TOBIAS (Terahertz Optics for Biological In-situ Analytical Spectroscopy)[1] is a project targeting the implementation of a Near-field THz spectroscopic imaging (0.3- 3THz) system with specific reference to matter and bio-matter characterization, exploiting electromagnetic transmission fingerprints (i.e. characteristic spectral responses). Recent studies demonstrated that many compounds of interest like polymers, proteins, amino acids and even explosives possess specific global and sub-global modes in the THz band. The interest on the THz band is catalyzed by the fact that THz radiation tends to excite overall molecular vibrational modes whereas standard visible or near-infrared illumination stimulates high energy transitions mostly related to electronic bindings. For this reason particular attention has been recently devoted to THz spectroscopy since it reveals information on the conformational state of molecules and potentially enables their discrimination in various compounds [1-4]. Most of the work on the interaction between THz light and matter has been performed in the context of imaging with low spatial resolution (limited by the long THz wavelength, typically 0.1-3mm), and has been directed to the discrimination between types or states of tissue. Unfortunately, while on the scale of T-ray wavelength macroscopic samples may not be heterogeneous, at smaller scales biological entities exhibit a rich spatial structures, which need to be discriminated with spatial sub-wavelength resolution. TOBIAS target the construction of a system that can be used for the discrimination of materials in a heterogeneous sample, for example in biological tissue. In particular, deep sub-wavelength resolution will enable to spatially map the spectroscopic signatures of small structures collected via a time-domain spectroscopy technique (TDS). This objective will be reached exploiting an "*In-situ*" generation (Fig. 1) by optical rectification, a nonlinear process which exploits a wide band laser pulse to generate the lower frequency radiation (THz). The *in-situ* generation ***represents the kernel of this project*:** specifically, the main goal is to illuminate with a suitable femtoseconds (fs-) pulsed (high peak power) pump beam a thin electro-optic (EO) crystal in contact with a sample of thickness smaller than the THz wavelength. The pump beam waist is smaller than the wavelength of the collected THz and such is the dimension of the effective THz source. Common Near-Field methods (e.g. based on apertures or guiding tip) are always accompanied by a power reduction due to diffraction effects that in general scales as the **sixth power** of the emitted/detected area radius. The in-situ generation permits to overcome such power limitation as the emitted THz power decreases only with the **second power** (or better) of the source dimension [5-7]. The key goal of the project, i.e. demonstration of a TDS-imaging system based on the optical rectification in sub wavelength generation areas has been achieved. (Fig. 2) The prototype of this device is presently working within the infrastructure of the INRS-EMT (Canadian partner of this IOF project) and is exploited for the characterization of complex materials like bio-matter. Part of the setup has been recently reproduced within the infrastructure of the IPCF-CNR (The Italian host). The investigation supported by this contributed to a broader understanding of characteristic of this type of imaging systems [6-10]. The work promoted by this project highlighted and solved peculiar problems in the accurate characterization of the spatio-temporal emission of those sources using standard beam-profiling techniques (Fig 3). [11] The development of this system has been characterized in a timely manner by a number of significant achievements with an expected broad general impact in photonics regarding the nonlinear spatio-temporal reshaping of THz bandwith-optical pulses [12-17], the optimization of sources

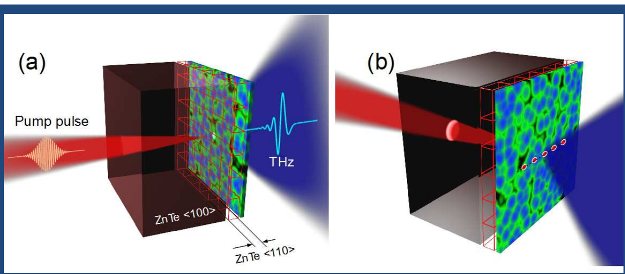

Fig. 1: (a) Generation geometry; (b)The image can be reconstructed by impinging with the pump beam in proximity to different sample surface positions.

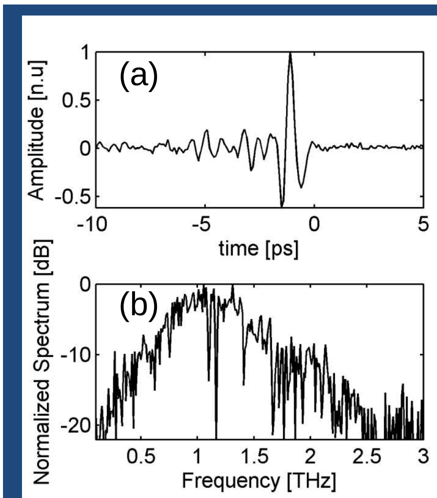

Fig. 2: (a) Emitted THz waveform; (b) associated spectrum.

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providing optical pulses with THz bandwidth [18], the methods required to fully characterize large bandwidth optical pulses [19], and the interaction of the generated THz with subwavelength structures [20,21] (We stress here that Ref. 21 is an invited paper, recognizing the overall expertize developed by the applicants in the field). Within the framework of this project alternative methods for subwavelength-localized generation and detection, e.g. using air-plasma, have been explored [22]. In addition the project also succeeded in assessing the potential hazard for biological targets represented by concentrated THz-fields [23].

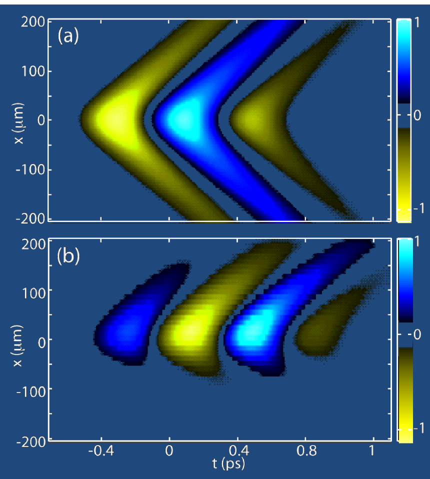

Fig. 3. (a) Predicted THz spatio-temporal profile directly detected at the crystal surface (b) and field retrieved by means of a knife-edge scanning measurement.

We predict a potential economical and societal impact from the achievements of this project. Despite the present activity in the field of THz Science and Technology in Europe, more activity in this domain and the build-up of a critical mass is needed to keep up with the fierce international competition. In addition international companies like TeraView, EKSPLA, demonstrate that the applications of THz spectroscopy are penetrating several different markets, spanning from biomedical scanning, environmental control, security etc. We stress here that the scientific panorama in ITALY still exhibit a significant delay in the development on the topics explored by this investigation. Hence, the project main impact perfectly relates with general goal of IOF Marie Curie action as it is already succeeded in the translation of knowledge on THz technology from the Canadian host INRS-EMT to the Italian host (CNR, Italy).

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