Proceedings of the World Congress on Recent Advances in Nanotechnology (RAN'16)
Prague, Czech Republic – April 1 – 2, 2016
Paper No. ICNNFC 124
DOI: 10.11159/icnnfc16.124

Fabrication of Gapless Moth's Eye Microlens Array using Selective Aluminium Anodizing based on Concentrated Electric Field

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Extended Abstract

The image sensor is a detection device that converts information of object into an electrical signal. Major issues in the development of image sensors are improvements of the signal-to-noise ratio (SNR), resolution and sensitivity. Through decades of research, photodetector was increased the SNR by reducing the area of the light receiving region in order to minimize the effect of the dark current, and also resolution could be increased by maximizing the number of pixels per unit area. However, the minimization of light receiving region and each pixel area for the improvement of SNR and resolution caused the problem of the reduction of the amount of light applied to the photodetector. To overcome this problem, microlens was formed on the each pixel in order to collect the incident light on each pixel [1]. Photoresist-reflowing process based on photolithography was a major fabrication approach of microlens array [2]. However, the gap between microlenses was inevitably formed in the microlens array prepared by photoresist-reflowing process. In order to minimize light loss, gap between microlenses must be reduced. In additions, the collecting of incident light could be maximized by reducing light reflection at the surface of microlenses like moth's eye which was covered by nano-protrusions [3].

In this paper, a simple approach of the fabrication of gapless moth's eye microlens array is proposed for the improvement of the light collecting efficiency. Gapless moth's eye microlens array was fabricated by UV-embossing process using aluminium mold which was prepared by selective anodizing based on locally concentrated electric field. In the aluminium anodizing process, the growth speed of anodic alumina depended on the intensity of electric field. That is, the bottom topology of anodic alumina was similar to the intensity profile of the electric field. Therefore, if the intensity profile of electric field on aluminium surface is controlled during anodizing, the bottom topology shape of anodic alumina can be controlled. The intensity profile of the electric field was easily adjusted by insulative micropatterns on the aluminium surface. In computational work, the intensity profile of the electric field was estimated, and the insulative micropatterns were made of photoresist of AZ-P4620 in experimental work. Photoresist was carbonized by heat treatment at 250 °C in order to enhance its chemical resistance [4]. Diameter, height and pitch of hexagonal insulative micropatterns were 17 □m, 10□□m, and 30 □m, respectively. After carbonization, selective anodizing based locally concentrated electric field was performed in 0.3M oxalic acid. Electrolyte temperature, applied current density, and process time were 0°C, 5mA, and 50 hr, respectively. During anodizing process, the bottom topology of nanoporous anodic alumina was changed into gapless microlens array due to the concentrated electric field. Finally, aluminium mold of gapless moth's eye microlens array was prepared by removing nanoporous anodic alumina using chemical wet etching process. On the surface of the concave microlens mold, nano-protrusions were formed. In order to replicate gapless moth's eye microlens array, UV-embossing process was carried out using UV-curable resin of reflective index of 1.474 and embossing pressure of 127.5 kPa. Replicated gapless moth's eye microlens array was measured by scanning electron microscope and white light interferometer. Focal length of microlens was approximately estimated as 42 □m. From the experimental results, the proposed approach for the fabrication of gapless moth's eye microlens array was verified. The proposed gapless moth's eye microlens array could be applied to various optical applications such as solar cell, photodetector and so on. This work was supported by the Human Resources Development program(No. 20154030200950) of the Korea Institute of Energy Technology Evaluation and Planning(KETEP) grant funded by the Korea government Ministry of Trade, Industry and Energy, and also supported by Development of master machining system and 10% energy saving molding system for 100nm~100□m nano hybrid structures.

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