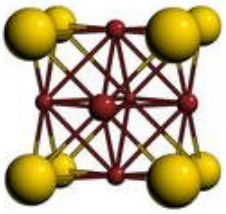
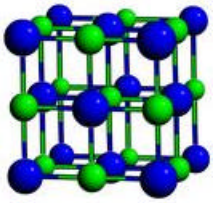


Introduction to Solid State Engineering ME265.03



Prof. Stefano Curtarolo
Room Hudson 229
Email: stefano@duke.edu

Who can take:	undergrads and grads
Who should take:	students of materials science & students interested in nanotech.
Exams:	3. Open-books, open-notes, open-homeworks OR take-home.
Homeworks:	One every week. Several problems.
When:	2:20 – 3:10 MWF
Where:	nobody knows
Grading:	problem sets 25%, exams 25% each.
Homepage:	TBA

Conductivity and Bands

- ✓ Origin of Ohm's Law and Drude Model
- ✓ Hall effect
- ✓ AC response of electrons
- ✓ Free electrons, plasma frequency, electromagnetic waves inside materials
- ✓ Electrons as waves and diffraction, wave-particle duality
- ✓ Bravais lattice, reciprocal lattice: structure factor
- ✓ Electron waves in solids
- ✓ Quantized electron energy: Boltzmann and Fermi-Dirac distributions
- ✓ Density of states for electrons. Fermi Energy
- ✓ Heat capacity

Quantum Mechanics stuff

- ✓ Nearly free electrons in solids
- ✓ Schrödinger Equation (introduction and justification)
- ✓ Periodic systems: Block theorem. Symmetry and properties of solutions
- ✓ Solution of SE in momentum space (Fourier)
- ✓ Band gap, excitations

Atoms, molecules, and materials.

- ✓ Hydrogen atom
- ✓ Chemistry approach: tight-binding model
- ✓ Bonding and building material atom by atom: Debye-Huckel model
- ✓ Electronic structure and polymer chains
- ✓ Hybridization
- ✓ Metals and insulators
- ✓ Band and Zones, carriers, effective masses

Semiconductors

- ✓ Intrinsic/extrinsic semiconductors
- ✓ Electrical activity of defects
- ✓ Hydrogenic model of extrinsic semiconductors

- ✓ Carrier, scattering, recombination and generation: defects, traps
- ✓ Drift diffusion and the continuity equations
- ✓ Diode: depletion region, built-in voltage and operation
- ✓ Electron in potentials: step, well, infinite well: quantum solutions
- ✓ Transistor and FET

Dielectric and optical properties of materials.

- ✓ Application of Maxwell's equations to capacitance
- ✓ Dielectric constant and polarizability
- ✓ Dielectric response at optical frequencies
- ✓ Local fields and Clausius-Mossotti relation
- ✓ Orientational, electronical, and ionical polarizability
- ✓ Pyroelectrics and ferroelectrics
- ✓ Defect and dielectric loss, dispersion attenuation in optical fibers
- ✓ Maxwell's equations in periodic systems: Photonic Band Gaps. Optical filters

Magnetic properties of Materials

- ✓ Application of Maxwell's equations to inductance
- ✓ Magnetization: paramagnetism, diamagnetism, ferromagnetism
- ✓ Microscopic origin of magnetization
- ✓ QM equations for magnetization and Hund's rule
- ✓ Pauli paramagnetism
- ✓ Exchange and ferromagnetism
- ✓ Mean-field theory, Ising model

Modern tools for quantum calculations in solids

- ✓ Introduction to *ab-initio:* many body problems
- ✓ Hartree-Fock approach
- ✓ Density Functional Theory: approximations, plane-waves, pseudo-potentials and k-points

References:

- ✓ TBA