111B – Hall Effect in Semiconductors

Neil Pichay

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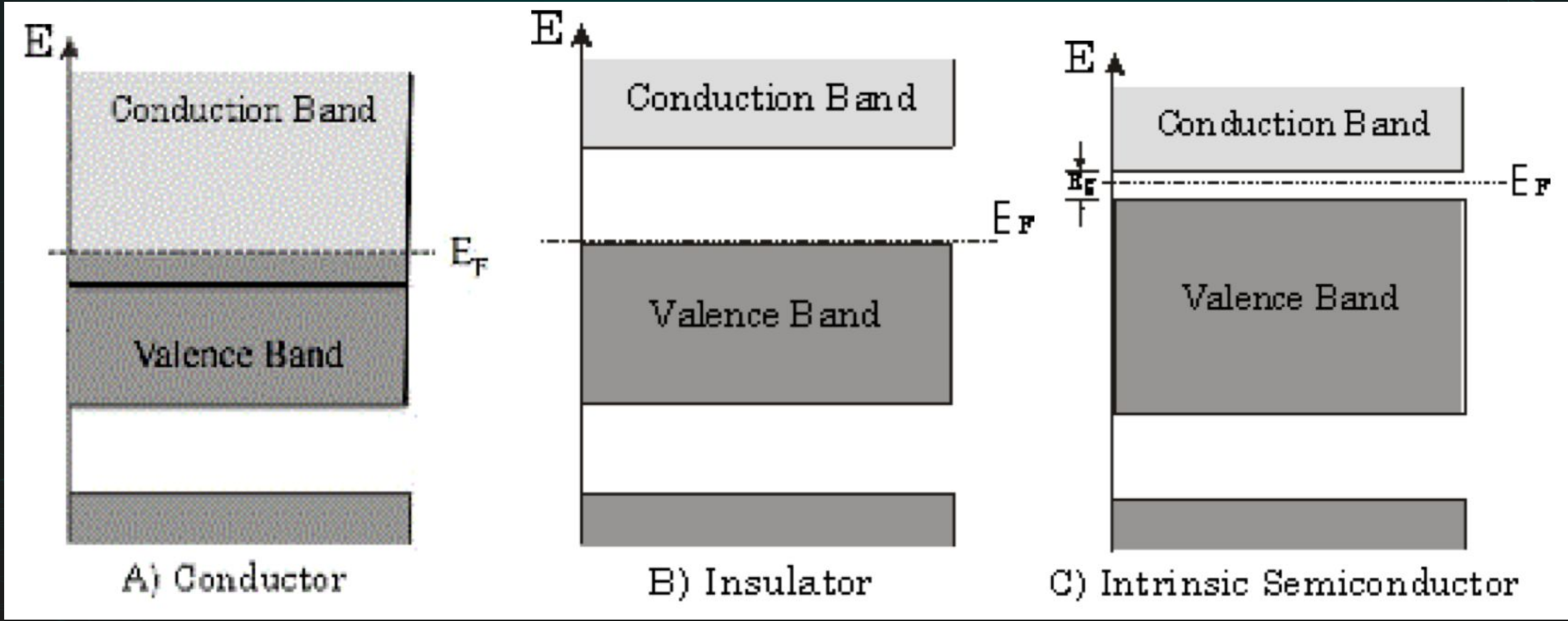
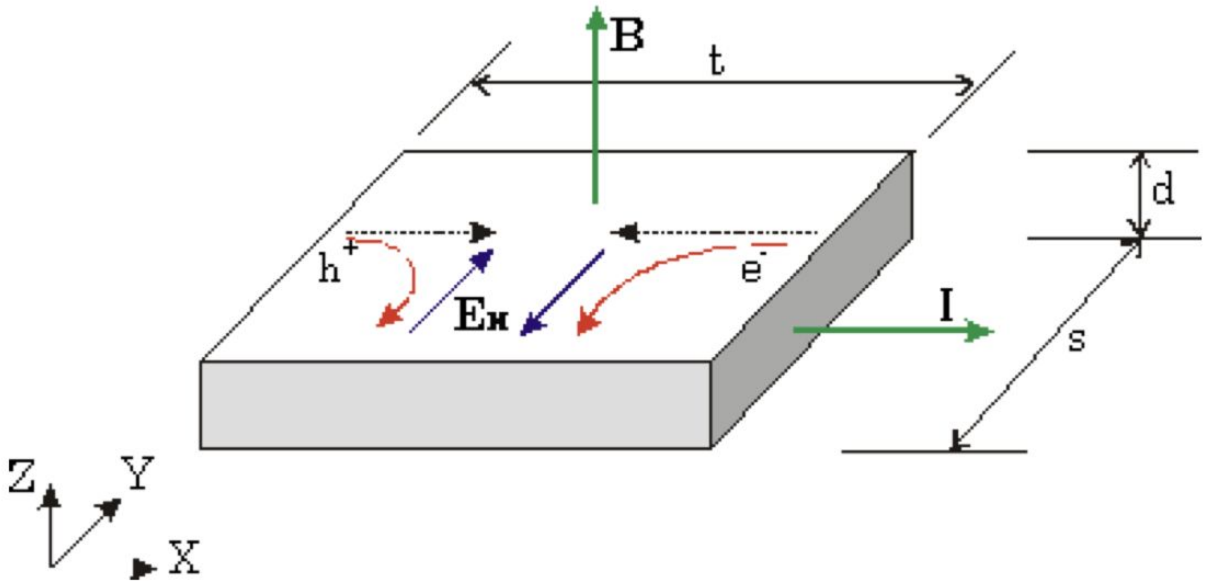
Semiconductors

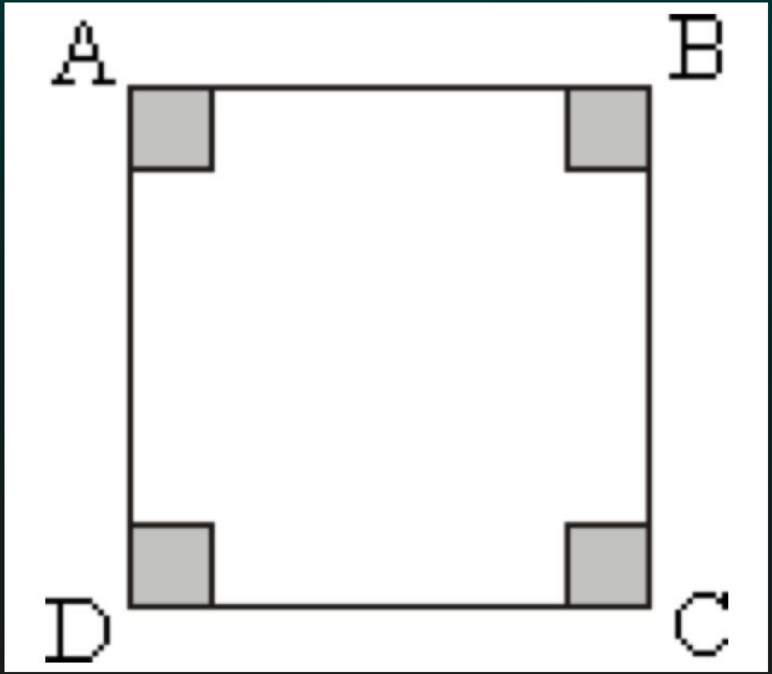


Hall Effect



Van der Pauw Method

- Contact points made up of Boron dopant layered with Palladium, gold, and indium



Apparatus

Source Meter

Electrometer

Gaussmeter

LabView Program

Temperature Controller

Gold Box

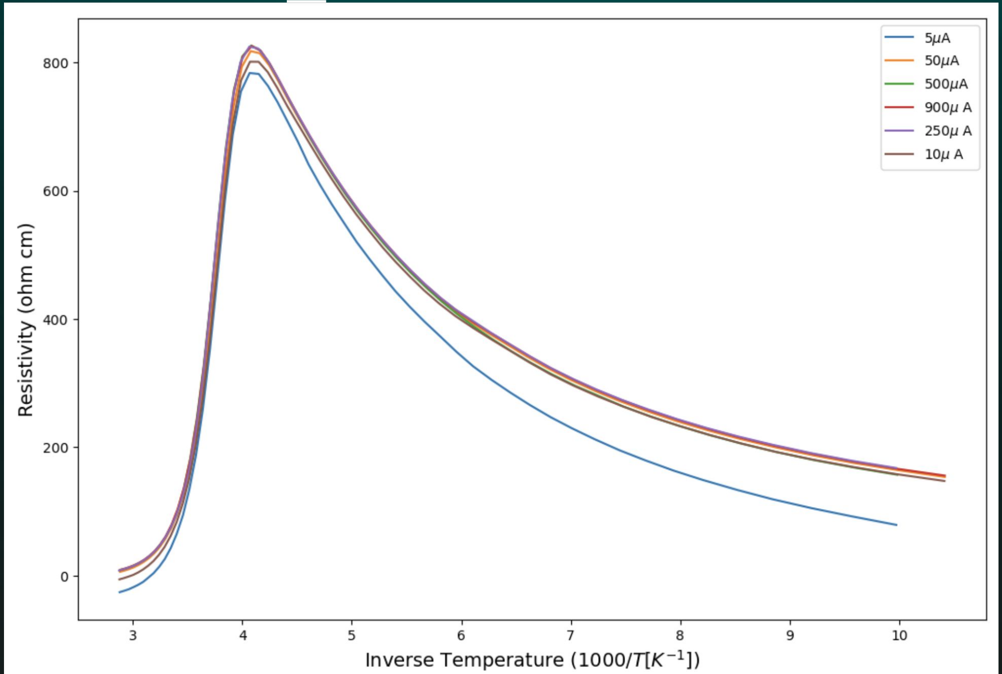
Magnet Power Supply

Apparatus

Procedures

1. Turn on all the electronics
2. Open the Return valve, then the Main Water valve
3. Turn on the two power supplies, followed by the Gold Box
4. Open the “Control Program v9_multified” LabView Program
5. Set your initial parameters
    a. Temperature range
    b. Sample Current
    c. Sample Magnetic field
6. Run the experiment
7. With blue gloves and a face shield, carefully fill the white dewar with LN2
8. Add LN2 to the Cryostat until temperature is sufficiently low
9. When the sample is cool enough (~ 98K), experiment will begin
10. Repeat steps 5-8 for various initial parameters

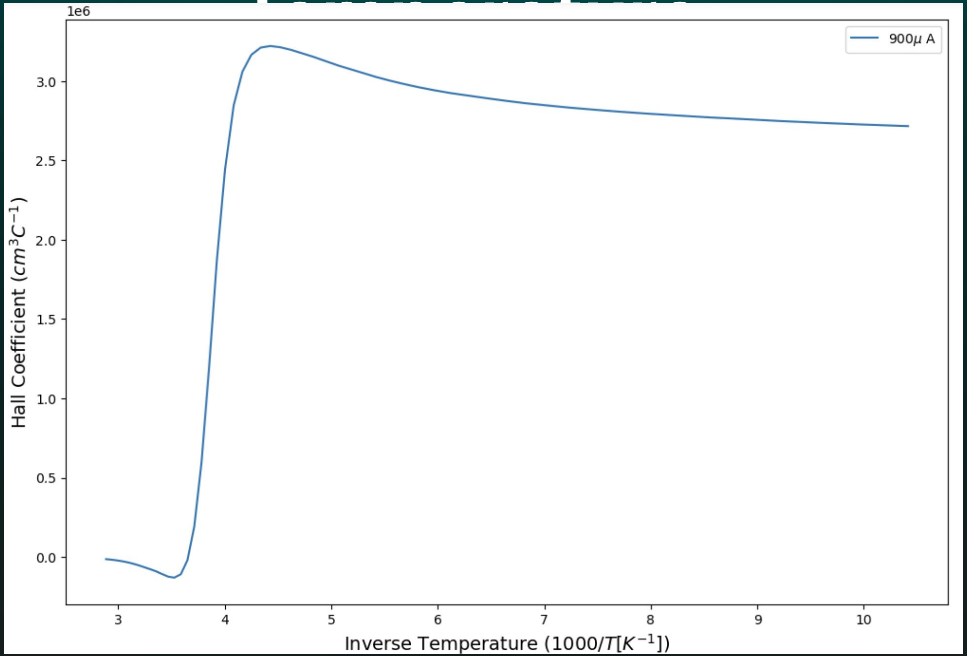
Resistivity vs. Inverse



$$\rho = \frac{\pi d}{\ln(2)} \cdot \frac{(R_{AB,DC} + R_{AD,BC})}{2} \cdot f\left(\frac{R_{AB,DC}}{R_{AD,BC}}\right)$$

Analysis

Hall Coefficient vs. Inverse Temperature



$$\text{Hall Coefficient: } R_H = \frac{V_H * t}{I * B} \frac{R_{AC,BD} + R_{BD,AC}}{2} * \frac{t}{B}$$

At room temperature:

$R_H = -8.96 \times 10^{4}\,cm^{3}C^{-1}$

$\varrho = 80.1\ \Omega cm$

Analysis

In extrinsic regime:
hole concentration: $p = 1.9 \times 10^{12} cm^{-3}$

$$R_H = -1/ep.$$

Analysis

Mobility: $\mu = 1.1\text{x}10^{3}cm^{2}V^{-1}sec^{-1}$

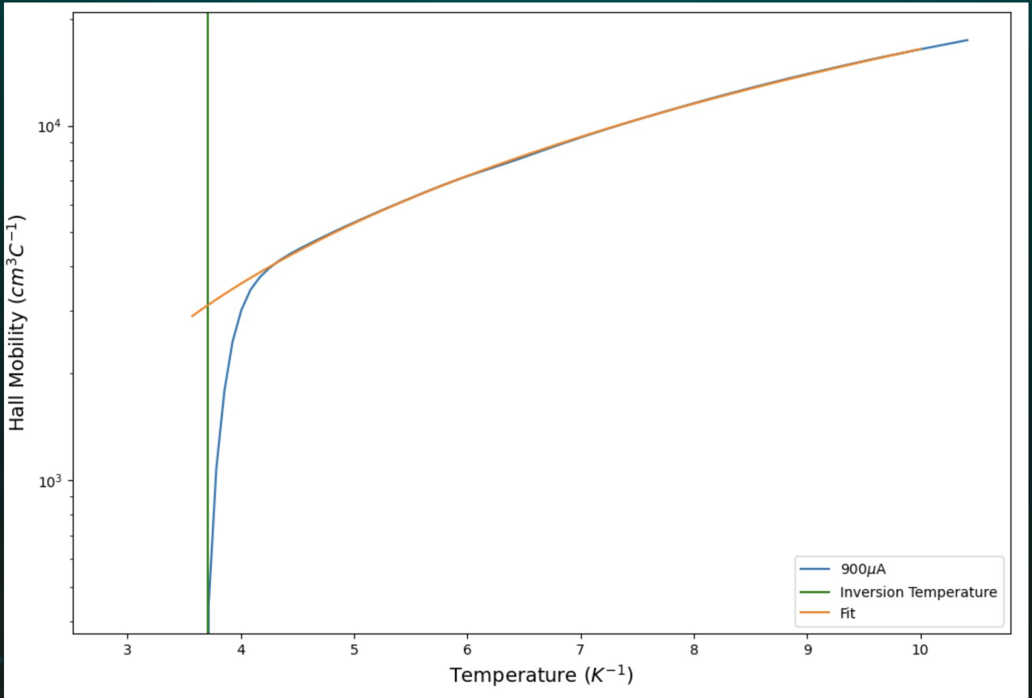
$$mobility : \mu = \frac{2ln(2)}{\pi B} \frac{\Delta R_{AC,BD}}{R_{AB,CD} + R_{BC,AD}} \frac{1}{f} [\frac{cm^2}{V * sec}]$$

Analysis

Hall Mobility vs. Inverse Temperature

Fit: $\mu_H \, \alpha \, CT^{\beta}$

$\beta = -1.5 \mp 0.019$



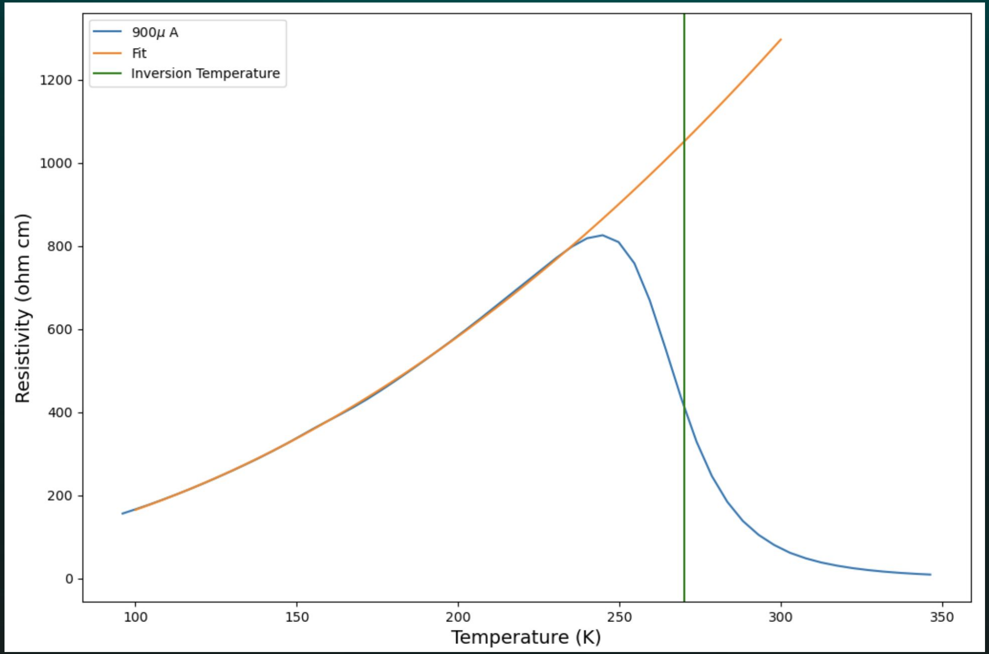
$\mu_H(p) = 3.11x10^{3}$ $cm^2V^{-1}sec^{-1}$

Analysis

Resistivity vs Temperature

Fit: ϱ α CT^{β}

β=2.05 ∓0.027

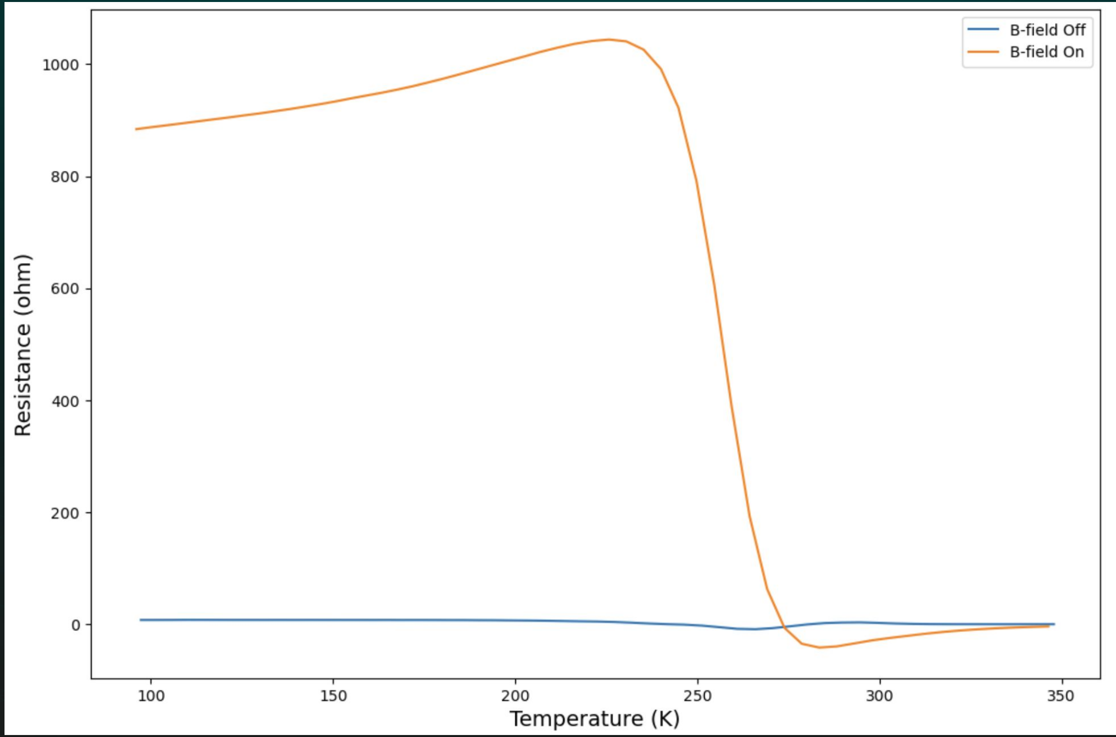


b = 1.55

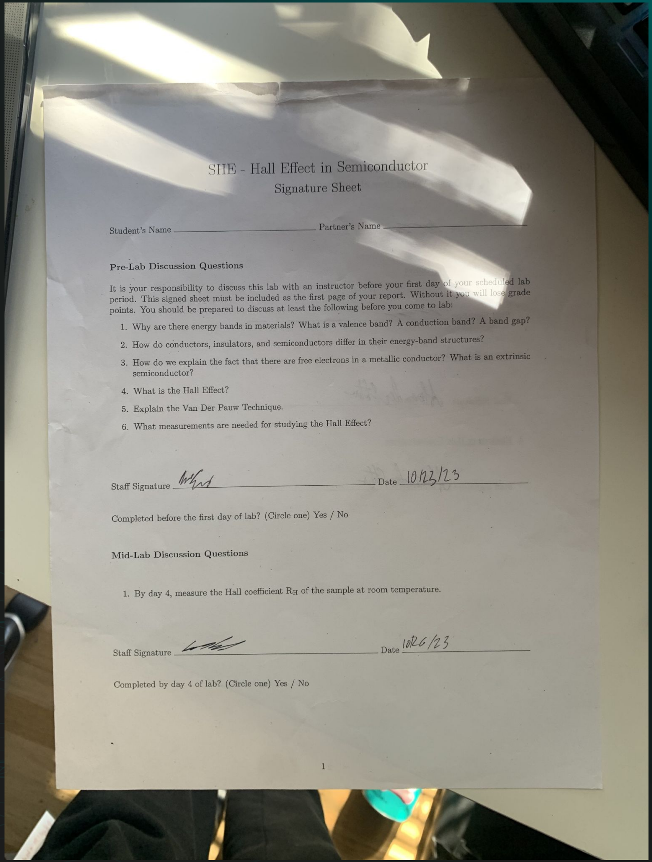
$\mu_H(n)$ = 4.83x10 ^{3} $cm^2V^{-1}sec^{-1}$

$$b = \frac{R_e(T = T_0)}{R_e(T = T_0) - R_0(T = T_0)} = \frac{\mu_H(n)}{\mu_H(p)} \rightarrow \mu_H(n) = b * \mu_H(p)$$

Resistance Comparisons



Signatures:



SHE - Hall Effect in Semiconductor

Signature Sheet

Student's Name ______________ Partner's Name ______________

Pre-Lab Discussion Questions

It is your responsibility to discuss this lab with an instructor before your first day of your scheduled lab period. This signed sheet must be included as the first page of your report. Without it you will lose grade points. You should be prepared to discuss at least the following before you come to lab:

1. Why are there energy bands in materials? What is a valence band? A conduction band? A band gap?
2. How do conductors, insulators, and semiconductors differ in their energy-band structures?
3. How do we explain the fact that there are free electrons in a metallic conductor? What is an extrinsic semiconductor?
4. What is the Hall Effect?
5. Explain the Van Der Pauw Technique.
6. What measurements are needed for studying the Hall Effect?

Staff Signature ______________ Date 10/23/23

Completed before the first day of lab? (Circle one) Yes / No

Mid-Lab Discussion Questions

1. By day 4, measure the Hall coefficient R_H of the sample at room temperature.

Staff Signature ______________ Date 10/26/23

Completed by day 4 of lab? (Circle one) Yes / No

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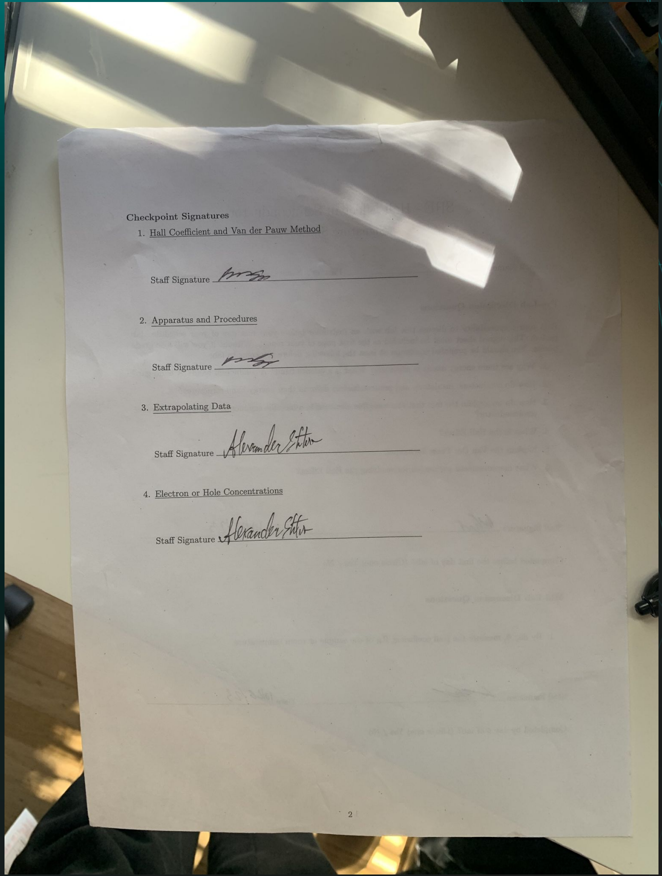

Checkpoint Signatures

1. Hall Coefficient and Van der Pauw Method

Staff Signature ______________

2. Apparatus and Procedures

Staff Signature ______________

3. Extrapolating Data

Staff Signature ______________

4. Electron or Hole Concentrations

Staff Signature ______________

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