Electronically Tunable Terahertz Detector Using Plasmons

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In Partnership with:

Sandia National Laboratories
Why the need for THz research?

Technology Gap:
Gap between Electronics and Photonics.

Electronics fail to produce adequate power above several hundred GHz

Photonics fail to produce adequate power below several THz

*THz = Terahertz = 1 Trillion Cycles per second
Current technology operates at ~1-10GHz or ~1-10 billion bits per second.

Terahertz frequencies operate at ~1-10 THz or ~1-10 trillion bits per second.

THz Applications

- Technology applications
  - Information
    - Ultra fast signal processing
    - Massive data transmission
  - Environment
    - Atmospheric sensing
  - Defense
    - Chemical/Biological agent detection
    - Digital radar
    - Imaging
    - Covert communication
      - Space-space
      - Short range battle field
  - Unknown applications created by new technology

Millimeter-wave radar images taken 9 km from a nuclear power plant can detect when the plant is operating (upper image) or idling (lower image).

http://www.thznetwork.org
Final Goals

Goals:
- Research and develop terahertz electronics (300 GHz – 10 THz)

Objectives:
- Nanoelectronics for THz sources and detectors.
  - Detectors
    - Tunable detectors for THz using plasmonic resonance
  - Sources
    - THz Bloch oscillator.
Resonant Frequency

Plasmon frequency dependence

\[ f_p^2 \propto n \]

Electron Density
Resonant Frequency

Plasmon frequency dependence

\[ f_p^2 \propto n \]
The Split-Grating Gate Detector

Source  |  Drain

Finger Gate

Grating gates

AlGaAs  |  GaAs

4μM

1mm
Future Work

- Continue to chart device’s behavior
- Determine optimized settings:
  - Source/Drain Current
  - Wiring
  - Temperature
  - Frequency Range
- Implement device into applications
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Extra slides
Current Research

Voltage Response
Gate Voltage -500mV    Current 10uA

Voltage (V)

Timebase (s)
Current Research

Signal response and relax time vs current

Vg: -500 mV, 20 K
Wiring Diagram for Split-Grating Gate Detector

Polarization
Why Image in THZ?

- Can see through visibly opaque objects
- THz has no or minimal health risk
- Can use passive detection (QinetiQ, UK, US)
Security

find concealed weapons

fingerprint chemical and biological terror materials in packages, envelopes or air

locate hidden explosives and land mines
Medical Imaging

improve medical imaging

diagnose skin cancer

spot tooth erosion earlier than x-rays
Quality Assurance

count items in packages

count items in packages

control quality of pharmaceuticals

develop jobs in space shuttle components

help airline pilots navigate through fog

develop dangerous flaws in space shuttle components