Continuous Wave THz Imaging System Based on Glow Discharge Detector

Lei Hou, Hongkyu Park and X.-C. Zhang
Center for Terahertz Research, Rensselaer Polytechnic Institute, Troy, NY, 12180

Introduction

A Glow discharge detector (GDD), based on a commercial neon lamp, was used in a continuous wave (CW) terahertz (THz) imaging system. The responsivity and noise equivalent power (NEP) of a GDD are 70 V/W and 1.26 × 10^{-6} W/Hz$^{1/2}$, respectively. The performance of the GDD can be improved as commercial neon lamps do not have an optimized structure as a THz detector. The preliminary results indicate that a well-designed GDD will be an excellent THz detector with **microsecond response time**, **wide spectral range** (0.1 ~ 10 THz), **high responsivity** (> 1000 V/W) and **low NEP** (< 10^{-12} W/Hz$^{1/2}$).

Challenges in THz Imaging

To use THz imaging for **Real-life applications**
- THz source: efficiency and compactness
- **THz detector**: response speed, sensitivity, operating temperature, operating spectrum and cost effectiveness

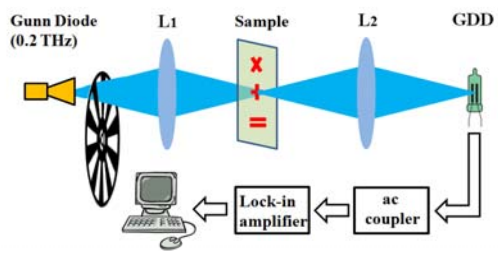
THz Detector	NEP (W/Hz$^{-1/2}$)	Response speed	Price
Schottky diode	10^{-10} ~ 10^{-12}	~ kHz	expensive
Pyroelectric	10^{-11} ~ 10^{-12}	< 100 Hz	expensive
Golay cell	10^{-11} ~ 10^{-12}	~ 20 Hz	expensive

Glow Discharge Detector

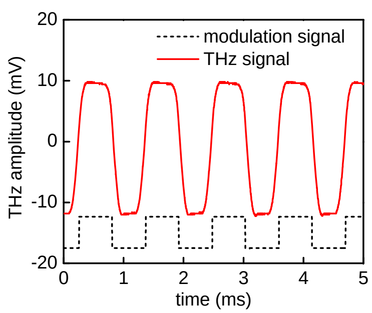
A GDD is a commercial neon lamp filled with low pressure inert gases with Penning mixture and typically coated with phosphor. Two electrodes are placed parallel within the lamp, which ionize the inert gases, resulting in discharge current. The incident THz wave enhances ionizing collisions of electrons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

- Low cost (less than $1)
- Electronic ruggedness
- Broad spectral range (MW, IR, UV)
- Room-temperature operation
- Fast response speed (microsecond rise time)

CW THz Imaging System

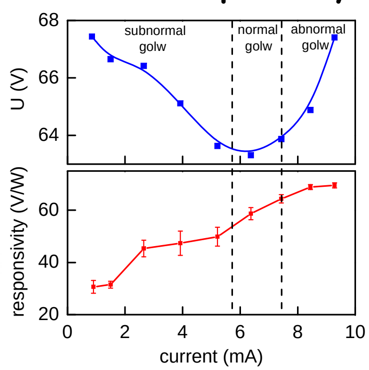


Schematic diagram of the 0.2 THz imaging system based on GDD.

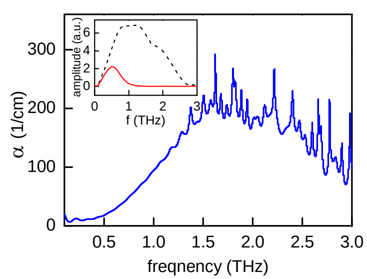


0.2 THz signal measured from the GDD by an oscilloscope. Chopping frequency : 900 Hz.

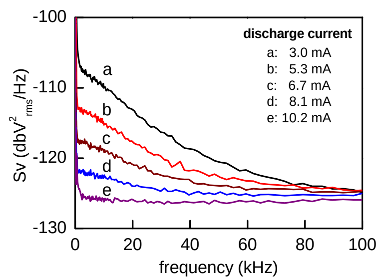
Responsivity and NEP of GDD



Amplified responsivity (Gain: 130)



Absorption coefficient of glass wall



Noise spectrum

$$NEP = \frac{\sqrt{noise\ power\ spectral\ density}}{responsivity}$$

$$= 1.26 \times 10^{-6} W / \sqrt{Hz}$$

when
:discharge current of GDD is 8.8 mA
:chopping frequency is 900 Hz

Deficient NEP caused by:

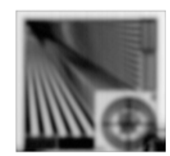
- Absorption of glass wall
- Scattering of glass wall
- Mismatch between THz beam size and gap size of GDD

THz Images (0.2 THz)

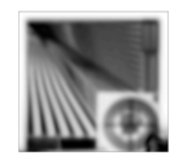
First Aid Kit

THz image by GDD

PC Board



GDD



Schottky diode

References

1. A. Abramovich, N. S. Kopeika, D. Rozban and E. Farber, *Appl. Opt.* **46**, 7207-7211 (2007).
2. D. Rozban, N. S. Kopeika, A. Abramovich, and E. Farber, *J. Appl. Phys.* **103**, 093306 (2008).

This material is based upon work supported by the U.S. Department of Homeland Security under Award Number 2008-ST-061-ED0001. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied of the U.S. Department of Homeland Security.