Dependence of Terahertz Emission and Detection in Photoconductive Antennas on Laser Parameters

G. Balistreri[1,2*], A. Tomasino[1,2], S. Stivala[1], P. Livreri[1], A. C. Cino[1] and A. Busacca[1]
[1]DEIM, University of Palermo Viale delle Scienze, 90128 Palermo, Italy
[2]INRS-EMT, 1650 Boulevard Lionel-Boulet, J3X 1S2, Varennes, Québec, Canada
*giacomo.balistreri@unipa.it

***Abstract*— In this study, we employ a standard Terahertz time-domain spectroscopy (THz-TDS) setup based on two photoconductive antennas (PCAs) for THz radiation generation and detection. The characterization of the emission and detection performance as a function of the input pulse wavelength and bandwidth is performed.**

Keywords—THz time-domain spectroscopy; photoconductive antennas;

I. Introduction

Despite the technical difficulties in developing efficient and compact sources and detectors for Terahertz (THz) radiation, this region of the electromagnetic spectrum is attracting an ever-increasing interest, because of its peculiar and high-potential applications in several fields, such as high-bandwidth communications, medicine, biology, non-destructive testing, security and defence [1]. In this work, we present first experimental results obtained by means of a THz-TDS setup based on photoconductive antennas (PCAs). The main elements of the setup are: i) a mode-locked Ti:Sapphire femtosecond laser (Mai-Tai SP), providing optical pulses at 800±20 nm with a duration <50 fs and repetition rate of 84 MHz; ii) two photoconductive antennas, made in Low-Temperature Grown Gallium Arsenide (LT-GaAs) [2], operating as THz emitter and detector; iii) an optical delay line.

II. Experiment

The input laser beam is split into two parts by means of a 55:45 beam splitter (pump and probe), which are sent onto the two PCAs. The pump beam is delayed by the optical delay line, whose position can be varied by a software-controlled stepper, thus allowing the THz pulse reconstruction. The THz beam between the two PCAs is collimated thanks to two Teflon lenses, whose focal is 5 cm. In this way, we can generate and coherently detect the THz pulses and study their properties as a function of the input pulse wavelength and bandwidth. The results of the first characterization are shown in Fig. 1(a). As it can be clearly seen, peak-to-peak amplitude of the temporal waveform increases as the wavelength shortens. Indeed, photon energies impinging on the PCA substrate are higher as the laser wavelength emission is shorter. This, in turn, implies a higher current flowing in the PCA substrate, since a higher photon energy means that a greater number of carriers is promoted from the valence band to the conduction band of the substrate material. The power spectra, corresponding to the temporal waveforms illustrated in Fig. 1(a), are presented in Fig. 1(b). In this case, one can clearly see how the signal level increases while the laser wavelength emission decreases, showing the same behavior observed in the temporal domain.

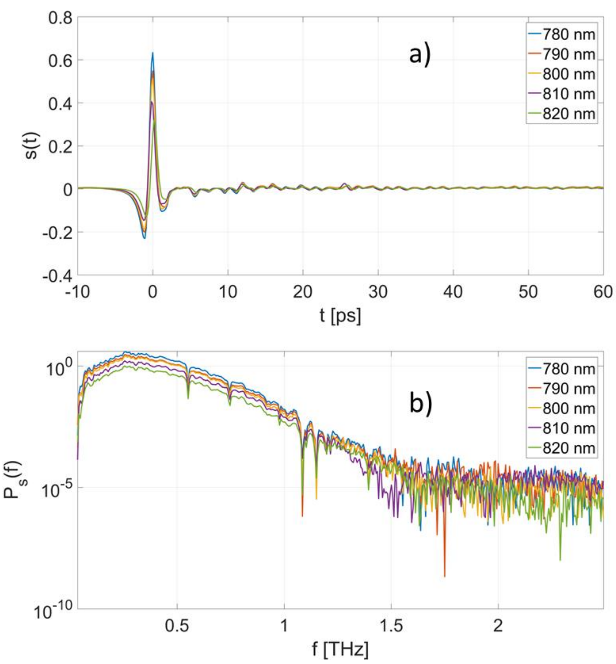

Figure 1: (a) Temporal THz pulse waveforms measured by varying wavelength laser emission, at a fixed laser emission band of 10 nm, and (b) their corresponding spectra.

In this work, we demonstrated the influence of the laser optical parameters (i.e., pulse wavelength and bandwidth) on the temporal and spectral profile of the emitted and detected THz pulses. This, in turn, allows a precise optimization of the widely employed THz-TDS setups.

III. References

[1] Q. J. Gu, "*THz Interconnect: The Last Centimeter Communication*", IEEE Communications Magazine, 206-215 (2015).
[2] D. Saeedkia, "*Terahertz photoconductive antennas: principles and applications*", EUCAP (2011).