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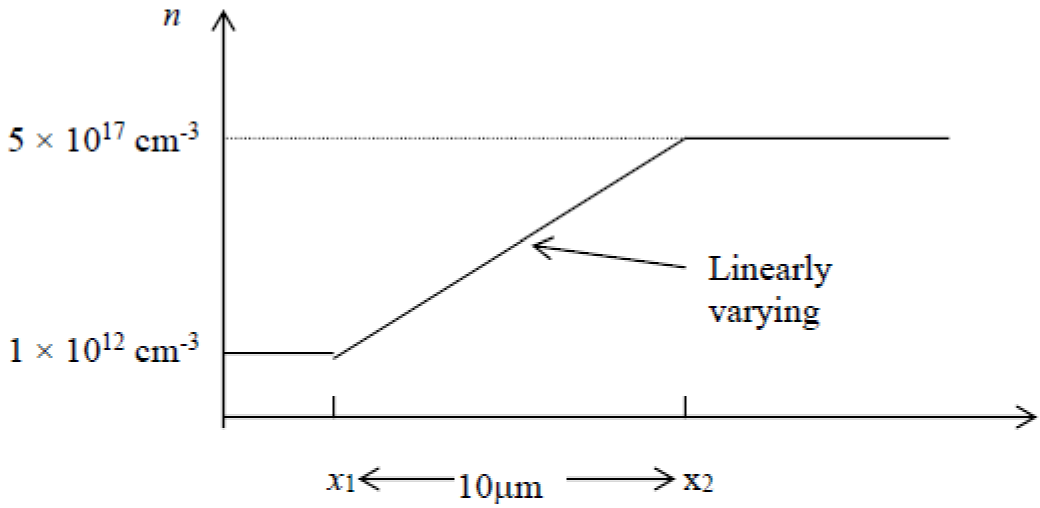
Microelectronics HW4

1. A silicon sample maintained at 300 K under thermal equilibrium has a non-uniform doping concentration profile, such that the electron concentration, n, varies linearly from 1×10^12 cm^-3 to 5 × 10^17 cm^-3 while going from point x1 to point x2 (see figure below). Assume that the mobility is constant at 1000 cm^2/Vs throughout the sample. Answer the following.



   a. Calculate the diffusion coefficient, D_n (in cm^2/s) for the electrons.

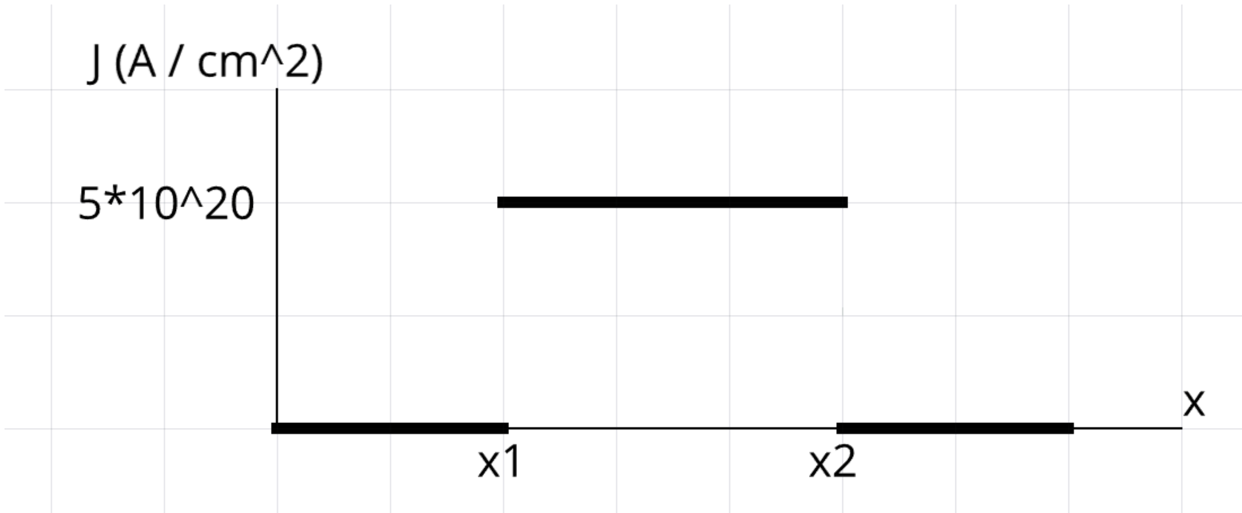
D_n=kT/q * u_n = .0256*1000=25.6 cm^2/s

   b. Explain why the electrons do not diffuse everywhere such that the concentration is uniform throughout.

Because there is non uniform doping.

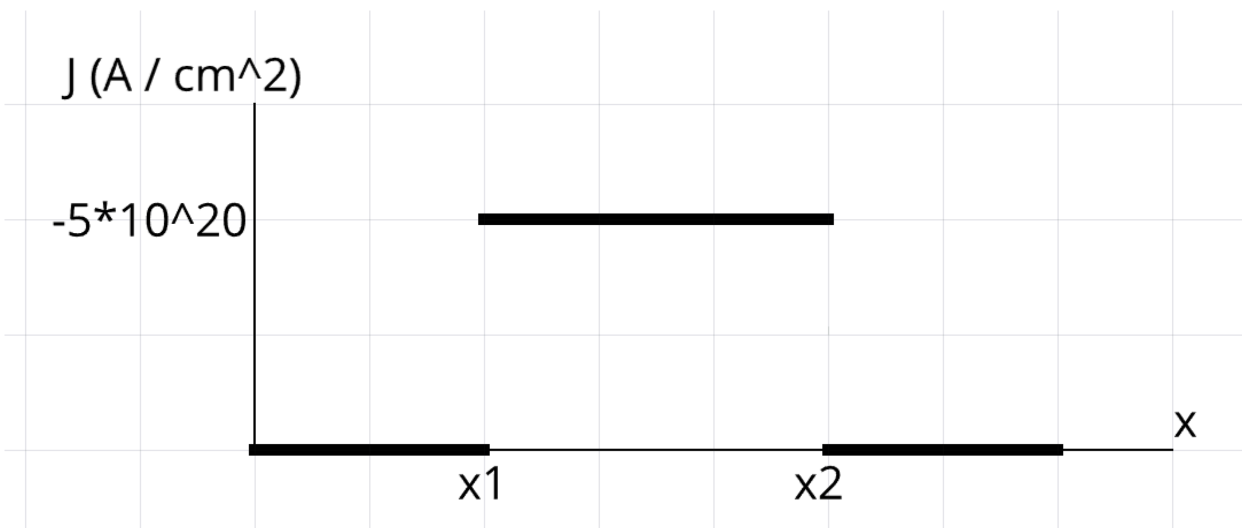
   c. Plot the diffusion current density (A/cm2) for the electrons as a function of x. Mark the numerical value on the graph. (Hint: What is the equation for diffusion current density?)

J_ndiff=q D_n delta n
1.60*10^-19 * 2.56 * slope = 5*10^20 A/cm^2
C * cm^2s^-1 cm^-3 cm^-1 = A cm^-2



d. Plot the drift current density for electrons as a function of x (Hint: What should be the total current? Then, obtain answer to this from part c).

Total current is 0, so drift must cancel out diffusion



e. Plot the energy band diagram as a function of x. (Hint: Plot the band diagram for x < x1 and for x > x2 and then plot qualitatively between x1 and x2).

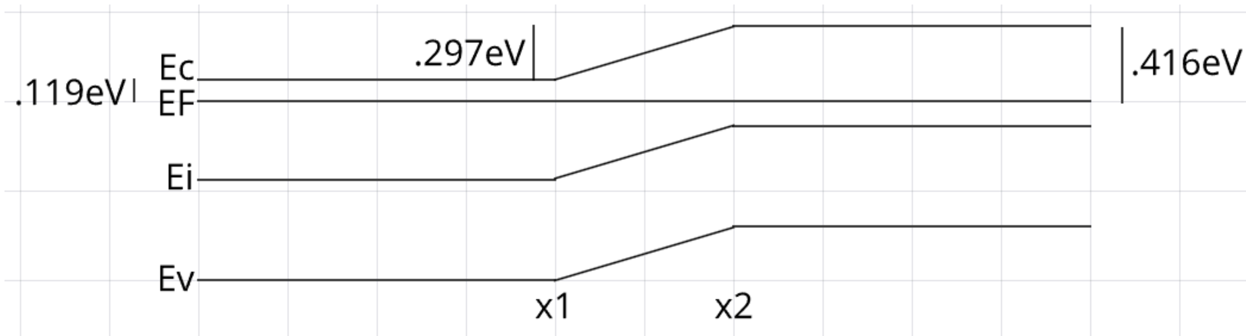
n=n_i e^((EF-Ei)/kT)

10^12=10^10 e^((EF-Ei)/0.0258)

10^2=e^((EF-Ei)/0.0258)

0.0258 ln(10^2)=EF-Ei=0.119

0.0258 ln(10^7)=EF-Ei=0.416

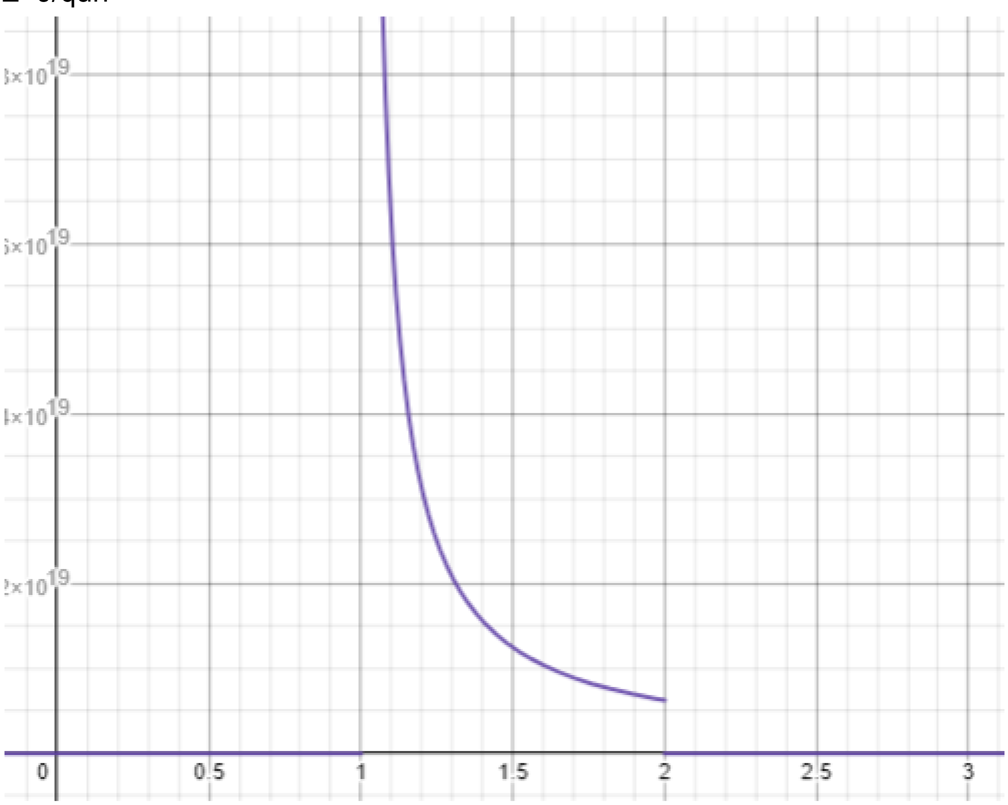


f. What is the potential difference (give a numerical value) between the two ends of the sample? (Hint: Read it off from the band diagram!)

.297eV

g. Plot a graph of the electric field versus x. (Hint: You can get this from part d and from the equation for the electron drift current density).

J=qunE
E=J/qun



2. A 5-Ohm resistor is to be made from a bar-shaped piece of n-type Si. The bar has a crosssectional area of 10^{-2} cm^2. The silicon is doped with $N_D = 5 \times 10^{17}$cm^{-3} and $N_A = 4 \times 10^{17}$ cm^{-3}. Determine the length of the silicon bar.

$n=10^{17}$

$p=10^3$

$rho=1/(q(u_n n + u_p p))=0.0625$

$R=rho*l/c$

$l=Rc/rho$

$=0.8$cm