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Transfer characteristics of sub-THz waves in volcanic ash erupted from volcanoes in japan

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Abstract—Toward the application of Sub-THz waves to the rescue system, sub-THz time-domain spectroscopy system is constructed. In our system, sub-THz waves up to 0.14 THz are obtained using a chaoticaly oscillated multimode semiconductor laser and a photoconduction antenna. Transmission characteristics of these sub-THz waves are measured on volcanic ash erupted from several volcanoes in Japan including Sakurajima, Mt. Kirishima, and Shikotsu volcano. In addition, we confirm the difference in transmission characteristics due to volcanic ash and discuss the optimal frequency for the rescue system.

1. Introduction

There are over 100 active volcanoes in Japan. In 2021, several volcanoes erupted including Sakurajima, Iwo-Jima, and Mt. Aso. A novel rescue system is needed which can search for a survivor covered with volcanic ash in a short time.

Toward the application of Sub-THz waves to the rescue system, we have already clarified the transmission characteristics of Sub-THz waves in the Sakurajima volcanic ash at several frequencies[1]. Since ash compositions vary from volcano to volcano, the transmission characteristics are expected to vary from volcano to volcano. In this paper, transmission characteristics of sub-THz waves are measured on volcanic ash erupted from several volcanoes in Japan. In addition, we confirm the difference in transmission characteristics due to volcanic ash and discuss the optimal frequency for the rescue system.

2. Experimental Setup

As shown in Fig.1, Sub-THz waves are generated using a multimode semiconductor laser and a photoconduction antenna (PA). The output from the semiconductor laser is split by the beam splitter 1 (BS_1) and then returned to the semiconductor laser by the external mirror M_{ex}. That is why, optical delayed feedback is introduced, and low-cost and

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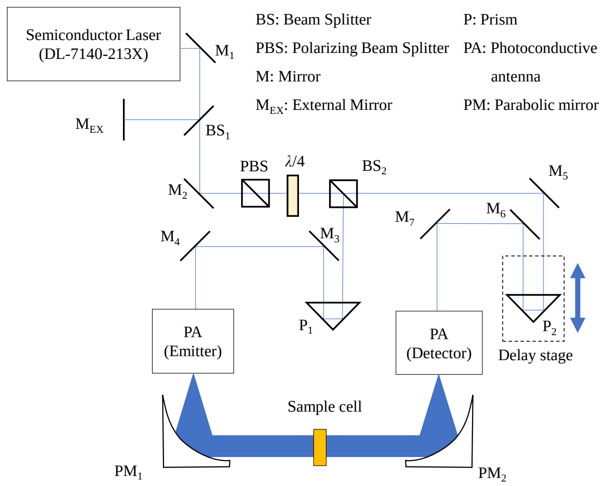

Figure 1: Measurement System for Sub-THz

high-power THz is generated [2][3]. In the previous experimental setup[1], it was difficult to control the angle of the mirror M_{ex} because of undesired waves reflected from PA as Emitter. In this paper, more easily tunable measurement system is achieved adding a polarized beam splitter (PBS) and a quarter-wave plate. For spectroscopy, a sample is placed between parabolic mirrors (PM_1, PM_2).

3. Results

Figures 2(a) shows the optical spectrum of a laser diode (SANYO, DL-7140-213X) with optical feedback by M_{ex}. As shown in Fig. 2(a), a bandwidth of 0.86 THz is observed when the power is 10 dB lower than the peak level of the total spectrum. The same laser condition in chaotic state is used for the actual THz measurement. Figures 2(b) shows the time series of the THz waves generated in our measurement system with a empty sample cell. The THz spectrum is shown in Fig. 2(c). It is obtained applying fast Fourier transform (FFT) on the time series. It is found

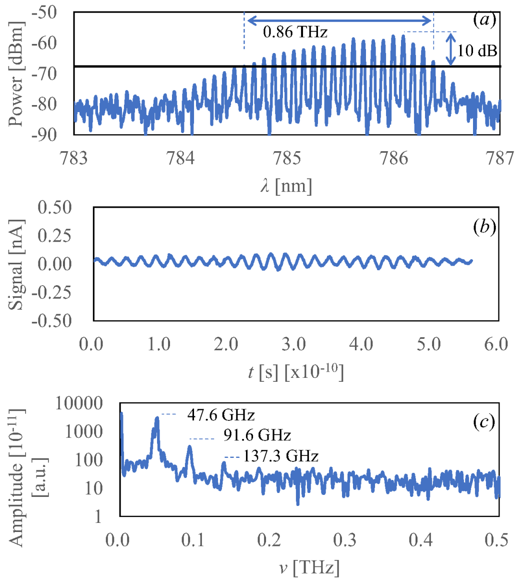

Figure 2: (a) Optical spectrum of laser diode (b) Time series of generated sub-THz waves (c) Spectrum of sub-THz waves

from Fig. 2(c) that sub-THz waves are generated at regular intervals (about 45GHz), which correspond to the frequency intervals between laser longitudinal modes. As can be seen from the figure, our measurement system can generate THz waves up to 0.14 THz. Transmission characteristics of these sub-THz waves are measured on volcanic ash erupted from several volcanoes in Japan including Sakurajima, Mt. Kirishima, and Shikotsu volcano. In addition, we confirm the difference in transmission characteristics due to volcanic ash and discuss the optimal frequency for the rescue system.

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