

Introduction to

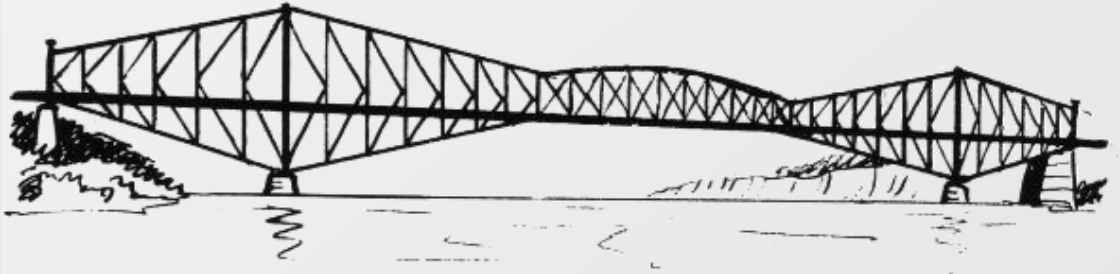
TERAHERTZ TECHNOLOGY

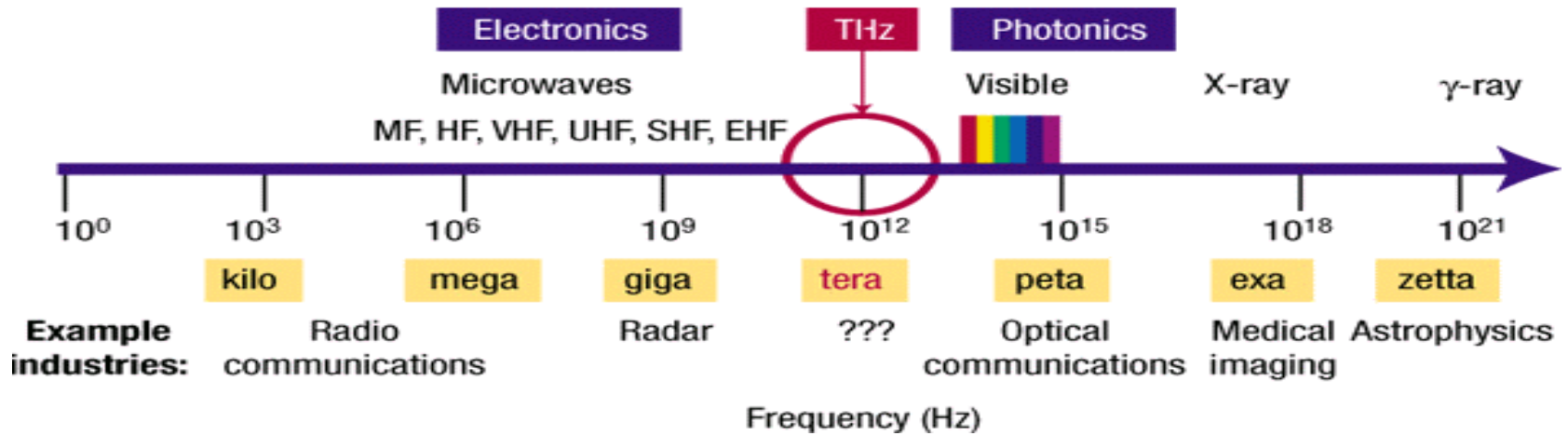
By Kittipong Kasamsook, Ph.D



งานประชุมวิชาการและนิทรรศการประจำปี 2559
ศูนย์เทคโนโลยีอิเล็กทรอนิกส์และคอมพิวเตอร์แห่งชาติ
12 กันยายน 2559 ณ ศูนย์ประชุมแห่งชาติสิริกิติ์

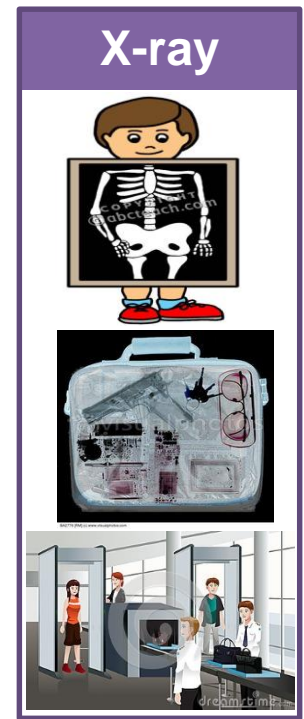
What is
Terahertz
(THz)?





Terahertz

- Frequency range: 0.1 - 10 THz
- Wavelength: 0.03 – 3 mm
- Wavenumber: 3.3 – 333 cm^{-1}
- Energy: 0.41 – 41 meV



Why's Terahertz?

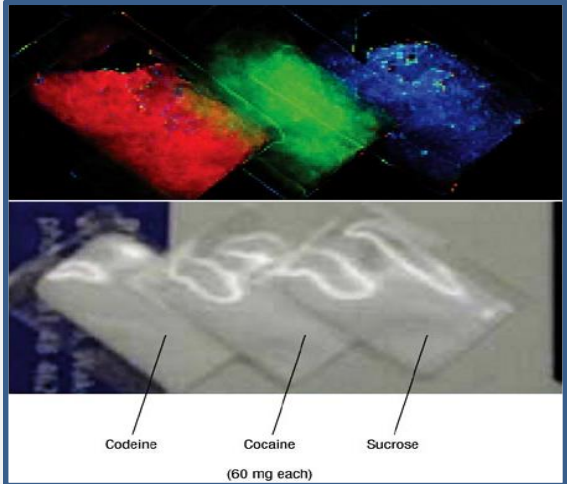
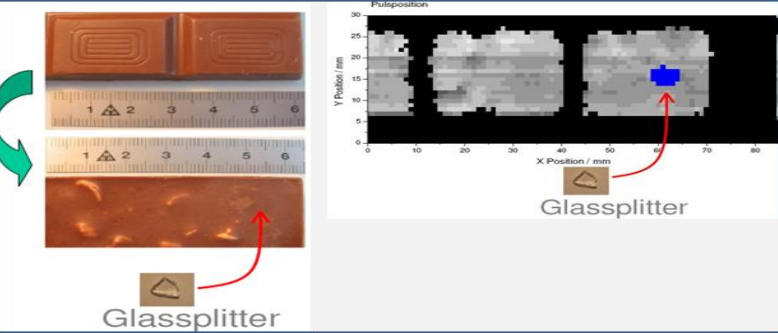
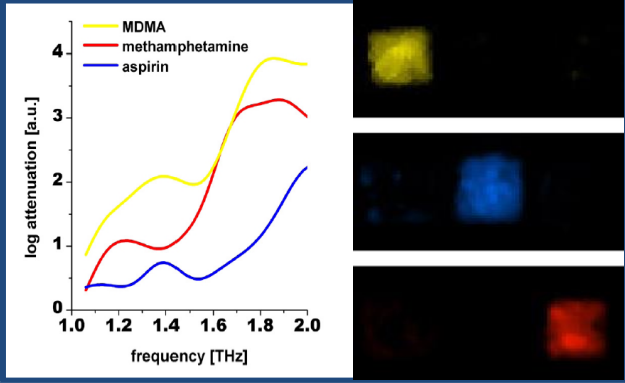
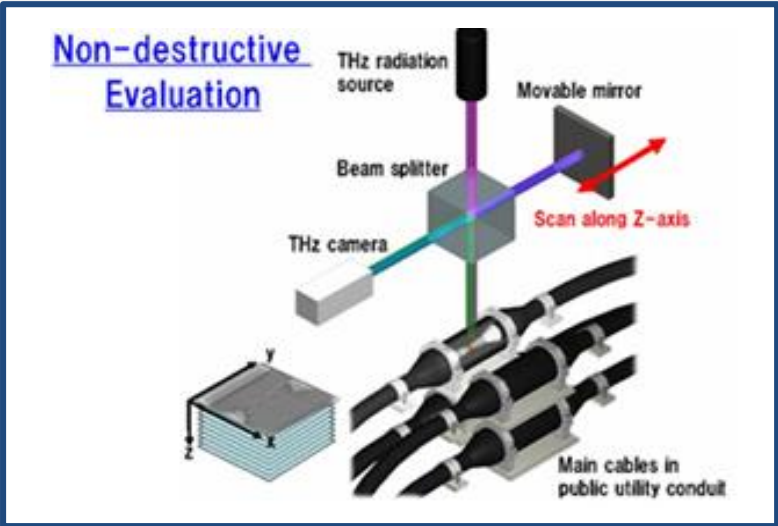
Terahertz Unique Properties

- THz radiation can penetrate through non-polar materials (e.g. plastics, wood, clothing)
- THz spectroscopy identifies specific materials (e.g. explosives)
- THz radiation is non-ionizing (and therefore safer than X-ray)
- THz radiation is strongly absorbed polar materials (e.g. water)
- Enabler for extreme high data rate communication

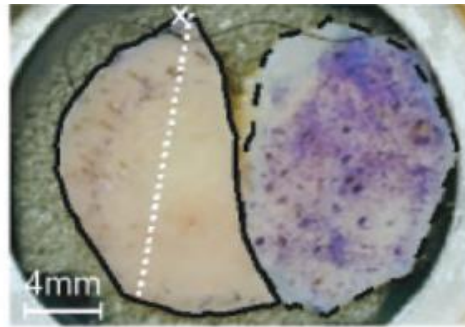
Terahertz Potential Impact & Application



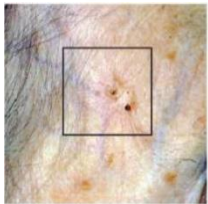
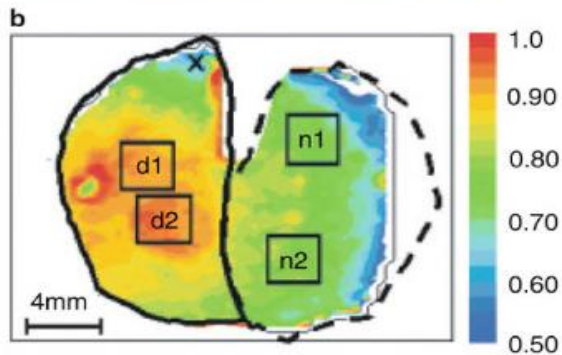
Non Destructive Testing (NDT) Application



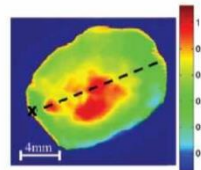
Medical Diagnostics



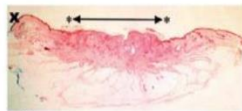
Time Post Pulse (Mean)



Clinical image



THz image



Histology section

Skin Cancer

Visible image of human tooth



Terahertz image of cavity in human tooth

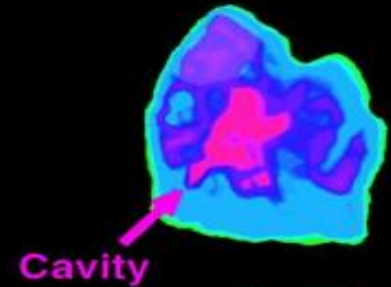
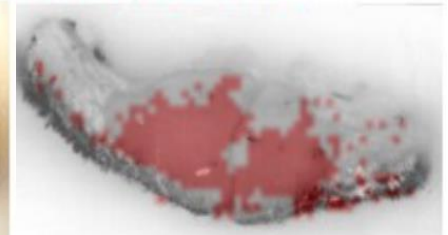
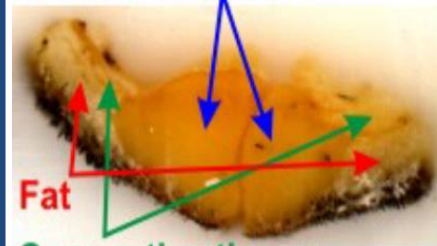


Image composed from absorption data

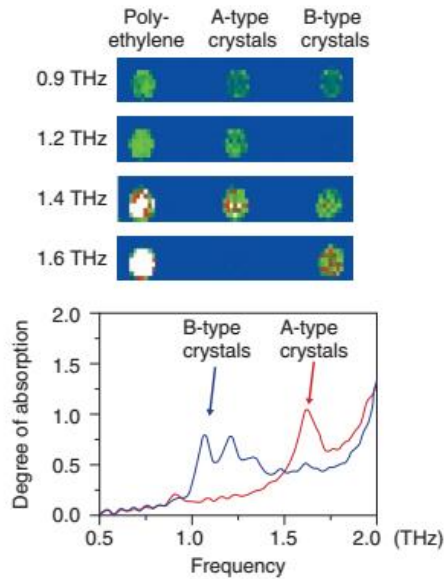
Tooth Cavity

Tumor

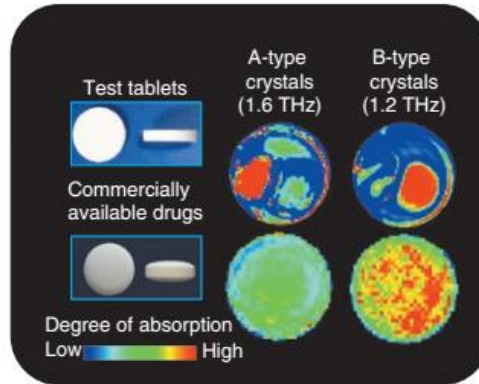


Dog Tumor

Pharmaceutical

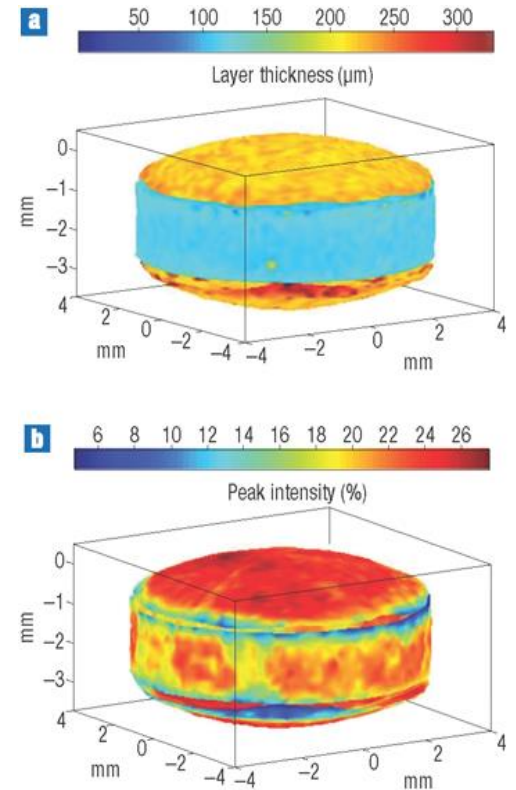


(a) Terahertz absorption spectra and transmittance images of a tablet of crystalline polymorphic famotidine.



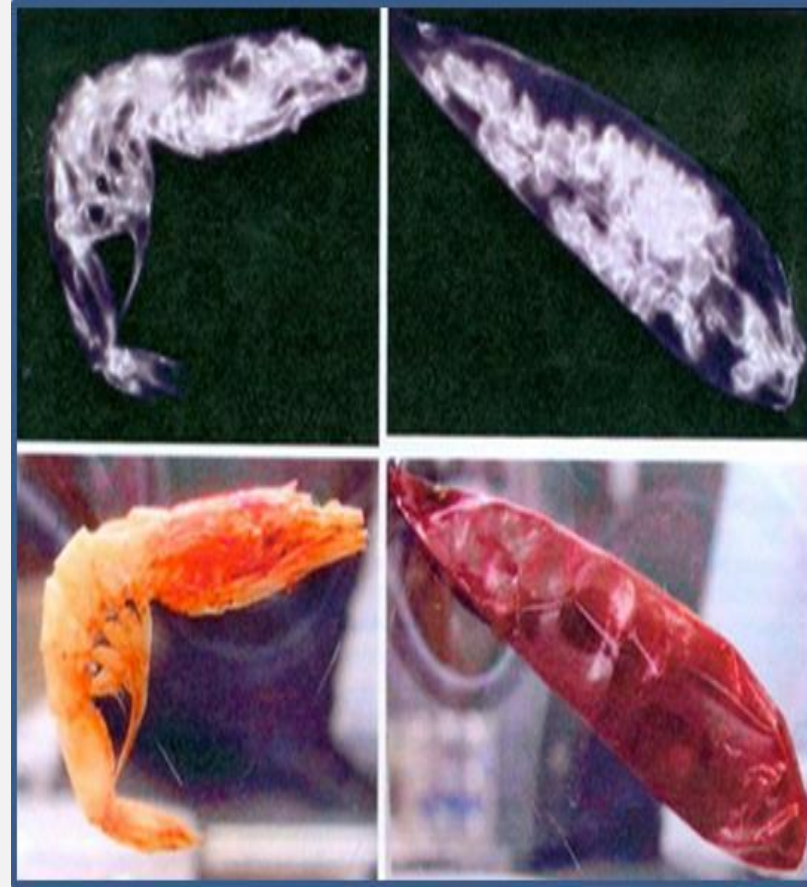
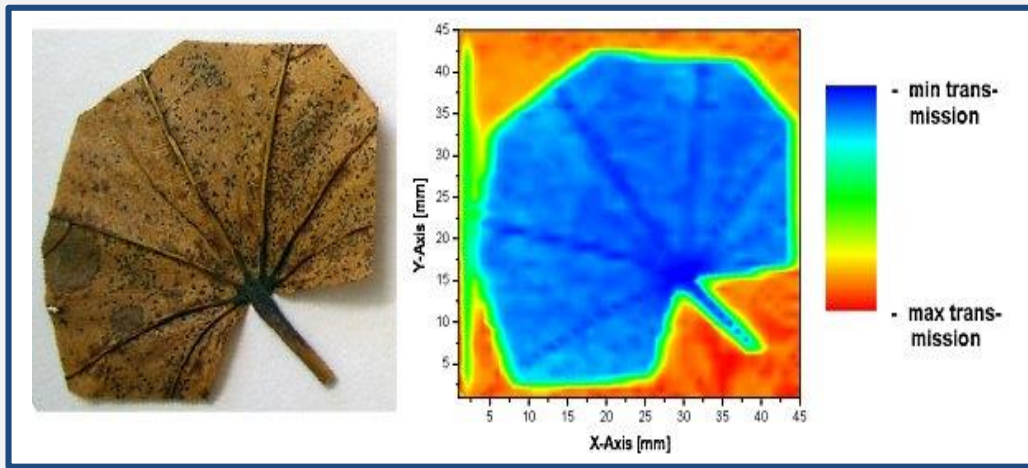
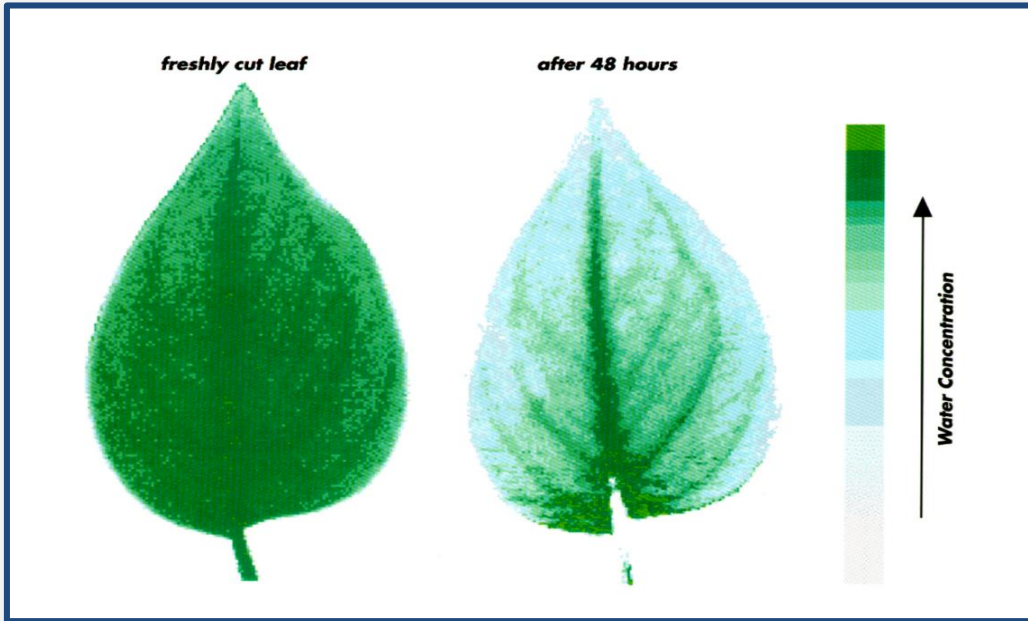
(b) Terahertz absorbance images of test and commercial tablets.

Crystalline Structure Analysis of drugs

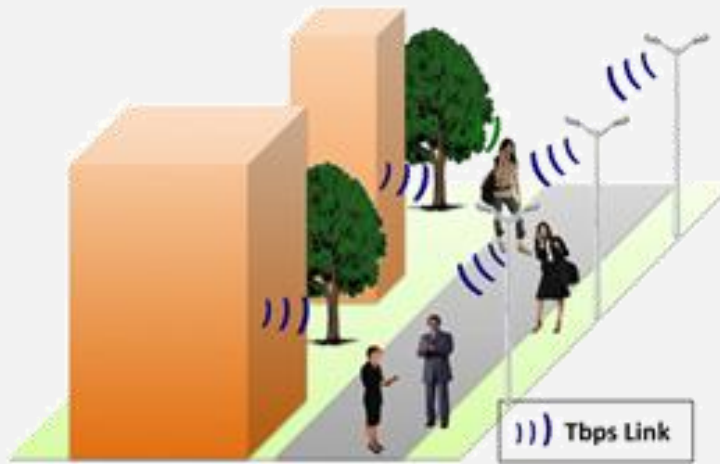


Tablet Coating Thickness In-line Control

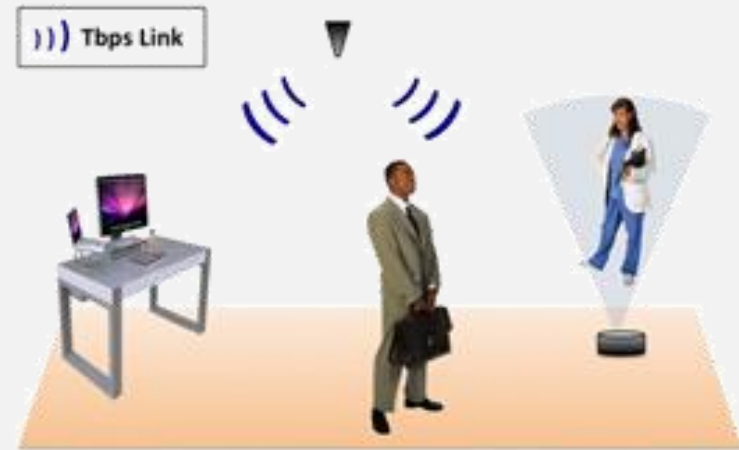
Agriculture



THz for Communication



(a) 5G cellular networks.



(b) Terabit wireless local area networks.



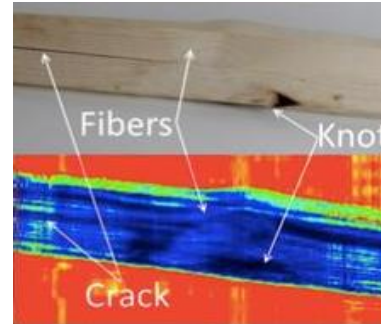
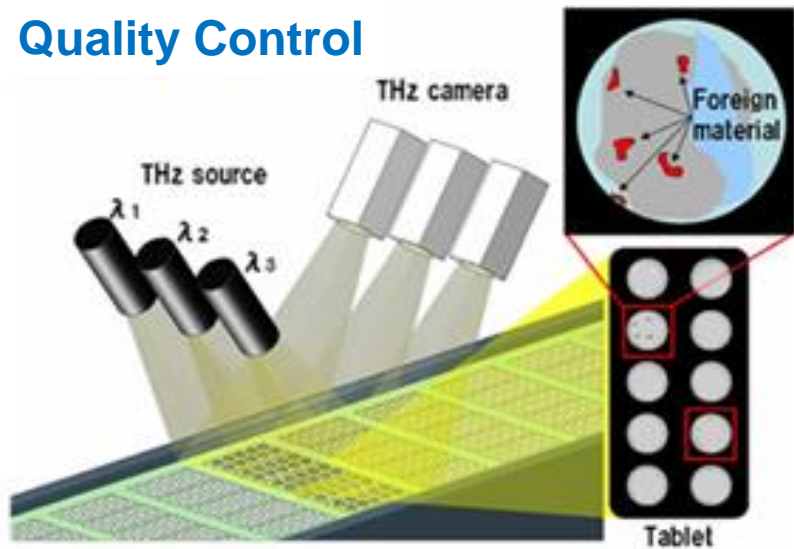
(c) Terabit wireless personal area networks.



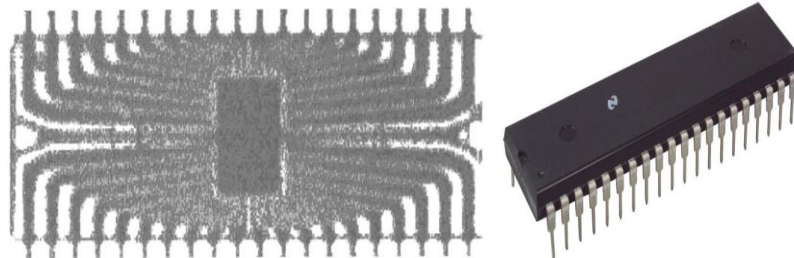
(d) Secure wireless communication for military applications.

QC Application

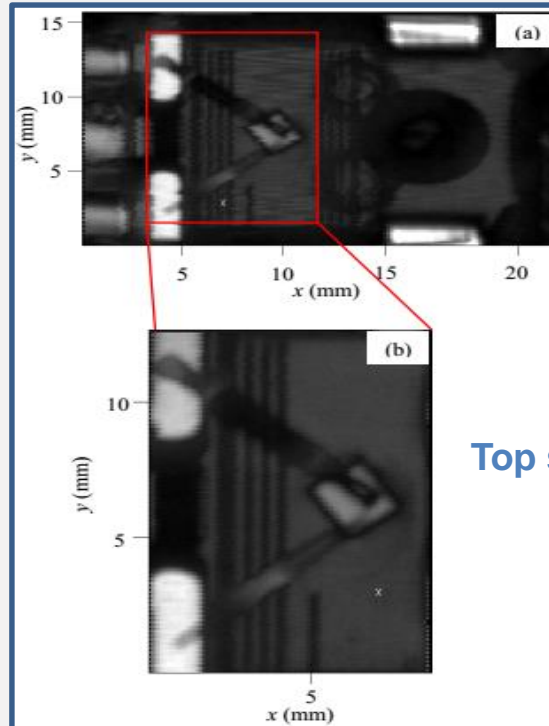
Quality Control



Wood Processing Industry



Inspecting Electrical Faults in Integrated Circuits



Top surface of Transistor

Security Scanning



Metal detectors

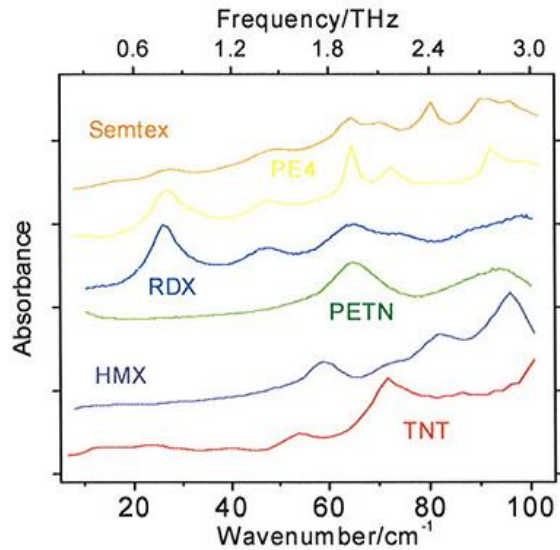


T-wave scanners

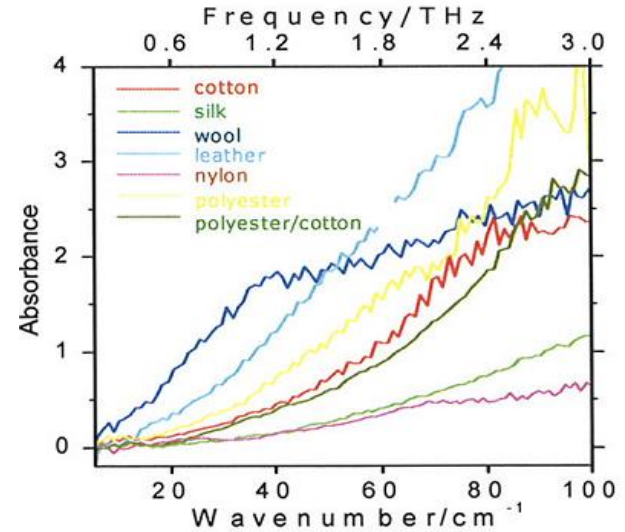


X-ray systems

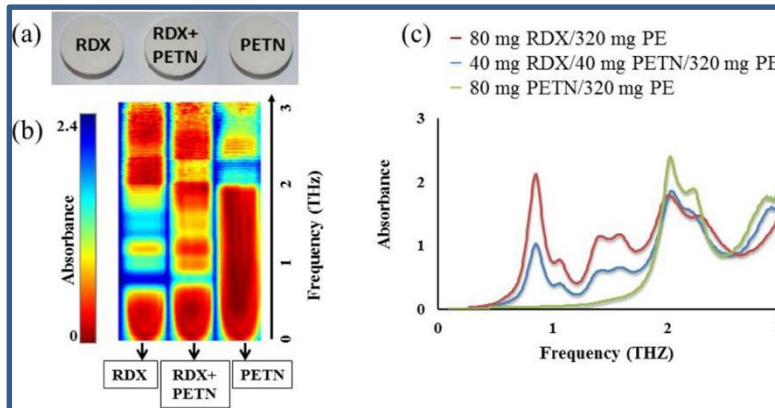
Security Scanning



T-Waves fingerprints of explosives-with sharp absorption features, including PETN used by attempted bomber in Detroit



T-Waves fingerprints of clothing-lack of sharp features allows for automated detection of explosives



Security Scanning

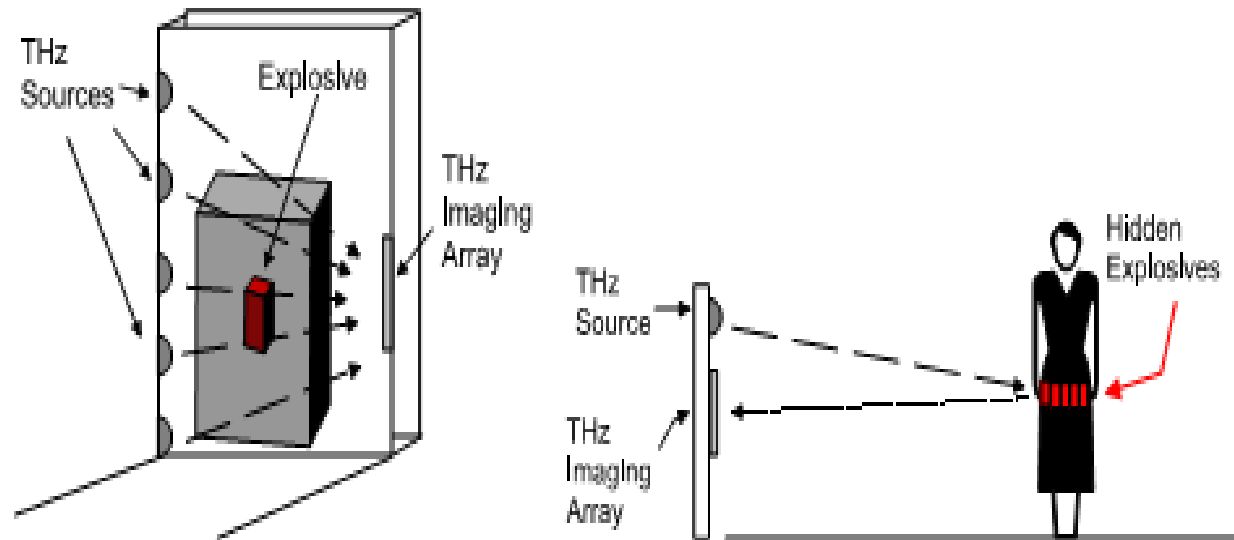
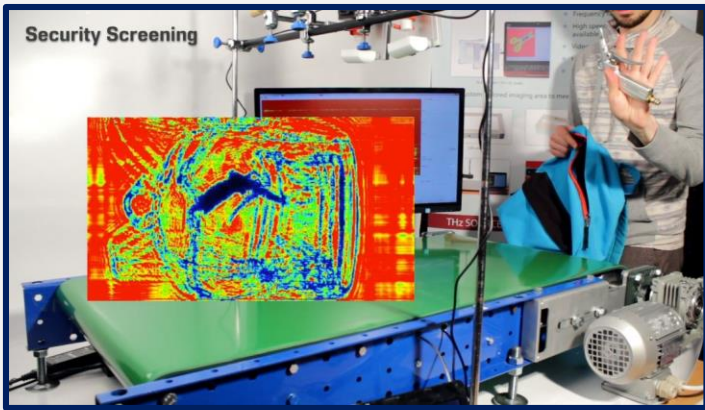
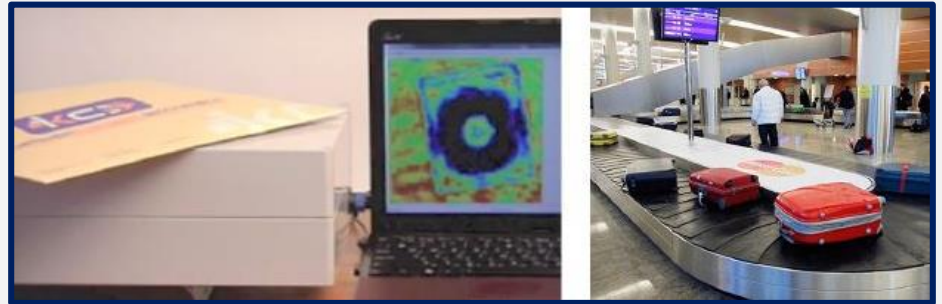
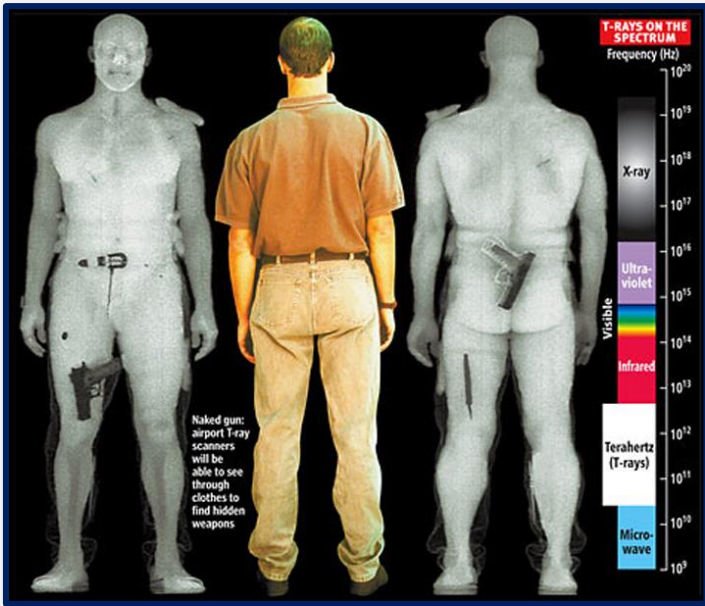
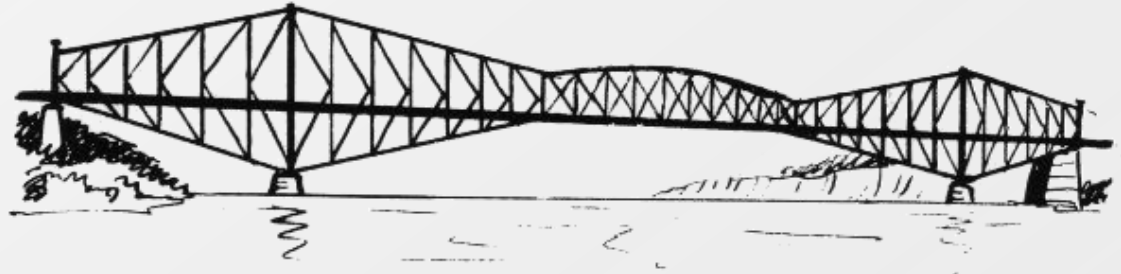


Illustration of a potential implementation of T-Waves imaging array in transmission mode (left) and reflection mode (right)

Terahertz Security Scanning



Comparison
with
Imaging
Known
Technology



3D Terahertz Imaging

A new method for Industrial Non Destructive Testing (NDT) ?

Strong competition by established methods:

X-ray: Industrial use since >100 years!

Ultrasound: Industrial use since > 50 years!

Active Thermography: Industrial use since > 20 years!

3D Terahertz Imaging: Industrial use since only > 3 years!

Terahertz Imaging VS X-ray CT



Pros.

- Easy handling, no protection necessary
- Access from only one side necessary
- Even components with size $>1\text{m}$ can be inspected

Cons.

- Lower resolution
- Can only be used for dielectric materials

Terahertz Imaging VS Ultrasound



Pros.

- Easy handling and non-contact (no preparation of samples)
- Inspection of foams, porous materials, hollow samples and sandwich samples

Neutral.

- Lateral resolution comparable

Cons.

- Can only be used for dielectric materials

Thank you



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