Terahertz Plasmonic Waveguides based on Metallic Rod Arrays

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1. Introduction

Surface plasmon polaritons (SPPs) of metals should be excited by the photons with electromagnetic (EM) frequencies from the UV to the near IR, which is far away from those of the terahertz (THz) photons. Based on the definition of dielectric constants, semiconductors are critical and well developed to generate THz–SPPs [1]. However, to control THz–SPPs, the integration of periodic structures with the semiconductors is becoming crucial, such as the phase–matching criteria to couple the EM–waves and the surface–guiding criteria with high confinement. Comparing to the semiconductor materials, spoof–THz–SPPs are also theoretically demonstrated in structured metal surfaces with the subwavelength–scaled periods, and the structure depth instead of the carrier concentration to dominate the field confinement is approved [2]. THz plasmonic waveguides based on the aforementioned surface waves certainly suffers the serious dispersion, attenuation, delocalized waveguide modes and the special incident angles to couple THz–EM waves. The micro–fabrication of high–aspect ratio for the surface structures on semiconductors and general metals is perplexed; especially the structure length/depth should be millimeter level. It is not easy to prepare in chemical or mechanical machining processes. To improve those disadvantages for developing chip–based spectrometers and lab–chip sensors based on THz plasmonics, this presentation demonstrates an edge–coupled plasmonic THz waveguide using the metal rods.

2. Waveguide Configuration and Characters

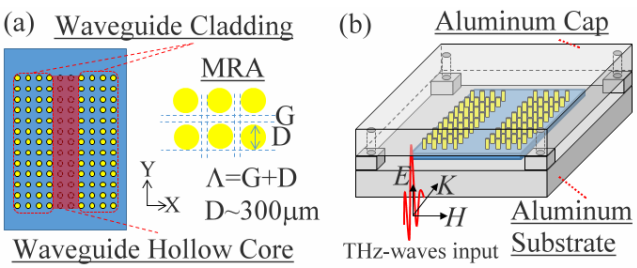

Fig. 1 Specification of a MRA based THz plasmonic waveguide for (a) the metal rod arrangement, and (b) the assembled configuration.

A THz plasmonic waveguide in the presentation is constructed by a waveguide cladding based on two metal–rod–arrays (MRAs) and a hollow–core channel with two–line space of periodic rods (Fig. 1(a)). To characterize the THz plasmonic waveguides, various MRA periods (Λ) are prepared while the same rod diameter (D) about 300μm is applied with different air gaps (G). THz–waves are illuminated via one edge of the hollow core with about 2mm–diameter beam spot, and the THz–wave polarization is parallel to the rod axis along the Z–axis (Fig. 1(b)).

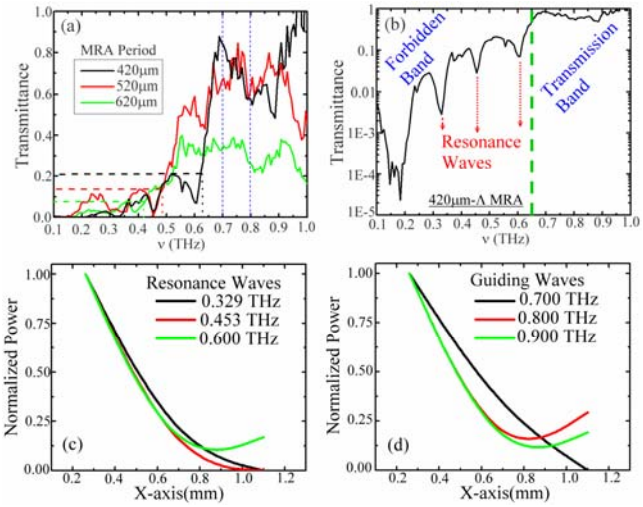

Fig. 2 (a) Transmittance of THz plasmonic waveguides with various MRA periods. (b) Transmittance of 420μm-Λ MRA waveguide. (c) The decay lengths of the resonance waves and (c) the guiding waves along the 420μm-Λ MRA waveguide.

The plasmonic waveguides have distinct high–pass spectral characters, dependent on the MRA periods (Fig. 2(a)). Take 420μm–Λ MRA as an example, transmission and forbidden bands are separated by the cut–off frequency around 0.63 THz and three resonance spectral dips are displayed in the forbidden band (Fig. 2(b)). The decay lengths of the evanescent field for the resonance (Fig. 2(c)) and waveguide (Fig. 2(d)) modes are also measured at different THz frequencies. Obviously, the waveguide modes are more critical to the THz frequency than the resonance modes.

3. Conclusions

A THz plasmonic waveguide is successfully demonstrated based on the 3D arrangement of metal rods, and characterized for in transmission spectrum and the guiding evanescent field, which are the crucial parameters to apply the waveguide device in future applications.

References

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