CHAPTER - III

SYSTEM DESIGN

3.1 INTRODUCTION

The material characterization is one of the important factor in research and development. The transport properties of the materials in thin film form give an account of many electrical parameters. These crucial parameters were measured by manual methods, in which possibility of human and instrumental error increases and varies person to person.

There is revolution take place in science and technology because of rapid development in the field of computer technology. During last few decades computer in the field of measurement and control extensively used because of significant improvement in measurement and control.

In the present work an attempt has been made to develop the computer based system for the measurement of resistivity and thermoelectric power. The system design is divided into two parts -

(i) Mechanical

(ii) Electrical

The present chapter give emphasis on mechanical system design and basics of the electronic system.

3.2 MECHANICAL SYSTEM DESIGN CONSIDERATIONS

1. The temperature range over which the system is to be operated must be fixed. This is because, both resistivity and thermoelectric power are temperature dependent parameters. In the present system the operating temperature range varied from 25°C to 450°C.

2. The resistivity can be measured by using two probe or four probe methods. In the present system design four probe technique is used.

3. The different physical parameters like temperature and voltage were measured during characterization.

   Thermocouple is used as a temperature sensor.

4. The size and shape of the sample is the another criteria. The present system is designed for the samples in thin film form with dimensions 3.5 x 1.5 cm.

By taking into account all these specifications, the four probe resistivity and TEP measurement system is designed.

3.3. ELECTRICAL RESISTIVITY AND TEP MEASUREMENT SET UP

A mechanical set up was designed and fabricated in the Departmental work-shop. The cross sectional view of the same is shown in fig. 3.1. The bakelite sheet is used to support the complete assembly and it is separated by the insulating layer to avoid heating of the bakelite. The system assembly mainly contains four-probe resistivity set up and TEP set up.

The different parts of the system are discussed below :-

3.3.1 System Platform

A bakelite sheet having one square feet area with thickness of 1.5 cm. is used as supporting base for the system. Since the system operating temperature range is wide, a highly temperature resistant bakelite material is selected as base.

On the surface of bakelite sheet a thin layer of Asbestos (with thickness of 5 mm) is placed as an insulating layer.

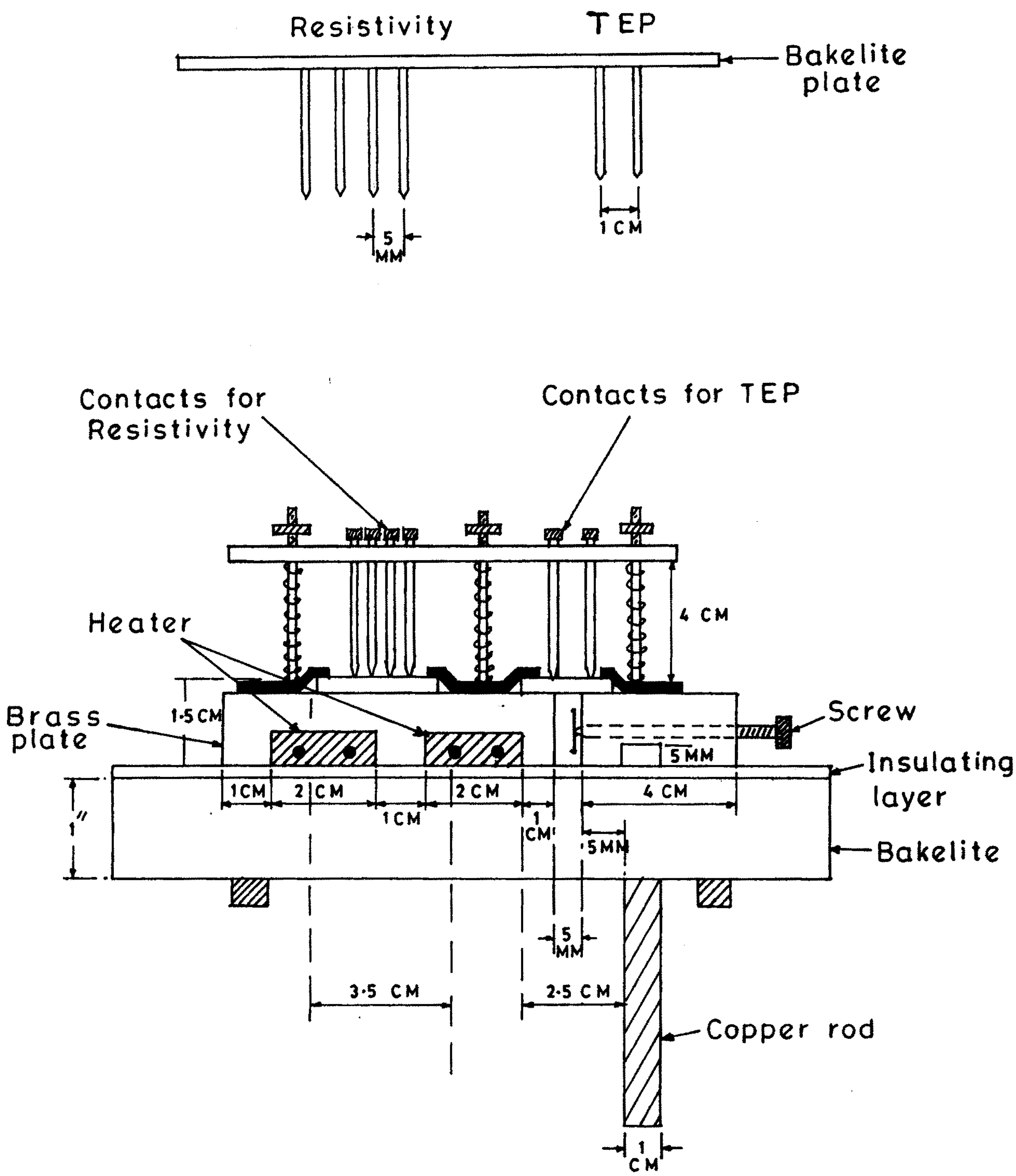

Fig. 3.1: Electrical Resistivity and TEP measurement set-up.

3.3.2 Hot Plates

To heat the sample during resistivity and thermoelectric power measurement brass slabs were used. The brass slab of dimensions 10 x 7 x 1.5 cm. is used for resistivity measurement. The brass plate is grooved to fix the strip heater of 100 watts.

The other brass with dimensions 5 x 4 x 1.5 cm. is fixed one centimeter away from the first slab to provide temperature gradient for thermoelectric power measurements. The copper rod is screwed in the second plate which is kept in ice bath during thermoelectric power measurement to achieve sufficient temperature gradient.

3.3.3 Heating Arrangement

The brass plate 1 is used as hot plate. To form the heating arrangement this plate is grooved at the bottom side to fix the strip type heater elements parallel to the length of brass plate in order to achieve uniform temperature.

3.3.4 Temperature Sensor

The cromel - Alumel thermocouple is used as temperature sensor due to its wide temperature range, linearity and low cost. The thermocouples are mounted on the brass plates by using screw arrangement.

3.3.5 Probe Assembly

The four probe assembly for resistivity measurement and two probes for TEP measurement are fabricated by using 1 to 2 cm. brass rod having probe of length of 5 cm. each. These probe rods were mounted on a thin bakelite sheet at proper distance using screws. While the other ends of probe rods were tipped, to form a point contact with the sample. The spacing between the four probes is 5 mm. while that of TEP electrodes is 1 cm.

For holding the probe assembly onto the surface of brass plates three equidistant rods are fitted inside these plates. To the other side of each rod threaded screw arrangement is provided. By using good quality springs in these rods and placing probe assembly on it, we can move the probe assembly vertically up or down with the help of threaded screws.

In order to hold the samples during measurement appropriately, a clamping arrangement known as 'Sample holder' is also provided. In addition to this a pellet holding arrangement is provided, to measure the TEP of pellets.

The four probe resistivity set up so designed and fabricated for resistivity measurement is useful for low resistivity samples. For high resistivity samples we can use the same unit for two point probe method without modification in the system.

3.4. BASICS OF ELECTRONIC SYSTEM

3.4.1 Operating Principle

The system works on the principle that, it senses the desired parameters required for electrical resistivity and thermoelectric power measurement by using suitable sensors. These analog signals generated by sensing elements are raised to desired level by using proper signal conditioning circuits and are converted into digital forms with the help of A/D interfacing card. The digital data produced is stored, manupalated and the results generated are displayed by the computer through system software.

Hence the PC-based resistivity and thermoelectric power measurement system needs resistivity and TEP measurement set up, signal conditioning circuits and A/D interfacing card for their operation. In its basic form the whole system is shown in the fig. 3.2.

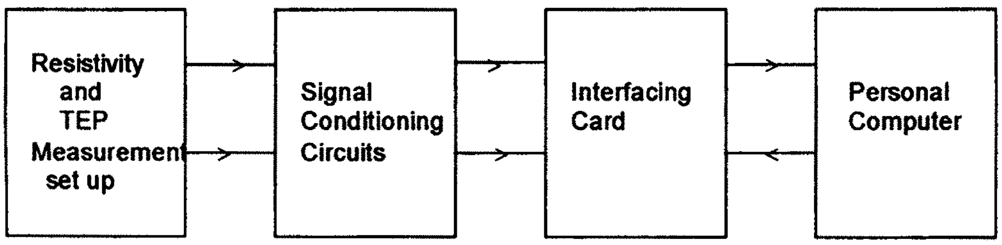

Fig. 3.2 : Basic system configuration

3.4.2 System Block diagram

The schematic block diagram of PC based electrical resistivity and thermoelectric power measurement system is shown in fig. 3.3.

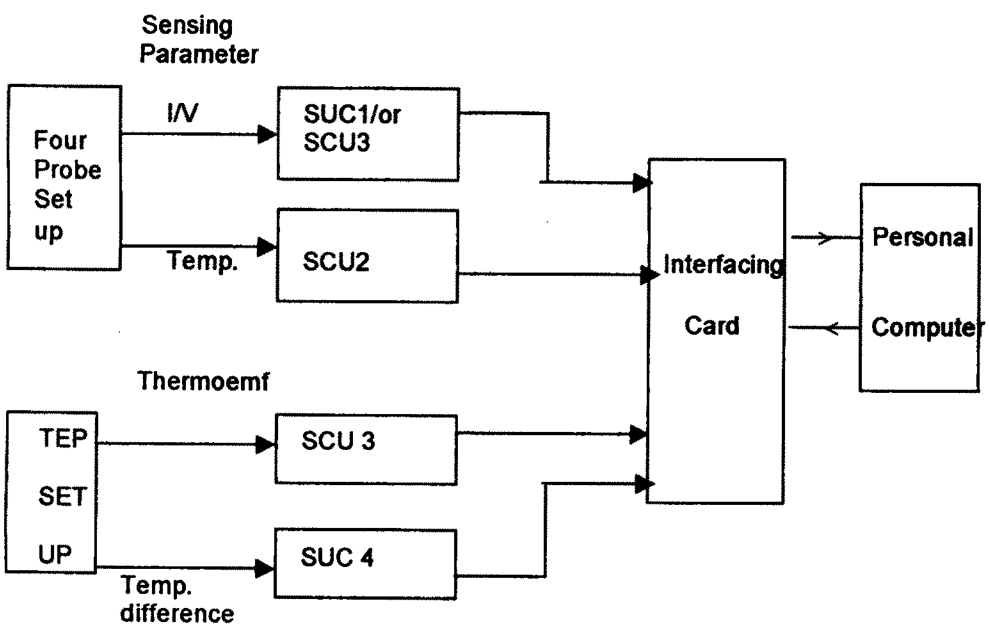

Fig. 3.3 : System block diagram

3.4.3 Description and working

The system block diagram contains a four probe and TEP set up, signal conditioning units (SCUs), A/D interfacing card and a PC. To understand the system operation clearly it is divided into two parts as -

(1) Electrical resistivity measurement.

(2) Thermoelectric power measurement.

3.4.3.1. Electrical Resistivity measurement

For the measurement of electrical resistivity of samples the Four-point probe or two-point probe methods are employed. In two-point probe resistivity measurement a constant voltage is applied across the sample and the current variation with temperature is converted into the voltage by I to V converter (SCU 1). Then it is fed to A/D converter card with proper scaling. The separate signal conditioning circuit (SCU 2) is developed for temperature measurement by using thermocouple as sensor and is fed to one of the channel of A/D interfacing card. This technique is useful for high resistivity samples.

In four probe resistivity measurement, a constant current is passed through the sample (outer probes) and the voltage variation with temperature across two inner probes is sensed and scaled to 0-5V using voltage amplifier (SCU 3). For temperature sensing the same signal conditioning unit SCU 2 is used. The four probe method is useful for samples having low resistivity.

The input parameters sensed by the system during resistivity measurement are current (or voltage) and temperature. Using heating system one can obtain the variation of resistivity with temperature.

All the outputs from signal conditioning card given to the A/D converter were covered into digital from one by one. This available digital data is read by the computer with appropriate sampling rate and stored. Further data processing is carried out through software.

3.4.3.2 Thermoelectric Power Measurement

In thermoelectric power measurement, the sample is mounted on the TEP set up properly. Using heating arrangement the hot end temperature is raised and the cold junction is kept at constant temperature using ice bath. Due to this temperature gradient the thermoemf is developed across the sample. The signal conditioning of thermoemf is carried out by using voltage amplifier (SCU 3) which is basically a single ended input instrumentation amplifier. To sense the temperature difference, a differential thermocouple is used and the output is signal conditioned by using instrumentation amplifier (SCU 4).

The outputs of signal conditioners are provided to the A/D interfacing card to convert the analog data into digital form. This data is read by the computer and stored. Using system software, the computer plots the graph of thermoemf against temperature difference. By computing the slope of this graph, the value of thermoelectric power is determined.

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