CHAPTER I

INTRODUCTION

Piezoelectric ceramics possess the ability to develop an electric charge proportional to a mechanical stress, and vice versa. There are many types of piezoelectric ceramics, lead based piezoelectric ceramics are the most used in various applications for over the years such as ultrasonic cleaner, transducer, sensor, transformer, etc. because of its excellence in dielectric and piezoelectric properties. However, piezoelectric ceramic systems which contain lead in their compositions have to suffer many problems. One of the problems is that lead oxide is volatile at lower temperature (800°C) than sintering temperature resulting in lead loss during the sintering process. This makes it difficult to reproduce in the production process. Also, lead is not environmentally friendly. It is a hazardous substance. Special care must be taken when handling to prevent any contamination to the worker and also the environment.

Bismuth Sodium Titanate ($Bi_{0.5}Na_{0.5}TiO_3$; abbreviated as BNT) was one of the candidates for lead free piezoelectric materials due to its large remanent polarization ($P_r \approx$ 38 $\mu C/cm^2$) and a high Curie temperature ($T_c \approx 320$ $^{\circ}$C). BNT had a perovskite structure (ABO_3), discovered by Smolensky et al [1]. BNT was found to have two structural phase transitions at the temperature range of 20-647 $^{\circ}$C where transition from a cubic phase to a tetragonal phase presented at higher temperature and a tetragonal phase to rhombohedral phase presented at lower temperature. A low-temperature phase transition from the ferroelectric to the antiferroelectric phase transition at approximately 230 $^{\circ}$C has interesting anomaly in piezoelectric properties of BNT material [2].

Some problems and difficulties to face for BNT were the difficulty to completely pole because of its large coercive field ($E_c \approx 73$ kV/cm) at room temperature [3] and a huge permittivity peak accompanied by an abnormal dielectric loss as a function of temperature and frequency. The causes mentioned above limited the use of this material.

The previous work of BNT with 0.5 at% of lanthanum ($Bi_{0.5}Na_{0.485}La_{0.005}TiO_3$) presented a high piezoelectric coefficient ($d_{33} \approx 90 - 100$ pC/N) and lanthanum doping in BNT system could suppress the abnormal dielectric loss [4, 5]. The purpose of this work was to investigate the generic influence of the isovalent (Zr^{4+} ions) and aliovalent (Fe^{3+} and Nb^{5+} ions) cations at Ti-site substitution on La-doped BNT. The main objective of this study was to develop piezoelectric properties of bismuth sodium lanthanum titanate ($Bi_{0.5}Na_{0.5}La_{0.005}TiO_3$; BNLT). Detailed of the objectives are described as follows:

1. To synthesize BNLT and three systems of modified BNLT compounds by conventionally mixed oxide method.
   1.1 Zr-BNLT [$(Bi_{0.5}Na_{0.485}La_{0.005})(Zr_xTi_{(1-x)})O_3$]; x = 0.005, 0.010, 0.015, 0.020 and 0.025.
   1.2 Nb-BNLT [$(Bi_{0.5}Na_{0.485}La_{0.005})(Nb_xTi_{(1-(5/4)x)})O_3$] ; x = 0.005, 0.010, 0.015, 0.020 and 0.025.
   1.3 Fe-BNLT [$(Bi_{0.5}Na_{0.485}La_{0.005})(Fe_xTi_{(1-(3/4)x)})O_3$] ; x = 0.005, 0.010, 0.015, 0.020 and 0.025.
2. To investigate the optimum calcining and sintering temperature.
3. To investigate phase transitions in all compositions by Differential Scanning Calorimetric (DSC) technique.
4. To investigate the effect of substituents on microstructural, physical, electrical, dielectric, ferroelectric and piezoelectric properties.