Chapter 5
Summary and Conclusions

5.1 Summary of results

The results of these experiments were shortly concluded.

5.1.1 Preparation and Microstructure

(A) Preparation

1. Conventional technique was used to prepare all compositions by mixing oxides and carbonates in ethyl alcohol solvent.

2. All Ba doped compositions were calcined at 850 °C except for BNT and 0.90BNT-0.10PT were calcined at 750 °C.

3. Not only does weight loss during calcination come from carbonate compounds, but PbO also results in weight loss.

4. After binder burn-out, all compositions were sintered for one hour at the sintering temperature in closed crucibles systems.

(B) Shrinkage and Weight loss

1. Shrinkage was approximately 18-19% of both systems.

2. Weight loss of both solid solutions was less than 0.9%.

3. The weight loss decreased with an increase of %Ba doped BNT but for an addition of Ba doped 0.90BNT-0.10PT it was likely constant and higher than that of Ba doped BNT.

(C) Microstructure

(C.1) Grain size

1. Grain size of both systems increased when the sintering temperature increased.

2. The addition of Ba up to 10% decreased the grain size of BNT and 0.90BNT-0.10PT.

3. The grain size of Ba doped 0.90BNT-0.10PT showed a few greater than that of Ba doped BNT.

(C.2) Second phase

1. Second phases appeared in most of Ba doped compositions.

2. The second phase increased with an increase of %Ba and existed greatly in 15% Ba doped both systems.

3. The second phase of Ba doped 0.90BNT-0.10PT appeared was likely higher than that of Ba doped BNT.

4. The components of the second phase detected by EDS and WDS were Ba and Ti.

5.1.2 The Crystal Structure and Phases by XRD

1. With 5% Ba doped both systems these compositions have the same structure as BNT and 0.90BNT-0.10PT.

2. XRD pattern of 10% Ba doped BNT was identical with 10% Ba doped 0.90BNT-0.10PT and the structure of these compositions could not identify.

3. XRD patterns of 10% Ba doped both systems showed $BaTiO_3$ second phase peaks.

5.1.3 Dielectric Properties

1. K' depened on %Ba and the appearance of the second phase.

2. Maximum K' increased as %Ba increased for Ba doped BNT but the anomalous second phase at 15% Ba caused a lowered K'.

3. For 5% Ba doped 0.90BNT-0.10PT, maximum K' increased. With further addition of %Ba, the K' lowered. In addition, for 10% Ba it gave a highly abnormal K' at 1 kHz.

4. K' at room temperature of Ba doped both systems increased as %Ba increased.

5. K' was also affected by sintering temperature and grain size in which maximum K' increased as the sintering temperature increased. A small grain size controlled by Ba dopant gave a higher K' than undoped materials.

6. The grain size of Ba doped 0.90BNT-0.10PT was larger than that of Ba doped BNT but it showed a higher K' than Ba doped BNT due to a small lead content.

7. For Ba doped both systems, the first transition temperature could be shifted to a lower temperature and disappeared when %Ba is up to 10% for 0.90BNT-0.10PT system.

8. The dissipation factor was nearly independence of the sintering temperature for Ba doped both systems but it increased as %Ba dopant increased for BNT system.

9. The dissipation factor of Ba doped 0.90BNT-0.10PT is likely lower than that of Ba doped BNT. However, with 10% Ba doped 0.90BNT-0.10PT showed the high and different dissipation factor characteristics.

5.2 Conclusions

1. Ba can control grain growth.

2. There was $BaTiO_3$ second phase in Ba doped both BNT and 0.90BNT-0.10PT.

3. Structure of 5% Ba doped both systems was the same.

4. Maximum dielectric constant (K') of Ba doped 0.90BNT-0.10PT was higher than that of Ba doped BNT system.

5. Dielectric constant (K') at room temperature of both systems increased as % Ba increased.

6. First transition temperature of both systems lowered near room temperature with a higher dielectric constant as %Ba increased.

7. Fist transition temperature of Ba doped 0.90BNT-0.10PT was lower than that of Ba doped BNT.

8. Morphotropic phase boundary (MPB) of Ba doped 0.90BNT-0.10PT system was between 5-10% Ba.