Whitepaper

TERA-Sed Emitters

The Laser Quantum Tera-SED is a device emitting intense terahertz (THz) radiation after excitation with a femtosecond (fs) laser pulse. It converts the light from the optical regime into the THz regime with a conversion efficiency of up to 2 x 10^{-3}. The impulsive excitation inherently leads to THz pulses covering a broad spectrum in the frequency regime. The spectrum covers almost two decades from about 100GHz up to 7THz with an intensity peak at 1THz (see figure 1). In this frequency range the electric field of the light is directly measurable in amplitude and phase which is important for a large variety of scientific and technological applications.

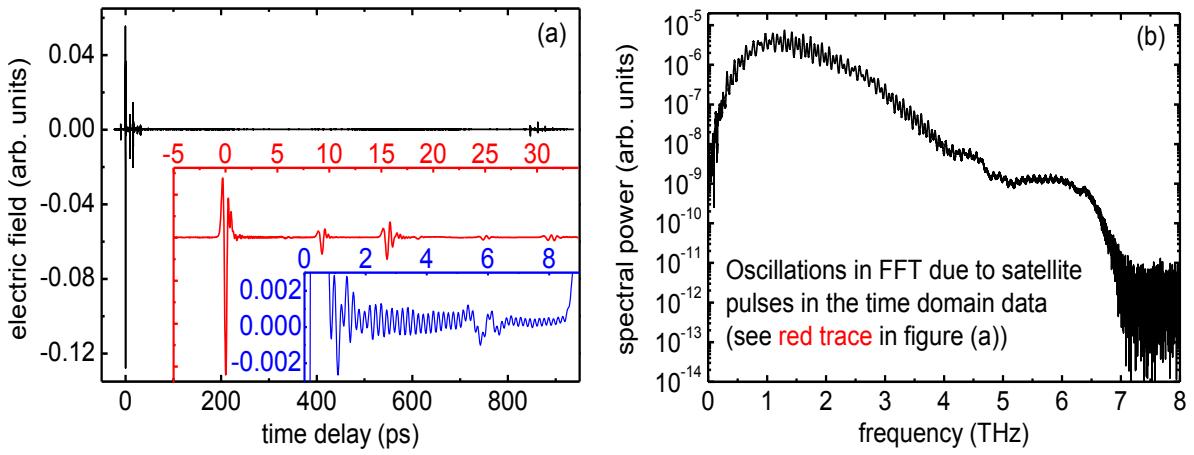

Figure 1: Time-domain data (a) and corresponding Fourier transform (b) from a Tera-SED emitter operated in a HASSP-THz system (522 s acquisition time). Both insets in the time-domain data show the enlarged traces of the same data. Data taken from reference (3).

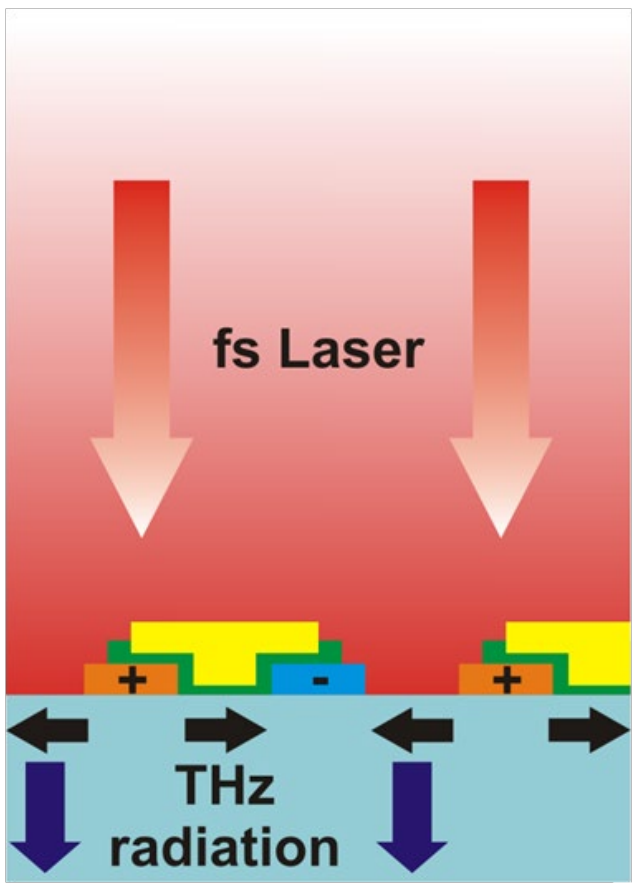

Figure 2: Basic THz generation principle of the Tera-SED emitters. The fs laser radiation (red) comes from the top and excites the GaAs substrate (blue). Every second gap between the + and – electrodes is masked with an isolation layer (green) and gold (yellow) in order to inhibit destructive interference between THz fields emitted from adjacent gaps in the far-field.

The Tera-SED emitter is an array of photoconductive switches[*1] made on a Gallium-Arsenide (GaAs) substrate. The principle of the generation process of the THz radiation is the acceleration of optically excited carriers in an external applied electric field applied to a photoconductive switch and the acceleration of the carriers itself generates the THz radiation. The Tera-SED emitter features a patented interdigitated electrode metal-semiconductor-metal structure (see figure 2), effectively multiplexing more than one hundred photoconductive switches. This multiplexing is key to low bias operation of the device, yet with unprecedented conversion efficiency from the optical to the THz regimes. The Tera-SED principle allows for a large active area with kV/cm bias fields between individual electrodes [1]. The distances between the electrodes is only 5 µm, leading to an acceleration field of 20kV/cm at a bias voltage of only 10V. Compared to a standard photoconductive antenna the bias voltage of the Tera-SED emitter is about one order of magnitude smaller enabling high modulation frequencies up to a few MHz of the bias voltage. The conversion efficiency into the THz regime with the Tera-SED emitter reaches up to 2x10^{-3}, orders of magnitude higher than conventional single photoconductive switches [2].

The Tera-SED emitter is available in two different versions. One has an active area of 3x3mm^2 and is suited for fs-oscillator systems, the larger one with an active area of 10x10mm^2 is suited for amplified systems. The large active area makes accurate alignment of the pump laser beam on the emitter obsolete and simultaneously allows larger spot sizes avoiding saturation effects. The Tera-SED emitter is mounted in a 1-inch holder fitting into standard 1-inch optic mounts. The holder is equipped with a MMCX[*2] connector allowing easy connection of the external bias. The Tera-SED emitter has now been in the field for 7 years and we have so far not seen a single failure of the product under its designated use conditions.

[*1] Photoconductive switch and photoconductive antenna are synonymous

[*2] An MMCX-to BNC-adapter cable is included in the delivery

References:
[1] Winner et al., High-intensity terahertz radiation from a microstructured large-area photoconductor, Applied Physics Letter Vol. 86, p. 121114 (2005)
[2] Beck et al., Impulsive terahertz radiation with high electric fields from an amplifier-driven large-area photoconductive antenna, Optics Express Vol. 18, p. 9251-9257 (2010)
[3] Klatt et al., Rapid-scanning terahertz precision spectrometer with more than 6THz spectral coverage, Optics Express Vol. 17. p. 22847-22854 (2009).

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