Hall Effect Lab

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Nothing is here

INTRODUCTION

APPARATUS

The apparatus consisted of the following.

- Doped silicon wafer
- Pre-wired circuit board
- Carbide scribe
- 2 soldering iron
- Indium solder
- Lead-tin solder
- Rubber cement
- Fine wire
- Electromagnet and power supply
- Current source (DC power supply)
- Two multimeters (for V and I)

MAKE HALL SAMPLE

Procedure

The first step of the experiment was to prepare a hall sample. This involved selecting and measuring a Si wafer, securing it to a circuit board prefitted with six insulated wires, and securing the wires to the four sides of the sample with thin wire and indium solder. Before soldering, the wafer was measured, width, height, and thickness. The configuration of the wires connected to the semiconductor is shown in 1.

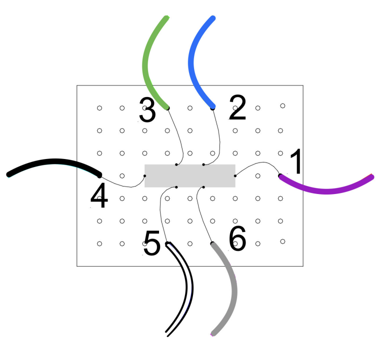

FIG. 1. Coloring/numbering convention of the experimental setup.

Resistances between each pair of wires was measured with an Ohmeter. One wire was found to have a bad solder and was resoldered until all measured resistances were $< 1\ M\Omega$.

Ohmic behavior was tested by generating a R(V) and I(V) curve. A current was applied to the two end wires and varied, such that the resulting power was between -0.1 and 0.1 Watts.

Results and Conclusion

Results for the two-wire method of measuring resistance are shown below, where in order to measure resistance between two nodes a ohmmeter is simply connected between them. This method is known to be inaccurate and a more precise method is used later in the experiment, however this verifies the test setup is correct.

Wire Pair	Resistance (Ω)
3-2	22760.0
3-6	24550.0
3-5	66430.0
3-4	26940.0
3-1	28570.0
2-6	11213.0
2-5	12445.0
2-4	12060.0
2-1	11665.0
6-5	51390.0
6-4	8893.6
6-1	9566.0
5-4	171760.0
5-1	176260.0
4-1	12296.0

TABLE I. Resistance for each combination of wires, given by their numbering convention matching that in 1.

Next we probed the behavior of the semiconductor as a resistor, measuring voltage and current as a voltage was applied, starting at 0 and increasing until the power was just under 0.1 Watts.

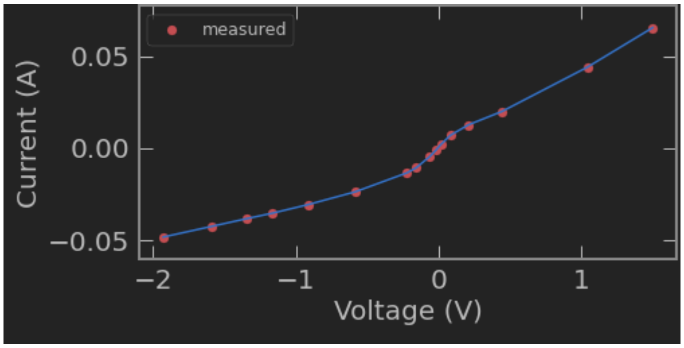

FIG. 2. I(V) shows different behavior closer to zero than elsewhere.

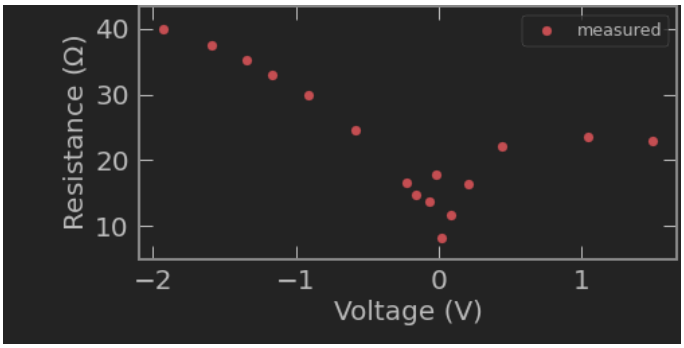

FIG. 3. R(V) is not constant, demonstrating non-ohmic behavior.

In this phase of the experiment, we were able to demonstrate that the test setup had no major issues and that the behavior of the semiconductor is non-ohmic. This is likely due to a certain voltage threshold inherent to semiconductors where resistance increases as the threshold is approached. If more voltages were able to be tested, we would see a decreasing trend with increasing voltage after this initial peak.

THE 4-WIRE METHOD FOR MEASURING RESISTIVITY OF A DOPED SILICON WAFER

Procedure

The 4-wire method was used to more accurately measure the resistivity of our material. In this method, instead of attaching an ohmmeter across the two wires, resulting in a resistivity that includes the wires and connections between said wires, two measurements that are orthagonal are performed. An ampmeter is used to measure an applied current across the same two wires (which gives an accurate measure of current because the circuit is isolated along that path), and a voltmeter is used to measure immediately along either side of the resistor, in this case across wires 2-3 and 5-6, where any resistance does not cause a meaningful voltage drop.

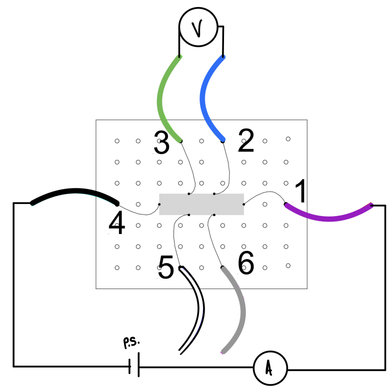

FIG. 4. Four-Wire measurement configuration.

These values for resistance were then used to calculate the material's resistivity ρ, using the earlier measurements of the wafer's dimensions.

Finally, measurements across the side wires were repeated with the ohmmeter for comparison.

Results and Conclusion

Two values for ρ were attained using equation 1, and a comparison was made between the two methods for measuring resistance, given in table II.

$$\rho = \frac{R \cdot A}{L} \tag{1}$$

Path	4-Wire R (Ω)	2-Wire R (Ω)	ρ ($m\Omega$)
2-3	147	20200.0	0.079131
5-6	235	213600.0	0.102832

There is indeed a substantial difference between the two measuring methods in this case, three orders of magnitude. Additionally, the two 4-wire measurements were different by about 2x, but the 2-wire measurements were different by an order of magnitude. Thus, the relative variance of the 2-wire method is much higher, implying that it has both worse accuracy and precision.

This is of course due mostly to the quality of the solder connections between the wires and the semiconductor, meaning that the connections on one side were probably just worse than the other side.

TABLE II. Measured and accepted values of the speed of light and refractive index of various materials.

Property	Measured Value	Accepted Value	Refs.	Deviation
ρ	0.09 ± 0.02 $(cm\Omega)$	$5.86 - 6.31$ $(cm\Omega)$	[**?**]	2σ
μ	320 ± 60 $(\frac{cm}{Vs})$	455 $(\frac{cm}{Vs})$	[**?**]	-3σ

Because two measurements of ρ were calculated, which are both measuring the same property of the same material, they were taken as a small distribution, with the mean as the measured value and the uncertainty the standard deviation. Our measured value is therefore 9 ± 2 $cm\Omega$.

SUMMARY

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[1] Wikipedia, Heat of Combustion: https://www.wikepedia.com
[2] Energysage, Most Efficient Solar Panels https://www.energysage.com/
[3] Carbon Commentary, Hydrogen made by Electolysis https://www.carboncommentary.com
[4] Energy.gov, Fuel Cell Fact Sheet https://www.energy.gov