CHAPTER 5

Summary and Conclusion

This study was aimed at establishing routes for fabrication of PLT and PCT bulk ceramics using mixed oxide method. The variation of processing conditions (e.g. calcining temperature, sintering temperature) that could be favorable for producing denser samples was carried out. These include characterization of ferroelectric behavior.

For fabrication of PCT and PLT ceramics; cconventional technique was used to prepare all compositions using mixed oxides and carbonates as raw materials in acetone solvent. All PLT compositions were calcined at 750°C for 2 hrs and PCT compositions were calcined at 800°C for 2 hrs. The calcined powders were formed into disk specimens using uniaxial hydraulic press and Cold Isostatic press (CIP) followed by heat-treatment of 1200°C for 2 hrs. However PT, PC5T and PC10T compositions could not be prepared to dense bulk specimens due to cracking during sintering.

After sintering, the weight loss and shrinkage of PLT composition decreased with increasing La^{3+} content. PCT composition resulted in decreasing weight loss with increasing Ca^{2+} content but shrinkage exhibited no significant of decreasing trend.

Microstructure analysis revealed an increase in grain sizes of PLT composition with increasing La^{3+} content. For XRD determination of the compositions with La^{3+} content higher than 10%mole, unreacted TiO_2 and PbO

were detected. But after sintering, all of PLT compositions showed a single phase. The PCT compositions with the Ca^{2+} content higher than 15%mole , $CaTiO_3$ peak was detected as a second phase in calcined powder. However, after sintering at 1200°C, only a single phase of those compositions was obtained. The c/a ratio of both PLT and PCT compositions for calcination and sintering process decreased with increasing La^{3+} and Ca^{2+} content, except PCT composition which the c/a ratio seemed to exhibit close values.

Electrical properties expressed that the dielectric constant (K') and dielectric loss (D) of PLT compositions increased with increasing La^{3+} content whilst those of PCT compositions decreased with increasing Ca^{2+} content. PL15T composition had the Curie temperature of 255°C with maximum K' value of 10189 at 10 kHz. PC15T composition resulted in the Curie temperature of 280°C with maximum K' value of 5229. The remanent polarization (P_r) of PLT compositions increased with increasing La^{3+} content. But P_r value of PL20T composition was ~842.3 $\mu C/cm^2$. However, this result may be effected by a conductive property of the samples. Coercive field (E_c) of PLT compositions increased with increasing La^{3+} content excepted PL20T which may lose insulating property due to high La^{3+}concentration present. Typical hysteresis loop was obtained for all compositions studied. Lossy capacitor characteristic and nonlinear ferroelectric exhibited for PL5T, PL10T and PL15T while hysteresis loop of PL20T composition was a reversal nonlinear ferroelectric. P_r and E_c of PCT compositions decreased with Ca^{2+} content corresponding to decreasing in c/a ratio. Since high Ca^{2+} level was doped into $PbTiO_3$ unit cell, leading to decreasing ferroelectric property, PC30T composition likely became a linear dielectric characteristic.

The main conclusions that can be drawn from the results of this study are summarized as follows.

Increasing La^{3+} concentration substitution for Pb^{2+} in the structure of $PbTiO_3$ unit cell leads to increasing grain size, increasing dielectric constant, dielectric loss and the remanent polarization. Especially, La^{3+} content larger than 20%mole in the composition resulted in higher conductivity.

Increasing Ca^{2+} concentration substitution resulted in decreasing grain size, cracking and lower values of dielectric constant, dielectric loss and the remanent polarization and coercive field. But Ca^{2+} content of 30mole% exhibited a denser microstructure with crack-free.