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Transflective LCD with Cholesteric White Reflector

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We propose a transflective liquid crystal display (LCD) without the pixel division by a simple structure with stacking a broadband cholesteric liquid crystal (ChLC) layer. By the ChLC layer as an optical retardation layer and an optical reflection layer, we could obtain a transflective LCD which was operable selectively in both transmissive and reflective mode in the whole pixel.

1. Introduction

LCD technologies have been developed for better performance on various factors and possibility of novel applications. Among these things, 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. The most attractive thing of transflective LCD is the readability in bright ambient as the power saving by an appropriate combination between reflective and transmissive mode [1]. However, by dividing into two sub-pixels as reflective and transmissive parts, the conventional transflective LCD 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 work, we propose the transflective LCD which can be convert the display mode between reflective and transmissive mode in a whole pixel area. This device is made by stacking a broadband ChLC film as an optical retardation layer and an optical reflection layer under a nematic LC cell which can be converted between 3λ/4 and λ/4 retardation. We could be obtained the novel transflective LCD which can be used the whole pixel area without the pixel divided design.

2. Structure and Operation

Figure 1 shows the schematic diagrams of the optical polarization paths of proposed switchable LCD consisting of a top analyzer with the transmissive axis to 0° direction, a nematic LC (MLC-6233-000, Δε = 4.3, Δn = 0.0901, Merck Ltd.) cell with molecules aligning to 45° direction for a thickness of 5.27μm (cell gap for the retardation film which can convert between a quarter and three quarter wave retarder by the applied voltage) as a optical switcher and a ChLC (mixed with a nematic LC (Δε = 15.1, Δn = 0.2306, Merck Ltd.) and the RM mixture (Merck Ltd.)) cell as a multi-functional film which can reflect the circularly polarized light with the same handedness and absorb the opposite handedness of the structure [5]. The bandwidth of the ChLC layer covers whole wavelength range of the visible ray from 400nm to 700nm by forming the pitch gradient in the specimen.

In the transmissive mode, after the randomly polarized light from BLU passes through the ChLC layer, the transmitted light becomes the left handed circularly polarized light (LCPL). In the absence of electric field in a nematic LC layer, the linearly polarized light (LPL) optically retarded by the LC cell for a function as three quarter wave retarder is absorbed to the top linear analyzer. As applying voltage for λ/4 retardation in a nematic LC cell, the LCPL is come to be LPL to 0° direction due to LC layer with the optical phase retardation.

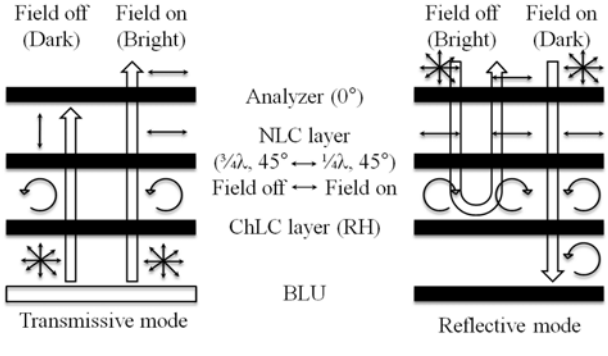

Figure 1. The schematic diagram of the polarization paths of transflective LCD proposed in this work.

High Aperture Transflective LCD mode with simple fabrication by using Cholesteric White Reflector

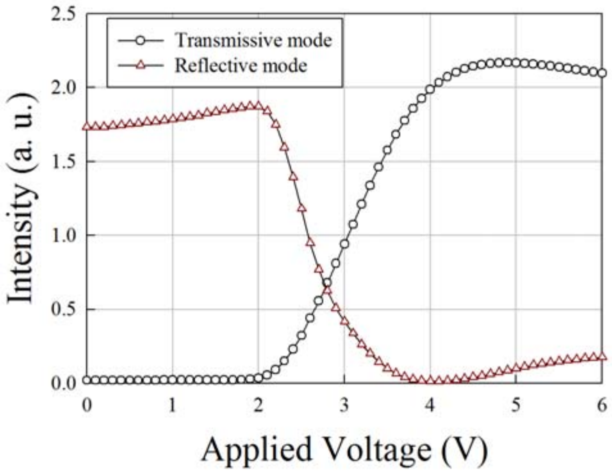

Figure 2. VT, VR curves of proposed device.

Thus, we could obtain the bright state.

In the field off state of the reflective mode, the randomly polarized light passing through top polarizer changes into the 0° polarization state. The changed polarized light is retarded to right handed circularly polarized light (RCPL) by the three quarter wave retardation film with the optical axis 45° and reflected by ChLC layer with the same handed chirality. This light turns back into the 0° polarization state by NLC layer and passes through the analyzer without absorption. This light could show bright state. When a LC layer is role as an optical phase retarder by electric field, the LPL passed through the top analyzer penetrates the NLC layer and become the circularly polarized light with left-handedness by the quarter wave retardation. This light passes through the ChLC layer without Bragg reflection. Hereby, we could obtain the dark state in the reflective mode.

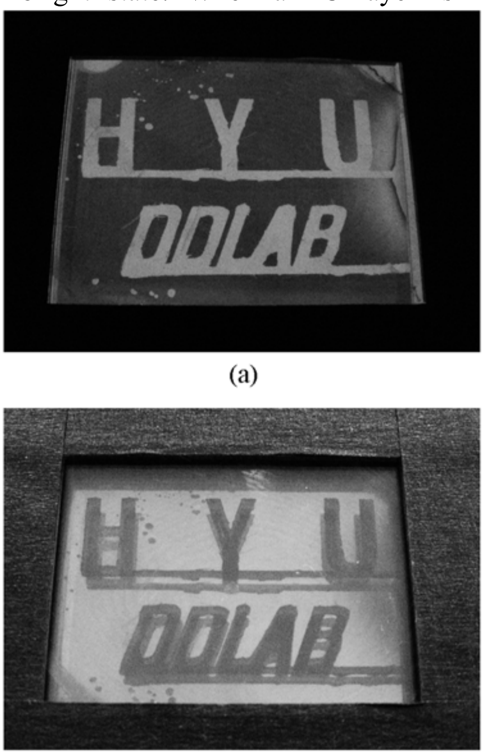

Figure 3. 2 inches prototype images of (a) transmissive mode and (b) reflective mode in proposed structure.

3. Results

Figure 2 shows the measured light intensity as a function of voltage applying to verify electro-optic characteristic on the transmissive mode and the reflective mode by using a He-Ne laser (λ = 632.8nm) as a light source with the same light intensity. Only the nematic LC layer was operated by electric field for switching optical retardation as a quarter and three quarter wave plate, while a ChLC layer stay in planar state without any external force. In the transmissive mode, the sample operated from dark state to bright state by the applied voltage, while it works from bright to dark in the reflective mode. From the measured data, we could find V_{th}~2 V_{rms}, V_{on}~4.2 V_{rms} in transmissive mode and V_{on} ~4 V_{rms} in reflective mode. The contrast ratio reaches for 100:1 and 150:1 for transmissive mode and reflective mode, respectively.

Figure 3 shows size of 2 inches prototype images with activating characters “HYU DDLAB”. We can find inverse brightness for each mode operations and parallax phenomenon under reflective mode from the stacked structure.

4. Conclusion

In this paper, we demonstrated a simple transflective LCD mode without pixel dividing by stacking ChLC white reflector with the optical functionalities. From its own optical property, this structure can be obtained without additional complex fabrications. This device shows a good reflectance with a high contrast ratio for reflective mode.

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