

WHITE PAPER

THERMAL MANAGEMENT SOLUTIONS

Empowering Electronics Manufacturers



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Protecting electronic components from heat helps enhance performance, maintain reliability, and extend life. This applies to almost every industry from transportation to consumer electronics. Thermal management materials protect these components, providing solutions for industry challenges such as improving vehicle braking systems and increasing electronics' charging speeds.

Rapid innovation in today's electronics industry is driving smaller scale and higher speed goods, making circuit board cooling a primary challenge. As this trend continues, it will drive the demand for higher performance and more cost-effective thermal management solutions, as well as the need for greater design flexibility. The ability to manage the temperature of electronics has a direct impact on the reliability, quality, lifetime, and cost of the device.

Two well-known principles govern thermal management: conduction and convection. While engineers understand how to dissipate heat, doing so within the constraints of budgets, production schedules, increased functional density, and quality expectations can be an overwhelming task. Most electronics manufacturers seek a complete thermal management solution that can be used across an array of products, but this is excessive for less-demanding applications. Often there are less expensive, easier to apply, and better suited solutions.

Types of Thermal Interface Materials

Thermally Conductive Adhesives

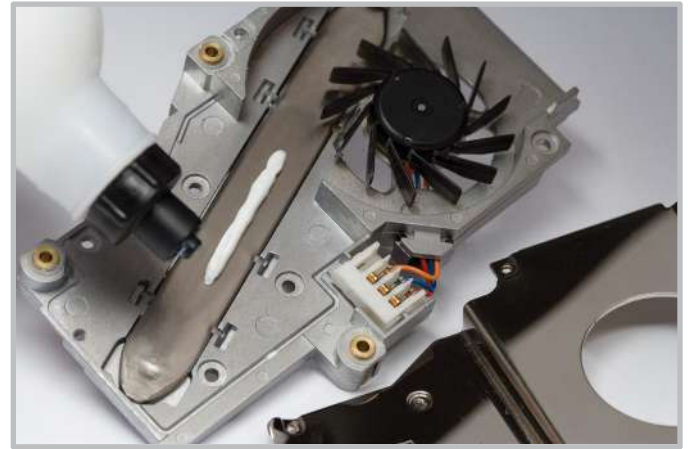
These adhesives permanently affix heat sinks to heat-generating components of a printed circuit board (PCB). One-part adhesives are easy-to-apply, but two-part epoxies are often stronger. Adhesives offer better conductance than thermal tapes, but do not convey heat as well as non-curing thermal compounds, though there is no risk of bleed-out or dry-out. Thermally conductive adhesives are not recommended for circuits that may need repairs or upgrades.

Non-Curing Thermal Compounds, Greases, Pastes & Gels

These materials consist of a thickened base liquid that has been filled with a thermally conductive material. They are quite viscous, which reduces the chance of bleed-out. Capillary action fills microscopic gaps between the heat sink and mounting surface to improve thermal transfer by reducing thermal resistance. Bleed-out and dry-out are the most notable drawbacks of thermal greases, making curing compounds more suitable when these factors are a concern.

Thermal Pads and Tapes

Best used for applications where a semi-permanent bond and short assembly times are

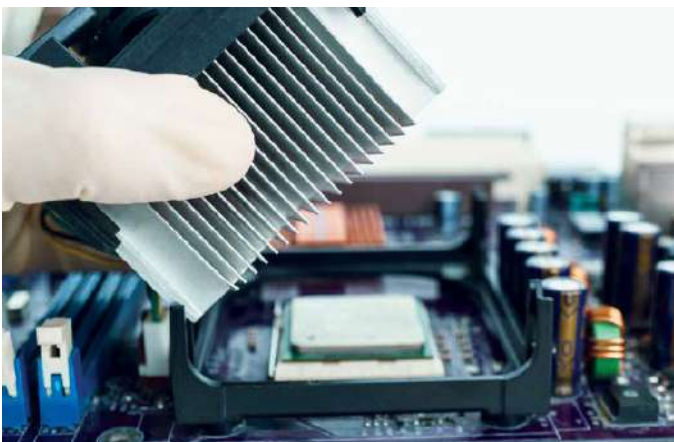


Thermal Grease

priorities, they are easy to apply, do not need to cure, and are available in prefabricated dimensions. Some thermal pads are available as a substrate that is firm at room temperature but transforms into a conductive paste at elevated temperatures to conform to circuit board topography and reduce thermal resistance. These are known as phase-change materials. Thermal pads serve the same purpose as thermal grease: to conduct thermal energy between the heat generating device and the heat sink. Thermal pads can be “dry,” meaning they contain no adhesive, or they may contain a pressure-sensitive adhesive that has lower bond strength than epoxies or adhesives.

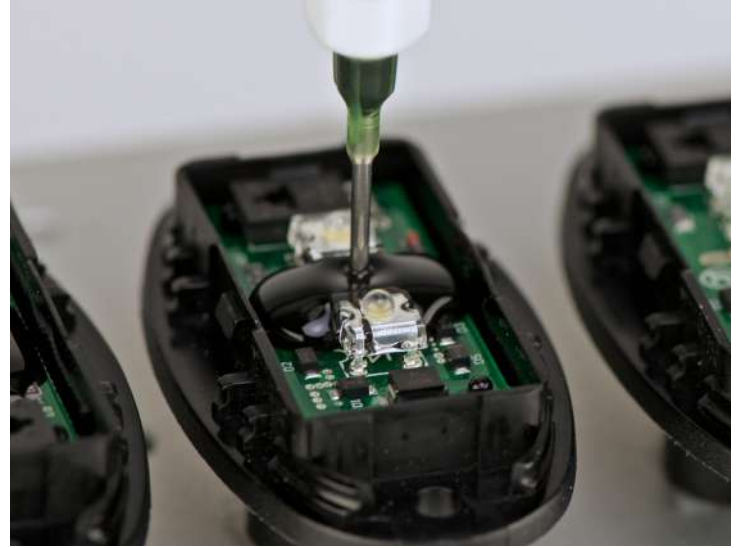
Thermal Encapsulants

Thermal encapsulants include two products: potting compounds, which cover an entire circuit, and glob tops, which cover a specific component or section of the circuit. These products provide protection from shock and vibration, environmental contaminants, and post-production alterations while electrically insulating the circuit. Potting compounds and glob tops are usually one or two-part compounds, and those that have been laden with filler material create a thermally dissipative and dielectric encapsulation.



Thermal Interface Material

The composition of most thermal interfaces can be viewed as two parts: base material and filler material. Base materials are chosen for their dielectric strength, cure times, viscosity, and other mechanical properties directly relevant to the application. The sole purpose of filler material is heat transfer, and it is dispersed in a concentration sufficient to dissipate heat. However, high concentrations of filler material may be abrasive to the circuit and dispensing equipment.



Base Materials

Polymers are inert, non-conductive, long-lasting, and suitable for high temperatures. They may be left to cure at ambient or warm temperatures, but some curing times can be adjusted by varying the ratio of catalyst and crosslinker. Silicone is by far the most popular base material, often as part of a room-temperature vulcanizing (RTV) compound. Polyurethane and acrylic bases are also available.

- Mineral oil is a classic dielectric fluid that is used sparingly in thermal interfaces.
- Ester oils with dielectric properties are sometimes used but are also rare.

Solders and fusible alloys such as gallium, tin, indium, lead, and/or bismuth do not need to cure. Some fusible alloys will melt at the end use temperature, but these liquid metal TIMs are also prone to bleeding. Metals are conductive and capacitive.

Filler Materials

- Metal powders are mixed with the base material to create a thermally conductive interface, but metal powders are also electrically conductive. Common metals include silver, aluminum, copper, zinc, and gold, and dissimilar metals are sometimes combined in the same thermal interface.
- Metal oxides (ceramics) and metal nitrides (inorganics) are thermally conductive and often dielectric but can be abrasive to components and dispensing equipment. Common types include beryllium oxide, aluminum oxide, zinc oxide, silica/silicon dioxide, boron nitride, aluminum nitride, and mica or other minerals.
- Carbon-based fillers such as diamond, carbon fiber, graphite, or graphene have exceptional thermal transfer properties. Natural diamond has the highest thermal conductivity of any material and is dielectric, but also prohibitively expensive. Carbon fiber and graphite are electrically conductive.

Dispensing Thermal Interface Materials

Integrating TIMs into the electronics assembly process can be a larger challenge than selecting the technique and materials. Adhesives, greases, and encapsulants are quite viscous and may require a storage reservoir with an integrated agitator or heater to improve flow. Operators typically want

the fastest application methods possible but must consider how to integrate TIM solutions into current processes effectively. Many fillers are quite abrasive and can quickly erode processing equipment. Air bubbles within a compound can disrupt internal pumps in dispensing equipment. Potting compounds should be applied with a technique that eliminates air gaps, such as bottom-filling the circuit or applying the material in a vacuum chamber.

The engineers at Ellsworth Adhesives can seamlessly implement a customized solution for all manufacturing needs, and no other TIM provider offers the same level of comprehensive customer service. A personal representative can determine an operation's requirements on site, acquire the necessary dispensing equipment, and maximize the benefits of the organization's relationship with Ellsworth Adhesives.

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With 70+ experienced engineering sales representatives in North America and 200+ globally, Ellsworth Adhesives has the knowledge to provide complete specialty chemical solutions across multiple industries.

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THERMAL INTERFACE MATERIAL MANUFACTURERS

The 3M logo, consisting of the numbers '3', 'M', and 'M' in a bold, red, sans-serif font.The BERGQUIST logo, featuring the word 'BERGQUIST' in a bold, black, sans-serif font inside a blue rounded rectangular border.The DOW logo, featuring the word 'DOW' in a white, sans-serif font inside a red diamond shape.The Henkel LOCTITE logo, featuring the word 'Henkel' in a white, sans-serif font inside a red oval, followed by the word 'LOCTITE' in a bold, red, sans-serif font.The Parker LORD logo, featuring the word 'Parker' in a white, sans-serif font inside a black rectangle, followed by the word 'LORD' in a bold, red, sans-serif font.The Resinlab logo, featuring a stylized molecular structure icon with three spheres (blue, orange, and red) connected by lines, followed by the word 'Resinlab' in a blue, sans-serif font.The TECHSPRAY logo, featuring a stylized purple and blue circular icon with horizontal lines, followed by the word 'TECHSPRAY' in a bold, black, sans-serif font.