EE 735
Assignment – 6
TCAD SDE pn Junction

8^{th} Oct 2019

Hints, assumptions and instructions:

1. Assume uniform doping of p and n regions and an abrupt junction between them.
2. Assume Ohmic contacts.
3. Refer to the user manual whenever you need help. For recombination models, refer to chapter-16 of sdevice_ug.pdf
4. You can use equations to give explanations but you also need to give a physical/intuitive reasoning for full credit.
5. Ensure that every plot has properly labelled x, y-axis and a corresponding legend.
6. Specify any physical quantity with the units.
7. It is mandatory to submit your code with the report (in pdf) in a single zip folder. Name the file as "RollNumber_Assignment6" for this assignment.

Questions:

Q1. Consider a pn junction as shown in Figure 1; $\mathrm{N_A} = 1\mathrm{e}18\ \mathrm{cm}^{-3}$ and $\mathrm{N_D} = 1\mathrm{e}18\ \mathrm{cm}^{-3}$

(a) Plot the band diagram (conduction, valence band edge and quasi-Fermi levels) along x, at equilibrium i.e. applied bias=$\mathrm{V_A}$ = 0V. What is the approximate depletion width?

(b) Plot the free electron and hole concentration along x.

Q2. Now apply a bias to the pn junction and use only SRH recombination model.

(a) Plot the band diagram in forward and reverse bias conditions. What is the depletion width (approx. values from the plots) and maximum electric field for $\mathrm{V_A} = \{0\mathrm{V}, -5\mathrm{V}, +2\mathrm{V}\}$. Give qualitative explanation for the variations.

(b) Plot the I-V characteristics of the device from a reverse bias of 10 V to a forward bias of 2V in both linear and semi log scale. Qualitatively explain the nature of the I-V characteristics.

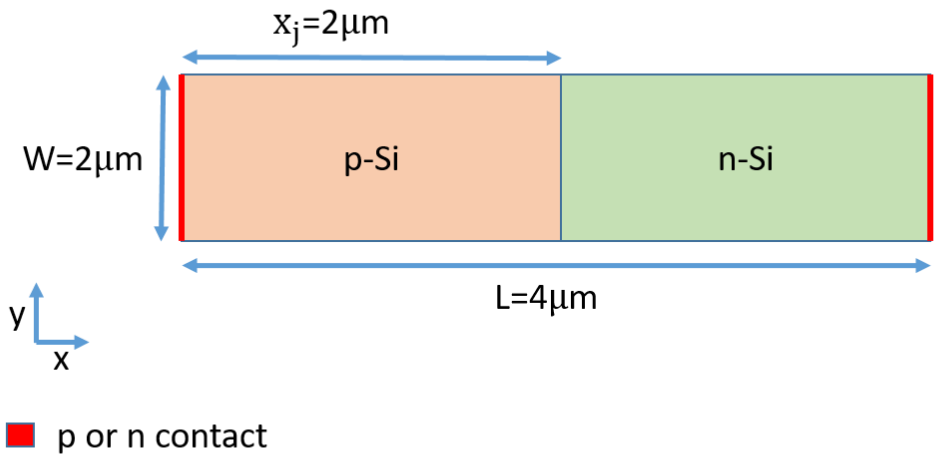

Figure 1

Q3. Plot the I-V in log scale for the following cases:

Note: For part (a) use only SRH and for part (b) use only band to band recombination models.

(a) SRH

(a.1) With and without SRH (Shockley-Read-Hall) recombination. Explain the difference in the plots (if any).

(a.2) In the "models.par" file, change the value of "taumax" to "1e-7" and "3e-8" for electrons and holes respectively. Explain the changes in the I-V (semi log).

(a.3) Repeat (a.2) for "taumax"="1e-4" and "3e-5" for electrons and holes respectively. Explain the changes in the I-V (semi log).

(b) Band to band

(b.1) With and without band to band recombination (E2 model). Explain the difference in the plots (if any).

(b.2) Find out the default model used for band to band recombination.

(b.3) For various doping $N_A = N_D = 5e17, 1e18 \text{ and } 1e19\ cm^{-3}$ with band to band recombination. Explain the trend.