

CHAPTER I

INTRODUCTION

Thermally conductive polymer composites offer new possibilities for replacing metal parts in electric system. The advantages of polymer composites as compared to metals include improved corrosion resistance, lighter weight, and the ability to adapt the conductivity properties to suit the application needs. Applications of conductive composites as heat sinks in electric systems require new composites with a thermal conductivity from approximately 1 to 30 W/mK (King *et al.*, 1999). The use of thermally conductive polymer composites for heat dissipation has increased drastically, especially in the field of electronic packaging (Procter and Solc, 1991; Bujard, 1994; Xu *et al.*, 2001). In general heat-conducting polymer material with a thermal conductivity above approximately 1 W/mK can be used in heat-sink applications (Weber *et al.*, 2003; Heiser and King, 2004). Most polymer resins are thermally insulating; typical thermal conductivity values for polymer resins are 0.1-0.3 W/mK. The addition of some heat-conducting filler material, such as metal, graphite, carbon and ceramic particles/fibers, etc. is commonly used to induce thermal conductivity into conventional polymers (Heiser and King, 2004; Lee *et al.*, 2006). The thermal and electrical properties of the polymer composites depend on the properties of the heat-conducting filler and the polymer resin, the volume content of the filler, the shape and size of the filler, the preparation process of the polymer composites and so on (Bigg, 1995; Heiser and King, 2004). The higher thermal conductivity can be achieved by the addition of high volume fraction of filler and the use of suitable filler. Fillers have to form a random close-packed structure to maximize a pathway for heat conduction through the polymer-matrix (Lee *et al.*, 2006). In a polymer containing conductive fillers, heat is transferred by two mechanisms, lattice vibration (phonon) and electron movement (Agari and Uno, 1985). It is known that the transport of heat in nonmetals occurs by phonons or lattice vibrations. In order to maximize the thermal conductivity, the thermal contact resistance at the filler-matrix interface must be minimized. One effective approach is through surface modifications of filler by using different types of surface-treating agents such as silane coupling agents (Xu *et al.*, 2001). However, surface

modifications also have important effects on the mechanical properties, the processing behavior, and the thermal properties of polymer composites.

A number of theoretical and empirical models have been proposed to predict the effective thermal conductivity of composites such as Maxwell's, Bruggeman's, Kanari's, and Lewis-Nielsen's models. It is interesting to note that most theoretical models for predicting the effective thermal conductivity of filled polymer composites are based on uniformly distributed regular particles (Zhang, 2009). Furthermore, the theoretical predicted thermal conductivity also depends on the volume content of filler, the shape of filler, the interaction between filler particles and the packing density of filler in the matrix.

The purpose of this study is to develop highly thermally conductive BN-epoxy composites through (i) the use of different types and sizes of metal oxide in order to increase the formation of a thermally conductive network, (ii) the improvement in the formation of conductive networks by varying the mixing conditions, and (iii) the enhancement of the interfacial adhesion between the filler and matrix by filler surface treatments.