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 $5 \times 10^5$ and $8 \times 10^4 \text{ cm}^{-1}$ 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 $\lambda$ that will cause photo generation. The area of illumination is $A = (LxW)$ and the thickness (depth) of the semiconductor is $D$. If $\eta$ is the quantum efficiency and $\tau$ is the recombination lifetime of the carriers, show that steady state conductivity is given by

$$\Delta \sigma = \sigma (\text{in light}) - \sigma (\text{in dark}) = \frac{\eta I \lambda \tau (\mu_e + \mu_h)}{hcD}$$

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 $\mu s$. Take $D_p = 12 \ cm^2s^{-1}$. 
