ECE/PHY 235: Introduction to Solid State Electronics, Fall 2024
University of Wisconsin, Madison
Homework #7, Instructor Ying Wang
Due Friday, Nov 22th , 11:59 PM, by electronic upload

The drift and diffusion current;

1. An n-type silicon sample has a donor concentration of $N_D=10^{16}$ cm^{-3} at room temperature (T=300 K). Assume the electron mobility is $\mu_n=1350$ cm^2/Vs.
    a) Derive the expression for drift current density J_{drift}
    b) If an electric field of E=100 V/cm is applied, calculate the drift current density.
    c) Discuss how J_{drift} changes if the mobility is reduced due to increased doping to $N_D=10^{18}$ cm^{-3} (assume $\mu_n=400$ cm_2/Vs) (hints: how the scattering gets affected when the population of dopants increases)

2. A p-type silicon sample has a hole concentration of 10^{17} cm^{-3}. The diffusion coefficient for holes is $D_p=12$ cm^2/s.
    a) If the hole concentration varies linearly from 10^{17} cm^{-3} to $5\times10^{16}cm^{-3}$ over a distance of 50 μm, calculate the diffusion current density.
    b) Compare this to the drift current density if an electric field of 10^3 V/cm is applied and the mobility for p-type silicon is 450 $cm^2/V\cdot s$.

3. A silicon sample has a non-uniform electron concentration given by $n(x)=5\times10^{15}$ $cm^{-3}+3\times10^{14}$ $cm^{-4}\cdot x$. The sample is also subjected to an electric field of E=50 V/cm. Assume $\mu_n=1350$ cm^2/V and diffusion coefficient $Dn=35cm^2/s$.
    a) Derive the total current density $J_{total}=J_{drift}+J_{diff}$
    b) Calculate J_{drift}, J_{diff}, and J_{total}, at x=10 μm.
    c) Discuss the relative contributions of drift and diffusion currents to the total current.

Please upload a write-up of your solution as a single PDF file. Name the file "Lastname_HW7.pdf"