이광자흡수 현상을 통한 3차원 나노구조의 제작 기술

Fabrication Technique for a 3D Nanostructure through the Two Photon Absorption Polymerization.

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Recently, the three-dimensional (3D) photonic crystal has received a huge attention and, simultaneously, has been realized in various ways. The two-photon absorption (TPA) polymerization process which is suitable for three-dimensional (3D) nanofabrication is one of the means. Because TPA probability depends on the photon fluence density quadratically, the resin polymerizes only in the vicinity of the focal spot and sub- diffraction limit fabrication can be acquired. Furthermore an infrared laser penetrates deeply into the resin enabling a 3-D positioning.[1),(2)]

The 780nm mode-locked Ti: sapphire laser whose the laser pulse width is 80fs and the repetition rate is 82MHz was operated as the radiation source. The N.D. filter attenuated the laser power to mW regime and the computerized electric shutter controlled the exposure time in several times of msec. These two equipments could adjust the condition of incident light. The incident light was focused by micro scope objective lens with N.A 1.25 and 100 magnification. The computer-controlled scanning system consisting of two parts was introduced to fabricate the nano structure. One is the focus-positioning system, and the other is resin-positioning system. The focus-positioning system was 3-axis movable PZT on which the objective lens was installed. The resin-positioning systems , x-axis picomotor and y-axis micrometer, could move the glass substrate in mm length range. These two moving systems provided the capability of variety 3-D structure fabrication.

Because the resin responds only in the vicinity of the focal spot, searching the focal point precisely is as important as positioning process. In order to position the focal point on the interface of glass and resin, a simple principle in geometrical optics was applied. That is where the diameter and intensity of the light is smallest and highest at the focal point respective.[3)] From the observation of the diffraction patterns of reflected light from the glass surface, brightest and smallest spot should be identified by reflected light from the focal point. Thus the focal point is identified by the observation of reflected light from glass as varying the distance between the substrate and the objective lens. We name this technique as 'method of scanning focal point', that is a simple and

powerful method for searching the focal point.

The resin, EA4BPA-VB, [1,4-bis (2- ethylhexyloxy)-2,5-bis (2 {4[bis~4-bromophenyl] amino} phenyl) vinyl] benzene] with two-photon crosssection of $\delta=4.7\times10^{-48}$ cm^4 s/photon at 780 nm and peak absorption wavelength at 423 nm, was used for TPA photopolymerization.[4] The exposure condition was selected where the power of the incident beam to resin was 5mW and the exposure time was 32msec per voxel throughout the whole experiment.

Fig 1 is SEM image of 2D structure. The parallel lines were fabricated 2μm apart and the angle θ between x-axis and line changed from 0 to π/2 at π/12 interval. In fact, the line consisted of many voxels, and the spacing of each voxel was 500nm. Fig 2 is SEM images of 3D structures which were built by using z-axis PZT as well as x, y axis PZT. Fig.2, (a), (b) and (c) look like the same structure at a glance, but these are not one thing in detail. In fact these are different combination of π/12, π/4 and 5π/12 line array. (a) consists of π/4, 5π/12, and π/12 from bottom layer to top layer while (b) is set of π/12, π/4, and 5π/12 and (c) is formed with π/12, 5π/12, and π/4.

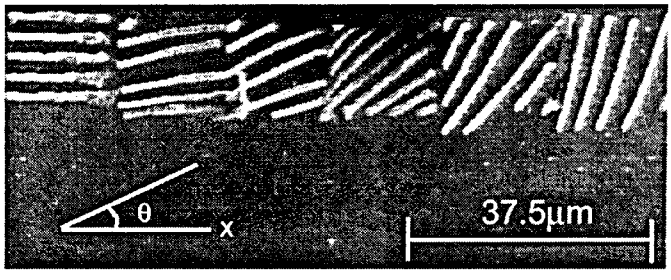

Fig.1 SEM image of 2D structure.

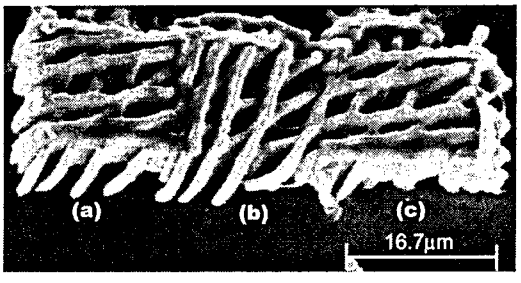

Fig.2 SEM image of 3D structure.

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Fabrication of the various nanostructures should be achieved by using the two parts of scanning systems. These periodic nano structure are expected to be useful in various studies including the photonic crystal and nano pattern.

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