第64回応用物理学会春季学術講演会 講演予稿集 (2017 パシフィコ横浜)

Terahertz Generation from Split Ring Resonator Array Fabricated from Silver Nano-Particles

Institute of Laser Engineering, Osaka Univ.,°Khoa Nhat Thanh Phan, Kosaku Kato, Keisuke Takano, Masashi Yoshimura, Hiroshi Azechi, Makoto Nakajima

E-mail: phan@ile.osaka-u.ac.jp

1. Introduction

The study of terahertz (THz) wave is bringing back many developments in science and application. Previous reports show that terahertz emission from metal surfaces irradiated with ultra-short laser pulses is improved significantly by plasmon resonance on nano-structures [1,2]. In this report, we propose a split ring resonator (SRR) array fabricated by silver nano particles, which exhibits both resonances for generated terahertz wave and incident laser light [2], respectively. This structure is expected to enhance the nonlinear process converting the laser pulse into the THz pulses.

2. Experiment

A quartz substrate was coated with silver nano ink (ULVAC, Ag1TeH, particle size 3-7 nm), baked at 220°C, and then laser-ablated to form the metallic SRR (Figure 1) with period p = 100 µm, arm length L = 60 µm, line width w = 20 µm and gap g = 20 µm.

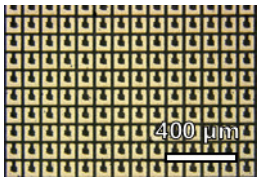

Figure 1: Microscopic image of fabricated SRR array on quartz substrate.

The resonance frequency was checked by measuring the transmission with THz time domain spectroscopy (THz-TDS) system (Advantest, TAS7500-TS).

To generate THz pulses, a regenerative amplifier laser (Spectra-Physics, Soltice, wavelength 800 nm, pulse duration 50 fs, repetition rate 1 kHz) with p-polarization was irradiated onto the sample surface at 45° incidence. The electro-optic sampling with a ZnTe (110) crystal was used for THz wave detection.

3. Results

In THz transmission spectra (Figure 2), when the SRR gaps were perpendicular to THz wave electric vector, resonances at 0.5 and 1.2 THz are excited.

Figure 3 shows the THz generation spectra, normalized to the ink area. No generated THz wave is detected from an unbaked ink film. In contrast, the THz emission is detected from a plain baked film without SRR structure. It is ascribed to the surface plasmon resonance at optical region on the surface nano-structures spontaneously formed by baking [2].

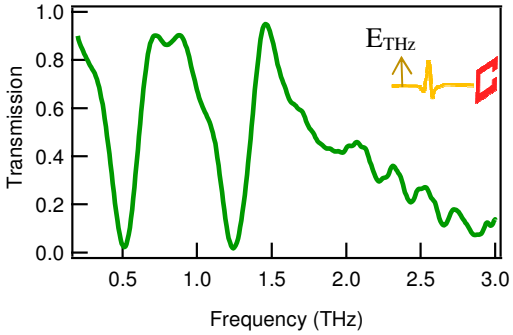

Figure 2: Transmission spectra of SRR array

Additionally, the THz wave from the SRR-patterned film is enhanced at the resonance frequencies of the SRRs of 0.5 and 1.2 THz, when the SRR gaps are perpendicular to the incident plane.

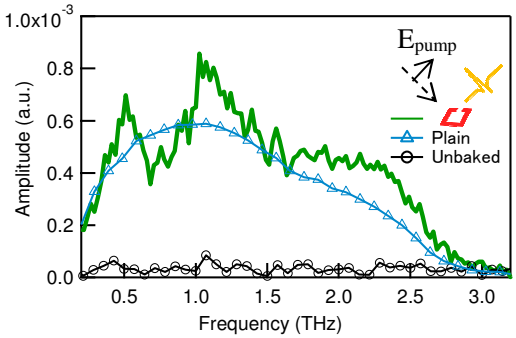

Figure 3: Fourier transformed spectra of generated terahertz waves.

4. Conclusion

We observed the THz radiation from the metallic micro SRR structure fabricated with nano Ag material. The THz emission is enhanced by resonances at both optical and terahertz regions. The resonance effects appear at wide frequency range by the nanostructures and at the specific resonant frequencies by the micro SRR structures.

Reference

[1] D.K. Polyushkin et al, Phys. Rev. B **89** (2014) 125426.

[2] K. Kato et al, Opt. Lett. **41**(9) (2016) 2125