CHAPTER 1

Introduction

There have been many researches in recent years on the development of lead titanate ($PbTiO_3$) based ceramics for variety of piezoelectric and pyroelectric device applications. The interest in lead titanate ($PbTiO_3$) based ceramics arises because of their attractive dielectric, piezoelectric and pyroelectric characteristics such as a high Curie temperature , high spontaneous polarization , low dielectric constant (~200) , a very small aging rate of dielectric constant , a large difference between the thickness coupling constant (k_t) and planar coupling constant (k_p) and relatively low mechanical quality factor (Q_m) that make them promising candidates for high frequency ultrasonic transducers for nondestructive evaluation of materials, medical diagnostics, SAW devices, infrared sensors and infrared detectors etc. [1-2]. However, it is very difficult to fabricate pure (undoped) $PbTiO_3$ because of their large anisotropy in lattice constant (c/a = 1.063) upon transversing the Curie point at 490°C, which usually results in cracks. Doping with alkali metals , transition metals of rare earth oxides have been shown to produce crack-free high density material. For the latter pyroelectric application Calcium and Lanthanum modified lead titanate have been attracted some interest.

Recently, there have been widely studied the preparation of Calcium and Lanthanum modified $PbTiO_3$ thin films. In this way, highly oriented lead titanate films give important piezoelectric and pyroelectric response without poling. On the other hand, there have been few studies on Calcium modified $PbTiO_3$ of which the compositions ($Pb_{1-x}Ca_xTiO_3$) containing $\leq$ 30 mole% Ca, exhibiting the tetragonal $PbTiO_3$ - type structure and Lanthanum modified

$PbTiO_3$ ($Pb_{1-x}La_xTi_{1-x/4}O_3$) of which La^{3+} substituting for Pb (A-site ions) and vacancies occurred in Ti (B-site ions) were prepared in bulk form using conventional technique. Characteristics of Calcium and Lanthanum modified $PbTiO_3$ bulk ceramics have not yet been fully understood.

This project set out to adapt a mixed oxide route so as to produce the $Pb_{1-x}Ca_xTiO_3$ and $Pb_{1-x}La_xTi_{1-x/4}O_3$ bulk ceramics. These compositions are of interest for pyroelectric applications. The routes were modified in comparison with thin films produced using a sol gel route.

Specific objective

The objective of this thesis was to produce and characterize high quality $Pb_{1-x}Ca_xTiO_3$ and $Pb_{1-x}La_xTi_{1-x/4}O_3$ bulk ceramics, which involved the following steps.

a) Optimize processing conditions of composition

b) Determine the suitable calcining temperature.

c) Characterize the phase development and microstructures of mixed oxide derived bulk ceramics

d) Measure the electrical properties of $Pb_{1-x}Ca_xTiO_3$ and $Pb_{1-x}La_xTi_{1-x/4}O_3$ bulk ceramics and attempt to correlate them to observe crystallographic and microstructure feature if possible.