Due Tuesday, April 15, 2025 by 11:59 pm on Carmen ECE 3030 Speedgrader

EE 3030 **Computer Homework**

CAD Problem

We wish to plot the quasi-Fermi levels F_n, F_p, potential, electron and holes concentration and electric field of a diode under various applied voltages (0, -3, 0.3 and 0.7 V). We shall use the 2D device simulator PISCES to do this problem. PISCES is available in the Linux workstations of the COE network.

You can connect remotely to these workstations using on your laptop the Linux remote desktop tool: FastX (see instructions at:

https://wiki.engineering.osu.edu/display/DOCS/FastX+v3+Install+Instructions

The computers **rh050-rh052** are available. For example the full address of the rh050 host is:

rh050.coeit.osu.edu

Use Port 22 in FastX. Unless you are on the COE network you must launch first the VPN PulseSecure before starting FastX.

To run the software, enter this command to set the environment variables:

source /opt/local/silvaco/SETUP.sh

Next create a directory called pisces in your ER4 account and move to it.

```
mkdir pisces
cd pisces
```

Copy the following three homework files

diodeex03.in
diodeex03.set
demo.set

from the share directory:

/share/ECE/class/ece3030-roblin.1/diode/

This is done in Linux using:

```
cp /share/ECE/class/ece3030-roblin.1/diode/diodeex03.in .
cp /share/ECE/class/ece3030-roblin.1/diode/diodeex03.set .
cp /share/ECE/class/ece3030-roblin.1/diode/demo.set .
```

Note that in unix the '.' (meaning present location) is required!

You are now ready to do the problem. First run the PISCES manager program:

```
deckbuild  &
```

A new window with two main partitions on the left side should appear. The top menus includes the icons of the ATLAS simulator tools available. Click on File and select Open. In the menu click on diodeex03.in and click on Open. The uploaded diode file should appear in the top partition. You can scroll through it but do not modify it yet. The device (diode) is implemented together with the simulation experiment. It is not the purpose of this exercise to create such an input file. We shall now run this PISCES program. Click once on the **run** icon (green triangle). Output comments appears in the bottom partition. The simulation should take a couple minutes or more depending on the number of users on your computer. Four windows will be generated.

- The first window is for $V_D = 0$ V : diodeex03_0.str
- The second window is for $V_D = -3$ V: diodeex03_2.str
- The third window is for $V_D = 0.3$ V: diodeex03_1.str
- The forth window is the I-V characteristic: dio.log

The first 3 windows have already been partitioned in 2 subplots. You can look at the first window while the computation proceeds. Using your left mouse button select the first window (V_D = 0 V: diodeex03_0.str). and left click on its right subplot. Right click on the right subplot and select **Duplicate** to introduce a third partition. Repeat the operation a second time to obtain 4 partitions (2x2).

Click on the top left partition. The diode simulated is 350 μm long. The red line in the middle (150 μm) indicates the location of the p-n junction and the edge of the depletion

width. By pressing and holding the left mouse button you can draw a box and zoom in around the depletion region when you release it. **What** is the approximate depletion width in equilibrium?

Select the top right subplot. Then click on **Plot** and select **Display**. Select **Potential**, **Electron QFL**, and **Hole QFL**. Unselect **Net Doping**. Then click on **Apply**. Note that the quasi-fermi level plotted are $-F_n/q$ and $-F_p/q$. Do not click on **OK** as this menu can be used for the other sub-plots. **What is the builtin potential** of the diode in equilibrium? **Compare it** with the variation of the quasi-Fermi levels.

Next click on the bottom right subplot and select the **Electron Conc** and **Hole Conc**. Unselect **Net Doping**. Then click on **Apply**.

Finally select the bottom left window and activate **E Field Y**. Unselect **Net Doping**. Then click on **Apply**. Zoom around the depletion region to observe the triangular shape of the electric field. **Record** the maximum electrical field.

Repeat the same procedure for the second window: $V_D = -2$ V (diodeex03_2.str) and for the third window: $V_D = .3$ V (diodeex03_1.str)

Explain the behavior of the quasi-fermi levels and concentration data in the third window: $V_D = 0.3$ V: diodeex03_1.str? **Highlight** the region where excess carriers are observed.

Cut and paste the various plots obtained in a PPT file for the 3 biases. Annotate all the variables plotted. Highlight the results requested above. Include the answers to all the various questions in this PPT file.

Finally the Homework **asks** for a voltage (vfinal) of 0.7 instead of 0.3 V for the IV plot in the 4th window (dio.log). To do so you can first change the line:

```
solve vanode=0 vstep=.05    vfinal=.3   name=anode
```

to

```
solve vanode=0 vstep=.05    vfinal=.7   name=anode
```