

1. Submitted to Area 7
   Optoelectronic Devices and Photonic Crystal Devices
2. Poster presentation preferred