Fabrication Method of Microlens Arrays using Liquid Crystalline Polymer

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Abstract

We proposed a novel fabrication method of the microlens array (MLA) using liquid crystalline polymer (LCP). By using the electrohydrodynamics (EHD) technique, we can easily obtain the MLA having a polarization-dependence property. Therefore, we believe that it is applicable to the data pickup system of double-layer DVD and other applications such as optical interconnections, 3D display and so on.

1. Introduction

Microlenses array (MLA) has been researched because it can be applicable to the wide list of devices in photonics and optoelectronics. MLAs are found as important elements in flat panel displays, optical communication and micro-scanning system etc. Generally, there is a variety of the methods of fabricating MLA. For example photoresist reflow method [1], UV molding with electroformed metal mold [2] and polymer replication processes, including injection molding [3] and hot embossing [4], have been reported. Among them hot embossing and injection molding are considered as the best fabrication method for MLA in mass product But they involve complicated and time-consuming process and must be progressed under high pressure and high temperature.

In this paper, we proposed a novel fabrication technique, using LCP, for MLA by applying an electric field between top and bottom substrates [5, 6]. Through this method, we can easily and quickly fabricate the MLA. So, it can be useful device in the data pickup system of double-layer DVD [7] and other applications such as optical interconnections and 3D display and so on [8].

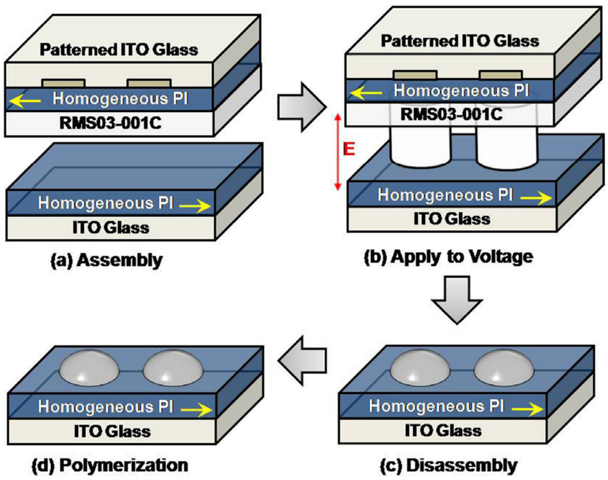

Fig. 1. Fabrication procedure of proposed method for MLA

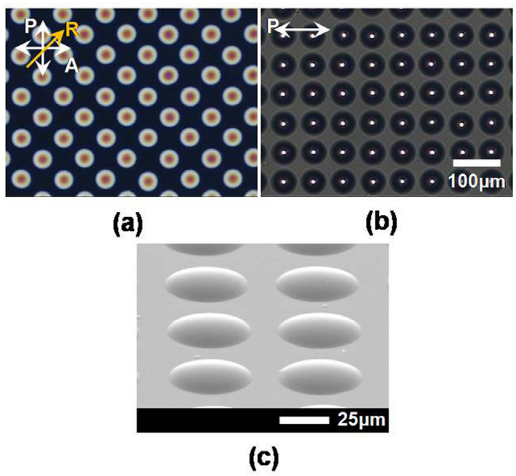

Fig. 2. (a) Microscopic texture under crossed polarizer, (b) focusing image and (c) FESEM image of the proposed MLA.

2. Experimental

For this method, we first fabricated patterned indium-tin-oxide (ITO) glass substrate by using photo-lithography process. After a fabrication of patterned electrode, we spin-coated a planar alignment material (RN1199, Nissan Chemical) on the patterned ITO glass substrate and spin-coated another planar alignment material (AL22620, JSR) on the non-patterned ITO glass substrate. The spin-coated alignment layer was pre-baked at 100°C for 10min to evaporate the solvent in alignment material, and then cured at 210°C for 1 hour to completely imidize. Next, we rubbed both substrates and spin-coated a LCP (RMS03-001C, n_e=1.68, n_o=1.525, Merck) with 1000rpm for 30 sec on the patterned ITO glass substrate. Then, we baked at 60°C to evaporate the solvent in LCP. To preserve a constant gap between two substrates, we assembled patterned substrate, spin-coated LCP, and non-patterned one using a glass spacer of 5.5μm to maintain a gap between two substrates. After assembly, we applied voltage (~60V) to both ITO substrates until LCP formed cylindrical pillars, only on the patterned electrode region. In order to form the lens shape, we separated two substrates. The non-patterned substrate finally was irradiated by UV light (λ=365nm), which has an intensity 20mW/cm^2, in a nitrogen atmosphere for about 5 min to completely polymerize the LCP. Eventually, we can obtain the MLA having polarization-dependence property.

3. Results and discussion

Figure 1 shows the fabrication procedure of proposed MLA. This method originated from the electrohydrodynamic (EHD) instabilities [5, 6]. Figure 2 (a) shows the microscopic texture of the proposed MLA observed under crossed polarizers, having 45° with respect to transmission axis of polarizers. Figure 2 (b) shows the focal plane image of our MLA and fig. 2 (c) shows the FESEM image of that. The measured height and curvature of our MLA are about 3μm and 81μm, respectively. Figure 2 (c) shows the field-emission scanning electron microscope (FESEM) images of our MLA. The well-defined curvature of MLA observed through FESEM image. The calculated focal lengths, by using the spherical model, are 119μm and 154μm according to the slow and fast axis of MLA, respectively. And the measured focal lengths are about 105μm and 120μm, respectively, according to those of MLA.

Through the proposed method, we can easily and fast fabrication of MLA having polarization-dependence property. Consequently, it is applicable to optical interconnections, 3D display, and the data pickup system of a double-layer DVD, if it use in company with polarization switching device.

4. Summary

We proposed a novel fabrication of MLA by using the EHD instability of LCP under applied voltage. Because of the used LCP material, our MLA has a polarization-dependence property, especially in the focal length. Therefore, it which combined with polarization switching device, such as TN, can be useful device in the data pickup system of a double-layer DVD, optical interconnections, 3D display, and so on.

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