EE669: Simulation Exercise

Cleanroom Practice

Effect of minority carrier life time on a silicon pn junction diode reverse bias current – a simulation exercise

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Credits: First version of this exercise, Mr. Srinu Rowtu

Credits: Daniel Mejia, Gerhard Klimeck (2022), "PN Junction Lab (New Interactive Front End)," https://nanohub.org/resources/pnjunctionlab. (DOI: 10.21981/370V-EJ38).

Introduction

nanohub.org host several software tools for the simulation of a large variety of nano electronic materials, devices, etc. We will use the "**PN Junction Lab"** simulation tool in this exercise.

- Create an account in nanohub. (You can register with your gmail, or IIT Bombay email id)
  - Link: https://nanohub.org
- Tool link: https://nanohub.org/resources/pnjunctionlab/about
- Read about the tool on web page. Tool name "**PN Junction Lab (New Interactive Front End)**"
- Demo video is available on the page.
- Introduction to the tool: https://nanohub.org/resources/34222/download/PNJUNCTION_v1.pdf
- We can simulate and view the following plots
  - Energy Band, I-V Characteristics, C-V Characteristics, Total Current, Total Density, Electric Filed, Electric Potential, Recombination, Carrier Density (shown in the left side in figure We can edit the structure, materials and Environment in **settings.**

Setting up the simulation

- We can edit the **structure**, **materials** and **environment** in **settings.**
- Doping concentrations, p-type, n-type lengths are edit in the **Structure** section
  - Na: $2x10^{16}$ cm^{-3}; Nd: $1x10^{15}$ /cm^{-3}
  - P-type length 3 um, N-type length 6 um (default values)
- The minority carrier life time values can be edited in the **Materials** section. In this exercise, we would like to vary the minority carrier lifetime.
- The bias voltage can be given in the **Environment** section. To obtain the current – voltage characteristics from -1 V to 0 V, set applied voltage to -1.0 V. To keep the simulation time low, you may choose the number of points as 10.
- To run the simulation, click on I-V characteristics or any of the boxes on the left other than the **Settings**.

Exercise

1. Simulate the reverse current density (leakage current density) at -1.0 V for minority carrier lifetimes of 10^{-9} sec, 10^{-7} sec, 10^{-5} sec.
2. Make a log – log plot of the leakage current density versus minority carrier lifetime.

3. Write the conclusions of this experiment in one sentence.

Appendix

Steps for the simulation are given below with illustrations:

1. P+N junction is created with the following structure
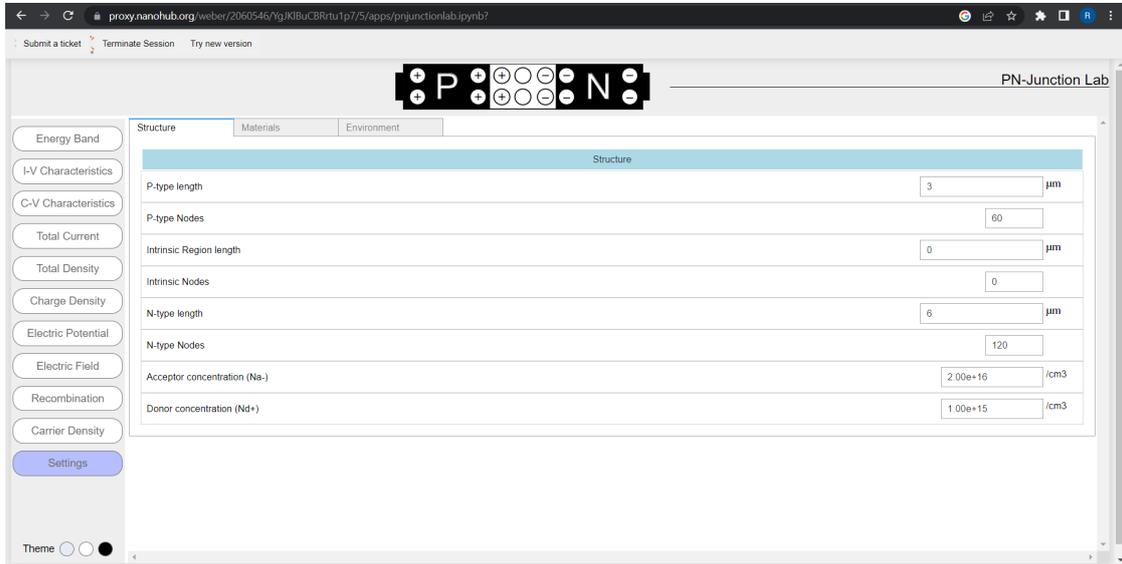
2. Simulation started with Default carrier life time is 1e-10 s. You can edit the lifetime values.
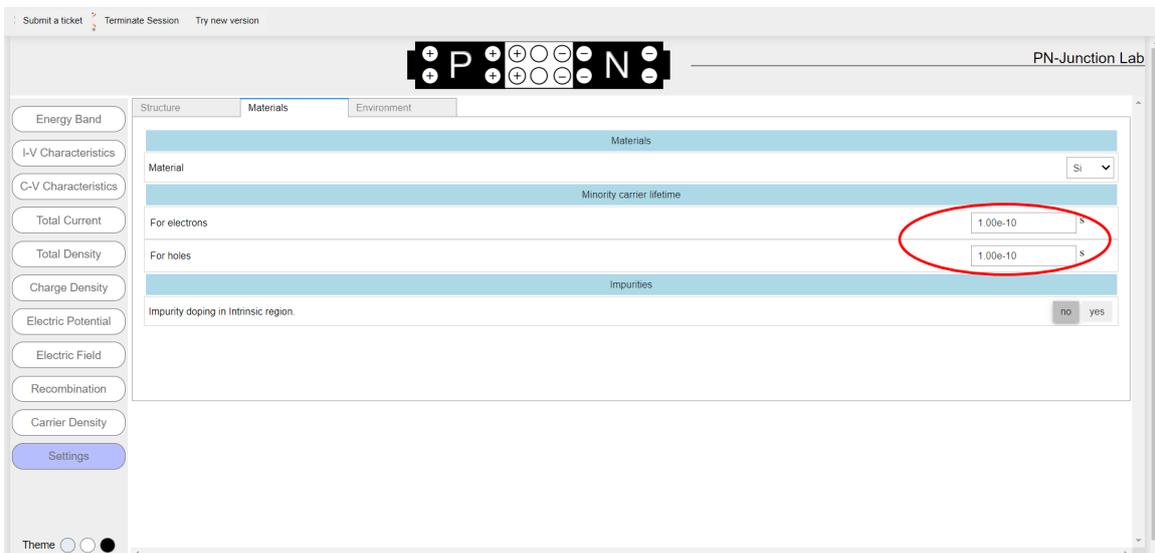
3. Set voltage is sweep from -1 V to 0.

4. Example, IV plot for the minority carrier life time of 1e-10 s