Ultra Short Pulse Laser Microfabrication Using Nonlinear Absorption in Photopolymerization

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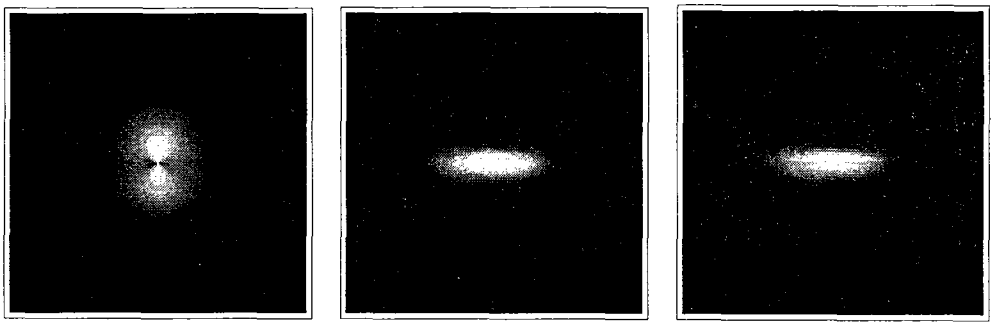
Tightly focused laser light with a ultra short pulse can cause nonlinear effect such as two- or multi-photon absorption becuase of its high peak power. A two-photon absorption photopolymerizing microfabrication has been studied and performed in this research.

Since the multi-photon absorption occurs only in a tightly focused region with a ultra short pulse the two-photon absorbed polymerizing microfabrication makes it possible to fabricate a 3-D structure with direct writing. Furthermore it makes the fabricating resolution far smaller than that of the linear absorption fabrication. The technique is applied to correcting photomask, 3-D photonic crystal, 3-D optical storage, 3-D lithography and so on[1]. We have performed the basic experiment and fabrication of the two-photon absorbed polymerization. Also the theoretical simulation is calculated such as the light distribution in tight focus(Fig. 1). The objective lens with the high numerical aperture has given the different focal intensity distribution from that of the lower NA(<0.4).



(a) (b) (c)

Fig.1 Vector Point Spread Function (a) focal plane (b) x-z plane (c) y-z plane around focus of N.A.=0.86

The two-photon absorbed polymerizing stereo-lithography system has been built (Fig.2). Galvano mirrors and the mechanical shutter are used to move the focal position and control the exposure time for the voxel size, respectively. Moreover the resin which we used was a urethane acrylate

resin. From the system, a few 2-D structures have been fabricated.

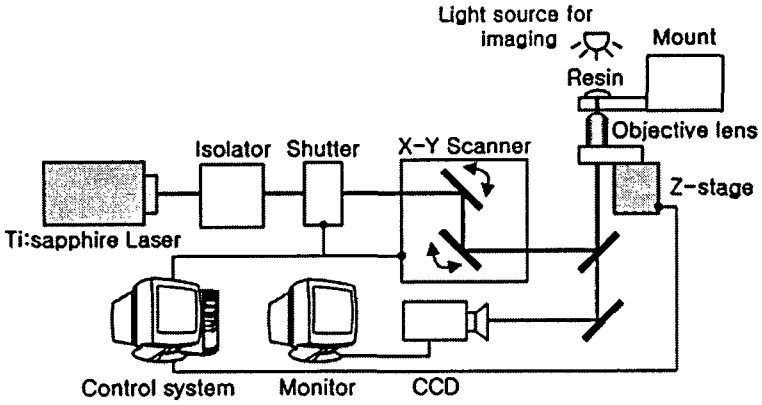


Fig.2. Two-Photon Absorbed Polymerizing Microfabrication System Setup

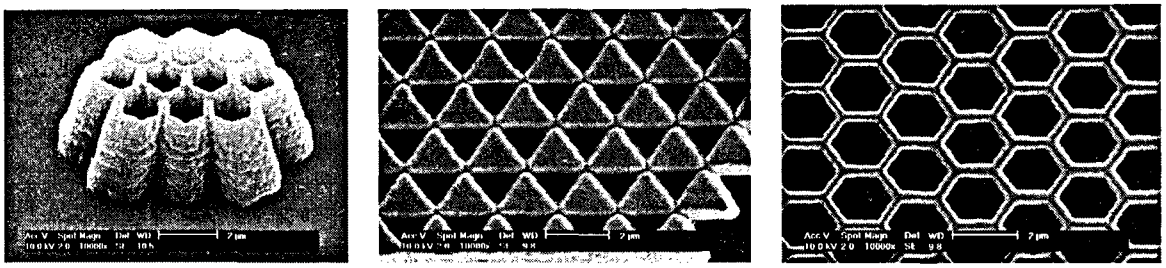
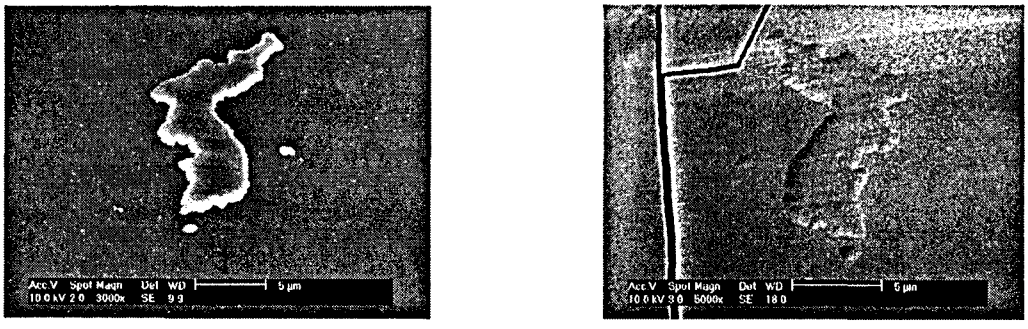


Fig.3. 2-D and 3-D Structures

The technique has been also adapted to the application such as the PDMS (Poly -DiMethylSiloxane) molding as well[2]. We have a plan to make the diffractive optical element by the two-photon absorbed polymerizing microfabrication.



(a) (b)

Fig.4. (a) 2-D structure (b) its PDMS molding

References

1. S. Y. Lin, *et al.*, "A three-dimensional photonic crystal operating at infrared wavelengths", Nature, **394**, 251 (1998)
2. ShinWook Yi, *et al.*, "Three-Dimensional Micro-Fabrication using Two-Photon Absorption by Femtosecond Laser", Proc. of SPIE, 5432, 137 (2004)