ME 597F
Micro- and Nano-Scale Energy Transfer Processes

Course Objectives

Students in this course will:

1. Gain an understanding of the fundamental elements of solid-state physics.
2. Develop skills to derive continuum physical properties from sub-continuum principles.
3. Apply statistical and physical principles to describe energy transport in modern small-scale materials and devices

1. Microstructure of solids (1 week)

1. Atomic bonds
2. Crystalline, polycrystalline, amorphous materials
3. Bravais lattice, reciprocal lattice, Miller indices

2. Vibrations in solids (3 weeks)

1. Crystal vibrations, dispersion relations
2. Quantization and phonons
3. Phonon branches and modes
4. Lattice specific heat
5. Phonon scattering and heat conduction

3. Electrons in solids (2.5 weeks)

1. Electron structure and quantization
2. Free electron theory of metals
3. Fermi-Dirac statistics
4. Band structures of metals, semiconductors, and insulators
5. Electron scattering and transport

4. Photon-solid interactions (2 weeks)

1. Classical theories of EM waves in solids
2. Quantum theory of photon-solid interaction
3. Electron-hole recombination

5. Statistical transport theories (3 weeks)

1. Time and length scales
2. Boltzmann transport equation
3. Carrier scattering
4. Moments of the BTE

6. Modern applications (3.5 wks)

1. Monte Carlo simulation
2. Sub-continuum heat conduction
3. Electro-thermal modeling of semiconductor devices
4. Thermionics and thermoelectrics

Sample Projects

1. Thermal Effects on Operation and Reliability in Power Vertical DMOSFETs
2. Thermal Characterization of Field Emission from Diamond Thin Films
3. Microscale Engine Development: The Effect of Large Surface Area to Volume Ratio on Chemical Kinetics

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