Single-Polarizer Liquid Crystal Display using Polarization-Dependent Microlens Arrays

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A variety of liquid crystal (LC) display modes, such as twisted nematic (TN), patterned vertical alignment, and in-plane switching modes, mandatorily require two polarizers since they control the polarization state of light. Recently, we have proposed a single-polarizer LC mode based on switchable microlens arrays (MLA) with beam-blocking masks [1]. Here, the linear polarization of the incident light passing through the polarizer was changed by the LC layer, and focused or defocused by the MLA with the beam-blocking masks depending on an applied voltage. By the beam-blocking masks, the focused beam was passed but the defocused one was blocked. However, this single-polarizer LC mode showed a slow response time because of non-flat surface induced by surface relief structure.

In this work, we propose a single-polarizer LC mode with an enhanced response time, having a flat surface by using a well aligned liquid crystalline polymer (LCP) [2]. Our LC mode consists of a polarization-dependent MLA and LC layer for controlling the polarization state. Here, the static MLA with polarization dependence was fabricated by filling the LCP on the relief. Therefore, the response time of the LC mode was just governed by the LC layer. For a simple control of the polarization with wide fabrication margin, we used the TN configuration in the LC later. In the absence of an applied voltage, the incident polarization was rotated by 90° in the TN configuration and focused by the MLA. The polarization-independent MLA focused the polarization light perpendicular to the incident polarization but defocused the light parallel to the incident polarization. The focused light passes through the pinhole mask and thus the bright state was obtained. On the other hand, when the external voltage was applied, the incident polarization was unchanged through the LC layer and defocused by the polarization-independent MLA. The defocused light was blocked by the pinhole mask and the additional stop mask [1]. It should be noted that LC molecules in the TN structure were switched at the flat surface, filled up the surface relief structure by LCP. As a result, the response time was remarkably enhanced and matched to that of the TN LC display.

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References

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