WHITE PAPER

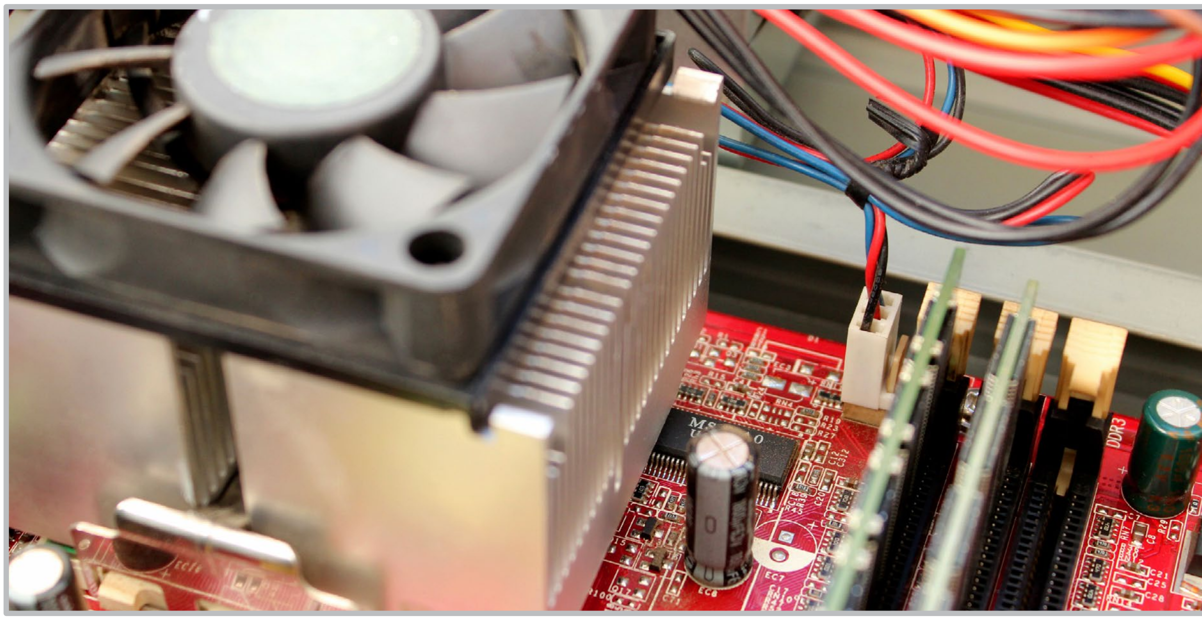
Thermal Management Solutions

Empowering Electronics Manufacturers

Diane Elliott & Dan Strawn, Engineering Sales Representatives - Ellsworth Adhesives

Rapid innovation in today's electronics industry is driving smaller scale and higher speed, because of this, circuit board cooling remains a primary challenge. Two well-known principles govern thermal management—conduction and convection—and 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, one that can be used across an array of products, but this is excessive for many less demanding applications. Often there are solutions that are less expensive, easier to apply, and better suited. Today, engineers have the benefit of an expanding selection of thermal interface materials (TIMs) and techniques, so impractical thermal management solutions can easily be avoided.

Technical advice is an invaluable resource for busy engineers. But the ability to see a customer's needs and address them from beginning to end, with industry-leading analytics and customer commitment, is what distinguishes a thermal solutions specialist from a mere supplier of TIMs.



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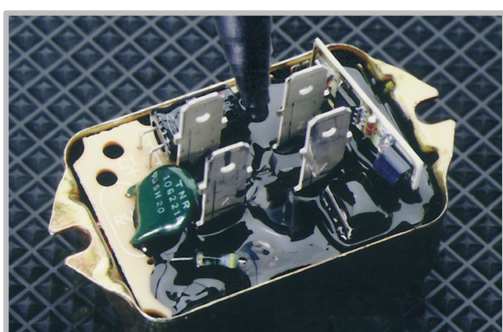
TYPES

The application and operational parameters of the circuit board largely determine the technique needed to apply TIMs in the correct manner, although sometimes multiple techniques are appropriate.

Thermally conductive 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. No additional structures are required to secure the heat sink, and a minimal bond line thickness ensures a reliable bond without exceeding dimensional tolerances. 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.

Thermal greases, pastes, gels, and other non-curing compounds 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, and 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, and curing compounds may be more suitable when these factors are a concern.



Left: Potting compound from Resinlab

Right: Thermal grease from Henkel Electronics

Dispensable thermal pad from Dow Corning

Thermal pads and tapes are best used for applications where a semi-permanent bond and short assembly times are 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 transform into a conductive paste at elevated temperatures to conform to circuit board topography and reduces 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.

Encapsulants comprise 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, post production alterations and electrically insulate 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.

MATERIALS

The composition of most thermal interfaces can be viewed as two parts, base and filler materials. Base materials are chosen for their dielectric strength, cure times, viscosity, and other mechanical properties directly relevant to the application. The sole purpose

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 cross-linker. 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 alloys of 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

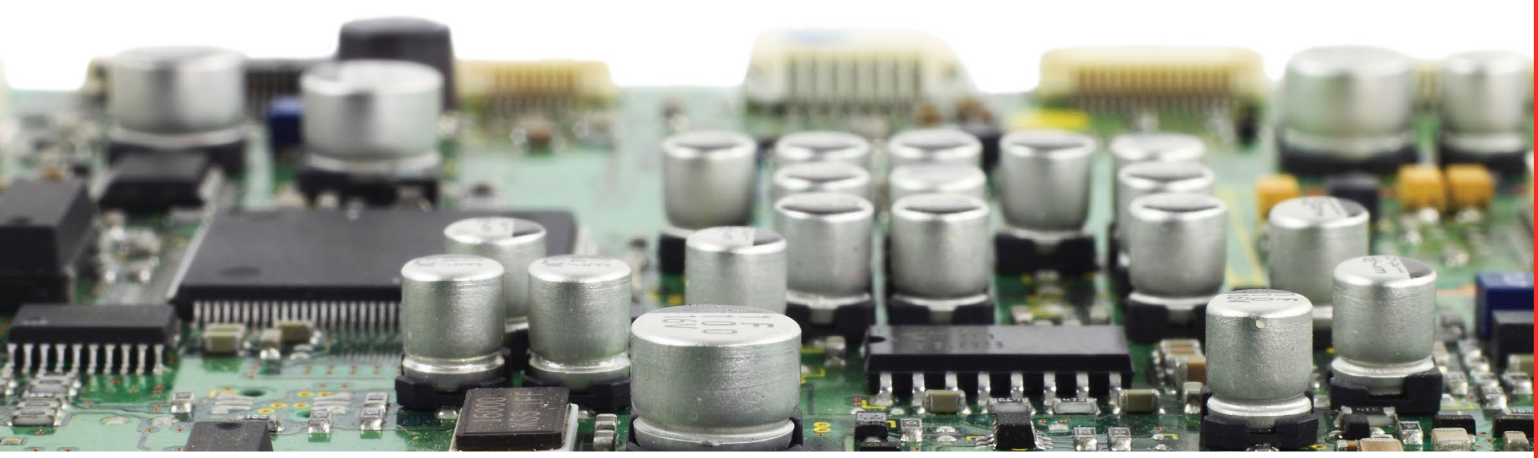
- Metal powders are mixed with the base material to create a thermally conductive interface, but metal powders are also electrically conductive. Common metals include silver, aluminum, copper, zinc, and gold, and dissimilar metals are sometimes combined in the same thermal interface.
- Metal oxides (ceramics) 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, is dielectric, but also prohibitively expensive. Carbon fiber and graphite are electrically conductive.

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.

DISPENSING

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 to increase productivity, but also must consider how to integrate TIM solutions into current processes. 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 by bottom-filling the circuit or applying the material in a vacuum chamber.

This is only a small sample of the factors an electronics manufacturer must consider when selecting a thermal interface material. The engineers at Ellsworth Adhesives can seamlessly implement a customized solution for your manufacturing needs. No other TIM supplier offers the same level of comprehensive customer service. Not only will you have our expertise when evaluating and qualifying the numerous thermal management techniques available, but a personal representative can determine your operation's requirements on site, acquire the necessary dispensing equipment, and maximize the benefits of your organization's relationship with Ellsworth Adhesives.



Ellsworth Adhesives

is a global corporation specializing in the distribution of specialty chemicals and equipment, distributing a wide range of adhesives, sealants, lubricants, coatings, encapsulants, tapes, soldering products, surface preparations, specialty chemicals, maintenance and repair products and dispensing equipment. Not only is Ellsworth Adhesives' product line extensive, but they are the only integrator specializing in the supply and logistics of specialty chemicals.

ELLSWORTH ADHESIVES

W129 N10825 Washington Drive, Germantown, WI 53022

800.888.0698 | ellsworth.com

info@ellsworth.com

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