Electrical Conduction in Solid

Purpose

To study the nature of electrical conduction in metals and semiconductors.
To estimate the temperature coefficient of resistance (α) of platinum.
To estimate the energy gap (ΔE) of a semiconductor.

Background

The temperature-dependency of the specific resistance R is a simple test for models of electric conductivity in conductors and semiconductors. In electrical conductors, R rises with the temperature, as the collisions of the quasi-free electrons from the conduction band with the incomplete atoms of the conductor play an increasing role. In semiconductors, on the other hand, the resistance decreases as the temperature increases since more and more electrons move from the valence band to the conduction band, thus contributing to the conductivity.
This experiment measures the resistance values of a noble-metal resistor and a semiconductor resistor as a function of the temperature.
For the noble metal resistor, the relationship
$\mathbf{R = R_0 (1 + \alpha\, t)}$
(where, R_0 is the resistance at t = 0 °C) is verified with sufficient accuracy in the temperature range under study.
For the semiconductor resistor, the evaluation reveals a dependency with the form
$\mathbf{R \approx \exp(\Delta E/2kT)}$
where, $k = 1.38\times10^{-23}$ J/K is the Boltzmann constant, T is the temperature in Kelvin.

Equipment list

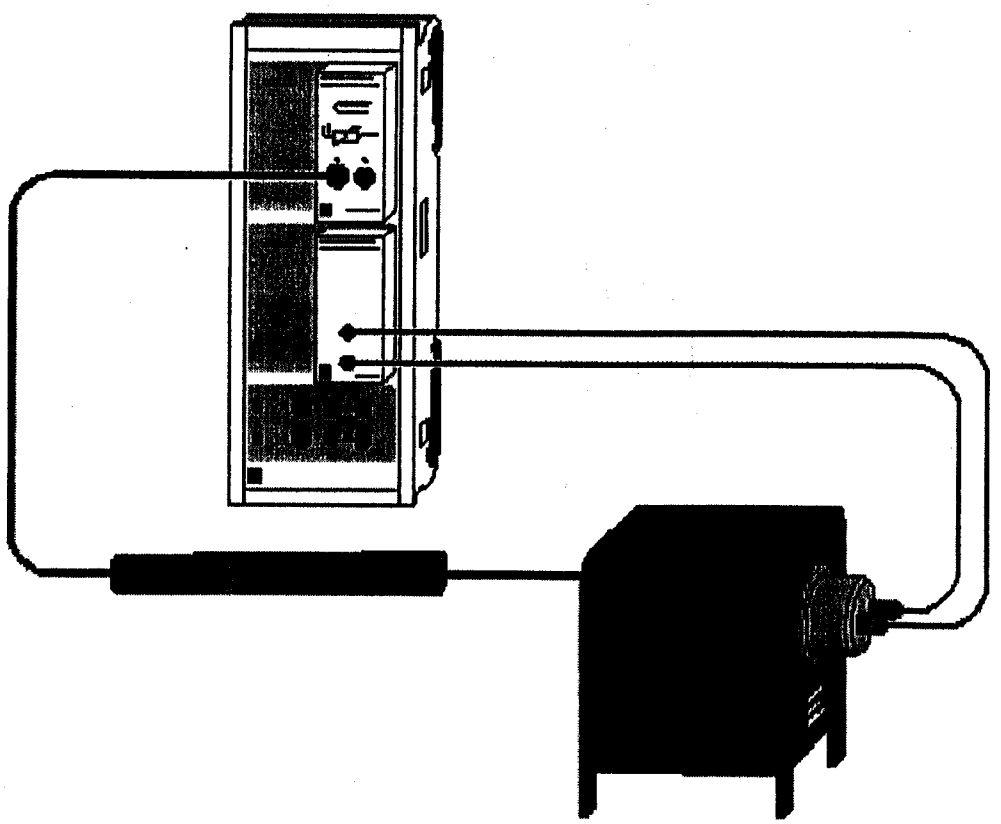
Sensor-CASSY	524 010
CASSY Lab	524 200
Current supply box	524 031
Temperature box	524 045
Temperature sensor NiCr-Ni	666 193
Noble metal resistor	586 80
Semiconductor resistor	586 82
Electric oven	555 81

PC with Windows 95 or higher version

Experiment setup

The temperature box at Sensor-CASSY input A measures the temperature of the sensor in the electric oven. Insert the measuring tip into the hole on the back of the oven so that the

tip is in direct proximity to the resistor element. The current supply box at input B registers the electrical resistance.



Procedure

1. Load settings
2. Start the measurement with F9 (a value pair is recorded for every temperature increase of 5 K).
3. Switch on the oven.
4. Stop the measurement with F9 at the latest when the temperature reaches 470 K (approx. 200 °C).
5. Switch off the oven and remove the resistor.
6. When the oven has cooled off repeat the measurement with a different resistor.

Analysis

1. Discuss the different nature of electrical conduction in metals and semiconductors.
2. Fit a straight line to the data of noble metal (platinum) resistor, find its α, and compare with the literature value (0.0039 /K).
3. Fit an exponential function to the data of the semiconductor resistor for higher temperatures T, find its ΔE, and compare with the literature value (0.48 eV).