Formation of spiral surface relief with a Hermite-Gaussian beam

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Submicron-scale chiral structures have been attracting much attention in a myriad of fields, such as ultrahigh-density optical data storages with a freedom of chirality, chiral metamaterials and chiral plasmonics. To date, several researchers have discovered that an optical vortex with orbital angular momentum (OAM) twists azopolymers to form chiral surface reliefs, reflecting a helical wavefront of the irradiated optical vortex, with the help of spin angular momentum (SAM) associated with circular polarization [1-2].

In this paper, we here propose a new approach for light induced chiral surface reliefs, in which the chiral surface reliefs of azopolymers are formed by the irradiation of the temporally rotating Hermite-Gaussian (HG) beams without OAM.

A continuous-wave (CW) green laser with a wavelength of 532 nm was used, and its output was directed to a spatial light modulator (SLM) to produce a rotating $HG_{1,0}$ beam with a rotation speed of $\pm\pi/8$ phase step per second. The rotating HG beam was deliveded towards a microscope, and it was focused to be a 4 μm annular spot onto a spin-coated azoplomer film (thickness of ~1 μm) by an objective lens with NA=0.90. The exposure time was then fixed to be 20 seconds. The left- (right-) handed circularly polarized $HG_{1,0}$ beam was then generated by employing a quarter wave-plate (QWP).

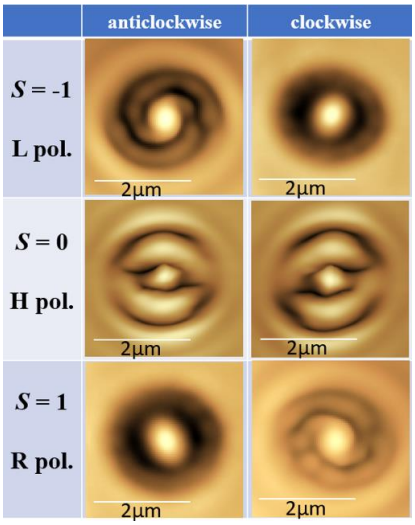

Fig.1 Surface reliefs of azo-polymers by changing the rotation direction of the $HG_{1,0}$ beam with a rotation speed of $\pm\pi/8$ per second and various spin angular momenta s = -1, 0 and 1 (L, H and R polarizations)

A left- (or right-) handed spiral surface relief with two arms was formed in the azo-polymer film only by the irradiation of anticlockwise (or clockwise) rotating $HG_{1,0}$ mode with left- (or right-) handed circular polarization, as shown in Fig. 1. Conversely, spiral surface reliefs were never produced even by illumination of rotating $HG_{1,0}$ beams when the rotating direction of HG mode and circular polarization was opposite. It is worth noting that a linearly polarized rotating $HG_{1,0}$ beam also enabled the twist of azopolymers, however, it did not create any spiral surface reliefs. Such spiral surface relief formation will provide us a new fundamental aspect of interaction between angular momentum of light and materials, and an advanced technology, such as ultrahigh-density optical storage with a new freedom of chirality.

[1] Masuda, K., Nakano, S., Barada, D., Kurama, M., Miyamoto, K., Omatsu, T., "Azo-polymer film twisted to form a helical surface relief by illumination with a circularly polarized Gaussian beam," Opt. Express **25**, 12499 (2017).

[2] Barada, D., Juman, G., Yoshida, I., Miyamoto, K., Kawata, S., Ohno, S., Omatsu, T., "Constructive spinorbital angular momentum coupling can twist materials to create spiral structures in optical vortex illumination," Appl. Phys. Lett. **108**, 051108 (2016).