Real In-cell Integrated Touch Sensor for Flexible OLED Display

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Abstract

This work presents a novel structure for integrating capacitive touch sensor within thin film encapsulation (TFE) of OLED display. Through patterning the cathode with an undercut structure, one region is allocated for display and another for touch sensing. Finally, a 1.43-inch prototype was developed, which exhibits sensitive touch and superior display quality. The adoption of the in-cell structure not only eliminates the need for the external touch sensor manufacturing process outside TFE but also reduces the overall module thickness.

Author Keywords

capacitive touch sensor; integration; in-cell; OLED; undercut

1. Introduction

In the field of LCD displays, touch technology has undergone the evolution from add-on, to on-cell, and finally to in-cell. As the integration level of the touch structure and the LCD panel continues to increase, the display module has not only become thinner but has also seen significant improvements in both light transmittance and brightness.

For OLED displays, the technological path for the touch structure is transitioning from the add-on type to on-cell. Particularly in products such as wearables, smartphones, and foldable devices, the on-cell touch structure has become the mainstream . This structural evolution has led to a significantly thinner module, enhanced panel flexibility and thinness, improved light transmittance. Progressing from on-cell to in-cell integration serves to further minimize module thickness, and thus lowers the risk of touch sensor layer fracture during OLED bending. In addition, the adoption of the in-cell touch structure eliminates the need for the touch sensor layer deposition process after TFE, which reduces the number of the required photomasks and optimizes the manufacturing cost of OLED display modules (Figure 1).

2. Results and Discussion

2.1. Challenges

The realization of the in-cell touch structure in AMOLED displays presents two major challenges. First, OLED displays feature a common cathode that is distributed across the entire surface.

When the touch structure is integrated into the TFT array, the electric field generated by the touch sensor are shielded by the common cathode, preventing the detection of finger touch. Second, the in-cell touch structure significantly reduces the distance between the touch electrodes and the cathode, anode, and other signal lines. This not only leads to a large capacitive loading, but also causes interference between the display and touch functions.

2.2. Technical Solution

In this paper, we propose a novel design scheme that utilizes cathode patterning technology to segment the cathode into two independent parts: one serving as the display cathode and the other as the touch electrode. As illustrated in Figure 2, the cathode above the undercut structure acts as the touch electrode, while the cathode in the pixel aperture area remains used for the OLED display.

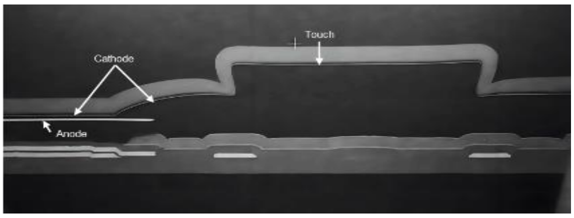

Fig. 2. FIB image showing the distribution of the display cathode and the touch electrode.

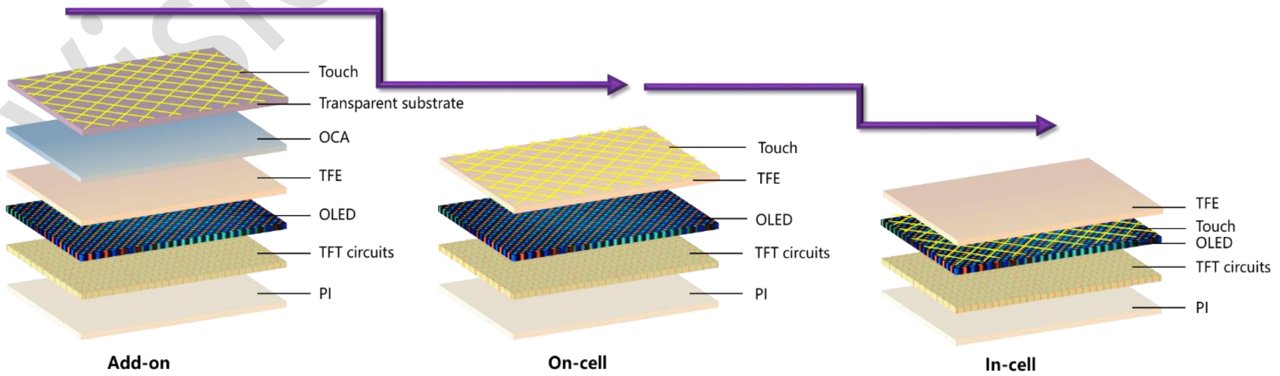

Figure 1. The comparison of the stacked structures for different OLED display modules.

2.3. Prototype

A prototype of a 1.43-inch OLED display module with a real in-cell integrated touch sensor has been developed, with its key display parameters summarized in Table 1.

Table 1. Specifications of the Prototype.

Item	Specifications
Panel size	1.43inch
Resolution	466RGB*466
Substrate	Polyimide
Encapsulation	TFE
Process	LTPS
Pixel density	326ppi
Touch Type	Self-capacitance
Touch channels	32

The in-cell panel in the display state exhibits any visible Mura, as presented in Figure 3.

Fig. 3. Photograph of the 1.43-inch in-cell AMOLED display module prototype.

The touch performance was first evaluated, using a grounding copper pillar with a diameter of 7 mm to simulate the human finger during the testing. Benefitting from the high signal and low noise level, its statistical SNR is calculated to be higher than 35dB, the corresponding parameter measurements are summarized in Table 2.

Table 2. Test results for touch performance metrics.

Touch Performance	Spec.	Test Value
Report Rate	120Hz	120Hz
Display White SNR	>35dB	37dB
Response Time	<30ms	22ms
Two-Finger Separation	<15mm	11mm
Accuracy (Φ7mm)	Center<1.0mm Edge area<1.5mm	Center0.8mm Edge area1.2mm
Jitter (Φ7mm)	Center<0.4mm Edge area<0.5mm	Center0.3mm Edge area0.4mm
Linearity (Φ7mm)	Center<1.0mm Edge area<1.5mm	Center0.8mm Edge area1.1mm

3. Conclusion

In this work, we designed and fabricated the undercut structure to divide the cathode into two parts: one for the OLED cathode, and the other one for the touch electrode. This addresses the cathode shielding issue, allowing for the realization of an in-cell integrated touch sensor. A 1.43-inch circular smartwatch with an in-cell touch structure was developed by employing the above structure. The touch measurement results demonstrate that the prototype exhibits a touch SNR greater than 35 dB, a reporting rate of 120 Hz, and high sensitivity for smooth line drawing.