

28.4: High-Resolution Stereoscopic TFT-LCD with Wire Grid Polarizer

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Abstract

We developed a 5.5 inch, VGA (640×480×RGB), stereoscopic 3D display using a precisely patterned wire grid polarizer (WGP) with rows of alternating polarization angle. Such a wire grid polarizer is invisible without the polarizer and thus a 2D/3D convertible display can be formed. The proposed structure is free of any limitations on both viewing angle and viewing distance inherent in the conventional stereoscopic displays, whereby enabling several persons to view stereoscopic image simultaneously. Because the proposed structure does not use conventional polarization film of TFT-LCD panel, it can be manufactured with low-cost.

1. Introduction

The cost of TFT-LCD is decreasing continuously and thus it is getting more popular as a home TV. The displays less than 40 inch diagonal on the market are mostly LCD displays because of its low cost and good image quality in addition to light weight. The application was growing, from small game panels, laptop and desktop monitors through TVs to home cinema.

The major 3D displays are based on multi view such as 2 view, 4 view, -, -, -, which belongs to a non-glass type 3D display [1,2]. On the other hand, the active shutter and polarized glass methods belong to a glass-type 3D display. However, the non-glass 3D displays provide limited viewing angle and viewing distance even though they offer a merit of making it unnecessary for a viewer to wear any glass. The active shutter method causes a viewer to feel dizziness by producing stimuli, due to the flicker phenomenon, to the eyes of a viewer, whereas the polarized glasses method, even though it has an advantage of wide horizontal viewing angle, provides the short viewing distance and narrow vertical viewing angle.

To overcome these weaknesses and limitations, we have developed a new structure of the 2D/3D convertible display using one LCD panel. Therefore, this new structure does not provide limitations on both viewing distance and viewing angle, which is inherent in the conventional polarized glass 3D method.

Figure 1 shows the conventional stereoscopic display, where the rows with an odd number on the TFT LCD designated as R, R, R... are for the right eye image, and the rows with an even number on the TFT LCD designated as L, L, L... are for the left eye image. And a glass substrate having horizontal strips of half-wave

retarders in the rows of odd number, and transparent strips in the rows of even number is affixed to the TFT LCD [3,4]. In this structure, a viewer wearing polarized glasses can view stereoscopic image in the areas defined by blue color. However, he/she can not view stereoscopic image in the areas defined by red color.

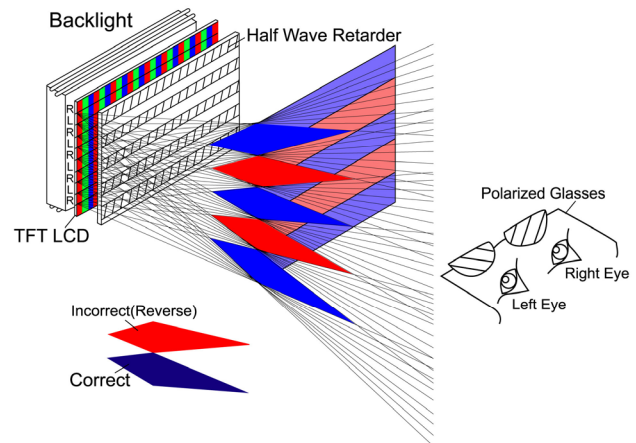


Figure 1. A schematic view of the conventional stereoscopic display having limited viewing area and viewing distance.

There are the limited visible viewing distance and visible viewing angles in the conventional stereoscopic display, since the thickness of glass 2 and polarizer 2 combined causes a parallax problem. Thus, the structure of the conventional stereoscopic display needs to be improved to overcome these limitations on viewing angle and viewing distance.

2. Principle of the proposed structure

In our previous work, we reported a 2.0 inch, QCIF(160×128×RGB) resolution, stereoscopic 3D display using WGP containing rows of alternating polarization angle [5]. The principle of the proposed structure for the WGP containing rows of alternating polarization angle can be seen in Fig. 2. When a voltage is applied, an incidence light (L1) entering the wire grid polarizer one (WGP 1) of a polarization orientation of 45 degrees, transmits it and then the liquid crystal (LC) Layer before being

blocked by the wire grid polarizer 3 (WGP 3) which has a polarization orientation of 135 degrees, whereas the incidence light (L2) transmits the wire grid polarizer two (WGP 2) and LC layer. After this, it is absorbed by the wire grid polarizer four (WGP 4), which has a polarization orientation of 45 degrees. Of course, when an electric field is turned off for the LC layer, the incidence beam L1 and L2 transmits WGP 3 and WGP 4, respectively.

In case of the proposed structure, WGP 1 and WGP 2 having rows of alternating polarization angle are affixed to the inner surfaces of TFT panel substrate and color filter panel substrate. Therefore, the polarizers are disposed adjacent to the LC layer and the polarizers removing parallax problem remarkably.

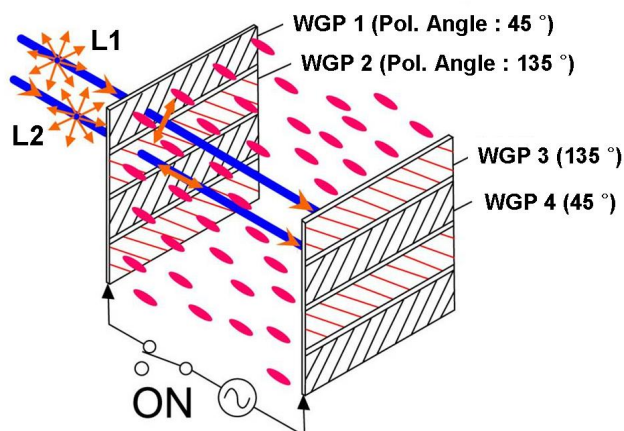


Figure 2. A schematic view of the stereoscopic display using wire grid polarizer (WGP).

3. Results and discussion

We designed and fabricated a 5.5 inch VGA (640×RGB×480) resolution-stereoscopic display using WGP having rows of alternating polarization angle.

Figure 3 shows a SEM image of the WGP patterned with rows of alternating polarization angle (a). The pitch of WGP is 144 nm. In addition, to check the black state of the WGP, we compared the assembled WGP with a conventional polarized film for the transmittance as function of the wavelength (b). The assembled WGP is designed such that it alternates a polarization orientation of 45 degrees with a polarization orientation of 135 degrees from one row to another. It was found that the incidence light can not perfectly block the incidence light at the visible ray region and its transmittance was 1.3 % in shown Fig 3(b).

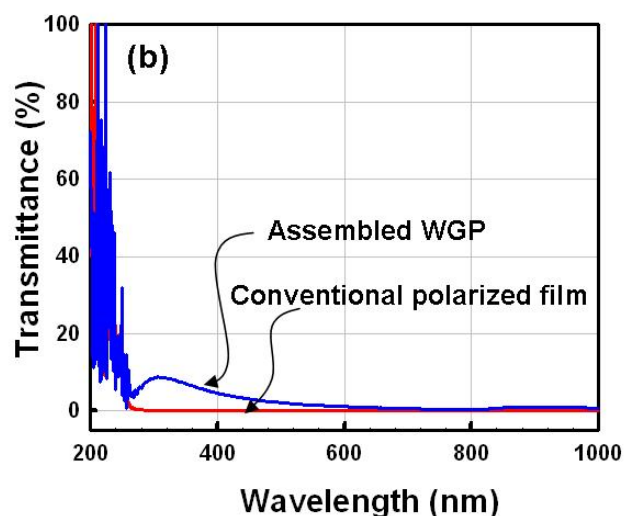
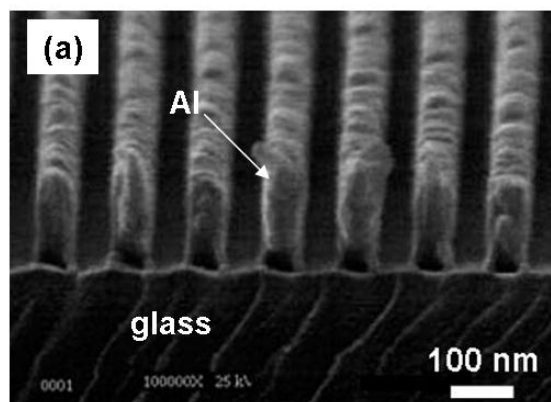


Figure 3. SEM cross-sectional view of the WGP containing row of alternating polarization angle (a) and the transmittance of both the assembled WGP and a conventional polarized film as function of the wavelength (b).

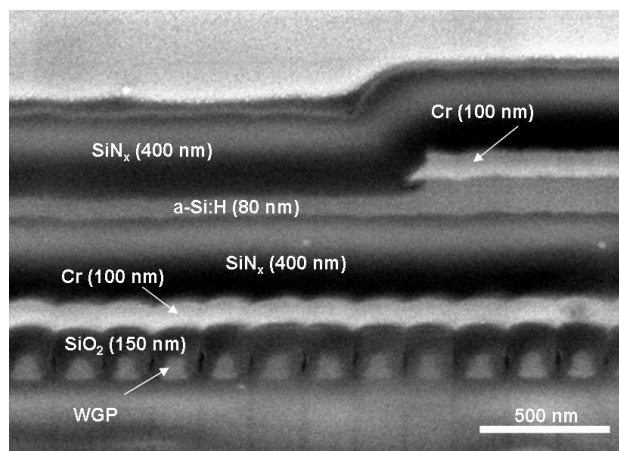


Figure 4. A cross-sectional SEM image of inverted a-Si:H TFT structure built on WGP containing row of alternating polarization angle.

Figure 4 shows a cross-sectional SEM image of inverted staggered a-Si:H TFT structure on the WGP containing rows of alternating polarization angle. A 100 nm thick Cr was deposited on SiO₂ (150 nm)/ precisely patterned WGP (72 nm) / glass and the patterned chrome for gate electrodes. The three layers of SiN_x, a-Si:H and n⁺ a-Si:H were deposited consecutively in a PECVD (plasma enhanced chemical vapor deposition) reactor at the substrate temperature of 280 °C. The a-Si:H film is used for the active layer of TFT, and the SiN_x is utilized as a gate insulator of the switching TFT and also passivation layer. The n⁺ a-Si:H layer was deposited with a mixture of SiH₄ and PH₃. The RF power for the a-Si:H and n⁺ a-Si:H depositions was 50 W. The islands for TFT layers were defined by NF₃ plasma etching. A chrome layer (100 nm) for data lines and source/drain contacts of the TFT was deposited by DC sputtering. Then, the n⁺ a-Si:H layer on the TFT channels was etched away. Passivation layer, SiN_x, was deposited by PECVD and patterned to form via-holes by RIE (reactive ion etching). Finally, a 50 nm thick IZO film for a pixel electrode was deposited by magnetron DC sputtering.

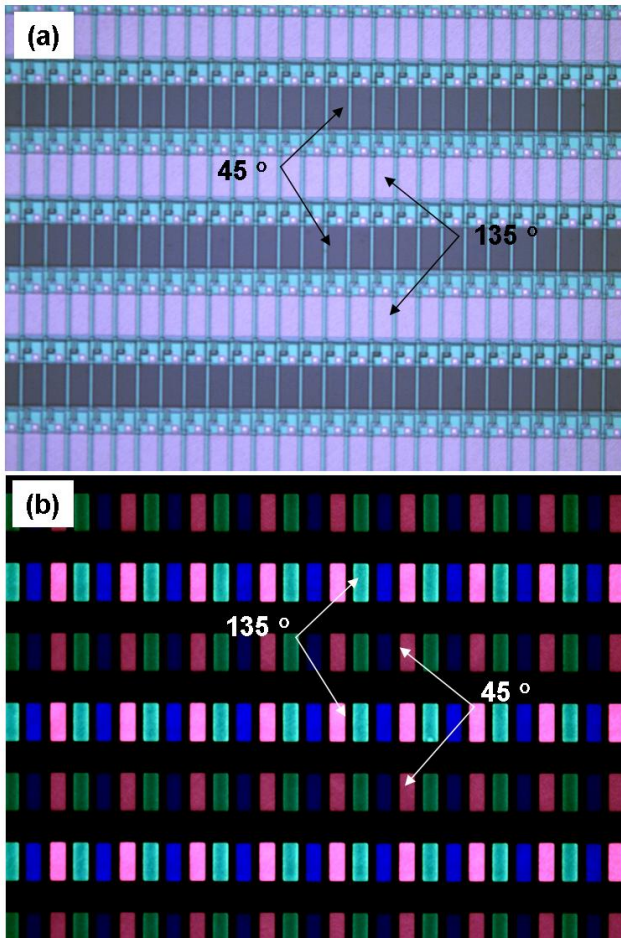


Figure 5. The optical microscopy images of the TFT array (a) and color filter array (b) for stereoscopic display.

Figure 5 shows the optical microscopy images of the TFT array (a) and color filter array (b) for stereoscopic display. As a result, the optical images of TFT array and color filter array

appear crossing orientations of 45 and 135 degrees through a light. Each light ray from the WGP has its own direction and makes corresponding right or left image. To assemble TFT array and color filter array with high alignment accuracy, alignment marks on both TFT and color filter array were used.

Table 1. The specifications of a 5.5 inch stereoscopic display with WGP's

Panel Size	5.5 inch Diagonal
Resolution	VGA (640 × 480 × RGB)
Sub-pixel Size	174 μm × 58 μm
Viewing Distance	Free
Viewing Angle	Free
Aperture Ratio	41 %
Polarized Glasses	Linear Polarizer

We fabricated a 5.5 inch, VGA (640×480×RGB) resolution, stereoscopic 3D display using wire grid polarizer (WGP) with rows of alternating polarization angles on it. The specifications of the stereoscopic display are shown in Table 1. The sub-pixel size is 174 μm×58 μm and the aperture ratio is about 41 %. The proposed structure gives a viewer freedom of viewing distance and viewing angles.



Figure 6. The photograph of an image displayed on a 5.5 inch stereoscopic display using WGP containing rows of alternating polarization angle.

Figure 6 shows a photograph of an image displayed on the 5.5 inch stereoscopic display using WGP containing rows of alternating polarization angle.

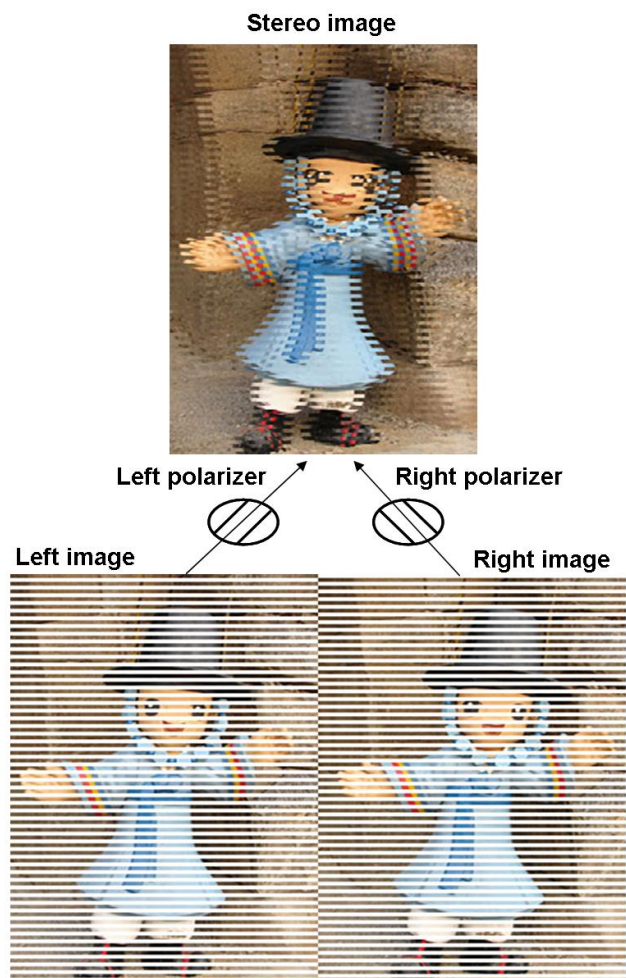


Figure 7. The image shows how to observe a stereoscopic image.

Figure 7 is a picture showing a way to observe two stereoscopic images displayed onto for the left eye and the other

for the right eye. Since a WGP with rows of alternating polarization angles was already affixed to the inner surface of the upper plate of the proposed stereoscopic TFT-LCD, left image is placed in the rows designated with an odd number and right image in the rows designated with an even number on the screen. When one sees the left and right images through polarized glasses, the left image in the rows with a odd number transmits the left polarizer and is projected into one's left eye, and the right image in the rows with an even number transmits the right polarizer and projected into one's right eye whereby the viewer can feel a three dimensional image.

Since the wire grid polarizer is placed adjacent to the LC layer, there is no limitation on viewing angle and viewing distance. Therefore, it is possible that many persons can watch stereoscopic image simultaneously.

4. Conclusion

We demonstrated a high resolution, stereoscopic display of a 5.5-inch VGA (640×480×RGB) TFT-LCD with wire grid polarizer.

Even though the new stereoscopic display was manufactured with one TFT-LCD panel, it serves as a 2D/3D convertible display. Besides, it allows multiple people to view simultaneously as it has no limitations on viewing angle and viewing distance.

5. References

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