Optical vortex induced flower-shaped surface relief of azo-polymers

°A. Shiraishi [1], K. Masuda[1], K. Miyamoto[1,2], T. Omatsu[1,2]

(1. Chiba Univ., 2.MCRC, Chiba Univ.)

E-mail: omatsu@faculty.chiba-u.jp

Optical vortex possesses an orbital angular momentum (OAM) associated with its helical wavefront, and it has been studied in a variety of fields, such as optical manipulations, optical and quantum communications, scanning fluorescence microscopes, and materials processing. Surface relief formation of azo-polymers occurs via a single-photon or two-photon induced trans-cis isomerization, and it has the potential to develop rewritable optical data storages with high data capacity.

To date, there are several demonstrations of optical vortex induced chiral surface relief of azo-polymers, in which the optical vortex twists an irradiated azo-polymer film to form chiral surface structures owing to OAM transfer effects. Such chiral surface structures of azo-polymers will allow us to develop ultrahigh density optical data storages with the freedom of OAM.

In this presentation, we report on, for the first time, a new class of optical vortex induced surface relief with 3 (or 6) petals along an azimuthal direction, that is an optical vortex induced 'flower-shaped surface relief'.

Figure 1 shows an experimental setup. A near-infrared picosecond laser (wavelength: 1030 nm, repetition frequency: 40 MHz, pulse width: 2 ps) was used, and its output was converted into a circularly polarized optical vortex with ℓ = 1 (or 2) by a spiral phase plate (SPP) and a quarter wave plate (QWP). The generated optical vortex was focused to be an annular spot with a diameter of ~4μm on the azo polymer film by an objective lens (NA=0.9). The intensity of the focused optical vortex was measured to be 5 GW/cm^2, corresponding to ~10 times intensity required for azo-polymers mass transfer via two-photon absorption.

A flower-shaped surface relief with 3 (or 6) petals along an azimuthal direction was then created at an exposure time of 300 seconds. The diameter and height of the relief were measured to be ~2 μm (or ~4 μm) and ~280nm (or ~590nm), respectively. Such flower-shaped surface relief manifests the spatial modal instability originating from optical nonlinearities, such as photo-bleaching effects of the azo-polymer film.

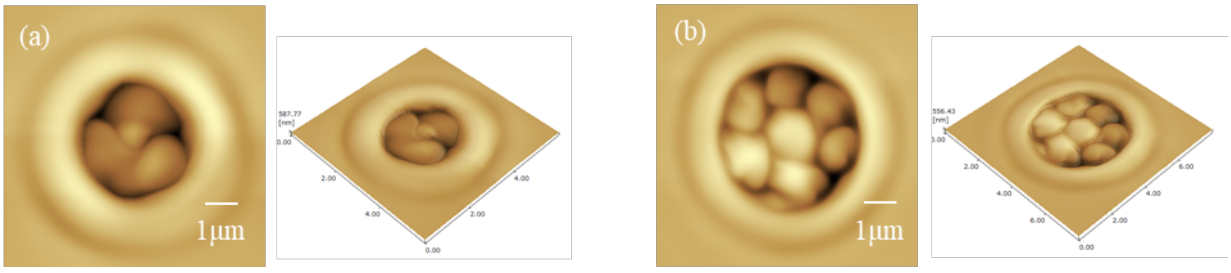

Fig. 2 Surface reliefs formed by illumination of an optical vortex with (a) ℓ = 1, (b) ℓ = 2

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[2] K. Masuda, R. Shinozaki, A. Shiraishi, M. Ichijo, K. Yamane. K. Miyamoto, and T. Omatsu, "Picosecond optical vortex-induced chiral surface relief in an azo-polymer film," J. Nanophotonics **14**, 016012 (2020)