3B SCIENTIFIC® PHYSICS

Undoped germanium on circuit board 1008522

Instruction manual

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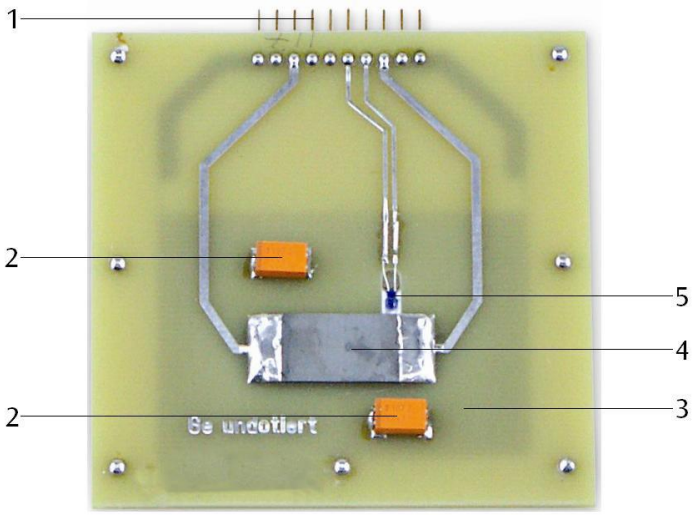


1 Multi-pin plug
2 Spacer
3 Heating element
4 Undoped germanium crystal
5 PT100 thermocouple

1. Safety instructions

The germanium crystal is highly breakable:

- Handle the board carefully and do not put any mechanical stress on it.

The sample circuit board can get very hot when in operation (170°C) and there is a risk of burns.

- Before dismantling the board from the apparatus, allow it sufficient time to cool.

Because of its high resistivity, the germanium crystal will start to heat up as soon as a sample current is put through it.

- Do not exceed the maximum sample current $I = \pm 4$ mA.
- Turn the trimmer for setting the sample current to a position in the centre.

2. Description

The circuit board is intended for use with the Hall effect basic apparatus (1009934) in order to measure the conductivity of undoped germanium as a function of temperature.

The circuit board has a multi-pin plug with contacts for a sample current, the resistive heating element and the temperature sensor underneath the crystal.

3. Contents

1 Circuit board with germanium crystal
1 Test record
1 Instruction manual

4. Technical data

Maximum sample current:	±4 mA
Dimensions of crystal:	20x10x1 mm approx.
Dimensions:	70x70x10 mm approx.
Weight:	30 g approx.

5. Pin assignment

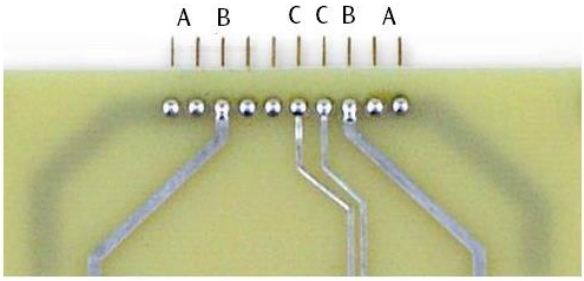


Fig. 1 A Heating element, B Sample current through germanium crystal, C PT100 thermocouple

6. Operation

Installation of the circuit board in the Hall effect console and the circuit diagram for the experiment are included in the instruction manual for the Hall effect equipment itself.

7. Care and maintenance

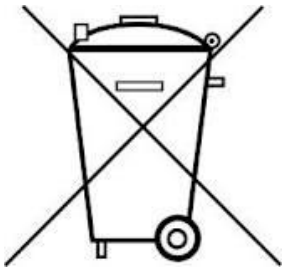
- Use a soft brush to clean the board. Do not touch the crystal with your fingers if possible.
- Keep in the original box after the equipment has been used and has cooled down.

8. Disposal

- If you need to dispose of the circuit board, never throw it away in normal domestic waste. Local regulations for the disposal of electrical equipment will apply.

The packaging is made of environmentally-friendly materials and can be recycled.

- You can dispose of it at local recycling points.



9. Experiments

Measurement of conductivity as a function of temperature

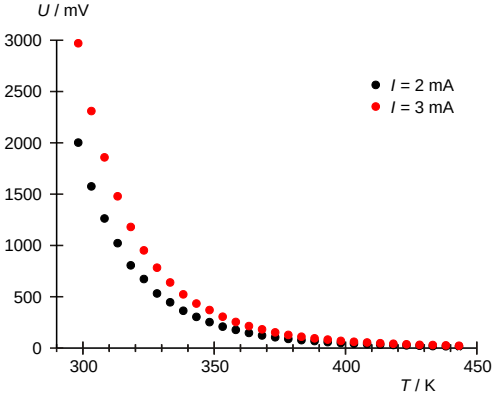


Fig. 2 Sample voltage *U* as a function of temperature *T* (Voltage drop across germanium crystal for sample currents of 2 and 3 mA)

Measurements:
U_P: Sample voltage (basic apparatus)
T_P: Sample temperature (basic apparatus)

Derived values:

Conductivity: $\sigma = \frac{I}{U} \cdot \frac{20\ \text{mm}}{10\ \text{mm} \cdot 1\ \text{mm}}$

Absolute temperature in Kelvin: $T = T_P + 273{,}15\ \text{K}$

Form: $\ln \sigma = f\left(\frac{1}{T}\right)$

This is because at high temperatures (intrinsic conductivity) the following applies:

$$\ln \sigma = \ln \sigma - \frac{Eg}{2\ \text{K}} \cdot \frac{1}{T}$$

$Eg \approx 0.7$ eV band gap for germanium

$k = 8{,}625 \cdot 10^{-5} \frac{\text{eV}}{\text{K}}$ Boltzmann's constant

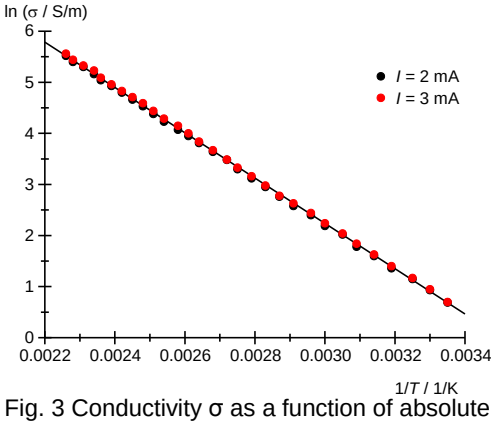


Fig. 3 Conductivity σ as a function of absolute temperature *T*