HW 8

due Friday 4/20/2012

EE40

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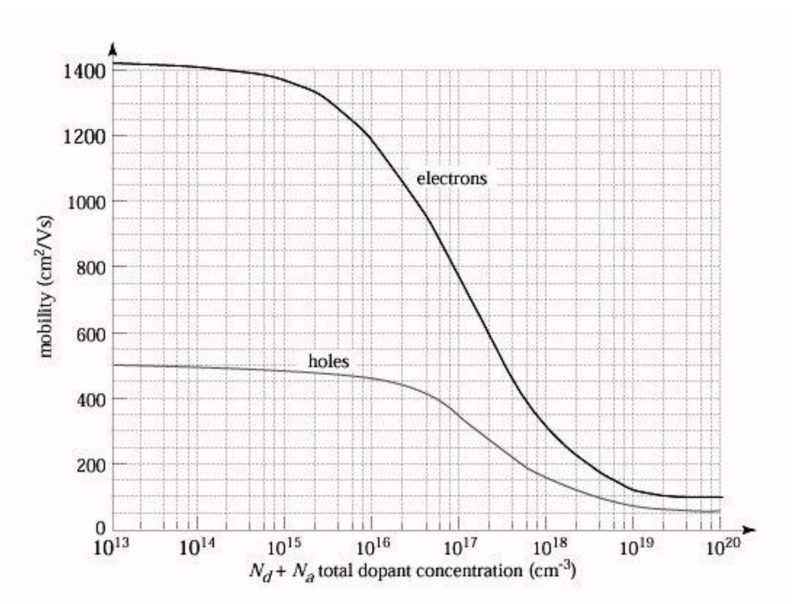
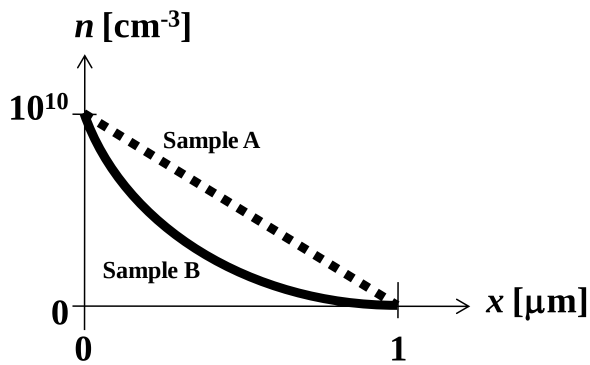
1. The first transistors were fabricated using germanium (Ge) as the semiconductor material. Ge has a much smaller bandgap energy ($E_{g,Ge}$ = 0.66 eV) than silicon ($E_{g,Si}$ = 1.12 eV). Would you expect the intrinsic carrier concentration in a Ge sample to be larger or smaller than that in a Si sample maintained at the same temperature? Explain your answer qualitatively, *i.e.* without resorting to any equations.

2. Consider a Si sample maintained under thermal equilibrium conditions at T = 300K, doped with arsenic at a concentration of 3×10^{16} cm^{-3}.
   a) Is this material n-type or p-type? What are the majority and minority carrier concentrations?
   b) Suppose this sample is additionally doped with phosphorus at a concentration of 10^{16} cm^{-3}. How will the carrier concentrations change? Explain qualitatively why this is the case.

3. The electron and hole mobilities in Si at 300K are plotted as a function of **total** dopant concentration below. Consider a silicon sample maintained at 300K, doped with arsenic at a concentration of 10^{17} cm^{-3}.
   a) If an electric field equal to 0.2V/μm is applied, what are the drift velocities of the electrons and holes?
   b) Calculate the resistivity of this sample.
   c) How will the resistivity of this sample change if it were to be additionally doped with boron to a concentration of 2×10^{17} cm^{-3}?

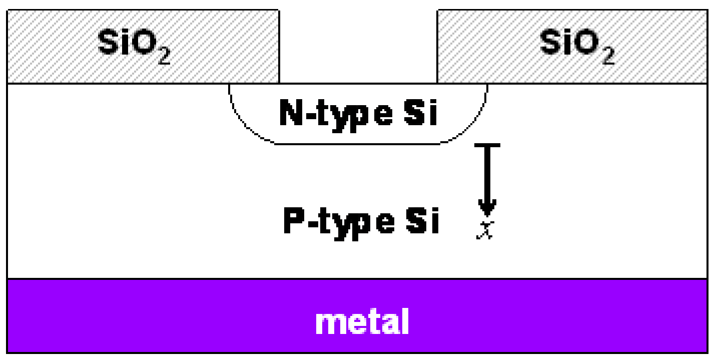


4. Suppose electrons are continuously injected (at x = 0) into two p-type silicon samples maintained at 300K (each with $N_A = 10^{17}$ cm^{-3}), resulting in the following electron concentration profiles:



a) Indicate the direction (+*x* or –*x*) of electron diffusion and the direction of electron current flow.
b) In which sample is the electron injection rate larger? Explain briefly.
c) Calculate the diffusion current density (in units of A/cm^2) in Sample A.

5. Suppose a PN junction is formed by locally introducing arsenic into the surface region of a silicon sample that is uniformly doped with 3x10^{17} cm^{-3} boron:



The arsenic concentration is uniformly 3x10^{18} cm^{-3} in the N-type region. You may use the depletion approximation.

a) Calculate the built-in potential, V_0.
b) Calculate the width of the depletion region, W_{dep}.
c) Calculate the junction capacitance, C_j, in units of F/cm^2.