介電質超穎介面的新契機

New opportunities from dielectric metasurfaces

Chao-Tsung Huang[1], Fan-Yi Lin[2] and Chang-Hua Liu[2*]

[1] Department of Electrical Engineering, National Tsing Hua University, Hsinchu, 30013, Taiwan

[2] Institute of Photonics Technologies, National Tsing Hua University, Hsinchu 30013, Taiwan

E-mail: chliu@ee.nthu.edu.tw

Developing ultra-flat and -thin optical elements is central to several technological applications in imaging, spectroscopy, and energy harvesting.[1-3] Dielectric metasurfaces, composed of arrays of nanoscale quasi-periodic optical resonators, are recently considered as ideal candidates for such approaches, because they could effectively manipulate the phase, amplitude, and polarization of light at subwavelength resolution. However, the current dielectric metasurfaces are generally realized by using electron beam lithography, and they require high aspect ratio nanostructures to cover full 2π phase. These technical challenges limit the practical applications of dielectric metasurfaces.

In this project, our team focuses on addressing the above-mentioned challenges. Specifically, we exploit the incomplete phase design approach, which could effectively reduce the aspect ratio of nanostructures to ~2, realizing ultra-flat optical components.[4] More importantly, by using the photolithography and dry etching tools, we further demonstrate the possibility of fabricating the large scale and array of dielectric metalenses, as shown in Fig. 1a-c. The fabricated metalenses are based on the Si_3N_4 nanopillars on the transparent quartz substrate. To examine their optical performances, we characterized the intensity profile of representative designed lens and the result shown in Fig. 1d clearly indicates the fabricated metalenses could focus the light into a near diffraction-limited spot.

With these successful demonstrations, we further show our developed dielectric metalenses could be useful to practical imaging applications. Specifically, we incorporated these lenses into a home-built single pixel imaging system, as schematically shown in Fig. 2a. As the lenses are ultra-flat with short focal length, the size of entire system could be scaled down. More importantly, via exploiting dielectric metalenses, we further demonstrate the light scattered from the illuminated object could be effectively focused onto a detector, which leads to an excellent imaging quality in terms of brightness, contrast as well as sharpness (Fig. 2b-c).

References

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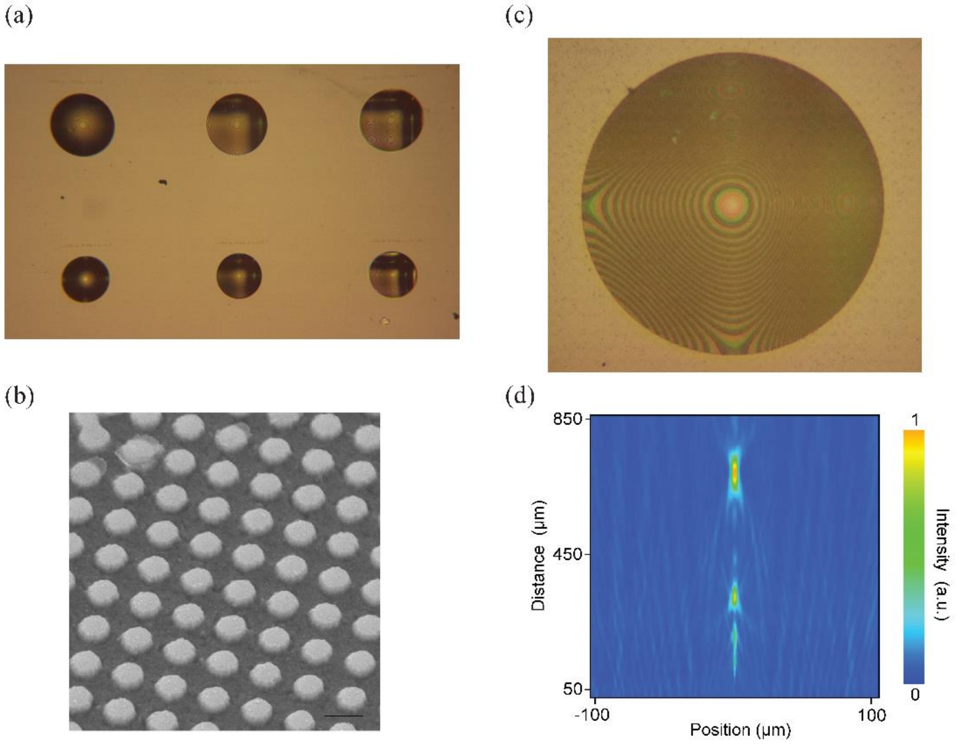

Figure 1. (a) Optical microscopy image of the arrays of dielectric metalenses. (b) Scanning electron microscopy image of the portion of metalens. Scalar bar: 1 µm. (c) Optical microscopy image of the representative metalens with the diameter ~0.8 mm. (d) Intensity profile measured along the axial plane of the metalens. The result clearly shows the focusing performance.

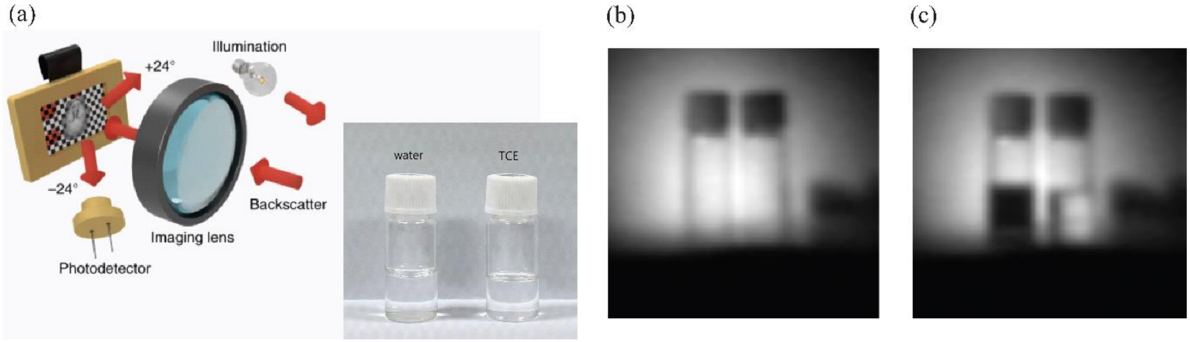

Figure 2. (a) Schematic of the home-built single pixel imaging system. The illuminated objects are two bottles that contain different chemicals. Part of the image is adopted from ref. 5. The metalens is placed in front of the photodetector to enhance the collection of scattered light. (b) The imaging result which was obtained by illuminating the objects with the visible light. (c) The imaging result which was obtained by illuminating the objects with the infrared light.