Micro 3-D Fabrication and Nano Scale Metrology by Controlling Localized Light Energy

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The purpose of this research is to develop the new types of laser applied micro 3-D fabrication and metrology techniques by making the use of localized property of light energy. Here, the localized light energy means not only the focused light energy of freely propagating light, but also the diffraction-free light energy such as the evanescent light and near-field light energy. The main topics of our proposed applications are as follows:

1. Evanescent light energy application

By using the evanescent light energy, we are trying to develop the super-resolution microscopy (Fig. 1) beyond the diffraction limit as the metrology technique and the micro-stereo-lithography as the 3-D microstructure fabrication technique. Fig. 2 shows an example of microstructure object fabricated by the micro-stereo-lithography using the evanescent light energy. This method has a potential to fabricate micro 3-D objects with a 100-nanometer resolution by laminating resin layers cured by evanescent light exposure.

2. Near-field light energy application

We are applying this near-field light energy to measurement of the residual thin-film (about 100 nm or less) thickness for nanoimprint lithography. In nanoimprint lithography, the area of the residual thin-film is horizontally limited less than 100 nm, so, the conventional optical thin-film thickness measurement methods such as ellipsometer can not be applied due to its low ability of horizontal resolution. Target of this research is to measure the residual thin-film thickness with the resolution of several nm.

3. Light energy of focused beam application

Focused beam can be generated by converging the laser beam using the high-numerical aperture objective. The localized size of the focused beam energy is about 1μm. This size is not very small compared with the other localized light energies mentioned above. However this light energy does not need the approaching process of TIR surface, fiber probe tip, and so on. Then, we can easily control the light energy of beam waist in the 3-D space. By using this localized light energy, we are proposing and developing a new 3-D metal microstructure fabrication technique. In this proposed method, nano particles of photocatalysis (TiO_2) in the metal ion solution are excited by the localized light energy of the focused beam and the photocatalytic reduction causes the metal deposition. Then we can fabricate the complex 3-D metal microstructure by sweeping the beam waist in 3-D space as the laser direct writing method.

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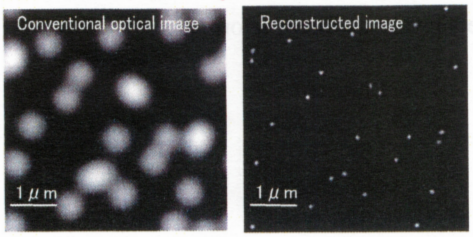

Fig.1 Super-resolution technique with standing evanescent light illumination.

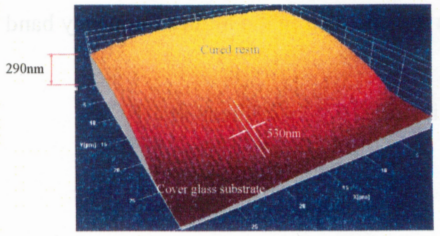

Fig.2 Periodic submicron structure fabricated by nano-stereo-lithography using evanescent light.