### University of Arizona

# Materials Science and Engineering

## MSE 110: Solid State Chemistry

##### Measurement of the Band Gap of a Semiconductor

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#### Measurement of the Band Gap of a Semiconductor

**Introduction**

The goal for this lab was to define and understand the relationship between the temperature and the energy of a semiconductor, specifically the band gap energies. Higher temperatures normally indicate more energy, and this allows electrons to cross the gap to get into the valence area. The electron in the valence area can then conduct electricity as it is free to move around and is not “tied down” in some sense. And since temperature and energy are directly proportional, and energy and semi conductivity and also directly proportional, that would indicate that temperature and semi conductivity are directly proportional themselves. So the higher the temperature, the easier it is for something to become semi conductive and conduct the flow of electricity. In this experiment, we are measuring two variables, temperature, and resistance. Resistance in the inverse of conductivity, and therefore should theoretically be indirectly proportional to temperature. Thus, as temperature decreases, resistance should increase.

###### Experimental Procedure

For this experiment, we will be using the following materials:

* Silicon diode connected to a 9 V battery.
* Heat sink in the form of an aluminum block.
* Thermometer to measure the temperature of the heat sink, will be inserted into one of the holes in the heat sink.
* Voltmeter to measure the resistance of the heat sink as temperature decreases.

For the procedure itself, it is fairly straightforward, however, certainly time consuming. Do note that the heat sink is extremely hot and no attempts to touch it without proper protection and equipment should be made.

1. Set up the silicon diode and the 9 V battery. They should be connected in the reverse bias condition where there is very little current flowing through the diode.
2. Connect the voltmeter to the diode and the thermometer and record the voltages of V1 and V2 at room temperature.
3. Once the heat sink has been placed on the insulating brick, place the thermometer and the diode into the heat sink and check the temperature. Wait till the temperature on the thermometer reads 150 degrees Celsius before collecting data.
4. To record the data, measure the voltages V1 and V2 every 5 degrees.

###### Experimental Results

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Temp (C)** | **Temp (K)** | **V1** | **V2** | **R (V1/V2)\*resistor** | **𝜎 (1/R)** | **ln(𝜎)** | **1/T** |
| 150 | 423 | 9.2 | 0.101 | 13663366.34 | 7.31884E-08 | -16.43022882 | 0.002364066 |
| 145 | 418 | 9.21 | 0.084 | 16446428.57 | 6.08035E-08 | -16.6156189 | 0.002392344 |
| 140 | 413 | 9.22 | 0.07 | 19757142.86 | 5.06146E-08 | -16.79902565 | 0.002421308 |
| 135 | 408 | 9.24 | 0.058 | 23896551.72 | 4.1847E-08 | -16.98924473 | 0.00245098 |
| 130 | 403 | 9.25 | 0.048 | 28906250 | 3.45946E-08 | -17.17956839 | 0.00248139 |
| 125 | 398 | 9.25 | 0.039 | 35576923.08 | 2.81081E-08 | -17.38720776 | 0.002512563 |
| 120 | 393 | 9.26 | 0.033 | 42090909.09 | 2.37581E-08 | -17.55534234 | 0.002544529 |
| 115 | 388 | 9.27 | 0.027 | 51500000 | 1.94175E-08 | -17.75709237 | 0.00257732 |
| 110 | 383 | 9.27 | 0.022 | 63204545.45 | 1.58216E-08 | -17.96188678 | 0.002610966 |
| 105 | 378 | 9.28 | 0.018 | 77333333.33 | 1.2931E-08 | -18.16363564 | 0.002645503 |
| 100 | 373 | 9.28 | 0.014 | 99428571.43 | 1.00575E-08 | -18.41495007 | 0.002680965 |
| 95 | 368 | 9.28 | 0.012 | 116000000 | 8.62069E-09 | -18.56910075 | 0.002717391 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| -Eg/2k | .= | -6105 |  |  |
| Eg | .= | 6105\*2k | k= | 1.38E-23 |
| EG | .= | 1.69E-19 | J to eV | 6.242E+18 |
| COMAPRE TO BAND BAP OF SILICON DIODE | | |  | 6.242E+18 |
| ACTUAL |  | 1.05E+00 |  |  |
| 1.12 eV |  | Derived ^ |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| -Eg/2k= | -6104.6 |  |  |  |
| Eg= | 2\*6105\*1.38E-23 | in J |  |  |
| Eg= | -1.68E-19 | in J |  |  |
| Actual | Derived |  |  |  |
| 1.12eV | 1.05eV |  |  |  |
|  |  |  |  |  |
| Percent Error | 6.25% |  |  |  |

###### Discussion and Conclusions

The values obtained in the lab could not be compared with accepted values most likely due to poor Google searching skills. However, based on what has been found, the data matches up with our obtained, with some slight variations. Our data could be off but 0.5 degrees due to how fast we took the data, and at what temperature. For example, instead of taking the data at 145.0 degrees, we might have taken it at 145.3 degrees. Understandably, 0.3 should not be that great of a difference nor should it drastically affect our data. However, if inconsistently taken, this may result in some slight variations over the long run. Therefore, we should aim to accurately and consistently obtain data the same way throughout the whole experiment. Another source of potential error could arise from how we were treating the heat sink. Due to how high the initial temperature was for the heat sink, the thermometer registered a peak of 210 degrees Celsius, we employed several techniques to attempt to cool the heat sink down to our desired temperature of 150 degrees Celsius, of which involved fanning the heat sink with a book or spraying it with some water. It is unknown if that may have drastically altered the data, however, it is understandable if it had.