Terahertz emission from silver nano-metal ink

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1. Introduction

Nano-metal ink [1] serves as a powerful tool to make terahertz metamaterials [2] by using a superfine inkjet printing system [3]. On the other hand, since it consists of metal nanoparticles, the ink itself has structures with a nanometer scale. It has recently reported that, when such metal nanostructures are irradiated by femtosecond laser pulses, the surface plasmon is excited and the resulting local field enhancement produces terahertz emission [4–6]. In this work, we study the emission of terahertz pulses from the surface coated by the nano-metal ink.

2. Experimental

As a sample, we used the silver nano-metal ink (ULVAC, Ag1TeH) coated on a fused-silica substrate. In this ink, the silver nanoparticles covered with surfactants are dispersed. When the ink is baked, the surfactants are resolved and the nanoparticles get sintered [1].

Figure 1 shows a schematic diagram of an experimental setup. The baked silver nano-metal ink was pumped by a regeneratively amplified femtosecond laser pulses (Spectra-Physics, Solstice; 800 nm center wavelength, 50 fs pulse duration, 1 kHz repetition rate) at an angle of incidence of 45°. The diameter of the pump light on the sample was ~ 4 mm. The terahertz pulses emitted from the sample surface were focused on a (110) ZnTe crystal with a thickness of 1 mm for electro-optical sampling. A piece of polystyrene foam and a black polyethylene filter were used to remove the pump light from the terahertz signal. A pair of wiregrid polarizers was used for measuring polarization of the signal [7].

3. Results and discussions

In Fig. 2, the red solid curve and blue dotted curve show the terahertz waveforms emitted by irradiating the sample with the *p*-polarized and *s*-polarized pump pulses, respectively. The intensity of the pump pulse was ~ 60 GW/cm^2. The generated terahertz waves are

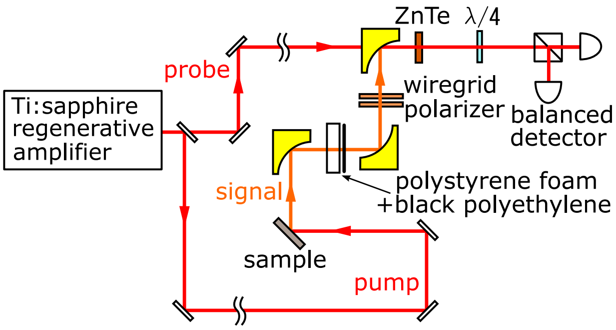

Figure 1 Schematic diagram of the experimental setup.

p-polarized, which is irrespective of the polarization of the pump pulses. The *p*-polarized pump pulses generate larger terahertz signal than the *s*-polarized pump pulses.

In our sample, nanostructures of the ink-coated surface produced during the sintering process can support the localized plasmon resonances. The terahertz emission from silver nano-metal ink can be explained by the same mechanism as proposed in Ref [5]: The field of the pump pulse excites plasmon oscillation in the metal nanostructure and the enhanced electric field induces optical rectification through the broken symmetry perpendicular to the sample surface.

4. Conclusions

We observed terahertz emission from silver nano-metal ink irradiated by femtosecond laser pulses. Irrespective of the pump pulse polarization, the observed signals are *p*-polarized. The mechanism of the terahertz generation is explained by optical rectification induced by the enhanced local fields in the nanostructures. This study will lead to future development of a unique metamaterial which itself emits terahertz waves.

References

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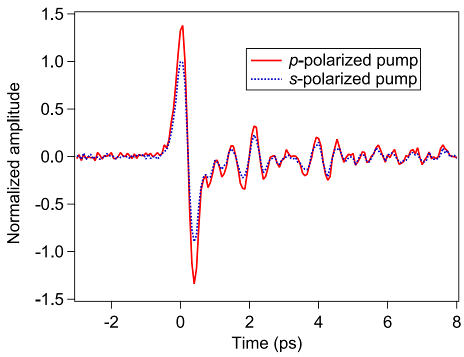

Figure 2 Terahertz waveforms emitted from silver nano-metal ink. The red solid curve and blue dotted curve show the signal pumped by *p*-polarized and *s*-polarized pulses, respectively. The amplitudes are normalized by the maximum value of the signal pumped by *s*-polarized pulses.