High contrast-twisted nematic liquid crystal device advanced by a new microlens array configuration

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Abstract

Recently, several types of microlens arrays with liquid crystals (LC) have been proposed for a tunable focal length and focus intensity which can be obtained by controlling electrically the birefringence of LC molecule [1-4]. Up to now, microlens arrays have been applied to optical communication, three-dimensional display, and data storage.[1,2]

In this paper, as a new approach, we present a high contrast ratio-twisted nematic liquid crystal (TNLC) device characterized by microlens array configuration with a new concept. The device is composed largely of electrically controllable LC layer (CLCL), a fixed LC layer aligned along to one direction by polymer (LCP), microlens array layer (MAL), and small circular black matrix layer (BML). The retardation of CLCL was set up as Δnd=0.9 being respectively, birefringence and cell thickness. The extraordinary refractive index (n_e) and the ordinary refractive index (n_o) of LCP was 1.684 and 1.529, respectively. A concave microlens array used in here is manufactured by a UV curable polymer (UV-P), of which refractive index, n_p is 1.56. BML is positioned at center area of a pixel with diameter of 30 μm.

As a simple optical description for this configuration with parallel polarizer, the polarization of incident light polarized linearly by input polarizer whose optic axis coincides with the rubbing direction is rotated by 90° due to a typical wave-guide-like effect at CLCL under electrically off state. Then, because n_e of LCP acts on the light, it converges at the microlens due to $n_e > n_p$. The BML placed at its focal point blocks the light and the light leaked from the BML is blocked again at output polarizer. Such double blocking promotes darkness at dark state and then, contrast ratio (CR) increases. On the other hand, the polarization of the incident light is not rotated at CLCL under on state. Then, because n_o of LCP acts on the light, it diverges at the microlens due to $n_o < n_p$. The light under parallel polarizer comes out of output polarizer. In this case, transmittance at maximum bright state decreases slightly due to BML as compared to a general TN mode. However, the reduction is very small because the area is about one-twentieth of total pixel area.

In summary, a new twisted nematic liquid crystal (TNLC) device microlens array configuration was proposed simply. CR of the proposed device is improved dramatically by double light-blocking structure using BML even thought the reduction of transmittance at bright state occurs slightly.

References

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