Study on Fabrication of Submicrometer Structures Using Synchrotron Radiation Lithography for Optical Applications

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In this research, process techniques using synchrotron radiation (SR) x-ray lithography to fabricate a high-aspect-ratio structure and three-dimensional structures with sub-micron for optical applications were developed. Four fabricated optical components are reported in this work: a high-aspect-ratio diffractive optical element (DOE) for visible light, a blazed DOE for infrared light, an anti-reflective structure of poly-methyl-methacrylate (PMMA), and an x-ray telescope mirror element of nickel. Evaluations for optical characteristic of each optical component are summarized.

In the fabrication of the high-aspect-ratio DOE: a grating with a line-width of 250 nm and an aspect ratio of 8 was formed by the direct x-ray exposure. The grating was measured the diffraction efficiency irradiating a 406 nm-wavelength laser. The measured efficiency was fitted in less than 10% of the error from that of the ideal cross-sectional structure. The result confirms that the element is compatible with the application of blue-ray disc.

In the fabrication of blazed optical element: a grating with a pitch of 1.48 μm and 600 nm-height was realized by PCT (Plane-pattern to Cross section Transfer) method for an application of wavelength division multiplexer for optical communication. The fabricated structure has achieved an aim in shape. The surface roughness has yet to be improved for the optical application.

In the fabrication of anti-reflective structure: a sub-wavelength structure was successfully fabricated using a variable-gap-exposure. This result showed the acceptable filter characteristic which absorbs approximately 65% at wavelength 350-700 nm.

In the fabrication of x-ray telescope mirror element: smooth surface roughness and high aspect ratio structure is required. A nickel mirror element was fabricated using Lithographie Galvanik Abformung (LIGA) process. The grinding method by a magnetic fluid was employed for reducing the surface roughness. The mirror surface roughness was reduced to 4 nm(r.m.s.) and the reflectance of x-ray light is measure. From the result, the light weight x-ray telescope is prospected for satellite

The results from development of the four optical elements confirm that the fabrication technology using SR lithography is technologically remarked for the optical applications of infrared light, visible light and x-ray light.