The World's Largest 100inch TFT-LCD for HDTV and Public Display Application

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Abstract

Recently LG.Philips LCD (hereafter "LPL") has announced the development of the world's largest 100-inch TFT-LCD with Advanced Super IPS technology. This magnificent LCD achieves the feature of a full high definition resolution 1920×1080(16:9), 600nit brightness, 3000:1 dynamic contrast ratio, 92% color gamut, 180 degree viewing angle, and 5msec response time at all grays, targeted for HDTV and public display applications. Some unique technologies such as Cu bus line, advanced wide view polarizer, and high color gamut lamp were applied. A new stitching free technology was developed to overcome the size limitation of photo mask in both the TFT and CF processes. The size of the panel (100-inch) based on the wide format (16:9) is determined by the maximum efficiency of world's 1st seventh generation line (glass size: 1950×2250mm) in LPL's Paju display cluster. In this paper, we will discuss the issues of 100-inch TFT-LCD.

1. Introduction

There will be growing demands for larger flat panel displays with the growth of new digital TV market as well as the huge potential public display market as shown in Figure 1. LPL has been playing a leading role in the large size LCD market with a full line up of large LCD panels for TVs including 42-inch, 47-inch, 52-inch, and 55-inch. These products are currently taking an exclusive position in large size displays of 40 to 50inch. In near future, issues will move to over 60-inch area, mainly taken by PDP up to now. As a one of the leading LCD manufacturers, LPL is studying how to prepare another war over the 6-0inch market against PDP.

TFT-LCD has continuously evolved to overcome various barriers to enter new market during last decade. To create the large size display market over 60-inch, TFT-LCD has to not only overcome size limitation, but also improve display performance better than that of PDP. In terms of size limitation, no more issues will discuss due to Samsung's 82-inch announcement in SID05 [1] and LPL's 100-inch demonstration in SID of this year. Performance wise, it is required to strengthen the predominant performances such as power consumption, display thickness, and resolution. On the other hand, TFT-LCD's demerits such as contrast ratio, image sticking, and moving image reproduction should be improved.

In this paper, we have described several core technologies applied to the 100inch TFT-LCD and the advantages of IPS (in plane switching) mode over other LCD modes.

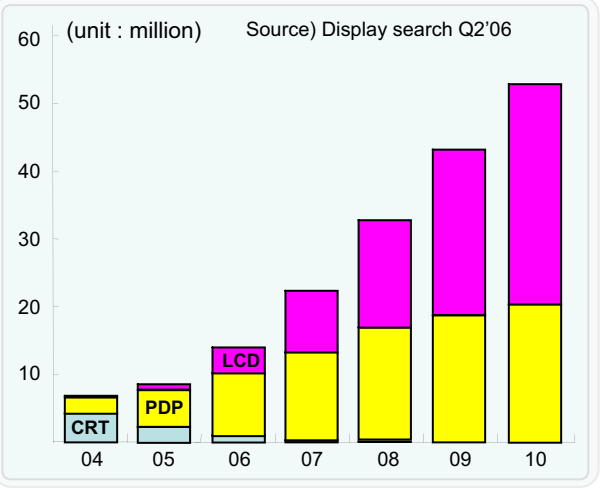

Figure 1. TV market trends over the 40inch

2. Core Technologies

Table 1. shows the characteristics of the 100-inch panel that is fabricated in our 7th generation line (1950x2250mm). It includes wide viewing angle, fast response time, high brightness and high color purity. Five core technologies were applied to realize the world's largest panel.

First, well-known Super IPS technology was used as a wide viewing angle platform. Fast response time was achieved by the combination of ODC (Over Driving Circuit) and newly blended low viscosity LC (Liquid Crystal). A stitching-free technology was applied in both C/F and TFT substrate with new compensation method. To minimize signal delay, copper gate and bus line technologies were adopted. Finally, we applied advanced wide view polarizer to achieve better contrast ratio in the diagonal direction.

In addition to these core technologies, 10bit for high color depth, high color gamut lamp for 92 % color saturation and backlight brightness control for 3000:1 dynamic contrast ratio were applied.

Table 1. The specification of 100-inch TFT-LCD

Spec	100inch LCD
Outline Dimension	2280(W)×1332(H)×64(D)
panel size	2229(W)×1265(H)
Aspect ratio	16:9
Resolution	1920×1080
Number of pixels	~2M pixels
Number of colors	1.07B (RGB 10bit)
Brightness	700 cd/㎡
Max Contrast Ratio	3000:1(Dynamic CR)
Viewing angle	178 / 178 (S-IPS mode)
Color Saturation	92% (High color gamut lamp)
Color Temperature	12000K
Response Time	5ms(GTG, Fast LC with ODC)
Interface	LVDS

2.1. Advanced Super IPS Technology

Super IPS mode is adopted for 100-inch panel because it shows a wide viewing angle and a fast gray-to-gray response time which is one of the important factors to get fast motion blur response time in TV [2].

Super IPS shows an excellent viewing angle property in terms of color shift and contrast ratio uniformity [3]. Figure 2. represents effective gamma curve of Super IPS (A) and VA (B). In spite of recent improvement of VA mode using multi domain technology, Super IPS mode shows superior characteristics. However, Super IPS has poor color performance having relatively less uniformity in the diagonal direction. One biaxial compensation film was used on the upper glass to improve the uniformity of the diagonal direction [4][5]. With the new film, much improved quality in the direction has been achieved. Figure 3. (A), (B) shows the viewing angle dependence of contrast ratio of the conventional Super IPS mode and Advanced Super IPS, respectively.

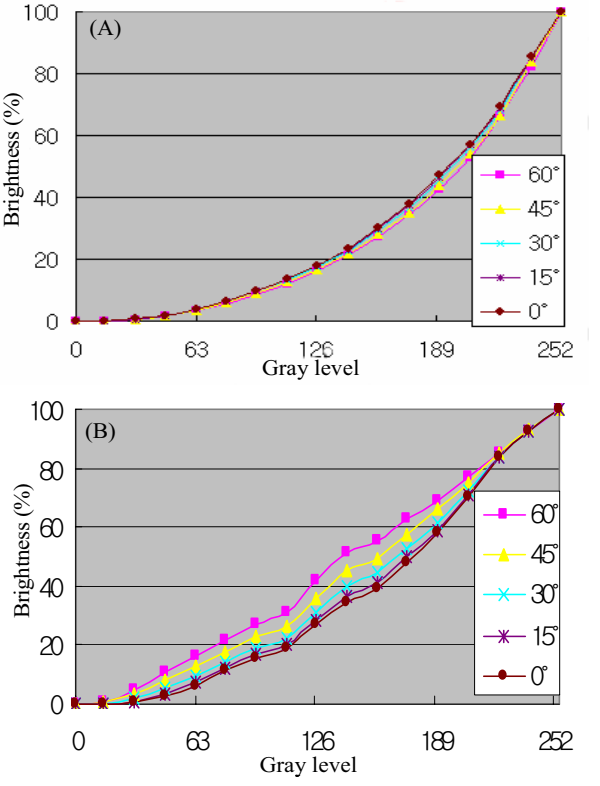

Figure 2. The effective gamma curve in each viewing angle (A) S-IPS , (B) VA

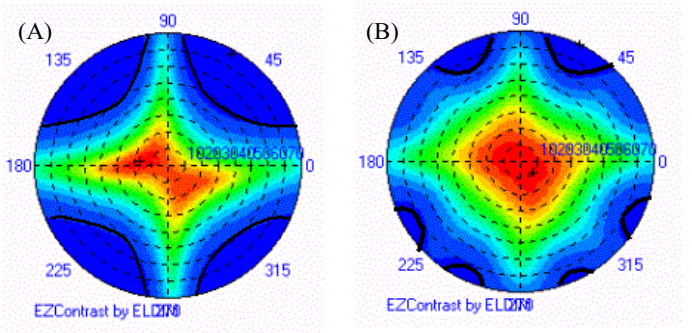

Figure 3. Dependence of contrast ratio on viewing angle for (A) Conventional S-IPS, (B) Advanced S-IPS

Table 2. shows the performance comparison between LCD and PDP. Although LCD solves the large size issue, many disadvantages such as total cost, response time, viewing angle should be improved shortly to compete with PDP in the over 60inch market. But PDP also has some serious problems for larger panel. High power consumption, low contrast ratio at living room, low full white brightness will be more serious according to the increase of display size. Environment issues due to the use of restricted material, short lifetime due to the burning of a fluorescent material, difficulty to realize high resolution, and heavy weight are another critical issue in PDP area.

With the successful development of 100-inch LCD, LPL completed basic technologies for large size LCD panel based on Advanced Super IPS.

Table 2. General comparison of LCD vs PDP.

	LCD	PDP
Brightness	◎	○
Contrast (living room)	◎	△
Contrast (dark room)	○	◎
Color reproduction	○	◎
Viewing angle	○	◎
Response time	○	◎
Resolution	◎	○
Power consumption	◎	○
Life time	◎	○
Cost / inch	△	○
Size and weight	○	△

2.2. Stitching-free technology

Since a 100-inch panel (2229 x 1265mm) is too large to be covered by a one shot of photo mask in both TFT patterning (1220mm x 1400mm) and C/F patterning (1220 x 1400mm), it should be made by multiple shots. In order to make shot to shot boundaries, which are caused by shot-to-shot misalignment invisible, several attempts have been made.

The stitching-mura on CF side is easily minimized by our stitching-free technology so called "LEGO Shot"[6][7]. On the other hand different stitching-free technology so called VFS (variable field stop) was applied for TFT as shown in the Figure 4. Different from LEGO shot, a part of small sized panel on photo mask is projected to glass depending on switching of lens modules, which are controlled independently.

2.3. Fast response time between all grays

One of the most required characteristics of LCD TV is fast response time for clear moving picture. Super IPS also has an advantage of fast response at intermediate levels of gray scale. VA is known to have fast enough response time for the transition from black to white level, but it has three times longer response time at intermediate gray levels as that of black to white. To obtain fast response time, three main factors including low viscosity LC (Liquid Crystal), low cell gap, and ODC (Over Driving Circuit) were developed.

In case of liquid crystal development, the maintaining of maximum dielectric constant difference ($\Delta\varepsilon$) and lowering rotational viscosity (γ) at the same time are indispensable to achieve fast response time [8]. The newly developed LC materials meet well these properties, possessing a good combination of $\Delta\varepsilon$ (6 ~ 8) and γ (50 ~ 70 mPas). A 5msec gray to gray (GTG) response time was successfully obtained with this new LC with both very low cell gap process and the over driving circuit scheme.

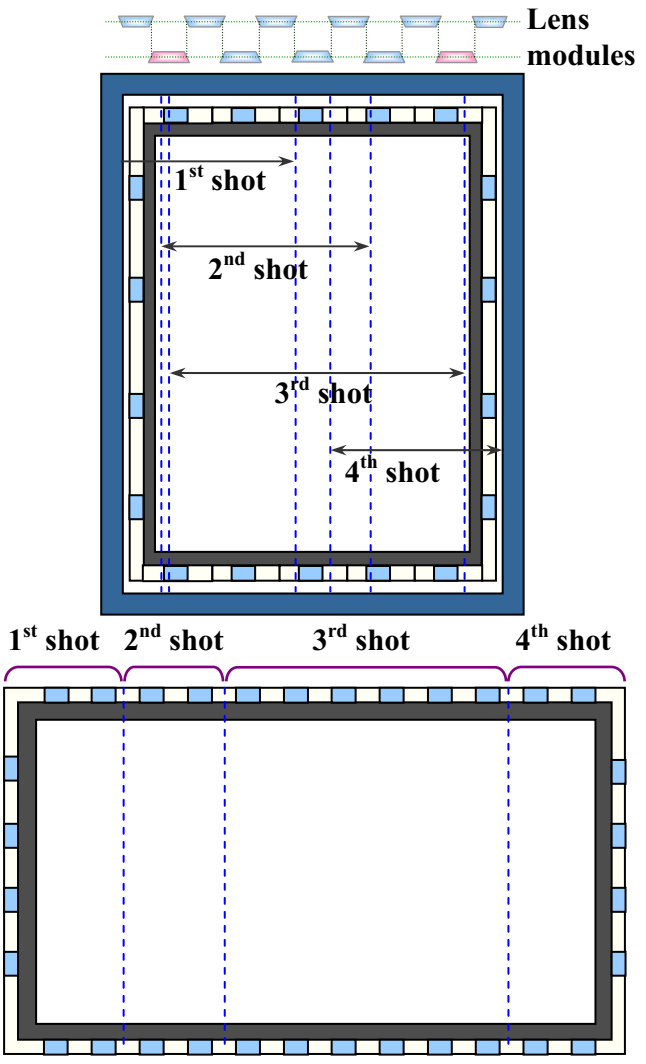

Figure 4. The principle of VFS.

2.4. Low resistance signal line

IPS with Cu bus line technology is the one of promising technologies over the 60-inch display. Signal line delay of the panel is getting worse according to the increase of panel size, resolution, and frame frequency. Generally, IPS mode has less line delay than VA which uses negative liquid crystal [9]. Both relatively less line delay of IPS mode and the lowest resistance metal (copper) technology became more strong points in large size high definition display.

LPL own Cu bus line technology is applied both on gate and data line for 100-inch panel. Through this technology, we have high quality image without any noise and signal distortion

3. Conclusion

LPL announced the world largest 100-inch TFT-LCD module with Advanced Super IPS technology. It is targeted for the high definition TV and public display market, mainly competing with PDP. In conclusion, we summarizes as follows

First of all, 100-inch panel made it meaningless to say that larger display market divided into size groups by FPD technology. Everybody believed it is impossible to achieve 100-inch in TFT LCD. However, LPL show the possibility and hope LCD would lead the market over the 60inch more rapidly than expected

Secondly, since the signal delay and pixel load became so critical in larger size high definition panel, Super IPS based on the Cu bus line technology shows relatively competitiveness compared to other LCD mode such as S-PVA, MVA etc. In addition to, Advanced Super IPS provides the unique high display quality especially on the wide view and response time. Therefore IPS mode will be the one of the best choices for the fabrication of super large panels.

Finally, the successful development of 100-inch panel with timely investment to the 8th or 9th generation line will drive LCD to compete with the PDP in near future.

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Figure 5. The world’s largest TFT-LCD panel (100-inch)