1. A 100 mW laser beam with wavelength $\lambda = 6328$ Å is focused onto a GaAs sample that is 0.5 μm thick. The absorption coefficient at this wavelength is 3×10^4 cm^{-1}, the bandgap is $E_g = 1.42$ eV at 300 K, and $m_e^* = 0.067\ m_o$.
   a) Find the number of photons emitted per second by radiative recombination in the GaAs, assuming perfect quantum efficiency.
   b) What is the power delivered to the sample as heat?
2. An aluminum layer having the work function $q\phi_m = 4.1$ eV is deposited onto a SiC substrate. SiC has an electron affinity of 3.9 eV and a bandgap of 3.0 eV and its effective density of states at room temperature of $N_C = N_V = 2.51 \times 10^{19}$ cm^{-3}. Determine the doping type and level so that the work function of the SiC matches the Al layer at room temperature.

1) The fraction of incident power absorbed is $f = 1 - e^{-\alpha L}$ where α is absorpt coeff and L = thickness.

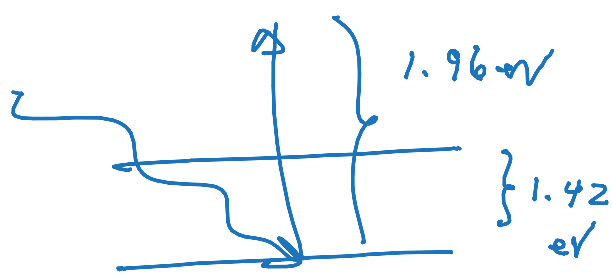
Here $f = 1 - \exp(-3\times10^4 \cdot 0.5\times10^{-4}) = 0.777$

The energy of an incident photon is

$$E_{ph} = h\frac{c}{\lambda} = \frac{6.63\times10^{-34} \times 3\times10^{8}}{632.8\times10^{-9}} = 3.14\times10^{-19}\text{ J} = 1.96\text{ eV}$$

$\Rightarrow$ #photons/s absorbed is

$$\#ph/s = \frac{f \cdot 100\times10^{-3}}{3.14\times10^{-19}} = 2.47\times10^{17}\text{ photons/s}$$



q	1.6×10^{-19} C	electron charge
ϵ_o	8.85×10^{-14} F/cm	permittivity of free space
K_s	11.8 (Si)	relative dielectric constant
K_o	3.9 (SiO_2)	relative dielectric constant
k_B	8.617×10^{-5} eV/K	Boltzman's constant
h	6.63×10^{-34} J s	Planck constant
m_o	9.11×10^{-31} kg	electron mass
k_BT/q	0.0259 V at 300 K	thermal voltage
c	3×10^8 m/s	speed of light

Each excited electron falls back down to C.B. edge (giving off heat) and then with unity quantum efficiency emits a photon.

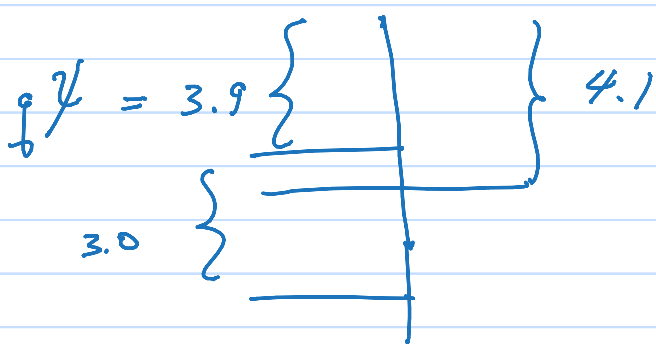
$$\Longrightarrow \frac{\#\text{ph emitted}}{s} = 2.47\times10^{17}\ \frac{\text{ph}}{s}$$

The heat generated is this number $\times\ E_{ph} - E_g = 0.54\ eV$

$$\text{Heat} = 2.47\times10^{17} \times 0.54 \times 1.6\times10^{-19}\ J/s$$

$$\text{Heat} = 21.5\ mW$$

2)



- E_F close to CB $\Rightarrow$ n-type
- $n = N_c\, e^{(E_F - E_c)/kT}$

$$= 2.51\times10^{19} \times e^{-0.2/.0259}$$

$$= 8.15\times10^{15}\ cm^{-3}$$