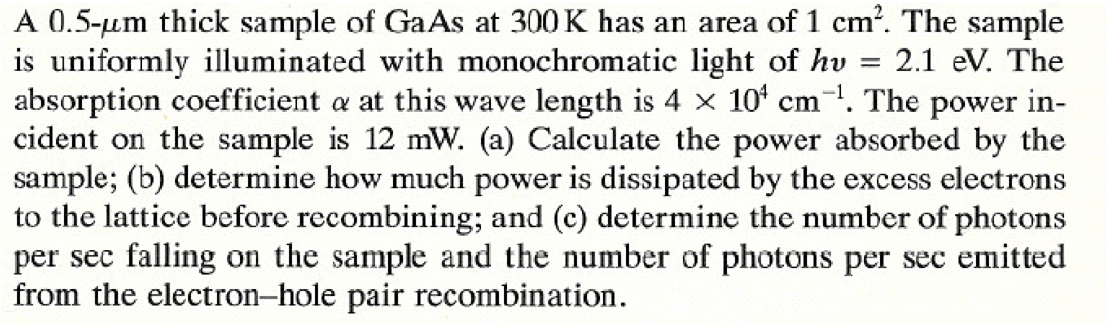
ELEG 646; ELEG 446 - Nanoelectronic Device Principles – Spring 2005
Homework #4 - due Tuesday, 22 March 2005, in class

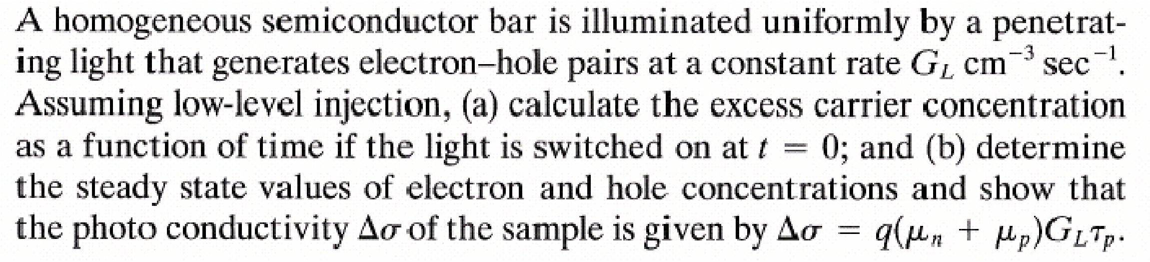
1.



A 0.5-μm thick sample of GaAs at 300 K has an area of 1 cm^2. The sample is uniformly illuminated with monochromatic light of $h\nu = 2.1$ eV. The absorption coefficient α at this wave length is 4×10^4 cm^{-1}. The power incident on the sample is 12 mW. (a) Calculate the power absorbed by the sample; (b) determine how much power is dissipated by the excess electrons to the lattice before recombining; and (c) determine the number of photons per sec falling on the sample and the number of photons per sec emitted from the electron–hole pair recombination.

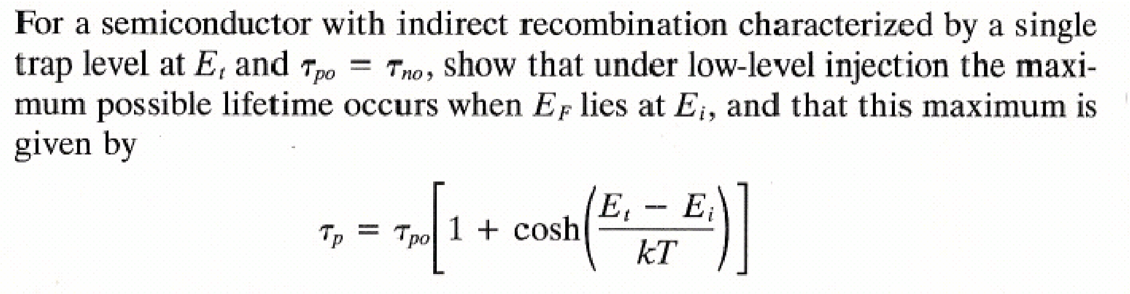
2. Let the sample in Prob. 1 (above) be n-type with $n_o = 10^{16}$cm^{-3}. (a) Assuming that each of the absorbed photons produce one electron-hole pair in the sample, calculate the excess electron and hole concentrations in the steady state. (b) Calculate the photoconductivity (see problem 3 below) of the sample and determine whether it is the case of low- or high-level injection. Use the data from Table 1.3 for GaAs.

3.



A homogeneous semiconductor bar is illuminated uniformly by a penetrating light that generates electron–hole pairs at a constant rate G_L cm^{-3} sec^{-1}. Assuming low-level injection, (a) calculate the excess carrier concentration as a function of time if the light is switched on at $t = 0$; and (b) determine the steady state values of electron and hole concentrations and show that the photo conductivity $\Delta\sigma$ of the sample is given by $\Delta\sigma = q(\mu_n + \mu_p)G_L\tau_p$.

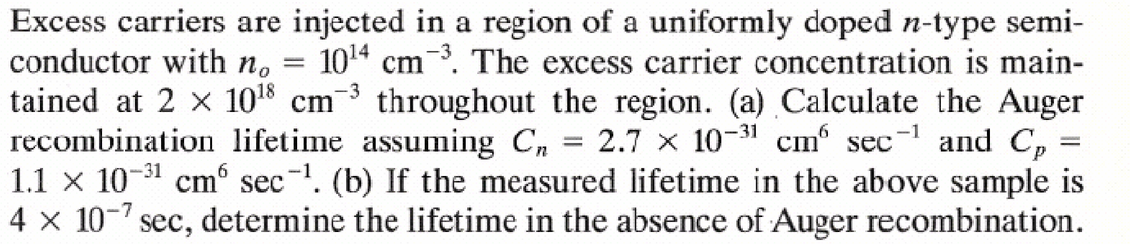
4.



For a semiconductor with indirect recombination characterized by a single trap level at E_t and $\tau_{po} = \tau_{no}$, show that under low-level injection the maximum possible lifetime occurs when E_F lies at E_i, and that this maximum is given by

$$\tau_p = \tau_{po}\left[1 + \cosh\left(\frac{E_t - E_i}{kT}\right)\right]$$

5.



Excess carriers are injected in a region of a uniformly doped n-type semiconductor with $n_o = 10^{14}$ cm^{-3}. The excess carrier concentration is maintained at 2×10^{18} cm^{-3} throughout the region. (a) Calculate the Auger recombination lifetime assuming $C_n = 2.7 \times 10^{-31}$ cm^6 sec^{-1} and $C_p = 1.1 \times 10^{-31}$ cm^6 sec^{-1}. (b) If the measured lifetime in the above sample is 4×10^{-7} sec, determine the lifetime in the absence of Auger recombination.

Homework assignments will appear on the web at:
http://www.ece.udel.edu/~kolodzey/courses/eleg646s05.html

Note: On each homework and report submission, you must please give your name, the due date, assignment number and the course number.