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Terahertz Applications for Detection of Explosives

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Abstract

In this project, we first used THz time domain spectroscopy (THz-TDS) to investigate explosives and establish a spectra database of these materials in the THz frequency range. The future THz imaging system will apply innovative pattern recognition and classification methods to distinguish explosives from non-explosive objects via these THz spectra.

Why should we care about THz waves?

Energy: objects at room temperature (300 K) emit thermal energy in this range (6 THz). Half of the cosmic background radiation from the Big Bang is in the THz region.

Signature: from GHz to THz frequencies, numerous organic molecules exhibit strong absorption and dispersion due to rotational and vibrational transitions. These transitions are specific to the targets and enable T-ray fingerprinting.

Safety: T-rays have low photon energies (one millions times weaker than a x-ray photon) and will not cause harmful photo- ionization in biological tissues.

THz Time Domain Spectroscopy

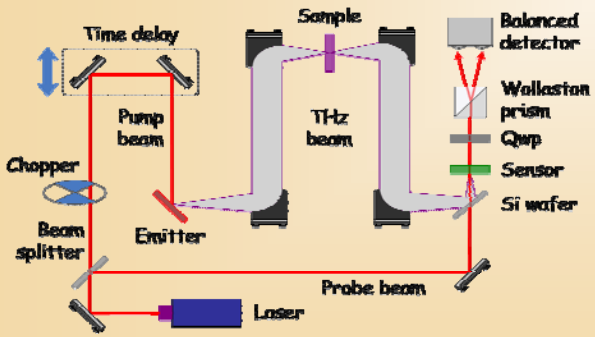

Fig.1 the schematic diagram of Terahertz Time Domain spectroscopy (THz-TDS)

Achievements

- Signatures of selected explosives and related compounds (ERCs) are identified in the THz band
- THz spectra of ERCs are calculated based on Density Functional Theory
- Good agreement between the calculated and measured spectra is achieved
- The results obtained from THz-TDS agree well with that from FTIR

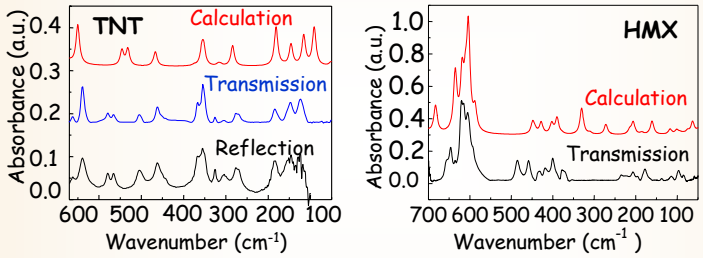

Fig.2 Comparison of transmission, reflection and calculated spectra of two explosives: left, TNT; right, HMX

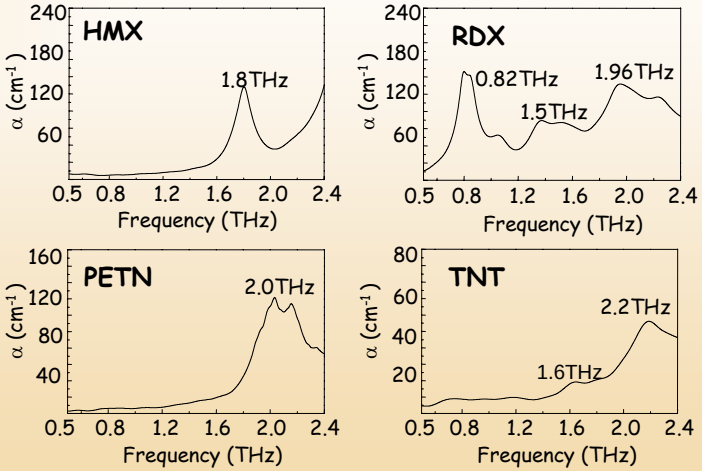

Fig.3 The absorption spectra of four typical explosives in THz range measured by Terahertz Time Domain spectroscopy (THz-TDS)

Future Plan

For applications of THz system under condition close to real-life, there are several obstacles needed to be overcome: the long-distance propagation of a THz wave in the air, the size and shape of the samples, etc.

We have developed the following plans that will contribute to the sustainability of the research:

Optimizing the performance of the THz time domain system (dynamic range, signal to noise ratio); building the compact THz system for long-distance real-time standoff detection (30m and greater).

Building a field-deployable THz system capable of detecting materials of interest; creating an integrated instrument design for commercialization.

Acknowledgement

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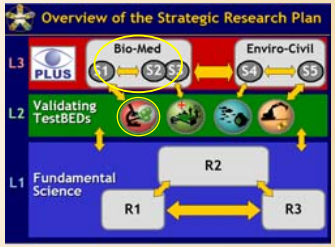
This project fits level 3: Bio-Med .



Reference

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[2] Yunqing Chen, Haibo Liu, X.-C. Zhang, etc, "Spectroscopic characterization of explosives in the far infrared region", *Proceedings of SPIE*, 5411, pp1-7, 2004;