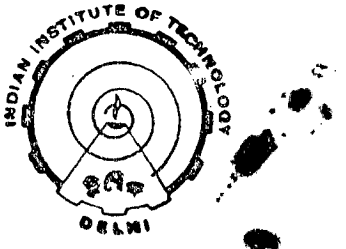
INVESTIGATIONS ON THE DIELECTRIC, ELECTRICAL AND STRUCTURAL PROPERTIES OF LEAD ZIRCONATE TITANATE - POLYMER COMPOSITES

By

DOLLY SINHA

Thesis Submitted in fulfilment of
the requirements of the degree of
DOCTOR OF PHILOSOPHY



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CERTIFICATE

I am satisfied that the Thesis entitled "Investigations of the Dielectric, Electrical and Structural Properties of Lead Zirconate Titanate-Polymer Composites" by Dolly Sinha is worthy of consideration for the award of the degree of DOCTOR OF PHILOSOPHY and is a record of original bonafide research work carried out by her under my guidance and supervision and that the results contained in it have not been submitted in part or full to any other university or Institute for award of any degree/diploma.

27.6.89

for PROFESSOR P.K.C.PILLAI
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Dedicated to Late N. Ramanujan

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CHAPTER - II. MATERIALS & EXPERIMENTAL METHODS

CHAPTER - III DIELECTRIC BEHAVIOR

ABSTRACT

In recent years composites are attracting much attention because of the performance limitations of single phase materials. A ceramic-polymer composite offers the advantages of combining the superior mechanical, breakdown and fabrication properties of polymer with the excellent thermal and dielectric properties of a ceramic. These materials may, therefore, be a better substitute for conventional ceramic ferroelectrics. A thorough investigation of their electrical and structural properties is important in order to select the proper combination for particular application viz. as transducer element, dielectric memory, capacitive material and various other applications. However, reports on systematic studies of electrical, dielectric and piezoelectric properties and their correlation to structure of ceramic-polymer composites are very few. The present thesis reports a systematic study of the dielectric, dc conduction, hysteresis, piezoelectric and structural properties of the composites of lead zirconate titanate with different polymers.

The work is presented in eight chapters. Chapter-I gives brief introduction of the ceramic-polymer composite. The terminology of the composites based on connectivity pattern has been defined. A brief review of the reported methods of preparation and dielectric, piezoelectric, dc conduction and hysteresis behavior of ceramic-polymer composites has been presented. A brief discussion on ferroelectric ceramic and ferroelectric polymer is also included. The aim and scope of the present studies are briefly outlined.

In chapter-II a brief description of the instrumentation and underlying principles for measuring electrical properties is given.

The method of sample preparation and the design of the measurement cell are also described.

Chapter-III presents a systematic study of the temperature and frequency dependence of dielectric properties of the composites of lead zirconate titanate-polyvinylidene fluoride (PZT/PVDF) as a function of PZT wt% (or vol%). A brief discussion on the important mixture rules of dielectric constant is also included. An ellipsoidal dispersion model is found suitable to explain the observed properties. Dielectric relaxations in PZT/PVDF, PZT/PMMA and PZT/PVC systems are also discussed. The results of this study show that the presence of PZT causes a definite strain in the polymer matrix and affects the morphology of the polymers. A phase transition has been observed for a particular composite (P9) of PZT/PVDF.

The results of dc conduction studies are presented in chapter IV. A brief review of various conduction mechanisms proposed by different workers has been presented. It is found that the nature of conduction in composites is predominantly ionic. Evidence of a phase transition in P9 is observed by this study also.

Chapter-V presents the results on hysteresis studies of these composites. A two-phase local field model has been used to estimate P_r. The temperature dependence of P_r and E_c shows a transition in P9.

Chapter-VI explores the structure of composites by different techniques viz. infrared spectroscopy (IR), X-ray diffraction (XRD), scanning electron microscopy (SEM), and differential scanning calorimetry (DSC). The results of these studies are in agreement with that of electrical studies.

The piezoelectric co-efficient of the composite of PZT/PVDF, PZT/PVC, PZT/PMMA have been studied and the results are given in chapter-VII. It is found that the PZT/PVDF composite is a better piezo-electric transducer and capacitor material than other composites.

In the last chapter (ch.VIII) summary of the conclusions drawn on the basis of above mentioned studies are given. Scope for further investigations is also briefly outlined.