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Technology Trends for Improving Contrast Ratio in IPS Mode

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The IPS mode is going to lead the large TFT LCD technology for application among other liquid crystal (LC) mode. TFT-LCD TV has begun to rapidly occupy a large portion of the TV display market due to features including thinness, light weight, compactness. Aside from specification of features, the most emphasized aspect has been the contrast ratio for better image quality. To increase contrast ratio, Back Light (B/L) optical configuration, color filter material, sub-pixel structure, rubbing condition optimization, and all that cell characteristics have been investigated. As the results from experimental, applications of a newly developed color resin, new light collimation optical sheet, and surface morphology of finger electrode were the most effective for achieving high contrast ratio.

Keywords: color filter; contrast ratio; Cu electrode; LCD TV; light collimation

1. INTRODUCTION

Nowadays TFT-LCD is deeply penetrating into the TV market, supported by digital television broadcasting and the progress of flat panel displays. TFT-LCD TV, with advantageous properties of compact size, light weight, and low power consumption, competes strongly with PDP

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in flat panel displays and recently reaches close to the quality of CRT, but some characteristics of PDP, such as full white luminance, power consumption, contrast ratio under the bright condition and resolution in comparatively small size (less than 50″) are inferior to that of the LCD TV [1]. Image quality will be a main issue to satisfy customer's desire in flat panel display field in the near future. Current TFT-LCD technologies have many important requirements for TV application such as wide viewing angle, high brightness, and fast response time, high contrast ratio. IPS (in plane switching) mode has made it possible to achieve wide viewing angle. High brightness has been accomplished by TFT design of high aperture ratio and light recycling film (Commercial product name is DBEF; Dual Brightness Enhancement Film) in an optimized design of a backlight system. The fast response time has been realized by the use of a new liquid crystal mixture with ODC (Over Driving Circuit) [2,3,5].

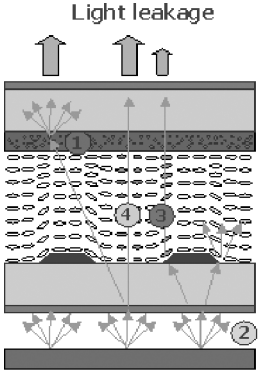
In this paper, we will discuss recent technology trends to achieve high contrast ratio in IPS mode.

2. TECHNOLOGY REVIEW

We achieved high contrast ratio by innovative material change and manufacturing process improvement based on the study of main factors of the contrast ratio (Fig. 1).

2.1. Development of Color Resin for High Contrast Ratio

The physical characteristics of pigment-dispersed color resin such as morphology and rheology affect the contrast ratio as used in color



	Items	Prospective Effects	Methods
1	Color Filter(C/F)	Minimizing Light Scattering	High Contrast Ratio C/F
2	Back Light(B/L)	Optimizing Inclined Light (Light Collimation)	New Optical Film
3	Surface Morphology	Surface Planarization	Cu Common Electrode
4	LC Alignment Uniformity	Uniform Alignment	Optimization of R/B condition

FIGURE 1 Technical issue to achieve high contrast ratio in IPS mode.

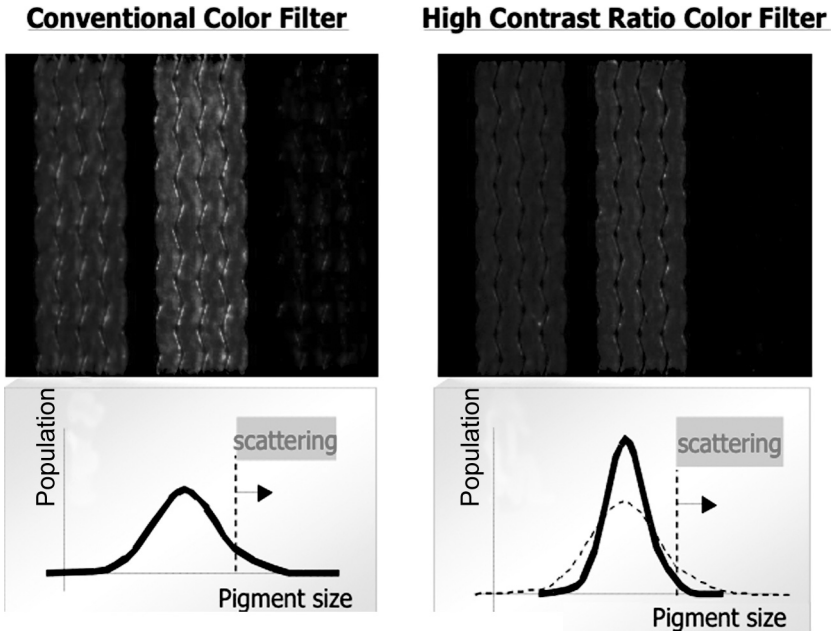


FIGURE 2 Comparison of conventional & high contrast ratio CF (pigment size distribution of color resin and microscopic pictures).

filter (CF). According to the following equation, the intensity of light scattering reduces with the decrease of pigment size [4] (Fig. 2).

$$\frac{I_s}{I_i} \propto \frac{d^4}{\lambda^6}$$

where I_s is intensity of scattered light, I_i is intensity of light source, d is pigment diameter and λ is wavelength.

The uniform and fine dispersed color pigments with well defined chemical composition are required to achieve small light scattering as well as high color gamut. Small light scattering prevents depolarization of incident light so that a high contrast ratio can be realized. As results from product adopting new high contrast ratio CF, the contrast ratio was improved than conventional one by about 40%.

2.2. High Efficiency Back Light System with New Optical Sheet

TFT-LCD TV panel usually uses direct type B/L system adopting couples of optical sheet. One of them is light recycling film to enhance the total efficiency of back light. The film is used as form combined

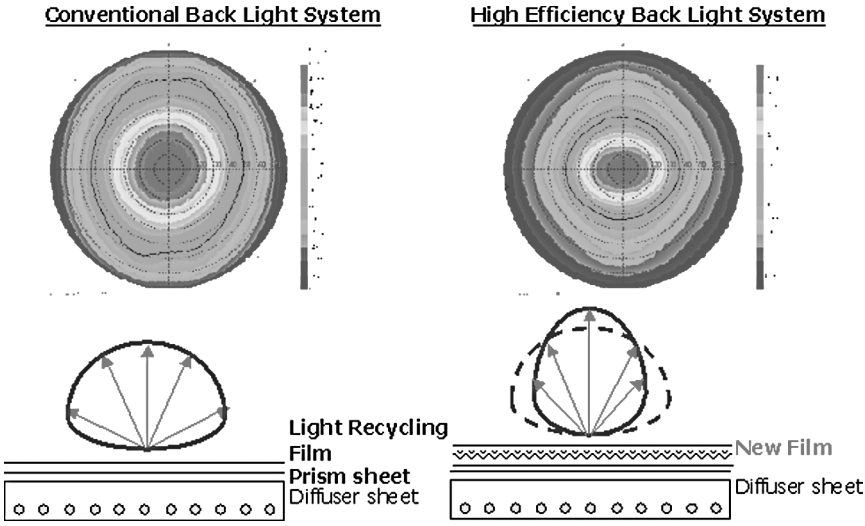


FIGURE 3 Isoluminance contour and simple image optical configuration of conventional and new B/L system.

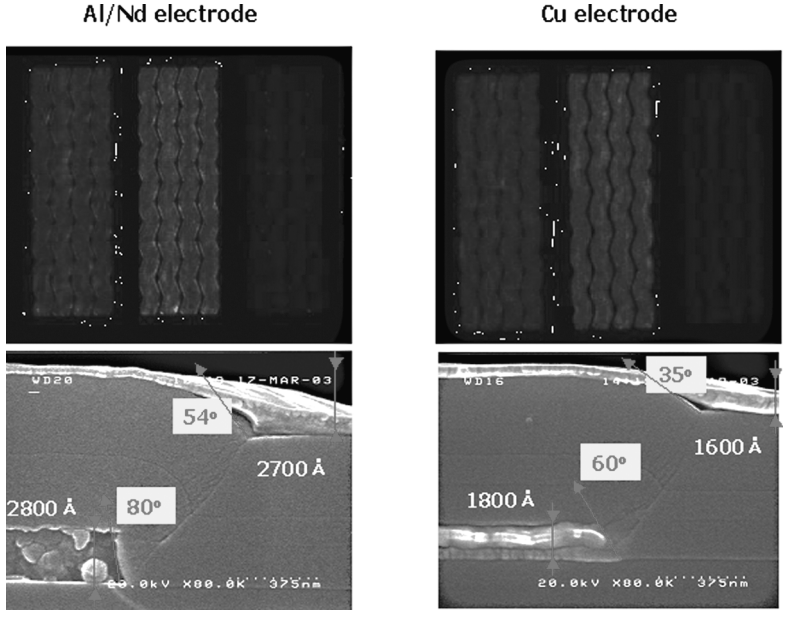


FIGURE 4 Polarization microscope pictures and SEM images of TFT adapted Cu and Al/Nd, respectively.

with polarizer film of TFT glass or backlight sheet by itself. Main purpose of optical film is control of gathering and scattering of output light configuration. The tilted incident light is the reason of light leakage to the normal direction by scattering or diffraction, To decrease tilted incident light; collimate light, we separate light recycle film from polarizer, and recombine prism sheet and light recycling film. Not only the number of total film is reduced, but also light collimation was achieved. Consequently, the contrast ratio was approved about 30% by adopting new optical sheet (Fig. 3).

2.3. Surface Morphology of TFT

In IPS mode, rubbing process is necessary to control LC molecular at initial state (black state). But uniformity and stability of rubbing process is affected by surface morphology of TFT, especially near electrode. Instability of electrode is caused by light leakage. Taper angle of electrode as well as thickness of one is important to reduce light leakage near electrode. To obtain uniformity and stability of alignment near electrode, we employed thin Cu metal with smooth taper angle (about 30 degree), without diminishing line resistance. Due to flat surface (Height difference is reduced from 2700 Å to 1600 Å), contrast ratio was increased by 20% (Fig. 4).

3. CONCLUSIONS

In order to obtain high contrast ratio, high contrast ratio color filter which has well-dispersed color pigments to reduce scattering of incident light, high efficiency back light system with new light collimation sheet, and morphology improvement by using Cu metal as common electrode make black luminance more lower. High contrast ratio (about 700:1) in IPS mode has been achieved.

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