VIJAYANTA
VIJAI ELECTRONICS
28/147, CIVIL LINES
ROORKEE – 247667

ISO – 9001-2008
Certificate No. WSC-215028-A

FOUR PROBE SET – UP
(Advance Model)
Model : DFP – 03

Resistivity of semiconductor 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. In its useful form, the four probes are collinear. The error due to contact resistance, which is significant 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 resistance's 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 sample.

DESCRIPTION OF THE EXPERIMENTAL SET-UP

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

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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 enbeded 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, DFP-03
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 auto polarity and decimal indication
Power	:	150W

(i) Multirange Digital Voltmeter:
In this unit, intarsia 3½ digit single chip A/D Converter ICL 7107 has been used. It has accuracy, auto zero to less than 10 µV, zero drift-less than 1 µV/ °C, input bias

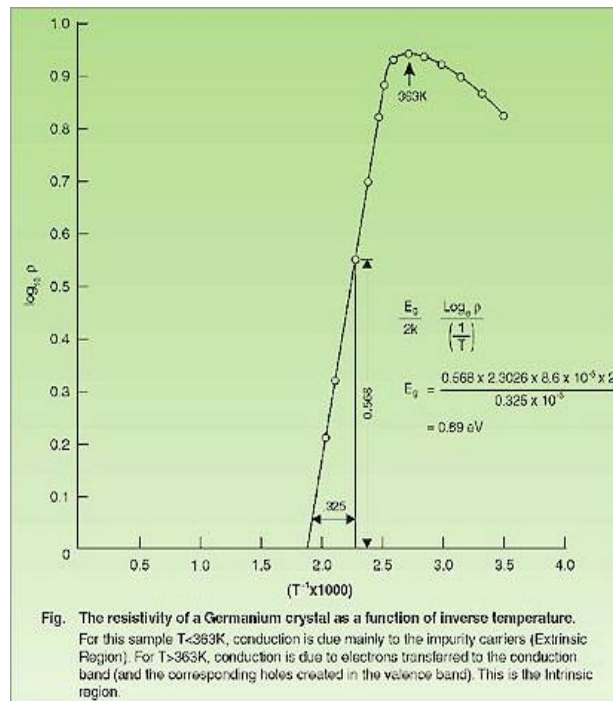current of 10 pA and roll over error of less than one count. Since the use of internal reference causes the degradation in performance due to internal heating, an external reference has been used.

Specifications of the Oven		
Range	:	X1 (0-200mV) & X10 (0-2V)
Resolution	:	100 ⎧V at X 1 range
Accuracy	:	± 0.1% of reading ± 1 digit
Display	:	3½ digit, 7 segment LED with autopolarity anddecimal indication
Overload Indicator	:	Sign of 1 on the left & blanking of other digits.

$$\frac{E_g}{2k} \quad \frac{Log_e \rho}{\left(\frac{1}{T}\right)}$$

$$E_g = \frac{0.568 \times 2.3026 \times 8.6 \times 10^{-5} \times 2}{0.325 \times 10^{-3}}$$

$$= 0.89 \ eV$$

Fig. The resistivity of a Germanium crystal as a function of inverse temperature. For this sample T<363K, conduction is due mainly to the impurity carriers (Extrinsic Region). For T>363K, conduction is due to electrons transferred to the conduction band (and the corresponding holes created in the valence band). This is the Intrinsic region.

(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 of the Oven		
Open circuit Voltage	:	18 V
Current Range	:	0 - 20 mA
Resolution	:	10 µA
Accuracy	:	± 0.25% of the reading ± 1 digit
Load Regulation	:	0.05% for 0 to full load
Load Regulation	:	0.05% for 10% changes

The experimental set-up is complete in all respect
Typical results obtained from this set-up are shown in the graph.