Wavelength-selective phase modulation using Fano-resonance-based metasurface

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1. Introduction

Recently, metasurfaces composed of artificial nanostructure array of subwavelength scale provide a wide versatile applications due to the ability of controlling the amplitude and the phase of an electromagnetic field at nanoscale. Many studies using metasurfaces such as metalens and metaholograms have focused on the implementation of a broadband operation [1,2]. On the other hand, a narrowband nanostructure are essential for applications such as filtering and sensing, and the characteristics of Fano resonance can be used to design such a metasurface to control an electromagnetic field in narrow bandwidth [3].

In this study, wavelength-selective phase modulation using a Fano-resonance-based metasurface is demonstrated in near-infrared (NIR) spectral region. We use a simple nanostructure which consists of asymmetric double rods above metal film. Based on the Fano resonance in the proposed metasurface, a reflection type phase modulation is achieved at the certain wavelength with narrow bandwidth.

2. Results and Discussion

We focus on the characteristics of the Fano resonance that has a sharp resonance property with high quality factor in the far-field spectrum. When an electric field in a direction parallel to the metal rod is incident on the metasurface composed of double rods placed on the metal film as shown in Fig. 1(a), a unique line-shape of reflection with the dipole and the Fano resonances is observed due to the strong coupling between the metal rods and metal film [4]. In addition to the intensity property (i.e. amplitude), the phase of the reflected light also exhibits an interesting feature that a wide variation of full phase is possible by backplane film.

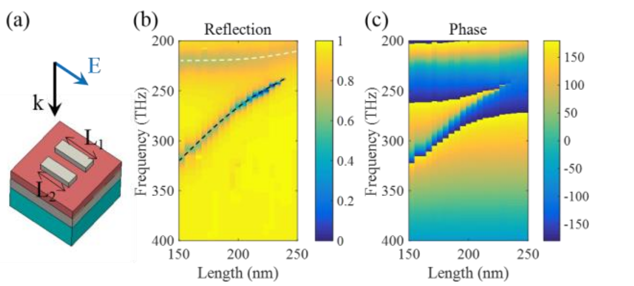

Figure 1. (a) The unit cell scheme of the Fano-resonance-based metasurface, which consists of asymmetric double rods with length L_1 = 250 nm and variable length L_2. (b) Reflection and (c) phase spectra with variable length L_2. The white and black dashed lines in (b) indicate the dipole and the Fano resonances, respectively.

The amplitude and phase of the proposed metasurface in reflection are shown in Fig. 1(b,c) according to the change of rod length L_2. As can be derived from the phase map, we can reliably confirm the phase modulation for various lengths and wavelengths in Fig. 2(a,b). Consequently, full phase modulation is possible only at the certain target wavelength with narrow bandwidth through Fano-resonance-based metasurface.

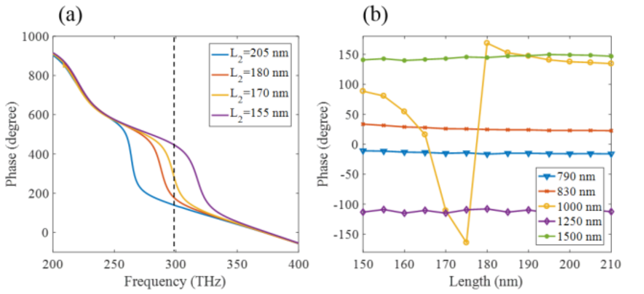

Figure 2. (a) Phase information for length L_2 of 205, 180, 170, and 155 nm. (b) Full phase modulation is only covered at 1000 nm wavelength.

3. Conclusions

We demonstrate the wavelength-selective phase modulation based on the Fano-resonance-based metasurface composed of asymmetric double rods with metal film as backplane. The results based on the proposed metasurface have advantages of easy fabrication and it will be based on many applications such as filter, sensor, and switch in the NIR spectral region where there are many molecular vibration modes.

Acknowledgments

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