

THERMAL CONDUCTIVE COATING FOR THERMAL INTERFACING MATERIAL

Field of the Invention

[0001] The present invention relates to thermal interfacing material (TIM). In particular, the invention relates to a thermal conductive coating for TIM and a method of producing the same.

Background

[0002] In advance electronics, tremendous heat that needs to be dissipated to maintain the working state of the electronic components. In the current state, heatsink is still widely used for dissipating heat generated by the electronic components, such as microprocessor. However, it is well known in the art that the contact surfaces of the heat sink and the electronic component are irregular in microscopic scale, which forms air gaps when the two contact surfaces are abutting together. It is well known in the art that air is very poor in conducting heat, i.e. trapped air pockets introduces heat resistance between the contact surfaces.

[0003] Thermal interfacing materials (TIM) have been widely used as a medium to fill the gaps between the thermal transfer surfaces to increase thermal transfer efficiency. The most common form of TIM includes thermal grease. The material is easy to use but it can be messy when applying/removing it. Due to the nature of the material, it is commonly not suitable for rework purpose.

[0004] An alternative TIM is made in a form of sheets. Such TIM sheets are easy to handle. The TIM sheets can be cut and trimmed to size of the applications and are then sandwiched between the two thermal conducting surfaces. To obtain a better thermal performance, the two thermal conducting surfaces can be clamped to pressure the TIM sheet to have a better conformance with the two surfaces. **FIG. 1** illustrates a microscopic view of a surface **102** of a TIM sheet. The TIM sheet is a graphite-based TIM. Due to the graphite molecular structure, the surface **102** consists of pores **101** that form air pockets when in used. As TIM is flexible, clamping it with greater force would improve the conformity of the TIM to the application surfaces. However, due to the irregular surface of the TIM sheet, air gaps between the TIM sheet and the application surface are unavoidable.

[0005] TIM sheet can be attached to the surface of application through adhesive tape or gel when required. However, such adhesive tape and gel are also poor in thermal conductivity, and they may sometime be hard to handle.

Summary

[0006] In one aspect of present invention, there is provided a thermal interface material (TIM) sheet comprises a layer of thermal conductive coating.

[0007] In one embodiment, the thermal conductive coating may comprise a thermal and pressure sensitive material and thermal conducting particles. The thermal conducting particles are suspended within the thermal and pressure sensitive material. The thermal conducting particles may be micronized or pulverized thermal conducting particles. The particles can also be metal particles, such as silver particles.

Alternatively, the thermal conducting particles may also be copper, aluminum, gold or diamond particles.

[0008] In another embodiment, the thermal sensitive material may be a water-based adhesive, such as PVA or PVC glue. The thermal and pressure material serves as a bonding agent when it is heated over a molten point of said material.

[0009] In a further embodiment, the TIM sheet is removable on an application surface when it is re-heated to the molten point. It is possible that the thermal conductive coating is coated on both side of the TIM sheet. The thermal conductive coating may comprise about 45-50%-wt of the thermal and pressure sensitive material and about 50-55%-wt of the thermal conducting particles.

[0010] In yet a further embodiment, the TIM sheet is a commercially available TIM sheet.

[0011] In another aspect of the present invention, there is provided a thermal conductive coating in accordance with any one of the preceding claims.

Brief Description of the Drawings

[0012] This invention will be described by way of non-limiting embodiments of the present invention, with reference to the accompanying drawings, in which:

[0013] **FIG. 1** exemplifies a microscopic view of a TIM sheet available in the market;

[0014] **FIG. 2** illustrates a cross sectional view of a TIM sheet with thermal conductive coating in accordance with one embodiment of the present invention;

[0015] **FIG. 3A** exemplifies a microscopic view of the TIM sheet where the coating can be seen;

[0016] **FIG. 3B** illustrates a cross sectional view of a coated TIM sandwiched between a thermal transfer surface of an electronics device/component and a thermal transfer surface of a heat sink;

Detailed Description

[0017] In line with the above summary, the following description of a number of specific and alternative embodiments are provided to understand the inventive features of the present invention. It shall be apparent to one skilled in the art, however that this invention may be practiced without such specific details. Some of the details may not be described at length so as not to obscure the invention. For ease of reference, common reference numerals will be used throughout the figures when referring to the same or similar features common to the figures.

[0018] **FIG. 2** illustrates a cross section view of a thermal interfacing material (TIM) **200** in accordance with one embodiment of the present invention. The TIM **200** comprises a TIM sheet **202** coated with a layer of thermal conductive coating **204**. The TIM sheet **202** generally has irregular surface with pores. The thermal conductive coating **204** is provided to fill up the pores on the surface of the TIM sheet **202** to

improve the regularity of the surface of the TIM sheet **202**. The thermal conductive coating **204** in this case was applied to only one surface for illustration purpose only. Two side coating may also be possible when necessary. The thermal conductive coating **204** comprises a mixture of a thermal and pressure sensitive material **206** and thermal conducting particles **208**. The thermal and pressure sensitive material **206** serves as a filling agent for the TIM sheet **202**. The thermal and pressure sensitive material **206** generally may have low thermal conductivity. The thermal conducting particles **208** are mixed into the thermal and pressure sensitive material **206** to improve the thermal conductivity of the TIM sheet **202**. The thermal conducting particles **208** are micronized or pulverized thermal conductive material that are mixed and suspended within the thermal and pressure sensitive material **206**.

[0019] Depending on the type of material used as the thermal and pressure sensitive material **206**, it can be served as a bonding agent. In the present embodiment, the adhesiveness of the thermal and pressure sensitive material **206** is activated, i.e. soften/molten, at its melting point, which allows the TIM sheet **202** to adhere on the application surface once it is cured. Further, the thermal and pressure sensitive material **206** may be re-workable by reheating the same to the melting point for easy and clean removal. Re-attaching the coated TIM sheet **202** or a new piece of coated TIM sheet **202** onto the application surface can be done by simply heating the thermal and pressure sensitive material **206** to the melting point.

[0020] The thermal and pressure sensitive material **206** can be simply sandwiched between two application surfaces. With sufficient pressure, the thermal and pressure sensitive material **206** serves as a medium to the TIM **200** to conform well

with the two application surfaces, whereby increasing the contact between the two application surfaces through the coated TIM **200**. The coated TIM **200**, whether or not it is adhered to the application surfaces, provides a good conformity between the two application surfaces thereby improving the thermal performance of the application. When the thermal and pressure sensitive material **206** is at its molten state, then conformity between the two surfaces is further improved.

[0021] Depending on the applications, the thermal conductive coating **204** may be coated on one side or double sides of the TIM **200**. In one embodiment, the coated TIM **200** can be used in a burn-in test/functional testing, where the coated TIM **200** is required to attach onto a test head only, but not the device-under-test. Accordingly, the TIM **200** is required to be coated on one side only. In an alternative embodiment, the coated TIM **200** can be used inside the packaging where two sides of the TIM sheet **202** would need to be coated for attaching both sides of the applications surfaces.

[0022] In one embodiment, the thermal and pressure sensitive material **206** include a water-based adhesive, such as PVA or PVC glue. These adhesives have the advantage of softening or molten when subjected to a certain temperature and pressure to create re-adhesiveness onto the application surfaces for allowing rework. The thermal and pressure sensitive material **206** can be soften or molten at about 120°C onwards. When the application surface is heated up to said temperature, the thermal and pressure sensitive material **206** creates bonding adhesiveness between the TIM sheet **202** and the application surface, e.g. electronics component/device or heat sink. The TIM **200** is bonded to the application surface once the thermal and pressure sensitive material **206** is cured. To rework, the TIM **200** is heated up to the melting point again,

and the TIM **200** can be easily removed from the application surface once the thermal and pressure sensitive material **206** is molten. It can be seen that as the adhesiveness is only activated at the operating state, working and re-working with the coated TIM **200** is clean and easy.

[0023] In another embodiment, silicone based or phase changing materials, for example, are also suitable candidates in replacing the thermal and pressure sensitive materials **206**, which fill the cavities/pores of the uneven surface on the TIM sheet **202**.

[0024] It is understood to the person skilled in the art that the above thermal and pressure sensitive material **206** is illustrated by way of example, not limitations. Other thermal and/or pressure sensitive materials may also be desired depending on the need. For example, a thermal sensitive material with lower melting point such as 50-70°C may be desired for PC or laptop application. When clamp is available to press the two application surfaces against each other, the coated TIM **200** can still be applied there between, regardless of the melting point of the thermal and pressure sensitive material **206**. In such application, the adhesiveness of the material is optional, but due to the coating, the coated TIM **200** has a better surface conformance than normal TIM sheet alone.

[0025] The thermal conducting particles **208** can be any thermal conductive materials. Silver, copper, aluminum, gold particles are suitable materials for thermal conducting particles as it has high thermal conductivity. Diamond can also be selected with its high thermal conductivity. The thermal conductive materials are provided to enhance the thermal conductivity of the thermal and pressure sensitive material **206**.

[0026] In one embodiment, the thermal conducting particles **208** can be off-the-shelf metallic products. It is possible to select particles having either all small particles, or all large particles or mixtures of particles of different sizes in any proportion. Typical size of the thermal conducting particles available in the market that ranged from 30nm to 3.6 μ m may be suitable for the present invention, though other sizes may also be desired depending on the applications.

[0027] In one embodiment, the thermal and pressure sensitive material **206** is mixed with the thermal conducting particles **208** before coating onto the TIM sheet **202**. Once mixed, the thermal conducting particles **208** are suspended within the thermal and pressure sensitive material **206**.

[0028] In one embodiment, the thermal conductive coating **204** comprises about 50-55%-wt of the thermal conducting particles **208** and about 45-50%-wt of the thermal and pressure sensitive material **206**. The mixture ratio above is provided by way of examples only, not limitations. Selections of the mixture ratio can be dependent on various factors that include the material (mixture or single type) of the thermal conducting particles **208**, size of the particles, type of the thermal and pressure sensitive material **206**, viscosity of the thermal and pressure sensitive material **206**, etc.

[0029] **FIG. 3A** exemplifies a microscopic view of the surface of the TIM **200**. As shown, the thermal conductive coating **204** fills the pores **302** making the surface less irregular.

[0030] When in used, the TIM **200** is sandwiched between an electronics device/component and a heat sink.

[0031] FIG. 3B illustrates a cross sectional view of the TIM sheet 200 sandwiched between a thermal transfer surface 350 of the electronics device/component and a thermal transfer surface 360 of the heat sink. As the thermal conductive coating 204 consists of thermal and pressure sensitive material 206, the coated surface of the TIM 200 conforms better to the heat transfer surface 360 thereby avoiding unnecessary air gap pockets and increases contact surface on both application surfaces of the device and the heat sink. The embedded thermal conducting particles 208 within the thermal conductive coating 204 improve the thermal conductivity of the TIM 200. With this current thermal conductive coating 204 onto the TIM 200, there is an increased on the thermal performance of about 15-20%.

[0032] The mixture contains preferably around 54%-wt of thermal conducting particles 208 and about 46%-wt of thermal and pressure sensitive material 206.

[0033] Many methods known in the art are available for depositing the thermal conductive coating 204 on the TIM 200. Examples of which includes spraying, spreading, flowing, and etc. It is preferred that only a relatively thin layer of coating on the TIM 200 is provided as increasing the coating thickness does have an impact on the overall thermal resistance of the TIM 200. The thickness required would largely depend on the applications and materials used.

[0034] While specific embodiments have been described and illustrated, it is understood that many changes, modifications, variations and combinations thereof could be made to the present invention without departing from the scope of the invention.

Claims

1. A thermal interface material (TIM) sheet comprising a layer of thermal conductive coating.
2. The TIM sheet according to claim 1, wherein the thermal conductive coating comprising a thermal and pressure sensitive material and thermal conducting particles, wherein the thermal conducting particles are suspended within the thermal and pressure sensitive material.
3. The TIM sheet according to claim 2, wherein the thermal conducting particles are micronized or pulverized thermal conducting particles.
4. The TIM sheet according to claim 3, wherein the thermal conducting particles are metal particles.
5. The TIM sheet according to claim 3, wherein the thermal conducting particles are silver particles.
6. The TIM sheet according to claim 3, wherein the thermal conducting particles are any of copper, aluminum and gold particles.
7. The TIM sheet according to claim 3, wherein the thermal conducting particles are diamond particles.
8. The TIM sheet according to claim 2, wherein the thermal and pressure sensitive material is a water-based adhesive.

9. The TIM sheet according to claim 2, wherein the thermal and pressure sensitive material includes PVA or PVC glue.
10. The TIM sheet according to claim 2, wherein the thermal and pressure sensitive material includes silicone based or phase changing materials.
11. The TIM sheet according to claim 2, wherein the thermal and pressure sensitive material serves as a bonding agent when it is heated over a melting point of said material.
12. The TIM sheet according to claim 7, wherein the TIM sheet is removable on an application surface when it is re-heated to the melting point.
13. The TIM sheet according to claim 1, wherein the thermal conductive coating is coated on both side of the TIM sheet.
14. The TIM sheet according to claim 2, wherein the thermal conductive coating comprising about 45-50%-wt of the thermal and pressure sensitive material and about 50-55%-wt of the thermal conducting particles.
15. The TIM sheet according to claim 1, wherein the TIM sheet is a commercially available TIM sheet.
16. A thermal conductive coating in accordance with any one of the preceding claims.