CHAPTER I
INTRODUCTION

In recent year, the embedded capacitor technology plays important role for miniaturization products because they have major benefits over traditional discrete capacitors including better electrical performance, higher reliability, small size, and improved design options. Importance requirements for the embedded capacitors materials include high dielectric constant, low capacitance tolerance, good processability, and low cost (Rao and Wong, 2004). Materials required for the embedded capacitor should have dielectric constant of 25-170 and should be processed at low processing temperature, tough, and flexible in order to compatible with the printed circuit board (PCB) manufacturing process. Polymer has generally low dielectric constant and it is not suitable for the capacitor requirements. On the other hand, ceramics have high dielectric constant but require high processing temperature (Kuo *et al.*, 2004).

Polymer-ceramic composites are one of the great interest and the candidate materials for the embedded capacitor because they combine the processability of the polymer with high dielectric constant of the ceramics, resulting in low processing temperature and cost. Among the composites studied so far, the simplest type is 0-3 connectivity, consisting of a three-dimentionally connected polymer matrix filled with ceramic particles. This type of connectivity is easy to fabricate and suitable for mass production (Dias and Das-Gupta, 1996).

In this study, polybenzoxazine is used as the polymer matrix because of the advantages over the traditional phenolic resins and epoxy such as not requiring acid or alkaline as catalyst, no by-product during the curing reaction, and zero volumetric shrinkage. The polybenzoxazine also has good heat resistance, excellent dimensional stability, low water absorption, and better molecular design structure (Ning and Ishida, 1994). On the other hand, barium titanate ($BaTiO_3$) and barium strontium titanate ($Ba_{1-x}Sr_xTiO_3$), well known ferroelectric materials, are selected as ceramic fillers because they have high dielectric constant, low loss tangent, and lead-free composition. They are of great interest dielectric material for many applications, such as capacitor, dynamic random access memories (DRAMs), IR detectors, and

tunable microwave devices. The dielectric constant of $BaTiO_3$ has highest value at Curie temperature. The strontium (Sr^{2+}) is used to dope in $BaTiO_3$ by substituting in Ba^{2+} in order to shift the Curie temperature toward to room temperature, which can improve the dielectric constant (Girindharan *et al.*, 2001). For ceramic powder preparation, sol-gel method was used to prepare because it offers significant advantages in obtaining the fine powder with high chemical purity, narrow size distribution, and homogeneity through a lower temperature process, avoiding contamination of materials (Yang *et al.*, 2002).

The purpose of this work is to synthesize $Ba_{1-x}Sr_xTiO_3$ nano-particles by sol-gel method. The effect of strontium molar fraction (x) on the microstructure and dielectric properties of $Ba_{1-x}Sr_xTiO_3$ ceramics with x = 0, 0.3, 0.5, and 0.7 were investigated. The sol-gel $Ba_{0.7}Sr_{0.3}TiO_3$ powders were used as ceramic fillers and incorporated in polybenzoxazine to make the composites. The dielectric properties of composites were investigated as functions of ceramic content, frequency, and temperature.