Continuous Wave Terahertz Imaging

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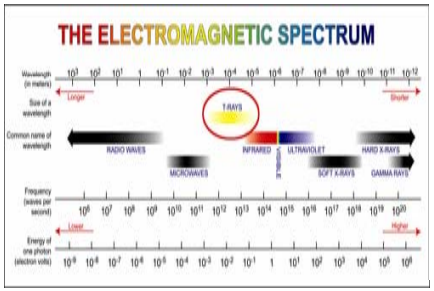
Abstract

With the advancement of Terahertz (THz) technologies, THz sensing and imaging have a tremendous impact on defense and security. Inexpensive and highly effective detectors are urgently needed. In this work, a compact portable continuous wave (cw) imaging system is built based on a glow discharge detector (GDD). The GDDs are inexpensive neon indicator lamps that are dependable, efficient detectors of THz radiation. Some imagings were obtained by GDD and the Schottky detector. The results illustrate that the GDD is nearly as good as the Schottky detector in THz imaging. However, further research and development is necessary to improve the performance of GDD.

Terahertz Overview



- Terahertz waves are electromagnetic radiation in a frequency interval from 100 GHz and 10 THz lying between the infrared and microwave sections of the spectrum.
- Terahertz waves possess weak photon energies, are non-ionizing and thus are not expected to damage tissues and DNA, unlike X-rays.
- Sub-millimeter wavelength allow a high special resolution in imaging and many materials exhibit unique special fingerprints in the THz range.
- THz radiation is readily transmitted through most non metallic and non polar mediums enabling THz waves to pass through fog, fabrics, plastic, wood, ceramics and even a few centimeters of brick, yet they can be blocked by metal objects or thin layers of water.
- Therahertz waves offer innovative sensing and imaging technologies that provides information that can significantly impact imaging techniques through proper applications.
- Terahertz waves present advancements in security and defense by allowing detection of concealed weapons and objects, analysing chemical contents of enclosed packages as well as biomedical applications such as identifiying the onsets of cancer.
- THz wave imaging has been a major interest of Dr. X.-C. Zhang's research group at the Center for Terahertz Research. The group has experimented with Electro-optic sampling which promoted THz imaging and detection. Work has also been done with T-ray tomographic imaging which allows pulsed terahertz radiation to probe the dielectric properties of three-dimensional (3D) structures and provides sectional images of objects.

Objectives

To gain knowledge and experience with Terahertz imaging techniques.

To design and construct a compact portable cw terahertz imaging system.

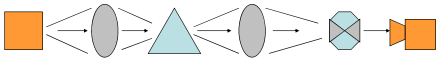
To differentiate between the effectiveness of the GDD and the Schottky Diode.

Glowing Discharge Detector

A GDD is a lamp filled with low pressure neon inert gas with Penning mixture and typically coated with phosphorous. Two electrodes are placed parallel within the lamp which ionizes the inert gas, resulting in an electric current. The incident THz wave enhances ionizing collisions of electrons with neutral atoms and causes an increase in the discharge current.

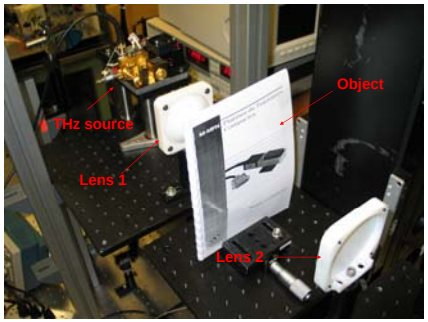
The GDD is highly effective due to its low cost, durability, broad spectral range and high responsitivity.

Experimental setup



THz source 0.2 THz | Lens 1 | Object | Lens 2 | Chopper | Diode/GDD

Chopping Frequency: 900 Hz



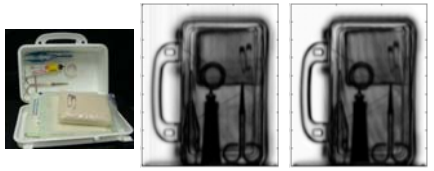
The basic setup of the experiments involves a continuous wave THz source, which emits 0.2 THz wave. The waves are directed through a HOPE lens (FL: 66mm) where the THz beam is focused onto an object. The THz waves continue through another lens (FL: 66mm) where they are focused through a chopper towards a GDD or the Schottky Diode detector.

References

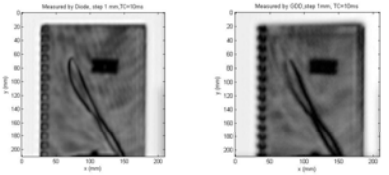
Hou, Lei GDD Imaging presentation 2009
Federici, John THz Imaging and sensing for Security Applications 2005
Karpowicz, Nicholas Comparison between pulsed terahertz time-domain imaging and continuous wave terahertz imaging 2005
RPI Center for Terahertz Research 2009

THz Images (0.2 THz)

Teapot GDD Schottky diode



First Aid Kit GDD Schottky diode



Schottky Diode GDD

Figures above display the results of THz imaging using the GDD and Schottky Diode respectively.

Conclusions

- The GDD and Schottky diode are both effective detectors for Terahertz imaging.
- Challenges of THz imaging involve the limits in wave penetration depth as well as the limited spatial resolution.
- Deeper exploration into Terahertz imaging systems will have a significant impact on modern day screening and imaging techniques.

Future Projects

- Currently we plan to establish a Terahertz research lab at Morehouse College where further research can be done as well as an opportunity to instruct more students on the subject of Terahertz radiation.
- Future projects include further improving the performance of the GDD and developing the reflective imaging setup.

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