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Fabrication of Flexible OTFT-backplanes for Active Matrix Electrophoretic Display

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1. Introduction

Electrophoretic display(EPD) is attracting much attention as a display for electronic books because of its paper-like appearance, flexibility and low power consumption. Since EPD dose not have threshold voltage for rotating micro-capsule, it should be controlled by a switch with threshold voltage such as Organic Thin Film Transistors(OTFTs) in order to implement a display panel. Recently, Sony produced a e-book with EPD in market which used α-Si TFT-backplane on rigid glass substrate. Plastic Logic demonstrated EPD panel driven by OTFT-backplane on plastic substrate. But the OTFT-backplane using plastic substrate is still under development.

In this paper we reported fabrication results of OTFT-backplanes on PEN substrate. This work is characterized by the batch processes of four backplanes on 200 mm x 200 mm size substrate. The OTFT-EPD panel worked successfully and demonstrated to display some patterns.

2. General Instructions

We used 200um thick and 200 mm x 200 mm size PEN plastic as substrate purchased from DuPont Teijin. Particle contamination is minimized by cleaning the substrate prior to deposition of the backplane in class 1000 clean room. The PEN substrate was pre-annealed for the reduction of polymer shrinkage. The OTFTs used the bottom contact structure with 30μm channel length and 150μm width. Pentacene was used for active layer and PVP for gate dielectric and Au for S/D electrodes. All electrical measurement were performed under ambient conditions. The main parameters of device performance, that is mobility, Vth, Ion/Ioff and subthreshold slope(SS), were calculated based on the standard metal-oxide-semiconductor field-dffect transistor(MOSFET) equations in the saturation current regimes and are summarized in Table 1. The performance parameters were measured from 40 OTFTs from each substrate sheet and exhibited very good uniformity over the whole substrate area with the variation less than 20%. In order to control EPD, OTFTs have to interlayer between backplane and EPD panel. Especially, we used PVA/Acryl double layers for interlayer as well as passivation of backplane. The drain electrode pads, which were directly contacted to EPD panel and applied voltage to pixel, were connected to drain electrode of OTFT below through via holes formed in PVA/Acryl interlayer. It is important to make a good interlayer which is required not to give a serious damage to the lower OTFT-backplanes and also protect it from upper EPD panel lamination process. PVA as interlayer is water-soluble and the damage to the pentacene active layer can be minimized compared with other materials dissolved in organic solvents. Furthermore, dichromated PVA, PVA mixed with ammonium dichromate, is photo-sensitive so that conventional photolithography can be used to make a pattern. The OTFTs deposited by the PVA/Acryl interlayer exhibited about 40% degraded performance as shown in Table.1 and Fig.2 but they were still applicable and operated over two months.

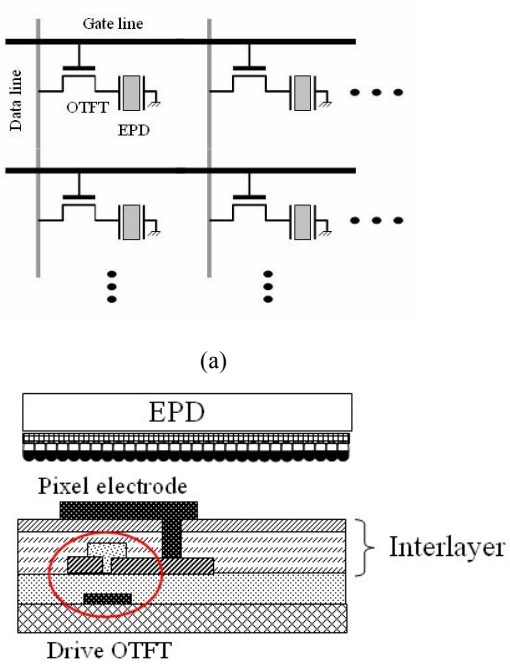


Fig. 1. a) The circuit configuration of AMEPD pixel b) The cross-section of a pixel consisting of OTFT and EPD

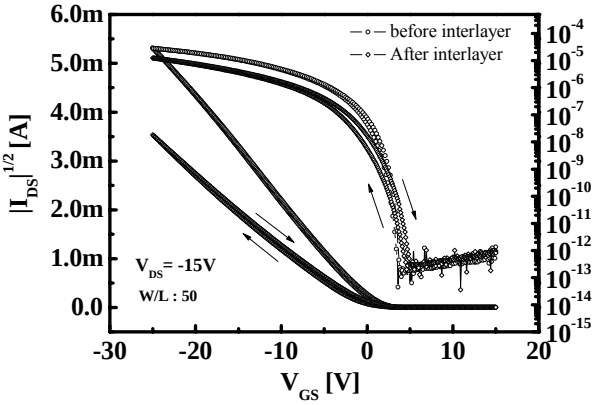
3. Conclusions

We fabricated flexible OTFT-backplanes for the electrophoretic display (EPD). The size of backplane was 2.5” in diagonal direction and consisted of 128 x 96 pixels, containing one OTFT in each pixel. The backplanes were batch-processed on 200 mm x 200 mm PEN substrate

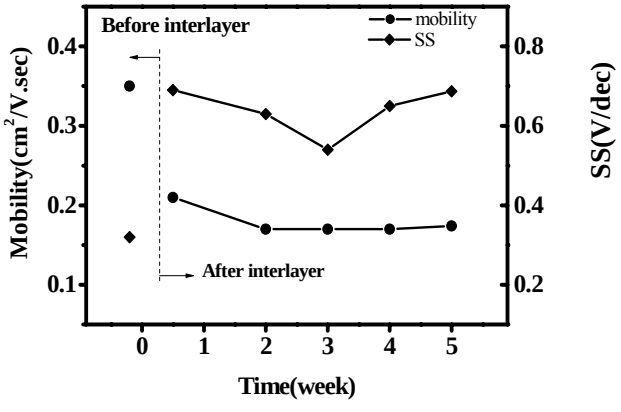
which included four backplanes. The OTFTs employed bottom contact structure and used the cross-linked polyvinylphenol for gate insulator, pentacene for active layer.

Table 1. The performance parameters of OTFTs in backplane before and after PVA/Acryl interlayer deposition.

	Unifomity	After interlayer (before interlayer)
Mobility ($cm^2/v{\cdot}s$)	0.213 ± 0.021	0.21 (0.35)
SS(V/dec)	2.43 ± 0.43	0.69 (0.32)
Ion/Ioff	$4.8 \pm 1.36 \times 10^5$	$3.66\ (14.5) \times 10^7$
Vth(V)	7.42 ± 0.59	-3.7 (-0.5)
Off-state current (pA/um)	0.056 ± 0.0142	0.0003 (0.0002)



(a)



(b)

Fig 1. a) The transfer characteristics of OTFT before and after PVA/Acryl interlayer deposition, and b) the variation of mobility according to time.

The OTFT produced good uniformity over the whole substrate area with the variation less than 20%. The OTFTs exhibited mobility of 0.21 ± 0.02 cm^2/V.sec, off state current 0.056 ± 0.014 pA/um, threshold voltage 7.42 ± 0.59 V, and the Ion/Ioff current ratio of $4.8 \pm 1.36 \times 10^5$. And then, we used PVA/Acryl double layers for passivation of backplane as well as for interlayer between backplane and EPD panel. The OTFT-EPD panel worked successfully and demonstrated to display some patterns.

Acknowledgements

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