Single Shot Measurement of THz pulses based on Pulse Front Tilting by reflective grating

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***Abstract*—A femtosecond pulse with tilted intensity front generated by a reflective grating were used as the probe beam for the single shot measurement of THz pulses with high frequency resolution and low distortion. The time window is up to 20 ps and spectrum range covers 0.1-2.5 THz. The result agrees well with the traditional electrical-optic sampling method.**

SINGLE shot measurement of terahertz pulses is of great importance to the terahertz spectroscopy study on ultrafast irreversible processes such as shock wave induced phase transition, or low repetition events where energy fluctuations of THz pulses is large, such as THz sources from FEL or laser induced plasma[1-3].

In this work, we measured the THz pulses' trace with single shot ability, by using a reflective grating to generate a probe pulse with tilted intensity front, where the THz pulses was generated by LiNbO3 crystal pumped by a femtosecond laser pulse with 0.5mJ energy. The experimental scheme was show in Fig. 1. The probe beam was diffracted by the reflective grating and then imaged by a lens. The image of probe beam with tilted intensity front coincides with the THz pulse in the electro-optic sampling crystal ([110]ZnTe). The polarization state of the probe beam was modulated by the electrical field of THz pulse. After the EO crystal, the polarization state was analyzed by the combination of a half wave plate and a polarized beam splitter and then recorded by a CCD camera. The use of grating to generate probe pulse with tilted intensity front gives two advances: large time window (thus high frequency resolution) and low distortion.

The raw data from the CCD camera was show in Fig. 2. The horizontal position represents different time delay of the probe beam with respect to the THz pulse. One can get the trace of electric field of THz pulses as show in Fig. 2(b), by integrating the intensity in the vertical direction. Fig. 2(c) gives the spectrum of THz pulses. The time window was ~23ps and the spectrum covers 0.1-2.5THz. The result agrees well with result from traditional EO sampling method. Further optimization of the scheme is under way to increase the SNR, in order to apply this technique for the study of shock wave induced phase transition of various materials.

REFERENCES

[1]. I. Wilke, A. M. MacLeod, W. A. Gillespie, et al, "Single-Shot Electron-Beam Bunch Length Measurements", *Phys. Rev. Lett.* 88, 124801(2002).

[2]. G. Berden, S. P. Jamison, A. M. MacLeod, et al, "Electro-Optic Technique with Improved Time Resolution for Real-Time, Nondestructive, Single-Shot Measurements of Femtosecond Electron Bunch Profiles", *Phys. Rev. Lett.* 93, 114802(2004).

[3]. H. Hamster, A. Sullivan, S. Gordon, W. White, and R. W. Falcone, "Subpicosecond, electromagnetic pulses from intense laser-plasma interaction", *Phys.Rev. Lett*. 71, 2725(1993).

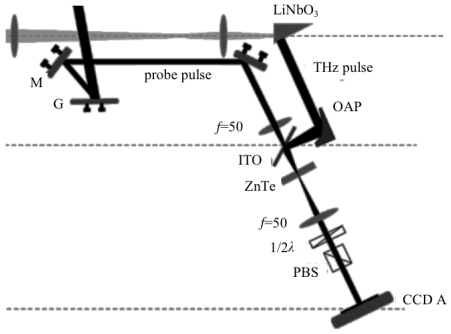

Fig. 1. Schematic of single shot measurement of THz pulse based on pulse front tilting. G: grating. M: mirror. PBS: polarizing beam splitter. OAP: off-axis parabolic. The reflective grating has a groove density of 1200lines/mm with blazing wavelength of 800nm. The THz pulse was generated by LiNbO3 crystal pumped by a fs laser pulse with 0.5mJ energy.

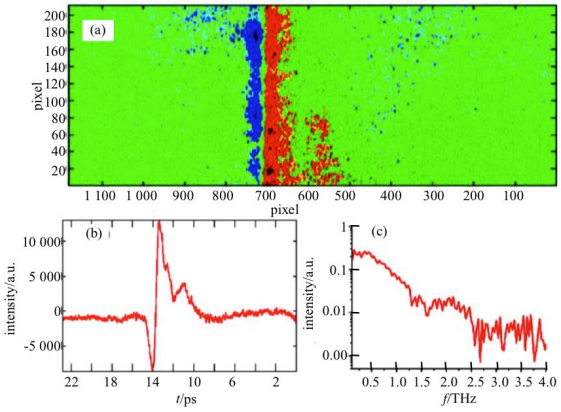

Fig. 2. (a) Raw data of single shot measurement from CCD camera. Temporal trace (b) and spectrum (c) of THz pulse.