Terahertz sensing technology

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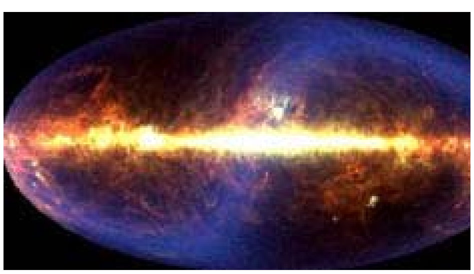
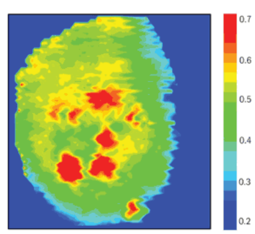
Terahertz sensing is enabling technology for detection of biological and chemical hazardous agents, cancer detection, detection of mines and explosives, providing security in buildings, airports, and other public space, short-range covert communications (in THz and sub-THz windows), and applications in radioastronomy and space research. This lecture will review the-state-of-the-art of existing THz sources, detectors, and sensing systems. As application examples, I will discuss THz space exploration, sensing of biological materials, broadband THz reflection and transmission detection of concealed objects, THz explosive identification, THz nanocomposite spectroscopy, and THz remote sensing [1].

Most existing terahertz sources have low power and rely on optical means of the terahertz radiation. Terahertz quantum cascade lasers using over thousand alternating layers of gallium arsenide and aluminum gallium arsenide have achieved the highest THz powers generated by optical means. Since the energy of a terahertz photon (4.2 meV for 1 THz) is much smaller than the thermal energy at room temperature, room temperature operation of THz lasers might be limited to the high frequency boundary of the terahertz range of frequencies (*e.g.* close to 30 THz). Improved designs and using quantum dot medium for THz laser cavities are expected to result in improved THz laser performance. Huge THz powers are generated using free electron lasers.

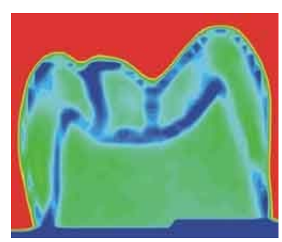
Two-terminal semiconductor devices are capable of operating at the low bound of the THz range, with the highest frequency achieved using Schottky diode frequency multipliers (exceeding 1 THz). High speed three-terminal electronic devices (FETs and HBTs) are approaching the THz range (with cutoff frequencies and maximum frequencies of operation above 1 THz and close to 0.5 GHz for InGaAs and Si technologies respectively. A new approach called plasma wave electronics recently demonstrated terahertz emission and detection in GaAs-based and GaN-based HEMTs and in Si MOS and SOI, including the resonant THz detection at room temperature.



COBE satellite composite galaxy image at THz wavelengths of 60, 100, and 240 um. (photo: Michael Hauser)



Imaging breast cancer (from Opto & Laser Europe, October 2002)



THz image of human tooth (http://www.teraview.com/ab_imageLibrary.asp)

1. D. Woolard, W. Loerop, and M. S. Shur (eds.), *Terahertz Sensing Technology, Vol. 1: Electronic Devices and Advanced Systems Technology*, Singapore: World Scientific, 2003 [ISBN 9812383344]; *Terahertz Sensing Technology, Volume 2: Emerging Scientific Applications and Novel Device Concepts*, World Scientific, 2003 [ISBN 9812386114].