Homework 1

1. An 8” wafer currently sells for about 100$, and a 12” wafer currently sells for approximately 400$. Assuming 1mm dies:
    a. How many dice do you get from each wafer? Show your work, don’t forget to exclude partial dice! (8” and 12”)

    b. Does the increase in size from 8” to 12” wafers make financial sense if you only consider the silicon cost? Calculate cost/die for each.

    c. Assuming a marginal increase in process costs with size, total per-wafer cost of processing increases also from 500$ for the 8” process to 600$ for the 12” process. Calculate the cost/die for each wafer size, and state the overall % change in the cost/die.

    d. Does the increase in size make financial sense when including processing costs?

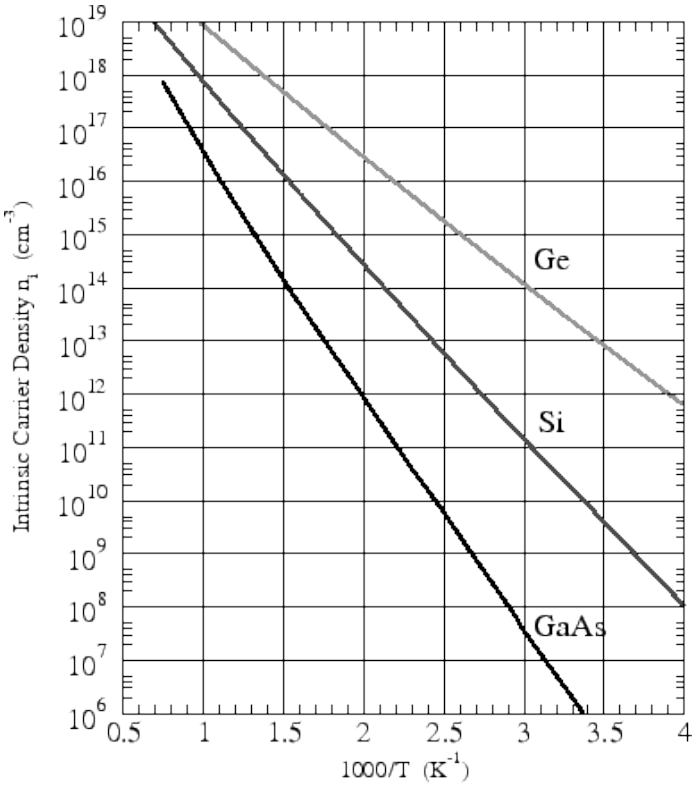
2. Starting with an intrinsic piece of Si which subsequently is doped by Indium with a concentration of $1x10^{17}cm^{-3}$. Assuming T = 300K.
    a. Is this a n or p type doping, why?

    b. After doping, is the E_F (fermi level) closer to the E_c (conduction band) or E_v (valence band)?

    c. Calculate the exact value of E_F-E_i in eV. Assuming silicon bandgap to be 1.12eV and equivalent effective mass (in other words $E_i = E_g/2$)

    d. Is this considered degenerate doping, why or why not?

    e. Now calculate the value of E_F-E_i in eV at T = 1300K given the following information:



(Sze & Ng 2007)

3. Consider a piece of silicon doped with Phosphorus (P, which has an ionization energy of 45meV) at a concentration of $1x10^{16}cm^{-3}$ and referring to the figure attached in Prob. 1e).
    a. What is E_F-E_i at T=300K?

    b. What is E_F-E_i at T=400K?

    c. Qualitatively, what starts to happen to E_F-E_i at T ≥ 600K?

d. What is E_F-E_i at T=0K? Why? (Might help to draw all of the energy bands/levels.) Calculate E_F-E_i at T=0K for this sample.

e. Does your answer to the last part (2d) change if we dope the silicon with a different donor material? If so, how does the value change? Calculate E_F-E_i at T=0K for n-type dopant of Arsenic (As). (Hint: ionization energy is 54meV for As when doped in silicon.)

f. Does your answer to 2d change if we dope the silicon with an acceptor rather than a donor? Calculate E_i-E_F at T=0K for p-type dopant of Boron (B). (Hint: ionization energy is 45meV for B when doped in silicon.)