§7. Development of Terahertz Wave Emission Using Fiber Laser Excitation for Large Plasma Experimental Device

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In the microwave-based measurement of high density plasmas, the demanding frequency is getting into terahertz regime. However, the generation and detection of terahertz waves are not a well-developed technology at present. In addition, since the transmission of terahertz wave is not easy, the terahertz diagnostic system have to be set adjoined to the plasma apparatus. A terahertz time domain spectroscopy (THz-TDS) configuration is a possible candidate, where the generator and detector mounted in small units are activated by femtosecond optical pulses delivered via optical fibers. To keep the pulse width in 100 fs order after a propagation of more than several meters distance, one need to use the optical pulses in telecom band (~1.5 μm wavelength). The aim of this research is to develop the terahertz generators and detectors exciting by a fiber laser at 1.5 μm. We have been constructing the THz-TDS test system at the diagnostic building in NIFS.

The photograph of terahertz TDS test system is shown in Fig. 1. A mode-lock fiber laser (Menlo T-light 780), which wavelength is 780 nm, pulse width ~ 120 fs, and repetition rate ~ 50 MHz, is used for excitation. In addition, this laser launches 1.5 μm light simultaneously. The laser light focuses to the THz radiation antenna, which is a bow-tie type photoconductive (PC) antenna made on low-temperature-grown (LTG) GaAs (Hamamatsu G10620-12). A part of the laser output is led to the delay section for the optical sampling detection. The excited power of THz wave is received by the same designed antenna. The output of detector antenna is amplified by a current amplifier (NI LI-76, gain ~10^6 V/m, f_c ~ 20kHz). The signal is led to a lock-in amplifier for high sensitive measurements and then the time domain trace of the signal is acquired by the PCI-based analog-to-digital converter (ADC).

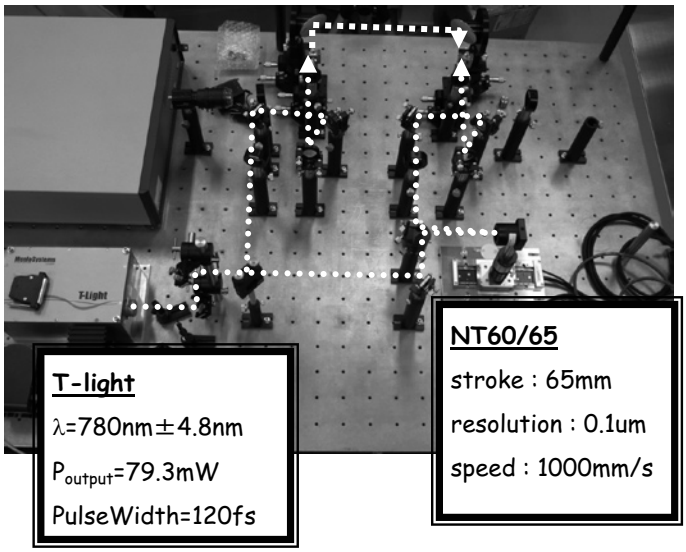

Fig. 1. Photograph of THz-TDS system

Example of the THz wave is shown in Fig. 2. Here, the femtosecond laser output is around 40 mW, the bias voltage of excited PC antenna is 10 V, and the lock-in amplifier sensitivity is 10 mV. The shape of frequency component of this signal is obtained by a Fourier transform analysis and it shows a typical spectrum shape of the bow-tie antenna. The peak of frequency components is around 0.1 THz.

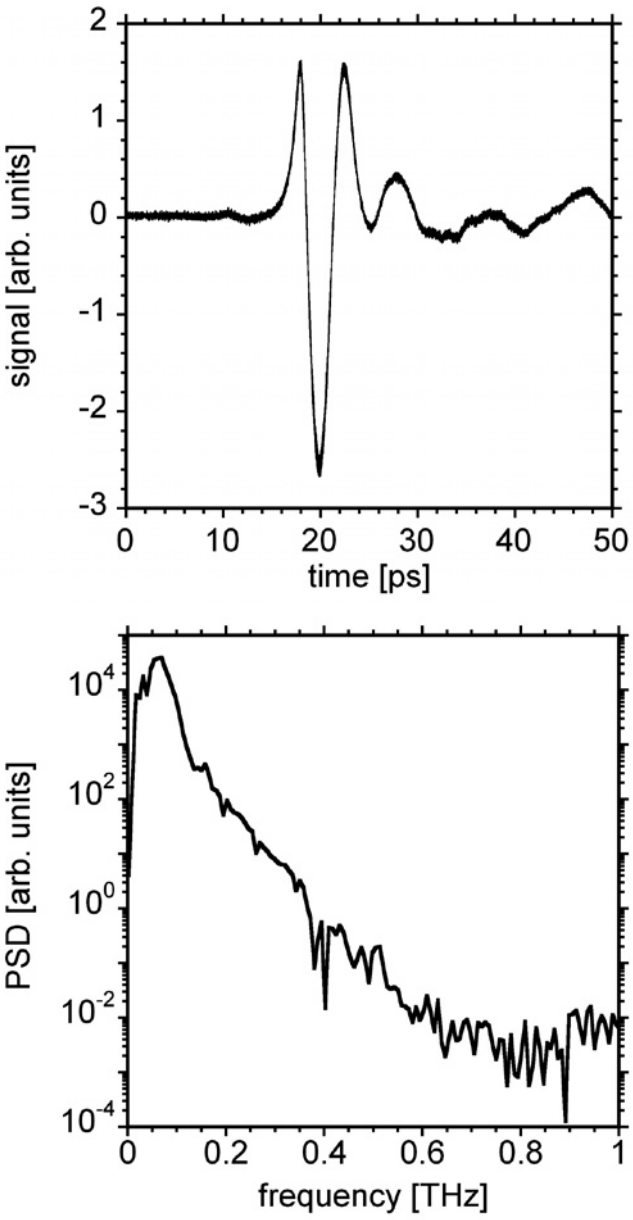

Fig. 2. Detector output signal (upper) and its frequency spectrum (bottom).