22P092-P

Developments of High-Temperature and High-Density Plasma Diagnostics Using a Terahertz Wave (II)
テラヘルツ波を用いた高温高密度プラズマ計測法の開発(Ⅱ)

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The terahertz wave diagnostics have been developing for current and future high- temperature and density plasma measurements. Since it requires wide-band frequency components, terahertz pulse is one of the possible sources. Recently, the terahertz time domain spectroscopy (THz-TDS) test system has been constructing diagnostic in NIFS. At the conference we will point out the current status and issues.

1. Introduction

In the high density plasma measurement using an electromagnetic wave, the demanding frequency is getting into terahertz regime [1] shown in Fig. 1. 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 [2-4] 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 needs to use the optical pulses in telecom band (~1.5 μm wavelength) [5,6]. The first goal 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.

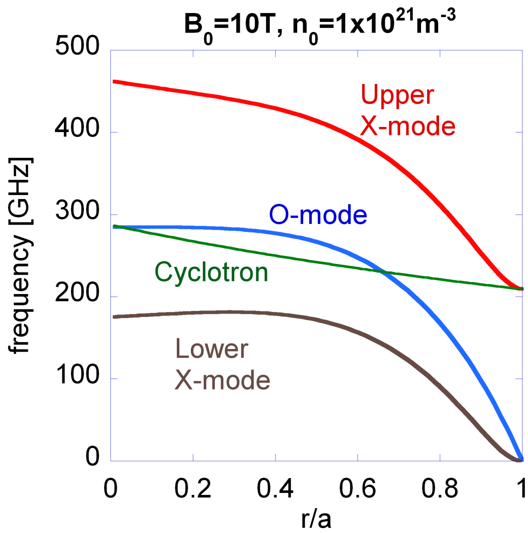

Fig. 1. Characteristic frequencies in a typical plasma parameter of DEMO

2. THz-TDS Test System

The photograph of terahertz TDS test system is shown in Fig. 2. 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

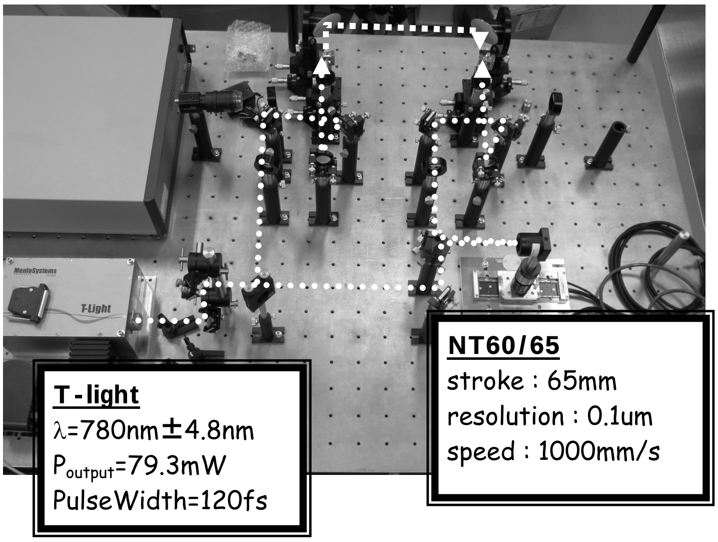

Fig. 2. Photograph of THz-TDS system

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).

3. Example of the current THz pulse

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.

4. Summary

We have been developing the THz-TDS system in NIFS for the high-temperature and density plasma measurements. Currently, the pulse signal of frequency range with sub millimeter is obtained. In near future, the pulse spectrum should be optimized for the plasma measurements and the test of long distance transimission will be done.

Acknowledgments

This work was partially supported in part by KAKENHI (Nos. 22360394, and 22017007). Also it was in part by a budgetary Grant-in-Aid of NIFS LHD project and the Joint Research of ILE Osaka University

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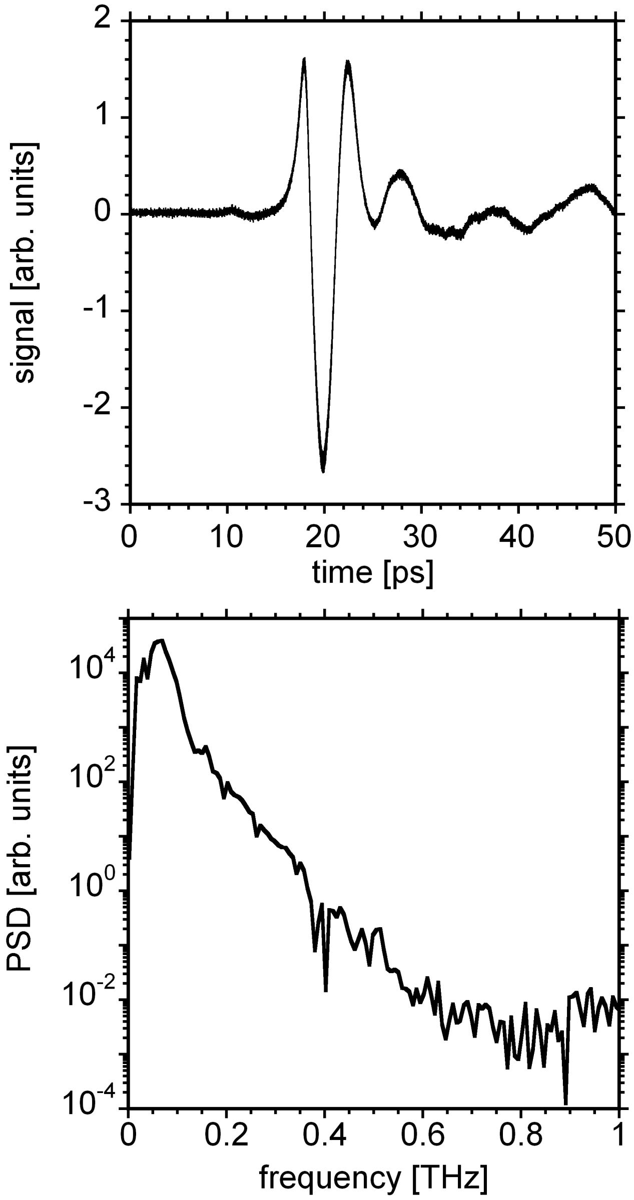

Fig. 3. Detector output signal (upper) and its frequency spectrum (bottom).