§42-13 Trial of Plasma Measurement by Terahertz Time Domain Spectroscopy for the Future Fusion Plasma Application

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For utilizing the broadband terahertz wave (THz pulse) for high-temperature plasma diagnostics, several developments of devices and components are needed. For example, the higher power THz source is demanded, since the huge size plasma is a sample. For this aim, a regenerative amplifier system and/or a Cherenkov phase matching technique might be useful. For the low loss transmission of THz wave, a corrugated waveguide might be useful and the shot length one was tested in FIR-FU. Also, the fast response of detection system is demanded, because the conventional THz time domain spectroscopy (THz-TDS) system is utilized mechanical moving delay line and its time response is over 1 sec in most cases. These developments are kept going.[1-3)]

Now, we have tested the plasma measurement by using a THz-TDS technique. Especially, an asynchronous optical sampling (ASOPS) technique has been applied, because it has a possibility of time resolved measurements. In this time, we use a commercial ASOPS system (ADVANTEST TAS7500) which can be scanned in 8 ms. The test ICP plasma is produced by 13.56 MHz RF coupling wave and the size of vacuum tube is 120 mm diameter and 350 mm length. Ar gas of 20 Pa is filled in the tube and the RF power of about 100 W is applied with the controlling impedance matching. The THz pulse is penetrating across the plasma tube shown in Fig. 1. The penetrating THz pulse signals in cases with and w/o plasma are shown in Fig. 2. The calculated phase difference caused by the plasma is also plotted in right figure. The resultant phase shift is almost zero, because the order of plasma density is $10^{16}\,m^{-3}$ in this test and it is too low to detect by THz wave. However, since the measurement system is almost working well, we think next step is more high density plasma production. Figure 3 shows the renewal test plasma source which diameter is 55 mm and the line-of-sight is changed and passing along the axis. In near future, we will test in this new plasma source.

In addition, when we use a THz-TDS system, the frequency spectrum of sample can be obtained automatically. In the THz region, there are a lot of absorption lines of H_2O, D_2O, T_2O, HDO, HTO, etc. Therefore, the isotope effects have been reported in the difference of the electric constant measured by several THz-TDS systems. In future, we also try to do this measurement.

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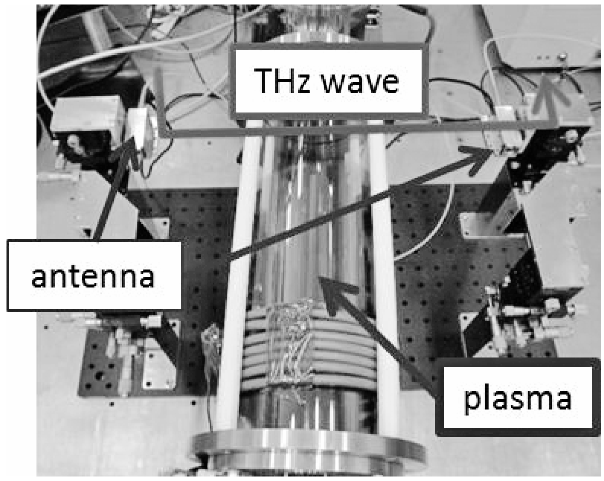

Fig. 1. Experimental setup of first test of plasma measurement. THz wave passes across the plasma.

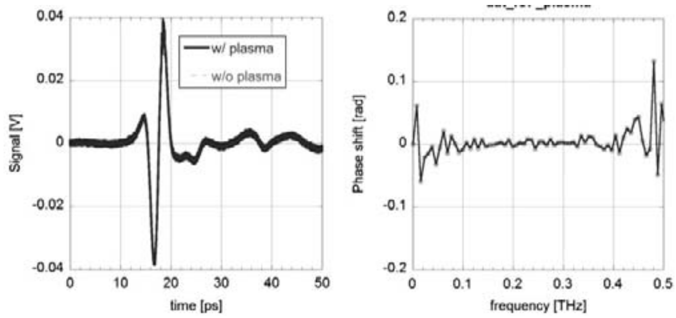

Fig. 2. Obtained THz pulse signal (left) and calculated phase difference (right).

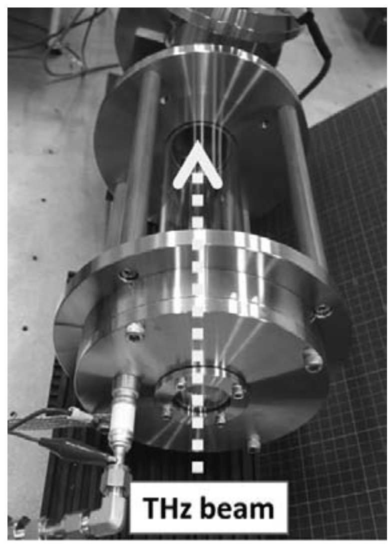

Fig. 3. New designed plasma source. THz beam can pass through the plasma center along the column axis.

1) Tani, M. et al. : Ann. Rep. NIFS (2011-2012) 147.
2) Tani, M. et al. : Ann. Rep. NIFS (2012-2013) 178.
3) Yamamoto, K. et al. : Ann. Rep. NIFS (2013-2014) 188