Terahertz Photonic Crystal Waveguide based on a Metallic Rod Array

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1. Introduction

Terahertz (THz) spectroscopy is becoming crucial in analytic chemistry to complement molecular properties of infrared ray spectroscopy. Following the basis of THz spectroscopy, THz-sensing technique plays an important role to develop the applications in THz region. THz-waveguide sensors are sensitive to molecules with minute amounts, like the particles and droplets. Due to the microstructure, photonic crystal (PC) THz waveguides are agreed as one excellent optical sensor. One- and two-dimensional PC waveguides have been presented [1, 2], but the sensing application does not work well. This is because the microstructure space is enclosed by the metal substrate without open space to load analytes. It is also a serious issue to use the dielectric PC fiber even though the nano-liter of liquid analytes can be recognized in theory. In the presentation, an open frame of PC chip is demonstrated in a metal rod array (MRA) structure. There are photonic band gaps to forbid THz photon's delivery and demonstrated in prior works [3]. The air gap size in a structural pitch modifies not only the photonic band gaps but also the waveguide modal confinement. Based on the investigation results in the presentation, the gap size should reduce to strictly confine THz field with strongly oscillation inside the MRA medium. A 420μm-period MRA is demonstrated to deliver THz waves of 0.40 ~ 0.65 THz with well confinement, where the electric-field strictly oscillates among the rods along the optic axis.

2. Optical Configuration and Measurement

The MRA structures are fabricated by stereolithography and the metal coating processes. The rod in the array has probably the same diameter and length, respectively, about 0.16mm and 1mm. Based on the same rod and different gap sizes in a MRA pitch, we used three periods of 420μm, 520μm and 620μm to observe waveguide modes along the MRA medium. Figure 1 illustrates optical configuration to observe THz waveguide modes in a MRA, including the strength of electric field oscillation among the metal rods(Fig. 1(a)), and the evanescent field outside the MRA medium (Fig. 1(b)). The line defect in Fig. 1(a) tests the waveguide modes strongly correlating the MRA to propagate. For long periods, 520μm and 620μm, the electric field oscillation is not strong at the MRA gaps and obviously leaked out of the MRA. The waveguide modes are thus not purely contributed by the MRA-PC structure. For short MRA period of 420μm, THz waves in 0.40 ~ 0.65 THz can be confined in MRA but the low frequency ones are leaked into the air cladding, as shown in Figs. 2(a) and 2(b) individually for the measured and calculated results.

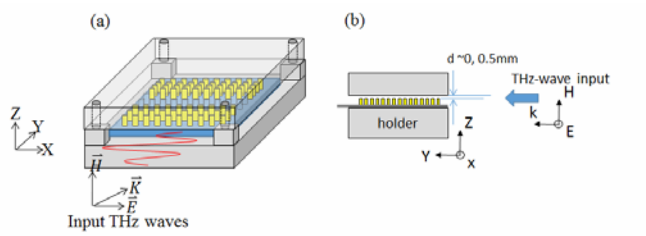

Fig. 1 Optical configuration to observe THz waveguide modes in a MRA.

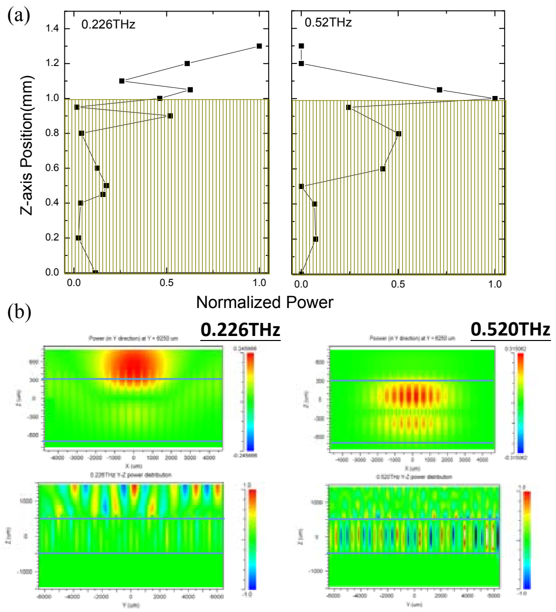

Fig. 2 (a) Measurement and (b) calculation of waveguide mode confinement.

3. Conclusions

Highly confined waveguide modes of a PC medium are demonstrated in an MRA structure based on the air-gap adjustment in a pitch. The MRA structure facilitates an on-chip sensing platform to guide THz-waves.

References

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