Exp. P- 5 Hall Effect in Semiconductors and Metals

References:

- Young & Freedman, University Physics, 12th edition: pp. 943-944
- Melissinos, “Experiments in Modern Physics”, 2nd ed., pp. 63-70
- PHYWE / Leybold Experiment Descriptions 5.3.01, 5.3.03

Objectives:

1. To demonstrate the Hall effect in a p-type semiconductor:

- *measure the Hall voltage and determine the sign of the charge carriers*
- *measure **n**, the density of charge carriers in the semiconductor*
- *observe how n changes as a function of temperature*

2. Attempt to observe a very small anomalous Hall effect in a conductor (Zn) using the microvolt range of the digital multimeter.

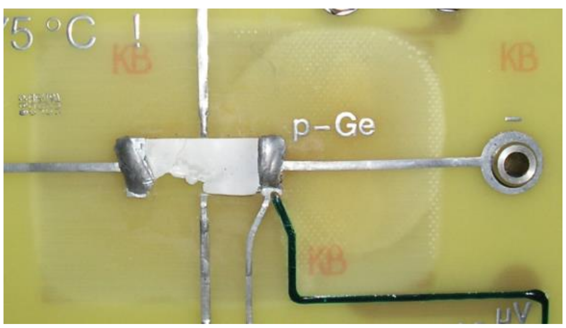
Equipment:

PHYWE Hall effect experimental apparatus (upgraded)

Instructions:

CAUTION:

- Before turning on power for the first time, please have your lab instructor check your cabling.
- The F.W. Bell Hall probe (magnetometer) used to measure the magnetic field applied to the sample is very fragile. Please be very careful when inserting and removing it from the small hole in the Hall module. Do not bend or twist the probe. If the Hall probe is not in use, please cover it with the plastic tube and store it in the black protective briefcase.
- Please touch the printed circuit boards holding the samples only briefly and only at the edges when installing and removing them. Never touch the Ge semiconductor sample itself! We do not want to see a reoccurrence of a result like this:



- Make sure the poles of the electromagnet never touch the Ge sample or the board (danger of electric short).
- After heating of the sample board it will remain hot for a while. Keep that in mind when manipulating it.

1. For the setup basically follow the procedures in the PHYWE / Experiment Descriptions starting with 5.3.01-01 (Hall effect in p-germanium) and then 11.8.04 (Hall effect in metals). See Sen. Lab web site.

2. Suggested measurements for p-type semiconductor:

- At room temperature:
  - sign of V_{Hall} and charge carriers
  - determine the "Hall constant" R_H and n in two ways:
    - V_{Hall} vs. I with constant B
    - V_{Hall} vs. B with constant I
  - effect of B field on sample resistance:
    - measure R_{sample}
    - measure $\Delta R_{sample}/R_{sample}$ as a function of applied B field

- As a function of sample temperature:
    - measure R_{sample} vs. T (at B = 0T)
    - V_{Hall} vs. T with constant, non-zero B

Quiz preparation:

Besides knowing the basics about the Hall effect, you are expected to be able to <u>derive</u> the main equation for the Hall voltage (starting from the Lorentz force):

$$V_{Hall} = I\, B \,/\, (n\, e\, t),$$

where I is the current through the sample, B the applied magnetic field, n the density of charge carriers, e the elementary charge, and t the thickness of the conductor sample.

Original 1/20/10 by M. Hohlmann, first revision 1/20/14 by MH