Instrumentation of Terahertz Time-domain Spectroscopic System Including Two Kinds of THz-radiation Source

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***Abstract*— We designed a THz time-domain spectroscopic system including two kinds of THz-radiation source, *i.e.*, low –temperature-grown GaAs photoconductive switching substrate and 4- dimethylamino-*N*-methyl- 4-stibazolium tosylate (DAST) crystal. The detector is common, low-temperature-grown GaAs photoconductive switching substrate, for two sources which can be replaced one another. The frequency-domain spectral ranges are 0.04-4.0THz and 0.1-8.0THz for the wave sources of low-temperature-grown GaAs photoconductive switching substrate and DAST crystal, respectively. The spectral data for pellet samples indicate that two kinds of THz-radiation source provide complementary information and extend the application of THz-TDS.**

I. Introduction

Terahertz time-domain spectroscopy (THz-TDS) provides a useful technique in order to investigate material characterization. A femto-second pulse laser in the infrared region has been widely for THz-TDS and generates broadband coherent radiation in the terahertz frequency range by emitting a laser pulse to a photoconductive (PC) antenna or a nonlinear optical crystal [1]. The system usually includes a pair of a THz-radiation source and a detector. We represent a new-designed THz-TDS system equipped with two kinds of THz-radiation source and a common detector, in order to construct a compact THz-TDS system covering a wide frequency range.

II. Design of Apparatus

Figure 1 represents a block diagram of THz-TDS system we designed. A compact mode-locked Er-doped fiber laser, Femtolite CS-20 (IMRA, AISIN) is used operating the repetition rate of 50MHz. The average power and the pulse width of the laser at 780nm are 26mW and 82fs, and those values at 1560nm are 33mW and 78fs. The pulse laser beams of 780nm and 1560nm emitted synchronously are separated with a band-path filter. The light of 780nm divides into a pump and a detection beams by a beam splitter cube. The emitter with 780nm laser pulse is a dipole PC antenna based on a low-temperature-grown GaAs (LT-GaAs) substrate which is also used as a detector. The bias electric field for the emitter is applied by an oscillator which generates ±6V sine-waves at 10kHz. The laser pulse of 1560nm radiated to DAST crystal [2] biased with an optical chopper at 10kHz. The terahertz wave radiated from the emitters is collimated at the sample with a pair of off-axis parabolic mirrors for each THz-radiation source. The second off-axis parabolic mirror can slide along the light axis and THz-wave source for the sample measurement is selected. The transmitted THz wave from the sample is focused onto the gap of an LT- GaAs-based PC antenna with another pair of off-axis parabolic mirrors and a semi-spherical silicon lens. A THz waveform is measured by delaying the timing of the trigger pulse to the pump pulse. The THz signal from the detector is obtained by lock-in detection scheme referenced to applied electric field and TTL signal from the optical chopper for LT-GaAs PC antenna and DAST crystal, respectively. The sample chamber including THz-radiation sources, four parabolic mirrors and a detector can be purged with N_2 gas in order to decline water vapor.

The size of the THz-TDS system we developed is 400mm (width), 540mm (depth), and 390mm (height).

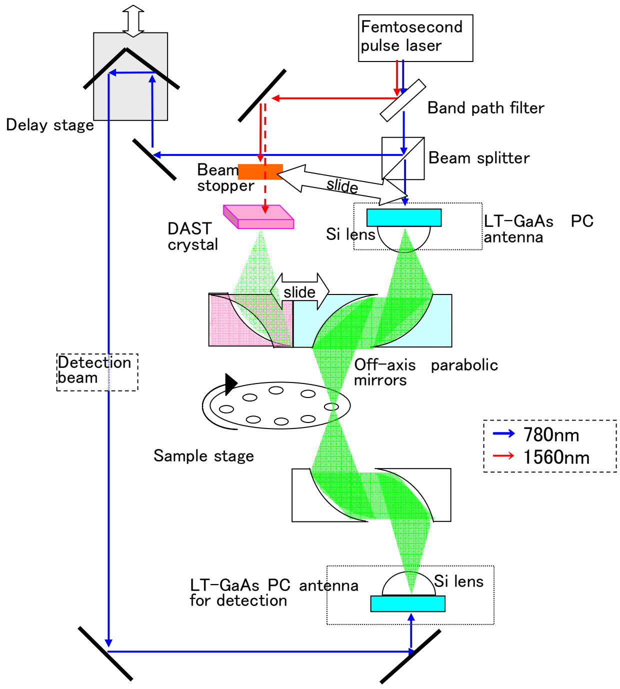

Fig. 1 Block diagram of THz-TDS system developed.

III. Results

The waveforms from two THz-radiation sources are shown in Fig. 2. The pulse widths are approximately 0.35ps and 0.15ps with LT-GaAs PC switching substrate and DAST crystal, respectively. The frequency-domain spectral ranges obtained by FFT are 0.04-4.0THz with LT-GaAs and 0.1-8.0THz with DAST.

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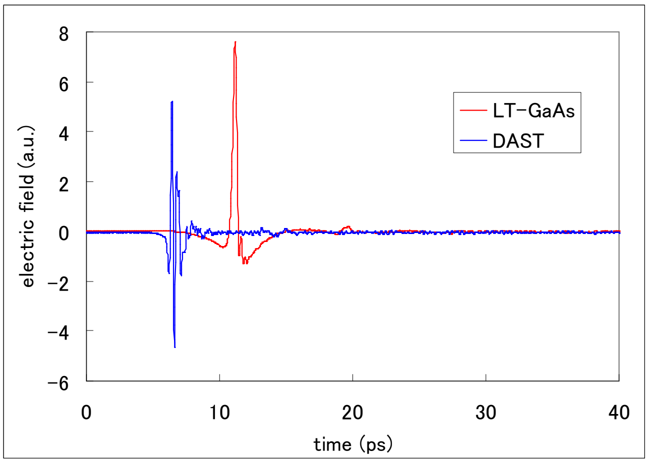

Fig. 2 THz-pulse waveforms observed with an LT-GaAs PC switch and a DAST crystal.

The frequency-domain absorption spectra of a maltose-pellet without diluent polymer are shown in Fig. 3. The spectra show similar peaks in the range between 1-2.5THz with both THz-radiation sources. More clear peaks can be observed in the frequency range larger than 2.5THz with DAST crystal, compared the spectra with LT-GaAs PC switching substrate.

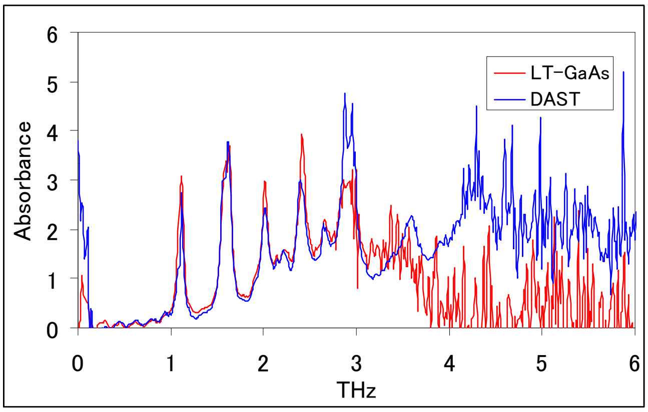

Fig. 3 Absorption spectra of maltose pellet with an LT-GaAs PC switch and a DAST crystal.

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