CHAPTER VII
CONCLUSIONS AND RECOMMENDATIONS

Benzoxazine based diamine was synthesized by using phenol:para formaldehyde:ethylenediamine as precursors with moral ratio of 2:4:1. Characterization showed that the benzoxazine has a melting temperature around 105°C and started to decompose around 250°C. $Ba_{1-x}Sr_xTiO_3$ (x = 0, 0.3, 0.5, and 0.7) were synthesized by using the sol-gel method. It was found that calcination temperature should be at least 800°C to obtain single phase of perovskite $BaTiO_3$. However, small amount of residual carbonate may remain in structure. The particle size of $BaTiO_3$ after calcined at 800°C was 50-80 nm, and increased with increasing calcination temperature. The splitting of the diffraction peak at $2\Theta \approx 45°$ [(200)/(002)] indicated the tetragonal structure. It could be observed that diffraction peak of $BaTiO_3$ became to split at calcinations temperature of 900°C, which indicated that the structure changed from metastable cubic phase to tetragonal phase. The sol-gel $Ba_{1-x}Sr_xTiO_3$ (x = 0, 0.3, 0.5, and 0.7) powder were pressed and sintered at 1350 °C for 2 h to form ceramics. It was found that $Ba_{1-x}Sr_xTiO_3$ ceramics with x = 0 and 0.3 were ferroelectric phase at room temperature because they showed hysteresis loop. When strontium molar fraction increased to x = 0.5, it changed to paraelectric phase. These results agree well with XRD results. The lattice parameter of unit cell decreased as strontium molar fraction increased, which occurred due to the substitution of the smaller ionic radius Sr^{2+} into the Ba^{2+}in the lattice. The average grain size of $Ba_{1-x}Sr_xTiO_3$ ceramics decreased as strontium molar fraction increased because ceramic and liquid phase became more refractory at higher strontium content. For dielectric measurement, the dielectric constant of the strontium composition of x = 0.3 showed highest value comparing with other compositions, and dipole relaxation was observed at frequencies above 1 MHz. Curie temperature (T_C) of $Ba_{1-x}Sr_xTiO_3$ ceramics linearly decreased with increasing the amount of strontium.

The compression molding machine was employed to fabricate the composites of polybenzoxazine and SG-BST by varying amount of SG-BST at 30-80 wt%. The dielectric constant of polybenzoxazine was found to be 3-4. By adding 80 wt% (48 vol%) of SG-BST, the dielectric constant of the composites can be increased around seven times of pure polybenzoxazine. The dielectric constants of all composites were weakly dependence on frequency and temperature indicating low relaxation behaviour, and higher ceramic contents lead to higher composite dielectric constant. Loss tangent values were less than 0.05 and depended on the porosity in the composites. Yamada model showed the best tendency to fit well with experimental results compared with other models indicating the composite connectivity is 0-3 type.

Recommendations

1. The calcining and sintering condition should be adjusted in order to obtain optimum condition for dielectric application.
2. The amount of solvent, pH, and concentration in sol-gel method should be controlled because they affect to gel time and crystallization of ceramic powders.
3. Glass transition temperature (T_g) of polybenzoxazine should be measured by dynamic mechanical analysis (DMA) because it was difficult to observed by DSC.
4. Both ceramics and composites should be measured the dielectric propeties in microwave frequency ( ).
5. In composite fabrication, it is difficult to prevent melted benzoxazine leak from mold resulting in obtain undesirable composition.
6. The composites should be poled before dielectric measurement, which may help the alignment of dipoles to increase dielectric constant of the composites.
7. The ceramic fillers in composites form large agglomeration; therefore the ceramic filler should be modified in order to obtain good distribution of fillers and good dielectric properties.