Terahertz radiations on target materials irradiated by an ultra-intense laser pulse

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***Abstract*—Terahertz (THz) radiations from thin foil targets, such as aluminum and Mylar films irradiated by a 30 fs Ti:Sapphire laser pulse with an intensity of 2×10^{18} W/cm^2 were investigated. The measured THz radiation shows interesting behaviors on the target materials, metal and insulator targets when compared with x-ray signals, which were also measured by using an x-ray photodiode with a 300 μm-thick aluminum filter. The polarization of the THz radiations was also found to have p-polarization as same as that of the incident laser pulse.**

I. Introduction And Background

Electromagnetic radiations in the frequency range of 1 to 10 terahertz (THz) have been recently much attracted due to its ability to probe materials in molecular base. This makes it possible to apply the THz radiations to various fields such as cancer diagnosis, security inspection, and material development[1]. Encouraged by successful demonstrations of the THz radiations on such fields with radiations sources utilizing semiconductors, photoconductive antennas, and electro-optics crystals, many efforts have been made to develop THz radiation sources with high power. Most of the schemes for high power THz radiations have utilized high energy electron beams of accelerators. Recently, on the base of a theoretical model, Schroeder et al, proposed an experiment scheme to generate THz radiations with energy of 100 μJ/pulse by irradiating an intense laser pulse on a target[2,3].

We investigated the characteristics of the THz radiations from thin foil targets irradiated by an ultra-intense laser pulse on target materials such as aluminum and Mylar.

II. Results

The schematic diagram of the experimental set-up is shown in Fig. 1. The 30 fs Ti:Sapphire laser pulse has p-polarization and was focused on thin foil targets of 18 μm-thick aluminum and 13 μm-thick Mylar targets at an incidence angle of 45^o by using an f/4.5 Off-Axis-Parabola (OAP) mirror. This resulted in a laser intensity of 2×10^{18} W/cm^2 in the focal plane. The THz signals generated from plasmas were delivered to a liquid-helium-cooled Ge:Ga detector through two indium-tin-oxide (ITO) film mirrors and one 30 mm-thick polyethylene (PE) filter. Considering transmittance and reflectivity of materials and sensitivity of the detector, the measured radiations were in the range of 1 to 7 THz[4]. X-ray signals were also measured by using a x-ray photodiode (IRD co., AXUV100) with an aluminum filter of 300 μm thickness (1 % transmission at 7.5 keV). A Faraday cup (FC) was also installed behind the target, which was used to detector accelerated charged particles.

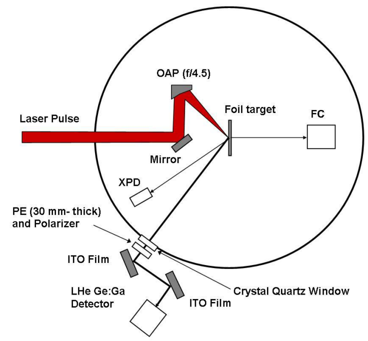

Fig. 1. Schematic diagram of the experimental set-up for the generation and detection of the THz radiations is drawn.

The x-ray signals are plotted against the THz signals on different target materials in Fig. 2. One can see that there is a clear difference between metal and insulator targets. In the case of the metal target, both of the signals are much stronger than those from the insulator target and there is strong correlation between the x-ray and the THz signal. This is considered to be caused by different behavior of electrons, which are ponderomotively accelerated by the laser pulse. In the insulator target, it is known that the energetic electrons are inhibited inside target due to high resistivity of the cold background plasma[5] which is generated by the laser prepulse. This inhibition can be considered to result in weaker signals and less correlation between the x-ray and THz signals in the case of the Mylar target.

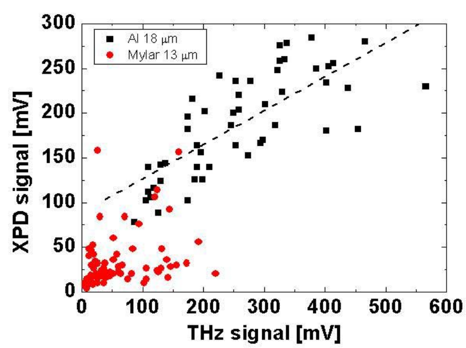

Fig. 2. X-ray signals against the THz signals are plotted on different target materials.

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