P-142: Single Cell Gap Single Mode TN Transflective Liquid Crystal Display

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ABSTRACT

In this paper, a novel single cell gap transflective liquid crystal display (LCD) using 90 degree twist nematic mode has been proposed. The electro-optical characteristics in the transmissive part and reflective part are matched. This single TN transflective configuration exhibits a high contrast, wide viewing angle, fast response and high transmittance / reflectance. Also the fabrication process is simplified by photoalignment technology.

1. Background and Objectives

The characteristics of transmissive LCDs and reflective LCDs are combined in Transflective liquid crystal displays (LCDs). The pixels of the traditional transflective LCDs are separated into the transmissive and reflective sub-pixels. The transmissive sub-pixels in a transflective display are transmitting with backlight illumination and the reflective sub-pixels are reflecting light from the environment under ambient illumination [1]. Conventional transflective LCDs are commonly fabricated using a double cell gap approach to maintain the same optical characteristics. In the double cell gap approach [2], [3], the cell gap for transmissive part is made approximately two times of that for the reflective part, to maintain the same optical path difference of the transmissive part and the reflective part. But at the same time, it makes the fabrication much more complicated. In the single cell gap approach, different LC modes in the transmissive and the reflective sub-pixels have been suggested recently [4],[5] to match the transmittance versus voltage curve (TVC) with the reflectance versus voltage curve (RVC).

In this study, we propose a new configuration of transflective LCD. The configuration possesses a single cell gap in the transmissive and reflective parts. Also there is no separate LC mode required for maintaining the equability of the TVC and RVC curves. In cell retardation films are applied to adjust the. Therefore, the easier fabrication process can be used due to simple transmissive and reflective sub-pixels requirements.

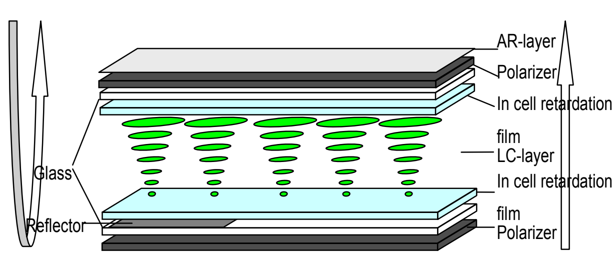

Fig. 1 Scheme of the transflective LCD; Left: reflective part; Right: transmissive part.

In this single cell gap configuration, 90˚twisted nematic cell is applied for both transmissive and reflective parts. Two in cell retardation films are inserted to the liquid crystal cell, with one fabricated on the front glass and the other on the rear glass substrate. Figure 1 shows the cell structure of the TN configuration with sub-pixel separation.

In the simulation, the optical performance, as well as the matching of transmittance versus voltage curve (TVC) and the reflectance versus voltage curve (RVC) [6], of both transmissive and reflective parts are adjusted by changing the orientation and the thickness of the retardation films. Table 1 shows the angle of indication of different layers. The angle indicates the anticlockwise value against the horizontal axis. In order to increase the contrast of the reflective mode, a antireflection (AR) layer has been inserted on the top of the configuration. [7]

Table 1 schematic structure of TN90˚ configuration

		TN90 transmissive	TN90 reflective
Polarizer1		0°	0°
Compensation film1	90nm	34°	0°
LC cell	cell gap	5μm	5μm
	twist angle	90°	90°
Compensation film2	60nm	48°	90°
Polarizer2		90°	/////////

2. Methodology

The calculations of the optical characteristics were carried out with the help of MOUSE-LCD [8], [9] software. In order to make the calculations more realistic, the real dispersion was introduced in a specific layers formed LCD structure. The parameters of ZLI-4792 from E. Merck with Δn equal to 0.099 at 546nm wavelength were used in our calculations. The ordinary and extraordinary refractive indices of ZLI-4792 were n0 = 1.4939 and ne = 1.5987, no = 1.4774 and ne = 1.5734, and no = 1.4774 and ne = 1.5734 at the wavelengths of 436 nm, 546 nm and 633 nm respectively. The dielectric anisotropy and the elastic constants were $\Delta\varepsilon$ = 5.2, K1 = 1.32 x 10-6, K2 = 6.5 x 10-7, and K3 = 1.38 x 10-6 dyne respectively.

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3. Results

In order to obtain a transflective characteristic, the TVC and RVC should be as close as possible to each other. Figure 2 shows the normalized TVC and RVC curve. The electro-optical characteristics in the transmissive mode and reflective mode match each other. This indicates that the transmissive and reflective TN can be effectively controlled and the same grey scale can be obtained by applying the same voltage to the transflective LCD [10].

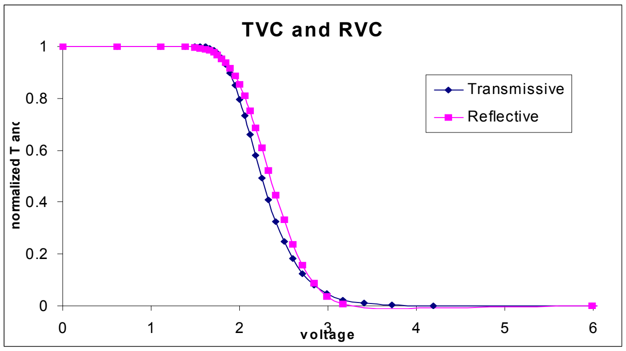
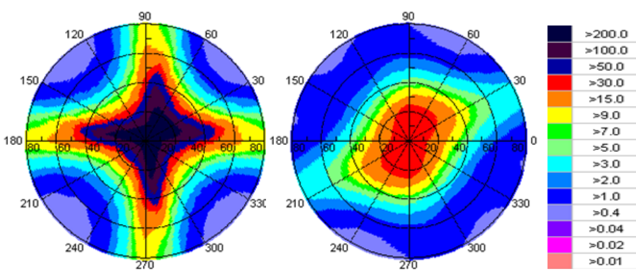


Fig. 2 Normalized voltage dependence of transmittance and reflectance

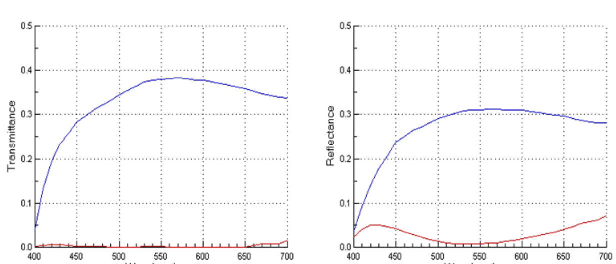
Figure 3 shows the contrast ratio distribution of both parts. The maximum contrast ratio of transmissive part and reflective part are 300 and 21 respectively at 5V applied voltage.



a) b)

Fig 3. Contrast ratio distribution of a) transmissive TN, b) reflective TN

Figure 4 shows the spectrum of a) transmissive part and b) reflective part. The transmittance of the transmissive part is greater than 74% of the polarized light while the reflectance of the reflective part is greater than 60%.



a) b)

Fig. 4 Simulated spectrum of a) transmissive and b) reflective part of the transflective LCD

4. Impact

In summary, a single mode single cell gap TN90˚ transflective LCD configuration has been proposed. In cell retardation films fabricated by photoalignment technology is applied to the configuration to adjust the performance. Also, an antireflective layer is applied to reduce the glare reflectance. This new TN transflective LCD configuration exhibits high contrast, high optical efficiency and wide viewing angle. The normalized transmittance and reflectance vs. voltage curves are matched, and the same gray scale voltage can be used in a transflective display operation. As a result, this TN transflective LCD shows good performance both in transmissive and reflective mode.

5. Acknowledgement

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