Effect of crystal thickness in localized terahertz generation via optical rectification in ZnTe – preliminary investigation

Hungyen Lin, Benjamin Seam Yu Ung, Bernd M. Fischer, Samuel P. Mickan and Derek Abbott
Centre for Biomedical Engineering and School of Electrical and Electronic Engineering,
The University of Adelaide, SA 5005, Australia

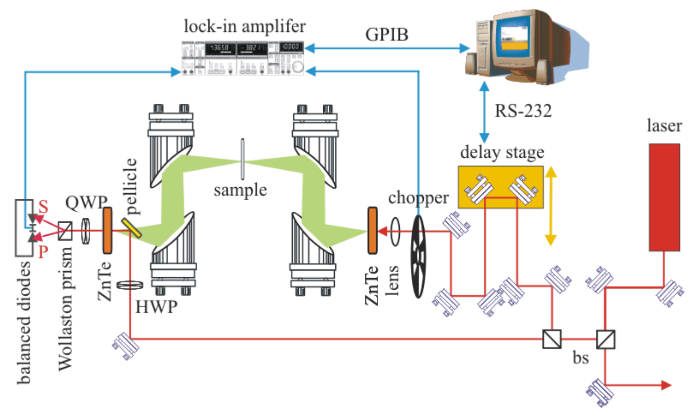
***Abstract*—Many techniques have been proposed in the literature with an aim of breaking the diffraction limit for THz imaging. The thin crystal in electro-optical based technique has been reported to generate THz power enhancement. This, however, is counter-intuitive as thicker crystals provide a greater volume for optical rectification and hence should generate more power. This paper therefore investigates THz optical rectification with thin crystal experimentally.**

I. Introduction and Background

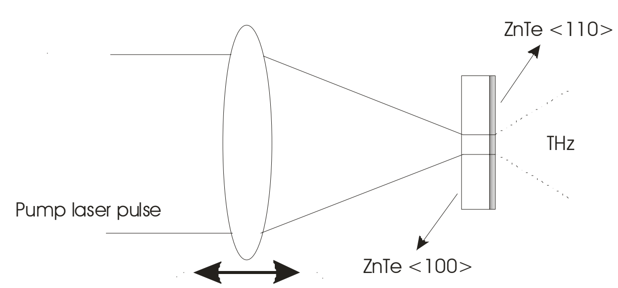
One of the major limitations with THz images is the low spatial resolution, as determined by Rayleigh's criterion with a comparatively longer wavelength (0.3 mm at 1 THz). In an effort to improve the resolution of THz images, various techniques have been proposed in the literature with an aim of breaking the diffraction limit. Yuan et al. [1] and Withayachumnankul et al. [2] present a review on near-field imaging techniques that encompasses the principle of operation and the achieved spatial resolution. The electro-optical approach that exploits the smaller THz emission point than the wavelength is of the particular interest here as it is apertureless and thus has no throughput limitation. One recent example of the electro-optical approach can be found in [3]. Very thin ZnTe (16 μm) has been observed to generate higher powered THz pulses at the point of focus than the thicker counterpart (250 μm) [4]. The spot size radius was measured to be 1.7 μm. The unexpected enhancement from the thin crystal is counter-intuitive as thicker crystals provide a greater volume for optical rectification. The field is an overlap between focusing theory and crystal thickness. Xu and Zhang [5] first studied the dependence of THz radiation on optical excitation size in a GaAs emitter (500 μm thick). The pump beam radius studied were either much larger or much smaller than the THz radiation wavelength. They observed dependence of the total THz radiation power on the square of the excitation diameter. Dakovski et al. [6] investigated on THz radiation as a function of optical excitation size and shown that THz emission under fixed optical excitation power is largely excitation size-independent, provided the size is smaller than THz wavelength. Their work is extended for lower pump power in Xing et al. [7]. In contrast, van der Valk et al. [8] detailed the effect of phase mismatch from varying crystal thickness (1 mm and greater) and its effect to both the terahertz shape and spectrum. The two fields, however, have not been studied together, this paper therefore investigates on focused THz optical rectification with thick (1 mm) and thin ZnTe (25 μm) experimentally.

II. Experiment

A standard electro-optical THz-TDS setup is used in our investigation. The laser source is a Ti:sapphire pulsed laser producing 800 nm pulses at a maximum of 2 W output power with a 80 MHz pulse repetition rate and 100 fs pulsewidth. The laser is used to pump a <110> ZnTe emission crystal and probe a <110> 1 mm thick ZnTe in the detection path. The detection setup is fixed in this investigation and only the emission crystal is varied.



The emission crystals comprises of a 1 mm thick ZnTe (Zomega Terahertz Corporation) that is annotated as the thick crystal. In contrast, the thin crystal is a 25 μm ZnTe (MaTeck GmbH) expoxed to a <100> 500 μm thick ZnTe in order to overcome fragility as reported in [1]. The epoxy has a thickness of 10 μm so therefore we can assume good index matching between the substrates. Such a setup follows the configuration in [6]. A 10 mm focal length objective lens is mounted on a linear translation stage to ensure the pump beam is well focused onto the emitter. The excitation size with the Gaussian beam is hence expected to have a radius of 2.5 μm, comparable to 1.7 μm in [4]. A pump power of 215 mW is used.



III. Results

Experimental results comparing the THz generation from thick and thin ZnTe will be shown in the conference.

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