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# Thermal Conductivity Composites: A Mini Review

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## Abstract

**Thermal conductive polymer composites have become a research hotspot and important branch in the field of thermal conductivity, such as communication equipment, electronic packaging, energy transmission and so on. However, At present, the thermal conductivity of the developed thermal conductive composites is reported (λ) is far from expected. The most important reason is the inherent interface between phases and high interfacial thermal resistance in composites, which leads to greater thermal resistance and lower thermal diffusivity. This paper summarizes the research progress of thermal conductive composites from the thermal conductivity mechanism and properties of polymer composites, the reaction mechanism and preparation methods of thermal conductive fillers Some suggestions on the thermal conductivity of high thermal conductivity composites are provided.**

## Keywords

**Composites; Thermal Conductivity; Filler Modification; Preparation Method.**

## 1. Introduction

Epoxy resin (EP) occupies a large market because of its excellent mechanical properties and thermal stability, excellent electrical insulation, chemical resistance and easy processability, and has been widely used in composites, coatings, adhesives and other fields [1-3]. However, with the rapid development of electronic information technology, especially the technological innovation of highly integrated, miniaturized and multifunctional electronic components, it will inevitably lead to the rapid accumulation of heat in materials, which will seriously threaten the stability and reliability of equipment, components and high-power systems [4]. The thermal conductivity of traditional epoxy resin is too low to meet the development requirements of modern science and technology and the upgrading of new materials. It is a simple and effective method to improve the thermal conductivity of composites by filling high thermal conductivity fillers, which has a certain inspiration for the study of the thermal conductivity of new composites. Generally, thermal conductive fillers are divided into carbon based fillers (such as graphene[5], carbon nanotubes [6], nano diamond [7], etc.), and ceramic fillers (such as BN[8], Al2O3[9], SiC [10] ,etc.).

## 2. Heat Conduction Mechanism

The process of heat conduction and diffusion is a complex process of heat diffusion and transfer. Phonons and electrons are the main carriers of heat conduction in complex solids. In complex crystals, heat diffusion and transfer are mainly realized through the thermal vibration process of free electron grains arranged orderly according to a certain law; In metals, free electrons play an important role in the heat conduction of materials, while the effect of phonon vibration is very weak and can be ignored; In amorphous, the diffusion and transfer of heat are mainly realized through a reciprocating process of disorderly arranged molecules and atoms [11]. In general, the thermal conductivity of composites depends on the content of thermal conductive filler in the matrix. In polymer composites, when a small amount of filler is filled, the thermal conductivity of the composites is not significantly improved because the thermal conductive filler is difficult to form a thermal conductivity network in the composites. When an appropriate amount of filler is filled, a relatively complete thermal conductivity network can be formed in the matrix, and the thermal conductivity of the composite increases obviously. Therefore, the more heat conduction paths in the composite, the better its thermal conductivity.

## 3. Factors Affecting Thermal Conductivity of Composites

Thermal conductive filler can effectively improve the thermal conductivity of composites. Its thermal conductivity mainly depends on the type, shape, size, defects, loading rate, surface roughness, edge state, orientation of filler in the matrix and the interaction between filler and matrix [12-14]. If the particle size of the filler is small, its specific surface area, interface energy and contact area with the matrix are large, which may lead to more phonon scattering [15]. Small size fillers are more vulnerable to external effects such as shear force, magnetic field and electric field to form directional structure.

The types of fillers can be divided into three categories: metal thermal conductive fillers, carbon based thermal conductive fillers and inorganic thermal conductive fillers. Common metal thermal conductive fillers mainly include Al, Cu, Fe, etc.. Carbon based thermal conductive fillers mainly include graphite, graphene, carbon nanotubes, carbon fibers, etc. Inorganic heat conductive fillers mainly include boron nitride (BN), silicon carbide (SIC), aluminum nitride (AlN), etc.

The existence of interfacial thermal resistance increases phonon scattering and reduces thermal conductivity. The interfacial thermal resistance decreases with the increase of filler particle size. With the increase of packing dimension, the heat transfer channel finally forms a three-dimensional thermal network, so as to improve the thermal conductivity. In addition to the structural design, the thermal conductivity can be greatly improved by building a three-dimensional network, so as to significantly reduce the thermal resistance between fillers. The selective distribution of filler can significantly reduce the percolation threshold, form a continuous heat path with good interfacial compatibility, and accelerate heat flow and phonon diffusion.

## 4. Preparation Method

The thermal conductive filler forms a thermal conductive network in the resin matrix, which improves the thermal conductivity of the composite. The key here is to form a three-dimensional network, so the research on improving the thermal conductivity of composites by three-dimensional network method has become a research hotspot in recent years. At present, the research methods commonly used to build three bit networks in the market include freeze drying orientation method [12, 16], metal foam [17, 18], ceramic foam [19], carbon foam method [20], electrostatic flocking [21], electrospinning [22], 3D printing method [23], etc. Through these three-dimensional network research methods, higher thermal conductivity can be obtained on the basis of lower filler content.

## 5. Conclusion

The application of thermal conductive composites is becoming more and more extensive, and the application prospect is broad. In this review, the heat conduction mechanism of composites and the methods to improve the thermal conductivity of composites with thermal conductive fillers are discussed. The key to improve the thermal conductivity is to mix the high thermal conductivity filler with the matrix. The improvement of thermal conductivity of material matrix interface depends on two factors:

(1) Interfacial thermal resistance of filler / matrix and filler / filler;

(2) Heat conduction path formed by filler in polymer matrix.

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Finally, I hope that more high thermal conductivity composites can better meet the needs of thermal conductivity composites.

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