CHAPTER - I

INTRODUCTION

1.1. GENERAL

In modern science and technology, the materials are developed according to the need of application. To know the basic properties of material, the characterization of material is essential (1). The various techniques used for characterization are electrical resistivity, thermoelectric power, optical absorption, XRD, SEM, TEM etc. In electronic applications the electrical properties of the material such as resistivity and thermoelectric power are most important. From the measurement of electrical resistivity, we can determine the conductivity of material; which provides valuable information about the energy band-structure, crystal defects, lattice vibrations etc. The thermoelectric power measurement provides information about the type of conductivity (either p or n), carrier concentration and mobility of charge carriers (2).

Now a days thin film materials are used in Integrated Circuit (IC) technology to form the solid state electronic devices (3). The device behaviour depends upon the electrical properties of thin film material. Also in thin film physics laboratories material characterization is an essential part of research work.

For electrical resistivity measurement of materials, commonly Two-point probe and Four Point Probe methods are used. By using these methods and conventional instrumentation techniques, the resistivity and thermoelectric power measurement systems have been designed and fabricated. But these manual measurement methods are laborious, time consuming and requires continuous observation of the parameters. The accuracy of such system depends upon the skill of user and accuracy of the instrument used. Also they have limited programming and upgrading capability (4-12).

In the world of automation and control, the intelligent instrumentation systems are increasingly used. The computer aided instrumentation and measurement becomes an important aspect in all fields. The powerful potential of computers is utilized to control experiments, take data, analyze it and display the results on line. In such systems the intelligence is moved from the system to software. The fundamental advantages of these intelligent instrumentation systems are : Flexibility, cost, ease and speed of development, and a superb user / operator interface. These systems replace the common test and measuring instruments and act as simulation tool and they are developed by using standard data acquisition hardware. Working with these systems reduces the requirements of operator skills (13-17).

1.2. REVIEW OF THE LITERATURE

The resistivity and thermoelectric power are the two important electrical properties of the material and they are temperature dependent (1). The variation of these properties with temperature provides valuable information about the material (2).

The resistivity measurement methods cover the entire range of contact and non-contact approaches. The contact techniques are by far the most widely used and include the two-point probe and four point probe methods. For low resistivity samples, the Four point probe method is useful. The application of four-point probe resistance measuring technique and the precautions to get reliable results were described by Kresin-Wolf (3). The conductivity of semiconducting material can be accurately determined by using this method. On the basis of Four-point probe technique, various systems were designed to measure the electrical resistivity (or conductivity) of the material (18-22).

For the measurement of high resistivity samples, two-point probe technique is useful. A simple and accurate method for all crystal structure types is the two point potential traverse technique (23).

The non-contact type resistivity measurement methods include capacitive and / or inductive coupling to resistance bridges(24) or circuit resistance Q meters(25), the decay of induced eddy currents(26), sample radiation shielding(27) and microwave (28) and optical absorption(29). Non-contact methods can be employed without causing probe damage and surface contamination especially at high temperature. These techniques reduce the effect of high resistivity grain boundaries and eliminate contact resistance. Though these methods have many potential advantages, they are seldomly used because of their inherent complexity of both measurement apparatus and parameter interpretation procedure.

The resistivity measurement has a rather linear temperature dependence. This behaviour is discussed by Halbritter *et. al.* (30). On the basis of Matthiessen's rule : $\rho\,(T) = \rho_o + \alpha\,T$ where ρ_o is temperature dependent term related only to impurity scattering.

For thermoelectric power measurement two-point probe (electrode) technique is useful. From the variation of thermoemf with temperature, the thermoelectric power is determined.

By using conventional instrumentation techniques, the various systems have been designed and fabricated for the measurement of resistivity and TEP of materials. A Four probe set up was developed in the Dept. of Physics, University of Pune by Prof. Nigvekar *et. al.* (31) to determine the resistivity of semiconducting material. The Raman Scientific instruments, Ramnagar, Roorkee (U.P) had also developed a four probe set up. The L.B. Valdas (21), H.H. Wieder (20), R. Hall (22), M.G. Buehler (19) etc. has developed four-point probe technique to determine resistivity of different materials.

A two-point probe resistivity and thermoelectric power measurement set up was designed and fabricated by Dr. M.D. Uplane, Shivaji University, Kolhapur (32).

All these conventional instrumentation systems have some limitations and their accuracy depends upon user skill and instrumental errors. Now-a-days intelligent instrumentation systems are increasingly being used for the measurement of various physical parameters(33). The powerful potential of computers is used in these systems. Many PC based systems were designed; for example computer control measurement of thermal conductivity by B.W. James (34) and A.K. Singh(35), specific heat measurement by G. Keelar (36) etc.

In the present work an attempt has been made to design and develop an intelligent, low cost PC-based system for the measurement of electrical resistivity and thermo-electric power of materials in thin film form.

1.3. STATEMENT OF THE PROBLEM

The measurement of electrical resistivity and thermoelectric power of thin film samples as a function of temperature is an essential part of research in the material science and technology. In the present work an attempt has been made to design and develop a PC-based system for measurement of these properties in the temperature range 25-450°C. The electrical resistivity measurement is based on Four-point probe method, while the TEP measurement is carried out by using two-point probe method.

The system development includes the following stages :

Hardware :

(1) The mechanical system has been developed according to requirement, for resistivity and thermoelectric power measurement.

(2) To carry out the measurement different parameters like temperature, voltage and current are to be sensed and signal conditioned. To achieve the same the hardware for sensing and signal conditioning has been designed and developed in the laboratory.

(3) The developed hardware will be interfaced to the computer through the ADC/DAC interfacing card.

With this hardware the typical physical parameters are sensed, converted into digital data and provided to the PC.

Software

The necessary software has been developed in higher level language 'C', in order to perform the task of interfacing with computer, data collection and calculation of the different parameters and store the data in appropriate file. This data will be finally displayed in graphical form and hardcopy will be made available to the system user.

1.4 ABOUT THE DISSERTATION

The different phases of work that has been carried out is divided into seven different chapters.

The chapter-I deals with the brief account of survey related to electrical resistivity and TEP measurement.

The chapter-II represents the theoretical background of different methods used for resistivity and TEP measurement, and the basic signal conditioning concepts.

The mechanical system design and development for the resistivity and TEP measurement is described in Chapter-III. The system block diagram and its operation is further described in the same Chapter-III

The Chapter-IV deals with the design and development of electronic system needed for resistivity and TEP measurement.

The system interface to PC and software development are explained in Chapter-V in detail.

The Chapter-VI deals with the Results and Discussion related to the system performance.

The overall summary and conclusion of the dissertation is presented in Chapter-VII.

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