FALL 2009
ECE594I – (Special Topics)
TOPIC: THz Science, Technology, and Systems
INSTRUCTOR: Elliott Brown
ENROLLMENT CODE: 56697
LOCATION: PHELPS 1431
TIME: TUES&THURS 4:00-5:50 P.M.

Spanning from 300 to 3000 GHz (or higher), the THz frequency region is one of the last frontiers of the electromagnetic spectrum and rapidly growing in popularity worldwide. As in the RF region below it, electronic devices are evolving that allow "field-based" rectification, amplification, mixing, and oscillation – the basic functionality in all RF systems, and guided-wave and transmission-line structures exist that can route and transform electromagnetic waves, albeit with much greater loss than in the RF region. As in the infrared region above THz, photonic devices are evolving that allow detection, mixing, and oscillation (i.e., lasing), and "quasi-optical" techniques exist that can route and transform electromagnetic waves in free space where components are simpler and losses are generally lower. This course aims to cover these technological issues as well as their implementation and integration into systems, both passive and active. An emphasis will be placed on active *sensor* systems (i.e., radars and active imagers) since they have shown the greatest promise recently, and are being actively pursued by a number of research groups for security (e.g., concealed object imaging) and medical (e.g., carcinoma and burn imaging) applications. In addition, the fundamental physics and chemistry of the THz region will be summarized, particularly the transition from classical to quantum transport in semiconductors and other solid-state materials, the behavior of optical phonons and related collective excitations in polar solids and large biomolecules such as nucleic acids and proteins, and the realization and utilization of quantum states and resonances. An overall emphasis will be placed on room-temperature phenomenology.

Tentative Syllabus:

- Radiative transfer: blackbody radiation, Kirchoff's relation, and propagation through common materials (vapor, solids, and liquids) at THz frequencies
- Electromagnetics and components at THz frequencies: skin-effect losses, diffraction effects, surface roughness effects, antenna types, waveguides, transmission lines, etc.
- Passive detection and sensor principles: direct and coherent detection with and without preamplification, sources of noise, radiometry, system sensitivity metrics (e.g. NEP and NETD), system resolution metrics (spatial and spectral).
- Active detection and sensor principles: transmitter types and associated waveform, detection mechanism (direct, coherent and in-between), effect of noise, radar-range equation, statistical detection theory based on maximum-likelihood criteria; probabilities of detection, false-alarm, etc.; receiver-operating characteristics (ROCs)
- Electron transport at THz frequencies: the transition from semiclassical to quantum Boltzmann transport, what happens when ν approaches k_BT/h, what happens when $\omega\tau$ approaches unity, etc.
- Collective excitations: optical phonons, plasmons, etc. Can the lifetime of these be long enough (> 1 ps) to be important at THz frequencies ?
- Low-lying quantum states: spatial quantization via quantum wells, superlattices, and quantum dots; Zeeman-split electron-spin states, etc.

Comments or suggestions welcome: contact E.R. Brown, erbrown@ece.ucsb.edu