1. INTRODUCTION

1.1 BACKGROUND AND MOTIVATION

Ferroelectric materials show a number of desirable properties such as a switchable polarization, high piezoelectric responses and high dielectric constants. For this reason, they are widely used in devices such as memory elements, ultrasound generators, capacitors, gas igniters and many more. One of the rare examples of a ferroelectric material is Lead Zirconate Titanate (Pb(Zr$_x$Ti$_{1-x}$)O$_3$), which has been studied extensively over the past decade as it is one of the most promising ferroelectric materials with high Curie temperature ($T_c$). The PZT offers a wide range of properties that make them very attractive candidates for a variety of microelectronic and sensing applications. For the past few decades, the solid solution PbZrO$_3$-PbTiO$_3$, commonly known as PZT, has dominated commercially because of its superior dielectric and piezoelectric properties. In particular, its large piezoelectric response has made PZT one of the most widely used materials for electromechanical applications.

The scaling down of some ferroelectric devices such as ferroelectric random access memory (FERAM) integrated circuits for the ultra-large-scale integration (ULSI) generations involves the shrinking of the storage capacitor area. Thin films of ferroelectrics in the lead-zirconate-titanate (PZT) family have been under investigation widely because of their large charge-storage densities. While PZT films exhibit adequate charge storage for FERAM applications, their resistivities are fairly low in comparison to conventional linear dielectrics and this can be a disadvantage, possibly leading to unacceptably short refresh times. The effects of introducing a variety of dopants in PZT have been studied and reported in the literature. The effect of adding lanthanum to the PZT system is mainly to increase resistivity and to reduce the Curie temperature. This latter effect leads to paraelectricity at low temperature. In the paraelectric phase, the material exhibits negligible remnant polarization ($P_r$) while maintaining the large values of maximum polarization attained ($P_{max}$) and this clearly should improve the FERAM charge storage density. Thus, for more than one reason,
paraelectric phases are preferred to ferroelectric phases for FERAM applications. There have been a few studies in the past which investigated thin films of PZT, but a detailed study of properties relevant to FERAM applications as a systematic function of grain size dependent ferroelectric study is lacking. The above mentioned interesting properties and applications of the PZT materials is the motivation of the work presented in this thesis.

1.2 AIM AND OBJECTIVE

The aim of the present work was to prepare the undoped and lanthanum doped lead zirconate titanate (PZT) ceramics and pulsed laser deposited thin film and to determine their electrical and optical properties. In this work, undoped and La-doped PZT (PLZT) ceramics were synthesized by sol-gel route. The sol-gel technique is a rapid, one-step process to produce the ceramic compounds near morphotrophic phase boundary (MPB). The prepared samples were characterized by X-ray diffraction (XRD) (PANalytical X'pert Pro), thermogravimetry analysis (TGA) and scanning electron microscope (SEM). The impedance spectroscopie (Solatron SI 1260 Impedance Gain-Phase Analyzer), ferroelectric loop tracer (Radiant Technologies) and spectroscopy ellipsometer (SOPRA ESVG) were used to investigate the electrical and optical properties of the PZT ceramics and pulsed laser deposited thin films.

The main focus of this work was to investigate the effect of lanthanum doping on the dielectric and ferroelectric properties of lead zirconate titanate for sensors and actuators applications and to study the optical properties of the PZT for the applications in optical devices. The analysis of the grain size dependence of ferroelectric properties given in this study will be an important result for various applications that use PZT. The results presented in the thesis will hopefully contribute to the progress of higher powered devices such as the FERAM, thermally stable ceramic capacitor and other microelectromemichanical system (MEMS) devices.

1.3 OUTLINE OF THE THESIS
This thesis is divided into nine chapters

1. Introduction
   This chapter briefly about the background and motivation of the research work presented in the thesis along with the aim and objective.

2. Literature overview
   This chapter contains a review of literature in the subject area under study. This review presents a detailed survey of previous published works on crystal structure, electrical properties, ferroelectric properties and optical properties of the PZT.

3. Experimental
   The detailed description of all processes mentioned throughout the thesis such as PZT powder preparation technique for various concentrations of doping components and the pellet preparation have been discussed in detail. The preparation of thin film by pulsed laser deposition method has been described. Also, the various characterization methods and the parameters used to investigate the properties of the samples prepared have been illustrated.

4. Electrical and optical characterizations of lead zirconate titanate PZT ceramics
   In this chapter, the temperature dependent band gap and electrical conductivity of lead zirconate titanate (PZT) ceramics have been discussed in detail. The dielectric and impedance studies carried out for PZT for various temperatures and as a function of frequency have been illustrated.

5. Electrical characterizations of Lanthanum doped PZT (PLZT) ceramics
   In this chapter, the dielectric and impedance studies carried out for lanthanum modified lead zirconate titanate for various temperatures and as a function of frequency have been presented. The temperature dependent dc conductivity (Arrhenius plot) was studied and the activation energy was calculated from the plot. The impedance measurements were carried out to analyse the variation of the impedance with different temperatures (Nyquist Plots) for the studied samples. The voltage dependent ferroelectric properties of lanthanum doped PZT was carried out and the effect of lanthanum on polarization was studied.
6. Electrical characterizations of PZT thin film prepared by pulsed laser deposition (PLD) method

In this chapter, the structural and ferroelectric characterization of nanostructured PZT (52/48) thin film coated on Pt/TiO₂/SiO₂/Si (100) substrate by pulsed laser deposition method have been presented. The variation of ferroelectric property with grain size of the thin film has been investigated and compared with other experimental results.

7. Optical studies of pulsed laser deposited PZT thin film by spectroscopic Ellipsometry

In this chapter, the optical properties of pulsed laser deposited Pb(Zr₀.₅₂Ti₀.₄₈)O₃ thin film studied by spectroscopic ellipsometry (SE) in the UV-vis-NIR region in the wavelength range of 200 – 900 nm have been presented. The optical properties such as refractive index, extinction coefficient, absorption coefficient and dielectric constant obtained from the ellipsometric parameters using a four layer model have been well discussed.

8. Conclusions

Here the results of the present work are summarized with concluding remarks.

9. Scope for further work

The further work for future is presented.