Optical Fiber Coupled THz Transceiver

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Abstract—Recently, optical fiber coupled terahertz (THz) transceiver module has been developed. The THz transceiver chip in the module has twin dipole antennas which are independently aligned by famto-second laser beam using polarization maintaining (PM) optical fiber. The measured THz pulse is 1 nA peak-to-peak amplitude, 1,000:1 signal-to-noise ratio, and 2.0 THz bandwidth when the THz pulse is reflected by metal surface.

I. INTRODUCTION.

Terahertz electromagnetic waves has a good sensitivity to measure biomolecule. Because low energy of THz is harmless for human body, many studies have been done at biomedical field. Recently, optical fiber coupled transmitter and receiver modules have been developed to freely emit and receive the THz beam. Because the modules have two units, applications are limited at biomedical and industry. However, THz transceiver is one of the solutions to expend the biomedical and industry applications because of very small single THz module.

More recently, M. Tani's group suggested single transceiver antenna [1] which was used both in THz emitter and receiver. Also, K. Sakai's group suggested twin dipole antennas in a chip [2] which were independently generating and detecting the THz pulses. More recently, very small THz emitter and receiver modules were used to THz endoscope for in-situ bio measurements [3]. In order to measure the biomedical samples, THz signal has to be strong enough. Our THz signal from optical fiber coupled THz transceiver module is stronger than the previous developed THz transceivers.

II. EXPERIMENTAL SETUP

The THz transceiver module is comprised of two PM optic fibers, LT-GaAs transceiver chip, and hyper-hemispherical Si lens as shown in Fig. 1. The transceiver chip which is 2 x 2 mm dimension has two dipole antennas to generate and detect THz pulses. The 20-um-wide antenna structure which was 5-um dipole antenna gap was located in the middle of a transmission line consisting of two parallel 10-um-wide. The antenna was driven by photoconductive shorting the 5 um antenna gap with 90 fs pulses coming at 73MHz rate in a 12 mW laser beam power to emitter and 10 mW laser beam power to receive. The laser beam is delivered by polarization-maintaining optic fibers without any optical lens to the antennas. The diameter of the hyper-hemispherical Si lens is 4 mm. The diameter of the transceiver module including the transceiver chip and Si lens is only 5 mm.

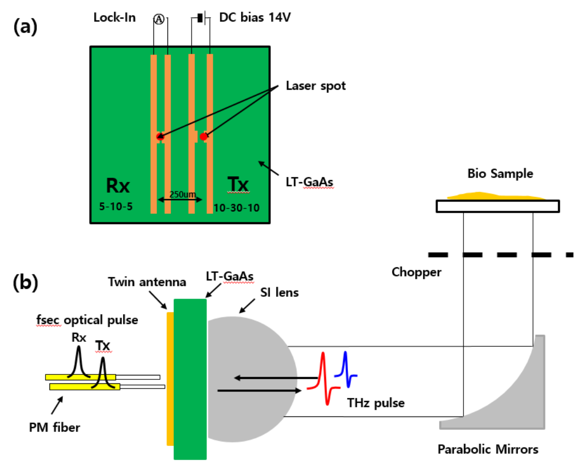

Fig. 1. Optic fiber coupled THz transceiver module. (a) the structure of transceiver chip. (b) Experimental setup. Famto-second laser coming from two independent PM optic fibers are aligned at each dipole antenna of the transceiver chip which is 2x2 mm dimension.

III. MEASUREMENT AND APPLICATIONS

Figure 2 shows measured THz pulses and spectra with different THz beam apertures. The measured peak-to-peak amplitude of THz signal reflected by metal surface with 16 mm aperture is 1 nA and its bandwidth is 2.0 THz. A signal-to-noise ratio (SNR) is 1,000:1. When the aperture is closed from 10 mm to 8 mm to 6 mm, the peak-to-peak pulse amplitudes are reduced to 790 pA, 572 pA, and 434 pA, respectively.

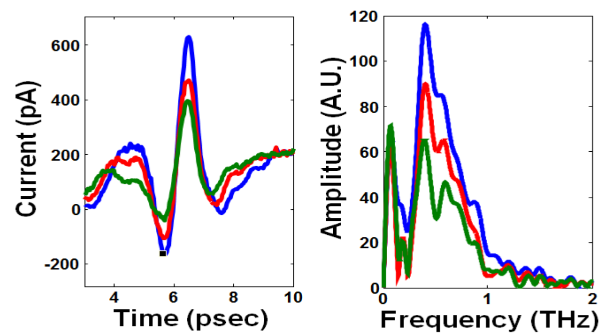

Fig. 2. (a) Measured THz pulses with different apertures. Green, red, and blue lines indicate 8, 12, and 16 mm aperture respectively. (b) Corresponding amplitude spectra for the pulses.

Figure 3 shows measured THz pulses and spectra with the glandular stomach (GT) and fore stomach (FT) samples from rat using the freely moving THz transceiver module as shown in Fig. 1. The bio-samples are located on 3-mm-thick quartz plate to make plate surface. The THz beam diameter is 12 mm. The THz reflection from water is measured to have a reference. The amplitude of the THz pulse reflected by GS sample is 6 % bigger than that of FS sample which is good agree to previous research [4].

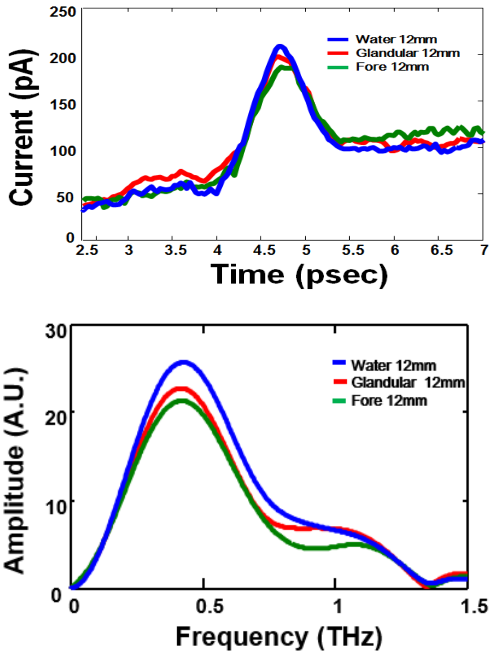

Fig. 3. (a) Measured time domain THz signals reflected from water, GS (Glandular stomach), and FS (Fore stomach) of rat. (b) Corresponding amplitude spectra for the pulses.

IV. SUMMARY

We made optic fiber coupled THz transceiver module which can freely move at any position. The measured THz pulse is 1 nA peak-to-peak amplitude, 1,000:1 signal-to-noise ratio, and 2.0 THz bandwidth when the THz pulse is reflected by metal surface. The GS and FT bio-samples are measured using the THz module. The THz reflection from GS sample is 6% bigger than that of FT sample. Because the transceiver module has small unit to emit and detect THz signal, the module will develop to THz endoscopy which will be used in-situ biomedical measurement in future.

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