CHAPTER - 1

CHAPTER-1

ESTABLISHMENT OF TEST LABORATORY FOR FERROELECTRIC/ PIEZOELECTRIC MATERIALS

The ferroelectric & the piezoelectric materials find a vast area of applications. Neverthless, the field of applications is still growing. To synthesize a material with required properties needs a thorough understanding of the physical process governing the phenomenon. And thus sophistication in the characterisation setups for these materials is an ever expanding need. The present attempt is towards designing the instrumentation, suitable for the characterisation of ferroelectric & piezoelectric materials, which employs modern techniques & which is interfaceable to a standard system bus. The interfaceability will allow user to modify the design to be a PC-ADD,ON or may hook the measurement system to any dedicated microcomputer. To sort out the requirements of instrumentation we attempt to summarise the subject matter below.

Historical background of the subject is nicely compiled by W.G.Cady(1) & the discovery of the direct piezoelectric effect is credited in the name of J & P Currie, that to in 1980. Till date a very great deal of investigation has made the subject area an enchanting pool.

The parameters relating to the direct & inverse piozoelectric effect are defined as-

$$d=\left(\frac{ds}{dE}\right)_T=\left(\frac{dD}{dT}\right)_E,\ g=\left(\frac{-dE}{dT}\right)_D,\ e=\left(\frac{dS}{dD}\right)_S=\left(\frac{dT}{dE}\right)_E,$$

$$h=\left(\frac{-dT}{dD}\right)_S=\left(\frac{-dE}{dS}\right)_D$$

These parameters play an important role while selecting the material for an application. Determination of these parametes is thus a prime need of the piezoelectricity laboratory.

Another important parameter of piezo-electricity is the electromechanical coupling coefficient `K' defined as

$$K^2=\frac{\text{electrical energy converted to mechanical energy}}{\text{I/p electrical energy}}$$

OR

$$K^2=\frac{\text{mechanical energy converted to electrical energy}}{\text{I/p mechanical energy}}$$

K = 0.4 for $BaTiO_3$

Further, it is to be noted that the $BaTiO_3$ & $PbTiO_3$ the concerned solid solutions are candidates for a wide range of applications. These ceramics undergo structural transitions along with the on-set of ferroelectricity in the material. It is found that study of macroscopic parameters like dielectric-constant (K), resistivity (S), thermopower (Q), piezoelectric current (I) etc. as a function of temperature may provide a potential information about the physical processes governing ferroelectric regime.

As far as application areas of the material is concerned, it is used either in generation of mechanical oscillations in response to an electrical to produce a mechanical stress. Thus the device will either generate or receive the mechanical oscillations. The characterisation of the piezoelectric material is therefore meaningful, if the medium of transmission of mechanical vibrations is characterised along with determination of parameters, discussed above. Though not included in the present work the related parameters are acoustic impedance `Z', attenuation `X' constant & velocity of propogation V.

Another class of properties which are not suitable for the system bus interface are the high field measurements. The property is basically determination of dielectric displacement D with applied electrical field, some times upto 10KV/cm. This property also does not form a part of present investigation.

The summary given was to highlight the parameters to be measured & emphasis is not towards discussing a particular class of material & related properties. As few general remarks we find that the measurement procedure, size & shape of the sample are specific to a type of parameter concerned & the specimen whether it was a single crystal or a polycrystal.

Despite of all these details, the low field measurements on the ferroelectric & piezoelectric materials are basically the measurement of impedance of specimen with frequency & temperature. For this purpose what one needs is a variable frequency impedance bridge. From the discussions in Sec.2.1, it will be evident how difficult it is to select a method of measurement to determine the impedance. The impedance could be capacitive or inductive or could be pure resistive. Keeping in view the area of application we have selected the design of a variable frequency impedance bridge. The frequency variation proposed is between 100Hz to 10MHz. The bridge & the interface is further modified to include calculation of impedance as a series mode capacitance or inductance & tanδ. The calculation & display of the measurement are dedicated tasks of the microcomputer interfaced. For simplicity we have assumed. Intel 8085 as the CPU to develop the software for the interface.

The layout of the dissertation is as follows. The chapter-2 presents background discussion. The discussion is useful to develop the remaining part of the dissertation. The points discussed are-

1] Series and parallel equivalent forms for capacitance and inductance.

2] Single frequency LCRQ meter.

3] Difference ICs used in the measurement circuits.

4] 8085 assembler, C-calculations.

The chapter-3 is devoted to the hardware design, while the chapter-4 discusses the software counter part in the intergrated manner. Various tables are provided to give numeric feel of the hardware design while the listing of the software gives exactness to the endeavour.

The chapter-5 are the concluding remarks & the extension/redesign proposed.