THz pulse generation and single shot detection in a single ZnTe Crystal IRMMW-THz 2022

Moses Eshovo Ojo, Frédéric Fauquet, Patrick Mounaix, Damien Bigourd

To cite this version:

Moses Eshovo Ojo, Frédéric Fauquet, Patrick Mounaix, Damien Bigourd. THz pulse generation and single shot detection in a single ZnTe Crystal IRMMW-THz 2022. 2022 47th International Conference on Infrared, Millimeter and Terahertz Waves (IRMMW-THz), Aug 2022, Delft, Netherlands, France. hal-03795104

HAL Id: hal-03795104
https://hal.science/hal-03795104
Submitted on 3 Oct 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
THz pulse generation and single shot detection in a single ZnTe Crystal

IRMMW-THz 2022

Moses Eshovo Ojo*, Frédéric Fauquet*, Patrick Mounaix*, Damien Bigourd*,
*Laboratoire IMS UMR CNRS 5218, Université de Bordeaux, France

Abstract: Single-cycle THz signal of few picoseconds duration, have been simultaneous generated via optical rectification and detected by electro-optic effect in the same ZnTe crystal. An unbalanced seemingly single shot detection scheme was performed to characterize the signal. The added simplicity of this scheme aided the independent analysis of the horizontal and vertical polarization arm of the chirped probe beam to explain the associated nonlinearities in the detected THz signal.

INTRODUCTION

THz generation has been appreciably reported in several non-linear second order crystals owing to their non-linear coefficient value and wide transparency in the optical and THz domains. Optical rectification (OR) is a second order nonlinear process which has been used to explain the mechanism by which THz are generated in these nonlinear crystals such as ZnTe. The passage of an ultra-short pulse through a non-linear crystal, gives rise to polarization term, within the crystal whose extent of polarization is dependent on the intensity of the incident pulse. The second order susceptibility term is mostly relevant for OR in which the difference frequency mixing within the spectral bandwidth of the laser pulse generates low frequency signal within the THz region. Although most of the work have been achieved with ultrashort pump pulse, a growing interest is also on the use of longer chirped pulse in order to scale up the energy in the THz range.

Though the spectral width of the THz signal are narrow-ranged, their signal amplitude can be optimized for detection. Usually, a similarly thinner crystal is utilized in the Electro optic Sampling (EOS) technique for the detection of the THz signal. Only a few THz related papers have explored the option of detecting the signal in the same crystal deployed for generation, of which the THz is sampled by a short probe beam in a multi-shot pattern. To the best of our knowledge, the single-shot detection scheme has not been incorporated in the single-layout configuration. In the single-shot geometry, the THz pulse which is generated in the leading part of the crystal by the incident pump beam, becomes superimposed on a chirped probe beam that passes through the crystal the cost effectiveness and less cumbersomeness of this scheme prompted the quest of our research. In this work, we study the generation and detection of THz signal in the single-crystal configuration with respect to a seemingly single shot measurement, pump-probe power ratio effect and comparison of the vertical and horizontal polarized THz signal arm.

A pre-chirped Ti-sapphire laser beam with center wavelength of 800 nm, 1 kHz repetition rate and ~ 1 mJ of energy was split by a beam splitter into two arms that forms the pump and probe beam. The probe beam was temporally stretched more by repeated passage through sets of dispersion blocks. The experimental set up as illustrated in Fig. 1.0 consist of the 3.6 ps FWHM stretched pump beam focused onto the 0.6 mm ZnTe crystal with few tens of µJ. A 5.2 ps FWHM chirped probe overlaps temporally and spatially with the pump beam on the crystal at a crossing angle of ~12°. The beam diameter of the probe and pump beam at the crystal position were 570 µm and 125 µm respectively. At the cross point of the two beams, the THz pulse generated via optical rectification by the intense pump beam overlaps with the propagating chirped probe. This probe-THz beam is collimated and subsequently circularly polarized of which the vertical and horizontal polarized component diverges upon exiting the polarizer. A half wave plate placed between the quarter wave plate and polarizer is used to switch the beam path of the two polarization, such that the same spectrometer detects the different polarization. The simplicity of this configuration does not only...
guarantine its affordability but also provide an avenue to independently analyze the signals of the different polarization with the aim to quantify the induced nonlinearities from the probe beam intensity. The effect of two photon absorption was minimized by rotating the polarization of the pump beam following the suggestion of [3].

RESULTS
The spectrum of the chirped probe was captured both in the absence and presence of the pump beam. The consistency in the spectrum profile was confirmed by recording hundred shots of the spectrum. An average recorded spectrum in the presence/absent of the pump is displayed in Fig. 2.0. The THz pulse shape is then retrieved according to the standard normalization. The average of one of the difference signal is shown in Fig. 3.0 (a). The linear relationship between time and frequency was obtained from the autocorrelation of the probe pulse although a FROG measurement will be performed in the near future to account for some nonlinear behavior.

While keeping the chirped probe intensity fixed, the pump beam intensity was varied, in which case both the THz horizontal and vertical signal maintain similar profile. At much higher intensity of the chirped probe, the form of the THz signal changed (see Fig.3.0 (a), blue). These changes might be related to the contribution of the OR from the probe or higher order susceptibility phenomena such as Kerr effects and self-focusing. Numerical simulations are in progress to validate these assumptions.

The corresponding spectrum obtained by the Fourier transform the THz signal is illustrated in Fig. 3.0(b).

Fig 2.0. An averaged single shot probe signal recorded by the spectrometer in the presence or absence of the pump beam.

Fig. 3.0. a). THz time domain signal in the presence of weak (red) and strong (blue) probe. b). corresponding THz spectrum in the presence of the weak probe.

REFERENCE