Rotational Varifocal Moire Metalens based on Dielectric Silicon Pillar Meta-atom

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1. Introduction

Metasurfaces, a planar branch of metamaterials, have attracted significant attention because they can tailor optical wavefront by arranging subwavelength patterns (meta-atoms) on surfaces. Especially, metasurface lenses, or metalens, has attracted considerable attention owing to their thinness and lightweight.

Tunable focal length, or varifocal lens, are a promising and expected functionality of metalens. Similar to conventional refractive lens doublet, the longitudinal motion of lens along with the optical axis have been demonstrated based on micro-electromechanical actuators [1]. However, the effect of the pull-in instability of the electrostatic parallel plates actuator limits the travel range of metalens, resulting in a narrow tunable range for the focal length.

Since metalens has a high degree of design freedom, it is not necessary to make the tuning method for the focal length similar to conventional refractive lenses. It is desirable to study how diffractive optical element (DOE) techniques or diffractive lenses can be applied to metalens. Moire lenses are a pair of axially asymmetric lenses that achieve tunable focal length with mutual rotation, as presented in Fig. 1.[2] They offer a wide range of focal lengths from negative to positive and has been realized using DOE. However, the demonstration at optical frequencies has not been reported yet due to the difficulty of fabricating at such frequencies.

In this paper, we experimentally demonstrate tunable focal length using Moire metalens at the near infrared frequency band using polarization-insensitive meta-atoms based on high-index contrast transmit arrays (HCTAs), which are made of amorphous silicon (a-Si) in this case.

We designed a-Si octagonal pillars with polarization insensitivity and full 2π phase coverage at a wavelength of 900 nm. Fig. 2 shows simulated and fabricated Si pillar meta-atom. The fabricated metalens exhibited focal length tunability at the ranges from -∞ to -1.73 mm and from +1.73 mm to +∞ at a mutual rotation of ±90° at 900 nm as shown in Fig. 3[3].

In conclusion, the results reported here reveal a proof of concept for focal length tuning with mutual rotation of lens components based on moire lens configuration at optical frequencies, and thus paving way for applications in optical frequencies, including near infrared, visible, and ultraviolet wavelengths.

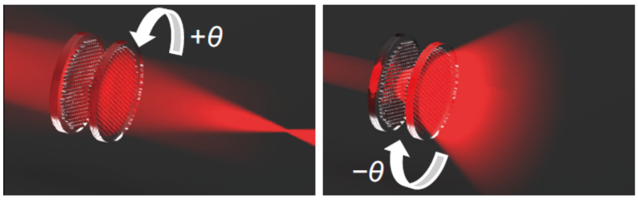

Fig. 1 Schematic Drawing of Moire Metalens

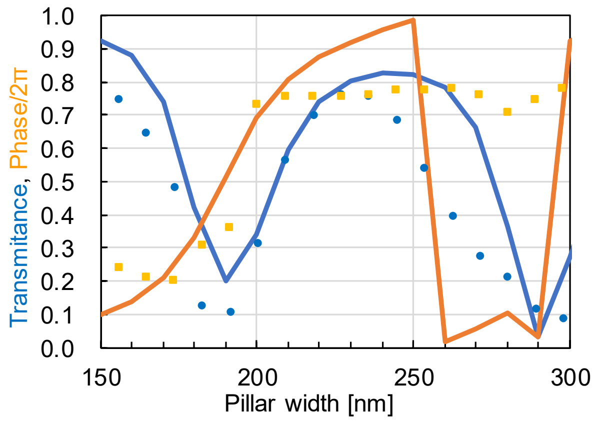

Fig. 2 Measured (dots) and Simulated (lines) transmission function of a-Si octagonal pillar meta-atom

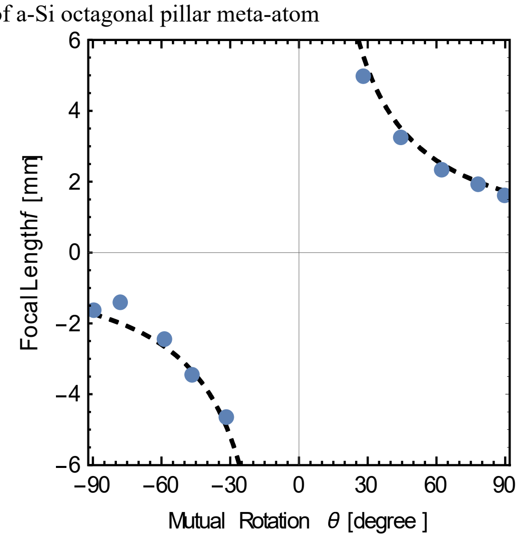

Fig. 3 Measured (points) and theoretical (curves) focal length as a function of mutual rotation angle

References

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[2] S. Bernet, et al., *Opt. Express*, **21**, 6955, (2013).
[3] K. Iwami et al., *arXiv*, 1912.11829 (2019).