Polarization independent Microlens Array by Controlling Temperatures of Liquid Crystal Layer

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Microlens array (MLA) with a tunable or switchable focal length are used extensively as an important element in many optical systems such as 2D/3D switchable displays, optical interconnection, high-density data storage, and so on [1-3]. Many approaches based on LCs have been proposed becuase of their reconfigurable focal length. However, in most LC optical devices, optical anisotropy of the LC results in the polarization dependence properties on the incident light, and that makes decreasement of light efficiency. Thus orthogonally aligned LC Fresnel lenses [4-5] or vertically aligned nematic liquid crystal (NLC) lenses have been suggested to eliminate the polarization dependence [4-6]. However, such MLAs require an extremely precise alignment technique and/or complicated fabrication processes. In addition, because those LC MLAs are switched from optically isotropic phase to anisotropic phase, it could not show real polarization independent properties. If even one of the two state shows polarization dependent properties, the light efficiency on the incident light could not exceed 50%.

In this paper, we report a truly optically isotropic MLAs by controlling the refractive indices of LCs. The MLA structure were made of a UV-curable polymer with concave shape on the bottom substrate using micro-transfer molding method. At initial state, the LCs are vertically aligned on the glass substrate and MLA surface and has an ordinary refractive index. Because the ordinary refractive index of LC's match to polymer layer's one, incidents light is defocused. Above the clearing temperature of LC, the LC layer has an averaged refractive index (n_a) of the extraordinary (n_e) and ordinary (n_o) refrative indices of the LCs, which can be calculated as $n_a = (n_e+2n_o)/3$. Becasue that refractive index of the LC layer is higher than that of the polyemr for the lens structure, incident light from all direction is focused. In experiment, for controlling the temperature, we used transparent electric heating layer, which is made of indium-tin-oxide (ITO). The ITO layer was patterned on the top substrate, and has high resistivity which make easily heating. Because the proposed MLAs are switched from vertical alignment to isotropic state, they have polarization independent characteristics, and, as a result, show truly optically isotropic properties over the entire switched state.

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