EE566 Solid State Devices
Spring 2007
Dept of Electrical Engineering
University of Notre Dame
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Assignment 6
Posted: 03/06/2007
Due: 03/19/2007

Reading
Class notes + Chapters 5 (& start reading Chapter 6) of Muller/Kamins/Chan **(MKC).**

Problem 1 (Heterojunction currents)
Instead of a homojunction diode, let us see what happens if a heterojunction is used as the emitter. The doping density in a GaAs based heterostructure p-n junction is $N_D=10^{17}/cm^3$ and $N_A=10^{16}/cm^3$. Design the emitter-base junction by introducing $Al_xGa_{1-x}As$ in the emitter layer, such that the total current in the diode improves by a factor of $\eta=100$ than the normal GaAs p-n junction. Work out the following -

a) Solve the zero-bias p-n junction problem and determine the depletion thicknesses on both sides.
b) Design your emitter layer such that there are no spikes that impede the current flow. Make generous use of 1D Poisson.
c) Explain why the depletion-edge in the emitter should encompass the whole change in the bandgap, ΔE_G.
d) What are the advantages of the heterojunction over the homojunction? What are the disadvantages?

Problem 2 (Generation-recombination currents)
Problem 5.10, **MKC** (keep your approach dimensionally correct to make life easier – not a trivial problem).

Problem 3 (Recombination currents in the space-charge region)

Problem 5.12, **MKC** (Label your sketches carefully, this is a qualitative question).

Problem 4 (p-n junction switching: design problem)

Problem 5.14, **MKC**.

Problem 5 (Charge storage and transit times in short-base diodes)

Problem 5.18, **MKC**.

Problem 6 (Solar Cell Device Physics)

Consider a *single* junction solar cell in operation, with G_{op} being the generation rate of carriers. The open-circuit voltage V_{OC} is defined as the voltage at which the current through the cell is zero. Similarly, the short-circuit current I_{SC} is defined as the current flowing through the cell when the applied bias across it is zero. From your knowledge of diode current flow mechanisms, find the bias voltage V_{max} for the cell at which the conversion of solar power in to electric is *maximized*. Plot the minority carrier profiles inside, and around the edges of the depletion region when the cell is biased at $V_{bias}=0$, V_{max}, and V_{OC}.

Sketch the solar spectrum (intensity vs wavelength) on the earth's surface, and outside the atmosphere. Explain why, to convert the radiation into electrical energy with the *highest efficiency*, one needs to use p-n junctions made of *multiple* semiconducting materials (the so-called multi-junction cells). What is the highest efficiency reported till date for a semiconductor solar cell?