Experimental Realization of Color Hologram Using Pancharatnam-Berry Phase Manipulating Metasurface

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Abstract: We design and fabricate a Pancharatnam-Berry phase manipulating metasurface to experimentally demonstrate a three-color RGB pattern. The color pattern is produced by illuminating a nanostructured silver metasurface hologram with a white light source.

OCIS codes: (090.1705) Color Holography; (250.5403) Plasmonics; (160.3918) Metamaterials.

1. Introduction

Three-dimensional polychromatic image generated in a separate image plane than an object is called a hologram. Color holograms have been recently demonstrated in some other works such as binary optical amplitude control [1], plasmonic nanoparticle scattering [2], and amplitude control using an aluminum gap-plasmon metasurface [3]. G Zheng et al. experimentally demonstrated 80%-efficient metasurface hologram with a Pancharatnam-Berry phase modifying gap-plasmon metasurface [6]. In our previous work [4], we proposed a scheme for generating color hologram using a Pancharatnam Berry Phase manipulating metasurface. We used a rotated resonant nanoslit [5] to produce a holographic image. By adjusting length of the resonant nanoslit, the slit can be selectively made resonant at red, green and blue wavelength of light. This enables simultaneous control of color and phase. In this work, we present experimental demonstration of red, green, and blue patterns generated with the hologram.

2. Sample Fabrication and Experiment

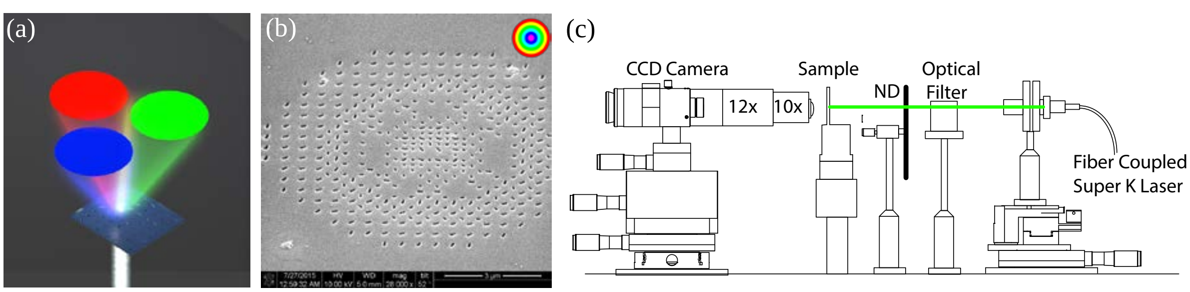

Fig 1. (a) 3-D illustration of the hologram generation. (b) FE SEM image of the fabricated sample (c) Experimental setup

Figure 1(a) shows a 3D conceptual demonstration of a generated hologram using a metasurface. Figure 1(b) shows SEM image of the fabricated metasurface. To fabricate the nanostructured metasurface we deposit a silver thin film grown with a germanium wetting layer [7] on a fused silica substrate using Leybold Ebeam evaporator. We use Gallium ion milling to write the pattern on the silver thin film using FEI 200 Focused Ion Beam. Figure 1(c) shows the experimental setup for testing the color holograms. We use a fiber coupled NKT Super K Laser to shine the broadband white laser into our sample, which is vertically mounted. A CCD Camera is used to capture images in the imaging plane.

2. Result and discussion

Figure 2 shows the simulation and experimental results of the hologram. FIB used for the pattern generation cannot create patterns larger than 10μm with a reliable resolution; so, the generated holograms exhibit strong diffraction patterns. This could be overcome with larger patterns produced through Electron Beam lithography. To overcome both the poor light output in the blue range of the Super K and weaker resonance of the silver nanoslits for

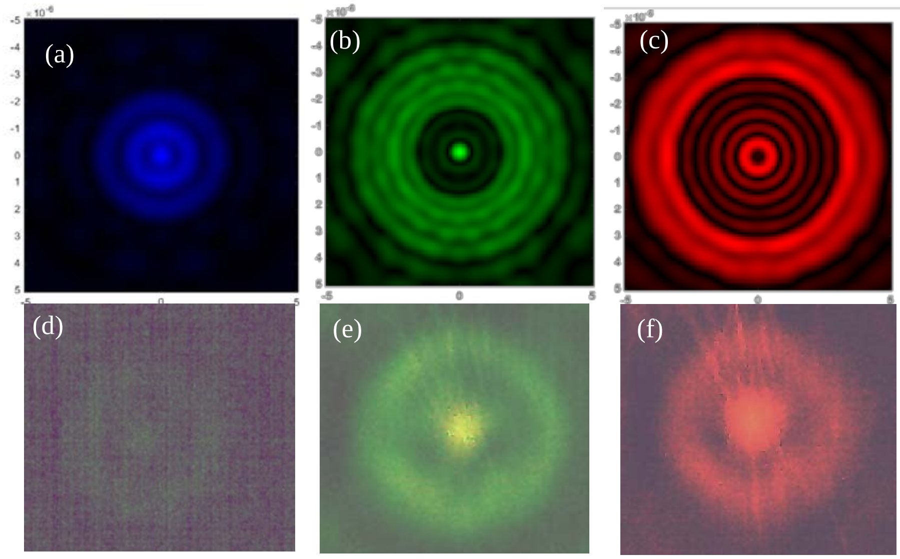

Fig 2. (a)-(c) Simulation results and (d)-(e) experimental results. (a),(d) Blue, (b),(e) Green, and (c),(f) Red images.

the blue region antenna, we separately capture blue, green and red colors using selective illumination of the sample through different optical filters. Figure 3(d)-(f) shows the experimental results. In order to verify the results, we simulated the individual color output of the hologram, which are shown in figure 3(a)-3(c). The generated patterns match the experimentally realized results.

3. Conclusion

In summary, we demonstrate color generation using Pancharatnam-Berry phase manipulating metasurface in transmission mode. The fabricated metasurface can successfully generate three individual component colors. We plan to further increase the dimensions of the pattern by using Electron Beam lithography to reproduce realistic images.

Acknowledgements

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