Fabrication Process of Fresnel Lenses with high resolution By Electrohydrodynamic Instability

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Fresnel lenses have been widely used in various optical systems, including long-distance optical communication and optical information processing [1]. The circular diffraction grating with an outwardly increasing line density creates point foci of different order via constructive interference. Conventional Fresnel lenses fabricated by thin film deposition or electron beam writing have several problems, including a low focusing efficiency, narrow fabrication tolerance and high coast of process [2, 3]. Here, interest in lateral structure in polymer films, fabricated by electrohydrodynamic instability (EHDI), was renewed by the potential development as a new method [4]. This EHDI method creates stripe or pillar shapes using optically isotropic organic materials according to the electrode structure. In this paper, we suggest the fabrication of binary type Fresnel lenses by using EHDI of the optically anisotropic layer. This method is simple, fast, and reliable fabrication for creating high resolution fresnel lens.

Fabricating a binary-phase Fresnel lens applied the EHD patterning method. The key process is the patterned indium-tin-oxide (ITO) with Fresnel zone patterns. The chrome mask for fabricating a binary-phase Fresnel lens was patterned according to several conditions. First, the innermost zone corresponding to first ring has radius r1=25 m and nth zone has radius rn which satisfies rn2 = nr12; n is the zone number. In the mask, the odd-zone patterns are transparent and even-zone patterns are opaque with chrome. Thus, indium-tin-oxide (ITO) layer remains following even-zone pattern and the EHD process will be take place in the even-zone electrodes resulting in phase retardation corresponding to the patterned electrodes. Second, the process that induce phase shift between neighboring binary-phase Fresnel zones is continue. The horizontal polyimide alignment layer (RN1199, Nissan Chemical) was spin-coated onto the substrate of patterned ITO glass and the other horizontal polyimide alignment layer (AL22620, JSR Inc.) was spin-coated onto the substrate of target ITO glass to align the molecules of liquid crystalline polymer (LCP), material for realizing binary-phase Fresnel zone. They were soft -baked to vaporize solvent under 100 ℃ for 10 minutes, hard-baked to polymerize a layer under 210 ℃ for two hours and rubbed each other. Next, the liquid crystalline polymer (LCP, RMS03-013c, Merck Ltd.) was spin-coated onto the patterned glass, coated polyimide (RN1199, Nissan Chemical) and baked at 60 ℃ for 1 minute to vaporize solvent. The patterned glass coated with LCP was assembled with target glass coated with horizontal polyimide alignment layer, AL22620. The cell was anti-parallel and maintained with 2.0μm ball spacers. The cell thickness was satisfied with a half-wave plate in the LCP rings. After the external voltage (100V) was applied to the cell and removed when the Fresnel zone structure was perfect, UV light was illuminated under the assembled cell. Finally, disassembled the cell, the Fresnel lens with LCP was remained on the target glass. The Fresnel lens has a high-efficiency performance with fast, simple and reliable fabrication for producing Fresnel lens.

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References:
[1] N. Kitaura et al., *Opt. Eng.*, **34**, 584 (1995).
[2] T. Fujita et al., *Opt. Lett*., **6**, 613 (1981).
[3] J. Jahns et al., *Appl. Opt.*, **29**, 931 (1990).
[4] S. Y. Chou, L. Zhuang, *J. Vac. Sci. Technol. B.*, **17**, 3197 (1999).