Thermoelectric Measurements

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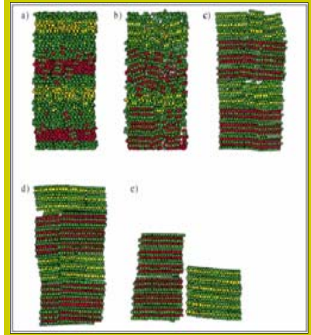
NSF Undergraduate Catalytic Outreach and Research Experiences

Deposition and Annealing



•Various elements are deposited on to a substrate in layers to form a chemical precursor that is mostly amorphous.
 •Figure a
•They then are annealed
 •At low temperatures the layers form small crystallites but is largely amorphous.
 •Figure b and c
 •At a specific temperature the crystals reach a maximum size.
 •Figure d
 •If the thin film was annealed at to high of a temperature, the sample layers will separate completely from each other.
 •Figure e
•Different thicknesses of each layer and patterns of layering are tested.
 •The goal is to find which produces the most ordered structure and the optimum electrical conductivity.

Thermoelectrics

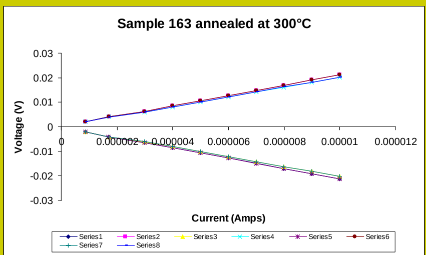
•Thermoelectric materials convert a heat gradient into electricity.
•These materials are used under high temperature gradients and produce little resistance heating.
•Materials with a high Seebeck coefficient, high electrical conductivity, and low thermal conductivity have ideal thermoelectric properties. This can be seen in the figure of merit equation at right.

S = Seebeck Coefficient
K = Low thermal conductivity
s = High thermal conductivity
T = Absolute Temperature
ZT = Thermoelectric figure of merit (no units)

$$ZT = \frac{S^2\sigma}{k}T$$

Resistance

•The resistance of a current through a sample is how well it can conduct a charge.
•Test the resistance using the van der Pauw.



van der Pauw Method

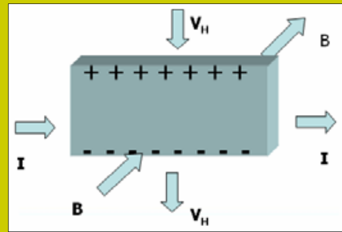
•To find the resistance of a sample a uniform shape is used, preferably the clover leaf or x pattern. A uniform shape is needed, because the geometry of the sample plays a role in calculating its resistance. The resistance of a sample is found by directing a current through one end of the x shaped pattern and letting it flow to the opposite side of the sample. The voltage is then measured on the same sides that the current has passed from and to. This pattern is repeated for all eight combinations of measuring current voltage. This process was used because the contact resistance cancels out and the homogeneity the sample can be indirectly observed.

V=IR

•The relationship between the voltage and the current according to Ohms Laws is linear

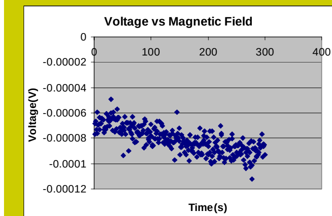
Hall Voltage

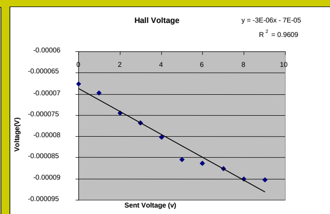
•Testing for voltage by directing a current through the sample, inducing a magnetic field, and measuring the voltage perpendicular to the current and magnetic field.
•The build up of charge is caused by the Lorentz force on charged particles.
 -A build up of these particles produces the Hall Voltage
•V_H =IB/nqd
 - V_H =Hall voltage
 I= Current
 B= Magnetic Field
 n=Density of Charge Carriers
 q= 1.60217646 × 10^-19 coulombs
 d= Width of sample



Hall Voltage for Silicon

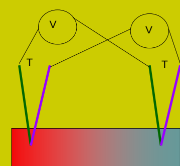
•The Voltage was measured at 10 different Magnetic Fields.
•Thirty data points were collected at each Field.
 •Each field was averaged to find the relationship between the Hall voltage and the Voltage used to make the magnetic field. When the sample was placed under a magnetic field the noise created by in adequate connection between the wire contacts and the sample, as well as defects in the sample that could be causing the resistance in the sample to increase. The purposed solution was to average the points take at different magnetic field and analyze the relation ship between the voltage use for the magnetic field and the Hall Voltage received. The Magnetic field was ranged from 0-10 Tesla increasing in one Tesla increments.
 •5 V ~1.5 Tesla
 •1 V ~ 3Tesla





Seebeck Effect

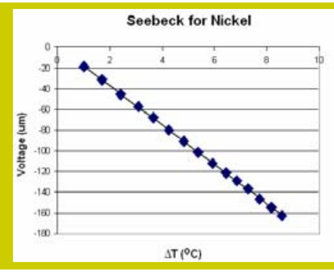
•The Seebeck effect is the measurement of a voltage between different conductors or semiconductors caused by a temperature gradient.
 •This will cause a flow of current across the material.
•Charge carrier diffusion
 •A change in temperature at different points causes the charge carrier to diffuse through the material.
 •The charge carriers are attracted to the cooled or heated sides of the sample.
 •The holes are positive nuclei that can diffuse to the heated side of the sample.
 •The electron are the negative charge carriers that can diffuses to the cooled side of the sample.



V = Voltage
T= Temperature

Seebeck Coefficient

•The relationship between the Voltage measured and the change in temperature is the Seebeck Coefficient.
 •The slope of the graph is the Seebeck Coefficient.
 •For Nickel the Seebeck Coefficient is -15.
 •The experimental best fit is y = -19.1x + 1.2 with a R^2 correlation of 0.9999.



Conclusion

•A relationship was found between the magnetic field and the measured Hall Voltage produced.
•The Seebeck Coefficient, Hall Voltage and Resistance were found to assess these materials as thermoelectric.

Future Work

•Find what layered structure has the desired Hall voltage, Resistance, and Seebeck Coefficient for PbSeMoSe.
•Improve the systems for finding the Hall Voltage, Resistance, and Seebeck Coefficient.

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