Quasi-CW THz-Imaging Based on a High-Efficiency Tunable Photonic Transmitter

Ja-Yu Lu, Hsu-Hao Chang, Li-Jin Chen, and Ming-Chun Tien
Graduate Institute of Electro-Optical Engineering and Department of Electrical Engineering, National Taiwan University, Taipei 10617, TAIWAN
Phone: 886-2-23659703, FAX: 886-2-23677467, E-mail: jayu@ms53.url.com.tw

Chi-Kuang Sun
Graduate Institute of Electro-Optical Engineering, and Department of Electrical Engineering, National Taiwan University, Taipei 10617, TAIWAN

Abstract: A quasi-continuous-wave THz imaging system is constructed based on a compact photonic transmitter with a record-high external converging efficiency. 2D transmission images of biological objects are demonstrated at various THz frequencies.

OCIS codes: (260.3090) Physical optics, (320.7160) Ultrafast optics

Terahertz technology has attracted a lot of attention recently and has been applied in molecular image systems. For high-resolution spectroscopy applications, high-power high-efficiency widely-tunable-wavelength narrow-band THz sources are needed for the improvement of image contrast, spectral resolution, and system sensitivity. Recently, we had demonstrated a novel edged-coupled membrane photonic transmitter that is based on a high bandwidth-efficiency product MSM traveling-wave photodetector and a co-planar-waveguide fed slot antenna. These devices perform record optical-to-THz power conversion efficiencies [1,2], which are superior to photomixing in photoconductive dipole antenna. Under 3.5mW optical excitation, 3.9µW average THz radiation at 645 GHz can be obtained. Even higher THz power can be obtained by increasing optical excitation intensity (peak power), laser repetition rate, or applied bias. In this presentation, we demonstrate a quasi-CW THz image system based on the compact edged-coupled membrane photonic transmitter. Our preliminary studies show promises of this new system on the T-ray bio-imaging with high image contrast (SNR>100) and wide wavelength-selectivity.

Fig. 1 shows the setup of the quasi-CW imaging system. A mode-locked Ti:sapphire laser combined with a tunable high finesse Fabry-Perot filter is used to mimic a quasi-CW excitation source. After passing the femtosecond pulses through the high finesse Fabry-Perot filter, broad temporal modulated pulse train can be created, where the temperal modulation frequency is controlled by the spacing of the Fabry-Perot filter [3,4]. The optical excitation was edged-coupled to active region of the photonic transmitter, high power quasi-CW narrow-band THz radiation, corresponding to the filter's FSR frequency, can thus be generated. By tuning the spacing of the Fabry-Perot filter, the wavelength of the narrow-band THz emission can thus be varied. The excited quasi-CW THz waves radiated from the substrate side into the free space were focused by off-parabolic mirrors to a spot size approximately 1mm on the test samples. The transmitted THz waves were then collected and measured with parabolic mirrors and a bolometer. By scanning the sample position with a PC-controlled x-y translational stage, transmission THz images on the focusing plane can thus be obtained.

Figures 2(a) and 2(b) show the acquired projection images of a dried seahorse and a fresh flower (with water) taking by the demonstrated quasi-CW THz image system with different radiation frequencies. The image sizes are 6cm×4.5cm and 1.6cm×5cm respectively. The scan step sizes are 0.5 mm. During expreiments all samples were contained in thick opaque plastic boxes and are thus invisible. Excellent S/N ratio (>100) is achieved with a 1-mm spatial resolution. In the presentation, wavelength-dependent bio-imaging will be discussed optically and biologically.

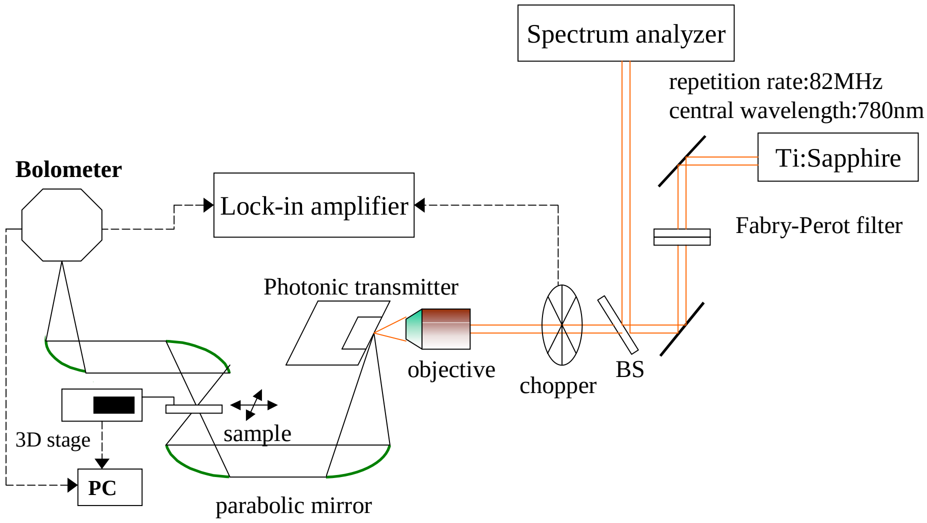

Fig. 1 Schematic diagram of the quasi-CW THz imaging system.

(a)

(b)

Fig. 2. Quasi-CW THz images of various samples. (a) A dried seahorse acquired with a 1THz radiation frequency. (b) Fresh flowers with water acquired with a 945GHz radiation frequency.

References

[1]J.-W. Shi, et al., “Edged-coupled membrane terahertz photonic transmitters based on metal-semiconductor-metal traveling –wave photodetectors,” *Appl. Phys. Lett..*, **81**, 5108-5110 (2002).

[2] M.-C. Tien, et al., “Device saturation behavior of submillimeter-wave membrane photonic transmitters,” to be published in March issue of *IEEE Photonics Technology Letters* (2004).

[3]A. S. Weling, et al., “Generation of tunable narrow-band THz radiation from large aperture photoconducting antenna,” *Appl. Phys. Lett.*, **64**, 137-139 (1994).

[4]Y. Liu, et al., “Enhancement of narrow-band terahertz radiation from photoconducting antenna by optical pulse shaping,” *Optical Letter*, **21**, 1762-1764 (1996).