

Exam #1 — EE 482  
Winter 2009

The test is open book/open notes. Show all work. Be sure to state all assumptions made and **check** them when possible. The number of points per problem are indicated in parentheses. Total of 100 points in 5 problems on 4 pages.

1. Sketch energy band diagrams ( $E$  versus  $k$ ) for two semiconductor (A and B). Assume that the two materials have the same scattering lifetime and the properties of the two materials are such that:
  - Semiconductor A has a significantly smaller electron mobility than B.
  - Semiconductor A has a larger density of states in its valence band than B. (They each have a single valence band).
  - Semiconductor A has a much smaller intrinsic carrier concentration than B.
  - Most recombination in semiconductor A gives off photons, while only a small fraction of recombination events emit photons in B.

To get partial credit, note what you can conclude about the bandstructure from each of these properties. (25)

2. Heavily damaged silicon ( $E_g = 1.12\text{eV}$ ) is doped with  $N_a = 5 \times 10^{16}\text{cm}^{-3}$  of boron. It is found that at 300K the Fermi level is located 0.4eV above the valence band maximum. The lattice defects resulting from damage have a donor level 0.3eV above the valence band and an acceptor level 0.6eV above the  $E_V$ .

(a) What is the density of lattice defects? (15)

(b) What is the resistivity of this sample (assume that only ionized impurities contribute significantly to scattering)? (15)

3. Light is incident on a silicon wafer doped with  $10^{14}\text{cm}^{-3}$  of boron. The recombination lifetimes are  $\tau_n = 1\mu\text{s}$  and  $\tau_p = 2\mu\text{s}$ . The traps are located at 0.2eV below the intrinsic Fermi level. If the electron concentration is increased by a factor of  $10^{10}$  due to the light, determine the generation rate of hole-electron pairs. Justify any assumptions made. (20)

4. In a silicon sample in equilibrium, the net doping is  $N_d(x) = 10^{17} \exp(x/100\text{nm})\text{cm}^{-3}$  (no variation in y and z). Assuming charge neutrality, what is the electric field at  $x = 0$ . (15)
5. For an ideal interface between silicon ( $E_g = 1.12\text{eV}$ ,  $\chi_s = 4.05\text{V}$ ) doped such that  $E_F - E_V = 0.1\text{eV}$  and copper ( $\phi_M = 4.4\text{V}$ ), what would be the voltage dropped between metal and semiconductor with zero applied bias? (10)

End Of Exam