CHAPTER VI
CONCLUSIONS AND RECOMMENDATIONS

Aniline based (BA-a) and fluorinate based (BA-f) benzoxazine monomer were synthesized by using solventless method. The reaction to synthesize the BA-a monomer was based on bisphenol A, paraformaldehyde, and aniline while the BA-f monomer was based on hexafluorobisphenol A, paraformaldehyde, and aniline. As known from DSC thermograms, the curing temperature of BA-a and BA-f monomer was around 240°C and 220°C, respectively. The dielectric constant of aniline based polybenzoxzine (PBA-a) and fluorinate based polybenzoxazine (PBA-f) was 4.94 and 4.54 at 1 kHz, respectively while PBA-f showed lower in dielectric loss than PBA-a at the same frequency. Moreover, the dielectric constants of the polymers showed weakly dependence on frequency and temperature indicating low relaxation behaviour. In comparison between the dielectric constants of PBA-a and PBA-f, it was found that PBA-f exhibited lower dielectric constant than PBA-a because of the incorporation of fluorine into the polymer structure. The substitution of fluorine is able to reduce dielectric constant of the polymer because of smaller dipolemoment and the lower polarizability of C−F bond compared with that of the C-H bond. However, the fluorinated substitution does not effect on the dielectric constant as high as the incorporation of aromatic rings or conjugated bonds due to the much higher polarizability of the C=C bonds compared with C-H bonds and C-F bonds.

Dielectric properties of polybenzoxazine-BST ceramic composite were also studied in this research. In this work, aniline based polybenzoxazine was used as polymer matrix and $Ba_{0.3}Sr_{0.7}Ti\ O_3$ was used as ceramic filler. For $Ba_{0.3}Sr_{0.7}Ti\ O_3$, it was synthesized by using the sol-gel method then calcined at 1000 °C to obtain single phase of perovskite. However, small amount of residual carbonate may remain in structure. From the XRD patterns that showed no peak splitting of (200)/ (002) at $2\theta = 46.1°$ referring that the crystal structure of the BST particle is cubic structure. The dielectric properties of composites with various amount of BST were measured. It was found that the dielectric constants of the composite can be increased by the ceramic volume fraction. In this work, the composite with 80 wt% or 48 vol% of BST showed the dielectric constant as high as 39 which about eight times of 4.9 for pure

polybenzoxazine at 1 kHz. The dielectric constants of the composites were weakly dependence on frequency and temperature indicating low relaxation behaviour. It also was observed that dielectric loss is strongly influenced by the porosity in the composites.

In this research, the effects of BST surface modification on the dielectric properties of the composites were also studied. The BST powders were modified with different three chemicals; silane coupling agent, BA-a monomer and phthalocyanine before mixing in polybenzoxazine matrix. It was observed that the modified BST surface could disperse well in polybenzoxazine matrix compared with the unmodified BST powders. And considering in dielectric properties, it was found that silane modification could improve dielectric constant of the composites compared with others. However, the composites with benzoxazine monomer and phthalocyanine treated BST powders showed the lower in dielectric loss because it could prevent the BST agglomeration in the polymer matrix more effectively than the silane coupling modification.

Recommendations

1. The calcination temperature should be increased in order to remove the undesirable phase of intermediate oxycarbonate in BST powders, however, the effect on size of the particles should be concerned.
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. Dielectric properties of the composites should be measured in microwave frequency.
4. The composites should be fabricated as thin film by using spin coating technic which may help to reduce air bubbles in the specimen.
5. It is difficult to fabricate composite at high ceramic content because the composite was brittle and was broken when released from mold.

6. In the phthalocyanine modification, it should be used 6-CN compound, the precursor of phthalocyanine, as starting material instead of metal-free phthalocyanine to let the Sr^{+}, Ba^{+} and Ti^{+} able to form the bond in phthalocyanine structure. Due to this way, the dielctric constant of composite may be increased as much.
7. In the silane coupling modification, it is recommended to use epoxy silane instead of amino silane because the functional group of epoxy may react with the functional group polybenzoxazine better than the amino group. Thus the dispersion of BST powders in the composite may be enhanced.