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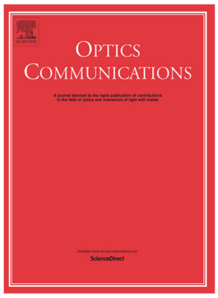

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Yiwen Jia, Tian Lan, Pinwei Liu, Zhigao Li

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Polarization-insensitive, High Numerical Aperture Metalens with Nanoholes and Surface Corrugations

Yiwen Jia, Tian Lan*, Pinwei Liu, and Zhigao Li

Key Laboratory of Photoelectric Imaging Technology and System, Beijing Key Lab. for Precision Optoelectronic Measurement Instrument and Technology

School of Optics and Photonics, Beijing Institute of Technology, Beijing 100081, China

*Corresponding author.

E-mail address: lantian@bit.edu.cn

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ABSTRACT:

Metalenses provide new solutions to the shortcomings of traditional lenses, such as bulky volume and low resolution. In this paper, an ultrathin planar metalens based on the nanohole structure in a gold film was designed, which had only one variable (the diameter of the nanohole) and showed the ability to focus at the designed wavelength of 980 nm. Then, further improvements were made by adding a finite array of circular surface corrugations, which could enhance the resolution and energy at the focal spot because of the excitation of surface plasmons (SPs). The central symmetry of the metalens makes it polarization insensitive. Besides, the metalens with surface corrugations had a relatively high numerical aperture (NA = 0.848). This method of adding surface corrugations could also be adopted for other metal surface plasmon metalens to enhance the focusing effect in the far-field.

1. Introduction

Lenses are indispensable components in optical systems and have been widely exploited. Traditional lenses control the amplitude, phase and direction of light by modifying the wave front, which relies on the light propagation over different light paths. Actually, the core of lens is the spatially varying phase response. By changing the optical path length through its convex interface, a lens can have a spatial phase response profile, and finally focus the light to a point. However, this conventional approach requires a relatively long propagation length, resulting in bulky components. And because of diffraction limitation, the resolution of lens is limited. In order to reduce the volume of lenses and gain a higher resolution, a lot of research has been conducted over the years. The emergence of metamaterials provides a different way of thinking. "Metamaterial" refers to the synthetic material which possesses artificially designed structures and exhibits extraordinary physical properties that cannot be found in nature. Different from traditional optical components, the metamaterial offers a wide range of optical properties only via changing the geometrical parameters of the unit construction. Generally speaking, it can provide arbitrary amplitudes and phase responses, covering the entire 2π phase range, which makes it widely applied in many fields, such as cloaks [1-3], negative refraction [4, 5], subdiffraction imaging [6] and the lens design.

In previous reported works, the earlier studies were about perfect lenses, hyperlenses and superlenses [6-11], which can restore evanescent waves, thus breaking the diffraction limitation, so that a higher resolution and evidently, a smaller volume can be acquired. Then, the concept of metalens was proposed, attracting significant attention [12-16]. The metalens is a kind of two-dimensional metamaterial based on nanoscale structural arrays. Different geometric dimensions of the unit array can usually provide different phase changes of the incident light, achieving the full control over the phase of 2π. V-shaped antennas are widely used as the basic building blocks, providing adequate phase shifts