Assignment 7: Optical properties

1. A sample of GaAs is 0.35 μm thick. It is illuminated with light source of energy 2 eV. Determine the percentage of light absorbed through the sample. Repeat the calculation for Si. Take absorption coefficients of GaAs and Si, for that wavelength, to be 5×10^5 and 8×10^4 cm^{-1} respectively.

2. A sample of semiconductor has a cross-sectional area of 1 cm^2 and thickness of 0.1 cm. Determine the number of EHPs that are generated per unit volume by the uniform absorption of 1 W of light at a wavelength of 630 nm. If the excess minority lifetime is 10 μs, what is the steady state excess carrier concentration?

3. Suppose that a direct band gap semiconductor with no traps is illuminated with light of intensity $I(\lambda)$ and wavelength λ that will cause photo generation. The area of illumination is $A = (LxW)$ and the thickness (depth) of the semiconductor is D. If η is the quantum efficiency and τ is the recombination lifetime of the carriers, show that steady state conductivity is given by

$$\Delta\sigma \;=\; \sigma\,(in\ light) \;-\; \sigma\,(in\ dark)$$

$$\Delta\sigma \;\frac{e\eta I\lambda\tau(\mu_e \;+\; \mu_h)}{hcD}$$

   A photoconductive cell has CdS crystal 1 mm long, 1 mm wide, 0.1 mm thick with electrical contacts at the end. The receiving area is 1 mm^2 and the contact areas are 0.1 mm^2. The cell is illuminated with blue radiation of 450 nm wavelength and intensity 1 $mW\ cm^{-2}$.

   (a) Calculate the number of EHPs per second.

   (b) The photoconductivity of the sample

   (c) The photocurrent produced when 50 V is applied to the sample.

CdS photo conductor is a direct band gap semiconductor with E_g of 2.6 eV, electron mobility $\mu_e = 0.034\ m^2V^{-1}s^{-1}$, and hole mobility $\mu_h = 0.0018\ m^2V^{-1}s^{-1}$.

4. Suppose that a GaAs sample is illuminated with a 50 mW HeNe laser beam (wavelength 632.8 nm) on its surface. Calculate how much power is dissipated as heat in the sample during thermalization. The band gap of GaAs is 1.42 eV.

5. A Si sample with 10^{15} $donors\ cm^{-3}$ is uniformly optically excited at room temperature to create $10^{19}\ cm^{-3}s^{-1}$ electron-hole pairs. Find the separation of the quasi-Fermi levels and the change in conductivity upon shining the light. Electron and hole lifetimes are both 10 μs. Take $D_p = 12\ cm^2s^{-1}$.