A Novel Pixel structure suitable for color scanner embedded TFT-LCD

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Keywords : photo sensor, scanner, TFT LCD

Abstract

We developed a 4 inch (qVGA, 320x240) a-Si TFT LCD which has the function of color scanner.

We have designed the novel pixel structure and got good scanning quality with minimum aperture loss. In this new pixel, the sensor capacitance was increased in double without decreasing the aperture loss.

1. Introduction

Since several years, some LCD makers have introduce the photo sensor or image sensor embedded LCDs based on the LTPS(Low Temperature Poly Silicon) and a-Si (amorphous Silicon) TFTs. [1]~[8] We also developed a-Si TFT-LCD with an embedded color image scanner by using the standard mass production compatible process.[9]

This device can be used to save the image information such as signature, name cards, memorandum, catalogs, documents etc. by instant scanning, and then can show that image right after scanning.

In ordinary times, users utilize this device as a display. When one needs to get any types of information listed in previous paragraph, the user just turn on the alternating switch which change the display into the scanner and then capture the images with the device.

By the way, there exists a trade-off relationship between the sensor and display quality for this type of scanner embedded display. For example, if we make good sensor with large photo TFT and large storage capacitance in the limited pixel area, the aperture ratio decreases. Decreased aperture ratio brings about the bad quality of display such as low luminance and contrast or high power consumption. Moreover, decreased aperture ratio deteriorates the sensing quality because illumination onto the photo TFT also decreases. In this reason, we focused on finding the new design rules of pixel suitable for satisfying both sensor and display qualities.

2. Experimental

The larger sensor TFT and charge capacitor are necessary to get the better quality of sensing. However, the larger sensor causes the loss of aperture ratio for good display quality. In conventional devices, the gate insulation layers are mainly used for constructing storage capacitor. To make large sensor capacitor in the limited space, we designed new pixel structure whose storage capacitor for sensor consists of not only the gate insulation layer but also the passivation layer.

Though the insulation and passivation layers are stacked in serial, our unique structure make the capacitors connected in parallel. So the total value of capacitance are more than that of conventional one.

3. Results and discussion

We designed the novel pixel structure to put together image sensor and display part in one sub pixel. Every pixel consists of sensor part for color scanning. The panel specification is shown in Table 1 and the panel structure and simple sensing principle is shown in Figure 1.

TABLE 1. The panel specification

Category		Panel Specification
Size and Resolution		4inch qVGA (320xRGBx240)
Sensor resolution		320 x RGB x 240
LC Mode		TN
Aspect Ratio		4 : 3
Pixel size		0.085 mm X 0.255 mm
PPI	Display	100
	Sensor	100(color),300 (black & white)

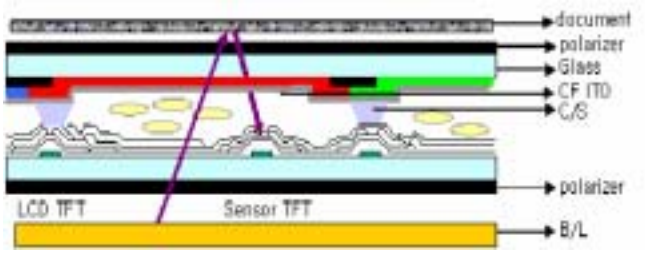
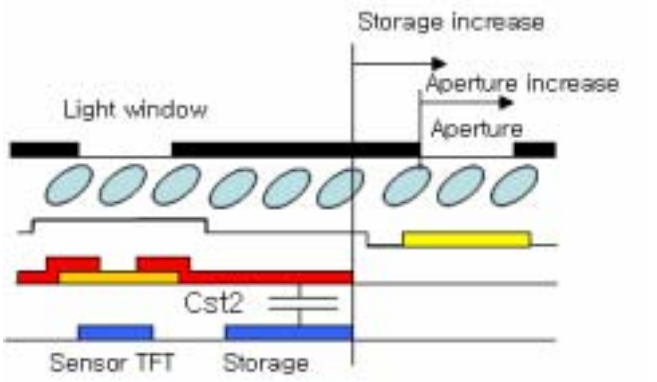
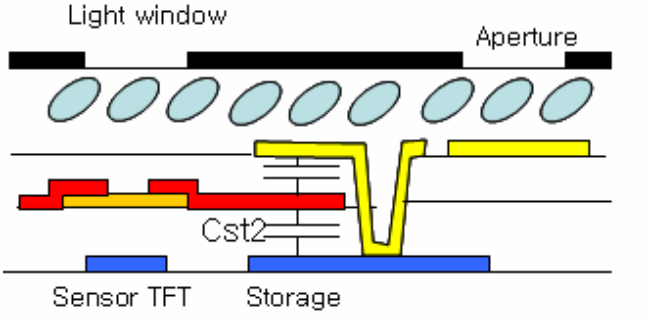


Fig. 1. The panel structure and simple principle of sensing

The scanning operation is done by using its own backlight as light source. So the large aperture ratio make the better scanning quality. Moreover, the good scanning quality is achieved by large photo TFT and large sensor capacitor, the loss of the aperture ratio must be minimized. In this reason we should design a novel pixel structure which satisfies the quality of display and sensor at the same time. The novel pixel structure is shown in Figure 2.



(a) Conventional structure (aperture loss)



(b) Novel pixel structure (no aperture loss)

Fig. 2. The Novel pixel structure

The top electrode is usually ITO which is used as pixel electrode. To make additional storage, we used the ITO layer as the storage electrode. The ITO storage electrode is connected to the storage electrode by the via hole. By doing so, we could make larger sensor capacitor without decreasing the aperture ratio.

Table 2 shows the comparison the normal structure and the novel structure

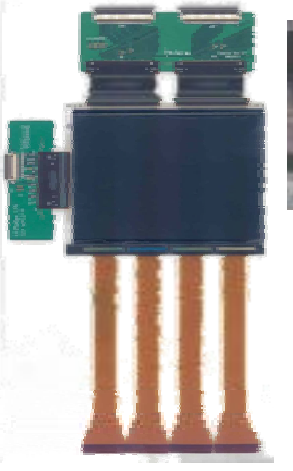
TABLE 2. Output comparison

	Normal structure	Novel structure
Sensor capacitor	0.18 pF	0.54 pF
Aperture ratio	42%	42 %
Sensed output	0.26 V	0.43 V
Image quality		

For the sake of convenience of measuring the sensed voltage, we choose the black and white image. The sensed output is the difference of white and black sensed voltage. The higher the difference is, the better contrast of black and white scanned image quality is got.

We have successfully get the good image quality of both display and scanning in color whit this novel device structure. The LCM and displayed images are shown in Figure 3.

The image of parrot is got by capturing the original photograph by this panel and displaying the image on its own screen



(a) LCM

(b) display mode

(c) scanned image

Fig. 3. LCM and images

4. Summary

We developed the world's first color image scanner embed TFT LCD with amorphous Si TFT technology.

In this study, we have found the key design factors of photo sensor and display pixel. The key is how to minimize the loss of the aperture ratio in adding the photo sensor in conventional display pixel. This design concept can be applied to another type of sensor embedded displays such as in-cell touch panel, luminance controllable LCD, and etc.

5. References

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