CHAPTER 6

CONCLUSIONS AND SUGGESTIONS

6.1 Conclusions

In this study, the novel BNZ and $BNZ_{1-x}T_x$ powder and ceramics when x = 0.1, 0.2, 0.3, 0.4, 0.5 and 0.6 were successfully fabricated by a mixed oxide method and conventional sintering techniques, respectively. Densification, phase evolution, microstructure, mechanical properties, thermal expansion, dielectric properties and ferroelectric properties of this ceramic system were investigated. Based on experimental observation, the following conclusions have been reached:

(1) BNZ pure powder was obtained as the optimized condition BNZ/10wt%Na_2CO_3 calcined at 800°C for 2 h with a heating/cooling rate of 5°C/min. In case of BNZT powder, it was obtained at same calcination temperature.

(2) BNZ ceramic with the relative density ~95% was obtained as the optimized condition BNZ72/4wt%Bi_2O_3 sintered at 850°C for 2 h with a heating/cooling rate of 5°C/min. For BNZT ceramics, the optimized sintering temperature was 950°C for 2 h with a heating/cooling rate of 5°C/min**.**

(3) BNZ compound possessed the orthorhombic phase. Meanwhile, Ti addition caused the structure transformation from orthorhombic to rhombohedral lattice for Ti-rich compositions.

(4) Both BNZ and BNZT showed partially the inhomogeneous area of microstructure due to volatile elements Bi and Na.

(5) The rhombohedral phase presence in Ti-doped BNZ system was a significant factor enhancing dielectric properties and shifting the maximum temperature forward to low temperature of BNZ material.

(6) All samples showed *P-E* lossy loop due to high conductivity and dielectric loss. Besides, *P-E* loop indicated that dielectric behavior at low and high electric field was attributed mainly to reversible contribution.

6.2 Suggestions for future works

From the results obtained in this study, several observations from the experiments have not yet been completely explained. Therefore, it is interesting to further conduct thefollowing studies,

(1) To understand more on electrical properties of BNZ and BNZT ceramics, i.e. impedance as a function of temperature should be investigated.

(2) In order to understand better the systems, BNZ and BNZT material fabrication using other techniques i.e. vibro milling, hot press sintering and spark plasma sintering should be carried out to compare the conventional method used.

(3) It was difficult to obtain a saturated *P-E* loop of this ceramic system due to high lossy and conductivity. Thus, ferroelectric behavior of the systems could not be studied deeply. In the future, ferroelectric measurement at high frequency and low temperature should be carried out in order to possibly obtain the better result.

(4) From the maximum dielectric point shift to low temperature, it displayed the important role of Ti increasing addition. Hence, more Ti^{4+} substitution in BNZ compound should be performed to move the maximum point to room temperature. This might lead to the promising application for electronic devices, i.e. capacitors.