Wide Viewing Angle ECB TFT LCD by a Single Discotic Optical Compensation Film

Ku- Hyun Park*, Hyung-Ki Hong, Hyun-Ho Shin and In-Jae Chung
LCD R&D Center, LG.Philips LCD Co., Ltd.,
Hogae-dong, Dongan-gu, Anyang-shi, Gyoungki-do, 431-080, Korea
Phone: +82-31-450-7762, E-mail: khpark@lgphilips-lcd.com

Abstract

A simple wide-viewing-angle solution of electrically controlled birefringence (ECB) LCD is proposed, which is based on a single discotic compensation film. The use of a single discotic film instead of two leads to a considerable reduction in cost while high performance is maintained.

1. Introduction

The wide-viewing-angle technology which is generally applied in small and medium LCDs using TN mode makes use of two optical compensation films which are consisted of splayed discotic liquid crystal structure [1]. The compensation films are made of disclike molecules, which are tilted with respect to the film plane. The orientation of the disclike molecules with respect to the orientation of the LC molecules at the adjacent liquid crystal substrate interface is shown in Fig. 1. Two optical compensation films are used between the front polarizer and front substrate and between the rear polarizer and the rear substrate.

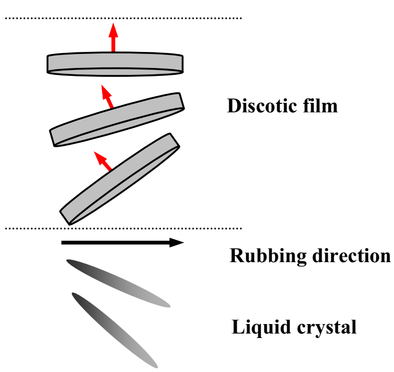


Figure 1. Orientation of the disclike molecules of the discotic compensation film with respect to the average orientation of the LC molecules at the liquid crystal film interface

In this paper, we propose that a wide viewing angle solution based on a single discotic optical compensation film can be realized in transmission type ECB LCD [2].

2. Single-film WVA ECB solution

Under crossed-polarizer condition, the light transmittance through film compensated ECB cell is described as $T_{\perp}=\sin^2(\delta/2)$. The net phase retardation δ is expressed as

$$\delta = 2\pi[d_1\Delta n_1(\lambda, V, T)- d_2\Delta n_2(\lambda, V)]/ \lambda \qquad (1)$$

where $d_{1,2}$ and $\Delta n_{1,2}$ represent the thickness and effective birefringence of the LC cell and compensation film, respectively.

The effective birefringence of a LC cell depends on the wavelength (λ), applied voltage(V) and temperature(T). The birefringence of a compensation film is mainly dependent on the wavelength and is not very sensitive to temperature.

Figure 2 shows the compensation concept of ECB cell. From equation (1), the LC thickness and phase retardation of compensation film have a great impact on the light transmittance and operating voltage, and they must be selected properly.

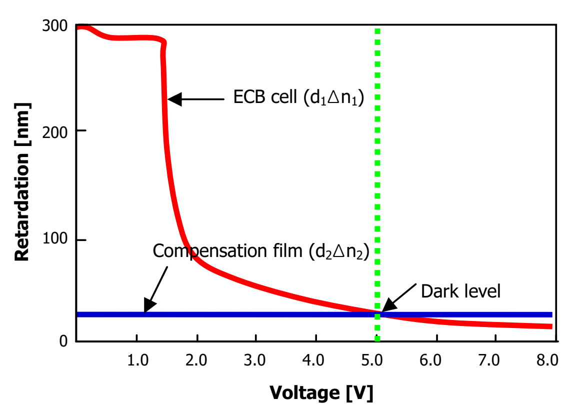


Figure 2. Retardation compensation concept of ECB cell

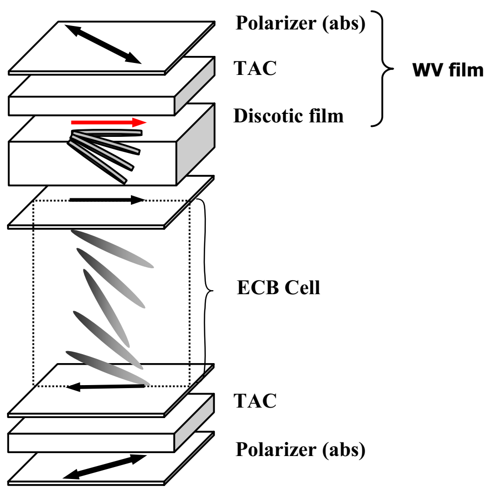


Figure 3. A typical structure of the ECB LCD with a single discotic optical compensation film

Compensation film plays an important role in not only deciding light transmittance and operating voltage but also widening viewing angle.

We have found that a wide-viewing angle ECB mode based on a single discotic compensation film can be realized. The use of a single discotic film instead of two has the advantage of cost and thickness of LCD simultaneously. Figure 3 shows a typical structure of an ECB LCD with a single discotic compensation film. The front polarizer has a discotic compensation film which is supported by TAC film and the rear polarizer has no discotic component.

In our computer simulations, the LC director distributions and the corresponding electro-optic properties of the ECB cells are calculated by Oseen-Frank elastic continuum theory and the extended Jones matrix method, respectively. The characteristics data of the cell and material parameters used in our calculation are listed in Table I. The material parameters of discotic compensation film we used are the same as conventional one.

Table I. Characteristics data of the cell and material parameters used for ECB TFT LCD.

Liquid crystal mixture	ML-0004
n_o [λ=589nm]	1.4771
n_e [λ=589nm]	1.5563
$\varepsilon_\perp$ [for 1kHz]	4.3
$\varepsilon_\parallel$ [for 1kHz]	13.8
dΔn (㎛) [λ=589nm]	0.317

3. Results and discussion

3.1 Electro-optic effect

The voltage-dependent light transmittance of ECB cell with single discotic compensation film is shown in figure 4. The dark state is occurred below 5.0V, thus our single discotic compensation ECB mode is suitable for conventional TFT driving methods.

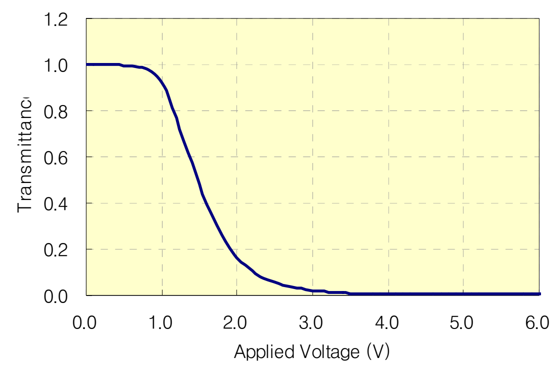
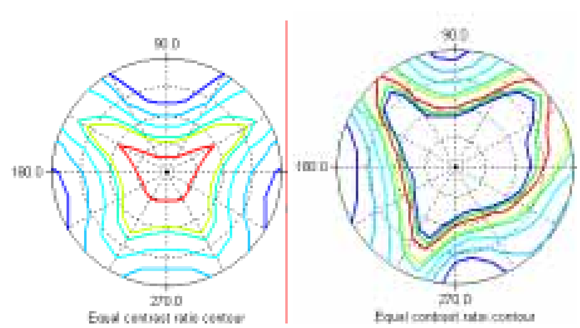


Figure 4. Electro-optic characteristic of ECB LCD with a single discotic optical compensation film

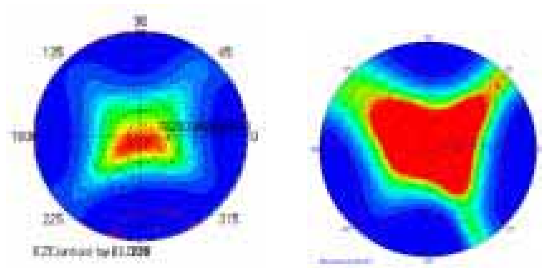
3.2 Viewing angle

To confirm the effect of the optical compensation method described above, we calculate the viewing angle characteristics for TN and ECB in which we use the discotic compensation film. Iso-contrast characteristics of optimized WV-SA TN and WV ECB are compared in Figure 4. It is clarified that ECB with a single discotic compensation film has almost same viewing angle characteristics (145°/135°) compared with WV-SA TN.



(a) WV-SA TN (b) WV ECB

Figure 5. Comparison of calculated iso-contrast diagram between WV-SA TN and WV ECB LCD



(a) WV-SA TN (b) WV ECB

Figure 6. Comparison of measured iso-contrast diagram between WV-SA TN and WV ECB LCD

Measurement of viewing angle characteristics is carried out using the discotic compensation films produced by Fuji Film [3]. We confirm that ECB LCD with a single discotic compensation film has similar viewing angle characteristics compared with WV-SA TN. However, these discotic films have been optimized for standard AM OCB TFT LCDs with an optical thickness of 0.66~0.7um under the assumption that two films are used. The use of a single discotic film in combination with ECB LCD yields good optical characteristics. The expectation that further improvement can be realized by optimization of film, i.e, by choosing the optimum retardation and the optimum tilted molecular structure, is justified

4. Summary.

We conclude that WV ECB LCDs can be made using a single commercially available discotic film instead of two. The use of a single compensation film leads to a considerable reduction in cost and high performance simultaneously.

5. Acknowledgements

We thank Fuji Film for the samples of Wide View film for ECB.

6. References

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