



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 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 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 holds the sample plate and thermocouple sensor. This stand also serves as the lid of PID Controlled Oven. Proper leads are provided for the current and voltage measurements.



2. PID Controlled Oven cum Cryostat

In this unit heating of sample zone is done through heating coil and cooling through controlled flow of liquid nitrogen. The necessary components such as the cryostat, the flow system etc. are included. Temperature range is from -190°C to 200°C. The unit is a high quality PID controller wherein the temperatures above ambient can be set and controlled easily. The P, I and D parameters are factory set for immediate use however the user may adjust these for specific applications as well as auto-tune the oven whenever required. The steps for these are given in its user's manual.

Specifications of the Temperature Controller

The controller is designed around Autonics Temperature Controller Model TK4S. Although this is a very versatile piece of equipment, below is a summary of the specifications that are relevant to the present application.

Temperature Range	: -190°C to 200°C
Oven	: Specially designed for Four Probe Set-Up
Display Accuracy	: $\pm 0.3^\circ\text{C}$
Sensor	: Thermocouple (Chromel-Alumel)
Setting Type	: Front push buttons
Display	: 7 segment LED, two rows
Control Method	: PID, PIDF, PIDS



Note: Specifications are subject to change.

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Values : Process Value, PV and Set Value, SV
 Temperature control range : Ambient to 200°C
 Power : 150W

3. Constant Current Source (for low resistivity to medium resistivity samples)

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 from the supply to preset value. Variations in the current are achieved by a potentiometer included for that purpose. The supply is a highly regulated and practically ripples free d.c. source. The constant current source is suitable for the resistivity measurement of thin films of metals/ alloys and semiconductors like germanium.



Open Circuit Voltage : 10V
 Current Range : 0-20mA, 0-200mA
 Resolution : 10mA
 Accuracy : $\pm 0.25\%$ of the reading ± 1 digit
 Display : $3\frac{1}{2}$ digit, 7 segment LED with autopolarity and decimal indication
 Load Regulation : 0.03% for 0 to full load
 Line Regulation : 0.05% for 10% changes

4. Low Current Source (for high resistivity samples)

Low Constant Current Sources are needed, when the sample resistance, is too large. As in the case of silicon wafers or high resistivity film deposits. Large resistance makes the measurement prone to pickups from various sources. This problem is reduced to very low level by using the battery instead of mains. Since the current requirement is very small, the batteries should have a reasonably long life. An internal voltage reference of 2.5V ensures reliable operation even when the battery voltage falls. A ten turn potentiometer makes the current adjustment very easy.



Open Circuit Voltage : 15V
 Current Range : 0-2mA, 0-20m A, 0-200mA & 0-2mA
 Resolution : 1nA at 0-2mA range
 Accuracy : $\pm 0.25\%$ of the reading ± 1 digit
 Display : $3\frac{1}{2}$ digit, 7 segment LCD with autopolarity and decimal indication
 Load Regulation : 0.05% for 0 to full load
 Power : 2 x 9V batteries

5. Digital Microvoltmeter (Detailed specifications as per datasheet attached)

Experiment is complete in itself (except liquid nitrogen)

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