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Semi-Conductors Lab

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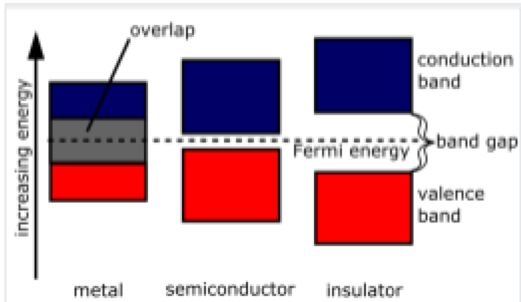
Chem 102-003

Semi-conductor Lab

Background:

Electrons behave differently depending on the material. In an insulator, electrons do not want to move, therefore there is no flow of electrons, or in other words, electricity. In a conductor electrons move when there is a voltage applied as the electrons are not restricted. This results in a flow of electrons and therefore conductors are great for electrical applications. There are some materials that requires a certain temperature or for light to hit it for the electrons to flow, hence why this class of materials is called semiconductors. However, for some applications such as computing, there may be a need to have electricity to flow through some parts of the material, and not others, all at the same temperature. Semiconductors also have a unique property, when an impurity is introduced its electrical properties are dramatically changed. This is prevalent in in the two different types of semiconductors, p-type and n-type. An understanding of these semiconductors requires insight into what is known as a band gap. A band gap is the distance between the valence band and conduction band (Band Gap). The farther the distance, the more energy it takes for the electrons in the valence band to get to the conduction band. The conduction band is where the electrons can flow, conducting electricity. The energy associated with this band gap is known as the fermi energy which, by depending of the magnitude of this value, classifies a material as an insulator, conductor, or semiconductor, which is shown to the right (Figure 1, Band Gap). The larger the distance, the harder it is for an electron to jump from the valence band to the conduction band, making the material less conductive.

Figure 1.



An n-type silicon semiconductor, as seen to the left, uses an antimony as the impurity (Figure 2, The Doping of Semiconductors). When antimony and silicon bond, there is a free electron left as the valence band is full. This free electron is now in the conduction band and makes the material conduct electricity. A p-type silicon semiconductor, as seen to the right, uses boron as the impurity (Figure 3, The Doping of Semiconductors). When Boron and silicon bond, it creates a hole due to the deficiency of an electron in the valence band since boron only has 3 valence electrons compared to silicon's 4. This hole accepts electrons and allows for them to move about the lattice. So, electricity can flow in the material.

Figure 2.

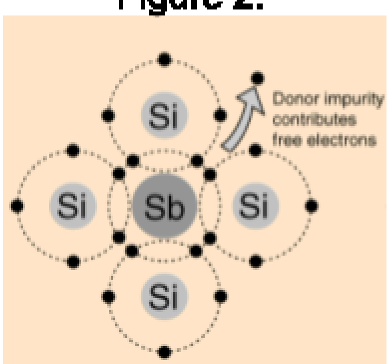
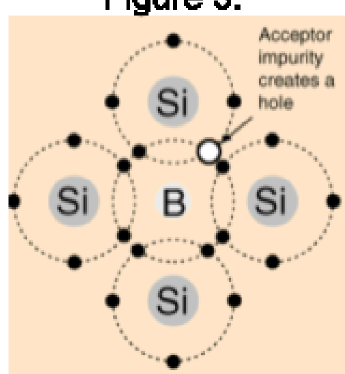


Figure 3.



Procedure:

Part 1: Set-Up

1. Gather wires with alligator clips, DC power source, multimeter, metal electrodes, glass disks, and semi-conductors

2. Set up Power source by first plugging it into outlet

3. Turn on power source

4. Adjust knobs to see if you have voltage reading. Turn back to zero once you see it works

5. Connect wires according to color to power source. Black to black and red to red. Leave the other side unconnected

6. Take out multimeter

7. Connect unconnected side of red wire to multimeter

8. Connect unconnected black wire to electrode

9. Connect a new wire to the black wire insert in multimeter and leave other side unconnected

10. Now the red wire should be connected leaving the black wire unconnected and the other side connected to the electrode. Make sure of this

11. Clean up wiring to make it neat

12. This current set up is for a negative bias (hence why the black wire is being connected to the sample)

13. To make this circuit positive bias you repeat steps 7-10 but with the opposite color resulting in the red wire having a exposed side

Part 2: Testing the Multimeter/Electrode

1. Now that your set up is completed turn on multimeter

2. Connect the electrode and exposed wire

3. Gently turn the voltage knob until 1 V

4. Check the readings on your multimeter for voltage and amperage. Record these values
5. If you don't get any readings try adjusting the connection and/or increasing the voltage by .5 V increments until 2 V

6. Now that you have a baseline and checked your tools turn voltage back to zero

Part 3: Testing Glass Slip, Semi-conductors

1. Now take out the glass slip and semi-conductors

2. Make sure your set up is negative bias (black wire is only wire not connected)

3. Place glass slip on top of the electrode connected to the black wire

4. Connect the remaining black wire to the glass slip. Then increase voltage incrementally by .5-1V until 10 V

5. Now repeat this with positive bias (look at set up procedure 13)

6. After you finish recording your data for both negative and positive bias turn off the voltage and remove the glass slip

7. Now you will test the semi-conductors so take them out

8. For each semi-conductor you will repeat steps 2-5 and record your data

9. After that turn off the power supply, unplug the power supply, and disconnect all the wires. Then put the glass slips, semi-conductor, and metal electrode where you got them

10. Then clean up your station of anything else

11. After your instructors approves you to leave your work station look at your data

12. Using the data try to see which semi-conductor was highly doped, medium doped, and non-doped. And using the results of testing them under positive and negative bias find which are p or n doped.

Results:

Electrode	Sample	Voltage applied (V)	Amperage reading (mA) (negative bias)	Amperage reading (ma) (positive bias)
Zn	LED	1.0	0.00	0.00
Zn	LED	2.0	0.00	0.00
Zn	LED	3.0	0.00	0.00
Zn	LED	4.0	.01	.01
Zn	glass	1.0	0.00	0.00
Zn	glass	2.0	0.00	0.00
Zn	glass	3.0	0.00	0.00
Zn	glass	4.0	0.00	0.00
Zn	glass	5.0	0.00	0.00
Zn	glass	6.0	0.00	0.00
Zn	glass	7.0	0.00	0.00
Zn	glass	8.0	0.00	0.00
Zn	glass	9.0	0.00	0.00
Zn	glass	10.0	0.00	0.00
Zn	Highly doped semi-conductor	1.0	0.00	0.00
Zn	Highly doped semi-conductor	2.0	0.00	0.00

Zn	Highly doped semi-conductor	3.0	0.00	0.00
Zn	Highly doped semi-conductor	4.0	.03	0.00
Zn	Highly doped semi-conductor	5.0	.13	0.00
Zn	Highly doped semi-conductor	6.0	.32	0.00
Zn	Highly doped semi-conductor	7.0	N/A	0.00
Zn	Medium doped n-type	1.0	0.00	0.00
Zn	Medium doped n-type	2.0	0.00	0.00
Zn	Medium doped n-type	3.0	0.00	0.00
Zn	Medium doped n-type	4.0	0.00	0.00
Zn	Medium doped n-type	5.0	0.00	0.00
Zn	Medium doped p-type	6.0	0.00	0.00
Zn	Medium doped p-type	7.0	0.00	0.00
Zn	Medium doped p-type	8.0	0.00	0.00
Zn	Medium doped p-type	9.0	0.00	0.00

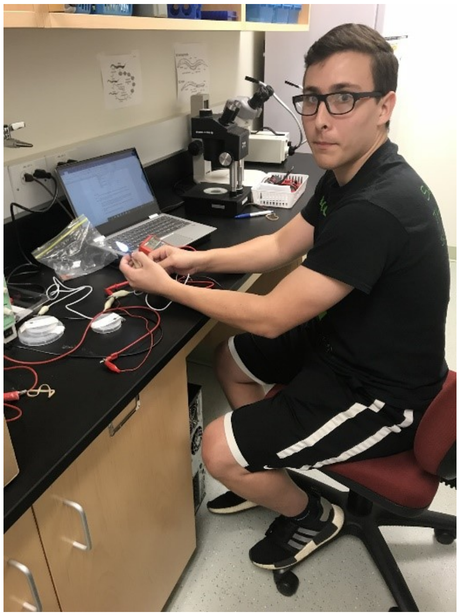
Zn	Medium doped p-type	10.0	0.00	0.00
Zn	Undoped sample	0.0	0.00	0.00
Zn	Undoped sample	1.0	0.00	0.00
Zn	Undoped sample	2.0	0.00	0.00
Zn	Undoped sample	3.0	0.00	0.00
Zn	Undoped sample	4.0	0.00	0.00
Zn	Undoped sample	5.0	0.00	0.00
Zn	Undoped sample	6.0	0.00	0.00
Zn	Undoped sample	7.0	0.00	0.00
Zn	Undoped sample	8.0	0.00	0.00
Zn	Undoped sample	9.0	0.00	0.00
Zn	Undoped sample	10.0	0.00	0.00

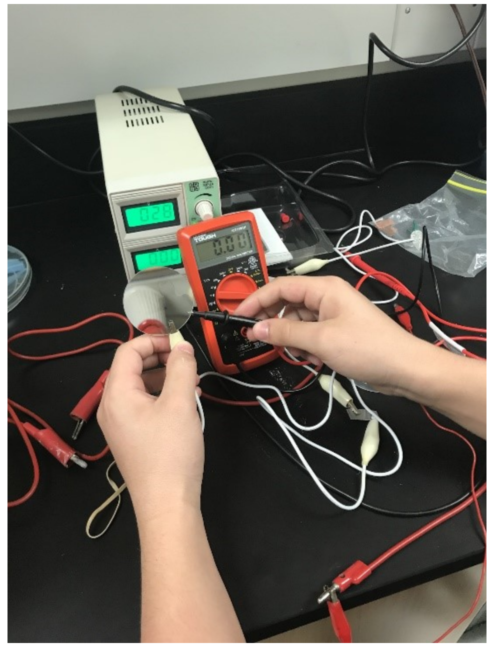
For this research project I was given semi-conductors which were doped n/p, and undoped, highly, and medium. So, I had to test what values I would get for each voltage. I followed the same procedure above but when I tested the multimeter at first it did not work. Also, my power source provided a voltage but there was no current running through the circuit. I eventually got the power source to work, but I am not confident that the results are accurate. The first multimeter I had did not work. I then received a new one which did work. I first tested just the electrode to see if I can get a current reading. To further test this I tried both positive and negative bias with a LED. The LED lit up at around 4 V. It worked on both sides when flipped accordingly. After this, I moved on to testing the other samples. The glass slip's results were expected to be 0 amps and were because it is an insulator. I then tested the semi-conductors. I started with the highly-doped sample and did not receive a reading until 4 V. Then it rapidly increased and I stopped at 6 V. When I tried 7 V the amperage reading jumped a lot. Also, the sample was getting exceedingly hot. For safety reasons I stopped testing that sample at 7 V. Then I tested the medium doped sample. I was not able to obtain any amperage values for both positive or negative biases up to 10 V. This could be due to too much resistance in the circuit or sample. Finally, I tested the undoped which also came back as zero expectantly.

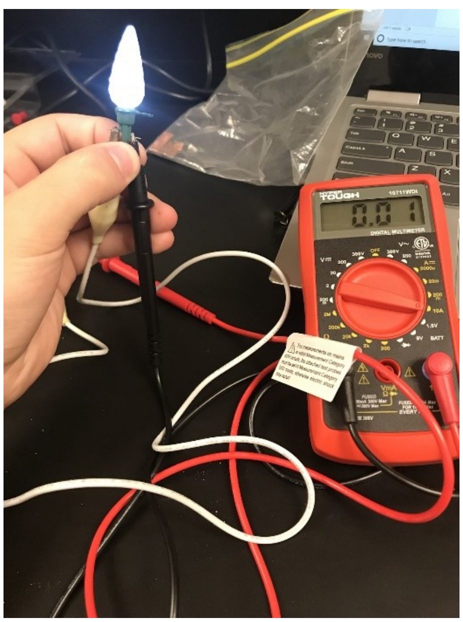
Conclusion:

In conclusion, I learned from this experiment what positive and negative biases are, how semiconductors work, how to treat them in a lab setting, how to make a functioning circuit, how to take accurate readings at different points in a circuit. I liked this lab and choose it because I am interested in electronic materials and how they function chemically. Seeing how they work in a circuit and in everyday devices can help me understand them better. This project is well thought out and involves a lot of chemistry. But, it also requires you to know how to make a functioning circuit and how to handle electricity. A hard part about this lab was learning how to use the multimeter properly and the power device. The difficult part should be interpreting your results, but it is hard to get through the lab itself. I think the lab should be shorter and before going into the lab the students should be given a rundown on an example circuit and how to use the multimeter/power source properly. If this is done the students can focus on the chemistry aspect of the lab and not on the logistics.

Pictures:







Works Cited

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“The Doping of Semiconductors.” Centripetal Force, hyperphysics.phy-astr.gsu.edu/hbase/Solids/dope.html#c3.