FINALE 2022-LuxPhO EXPERIMENT

Temperature measurement using diodes

Explanations

Materials:

- 1x wooden box with a halogen spot and connectors
- 1x metal plate with 2 strong magnets and a common ground connection
- 2x small metal crucibles with diodes soldered to them (one crucible contains an unknown solid white substance)
- 2x $5{,}1\ \mathrm{k\Omega} \pm 1\%$ resistors connected between the terminals
- 1x set of connection wires
- 1x multimeter for DC Voltage measurement (Fluke)
- 1x multimeter for DC mV measurements (can also be connected to the temperature probe)
- 1x Thermocouple temperature probe
- 1x 12V power supply
- 1x adjustable DC power supply
- 1x stopwatch
- 3x sheets of graphing paper size A4
- Blank sheets of paper

ALL MEASURED VALUES MUST BE CLEARLY INDICATED.

You will submit your data tables, graphs and data analysis on paper.

Use of a non-graphing calculator is allowed.

Write your full name on each sheet that you submit.

Introduction

Silicon diodes are electrical components which only let electrical current pass in one direction. They need to be biased using a certain voltage U to pass a small constant current I. For a given current, this voltage depends significantly on temperature T thus making diodes into simple and cheap temperature sensors. These sensors may be used to study temperature dependent phenomena, like phase changes for example.

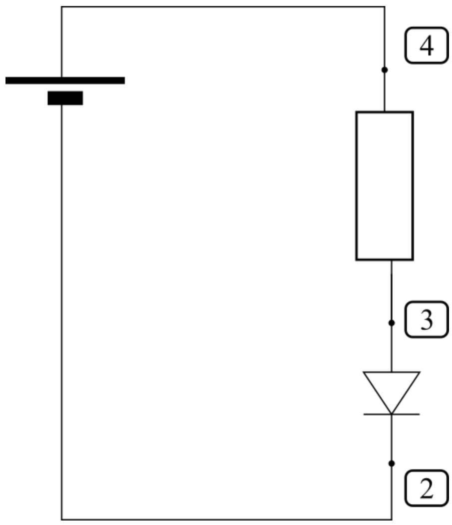
We connect a DC voltage source set to 5V to a $5{,}1\ \mathrm{k\Omega}$ resistor in series to the diode to provide a constant current for the diode.

A 12V halogen lamp powered by a separate supply is used to heat up the inside of the wooden box. Do not leave the lamp on for an extended time, you may cause a fire.

Experiment 1: Study of the temperature relationship

In the first experiment we will only use the diode without the solid substance.

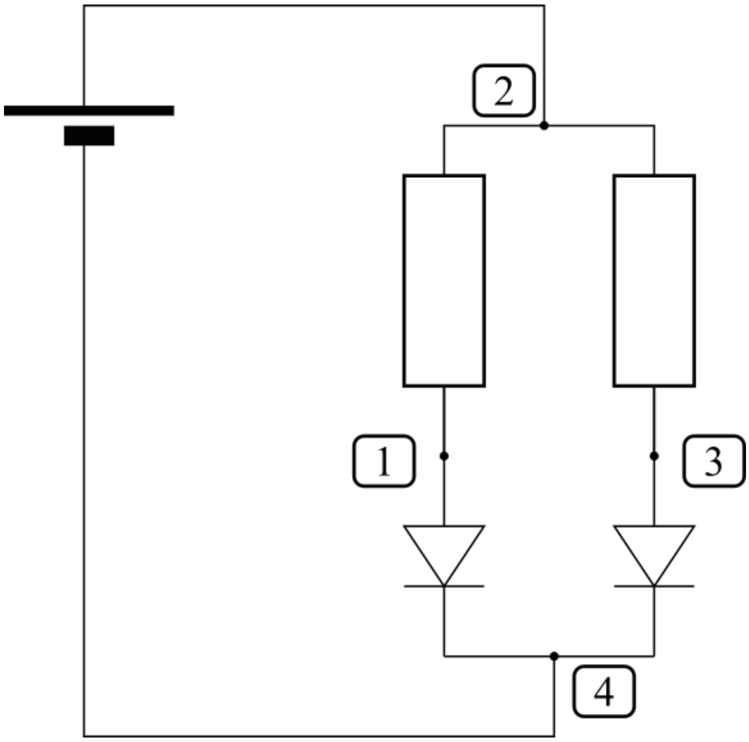
1. Use a wooden peg to clamp the tip of the temperature probe to the diode connection as close as possible to the diode. Close the box with the lid to avoid temperature fluctuations by convection.
2. Make the necessary connections for the following circuit and connect a multimeter to measure the bias voltage of the diode



3. Turn on the halogen lamp until the diode temperature has reached $\approx 100°C$. Then turn the lamp off.
4. While the diode is cooling down, record the bias voltage as a function of the temperature in $5°C$ increments down to $\approx 40°C$
5. Graph the temperature dependence of the bias voltage as function of the temperature.
6. Find a mathematical relationship $U(T)$.

Experiment 2: Differential measurement

For the second experiment, we will use both diodes simultaneously to determine the melting point of the unknown material. We measure the difference in bias voltage between the two diodes $\Delta \mathrm{U} = \mathrm{U}_{13}$ and the bias voltage $U = U_{14}$ for the diode in contact with the unknown substance as a function of time. The bias voltage may be converted into a temperature scale using the results from the previous experiment (Do not use the temperature probe for this).



1. Make the necessary connections and close the box with the lid to avoid temperature fluctuations by convection.
2. Calculate the voltage U needed to achieve a temperature of $\approx 90°C$ and heat the setup up using the halogen spot.
3. Take measurements of elapsed time t after turning off the lamp, the bias voltage U and the voltage difference ΔU at 30s intervals.
4. Graph $U(t)$ and $\Delta U(T)$ on 2 separate sheets of graphing paper.
5. Describe both graphs in detail and explain the main features you see on the graph
6. Analyze the graphs to determine the approximate melting point of the unknown material. Explain how you can spot the melting point on both graphs.
7. In an ideal situation, a non-zero voltage difference ΔU would only be caused by the unknown material in one of the crucibles. Discuss what other non-ideal effects could play a role.