EE 471: Transport Phenomena in Solid State Devices

HW 4

Due: 2/27/18

Please show all working (including equations you use to calculate your answers).

All numerical answers should include units

Calculate numerical answers to 3 sig. figs.

1. A vertical silicon diode with a shallow P diffusion of $N_a = 1.5 \times 10^{18}\ cm^{-3}$ above a deep N diffusion of $N_d = 1.1 \times 10^{16}\ cm^{-3}$ is to be used as a photodiode. Assume that:

   Electron minority carrier lifetime $\tau_n = 6 \times 10^{-7}\ s$
   Hole minority carrier lifetime $\tau_p = 1 \times 10^{-6}\ s$
   Electron mobility $\mu_n = 1150\ cm^2/V.s$
   Hole mobility $\mu_p = 180\ cm^2/V.s$

   a. If the bandgap of silicon is 1.1 ev, what can you say about the wavelength of light that might be absorbed by this photodiode? *(3 points)*
   b. How should the diode normally be biased to act as a photodiode? Why? *(3 points)*
   c. If the diode is reverse biased with $V_r = 3.5V$, what is the width of the depletion region? *(3 points)*
   d. What are the minority carrier diffusion lengths in the N and P neutral regions? *(6 points)*
   e. Estimate the transit time for a hole crossing the depletion region from the N-side to the P-side. *(3 points)*
   f. The depth of the P diffusion is 1 μm and the depth of the N diffusion is 13 μm. Is this a short or a long photodiode as described in Lecture 6, Slide 15? What depth of silicon will be available to absorb photons and generate optical current? *(4 points)*
   g. The photodiode is illuminated with light of $\lambda = 700nm$. At this wavelength, the absorption coefficient $\alpha = 1000\ cm^{-1}$. What fraction of the incident light will be absorbed in the active region of the photodiode? *(4 points)*
   h. If the area of the photodiode is $50\mu m \times 25\mu m$, what power of incident light (in W/cm^2) will be required to generate a photocurrent of 5.0 nA ? *(4 points)*

2. A new semiconductor has a direct bandgap of 2.07 eV. What would you expect to observe if a PN junction diode made with this material were forward biased ? (5 points)