

Four Probe Method - Basic Model

Resistivity of Semiconductors by Four Probe Method at Different Temperatures and Determination of the Band-gap

The Four Probe Method is one of the standard and most widely used method for the measurement of resistivity of semiconductors. The experimental arrangement is illustrated. In its useful form, the four probes are collinear. The error due to contact resistance, which is specially serious in the electrical measurement on semiconductors, is avoided by the use of two extra contacts (probes) between the current contacts. In this arrangement the contact resistance may all be high compare to the sample resistance, but as long as the resistance of the sample and contact resistances are small compared with the effective resistance of the voltage measuring device (potentiometer, electrometer or electronic voltmeter), the measured value will remain unaffected. Because of pressure contacts, the arrangement is also specially useful for quick measurement on different samples or sampling different parts of the same sample.

Description of the experimental setup

1. Probes Arrangement

It has four individually spring loaded probes. The probes are collinear and equally spaced. The probes are mounted in a teflon bush, which ensure a good electrical insulation between the probes. A teflon spacer near the tips is also provided to keep the probes at equal distance. The whole –arrangement is mounted on a suitable stand and leads are provided for the voltage measurement.

2. Sample

Germanium crystal in the form of a chip

3. Oven

It is a small oven for the variation of temperature of the crystal from the room temperature to about 200°C (max.)

4. Four Probe Set-up

The set-up consists of three units in the same cabinet.

(i) Multirange Digital Voltmeter

In this unit, intersil 3½ digit single chip A/D Converter ICL 7107 has been used. It has high accuracy like auto zero to less than 10mV, zero drift of less than 1mV/°C, input bias current of 10pA max. and roll-over error of less than one count. Since the use of internal reference causes the degradation in performance due to internal heating, an external reference has been used.

Specifications	
Range	X1 (0-200mV) & X10 (0-2V)
Resolution	100mV at X1 range
Accuracy	±0.1% of reading ±1 digit
Stability	Within ±1 digit
Input Impedance	1MW
Display	3½ digit, 7 segment LED (12.5mm height) with auto polarity and decimal indication
Overload Indicator	Sign of 1 on the left & blanking of other digits

(ii) Constant Current Generator

It is an IC regulated current generator to provide a constant current to the outer probes irrespective of the changing resistance of the sample due to change in temperatures. The basic scheme is to use the feedback principle to limit the load current of the supply to preset maximum value. Variations in the current are achieved by a potentiometer included for that purpose. The supply is a highly regulated and practically ripple free d.c. source. The current is measured by the digital panel meter.

Specifications	
Open Circuit Voltage	18V
Current Range	0-20mA
Resolution	10mA
Accuracy	±0.25% or ±1 digit
Stability	Within ±1 digit
Load regulation	0.03% for 0 to full load
Line regulation	0.05% for 10% change

iii) Oven Power Supply

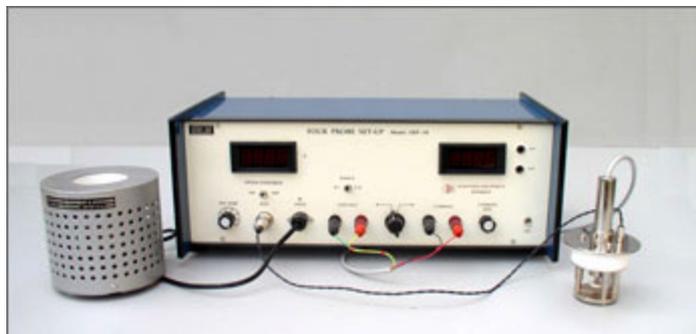
Suitable voltage for the oven is obtained through a step down transformer with a provision for low and high rates of heating. A glowing LED indicates, when the oven power supply is 'ON'.



Four Probe Method - Advance Model

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Description of the experimental setup

1. Probes Arrangement

It has four individually spring loaded probes. The probes are collinear and equally spaced. The probes are mounted in a teflon bush, which ensure a good electrical insulation between the probes. A teflon spacer near the tips is also provided to keep the probes at equal distance. The probe arrangement is mounted in a suitable stand, which also hold the sample plate. To ensure the correct measurement of sample temperature, the RTD is embeded in the sample plate just below the sample. This stand also serves as the lid of temperature controlled oven. Proper leads are provided for the current and voltage measurement.

2. SAMPLE

Germanium crystal in the form of a chip.

3. OVEN

This is high quality temperature controlled oven suitable for Four Probe Set-up. The oven has been designed for fast heating and cooling rates, which enhances the effectiveness of the controller.

4. FOUR PROBE SET-UP

The set-up consists of three units housed in the same cabinet.

(i) Oven Controller

Platinum RTD (A class) has been used for sensing the temperature. A wheatstone bridge and an instrumentation amplifier are used for signal conditioning. Feedback circuit ensures offset and linearity trimming and a fast accurate control of the oven temperature.

Specifications of the Oven

Temperature Range	Ambient to 473K
Resolution	1K
Stability	±0.5K
Measurement Accuracy	±1K (typical)
Oven	Specially designed for Four Probe Set-Up
Sensor	RTD (A class)
Display	3½ digit, 7 segment LED with autopolarity and decimal indication
Power	150W

(ii) Multirange Digital Voltmeter

In this unit, intersil 3½ digit single chip A/D Converter ICL 7107 has been used. It has accuracy, auto zero to less than 10 V, zero drift-less than 1 V/ C, input bias current of 10 pA and roll over error of less than one count. Since the use of internal reference causes the degradation in performance due to internal heating, an external reference has been used.

Specifications of the Oven

Range	X1 (0-200mV) & X10 (0-2V)
Resolution	100V at X 1 range
Accuracy	0.1% of reading 1 digit
Display	3½ digit, 7 segment LED with auto polarity and decimal indication
Overload Indicator	Sign of 1 on the left & blanking of other digits.

FOUR PROBE METHOD

(iii) Constant Current Generator

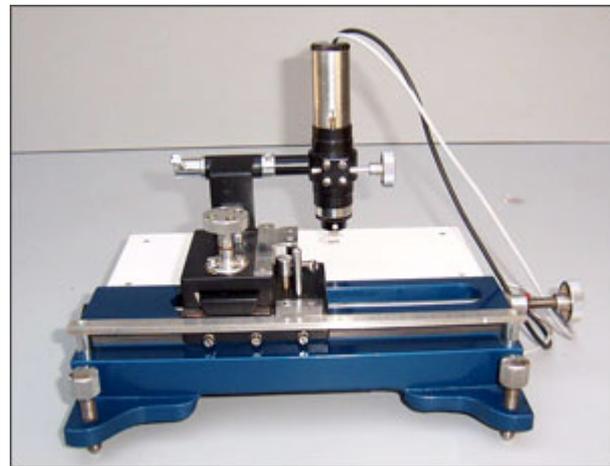
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Specifications of the Oven

Open Circuit Voltage	18V
Current Range	0-20mA
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Four Probe Method - Resistivity Mapping

- Easy resistivity mapping of large sample
- 2 – way movement with vernier scales (0.01mm)
- Spring loaded contacts for firm connections
- Four probe set-up for mapping the resistivity of large samples



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