Transflective Liquid Crystal Display using Cholesteric Liquid Crystal Film

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Abstract

We proposed a switchable liquid crystal display (LCD) between transmissive mode and reflective mode. The device has the high brightness due to use all of pixels area in both modes. The switchable display consisted of the stacked nematic LC layer and cholesteric LC layer. By the multi-functional cholesteric liquid crystal (ChLC) film as circular polarizer and reflector, both modes could be obtained.

1. Introduction

LCD technology has been researched on simple structure, cost-effective fabrication, high resolution, thinner thickness and more portability for the use of devices without the limitation of area. Transflective LCD with the advantage of their high performance under indoor and outdoor environments is one of the most attractive devices which can be satisfied with these requirements[1]. The most attractive thing of transflective LCD is the readability in bright ambient as the power saving. However, because the conventional transflective LCD has to be divided into two sub-pixels of the transmissive and reflective parts, it should be compensated the optical path difference between divided pixels for preventing the optical degradation by methods such as the variety of the LC structures with the different cell gaps in a single LC mode or the realization of the different modes in a single cell gap[2-4]. However, these technologies have the serious problems such as the complicated fabrication, optical degradation of the display performances and the reduction of aperture ratio of the pixel by pixel dividing.

In this paper, we propose the switchable LCDs which can be used in both transmissive and reflective modes. This device has the simple stacked structure with ChLC layer and nematic LC. In our structure, ChLC layer can reflect only the circularly polarized light coincided with handedness of ChLC on the whole pixel area[5]. In addition, it can also be transmitted the circularly polarized light with the opposite handeness. By the optical design using the difference of the polarization state in the transmissive and reflective mode, we could be obtained the novel transflective LCD which can be used the whole pixel area.

2. Cell structure and Operation

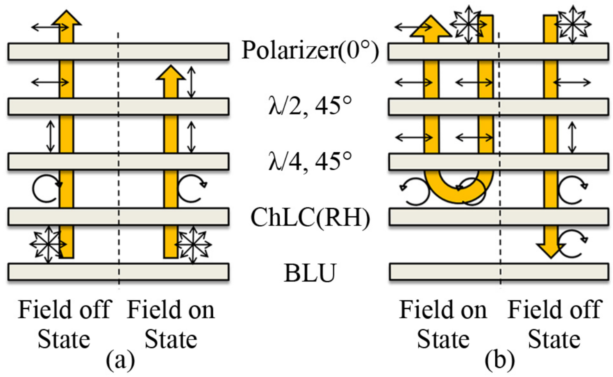


Fig. 1. The schematic diagram of the polarization paths of our proposed switchable LCD: (a) transmissive mode and (b) reflective mode

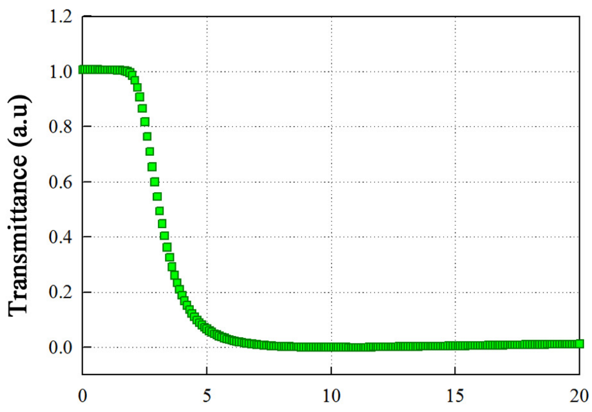
Figure 1 shows the schematic diagram of the polarization paths of proposed switchable LCD consisting of a top polarizer with the transmissive axis to 0° direction, a λ/4 retardation film with optical axis of 45°, a nematic LC cell (λ/2 retardation film) as the optical switcher and a ChLC (mixed with LC ($\Delta\varepsilon$= 15.1, Δn= 0.2306, Merck) and reactive mesogen (RM) mixture (Merck)) cell as multi-functional film which can reflect the circularly polarized light with the right handeness and the visible light with the wavelength range from 400nm to 700nm.

In the transmissive mode, after the randomly polarized light from back light unit (BLU) passes through the ChLC layer, the transmitted light become the left handed polarized light. This light become the linearly polarized light to 90° direction bottom polarizer become the left-handed circular polarization state after passing through the λ/4 retardation film with optical axis of 45°. In the absence of an applied voltage in nematic LC layer, the linearly light retarded by LC cell for function as a λ/2 retarder is penetrated the top linear polarizer. As applying voltage in nematic LC cell, the linearly polarized light to 90° direction is not changed due to LC layer without the optical phase retardation. Thus, we could obtain the dark state.

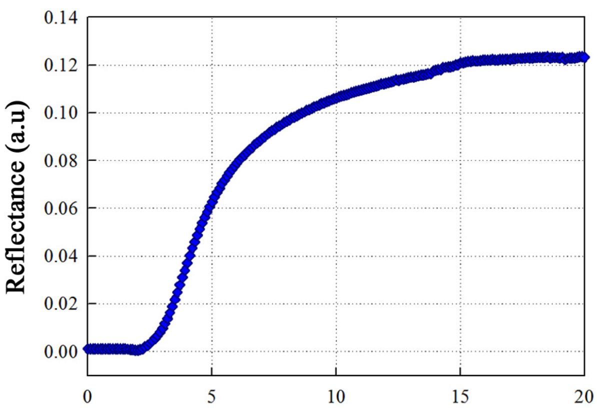
In the reflective mode, in the field off state, the linear polarized light to 0° direction passing through the top polarizer is changed to the 90° polarization state. The changed polarized light become the left handed circular polarization state by the λ/4 retardation film with optical axis 45° and passes through ChLC layer with the right handed chirality. When LC layer cannot function as optical phase retarder by an applied voltage, the linear polarized light passing through the top polarizer penetrates the LC layer and become the circular polarized light with right-handeness by the λ/4 retardation. This light is reflected by ChLC layer and become again the linear polarized light to 0° direction by the λ/4 retardation. Hereby, we could obtain the bright state in the reflective mode.

3. Results

We can obtain the reflectance and the transmittance from the measured V-T curves of our proposed switchable LCD. Figure 2 shows the measured voltage-transmittance curve in both modes. As shown in figure 2(a) which shows the result of the transmissive mode, the bright state was obtained by its optical design in the absence of an electric field. When the voltage of 6 V over is applied to the nematic LC layer, dark state can be obtained. In the reflective mode (figure 2(b)), electrically switching from the initial dark state to the bright state is generated over the voltage of 15 V. Contrast ratio of our cell is measured about 210:1 in the transmissive mode and 70:1 in the reflective mode.



(a)



(b)

Fig. 2. Measured V-T curves of our proposed switchable LCD: (a) transmissive mode and (b) reflective mode.

4. Summary

In this paper, we proposed a novel transflective LCD which can be switched between transmissive mode and reflective mode in the area of all pixels. The device has the high brightness due to use all of pixels area in both modes. The switchable display consisted of the stacked nematic LC layer and ChLC layer. By the multi-functional ChLC film as circular polarizer and reflector, both modes could be obtained without the pixel division. Thus, we could be achieved a display device that is expected to apply to the transflective LCD with high optical performances

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6. References

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