Homework #4 Due Friday Oct. 20, 2000

Note: Deadline extended to Monday Oct. 23, 2000

1. A piece of n-type silicon is doped with $10^{17}$ cm$^{-3}$ shallow donors. Calculate the density of electrons per unit energy at $kT/2$ above the conduction band edge. $T = 300$ K.

2. A metal-semiconductor junction consists of platinum and gallium arsenide with $N_d = 10^{17}$ cm$^{-3}$. The applied voltage equals -3 V. Calculate the electric field in the semiconductor at the metal-semiconductor interface. Use $\phi_i = 0.8$ V.

3. Phosphorous donor atoms with a concentration of $10^{16}$ cm$^{-3}$ are added to a pure sample of silicon. Assume that the phosphorous atoms are distributed homogeneously throughout the silicon. The atomic weight of phosphorous is 31.
   a) What is the sample resistivity at 300 K?
   b) What proportion by weight does the donor impurity comprise? The density of silicon is 2.33 gram/cm$^3$.
   c) If $10^{17}$ atoms cm$^{-3}$ of boron are included in addition to phosphorous, and distributed uniformly, what is the resulting resistivity and conductivity type (i.e., p- or n-type material)?
   d) Sketch the energy-band diagram under the condition of c) and show the position of the Fermi level.

4. Find the equilibrium electron and hole concentrations and the location of the Fermi level for silicon at 27°C if the silicon contains the following concentrations of shallow dopants.
   a) $1 \times 10^{16}$ cm$^{-3}$ boron atoms
   b) $3 \times 10^{16}$ cm$^{-3}$ arsenic atoms and $2.9 \times 10^{16}$ cm$^{-3}$ boron atoms

5. The electron concentration in a piece of lightly doped, n-type silicon at room temperature varies linearly from $10^{17}$ cm$^{-3}$ at $x = 0$ to $6 \times 10^{16}$ cm$^{-3}$ at $x = 2$ $\mu$m. Electrons are supplied to keep this concentration constant with time. Calculate the electron current density in the silicon if no electric field is present. Assume $\mu_n = 1000$ cm$^2$/V-s and $T = 300$ K.