Polarization Independent Liquid Crystal Microlens Arrays Based on Liquid Crystals

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Microlens arrays (MLAs) based on liquid crystals (LCs) play an important role in 2D/3D switchable displays and tunable photonic devices because of their tunable focusing properties [1,2]. However, in most LC MLAs, the intrinsic optical anisotropy of the LCs makes the optical characteristics of the resulting devices dependent upon the polarization of the incident light. Polarization dependency causes only half of the light to be involved in focusing, meaning that light efficiency cannot exceed 50%. To overcome these problems, orthogonally aligned LC Fresnel lenses [3,4] and vertically aligned (VA) LCs [5] have been proposed to increase the light efficiency by exploiting their polarization-independent properties. However, upon switching of the electric field, MLAs based on LCs are switched from an optically isotropic state to an optically anisotropic, birefringent state.

In this paper, we propose a optically isotropic MLA with tunable focal length using nanoencapsulated LCs. Because the radii of the LC capsules are much smaller than the wavelengths of the incident visible light, the encapsulated LC layer is optically isotropic. In the initial state with no electric field, the refractive index of the encapsulated LC layer is larger than that of the polymer lens structure, allowing the incident light to be focused. Under application of an electric field, the LC molecules become vertically aligned and the refractive index of the encapsulated LC layer becomes smaller than that of the polymer lens structure, and the incident light is defocused. For all MLA states, because the encapsulated LC layer is optically anisotropic, the proposed MLA has truly polarization-independent characteristics over the entire switching state.

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