Thermal Gap Fillers: New Material Overcomes Performance Trade-Offs

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Complex tradeoff issues have resulted in the development and commercialization of a wide range of thermal gap filler materials, none of which could truly be considered "optimum". Recently, however, a material with good thermal, mechanical, physical and flammability properties has been developed, whose cost premium is only about 50% compared to most alumina-based thermal gap fillers. Designated "Therm-A-Gap A574", this new material represents an optimized balance of performance and cost.

Bereits seit geraumer Zeit ist auf dem Markt eine Vielzahl von Materialien für thermische Gap Fillers verfügbar. Alle diese Materialien haben ihre spezifischen Vorteile, aber auch Nachteile. Neue Maßstäbe in puncto Preis/Leistungsverhältnis soll der neuentwickelte Werkstoff "Therm-A-Gap A574" setzen, der gute thermische, mechanische, physikalische und flammhemmende Eigenschaften besitzt und trotzdem nur etwa 50 % teuerer ist als aluminium-basierende Gap Fillers.

Des problèmes complexes et des compromis étant survenus dans le développement et la commercialisation d'une large gamme de matériaux de remplissage des discontinuités thermiques, aucun de ceux-ci peuvent vraiement êtres considérés comme « optimum ». Récemment, un matériau avec de bonnes propriétes thermiques, physiques et de flammabilité a été développé dont le coût est seulement de 50% comparé aux matériaux de remplissage des discontinuités thermique à base d'alumine. Nommé « Therm-a-gap A574 » ce nouveau matériau représente un compromis optimum entre la performance et le coût.

Nello sviluppo e nella commercializzazione di una vasta gamma di materiali di riempimento termico, si sono realizzate soluzioni con molti compromessi, nessuna della quali potrebbe essere considerata veramente „ottima". Recentemente, tuttavia, è stato sviluppato un materiale con buone proprietà termiche, meccaniche, fisiche e di infiammabilità, il cui aumento di costo è solo il 50 % in confronto al costo dei materiali termici di riempimento a base di allumina. Denominato „Therm-A-Gap A574", questo nuovo materiale rappresenta un ottimo bilanciamento fra le prestazioni ed il costo.

Thermal gap fillers are used to conduct heat across an air gap, from a hot device (such as a processor, IC, or ASIC) to a heat rail, spreader, or chassis, in enclosures with restricted convection and insufficient room for conventional heat sinks. *Figure 1* shows some common sheet and molded product forms. An example of a typical application of a gap filler pad, used to interface an IC package to an enclosure, is shown in *Figure 2*. These thermal gap fillers consist of thermally conductive ceramic filler particles dispersed in conformable but form-stable polymer binders.

Consideration of complex tradeoff issues (Conformability vs. Thermal Conductivity, Thermal Conductivity vs. Cost, Flammability vs. Conformability, Surface Tack vs. Thermal Conductivity, Thermal Conductivity vs. Physical Strength) has resulted in the development and commercialization of a wide range of thermal gap filler materials, none of which could truly be considered "optimum". Some have relatively high thermal performance but poor conformability, insufficient handling strength or very high cost. Others are quite conformable but also flammable or not very thermally conductive. Recently, however, a material with good thermal, mechanical, physical and flammability properties has been developed, whose cost premium is only about 50% compared to most alumina-based thermal gap fillers. Designated "Therm-A-Gap A574", this new material represents an optimized balance of performance and cost.

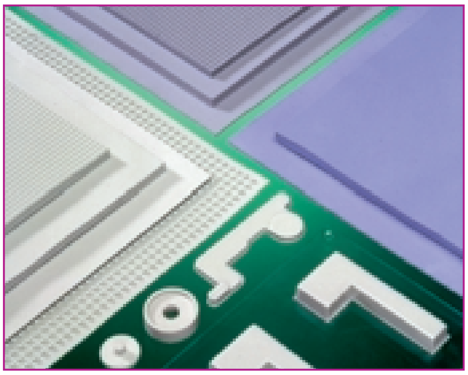

Figure 1.
Common sheet and molded Thermal Gap Fillers

Table 1 compares five key properties of thirteen commercially available thermal gap filler materials: thermal conductivity, conformability, flammability, physical strength and surface tack. These properties are characterized as follows:

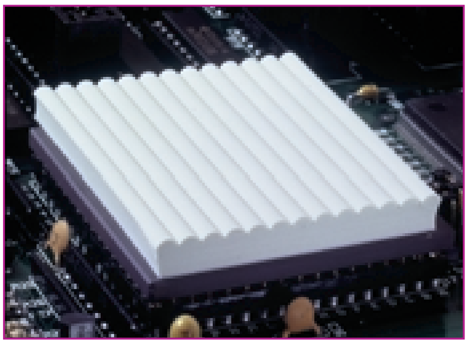

Figure 2.
Gap Filler pad to interface an IC package to an enclosure

Thermal conductivity, calculated from thermal impedance values determined at 5 psi as measured by ASTM D5470, expressed in units of W/m-K. Higher values represent better thermal conductivity. The test set-up used is depicted in *Figure 3*.

Conformability, measured according to ASTM D575, and expressed as the force required to achieve 20% deflection of a 1.0 in^2 circular button, reported in units of psi. Lower values represent better conformability.

Flammability, expressed as a UL rating (from the manufacturers' product literature).

Physical strength, expressed in terms of "supported" (by carrier or reinforcing layer) or "unsupported".

Surface type, expressed using the terms "tacky" or "dry".

Note that Therm-A-Gap A574 is highest rated in terms of both thermal and conformability properties, and possesses the desired features of flame resistance (UL 94V-0), physical strength (supported) and surface type (tacky). These features make it especially suitable for applications involving heat flux densities up to 5 W/cm^2 in package designs with large dimensional tolerances and minimum loading forces.

Numerous of unique formulation and process advances are responsible for the good balance of A574 performance properties and cost. For example, the thermally conductive filler is a blend of both alumina and boron nitride, which results in high thermal conductivity at a lower-than-normal filler loading level and moderate cost premium. The supporting carrier is aluminum foil, which not only provides physical strength but actually improves the material's thermal conductivity. And the flame retardant is a non-halogenated material, which results in lower hardness and also makes the product much more environmentally friendly. Considering the many factors and trade-offs to be balanced, Therm-A-Gap A574 has an attractive set of properties that makes it well suited for many applications. The need to balance cost and performance properties applies also to thermal interface materials used to reduce resistance between mating surfaces, such as a heat sink and a processor. Although less visible than a discrete air gap, most of the "mating" interface actually consists of air. These applications typically call for a thinner thermal interface material, often in the form of a double-sided tape or a phase-change material. In either case, most of the same trade-off issues of filler type and loading, physical properties, support structure and ease of application will apply.

Material	Thermal Conductivity (W/m-K)	Conformability (PSI for 20% Deflection)	Flammability (UL Rating)	Physical Strength	Surface Type
A574	1.50	5	94V-0/V-1	supported	tacky
T2	1.40	24	not rated	unsupported	dry
S1	1.10	237	94V-0/V-1	supported	dry
C1	1.00	52	94V-0/V-1	supported	dry
R1	0.95	28	94HB	unsupported	tacky
F1	0.95	80	94V-1	unsupported	tacky
B1	0.90	45	94V-0	supported	tacky
B2	0.90	24	94V-0	supported	tacky
G1	0.90	29	not rated	unsupported	tacky
K1	0.65	22	94HB	supported	tacky
F2	0.60	18	not rated	supported	tacky
1	0.50	220	94HB	supported	tack
T1	0.50	27	not rated	unsupported	dry

** With the exception of A574, all materials tested are designated by code numbers.*

Table 1. Comparison of key properties of thirteen commercially available thermal gap filler materials

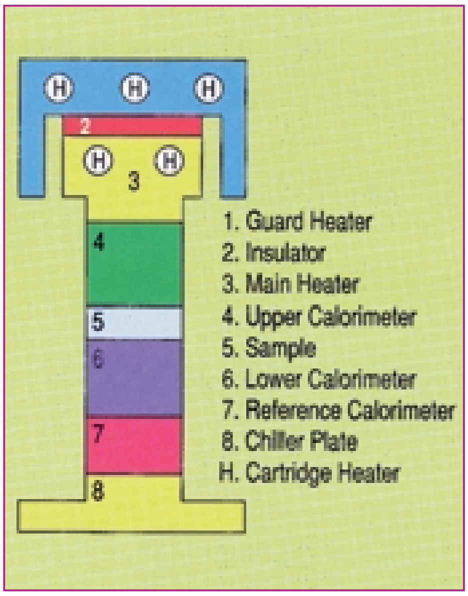

Figure 3.
Thermal conductivity:
Test set for ASTM D5470

As processors and power devices get faster and hotter, and as package densities increase, the need for higher performance thermal management materials is becoming critical. Regardless of the cooling methodology used, efficient heat conduction across interfaces from hot to cold devices or surfaces has become a key objective of electronics packaging engineers. Whether the interface is across a discrete air gap or simply the micro-gaps present between imperfectly mating surfaces, selection of interface materials with the best balance of thermal, mechanical and application properties is an important strategy for meeting this objective.