Design and Fabrication of Large Area Active Varifocal Metalens

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Abstract— Achieving a zoom function of the tradiational lens set requires a change in the relative position of the lens, which results in a large footprint of the optical systems. Metalenses as miniature flat lenses exhibit a substantial potential in replacing traditional optical component. Unlike traditional optical lens, whose functions rely on the geometric curvature of the surface, metasurfaces that construct of subwavelength artificial structures provides refractive index gradients to arbitrarily regulate electromagnetic waves. And metasurfaces exhibit a substantial potential in reducing the size and complexity of the optical components. However, few works have been reported about the realization of zoom metasurfaces [1], especially ones could work in visible light band, and their functions are limited by poor active ability, narrow operating band and small depth of field (DOF).

Here, a zoom metalens consist of high aspect ratio (> 10) TiO_2 nanopillars is fabricated by templated atomic layer deposition method, which achieves different focal lengths by changing the orbital angular momentum (OAM) of incident vortex light. The OAM provides a new degree of freedom to regulate the amplitude and phase of the electromagnetic waves [2]. Based on the Pancharatnam Berry (PB) phase which are origin from the symmetry breaking of the structures, this metalens realizes the regulation of OAM dependent change of focal length. Independent decoding of a specific OAM is achieved through phase configuration including spiral phase plate functionality. The multiple focal lengths can be finally obtained for 532 nm vortex beam with four nonzero OAMs, which implements switch from 5 mm to 25 mm. The multiband capability and large DOFs with conversion efficiency

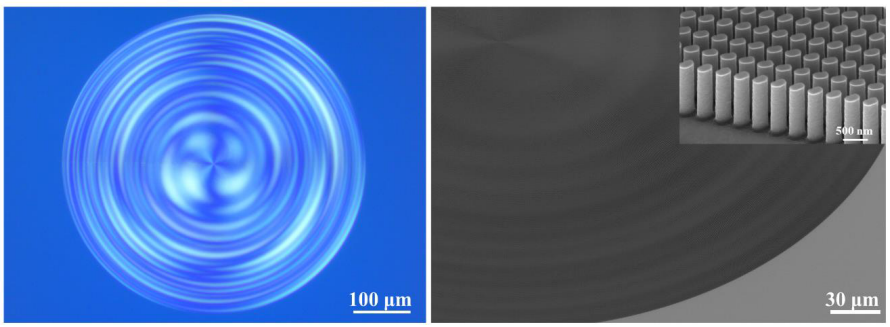


Figure 1: Optical shading containing helical and SEM images of metalens.

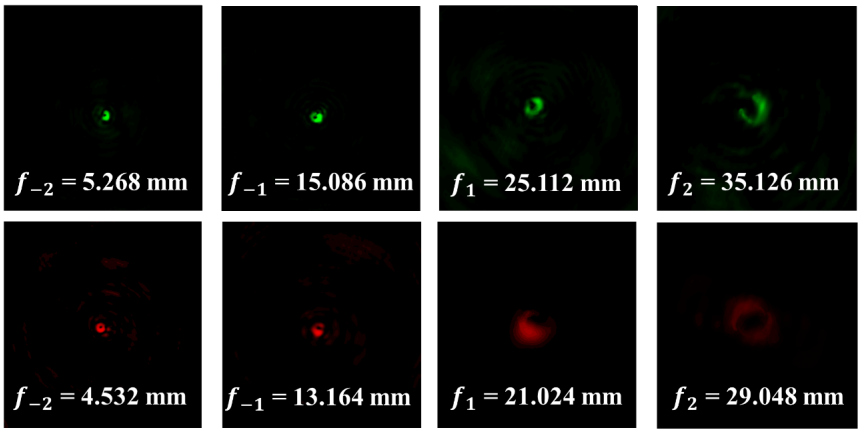


Figure 2: Experimental spots for four channels at 532 nm and 633 nm.

of 49% for this metalens are validated for both 532 nm and 633 nm, and the incidence wavelength can further change the focal lengths. Our work will provide real opportunities for non-mechanical tunable metasurface to realize zoom metalenses, which is expected to micro lens, 3D imaging and vortex optics.

REFERENCES

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2. Ren, H., et al., *Nat. Nanotechnol.*, Vol. 15, 948, 2020.