SUMMARY OF Ph.D. DISSERTATION

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Title

Study of Microlithography for Three-dimensional Fabrication

Abstract

Microlithography is utilized for fabrication of sensors and MEMS devices because of its high reproducibility and mass-productivity. Although conventional microlithography allows only planar processing, MEMS techniques such as Deep Reactive Ion Etching enabled so-called 2.5-dimensional fabrication. Furthermore, true 3-dimensional (3D) microlithography is recently demanded for fabrication of microstructures such as optical devices. In this study, new lithography techniques for 3D microfabrication was studied and its utility was demonstrated through trial fabrication. In particular, design restriction was reduced by applying image-processing technique on designing stage of photomask, whereby high flexibility on designing and rapid prototyping was accomplished.

In the 1st chapter, the background and the purpose of this study are described.

The 2nd chapter describes fundamental optics of photolithography and basic chemistry of photoresist for 3D microfabrication.

The 3rd chapter describes experimentation and test fabrication results of gray-scale lithography with image-processing technique, including a design procedure of a photomask. Gray-scale lithography provides 3D structures with single exposure step using a gray-scale mask that modulates shadowing rate. In this study, a half-tone gray-scale chrome mask was fabricated using Electron Beam lithography and plasma-etching. Fresnel lens profile of 10μm height was prototyped with parameters optimized through process simulation.

In the 4th chapter, novel technique of substrate penetration method using photosensitive resin is described. This method provides very high-aspect structures with curved surface and ultra-thick film of over 200μm. Fly-eye lens with height of 250μm was prototyped using chemically amplified negative-tone photoresist.

In the 5th chapter, new lithography techniques using rotary stage are described. An array of overhanging structures was fabricated using this method with high uniformity. Since exposure energy is uniformized by rotation, UV-LED array can be utilized as large-field light source.

The 6th chapter describes about lithography technique for substrate with 3D structures. A beam-shaping spray-coating system was upgraded to provide uniform thickness of photoresist, and each parameter was optimized. In addition, inclined exposure method was developed to expose top and side surface of micro beam structures simultaneously.

In the 7th chapter, conclusions of this paper are described.

Namely, this study proposed new lithography techniques for micro 3D fabrication by utilizing image-processing technique. These techniques can be applied for sensor and MEMS devices on a next generation because of their high flexibility and mass-productivity.