CHAPTER I
INTRODUCTION

There is a great demand for the use of electronic devices operated at higher frequencies. In order to support these applications, multifunction and miniaturization of the electronic components are required. To realize these goals, embedded capacitor technology is expected to be used (Cho *et al.*, 2002). Besides the multifunction and size reduction, embedded capacitor technology offers many other advantages compared with traditional discrete capacitor technology, such as lower cost, enhanced reliability, improved packaging efficiency, and electrical performance. The basic characteristics for the embedded capacitor materials for high freqencies applications are high dielectric constant, low dielectric loss properties at high frequency, combined with ease of processing and good adhesion to the organic substrate, e.g. the printed circuit board (PCB) substrate (Rao and Wong, 2004).

Currently, polymer-ceramic composites are the subject of much research as the key element in embedded passives because they combine the advantages of organic polymers (flexibility, processability with low processing temperature, and high dielectric breakdown field) and ceramic fillers (high dielectric constant and high thermal stability). So the incorporation of ceramic fillers into a polymer matrix results in a high dielectric constant composite with appropriate flexibility. There are many different connectivity patterns have been designed in polymer-ceramic composites but the simplest type is the 0-3 connectivity pattern, which consists of a three-dimensionally connected polymer matrix filled with ceramic particles. This is because the 0-3 design is easy to manufacture and fabricate in a variety of forms (Dias and Das-Gupta, 1996). Usually, in 0-3 polymer-ceramic composites, the dielectric properties are strongly influence by the loading volume and the uniform distribution of ceramic fillers (Ramajo *et al.*, 2005) however, some researches have reported that dielectric properties of the composites are also domiated by the properties of polymer matrix material (Adikary *et al.*, 2002).

In this thesis work, polybenzoxazine was selected as the polymer matrix, instead of the traditional phenolic resin, due to its superior properties such as excellent dimensional stability, low water absorption, and good dielectric properties, while it also provides high heat resistance and flame retardance properties that are found in the traditional one. Moreover, the molecular structure of polybenzoxazine offers design flexibility which can control properties of the cured material for specific applications (Ning and Ishida, 1994).

The ceramic used in this work was barium strontium titanate (BST, $Ba_{1-x}Sr_xTiO_3$). The lead-free BST is a ferroelectric ceramic which is a related compound of barium titanate ($BaTiO_3$), formed by the substitution of strontium for barium, enabling BST to have a large dielectric constant, low dielectric loss at room temperature and high frequencies, compared with $BaTiO_3$ (Lu *et al.*, 2003). Thus BST has been considered to be an important material for microwave applications. In this research, the powder of BST was prepared by the sol-gel method because it yields high purity and homogeneity, has low processing temperature, is stoichiometrically controllable, and is easy to process in narrow-size distribution (Yang *et al.*, 2002).

According to the prior thesis work of Panomsuwan G., dielectric constants (at 1 kHz) of benzoxazine based diamine and the polybenzoxazine-BST composite (BST = 0.48 vol%) were 3.81 and 28, respectively, and dielectric loss of the composite was about 0.05. Eventhough this composite can enhance the much higher dielectric constant than that of polymer, the dielectric loss is still high to use in high frequency range.

The main objective of this thesis is to improve the dielectric properties of the fabricated polymer-ceramic composites for using at high frequencies. The effect of polybenzoxazine type and surface treatment of the BST filler on dielectric properties were studied. In this work, benzoxazine monomers were synthesized as aniline based and fluorinate based monomers, while BST powders were prepared from the sol-gel method, followed by surface treatment in order to prevent the ceramic agglomeration. Finally the dielectric properties of polybenzoxazine-BST composites were measured at multi frequencies.