An In-Screen Optical Fingerprint Recognition Structure for Full-Screen LCD

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ABSTRACT

We report a new type of LCD screen with an in-screen optical fingerprint recognition structure. This in-screen fingerprint recognition structure uses layers on the TFT&CF glass to make a collimating structure for accurate recognition. It can achieve fingerprint recognition at any position on the screen. It has a better user experience than traditional fixed location recognition.

1. INTRODUCTION

With the rapid development of smart phones, full-screen smart phones have started to occupy the market. Full-screen phones usually have a screen ratio of more than 85%, which means that it has difficulty to put fingerprint recognition device on the screen. At present, there are three general solutions for off-screen fingerprint recognition: installing a fingerprint recognition device on the back of the mobile phone; and installing a fingerprint recognition device on the side of the mobile phone. However, both of these two solutions will greatly increase the thickness of the mobile phone and reduce the consumer experience. The third solution: use a pressure sensing device at the top of the screen for fingerprint recognition, but this solution requires hard pressing and has disadvantages of signal interference and slow unlocking speed. At present, many mobile phone manufacturers have installed the fingerprint recognition device under the screen instead outside the screen. This type of under-screen fingerprint recognition technology is divided into optical recognition and ultrasonic recognition for LCD. The optical scheme use infrared light outside the screen as a light source to achieve optical fingerprint recognition. Under-screen ultrasonic fingerprint recognition has strong penetration and high recognition. However, placing ultrasonic fingerprint recognition under a LCD screen is too complex and expensive.

In this paper, we propose a new in-screen optical fingerprint recognition (IOFPR) scheme

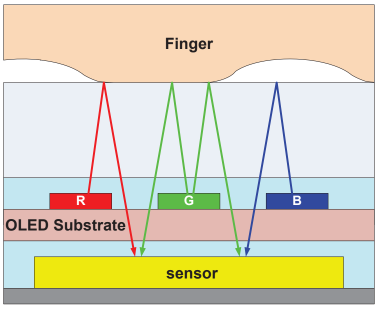
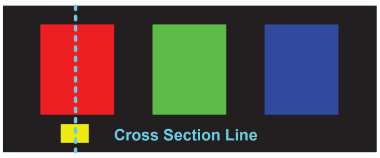
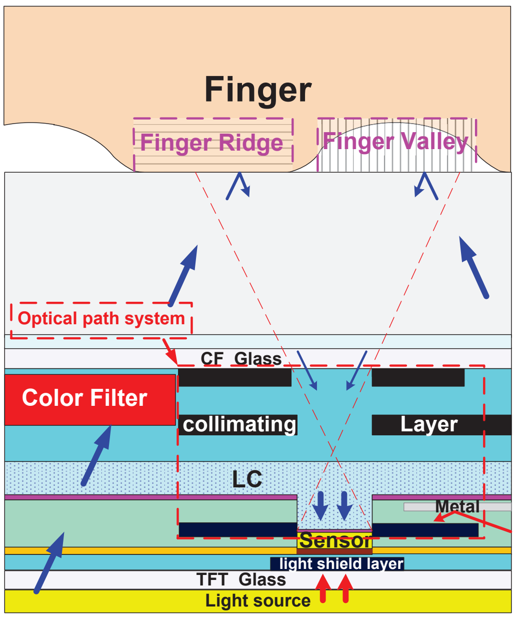


Fig. 1 Under-screen optical fingerprint recognition structure for OLED.



(a)



(b)

Fig. 2 IOFPR LCD (a) The top view of the pixels and sensor. (b) The cross section of the finger and sensor

for LCD screen that can realize fingerprint recognition at arbitrary position on the screen. This kind of scheme has great differences and advantages compared with the under-screen optical fingerprint recognition. As shown in Fig.1, the optical fingerprint under the screen requires an optical recognition sensor to be placed at the bottom of the screen. This method limits fingerprint recognition to a fixed position and is difficult to apply to LCD screen that cannot self-illuminate.

As shown in the Fig.2, the in-screen fingerprint recognition scheme is composed of in-screen optical path system (located in the CF film layer & TFT film layer), in-screen photosensitive sensor (on the TFT side), and light shielding film layer (on the TFT side). Optical path system is composed of several collimating layers, which are located both on TFT side and CF side. The collimating layers can block oblique incident light and reflected light to the sensor, so the fingerprint recognition become more accurate.

IOFPR scheme can reserve more space for identification unit when assembling the whole module because the fingerprint sensor is integrated with the pixel in AA area.

2. The principle of IOFPR

The principle of IOFPR device is as follows:

Based on the principle of illumination of LCD, the light source used for fingerprint recognition in this paper is the light emitted by the screen of the mobile phone.

As shown in Fig.2, when fingerprint recognition is performed, the backlight emits light upward and passes through the TFT side, the liquid crystal, and the CF side. When the light reaches the surface of the cover glass, a part of the light reaches the valleys of the finger pressed on the screen surface, and another part of the light reaches the finger ridges. These lights are reflected back to the sensor in the screen through the interface of glass-finger valleys (glass-air) and the interface of glass-finger ridges. The reflectivity of the two interfaces is different, so the photocurrent excited on the sensor is different, and finally the purpose of identifying the finger texture can be achieved.

The in-screen optical path system located in the CF film layer & the TFT film layer ensures that the sensor under the optical path only receives the reflected light of the finger within a small local area above the optical path, thereby achieved high-precision identification. The photosensitive sensor on the TFT side receives the electric signal formed by the light reflected from the finger. The light shielding film layer on the TFT side can prevent the light of the BLU from entering the photosensitive sensor, and the optical path film layer on the TFT side can prevent the reflected light of the metal on the TFT side from entering the photosensitive sensor.

3. RESULTS AND DISCUSSION

In Fig. 3, *Vout* refers to the voltage value output by the sensor after receiving the light, *Lum* refers to the luminance value of the light source, and the test environment is a dark room. It can be seen from the curve in Fig. 3 that *Vout* has a certain initial value when there is no light irradiation. As the luminance of the light source increases, the *Vout* value of the sensor increases linearly with the luminance of the light source. And *Vout* of the sensor is basically unchanged after the light source luminance reaches 10,000 nits, and the sensor recognition reaches saturation. The sensor receives the reflected light from the valley and the ridge of the finger. The luminance of the reflected light is much lower than the light source, so the sensor can perform fingerprint recognition in a wide working luminance range.

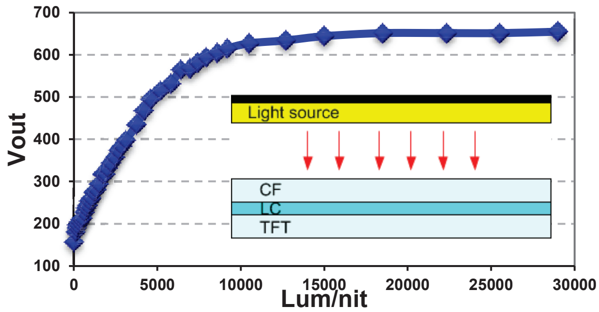
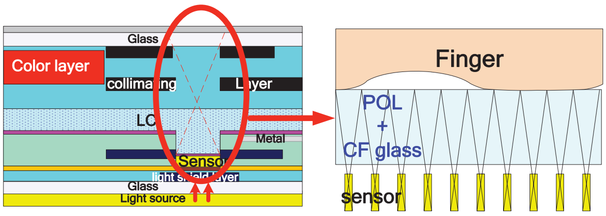
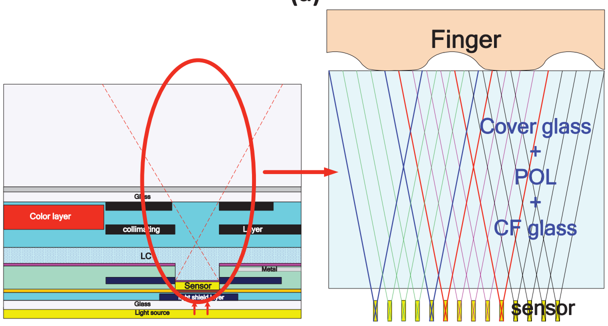


Fig.3. The sensitivity curve of the IOFPR sensor to the external light source obtained by placing the IOFPR screen under the light source.

Figure 4 (a) is a schematic diagram of the sensor and part of the fingerprint when IOFPR screen has no cover glass, and Fig. 4(b) is a schematic diagram of the sensor and part of the fingerprint when IOFPR screen has cover glass. The theoretical analysis is as follows: It can be concluded from Fig. 4(a) that the IOFPR screen without glass cover has high recognition accuracy due to the small height of the sensor to the fingerprint. The light receiving range of each sensor is small so the light collection intensity of each sensor is low, so high luminance is required to satisfy the fingerprint recognition. It can be concluded from Fig. 4(b) that the height of the sensor to the fingerprint is higher with the glass cover, and the range of the light collection of each sensor is larger, so the recognition accuracy is low, but the light collection intensity of each sensor is high, the required backlight luminance is lower. Therefore, in order to recognize fingerprints under the normal backlight luminance, it is necessary to find a suitable height of the sensor to the finger when other conditions remain unchanged.



(a)



(b)

Fig.4. Different states of IOFPR screen. (a) IOFPR screen without cover glass. (b) IOFPR screen with cover glass.

Figure 5(a) is a clear fingerprint image recognized by a fingerprint recognition display screen without a cover glass at a high luminance more than 150,000nits. Figure 5(b) is a blurred fingerprint image recognized by a fingerprint recognition display screen with a thin cover glass at a luminance less than 50,000nits. Figure 5(c) is a blurred fingerprint image recognized by a fingerprint recognition display screen with a thick cover glass at a luminance less than 15,000nits. Comparing the three results in Figure 5, it is easy to see that a very clear fingerprint image can be obtained under the high-luminance back light without the cover glass. Although the clarity of the recognized fingerprints is reduced after the addition of the thin cover glass, the luminance of the backlight is significantly reduced. Using a thicker cover glass allows fingerprint information to be recognized nearly with normal backlight luminance, but the image is very blurry. The above conclusions are the same as our previous theoretical analysis.

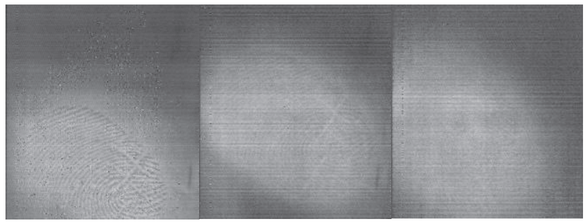

(a) (b) (c)

Fig.5. Different recognition results of IOFPR screen in different states. (a) IOFPR screen without cover glass. (b) IOFPR screen with a thin cover glass. (c) IOFPR screen with a thick cover glass.

4. CONCLUSION

The IOFPR device studied in this paper can realize fingerprint recognition in LCD screen, and fills in the technical gap of LCD screen fingerprint recognition. Our study lays a foundation for the future development of full-screen LCD. At the same time, compared with the under-screen ultrasonic fingerprint technology, the optical recognition scheme in the LCD screen has lower cost and has a huge mass production advantage in the future. However, the IOFPR device studied in this paper is still in the development stage, and many problems must be overcome to improve the fingerprint definition and reduce the luminance of the fingerprint recognition backlight. In the near future, the target of the LCD display using ordinary backlight for fingerprint recognition would achieve.

5. REFERENCES

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