The Development of 12.1" SVGA Reflective Color Thin Film Transistor Liquid Crystal Display with The New Structured Reflector and Optimized Optical Films

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Abstract

We have developed the 12.1" SVGA reflective type color TFT-LCD(Thin Film Transistor – Liquid Crystal Display) with the high aperture ratio and well designed reflector for the applications such as mini note PC, Note PC and electronic book. The panel shows the high reflectance(30%) and contrast ratio(20:1) resulted from optimizing the optical films and designing the embossing shaped reflector. By improving the chromacity, the color reproducibility was increased up to 20%. As removing the backlight unit, we reduced the power consumption, thickness and weight of the panel to 0.8W, 2.2mm, and 250gram, respectively. According to the above performances, we have obtained fabrication process for mass production, and furthermore, could have access to fast market launching.

Introduction

In active matrix liquid crystal displays, the reflective type TFT-LCD is characterized by its thin thickness, light weight and low power consumption. Because of the excellent presentation ability in using outdoor, the reflective type TFT-LCD is highly recommended to the portable appliances such as Notebook Personal Computer, Handheld PC, Personal Digital Asistant, IMT-2000, and Digital Still Camera.[1] Recently, the Mixed mode Twisted Nematic(MTN) type TFT-LCD has been adopted and showed superior properties in the reflectance, contrast ratio, color, reliability and producibility.[2],[3]

In here, we have done follows that the reflectance has been increased by the well designed reflector, called Embossing Metal Mirror, and the optical films have been organized with optimum conditions. In addition, the color reproducibility of the color filter has been improved by the new material and process.

Consequently, we have fabricated the 12.1" SVGA reflective type color TFT-LCD that shows the high reflectance(30%) and contrast ratio(20:1). It could be applicable to the portable note PC or the other appliances that need slim-light and power saving display at outdoor. Because the conventional transmissive type TFT-LCD can not meet the requirements, the reflective type appears prospective display for the mobile information tools at daylight.

Device Fabrication

Reflector

The main point of the reflective TFT-LCD is the light efficiency. To improve the reflectance, we have made embossing shaped metal surface as a reflector designed randomly on a pixel. The incident light also diffuses on it. Figure 1. shows the new reflector. we used organic resin as a planarizing basement layer and formed embossing pattern with it.[4] In fabricating the contact hole and embossing structured surface, the double exposure method was carried out for the cost effective process. The PR coating and developing step can be skipped by the method. The morphology of the embossing surface depends sensitively on the exposure, develop, ashing and baking of organic resin. We optimized the photolithographic process and have increased the reflectance about two times of the planar shaped reflector's.

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In MTN mode TFT-LCD, the liquid crystal process should be changed to meet the optical condition. The unique method, that is able to measure the cellgap and the birefringence of the reflective type LCD, has been found by applying the reflectance to the rotation angle of polarizer and fitting data of simulation. From the method, we could find the optimum conditions to cellgap, Δnd and twist angle for liquid crystal process. Figure 2. shows the illustration of the simulation with measured data.

Color Filter

Comparing to the transmissive LCD, the brightness of the reflective panel is very low. Thus we have made the high transmittable color filter by controlling the chromacity. Even it cause to be decreased the contrast ratio and the color reproducibility, we have found trade off condition for the suitable color reproducibility by using the new color filter material. Figure 3. shows the color property of the reflective type panel.

Optical Films

By combination of the compensating films(λ/4 plates ; retarder), the reflectance and the contrast ratio have been more improved, 10% in the reflectivity and 100% in C/R. Because the retarder affects the reflectivity and color, especially dark state, we surveyed the combined conditions of the multi-films and got the linearity of the dispersion property. To do this, we have done computer simulation to find the optimized ***Δnd*** and the combining angle, and we have found specific 4 conditions. Figure 4. and 5. show the reflectance and the contrast ratio of the panel applied the new conditions with several optical films including our new film. Except the improving of the reflectance and contrast ratio, the conditions give some benefits such as cost-down by using PC(Poly Carbonate) material that is chiefer than the competitive film and easy suppliance to commercialize.

Results

Figure 6. shows the 12.1" SVGA reflective TFT-LCD and its specifications are follows that I mentioned above.

- Reflectance : 30%*
- Contrast Ratio : 20:1
- Response Time : 40msec
- Thickness : 2.2mm
- Color reproducibility : 20%
- Power consumption : 1.0mW
- Weight : 250g

* : The quantity is to standard white reflector ; MgO plate

Conclusion

The reflective color TFT-LCD appears as a display for the portable and outdoor info-communication or multimedia appliances that need ultra thin, light and power saving function. Thus we have proposed several methods to improve the reflectance and have developed 12.1" reflective TFT-LCD for notebook PC application.

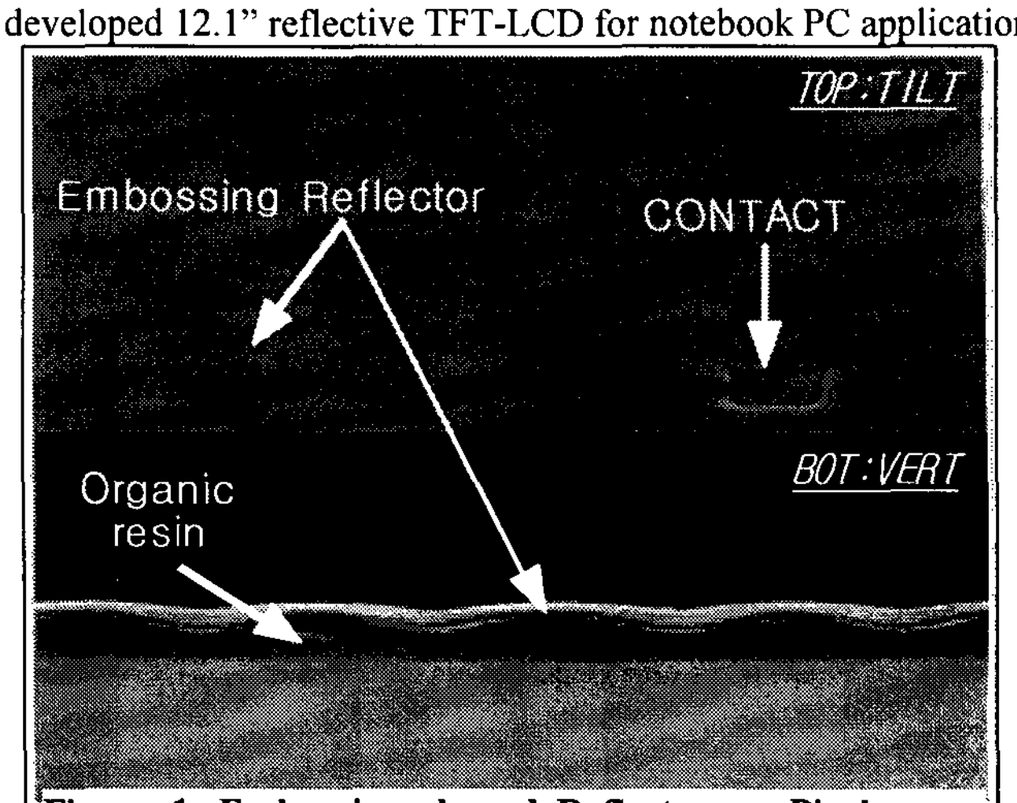

Figure 1. Embossing shaped Reflector on Pixel

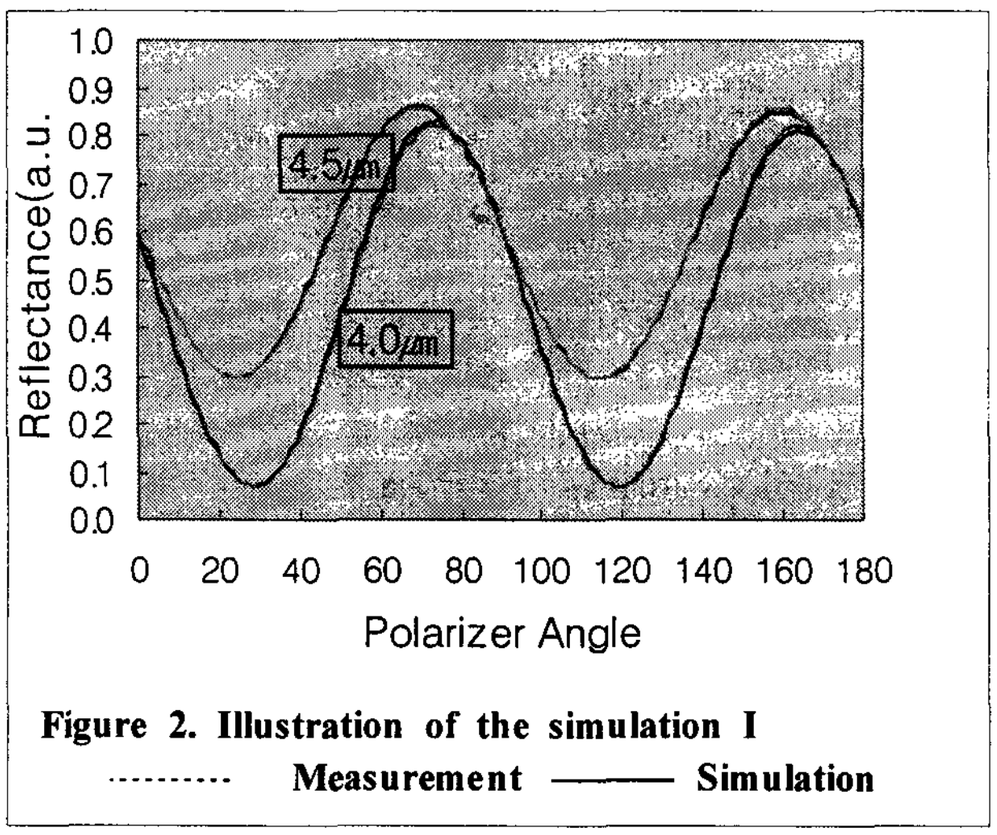

Figure 2. Illustration of the simulation I
..... Measurement ——— Simulation

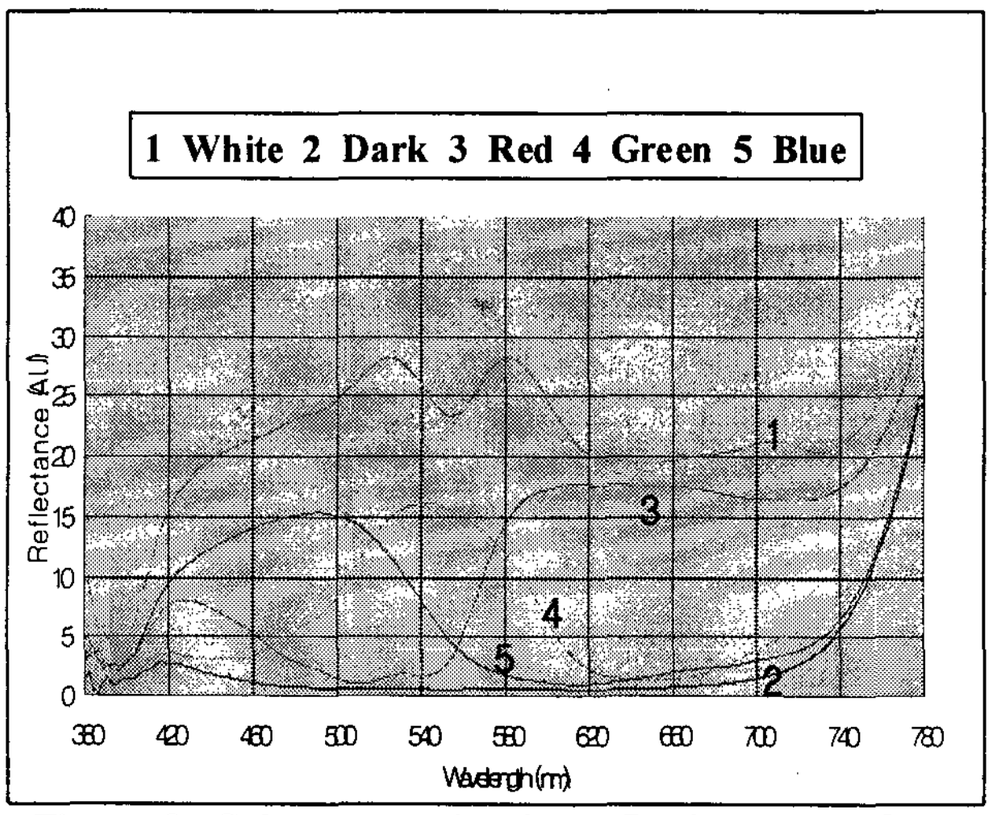

Figure 3. Color properties for reflective TFT-LCD

In addition to this performance, we need to set up the uniform process in handling the organic resin basement and to find the high reflectivity metal film with well designed embossing surface. Then, we'll have strong position in commercializing the reflective ty display.

References

[1] Nikkei microdevices 1997. 10.

[2] S.T. Wu, C.S.Wu, SID 97, DIGEST, p643

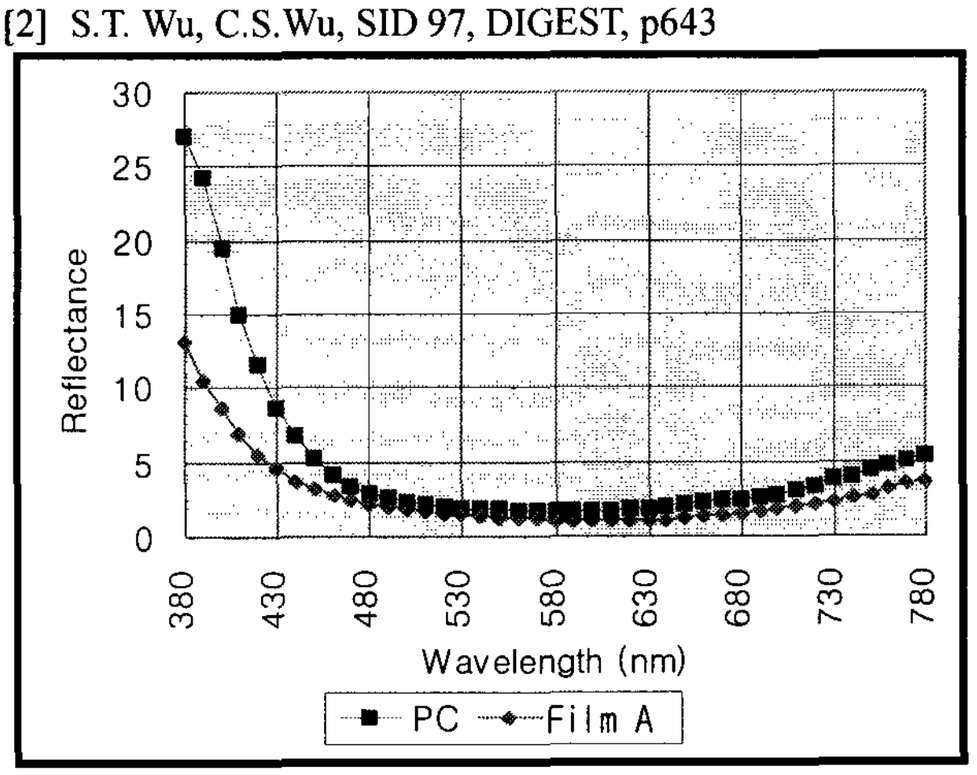

Figure 4. Reflectances to the optical films

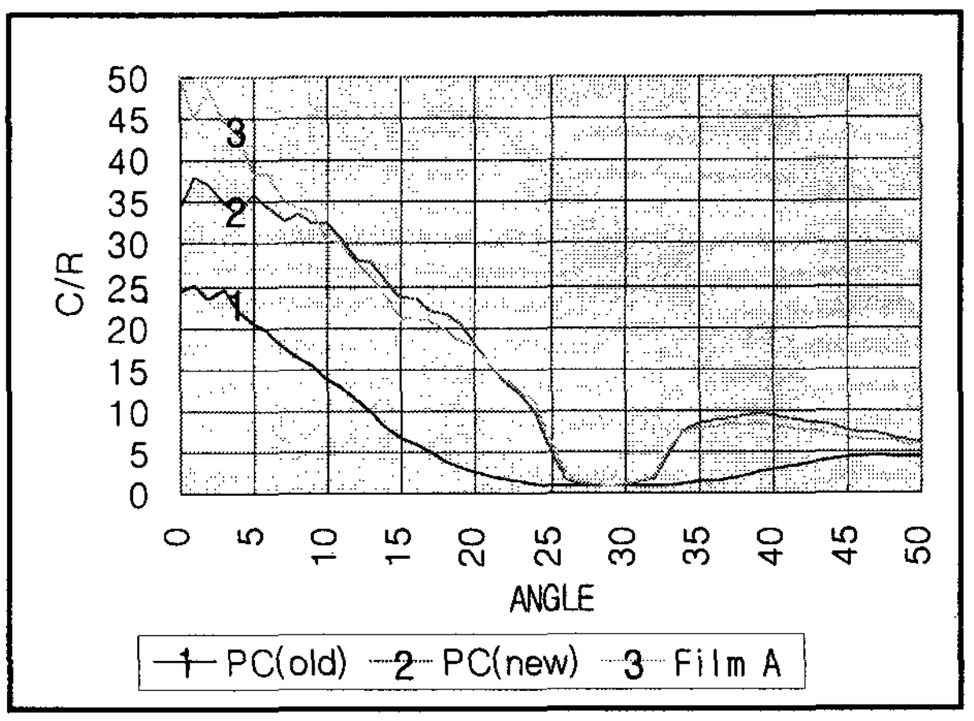

Figure 5. Contrast Ratio to the optical films

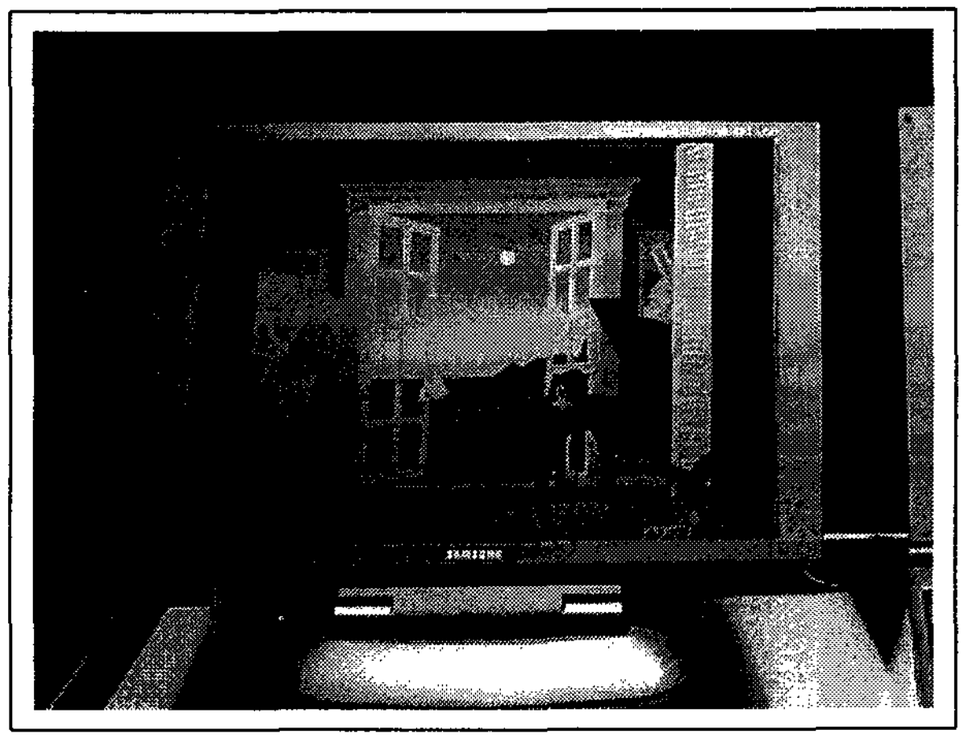

Figure 6. 12.1" SVGA reflective TFT-LCD

[3] S.T. Tang, J. Appl. Phys. 81, 1997, p5924

[4] Y. Itoh, et al. Influence of rough surface..., SID 98