Development of a 20.1-inch Diagonal SXGA TFT-LCD for Replacement of CRT Monitors

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Abstract

We have developed a 20.1-inch Diagonal SXGA (1280 x 1024) TFT-LCD which possesses high aperture ratio of 72%. We have adopted very-high-aperture-ratio (Super-HA) technology using pixel-on-organic-passivation structure and very-wide-viewing-angle (Super-VA) technology achieved by simulating and optimizing the optical parameters of LCD cells and optical compensating layers in this TFT-LCD. We have accomplished power consumption as low as 25W with 200cd/m^2 luminance. These LCD monitors possess sufficient picture image quality for high-end graphics applications: CAD/CAM, CG, DTP etc.for replacement of CRT monitors.

Introduction

The recent trend has shown that the large LCDs are applied to high-end PCsand WS monitors. To be applicable for those use, the large LCDs need tooffer better-performance in high image quality than the CRTs do, such ashigh brightness, high contrast ratio, wide-viewing angle, high response speed and low cost. It is also essential that these large TFT-LCDs be compatible withthe CRTs.

The importance of the IPS (In-Plane-Switching) technology has already beenpointed out. [1) 2) 3)] It has, however, a trade-off in the low-apertureratio, which makes it difficult to design modules with high brightness andlow power consumption.

We have developed two significant techniques to meet the above requirementsof high brightness and low power consumption. One is thehigh-aperture-ratio (Super-HA) technology to form a picture-pixel electrodeon an organic passiviation. The other is a 20.1-inch diagonal SXGA (1280 x 1024 picture-pixels) TFT-LCD to optimize the wide-viewing angle, using the Super-HA technology.Today a TFT-LCD with these two technologies is called Super-V LCD, which hassuch great potentiality in high image quality that it takes over from the CRTs.

1. Super-HA Technology.

In LCD monitors, aperture ratio is a key factor to obtain low power consumption. We have adopted the Super-HA technology in the 20.1-inch SXGA TFT-LCD.
This is how the Super-HA structure works:
The picture-pixel electrode is formed on the organic insulator and assignedin a different layer from gate array and source array, which functions tocut off the light. This way, the aperture area is expanded to the busline
edge, thus yielding a high-aperture ratio. In other words, the widthbetween the buslines largely affects the aperture ratio.

Figure 1 shows the interaction of the busline sheet resistance and theaperture ratio on the 20.1-inch SXGA TFT-LCD.When the busline sheet resistance exceeds 0.6Ω/o, the aperture ratio shows considerable decrease. This is where we applied the α-Ta (0.4Ω/o), whichhas already brought about the mass-production process and the high-apertureratio of 72%.

The Super-HA structure also reduces the capacity between the pixel electrodeand the busline because of the organic film functioning as a passivation. Imagequality has dependence on such capacity, thus the Super-HAstructure may be the most optimal for a large TFT-LCD applications to PCsand WS's.

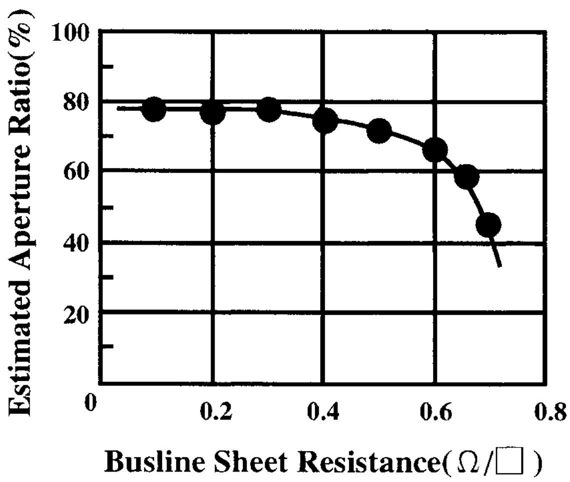

Fig. 1 Estimated aperture ratio dependence on busline sheet resistance in the 20.1-inch diagonal Super-HA SXGA TFT-LCD.

Furthermore, the Super-HA structure offers excellent
high-contrast ratio. Aliquid crystal molecule located at the edge of picture-pixel electrode is hardto control in the electrical field between the picture-pixel electrode and thecountering electrode, which results in light-escape. In the Super-HA
structure, on the other hand, the picture-pixel electrode overlaps thebusline, which means that the busline keeps light away from the edge ofpicture-pixel electrode. The Super-HA structure has now achieved the contrast ratio of over 300 on the 20.1-inch SXGA TFT-LCD.

2. Super-VA Technology

We have applied the Super-VA technology to the 20.1-inch SXGA TFT-LCD toaccomplish a wide-viewing angle replaceable for the CRTs. [4] A wide-viewingangle is obtained from the Super-VA technology through calculation tooptimize the optical parameters and the optical compensating layers, and itsoptimal condition for general twisted-nematic LCDs was determined by means of computer simulation research.

Application of the Super-VA technology to the 20.1-inch SXGA TFT-LCD hasachieved a very-wide-viewing angle from every direction, without degradingtransmission factor, aperture ratio, response, or contrast ratio.It is also notable that the optical compensation layer is formed under the polarizer. Therefore, the Super-VA technology does not require any increase in the number of TFT process, thus maintaining the current productivity.

3. Characteristics of the 20.1-inch SXGA TFT-LCD

Table 1 shows the module specifications of the 20.1-inch SXGA TFT-LCD. Thehigh-aperture ratio of 72% means low brightness of the backlight and lowpower consumption. Low backlight-brightness allows the temperature-difference between panel and room to remain small, which brings suchadvantages that;

i) the operating temperature range for TFT-LCDs will increase.

ii) the low-movement LC materials can be used, instead of uncommon materials.

Figure 2 shows the dependence on temperature difference between panel androom regarding the aperture ratio on the 20.1-inch SXGA TFT-LCD. As it illustrates, the temperature difference between panel and room largelyrelies on the aperture ratio.While large TFT-LCDs for high-end PC and WS applications usually requires the panel brightness of 200cd/m^2, the aperture ratio of 72% has achieved thepanel-room temperature difference of 5˚C on the panel edge and 3.6˚C in the panel center. Conventionally, when the IPS (In-Plane-Switching) technologyis applied to the 20.1-inch

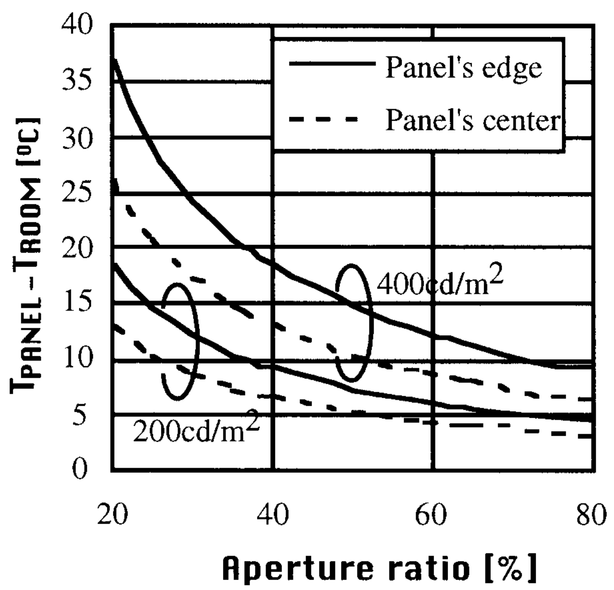

Fig.2 Dependence of difference between panel temperature and room temperature on aperture ratio in the 20.1-inch diagonal SXGA TFT-LCD.

Table1 Specifications of the 20.1-inch diagonal SXGA TFT-LCD.

Display Area	20.1-inch diagonal
Resolution	1280 x 1024
Pixel Pitch	0.312mm x 0.312mm
Viewing angle	
vertical	over 110˚
horizonal	over 140˚
Contrast ratio	300:1
Aperture ratio	72%
Luminance	200cd/m^2
Time of response	35msec.
Power consumption	25W
Weight	3.5kg

SXGA TFT-LCD, the aperture ratio shows only 35%and the panel-room temperature difference is more than 10˚C on the paneledge and 7.2˚C in the panel center.

While the CRTs for TVs require the panel brightness of 400cd/m^2, we have achieved the panel-room temperature difference of 10˚C on the panel edge and 7.2˚C in the panel center. (This is equivalent of the data obtained under the panel brightness of 200cd/m^2 by means of IPS method.) When the IPS method was implemented to a 20.1-inch SXGA TFT-LCD with the panel brightness of 400cd/m^2, the panel-room temperature difference shows more than 10˚C on the panel edge and 7.2˚C in the panel center. This surely restrains not only the module operating temperature range but also development and options for the new materials, such as the low-movement LC materials.

We additionally succeeded in achieving the low-power consumption of 25W, dueto the implementation of only two cold cathode fluorescent lamps for the 200cd/m^2 panelbrightness. The IPS method, on the other hand, requires more than four cold cathode fluorescent lamps to achieve the same level of brightness, and its power consumption shows approximately 50W.

Figure 3 and **Figure 4** illustrate the viewing-angle characteristics of the 20.1-inch SXGA TFT-LCD.
Ordinary twisted-nematic 20.1-inch SXGA TFT-LCDs take 80 degree (forhorizontal) and 85 degrees (for vertical) of the viewing angle without grayscale inversion. Improvement may be seen in the viewing angle with the

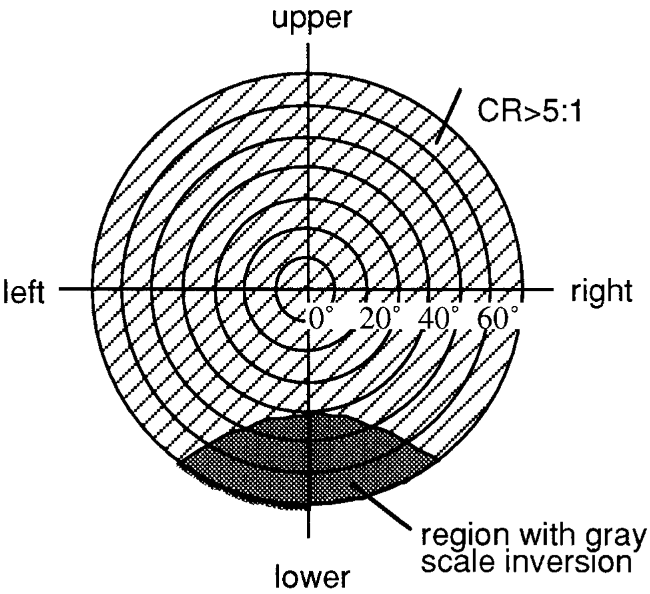

Fig.3 Hemispherical contrast ratio plot and region with gray scale inversion in Super-V TFT-LCD.

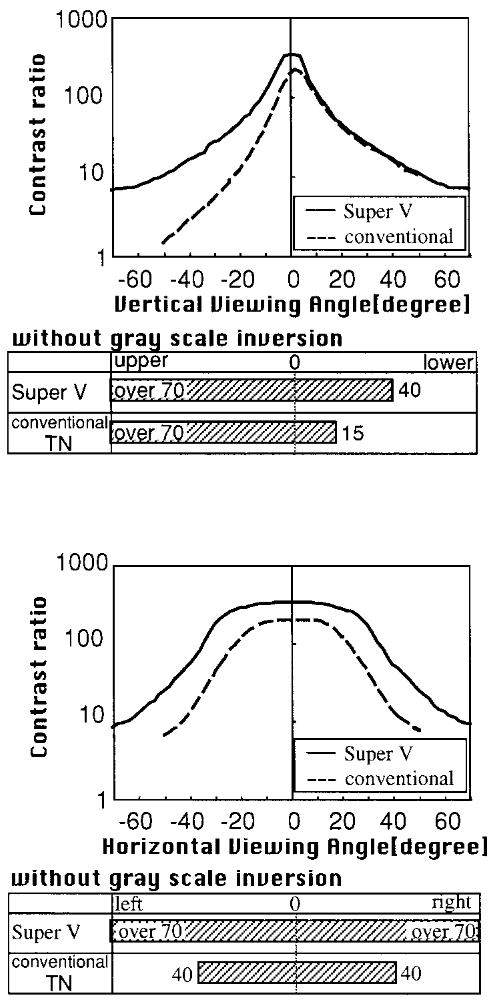

Fig.4 Viewing angle characteristics of the 20.1-inch diagonal SXGA TFT-LCD.

implementation of the Super-V: 140 degree (for horizontal) and 110 degree (for vertical). These viewing-angle characteristics are obtained withoutdeterirorating contrast ratio.

All these prove that the Super-V liquid crystal technology is an optimal method which enables wide-viewing angle characteristics without degradingimage quality.

Photo 1 shows a picture image on the 20.1-inch SXGA TFT-LCD. This TFT-LCD monitor is sufficiently applicable for high-end graphic applications, such as CAD/CAM, CG, and DTP. It offers high image-quality, replaceable for that of the CRTs.

Photo 1 Picture image of the 20.1-inch diagonal SXGA TFT-LCD.

Conclusion

The 20.1-inch SXGA TFT-LCD, which we have developed, is sufficiently applicable for high-end graphic applications, such as CAD/CAM, CG, and DTP. It offers high image-quality, replaceable for that of the CRTs. The high-aperture ratio of 72% realizes the low-power consumption of 25W and the panel brightness of 200cd/m^2, which means an environmentally-friendly, power-saving TFT-LCD. For the LCDs to take over the CRTs, they require display compatibility, low-power consumption rate and reduction of calorific value. In this aspect, the 20.1-inch SXGA TFT-LCD with the Super-V technology has enough potentiality to replace the CRTs for monitor and TV use. Further development will be necessary in the future to achieve its cost-performance, competitive with that of the CRTs.

Acknowledgments

The authors would like to thank Mr. hizikikawa at LCD Development Center(Tenri), and Mr. Kanatani and Mr. Fukuoka at TFT-LCD Development Center (Mie) for their support of this project. The authors also thank Mr. Shiraishi, Mr. Nishitani, Mr. Seo, and Mr. Miyashita at LCD Development Center Department 3, and Mr. Tajima and other staffs at New Process Development Division of LCD Development Center (Tenri) for their support and assistance of the research.

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(Received Oct. 8, 1997)