펨토레이저의 이광자흡수를 이용한 마이크로 공정
Micro-Fabrication using Two-Photon Absorption by Femtosecond Laser

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INTRODUCTION

As a femtosecond laser has recently been developed, nonlinear phenomena are easily obtained. The high photon density due to ultra short pulse of the femtosecond laser results in two photon absorbed photopolymerization of urethane acrylate resin whose wavelength of the absorption spectrum is usually UV region. The stereo-lithography using the two-photon absorption (TPA) makes nano scaled structures. We have used this phenomenon to make micron-sized structures with sub-micronresolution. Before fabricating 3-D structures, 2-D structures have been performed. Furthermore the TPA photopolymerization isapplied to poly-dimethyl siloxane (PDMS) molding. In this paper, we report the recent progress and application of this technology in our laboratory.

EXPERIMENT

1. Setup

A schematic diagram of optical system for the TPA process is setup as shown in Fig. 1.(a). The beam from a mode-locked Ti:sapphire laser is injected into the mirror-scanner (Galvano mirror) to deflect its direction in two dimensions. The beam is then focused vertically through an objective lens using the PZT translation stage to the z-axis. For the TPA micro-fabrication, 780nm wavelength Ti:sapphire femtosecond mode-locked laser with 80 MHz repetition and less than 100 fs pulse width was used in the system. A numerical aperture (NA) and magnification of a microscopic objective lens are 1.25(oil-immersed) and 100,respectively.

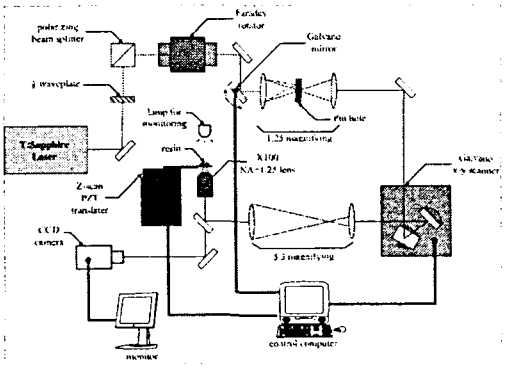


Fig. 1. Scheme of TPA fabrication system

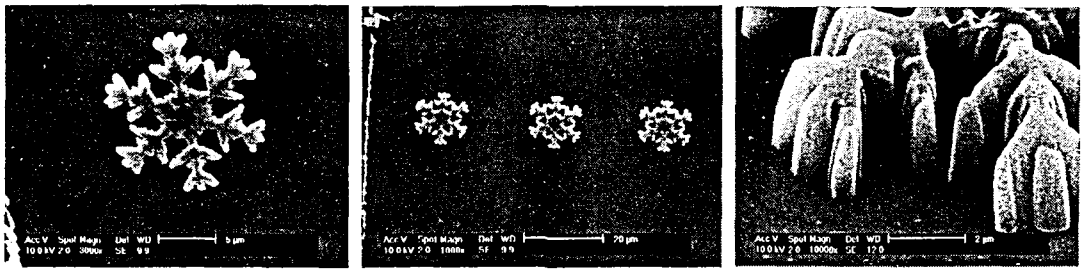
The resolution of the Galvano-scanner set is 24 nm and the z-stage is 10nm, respectively. An exposure time can vary from 500μs to several hundred ms by a mechanical shutter and a Galvano

shutter, both of which are computer-controlledas well as Galvano scanner and PZT z-stage. To prevent the optical damage of the laser oscillator, an optical isolator was used to block out the backward laser beam from surface reflection of each optical components.

2. Two Dimensional Fabrications

After measuring important physical parameters, such as distance and voxel size, many two dimensional fabrications were performed.

Replication of Sculptures of snow crystal was fabricated as shown in Fig. 2. It tells TPA process is easy to fabricate many copies of sculptures (Fig. 2. (b)). This sculpture also has longer height than axial resolution.

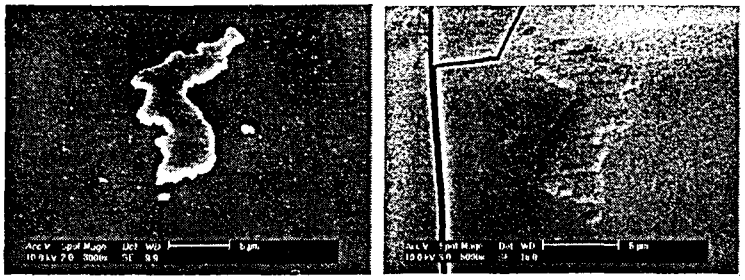


(a) (b) (c)

Fig. 2. SEM images of (a) a snow crystal (b) replication of snow crystals (c) side view of snow crystal

3. Molding of Microstructures

Following the TPA fabrication, PDMS molds of the 2D microstructures ware made. The PDMS, which stands for poly(dimethylsiloxane), is transparent and flexible like rubber, so that this method is frequently used to make microstructures for bio-mems.



(a) (b)

Fig. 3. (a) TPA 2-D structure of Korean peninsula and (b) PDMS mold

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References

1. *S. Maruo and S. Kawata, "Two-Photon-Absorbed Near-Infrared Photopolymerization for Three-Dimensional microfabrication", J. Micro Electro Mechanical Systems, 7, 411-415, 1998*
2. *S. Kawata, H.-B. Sun, T. Tanaka and K. Takada, "Fine features for functional devices", Nature, 412, 697-698, 2001*
3. *Duffy D. C., McDonald J. C., Schueller O. J. A. and Whitesides G. M., "Fabrication of microfluidic systems in poly(dimethylsiloxane)", Anal. Chem., 70, 4974-4984, 1998*
4. *J. Serbin, A. Egbert, et al., "Femtosecond laser-induced two-photon polymerization of inorganic-organic hybrid materials for applications in photonics", Opt. Lett. 28, 301-303, 2003*