Novel Technology for Achieving Contrast Ratio over 800:1 In Super IPS Mode TFT-LCD

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Abstract
We developed Super IPS mode TFT-LCD TV which have contrast ratio over 800:1. To increase contrast ratio, polarizer film, TFT design and color filter photoresist are investigated. In this report, we describe the basic concept and effectiveness of each item. The application of a newly developed color filter photoresist was the most effective for achieving this high contrast ratio.

1. Introduction
The main market of TFT-LCD is the display for notebook computer until early 2000s. In this kind of display, adequate viewing angle and low power consumption are more important than other properties. However, as the size of TFT-LCD is getting large to be used as TV and monitor, wide viewing angle, fast response time and high contrast ratio (CR) of TFT-LCD became mandatory.

Particularly, the CR characteristic of TFT-LCD TV is superior to that of other displays (PDP and CRT etc.) at bright room but is inferior at dark room [1]. Therefore the decrease of black luminescence is required more necessarily in LCD TV application.

We already reported about achieving CR over 600:1 in Super IPS mode using optimum backlight sheet combination, taper angle of electrode, rubbing condition and high contrast ratio CFPR (HCR Ⅰ CFPR) [2]. In addition to former research, we developed new polarizer, TFT design and novel HCR Ⅱ CFPR for accomplishing CR over 800:1 without any circuit technology. In this report, we show how increase the contrast ratio of TFT-LCD in Super IPS mode.

2. Results
We are researching into new technologies for improving contrast ratio of TFT-LCD. We describe each items to realize TFT-LCD TV with contrast ratio over 800:1.

2.1 Polarizer
The contrast ratio depends on the luminescence values when LCD is full white and full black. To increase contrast ratio, we must decrease black luminescence. From the polarizer point of view, the transmittance of a cross-nicol state means that LCD is full black. The cross-nicol state transmittance of polarizer depends on stretching ratio and iodine ion species ratio. In the two factors, the wavelength dispersion of the cross-nicol transmittance depends on the later. The old polarizer has much light leakage at short wavelength and this character cause the increasing of black luminescence and decreasing of contrast ratio. To improve this phenomenon, we developed the new polarizer controlled the iodine ion species ratio. There are the cross-nicol transmittance spectrums of the old polarizer and the new one in Figure 1. The increasing ratio of CF layer contrast ratio using new polarizer is about 20% and the measured data is summarized in Table 1.

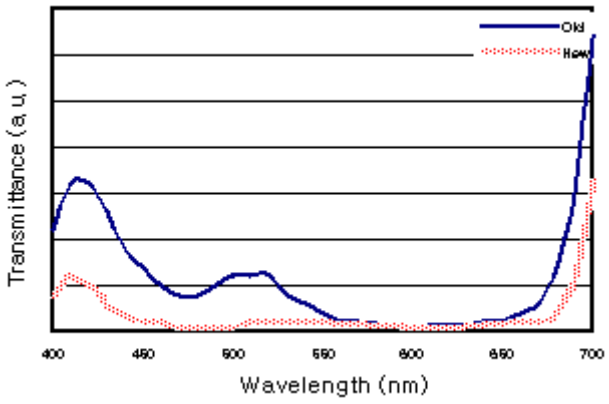

Figure 1 The cross-nicol transmittance spectrum of the old polarizer and the new one.

2.2 HCR Ⅱ Color Filter Photoresist
We already reported that the contrast ratio of color filter photoresist is improved by reducing pigment size [2]. The novel high contrast color filter

photoresist (HCR Ⅱ CFPR) have the same concept. To develop HCR Ⅱ CFPR, we use special pigment dispersed solution which is made by fine and narrowly distributed pigment, excellent dispersant and original binder polymer of color photoresist. Fine and narrowly dispersed pigment performs high contrast ratio and excellent dispersant disperses the pigment well. In addition, the original binder polymer of color photoresist in special pigment dispersed solution increases compatibility with other color photoresist components.

The schematic of experimental setting is described in Figure 2. Because we judge the pure CFPR effect, there is the only CF layer between analyzer and polarizer. The white and black state is realized by rotating analyzer. The evaluation of the new polarizer is performed by same method. The contrast ratio of CF layer was increased about 60% by HCR Ⅱ CFPR.

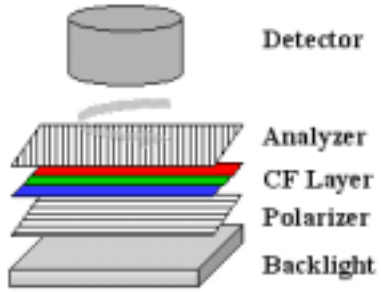

Figure 2 The schematic of experimental setting for measurement of contrast ratio of CF layer.

Table 1 The increasing rate of CF layer contrast ratio by new polarizer and HCR Ⅱ CF PR.

CF PR	Polarizer	White	Black	C/R	Increasing Rate(%)
HCR I	Old	512.4	0.332	1845	21.3 Polarizer effect
HCR I	New	518.3	0.273	2237	
HCR II	New	513.5	0.168	3652	63.2 CF PR effect

2.3 TFT Design

We previously showed improving contrast ratio with controlling the taper angle of gate metal. In results from this research, we could minimize the light leakage at the electrode edge. In spite of this effort, we couldn't prevent the light leakage at the pixel boundary electrode where is near the data line. The thickness of the pixel boundary electrode is thicker than other electrode in pixel area, because there is the Vcom metal electrode under the pixel boundary electrode. This thickness difference causes incomplete rubbing at the pixel boundary electrode. In order to essentially improve, the new TFT design concept was applied, that the whole boundary electrode is placed under the black matrix at color filter layer. After introducing the new design concept, the light leakage at the pixel boundary didn't occur any more (Figure 3). Therefore, the contrast ratio of LCD was improved about 2%.

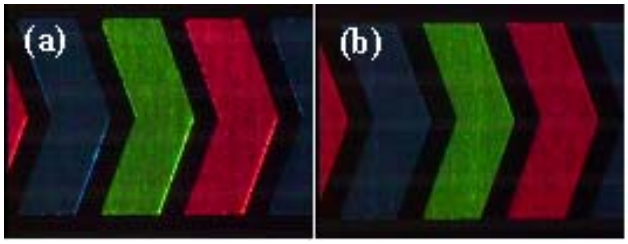

Figure 3 The pixel image formed by (a) old TFT design concept and (b) new TFT design concept.

3. Conclusion

TFT-LCD TV already plays a major role in the display market. TFT-LCD has many attractive points such as light weight, compact size, low power consumption and so on. Considering the aspect of image quality for TV application, TFT-LCD requires some additional properties and high CR is the one of them. In order to attain high CR; polarizer film, CF PR, and TFT design were chosen as key parameters. With combining the final optimum results for high CR, we can make Super IPS mode 32-inch WXGA TFT-LCD TV whose contrast ratio is over 800 for the first time. This development could enhance the competitiveness of Super-IPS-based LCD panels in the display market.

4. Acknowledgements

We would like to thank contributed engineers in panel design and product engineering teams for the development of the TFT-LCD with the contrast ratio over 800:1 in super IPS mode. We special thank to LG Chemical CFPR and optical development teams for the development of new materials.

5. References

[1] J. Nakamura, IMID '04 Digest, pp. 23-25 (2004).

[2] J. H. Kim et al.,SID '04 Digest, pp. 115-117 (2004)