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Using Thermally Conductive Paste or Liquid Materials

Thermally conductive materials are an effective way to resolve a variety of design and processing challenges. They fall into the categories of adhesives, coatings, films, encapsulants, and greases. The products are differentiated by the degree of thermal conductivity that measures the ability / efficiency by which a material transfers heat energy through its volume at a given temperature. Since films have distinctly different processing and handling factors, they are not addressed in this technical tip.

Benefits

Thermal filled materials help to provide:

- Efficient energy transfer from heat generating sources (such as power supplies and power ICs) to heat sinks
- Better thermal cycle and thermal shock resistance due to the high filler loading usually employed
- Lower Coefficient of Thermal Expansion (CTE) for improved performance with dissimilar materials due to the high filler loading
- Higher heat distortion temperature
- More uniform distribution of the heat of cure yielding a more uniform cure
- Faster dissipation of the heat of reaction than unfilled systems and are, therefore, less prone to exotherm
- Less linear shrinkage due to less resin
- Increased chemical resistance due to less resin
- Increased abrasion resistance due to high amounts of the often hard thermal fillers

The most important factors influencing thermal conductivity relate to processing (discussed below) and the material's formulation (filler type, amount, and size distribution).

Processing Mixing

Processing is important from several aspects, the first being the processing challenges that the filler content can create. The fillers are generally heavy and are prone to settling. This means each can must be thoroughly stirred when opened to assure a homogeneous filler distribution. Heavily filled systems may be so thick that heating to 60°C may be necessary to lower the viscosity for easy mixing.

A power mixer is often required when combining with the hardeners. Mixing for several minutes is recommended to achieve a complete mix. Improper mixing will result in a discontinuous resin/filler matrix resulting in uncured areas, poor thermal conductivity, and poor electrical insulating properties.

Mixing Equipment

Extremely hard fillers such as alumina can be very abrasive to mixing equipment necessitating the use of hardened metal valves and pipes (consult your equipment manufacturer). The lines of meter /mix equipment should be purged after each use as filler settling will quickly plug up pipes and valves.

Air Entrapment

Mixing often introduces large quantities of air, an extremely poor thermal conductor, into the system. After dispensing, vacuum deairing is often advisable to eliminate the entrapped air (see the Tech Tip entitled "Liquid Polymer Processing Tips").

Figure 1 Thermal Conductivity Conversions

	W/m °C	BTU-in / hr-ft ² - °F	BTU-ft / hr-ft ² - °F	Cal-cm / sec-cm ² -°C
Watts/meter °C	1	6.93	0.578	0.002357
BTU-in / hr-ft ² - °F	0.1442	1	0.0833	0.000344
BTU-ft / hr-ft ² - °F	1.73	12	1	0.004134
Cal-cm / sec-cm ² -°C	418.7	2902.9	241.9	1

Surface Contamination

Surface contamination is another common processing problem that causes a lack of intimate contact with the heat producing source. Cleaning of the surface will eliminate this potential problem.

Particle Size

Attention must also be paid to filler particle size. The most thermally conductive systems often contain large granular filler particles. While large filler particles function well for bulk potting, they can be filtered out when trying to pot parts with fine, intricate spaces. The liquid system may penetrate these spaces but leave the large particles behind. In these cases a product containing a finer particle size is recommended to maintain the uniform filler distribution.

When comparing various thermally conductive materials keep in mind that different units of measure are often used and must be normalized for easy comparison (see Figure 1 Thermal Conductivity Conversions).

Also there are several different methods for measuring thermal conductivity that can give very different results. Be careful when comparing data from different company's technical bulletins.

Fillers

Very few fillers significantly aid thermal conductivity. Tabular alumina (aluminum oxide), zinc oxide, silica (quartz, sand), aluminum, iron oxide, mica, wollastonite, and calcium sulfate (anhydrous) are the most common fillers used for thermally conductive and electrically insulating systems. Aluminum is not used in high dielectric applications due to its electrical properties. Silver and nickel are used when an application requires both thermal and electrical conductivity.

Other high thermally conductive materials are available but are rarely used due to toxicity (beryllium), high cost (boron nitride or aluminum nitride), or processing / handling considerations (diamond dust and polyaramide fibers). Dust and fibers require so much loading to get superior conductivity that the material often becomes too stiff and unworkable.

If you have any questions or need additional information call Emerson & Cuming Technical Service in Billerica, MA at 1-800-832-4929.

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