§6. 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 frequency to be used 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 waveguiding of terahertz wave is not easy, the terahertz system must be set adjoined to the plasma apparatus. A terahertz time domain spectroscopy (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. In 13th LHD experimental campaign, we investigated *in situ* signal-to-noise (S/N) ratio of the terahertz signals of the present system.

The experiments were performed using a special terahertz TDS receiver test module shown in Fig. 1. The detector was a photoconductive (PC) antenna made on low-temperature-grown (LTG) GaAs. A mode-lock fiber laser (IMRA Femtolite CX-20), which wavelength was 780 nm, pulse width ~ 100 fs, and repetition rate ~ 50 MHz, was used for excitation. The excited power of light was controllable by the variable attenuator (combination of ND filters). The output of detector antenna was amplified by a current amplifier (NI LI-76, gain ~10^6 V/m, f_c ~ 20kHz). The signal was led to a lock-in amplifier at the diagnostic room and then the time domain trace of the background noise was acquired during the plasma discharge.

Shown in Fig. 2 is the example of the standard deviation of the noise obtained by this test module. Three cases of excited laser power, which are 100%, 6%, and 0%, were compared. It was found that the noise level was not strongly affected by the excited laser power and also plasma itself. It is likely that the background noise in terahertz region is small and the system noise is dominant. Also, the center frequency of lock-in amplifier was changed from 500 Hz to 5 kHz. It was found that the center frequency around 2 kHz is not good and the higher frequency setting would expect the improvement. We will perform the development in the next year.

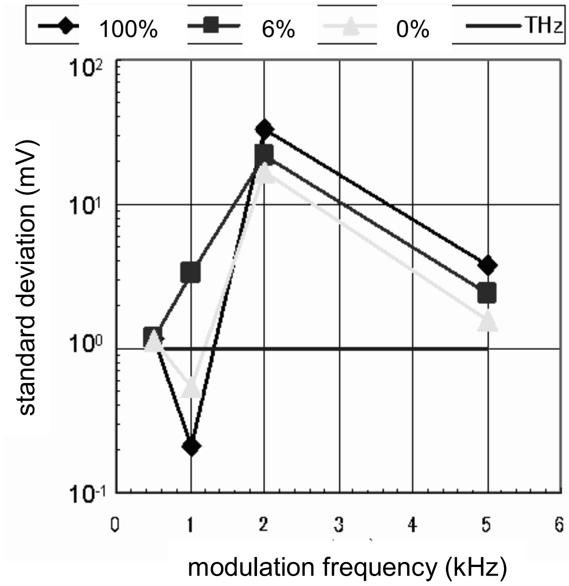

Fig. 2. Example of noise level measurement in the plasma discharge. The noise level is plotted as a function of center frequency of Lock-in amplifier. Excited laser power to PC antenna was changed; 100% (diamond), 6% (square), and 0% (triangle). Estimated radiated terahertz wave level is also plotted as a reference.

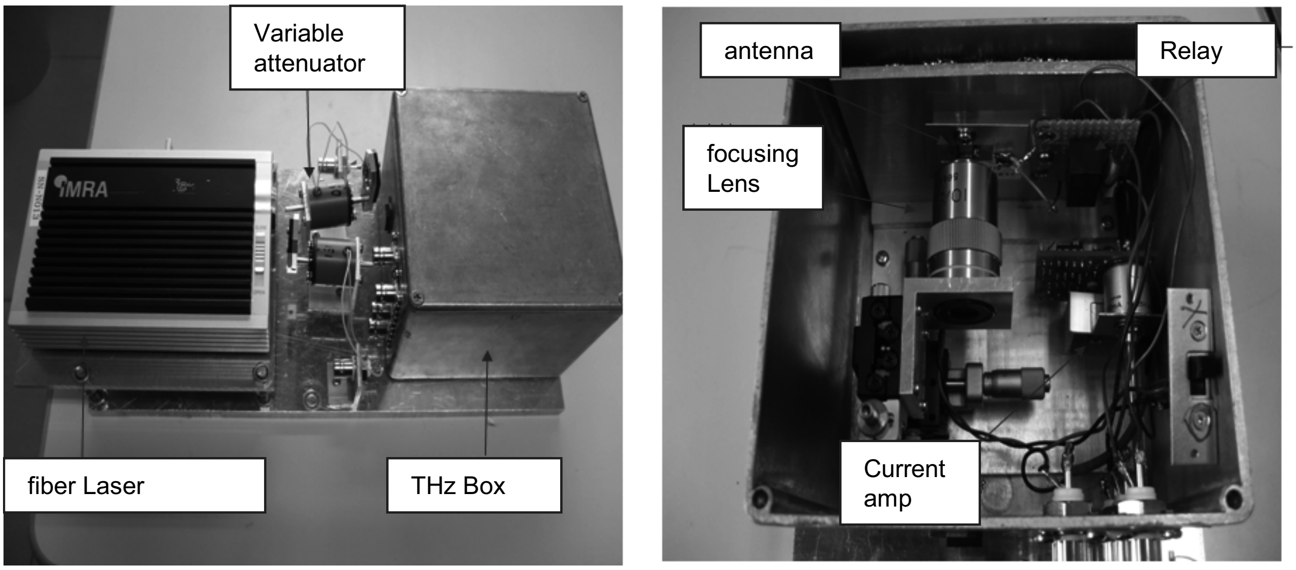

Fig. 1. Terahertz wave test module. This test module was installed at LHD 9-O port.