P-N Junction Diode
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Abstract: The determination of the band gap was determined from the I-V characteristics of the P-N junction with the 1N914 diode where data was collected at 5 total temperatures in a range of 20°C-141°C. The energy gap was determined to be at (1.12 +- 0.06)eV in the forward bias and (1.45 +- 0.1)eV in the reverse.

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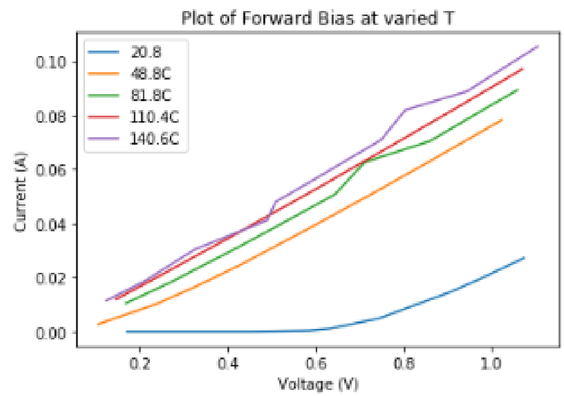
I. INTRODUCTION

A semiconductor is a crystalline solid in which the conduction band lies close to the valence band but is not populated at low temperatures. For semi-conductors, both electrons and holes are responsible for the properties of the semiconductor[1]. If a semiconductor is a pure crystal, the number of holes is equal to the number of electrons that are free. Each electron that is raised in the conduction band creates a hole in the valence band.

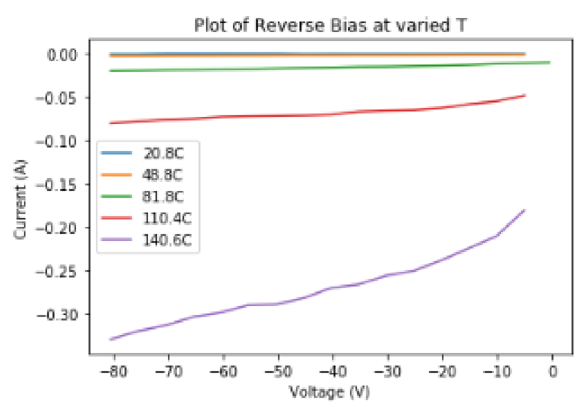
II. MEASUREMENTS AND PROCEDURES

By connecting a diode in series with a resistor and connecting two volt-meters, one to in parallel with the power supply, and the other to measure the voltage across the 10 ohm resistor in order to calculate the current going through the circuit. Measurements were taken at room temperature at 20.8C originally then by including an additional oven connected to an external power supply the diode was placed inside the oven while the remaining circuit was unchanged. Other temperature measurements were taken at 48.8°C, 81.8°C, 110.4°C, and 140.6°C.

III. DATA ANALYSIS



For the 1N914 diode, the max capacity of voltage in the forward bias was around 1-2V. The data collected started at 0.0 and measurements were taken in 0.1V increments. At higher temperatures the current increased across the diode due to the increasing of the temperature.



In the reverse bias of the diode the gaps between line trends is fairly large in comparison to the forward bias. In the forward bias the difference in values of the outputting currents across the diode are not statistically far apart. Yet, in the reverse bias as the temperature increases, the difference in current output across the diode was quite large.

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T(Celsius)	Eg Forward		T(Celsius)	Eg Reverse	
20.8C	1.31 eV	Avg	20.8C	1.78	Avg
48.8C	1.22 eV	1.12 eV	48.8C	1.64	1.45 eV
81.8C	1.10 eV	Err +/-	81.8C	1.39	Err +/-
110.4C	1.02 eV	0.059	110.4C	1.27	0.104
140.6C	0.94 eV		140.6C	1.15	
n	Saturation		n		
2.72	4.00E-06		3.07	STD Eg+	STD Eg-
2.25			2.79	0.133	0.232
2.08			2.51		
1.85			2.22		
1.71			1.71		

Statistics Found from P-N Junction Analysis

The band gaps calculated in the forward bias resulted in smaller band gaps as the temperature increased. In the reverse bias as well the band gap trended towards being smaller. So, at lower temperatures there will be a larger band gap yet at higher temperatures there should result in being a smaller band gap. When temperature is high then the bonds to free electrons become drastically weaker and more electrons are able to fill the gaps in the conduction band easily. The saturation current throughout the apparatus was calculated to be at around 4.0e-6. The saturation current was important in being able to determine n, the ideal diode factor, which shows how well the diode behaves in comparison to an ideal diode. This value usually ranges between 1 and 2 so due to possible errors seeing that values larger than 2 were found it is possible that inaccurate statistics were calculated. The average band gap for the forward bias was at (1.12 +-0.059)eV and the reverse bias resulted with a band gap of (1.45+-0.104)eV.

IV. CONCLUSION

The determined value of the band gap in the forward bias was at 1.2eV and 1.45 eV in the reverse bias. There is possibly human error to account for when putting the diode in the reverse bias due to not replacing the 10 ohm resistor in the circuit series with a different resistor.

[1] Adrian C. Melissinos *:Experiments in Modern Physics Date Accessed: 11/2/2021*