Development of 15-in XGA TFT-LCD with Viewing-angle Image Control

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Abstract

We have developed the VIC (Viewing-angle Image Control) TFT-LCD, which can change viewing-angle from 80° to 170°. This display has the same thickness and weight as existing TFT-LCD, because it is made of only single LC cell without additional components. Moreover, we developed ways to protect effectively the displayed information in narrow viewing angle mode.

1. Objectives and Background

TFT-LCD has been largely focused on development of wide viewing-angle (WVA) modes. Even in the display for portable devices such as mobile phone, personal digital assistant and notebook computer, a wide viewing angle has been regards as main issue. But this has a disadvantage that personal privacy is easily exposed to other people in public place such as airplanes, trains and so on.

For this reason, the demand for narrow viewing-angle (NVA) in displays has been increased and the displays which can change the viewing-angle mode have been studied and developed. [1,2,3,4] These are operated as WVA mode when user want to share his information with others and as NVA mode when he want to protect privacy. Just by pressing a button or clicking a mouse, the viewing- angle mode of display can be switched.

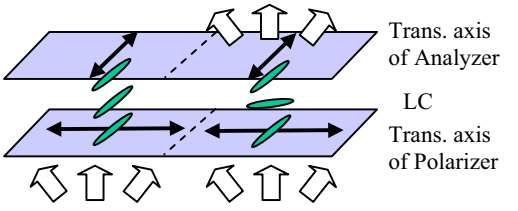
In this paper, we introduce the display which can protect conveniently privacy by only switching the viewing-angle mode. Especially, it is very suitable for portable displays which are accompanied with thin and light design because of being made of single LC cell. This also shows the outstanding effect in aspect of the protection of privacy.

2. Structure and Principle

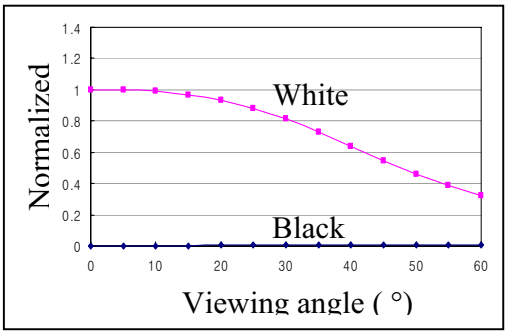
We designed the novel structure which is able to switch viewing-angle mode with single LC cell. This panel consists of major pixels for the image expression and minor pixels for viewing-angle image control (VIC). The former has the IPS (In-plane switching) electrode structure and the latter has the electrode structure such as TN using vertical electric field.

The rubbing direction of LC on the IPS and VIC pixels is the same. The transmitted axis of the polarizer attached on LC panel is either parallel or perpendicular to LC director. Therefore this structure does not need a special method for LC rubbing and use two pieces of polarizer such as existing LCD.

Fig. 1 shows the principle of IPS pixel. When LC keeps initial state in IPS pixel, the light is not transmitted to any viewing-angle. Otherwise, LC is rotated by transverse electric field and the light is transmitted to all viewing-angles.



(a) Structure

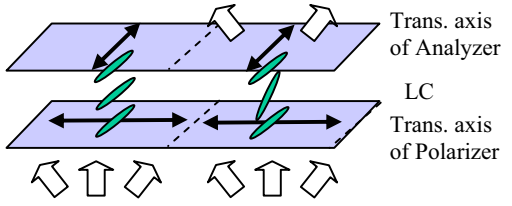


(b) The horizontal viewing-angle characteristics

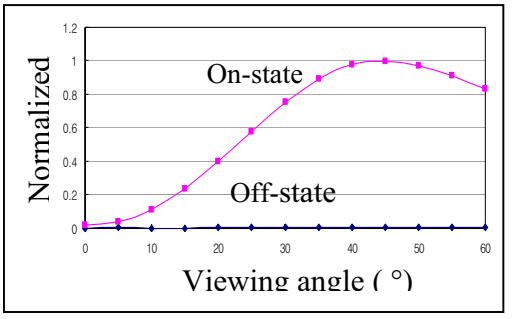
Fig. 1 The principle of IPS pixel

Fig. 2 is the principle of VIC pixel. As the initial state of VIC pixel is the same as that of IPS, the light is not transmitted to any viewing-angle. Otherwise,

the LC is tilted by vertical electric field and the light is transmitted to the left and light side.



(a) Structure



(b) The horizontal viewing angle characteristics

Fig. 2 The principle of VIC pixel

When VIC pixels are not operated, VIC LCD has the WVA characteristics such as IPS mode. On the other hand, if VIC pixels are operated, light is transmitted to the left and right side without regards to the on-off state of IPS pixels and then CR (Contrast Ratio) decrease deeply at the left and right side (NVA characteristics). Therefore, it is possible to switch the viewing-angle mode according to the on-off state of VIC pixels.

3. Driving Method

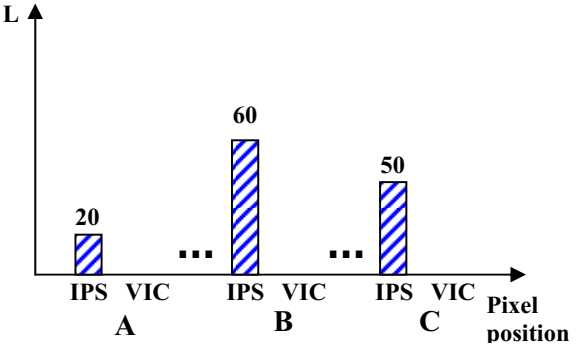
We could make the VIC LCD which is able to switch the viewing-angle mode by turning on and off the VIC pixels. But the method which changes the state of the VIC pixels from on to off was not enough to protect the displayed information in NVA mode. So we developed two types of driving methods to get the more protection effect in NVA mode.

3.1 Luminance Compensation

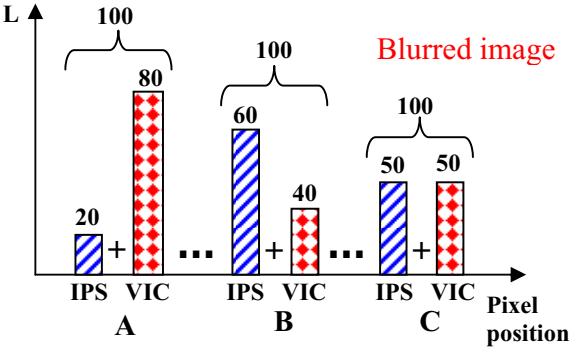
If the luminance of all pixels becomes similar values, a displayed image is blurred and then others do not get the correct information easily. Luminance Compensation method means that the luminance of all pixels has similar values at specified side angle by using VIC pixels.

Figure.3 shows how to realize the Luminance Compensation. The front images displayed by IPS pixels are represented as clear images because VIC pixels do not affect the luminance of the front side in NVA mode. (Fig. 3 (a))

However, if the luminance of VIC pixels compensates the luminance difference among IPS pixels in the specified side angle, it is shown as blurred images at the side angle. (Fig. 3 (b))



(a) The luminance of pixels at the front view



(b) The luminance of pixels at the side view

Fig. 3 Luminance Compensation method

Fig. 4 shows the VIC LCD which the Luminance Compensation method is applied to. In WVA mode, the VIC LCD represents a clear image at any viewing-angle. But, in NVA mode, it is not easy to distinguish the image because of the low luminance difference among all pixels.

(a) WVA mode

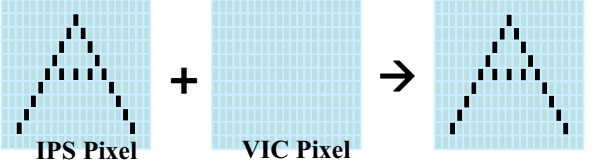
(b) NVA mode

Fig. 4 Viewing-angle switch by Luminance Compensation method

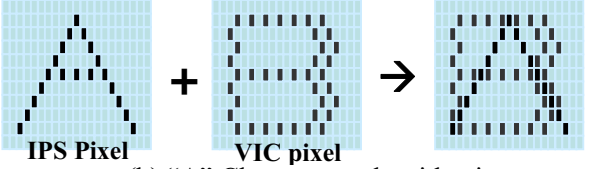
3.2 Background Character Insertion

If some VIC pixels are converted to on-state and the rest keep off-state, arbitrary character can be made by the luminance difference among VIC pixels. That is, according to the control of the VIC pixels, it is possible to make the imaginary data regardless of the real data by IPS pixels. Background character insertion (BCI) refers to insert arbitrary characters made by VIC pixels into original picture and they prevent others from getting the original information.

Fig. 5 shows the principle of background character insertion. In WVA mode, a clear character can be observed because IPS pixels represent the original characters and VIC pixels do nothing. However, in NVA mode, the imaginary characters are overlapped with the original characters and lower others' legibility in left and right side.



(a) "A" Character at the front view



(b) "A" Character at the side view

Fig. 5 Background Character Insertion Method

Fig. 6 shows the VIC LCD which the background character insertion method is applied to. In WVA mode, the VIC LCD represents a clear image at any viewing-angle. But, in NVA mode, the correct information is not perceived, because the inserted imaginary characters are overlapped disorderly with the real characters.

(a) WVA mode

(b) NVA mode

Fig. 6 Viewing-angle switch by Background Character Insertion method

3. Impact

We made the novel TFT-LCD with viewing-angle image control function and developed two ways to enhance the protection of information in NVA mode.

It shows the outstanding effect to protect privacy and can switch the viewing-angle mode conveniently. It is also very appropriate to portable display requiring thin and light characteristics because this display consists of single LC cell and is not added components.

4. References

[1] M. C. Tsai, et al., "Viewing-Angle Switchable LCD" , IDMC 2005, pp.805~806, 2005

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[3] M. Adachi, et at., "Controllable Viewing-Angle Displays using a Hybrid Aligned Nematic Liquid Crystal Cell", SID Digest, pp.705~708, 2006

[4] K. Takatoh, et al., "New Peeping Prevention Technology to Control Viewing Angle Properties of TFT-LCDs", SID Digest, pp.1340~1343, 2006