

# Influence of Polarizer with Different Haze Value on the Optical Properties of TFT-LCD

Shing, Lei

Panel Design Department Panel Design Division, Chunghwa Picture Tubes  
No.1, Huaying Rd., Sanho Tsun, Lungtan Shiang, Taoyuan, Taiwan, 325, R.O.C.

Chia-Ling Chuang

Panel Design Department Panel Design Division, Chunghwa Picture Tubes  
No.1, Huaying Rd., Sanho Tsun, Lungtan Shiang, Taoyuan, Taiwan, 325, R.O.C.

Tel: 002-886-3-4805678-7481

E-mail: leis@mail.cptt.com.tw

## Abstract

*Influence of polarizer with different haze value on the optical properties of TFT-LCD TV has been investigated. According to the results, a optimum optical performance can be achieved by using the polarizer with proper haze value.*

## 1. Introduction

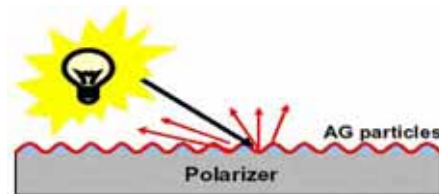
A thin film transistor (TFT) type LCD has been used to public welfare-related equipment such as a personal computer, word processor, and OA table television set, and expected to further expand its market. Except from the twisted nematic (TN) mode LCD, recently a vertical aligned (VA) mode using a vertical alignment film has been widely used to TV set [1].

Among the optical characteristics, contrast ratio has been realized to be influenced seriously by the surface treatment of polarizer. In Hong et al. (2) various kinds of surface treatment for polarizer including hard coat (HC), anti-glare (AG) has been propped to evaluate the influence of surface treatment of polarizer on the optical characteristics.

A schematic illustration to explain the principle of the surface treatment of AG is shown in Fig. 1.

AG polarizer has a hard-coat dispersion layer (may be not), which forms fine undulations. These disperse light in multiple directions, preventing light from directly entering the eyes and effectively eliminating glare.

In this paper, polarizer with various haze treatment was investigated to realize the influence of haze on the optical properties of LCD panel.



**Fig.1 Structure of polarizer with AG (anti-glare) layer**

## 2. Experimental Procedure

The various kinds of polarizer with different haze value were test in 32 inch TFT LCD panel. The detail of the surface treatment parameter is shown in Table1. The optical characteristics including contrast ratio, luminance, light leakage ,etc; for these test panel were measured by using the

corporation of France EZ-contrast XL88 device made by ELDIM.

**Table 1 Comparison of different haze value**

	AG			AGLR
Haze(%)	13	25	40	40
Clarity(%)	75	45	150	120
Hardness	3H	3H	3H	3H

### 3. Results and Discussion

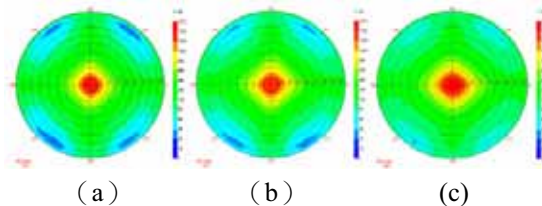
#### 3.1. Optical properties

##### 3.1.1 View cone

The contrast ratio (CR) was evaluated by using the so-called view cone graph. The CR results for the various haze treatment are shown in Fig.2 (a) to (c). and Table 2 respectively. As can be seen in Fig. 2 a higher haze value, a higher CR can be obtained. Table 2. shows that the results about the view cone. CR-Min ( $\theta$ ) means the minimum value of contrast ratio in diagonal direction and CR-Max ( $\theta$ ) means the maximum value of contrast ratio in right angle direction.

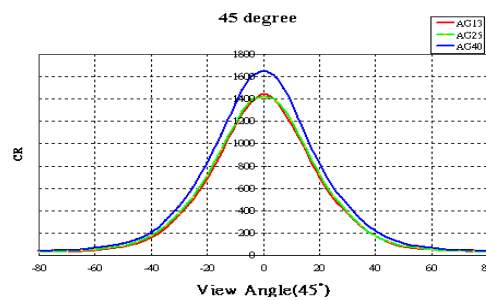
**Table 2 Measurement data about view**

	Haze Value 13	Haze Value 25	Haze Value 40
CR-Min( $\theta=45$ )	28	30	40
CR-Max( $\theta=0$ )	1445	1471	1643



**Fig. 2 Comparison of the measurement of view cone (a) haze=13; (b) haze=25; (c) haze=40.**

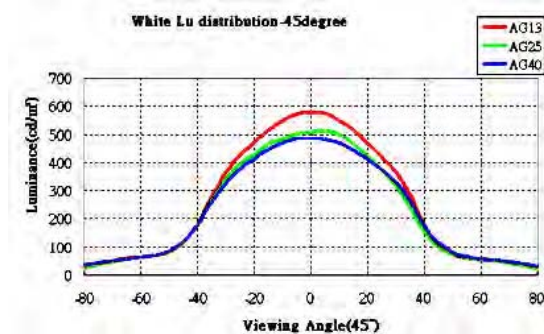
Fig. 3 shows the contrast variation in the viewing angle of -80 to 80 degree. The similar results can also be obtained in Fig. 3, which agreed with the result of Fig. 2 measurement.



**Fig.3 Comparison of contrast ratio with various haze value**

##### 3.1.2 White luminance distribution

The white state luminance measurement results for various haze values are shown in Fig. 4. As can be seen in Fig. 4. The luminance decreased along with the increased haze value. It may be due to that higher haze treatment which results in the decay of light efficiency, thus, to acquire a worse luminance performance.

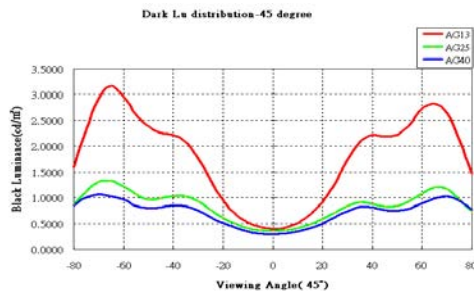


**Fig. 4 Comparison of white luminance with various haze value**

##### 3.1.3 Dark luminance distribution

Fig.5 shows the measurement result of the dark

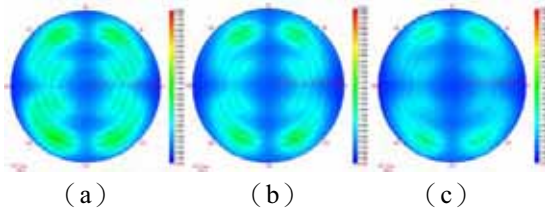
state luminance with different haze value in diagonal direction. It can be found in Fig. 5, with increasing haze; a better contrast ratio can be realized. It may be resulted from the higher haze which associated with a lower surface roughness, thus, result in a lower dark state luminance.



**Fig.5 Comparison of dark luminance with various haze value**

**3.1.4 Light leakage (off-state)**

Fig.6( a)to (c) show the results about light leakage at off-state for various haze value. It was found that as haze value increased, the light leakage phenomenon could be improved.



**Fig. 6 The off-state light leakage with various haze value (a) the haze=13, (b) the haze=25, (c) the haze=40.**

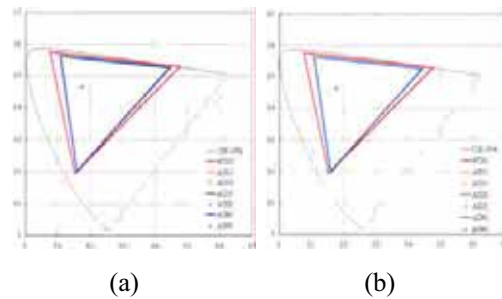
**3.1.5 RGB Color dispersion**

Table 3 shows the results of RGB color coordinates with various haze value conditions. There seem to be little difference on the dispersion. Fig.7 shows the chromaticity diagram

calculated by using the formula established in 1976 CIE conference. It was exhibited that various haze value have no influence in the color dispersion.

**Table 3 Measurement data of RGB color**

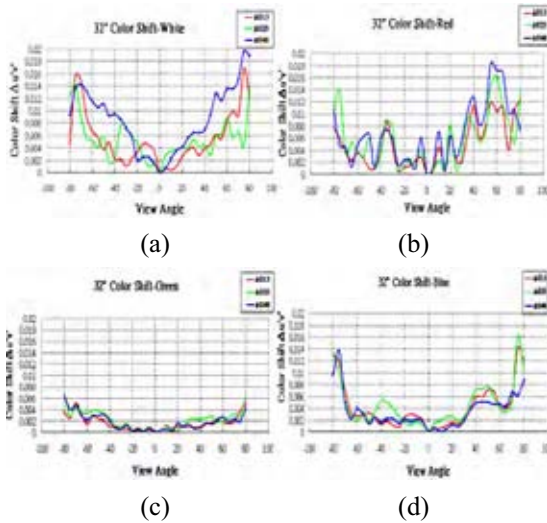
Horizontal	AG13		AG25		AG40	
	u'	v'	u'	v'	u'	v'
W	0.174564	0.463622	0.173337	0.463077	0.175784	0.466417
R	0.444539	0.525805	0.444526	0.525803	0.447879	0.526813
G	0.108532	0.562822	0.108181	0.562777	0.10857	0.563499
B	0.15893	0.19841	0.158489	0.201241	0.158119	0.201893
Vertical	AG13		AG25		AG40	
	u'	v'	u'	v'	u'	v'
W	0.177417	0.462941	0.175829	0.462548	0.177377	0.465991
R	0.44318	0.52611	0.442903	0.525998	0.444506	0.526319
G	0.108281	0.563151	0.10786	0.563083	0.108165	0.563747
B	0.15893	0.19657	0.158851	0.199859	0.158225	0.20014



**Fig. 7 The chromaticity diagrams (a) the dispersion in horizontal direction, (b) the dispersion in vertical direction.**

**3.1.6 RGB Color shift**

The color shift performance (on each color including R, G, B, white colors) for various haze value are shown in Fig. 8 (a) to (d), respectively. It was observed that by comparing these hazes, as haze value = 40, the color shift became more seriously in pattern white and red.



**Fig.8 Comparison of color shift with various haze value (a) in pattern white; (b) pattern red; (c) in pattern green; (d) in pattern blue.**

### 3.2. Summary of optical properties and visual evaluation

Based on the previous discussion, the evaluation summaries of optical properties were shown in Table 4. As can be seen in Table 4, the haze value 25 is the optimum condition by considering the overall optical properties. In order to investigate the anti-glare ability for each kinds of haze, an incident light was used to the test panel, then to observe the glare and reflection phenomenon. The visual evaluation results for haze 13, 25, 40 were shown in Fig.9 (a) to (c), respectively. By comparing the Fig.9 (a) to (c), the difference of glare phenomena between 25 and 40, seems to be very small. However according to the previous luminance will be decreased seriously by using the haze 40 polarizer. Therefore by considering all

of the optical properties, haze 25 will be a better choice for mass production.

**Table 4 Evaluation of optical properties**

	AG13	AG25	AG40
View Cone	○	○	⊙
CR	○	○	⊙
White Lum.	⊙	○	△
Off-State Light Lealage	△	○	⊙
Color Dispersion	○	○	○
Color Shift	○	○	△

※ Order: ⊙-The Best; ○-The Better; △-The Popular



(a) (b) (c)

**Fig.9 The outward appearance with various haze value (a) the haze=13; (b) the haze=25; (c) the haze=40.**

### 4. Conclusions

The influences of polarizer with different haze value on the optical properties were as follows:

1. As high haze value, a high CR can be obtained. But the luminance decreased along with increased haze value. It may be due to that higher haze treatment which results in the decay of light efficiency, thus, to acquire a worse luminance performance.
2. It was found that as haze value increase, the light leakage (off-state) phenomenon could be improved.

### 5. References

- [1] Takeda et al. U.S Patent No. 6661488
- [2] Hong et al. U.S 6,956,699 B2.