**MatSci 351-2 Detailed Learning Outcomes for Kasap Chapters 5 and 6.1-6.2**

**Chapter 5 High Level Questions**

* Calculate the density of electrons and holes are available for conduction (prereq).
* Draw band diagrams for doped semiconductors in equilibrium. (prereq)
* Explain what factors determine the carrier mobility in semiconductors. (prereq)
* Given the dispersion (E vs. k relationship) and scattering rates, calculate the mobility. (prereq)
* Explain how and why the conductivity varies with temperature for metals and semiconductors. (prereq)
* What processes change the number of carriers in a given region of a semiconductor (light, heating, electric field, stress)?
* What are the drivers of charge carrier motion?
* How do junctions perturb the carrier concentrations in adjacent materials, and what processes control carrier transport at interfaces?

**Photoconductivity, Generation/Recombination (5.4, 5.7)**

* Describe how band structure (e.g. band gap, direct or indirect) and density of states influence the absorption of light in a semiconductor.
* Given the absorption coefficient, calculate the total light absorption and intensity versus depth.
* Calculate steady state conductivity due to absorption of light (photoconductivity), taking into account both generation and recombination.
* Identify microscopic processes that determine minority carrier concentration and time response of photoconductor, and how these depend on material purity and defect structure.

**Drift and Diffusion (5.5, 5.6)**

* Determine built in voltage associated with difference in doping and built in field associated with doping gradient.
* Draw band diagrams for semiconductors out of equilibrium: under bias, under illumination
* Predict behaviors of injected electrons/holes (drift, diffusion, recombination).
* Given the carrier concentration, describe origin and magnitude of diffusion current of electrons (and holes).
* Given the carrier concentration and electric field, describe origin and magnitude of drift current of electrons (and holes).
* Relate mobility (response to electric field) to diffusion constant (response to concentration gradient), i.e. derive the Einstein relation.
* Know the solutions for (or solve) the steady state continuity equation for the boundary conditions discussed in lecture and homework.
* Illustrate how microscopic generation and recombination processes influence charge carrier concentrations and currents.

**Schottky and Ohmic Contacts (5.9, 5.10)**

* Describe how equilibrium is reached between a metal and a semiconductor, and the effect on the energy bands.
* Identify the microscopic processes that lead to current at the metal-semiconductor junctions.
* Calculate the current in a Schottky diode under forward and reverse bias, and explain the behavior in terms of the influence of the applied voltage on the bands.
* Given knowledge of the work function, electron affinity, and doping, predict when a metal-semiconductor junction will form an Ohmic or Schottky contact.

**pn Junctions (6.1, 6.2)**

* Describe how equilibrium is reached between semiconductors of different doping levels, and the effect on the energy bands.
* Calculate the built in voltage and built in field of a pn junction.
* Describe how the built in voltage and built in field of a pn junction are influenced by the semiconductor band-gaps and doping levels.
* Identify applications that make use of built in voltage and/or field, and relate these quantities to important performance metrics.

**Diffusion Currents in pn Junctions (6.1.2)**

* Describe effect of forward bias on space charge region and minority carrier distribution.
* Identify source of minority carrier diffusion currents outside the depletion region.
* Calculate the forward bias current due to diffusion.
* Relate semiconductor band gap to turn on voltage of diode.

**Generation and Recombination Currents in pn Junctions (6.1.3)**

* Provide semi-quantitative argument for recombination current under forward bias.
* Explain relative magnitudes of diffusion and recombination currents based on band gap and doping.
* Describe thermal generation process in depletion region and sign of resulting current.
* Explain reverse bias dependence of current based on contributions of diffusion and generation.