WHITE PAPER

Thermal Management Solutions

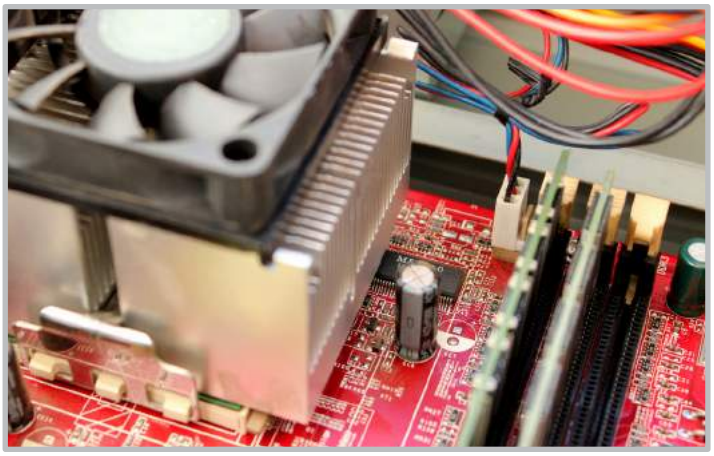
Empowering Electronics Manufacturers

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

Protect electronic components from heat to enhance performance, maintain reliability and extend the life of electronics. This applies to almost every industry from transportation to consumer electronics. Thermal management products provide 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, because of this, circuit board cooling remains 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, 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 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; 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.

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 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.

Encapsulants include two products: potting compounds, which cover an entire circuit, and globtops, 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.

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Materials

The composition of most thermal interfaces can be viewed as two parts. **Base** materials are chosen for their dielectric strength, cure times, viscosity, and other mechanical properties directly relevant to the application. Products with faster cure times increase manufacturing throughput, which provides cost savings. 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.

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, 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.

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 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

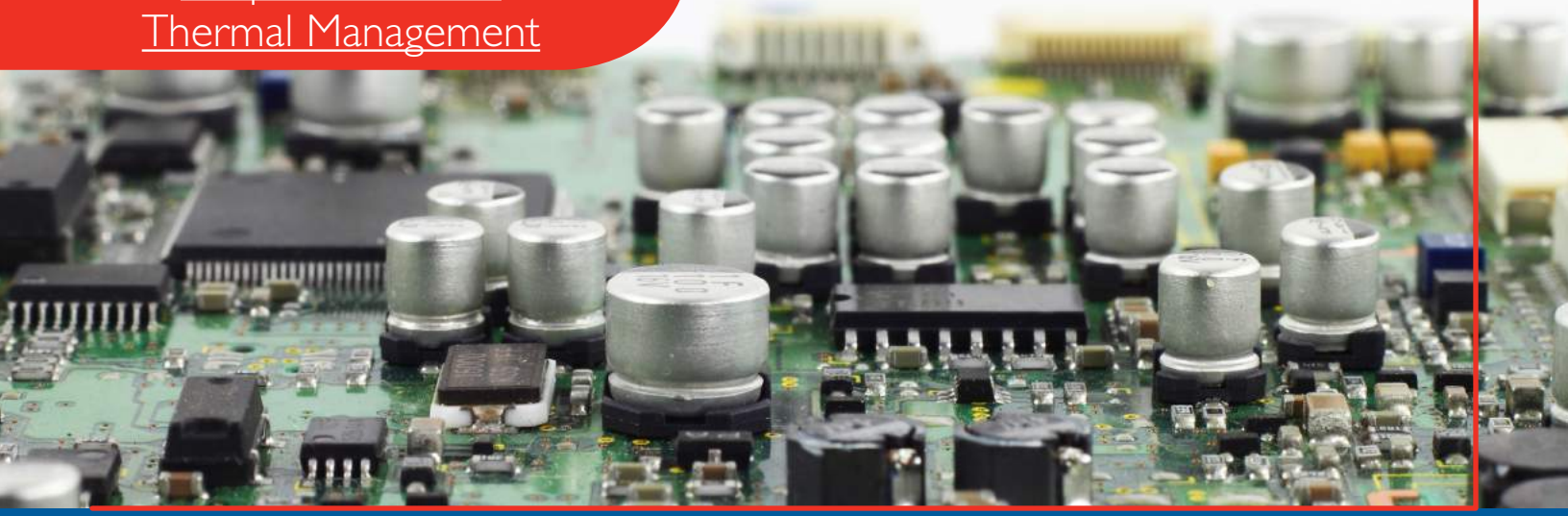
- Metal powders are mixed with the base material to create a thermally conductive interface, but metal powders are also electrically conductive. Common metals include silver, aluminum, copper, zinc, and gold, and dissimilar metals are sometimes combined in the same thermal interface.
- Metal oxides (ceramics)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

This is a small sample of the factors an electronics manufacturer must consider when selecting a thermal interface material. Ellsworth Adhesives provides a variety of these products and are always looking for new technologies to make today's electronics smaller, faster, and stronger. Ellsworth Adhesives top manufacturers for thermal management materials include 3M, Bergquist, Cytec Solvay Group, Dow Corning, Henkel LOCTITE®, ResinLab and Techspray.

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.

For more information, go to Ellsworth Adhesives' webpage dedicated to Thermal Management:

Keep it Cool with Thermal Management



Ellsworth Adhesives

is a solutions provider for all applications or manufacturing processes that utilize adhesives, sealants, encapsulants, lubricants, tapes and related equipment from major manufacturers.

Ellsworth Adhesives' specialty chemical knowledge spans across multiple industries. A global network of Engineering Sales Representatives is available to assist with the integration of adhesives through the complete production process. ISO 9001:2008 and AS9120A certified.

ELLSWORTH ADHESIVES

W129 N10825 Washington Drive, Germantown, WI 53022

800.888.0698 | ellsworth.com

info@ellsworth.com

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