CHAPTER 1

INTRODUCTION

1.1 Overview

Ceramics are one of the most recent classes of electronic materials. The electronics industry is demanding smaller, higher packing density, higher frequency electronic devices, which must have high reliability and low cost.[1] These demands are a direct result of the industry's drive to continuing miniaturization and the rapidly growing integrated circuit (IC) technology.[2] To satisfy these demands the use of multilayer ceramic capacitors (MLCs) has increased rapidly, since they offer: no polarity; small size; large capacitance per unit volume; high reliability; small internal inductance and excellent characteristics at high frequency.[1] The microelectronics industry continuously pushes toward higher volumetric efficiency i.e. the measure of capacitance that can be accommodated in given size of capacitor.[1,2]

Volume efficiency can be enhanced by reduction the thickness and by increasing the dielectric constant of the ceramic. In particular, within the capacitor industry, the use of high dielectric constant materials is an attractive route for this reason. This has led to a demand for materials which can store more energy per volume than those previously employed.[1] Traditionally, these are manufactured from modified barium titanate, $BaTiO_3$ (abbreviated BT), which have a dielectric constant ~ 3000 at room temperature (1 kHz).[1,3] However, with the promise of higher dielectric constants and lower firing temperatures, and hence lower electrode cost, lead-based perovskite compositions of the general form $Pb(B_1,B_2)O_3$, where B_1 and B_2 are aliovalent cations in a ratio maintaining charge neutrality, have been studied extensively for application as capacitor dielectrics for the past almost 30 years.[1-3]

A family of materials which are of great interest due to their high polarizabilities are lead-based relaxor ferroelectrics, specially lead magnesium niobate, $Pb(Mg_{1/3}Nb_{2/3})O_3$ or PMN, and its solid solution with lead titanate, $PbTiO_3$ or PT the so-called PMN-PT (PMNT).[1-5] These compounds have dielectric constants in excess of 20,000, making them potential candidates for capacitive applications. In addition, they also exhibit electrostrictive behaviour at temperatures above their phase transition temperatures. This behaviour extends their use to transducer and actuator applications.[1-4]

The excellent device potential of these materials to date remains largely unexploited. Many processing and fabrication problems still exist which prevent the widespread use of these materials.[5,6] The key properties of these materials depend strongly on the purity of the raw materials and method of preparation, since dielectric constant can be affected by second-phase pyrochlore which forms upon processing.

1.2 Objectives

The work carried out here was undertaken to better understand the processing-structure-property relationships of both powder and ceramic forms in the PMN-PT system. The objectives were as follows:

1. To develop appropriate routes for the preparation of powder and ceramic in the PMN-PT system.

2. To investigate crystal structure and microstructural development as a function of firing conditions and PMN:PT ratio.

3. To determine the optimum firing conditions for the fabrication of ceramics in the PMN-PT system.