A Study on the Color Performance of FFS Mode Using the Various Analysis Methods

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Abstract

So far, we have done much research improving quality of LCD TV. Recently, we have developed 26" WXGA LCD TV by advance fringe field switching (AFFS) technology with smooth and every scene realistic in color image that obtained from the amazing authentic color delivery, optical characteristic and fast response time. Our upgrade device has shown the brightness over 600nits (Color shift <0.015 and Transmittance ratio > 5.5%), gray to gray response time under 6ms, contrast ratio over 1200:1 and viewing angle over 178/178, respectively. And also, motion artifacts improved by fast response of LC with low viscosity, cell gap and dielectric constant.

1. Introduction

From Flat display panels, especially LCDs, have replaced CRTs as TV displays. In 2005, LCD TVs are forecasted over 11% of the global TV market, and also are expected more than 40% by 2010[1]. So far, many companies have developed large LCD-TV using wide viewing angle technologies(WV films, VA, IPS, AFFS etc), but now LCD-TV must compete with a variety of different technologies (Contrast Ratio, Transmittance Ratio, Response Time, Viewing Angle etc). So display quality has improved by deep approaching a CRT-like performance [2-5].

In recent, S-PVA improved gamma distortion, minimizing color shift and enabling 180 degree angle of view and S-IPS improved contrast ratio, response time by new process and compensating film [6-9]. However, there are some technical issues such as color shift, slow moving in gray-to-gray and low transmittance. To improve all issue quality, the advanced FFS technology was utilized to improve the natural fine display images by optimizing of pixel design and color filter design, process, adoption of improved polarizer with compensation of off axis and fast response for gray-to-gray.

To performance high display quality for CRT-like LCDs, we have been improved color variation/contrast ratio with wide view angle and high transmittance using upgraded true vision AFFS [10]. True vision AFFS is applied to our 32" TFT-LCD modules for television, which shows super high image quality comparable to AS-IPS. The cell structure and driving method technology of 32" AFFS had the contrast ratio over 900:1, color variation under 0.02 and the moving picture response time of less than 10ms [10].

In recent, we have developed the high performance LCD-TV by upgraded super higher **advanced fringe field switching (AFFS) technology** with the optimized polarizer, LC new design and newly higher transmittance without high aperture resin technology and backlight sheet for luminance enhancement. These concepts named "Super Higher Advanced FFS" are applied to our new 26" WXGA (1366x768) modules for LCD TV, which show better image quality than AS-IPS. This paper is described in detail high image quality of LCD TV designed with Super Higher Advanced FFS

2. Concept of transmittance optimization for CR improvement

The figure 1 shows scattering characteristic by the direction of TFT-LCD layer. Usually, transmittance becomes different by TFT-LCD array's thin film condition. The left graph displays CR that white (transmittance of thin film condition between parallel polarizers by case) divide dark (transmittance of thin film condition between the crossed polarizers by case). This graph shows that CR characteristic can

know good case#6 and case#7. The right graph displays transmittance of thin film condition between parallel polarizers by case. We can presume by characteristic change that change of scattering characteristic with direction is caused by thin film's uniformity. Therefore, we get result that small scattering change with direction and high transmittance is case#6. This means the minimum of light leakage in dark state. This concept can expect increase of contrast ratio 9% in thin film condition.

The figure 2 shows that the transmittance of upgraded AFFS increases to 5.5% in the 5.2 voltage, but old AFFS had transmittance 5% in the 5.5 voltage. Upgraded AFFS optimized cell design more than old AFFS [6].

The figure 3 shows that the curve of the transmittance with optimized polarizer is more low dark level than old polarizer. The optimal designed polarizer appears that lower cross transmittance in blue wavelength and red wavelength than old concept, but it doesn't change single transmittance. It is very difficult to low cross transmittance with keeping single transmittance. Therefore, optimized polarizer can improve CR more than 10%.

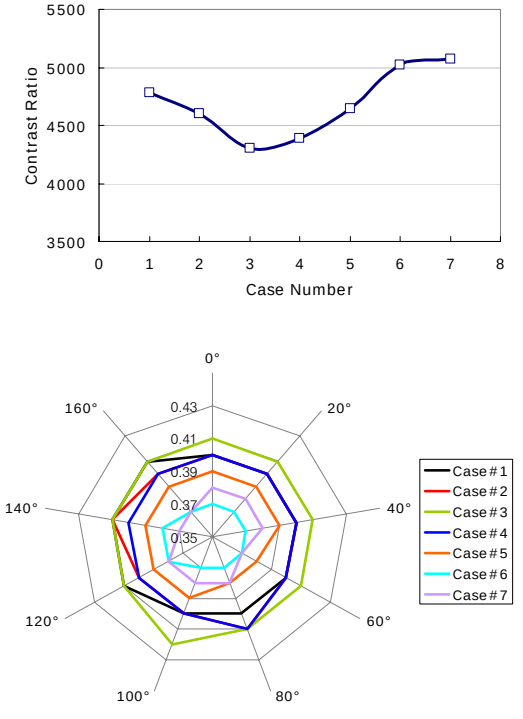


Figure 1. Contrast ratio (Up) and dark light leakage (Down) cause scattering with direction by case.

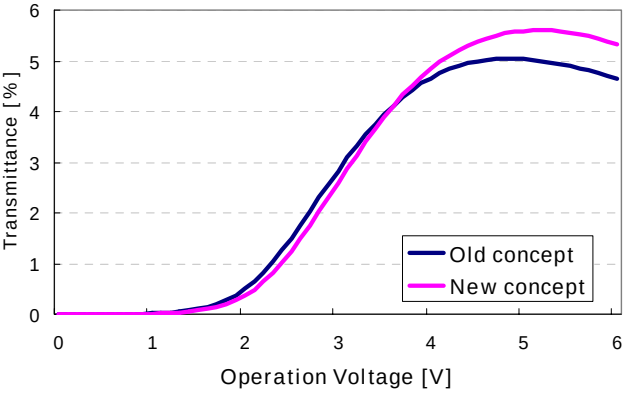


Figure 2. Comparison of VT curves in AFFS old and new concept

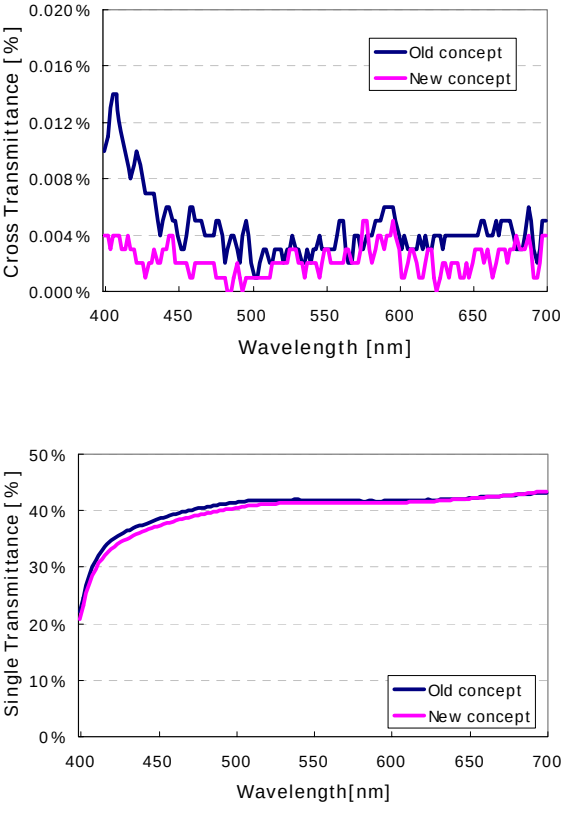


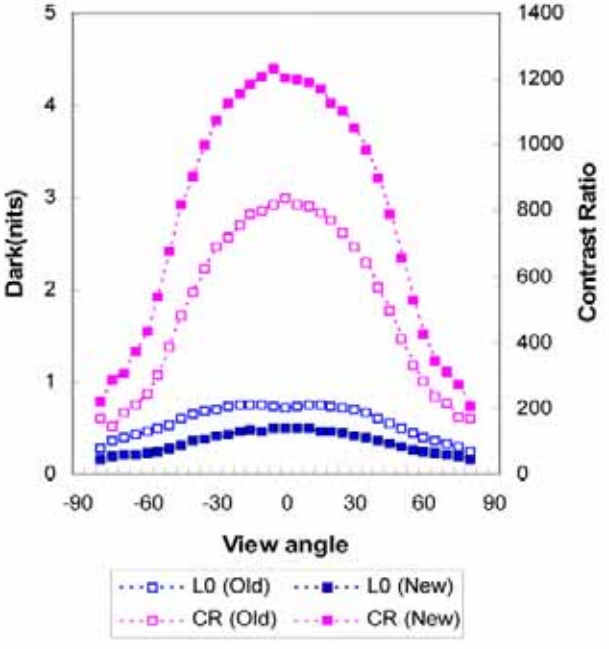
Figure 3. Comparison of cross transmittance (Up) and single transmittance (Down) by various wavelength.

3. Comparison with electro-optical characteristic of real super higher AFFS

The Figure 4 shows that the contrast ratio and contour uniformity were improved over 1200:1 and perfect, respectively, after application of real super higher advanced thin film concepts with optimized polarizer and fast response LC. The CR contour map has the behavior of a perfect dark and white CR over 100:1 in wider angle range of 80 degree. Specially, new concept appears CR over 200:1 in view angle of 70 degree. We will explain with the difference point of uniformity and pure contrast ratio.

The Figure 5 shows real image that appears dark luminance and color shift with viewing angle. Real dark image has a good uniformity by viewing angle and azimuth angle after application of new concept than old concept. In general, the white color shift in off axis has a large value due to light leakage of the LC anisotropic refraction. However, real super higher advanced FFS with perfect light control by optimized compensation show the world best non color shift in all angles.

Figure 6 shows that the response time characteristics of the total (on to off) and gray to gray were 4ms and 5ms. We have changed the viscosity γ 1and twist elastic constant K22 of liquid crystal.



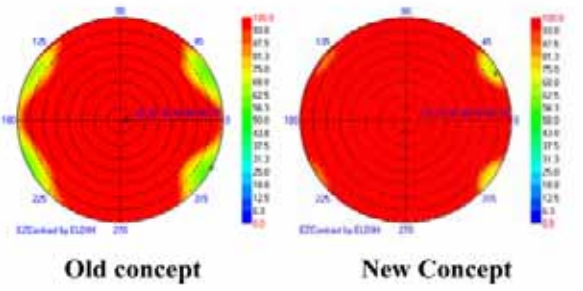


Figure 4. New concept polarizer dependence of CR contour map and CR/Dark in 26" TV-AFFS

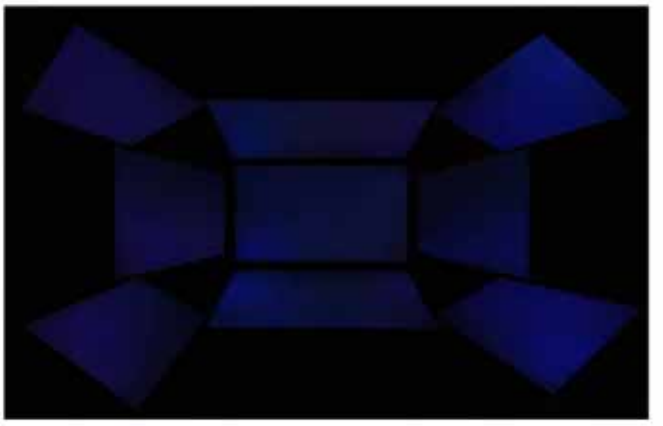


Figure 5. Real Image of dark with view angle using new polarizer concept

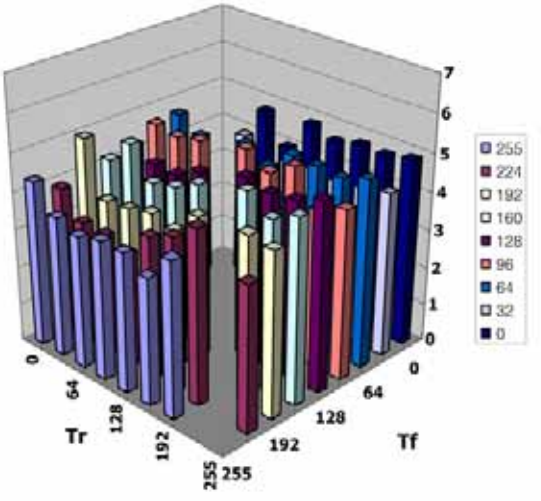


Figure 6. Gray-to-Gray response time by newly developed LC mixture

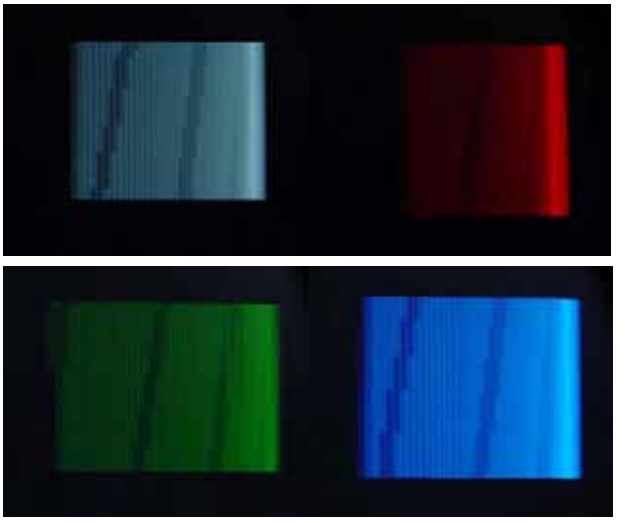


Figure 7. Real Image of moving picture when move square box of White, Red, Green and Blue (+2.0EV, F8.0, 1/1 sec, ISO 1600, ND16)

Figure 7 shows that the moving characteristics of the 26" WXGA TV when the square box moves by the speed of 80mm/sec from left to right in LCD. Gray level and different color of box and background are varied from L0 to L255, and then the real image take picture using ND filter. The moving color shift of TV-AFFS is not break out for moving time.

4. Results and discussion

Table 1 shows that the electro-optical performance of 26" TV has a transmittance ratio over 5.5%, contrast ratio over 1200:1, brightness of 600nits and response time of 4ms for gray to gray and unlimited viewing angle over 178deg. In summary, we will confirm you for all high quality products using advanced FFS technology such as TV.

5. Conclusion

In this work, real super higher advanced FFS pixel concept was defined as a specific region in the ubiquitous FFS mode. This technology, as a leading technology for wide viewing angle mode, can be used for all LCD products and future TV application. We will show the three dimensional analysis of the leakage light to off axis, and give you conviction of the real super higher AFFS for LCD TV.

Table 1. Electro-optical performance for 26" WXGA using AFFS pixel

Items	AFFS (Old concept)	AFFS (New concept)
Resolution	1366 (H)×RGB×768(V)	←
Pixel Pitch	0.422mm/60ppi	←
Power Consumption	100watt	←
Color Reproduction	72% (typ.)	←
Brightness	550nit (typ.)	>600nit
Contrast Ratio	800:1 (typ.)	>1200:1
View Angle	178/178 170/170 @ CR≥50	178/178 170/170@CR>200
Aperture Ratio	64%	←
Transmittance Ratio	5%	5.5%
Response Time On, Off Gray to Gray	 4㎳ (typ.) 6㎳ (typ.)	 4㎳ 5㎳

6. References

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