THERMAL INTERFACE MATERIALS

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In the electronics world of today, new gizmos and gadgets are being introduced almost daily, that are smaller, run faster, and do more. The components used in these devices also generate a greater amount of heat that can be detrimental to the life of the product. Thermal management is necessary to keep all electronic devices running smoothly. A well-designed thermal management program will keep operating temperatures within acceptable limits in order to optimize performance and reliability.

Electronic components, such as semiconductors, are kept within their operating temperature limits by transferring excess heat away from them. This is best accomplished by attaching a heat sink to the component, and in lay man's terms, drawing the heat from the source and transferring it into the air. Once the proper heat sink has been selected, it must be joined to the semiconductor to ensure efficient heat transfer. This combination of parts, called a thermal interface, works best when the joint is as thin as possible, both surfaces are in intimate contact, and air gaps are at a minimum. Air, between the surfaces, acts as a resistor to the heat instead of a conductor.

A thermal interface requires that two solid surfaces be brought together into intimate contact. Unfortunately, no matter how well prepared, solid surfaces are never really flat or smooth enough to permit intimate contact. All surfaces have a certain roughness due to microscopic hills and valleys. The hills on these surfaces may come into contact, but the valleys are air-filled gaps. As much as 99% of the component's surfaces are separated by a layer of interstitial air. Some heat is conducted through the contact points (hills), but much more has to transfer through the air gaps. Since air is a poor conductor of heat, it should be replaced by a more conductive material to improve heat flow across the thermal interface.

Several types of thermally conductive materials can be used to eliminate air gaps from a thermal interface. All are designed to conform to surface irregularities, thereby eliminating air voids and improving heat flow through the thermal interface. Most are able to be die cut very easily.

TYPES OF THERMAL INTERFACE MATERIALS

Thermal greases are made by dispersing thermally conductive ceramic fillers in silicone or hydrocarbon oils to form a paste. This paste can be applied to one of the mating surfaces directly or be applied to a carrier, which can be die cut to the surface configuration. The two surfaces can than be pressed together, with the grease flowing into all the voids to eliminate the interstitial air. Excess grease flows out past the edges and the thinnest possible thermal joint is formed. Thermal greases provide very low thermal resistance between reasonably flat surfaces, but are very "user unfriendly". Grease does not provide electrical insulation between the two surfaces, and excess grease that flows out of the joint has to be cleaned. It can also dry out in time, and joint integrity must be maintained with mechanical hardware.

Thermally conductive compounds are an improvement on thermal grease as these compounds are converted to a cured rubber film after application. Initially, these compounds flow as freely as grease to fill air voids. After the interface is formed, the compounds cure with heat to a rubbery state and develop secondary properties such as adhesion. No fasteners necessary. Large gaps can be filled where greases would tend to bleed out. Clean up is simple and there is no migration or dry joint problem like grease.

Thermally conductive elastomers are silicone elastomer pads filled with thermally conductive ceramic particles, often reinforced with woven glass fiber or dielectric film for added strength. They come in different thicknesses and durometers to handle different applied pressures. Unlike greases and compounds, elastomer pads provide electrical insulation. They can be easily die cut to the size and configurations of the mounting surfaces and there are no worries about contamination. The negatives of thermal elastomers are that they do not flow freely like the greases or compounds, and will deform if compressed too much. Also, they need to be mechanically fastened to hold the two surfaces together.

Thermally conductive adhesive tapes are double-sided pressure sensitive adhesive films filled with sufficient ceramic powder to balance their thermal and adhesive properties. The tape is usually supported with an aluminum foil or a polyimide film for strength and ease of cutting. Polyimide support also provides electrical insulation. After the tape is adhered with some initial pressure to conform to the irregularities, it needs no mechanical support. The bond is considered permanent. The convenience of this material comes at a price. Tapes are unable to fill large gaps between non-flat surfaces and because thermal tapes do not fill gaps, in general, as well as liquids, there is usually a considerable amount of interstitial air gaps. So thermal resistance is higher.

To summarize, a variety of materials are available to manage the resistance of thermal interfaces. Thermal greases and compounds have the best properties, but they are pastes and require care in handling. Elastomers eliminate messy handling problems but they sometimes require high compressive loads to close gaps. Thermal tapes offer convenience but their gap filling properties are limited. The success of any thermal interface will depend on the design, the quality of the interface material and its proper installation.