Physics

- Terahertz corresponds with the frequencies between 100 GHz to 10 THz
  - This rage is also called the Terahertz Gap because until recently there were no effective ways of producing or detecting them
  - Wavelengths of 3 millimeters to 30 micrometers
  - Between microwaves and infrared
- High chemical sensitivity
Physics

- Absorbed by water and many organic substances
  - Air moisture limits the propagation of terahertz rays to a few meters
    - the characteristic fingerprint enables high precision in humidity-sensitive measurements
  - Many common materials and living tissues are semi-transparent and have characteristic absorption lines
Physics

- Non-ionizing radiation
  - its photons are not energetic enough to knock electrons off atoms or molecules in human tissue
    - which can cause harmful chemical reactions like X-Rays can
  - emitted power is very low leading to insignificant amount of heat
Sources

- There is one main source for Terahertz radiation for commercial means.
- For both terahertz pulse spectroscopy and terahertz pulse imaging.
- This method was discovered in the late 1990’s and only became powerful enough in the last 4 years.
Sources

This commercial means is using a femto-pulsed laser and beam the light onto the sample and pick up the waves with a receiver.

That is the main way that the controversial scanners at airports work.
Many other sources have been used historically such as:

- The Gyrotron
  - High Powered Vacuum Tube
- Backward Wave Oscillator
  - Another Vacuum Tube and Electron gun
- Far Infrared Laser
  - Typical laser that produces light at the border of Infrared and Microwave
- Schotty diode
  - A typical diode but with very fast switching time, enough to pulse at terahertz speeds
- Varactor multipliers
  - Capacitors that work like Schotty Diodes
- Quantum cascade laser
  - Laser that can emit terahertz light
- Free electron laser
  - Laser with widely tunable spectrum from infrared to xray
- Synchrotron Light sources
  - We studied what the synchrotron is
- Photomixing Sources
  - The Laser technology I spoke of earlier, using Lasers and mixing them
The future technology is mainly concerned with data transfer and miniaturization.

Scientists have been able to make computer chips that transfer data at over 1 Ghertz using terahertz waves.

Some are also trying to make tiny antennas using graphene that would allow phones and low power devices to use that band.

Scientists in Japan broke the wireless transmission speed record with a terahertz diode that transmitted at over 3 Gbytes/sec over a range of 10 meters, which indicates that this technology could be used like a wireless router but at speeds 20 to 100 times faster than current connections.
Applications

- Non-destructive testing (NDT)
  - Useful for characterizing materials like wood, plastics, ceramics, and paper
    - Used in various analysis of paintings and other artifacts
    - Used to analyze uniformity and thickness of paints on metal, like cars
Applications

● Benefits from NDT
  ○ In car paint application
    ▪ Reduces paint use which in turn minimalizes cost as well as environmental impact
  ○ In ceramic structural analysis
    ▪ Offers a low cost method in analyzing aircraft composites for stress cracks and defects
Applications

● Medical imaging
  o Molecular imaging of epithelial cancer
  o Use as an intraoperative tool during breast cancer surgery
  o Early detection of enamel decay
Applications

● Benefits from medical imaging
  ○ Reduced treatment cost
  ○ Less hazardous than X-rays
  ○ Shown to be very accurate in surgery
  ○ Can provide a window of opportunity to reverse tooth decay
Applications

- Homeland security
  - Explosive detection
    - Explosives have a terahertz “fingerprint.” Some frequencies are absorbed while others aren’t
  - Mail screening
    - Goes right through paper but also reflects print. Able to noninvasively read mail content
      - This is terrifying
Applications

● Homeland security
  ○ Continuous Wave spectroscopy
    ▪ Used in detection of noxious gas
    ▪ Very accurate compared to infrared spectroscopy and other techniques
    ▪ Very low levels of false alarms
Resources

- www.teraview.com/index.html