

Chapter-3

Research Design and Methodology

3.1 Introduction:

Materials science research is based on the synthesis of desired materials. The syntheses of ceramics with desired properties are therefore important due to the rise in demand for the material in various industrial applications. Ceramic processing is a sequence of careful operations that systematically changes the chemical and physical aspects of the microstructure which in turn affect the physical properties of the material. The aim of the study of ceramic processing is therefore to identify the important properties and its relation with processing parameters of the materials.

3.2 Statement of the Problem:

The work mentioned in the thesis is aimed at developing a ceramic polymer composite with CCTO as the active material and PVC and PET as the passive (filler / matrix). The problem to be addressed is to optimize the dielectric constant of the material (composite), by systematically varying the ratio between CCTO and the polymer (PVC/PET). The problem of handling the material without deterioration of the figures of merit was also addressed to. Cost and level of purity was also balanced.

3.3 Objective of the Research work:

At present, it is generally accepted that the high dielectric response is not an intrinsic behavior¹⁰⁰. It is considered as a response due to barrier layer capacitance associated with grain boundaries, twin boundaries or dislocation networks. The explanation though accepted is not yet confirmed, because in the case of single crystals the material is devoid of all these yet they exhibit a large value of permittivity. This work also leads to an insight into the real phenomena i.e. the source of high permittivity

Another objective of the work was to replace lead from ceramics. Lead is an environmental and health hazard. Labor movements all over the globe have come up with demands to replace lead from the work place. Most of the high dielectric

ceramics used presently is based on Lead e.g. PZT (Lead Zirconate Titanate) or PMN (Lead Magnesium Niobate) etc. Although lead based ceramics are easy to prepare, cheap and the know how ubiquitous, in the long run industries may have to bear the brunt in terms of high medical expenses incurred due to lead toxicity. In the present study CCTO ceramics were prepared by the most economical mixed oxide process i.e., high temperature solid state reaction technique.

3.4 Hypothesis:

Although there are many models for effective dielectric constant, most of the composition does not fit into the predicted values offered by the theoretical models. The reason is attributed to the interaction between the different phases in a composite. In the present work we have chosen phases which are extremely passive with respect to the active part, that is, CCTO ceramic. Therefore it was very much expected that the results obtained from the synthesized composite, snugly fit into one of the many theoretical models offered in the literature. This way one can throw light into the microscopic behavior of the phases with respect to each other.

3.5 Scope of the work:

The work mentioned in the thesis has a lot of implication in the energy and electronic industry. The materials that are chosen are such that one is a large dielectric ceramic while the other is a filler with high breakdown field strength. One can therefore employ this material for energy storage, especially when large intermittent pulses are needed¹⁰¹. In the electronic industry where ultra miniature capacitive components are required this material shall prove handy. Apart from all these new knowledge and technology is created which will ultimately benefit science.

3.6 Research Design:

The work was planned in a manner such that collection of literature and relevant information regarding CCTO, PET and PVC were carried out. The next phase was the theoretical investigation of the various aspects of the material, its figures of merit and its source, the physical and chemical properties as a function of its microstructure.

The third phase was the development of logistics to materialize the ideas, as well as to set up some instruments and infrastructure needed to synthesize and characterize the material. Research grade raw material was ordered and used for the work.

3.7 Conclusion:

The Research Design and Methodology part of the work was given special importance and therefore the processes and plan were comparable to international standards. For these many journals and experts were consulted before the work was launched.

3.8 Summary:

In this chapter Introduction, statement of the problem, objective, hypothesis, scope ,research design and conclusion of the study have been specified.The study continued in chapter-4 Experimentation.