Transparent hologram based on photo-patterned cholesteric liquid crystals

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Holography enables the reconstruction of arbitrary wavefronts, which finds practical applications in security and data storage. Recently, there has been an increasing interest in computer generated holograms (CGHs) that digitally calculate and record the interference pattern without the objects. Among the various methods to encode phase distribution, metasurfaces, which are ultra-thin optical devices based on sub-wavelength structures, have recently been investigated intensively due to their ability to locally manipulate the phase, amplitude and polarization of light. Both transmissive and reflective CGHs have been proposed using metasurfaces, but the efficiency of transmissive CGHs is low in the visible light region due to fabrication errors and material losses. Meanwhile, reflective CGHs with efficiencies reaching 80% have been reported [1]. However, the hologram is opaque due to the use of a metal as a reflector, and therefore it is not suitable in applications where transparency is required.

Here, we propose a reflective hologram that is transparent in the visible light region based on a photo-patterned cholesteric liquid crystal (ChLC). ChLCs possess helical periodic structures and exhibit Bragg reflection over a wavelength band given by $n_o p$-$n_e p$, where n_o and n_e are ordinary and extraordinary refractive indices and p is the helix pitch. The phase modulation of the reflected light is achieved by varying the geometric phase of helical structure from 0 to π radian, which changes the phase of the reflected light from 0 to 2π radian [2,3]. Therefore, a transparent hologram can be realized by using a ChLC which reflects infrared light (Fig. 1b). In experiment, we designed a hologram that reconstructs a 2D image when illuminated by infrared light using the Gerchberg-Saxton algorithm, and confirmed its transparency in the visible region (Fig. 1c, d). The hologram proposed here may find a wide range of applications in security and information storage requiring transparency.

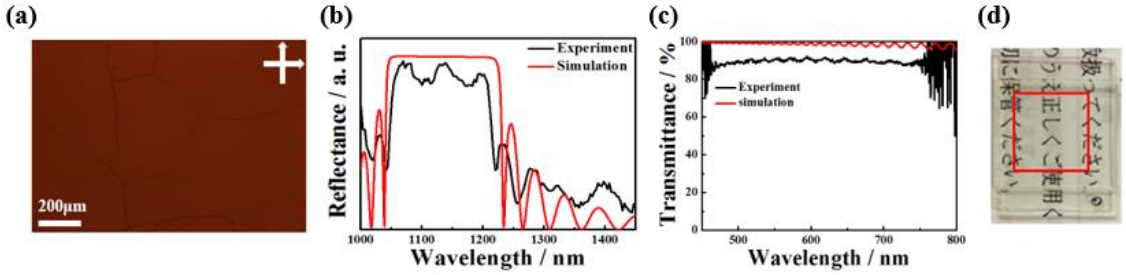

Fig. 1. Fabricated hologram cell. (a) Polarized optical microscope (POM) image. (b) Reflection spectrum. (c) Transmission spectrum in the visible region. (d) Appearance of cell (The inside of the red line is a photo-patterned area).

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