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(54) **Title:** ELECTRONIC DEVICE HEAT TRANSFER SYSTEM AND RELATED METHODS

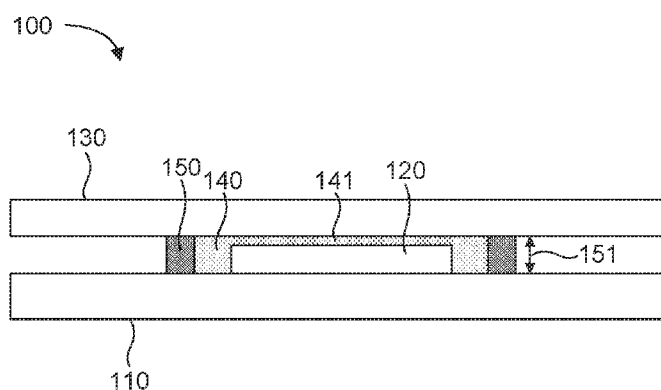


FIG. 1

(57) **Abstract:** Electronic device heat transfer technology is disclosed. In an example, an electronic device package can include a substrate. The electronic device package can also include a heat transfer component. The electronic device package can further include a heat-generating electronic component coupled to the substrate between the substrate and the heat transfer component. The electronic device package can also include a viscous thermal interface material (TIM) providing a heat transfer pathway between the electronic component and the heat transfer component. In addition, the electronic device package can include a barrier about at least a portion of a periphery of the viscous TIM to maintain the viscous TIM within a confined location in proximity to the electronic component. The TIM is uninterrupted by the barrier within the periphery.



ELECTRONIC DEVICE HEAT TRANSFER SYSTEM AND RELATED METHODS

Technical Field

[0001] Embodiments described herein relate generally to cooling of electronic devices.

5

Background

[0002] Heat generated by an electronic component, such as a computer processor, can negatively impact the component's electrical performance and lifespan. The heat can also negatively impact adjacent electronic components and surrounding hardware. As a result, heat-generating electronic components are often cooled by thermally coupling the component with a heat exchanger, such as a heat spreader, heat sink, etc. Thermal coupling can be achieved by interfacing a flat surface of the electronic component with a flat surface of the heat exchanger. The goal in interfacing the surfaces is to eliminate any air between them as air impedes heat movement. Unfortunately, the interfacing surfaces almost always have imperfections which prevent 100% surface contact between them. Therefore, a thermal interface material (TIM), such as a thermal grease, can be included to fill and eliminate air gaps between the heat transfer surfaces, and improve thermal performance, which in turn benefits the electronic component's electrical performance and life span.

Brief Description of the Drawings

[0003] Invention features and advantages will be apparent from the detailed description which follows, taken in conjunction with the accompanying drawings, which together illustrate, by way of example, various invention embodiments; and, wherein:

[0004] FIG. 1 illustrates a schematic cross-sectional view of an exemplary electronic device heat transfer system;

[0005] FIG. 2 illustrates a schematic top view of an exemplary electronic device

heat transfer system with certain elements omitted to reveal aspects of the system;

[0006] FIG. 3 illustrates a schematic cross-sectional view of another exemplary electronic device heat transfer system;

5 **[0007]** FIG. 4 illustrates a schematic cross-sectional view of a further exemplary electronic device heat transfer system;

[0008] FIG. 5 illustrates a schematic cross-sectional view of an exemplary electronic device heat transfer system configured as an electronic device package;

10 **[0009]** FIG. 6 illustrates a schematic cross-sectional view an additional exemplary electronic device heat transfer system; and

[0010] FIG. 7 illustrates a schematic view of an exemplary computing system.

[0011] Reference will now be made to the exemplary embodiments illustrated, and specific language will be used herein to describe the same. It will
15 nevertheless be understood that no limitation of the scope or to specific invention embodiments is thereby intended.

Description of Embodiments

[0012] Before invention embodiments are disclosed and described, it is to be
20 understood that no limitation to the particular structures, process steps, or materials disclosed herein is intended, but also included are equivalents thereof as would be recognized by those ordinarily skilled in the relevant arts. It should also be understood that terminology employed herein is used for the purpose of describing particular examples only and is not intended to be limiting. The
25 same reference numerals in different drawings represent the same element. Numbers provided in flow charts and processes are provided for clarity in illustrating steps and operations and do not necessarily indicate a particular order or sequence. Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of
30 ordinary skill in the art to which this disclosure belongs.

[0013] As used in this specification and the appended claims, the singular forms “a,” “an” and “the” include plural referents unless the context clearly dictates otherwise. Thus, for example, reference to “an electronic component” includes a plurality of such electronic components.

5 **[0014]** In this disclosure, “comprises,” “comprising,” “containing” and “having” and the like can have the meaning ascribed to them in U.S. Patent law and can mean “includes,” “including,” and the like, and are generally interpreted to be open ended terms. The terms “consisting of” or “consists of” are closed terms, and include only the components, structures, steps, or the like specifically listed
10 in conjunction with such terms, as well as that which is in accordance with U.S. Patent law. “Consisting essentially of” or “consists essentially of” have the meaning generally ascribed to them by U.S. Patent law. In particular, such terms are generally closed terms, with the exception of allowing inclusion of additional items, materials, components, steps, or elements, that do not
15 materially affect the basic and novel characteristics or function of the item(s) used in connection therewith. For example, trace elements present in a composition, but not affecting the composition’s nature or characteristics would be permissible if present under the “consisting essentially of” language, even though not expressly recited in a list of items following such terminology. When
20 using an open ended term, like “comprising” or “including,” in this specification it is understood that direct support should be afforded also to “consisting essentially of” language as well as “consisting of” language as if stated explicitly and vice versa.

[0015] The terms “first,” “second,” “third,” “fourth,” and the like in the description
25 and in the claims, if any, are used for distinguishing between similar elements and not necessarily for describing a particular sequential or chronological order. It is to be understood that the terms so used are interchangeable under appropriate circumstances such that the embodiments described herein are, for example, capable of operation in sequences other than those illustrated or
30 otherwise described herein. Similarly, if a method is described herein as comprising a series of steps, the order of such steps as presented herein is not necessarily the only order in which such steps may be performed, and certain of

the stated steps may possibly be omitted and/or certain other steps not described herein may possibly be added to the method.

[0016] The terms “left,” “right,” “front,” “back,” “top,” “bottom,” “over,” “under,” and the like in the description and in the claims, if any, are used for descriptive purposes and not necessarily for describing permanent relative positions. It is to be understood that the terms so used are interchangeable under appropriate circumstances such that the embodiments described herein are, for example, capable of operation in other orientations than those illustrated or otherwise described herein. The term “coupled,” as used herein, is defined as directly or indirectly connected in an electrical or nonelectrical manner. Objects described herein as being “adjacent to” each other may be in physical contact with each other, in close proximity to each other, or in the same general region or area as each other, as appropriate for the context in which the phrase is used. Occurrences of the phrase “in one embodiment,” or “in one aspect,” herein do not necessarily all refer to the same embodiment or aspect.

[0017] As used herein, the term “substantially” refers to the complete or nearly complete extent or degree of an action, characteristic, property, state, structure, item, or result. For example, an object that is “substantially” enclosed would mean that the object is either completely enclosed or nearly completely enclosed. The exact allowable degree of deviation from absolute completeness may in some cases depend on the specific context. However, generally speaking the nearness of completion will be so as to have the same overall result as if absolute and total completion were obtained. The use of “substantially” is equally applicable when used in a negative connotation to refer to the complete or near complete lack of an action, characteristic, property, state, structure, item, or result. For example, a composition that is “substantially free of” particles would either completely lack particles, or so nearly completely lack particles that the effect would be the same as if it completely lacked particles. In other words, a composition that is “substantially free of” an ingredient or element may still actually contain such item as long as there is no measurable effect thereof.

[0018] As used herein, the term “about” is used to provide flexibility to a numerical range endpoint by providing that a given value may be “a little above” or “a little below” the endpoint.

[0019] As used herein, a plurality of items, structural elements, compositional elements, and/or materials may be presented in a common list for convenience. However, these lists should be construed as though each member of the list is individually identified as a separate and unique member. Thus, no individual member of such list should be construed as a de facto equivalent of any other member of the same list solely based on their presentation in a common group without indications to the contrary.

[0020] Concentrations, amounts, and other numerical data may be expressed or presented herein in a range format. It is to be understood that such a range format is used merely for convenience and brevity and thus should be interpreted flexibly to include not only the numerical values explicitly recited as the limits of the range, but also to include all the individual numerical values or sub-ranges encompassed within that range as if each numerical value and sub-range is explicitly recited. As an illustration, a numerical range of “about 1 to about 5” should be interpreted to include not only the explicitly recited values of about 1 to about 5, but also include individual values and sub-ranges within the indicated range. Thus, included in this numerical range are individual values such as 2, 3, and 4 and sub-ranges such as from 1-3, from 2-4, and from 3-5, etc., as well as 1, 2, 3, 4, and 5, individually.

[0021] This same principle applies to ranges reciting only one numerical value as a minimum or a maximum. Furthermore, such an interpretation should apply regardless of the breadth of the range or the characteristics being described.

[0022] Reference throughout this specification to “an example” means that a particular feature, structure, or characteristic described in connection with the example is included in at least one embodiment. Thus, appearances of the phrases “in an example” in various places throughout this specification are not necessarily all referring to the same embodiment.

Example Embodiments

[0023] An initial overview of technology embodiments is provided below and specific technology embodiments are then described in further detail. This initial summary is intended to aid readers in understanding the technology more quickly, but is not intended to identify key or essential features of the technology nor is it intended to limit the scope of the claimed subject matter.

[0024] As interfacing heat transfer surfaces heat and cool with thermal cycles, such as power on/off cycles, the heat transfer surfaces expand and contract. This thermal deformation of the heat transfer surfaces can cause the TIM (e.g. thermal grease) to “pump out” from between the heat transfer surfaces and therefore reduce heat transfer efficiency as well as electrical performance. As a result, TIM materials have been developed to reduce pump out by altering flow characteristics. The trade-off with such materials is a reduction in heat transfer capability and/or increased cost.

[0025] Invention embodiments provide an electronic device package configured to contain, for example by physically trapping, TIM between heat transfer surfaces. In one aspect, the TIM is physically trapped without providing structural interference in the bond line or interface area between heat transfer surfaces. As a result, heat transfer capacity is not limited due to limitations on the proximity of the heat transfer surfaces, which in turn facilitates use in high power and high heat generation applications. The electronic device package can include: a substrate; a heat transfer component; a heat-generating electronic component coupled to the substrate between the substrate and the heat transfer component; a viscous TIM providing a heat transfer pathway between the electronic component and the heat transfer component; and a barrier about at least a portion of a periphery of the viscous TIM to maintain the viscous TIM within a confined location in proximity to the electronic component. Generally speaking, the TIM is uninterrupted by the barrier within the periphery.

[0026] Referring to FIG. 1, an exemplary electronic device heat transfer or cooling system 100 is illustrated schematically in cross-section. The principles disclosed herein can be applied to various heat transfer applications, such as

heat transfer from an individual processor or die (which can include multiple processors), an electronic device package (which can include multiple dies), or multiple components on a primary circuit board, for example. The heat transfer system 100 can include a substrate 110. The substrate 110 can be of any
5 suitable type or configuration, such as a substrate of an electronic device package, a motherboard, etc. The heat transfer system 100 can also include one or more heat-generating electronic components 120 (e.g., a processor), which can be coupled to the substrate 110. The heat transfer system 100 can further include a heat transfer component 130 to remove heat from the heat-
10 generating electronic component 120. As shown in the figure, the heat-generating electronic component 120 can be located between the substrate 110 and the heat transfer component 130. The heat transfer component 130 can be of any suitable type or configuration, such as a heat spreader, a heat sink, or any other type of heat transfer component of a thermal solution for an electronic
15 device. Ideally, the electronic component 120 and the heat transfer component 130 would be in thermal contact with interfacing surfaces that are perfectly flat, smooth surfaces. In reality, however, such interfacing surfaces have imperfections that reduce the effectiveness of a thermal interface by creating air gaps between the electronic component 120 and the heat transfer component
20 130, which serves to thermally insulate the components from one another. Thus, a viscous TIM 140 can be included to fill and eliminate air gaps at a bond line 141 or interface area between the electronic component 120 and the heat transfer component 130 and provide a heat transfer pathway between the components to improve heat transfer performance. The heat transfer pathway
25 can include the heat-generating electronic component 130. The heat-generating electronic component 130 can initiate movement of heat energy along the heat transfer pathway.

[0027] Thermal interface material is also known as thermal grease, CPU grease, heat paste, heat sink compound, heat sink paste, thermal compound, thermal
30 gel, or thermal paste. A TIM can be a thermally conductive adhesive, which is commonly used as an interface between heat sinks and heat sources (e.g., high-power semiconductor devices). As such, a TIM can provide mechanical

strength at the bond line 141 between the electronic component 120 and the heat transfer component 130. A TIM can have a polymerizable liquid matrix and large volume fractions of electrically insulating, but thermally conductive filler. Typical matrix materials are epoxies, silicones, urethanes, and acrylates.

- 5 Typical fillers are aluminum oxide, boron nitride, zinc oxide, and aluminum nitride. The filler loading can be as high as 70–80 wt % although this is not meant to be limiting. In some cases, a TIM can include metal, such as copper or silver.

[0028] Due to thermal expansion and contraction of the electronic component
10 120 and the heat transfer component 130 occurring with each thermal cycle, the viscous TIM 140 can “pump out” (i.e. be pressed or squeezed out) from between the components, which can reduce heat transfer efficiency. Pump out of the viscous TIM 140 can also cause the solids and liquids of the viscous TIM to separate, which can also contribute to reduced heat transfer efficiency.

15 **[0029]** FIG. 2 illustrates a top view of the heat transfer system 100 with either the substrate 110 or the heat transfer component 130 omitted to show certain additional aspects of the heat transfer system 100 discussed below. With reference to FIGS. 1 and 2, the heat transfer system 100 can further include a barrier 150 to prevent or minimize pump out of the viscous TIM 140 from
20 between the electronic component 120 and the heat transfer component 130. The barrier 150 can be disposed about at least a portion of a periphery 142 of the viscous TIM 140 to maintain the viscous TIM within a confined location in proximity to the electronic component 120. The viscous TIM 140 can be uninterrupted by the barrier 150 within the periphery 142, as shown in FIG. 2.
25 Because the barrier 150 does not interrupt the viscous TIM within the periphery 142, the barrier 150 provides no obstructions at the bond line 141 or interface area between the electronic component 120 and the heat transfer component 130. With no structural impediments or interference provided by the barrier 150 at the bond line 141 or interface area between the electronic component 120
30 and the heat transfer component 130, interfacing surfaces of these components can be freely located in close proximity to one another. This promotes heat transfer from one component to another, which can facilitate the use of the

barrier 150 with high power and high heat generating components.

[0030] The barrier 150 can contact both the substrate 110 and the heat transfer component 130 and extend between the substrate and the heat transfer component. In one aspect, the barrier 150 can be continuous about the
5 periphery 142 of the viscous TIM 140. Thus, the barrier 150 can dam or physically trap the viscous TIM 140 to prevent or minimize the flow or migration (e.g., pump out) of the viscous TIM 140 away from a predetermined location in a heat transfer pathway of the heat generating electronic component 120, such as from between the electronic component 120 and the heat transfer component
10 130. A predetermined location for a heat transfer pathway can be bounded by or between layers of components, such as between the substrate 110 and the heat transfer component 130. By maintaining the viscous TIM 140 in place between the heat generating electronic component 120 and the heat transfer component 130, heat transfer efficiency of a heat transfer pathway between
15 these components can be maintained, which can maintain performance of the electronic component 120.

[0031] In general, a barrier as disclosed herein can be utilized to maintain a viscous TIM between layers of components, such as between a heat generating component and a heat transfer component or between two heat transfer
20 components (e.g., a heat spreader and a heat sink). Furthermore, a metal-based TIM, which can be electrically conductive and capacitive, can cause malfunction and damage to circuits when pumped out from between components. The barrier 150 can prevent the flow of metal-based TIM onto a circuit and therefore avoid such problems.

[0032] In one aspect, the barrier 150 can be a gasket distinct from the viscous TIM 140. For example, a flexible, compressible material and gasket structure
25 can be used as the barrier 150 such that the gasket can compress to form a seal. Such a gasket can be of any suitable construction or configuration. In one aspect, the gasket can be configured as an electromagnetic interference (EMI)
30 shielding gasket. Nearly any material suitable for use as a gasket (i.e. for containing the TIM) can be utilized, such as rubbers and polymers. Examples

of suitable gasket materials can include without limitation, compressible elastomers, including fluoroelastomers, neoprene, nitrile, other polymeric materials, nitrile, ethylene propylene diene monomer (EPDM), silicone, fluorinated silicone, and butyl rubbers. A suitable gasket material may be

5 selected based on the viscous TIM. For example, a gasket material may be selected that is compatible with the viscous TIM, e.g., a material that does not react with the viscous TIM or a material that is impermeable to a liquid component of the viscous TIM. The barrier 150 can have any suitable thickness 151, which may depend on the thickness of the electronic component 120 or

10 any other component (e.g., a heat spreader) that is disposed between layers of components. For example, the thickness 151 can be from about 50 μm to about 500 μm when the electronic component 120 is a die or similarly sized component. The thickness between layers of components can be several millimeters when a heat spreader or similarly sized component is disposed

15 between layers of components. The gasket can have any suitable cross-sectional shape (as viewed in FIG. 1), as well as any suitable overall shape or configuration (as viewed in FIG. 2). For example, the gasket can have a round, oval, square, rectangular, hexagonal, curved, indented, or other cross-sectional shape. For example, the gasket can have an overall shape, including a

20 perimeter shape (e.g., rectangular) that resembles or conforms to a shape of the electronic component 120 (e.g., rectangular perimeter). Such configurations can efficiently utilize space about the electronic component 120, although the shape of the gasket and the shape of the electronic component 120 need not be similar. In one aspect, a gasket disposed about the viscous TIM 140 can form

25 the barrier 150 with a lateral gap or space 143, 144 between the heat generating electronic component 120 and the barrier 150 to form a volume 145 about the electronic component 120. The volume 145 can contain excess viscous TIM 140 that may be pressed or squeezed from between the electrical component 120 and the heat transfer component 130 at assembly. Such gaps

30 143, 144 can be of any suitable size and can be similar or different in dimension. In one aspect, the gasket can have an open configuration or shape, such that there is an opening in a portion of the periphery of the gasket, which

can be configured to provide for pressure relief, if desired, such as to accommodate expansion of the viscous TIM when heated. It should be recognized that the viscous TIM need not fill the entire volume 145.

[0033] In one aspect, an electronic device cooling system can be represented in FIG. 2, having either the substrate 110 or the heat transfer component 130, and the barrier 150 can be configured to engage the substrate 110 and/or the heat transfer component 130 at a location associated with a heat transfer pathway, such as about the electronic component 120. The barrier 150 can be provided with or without an adhesive. For example, the barrier 150 with an adhesive can be pre-attached to the substrate 110 or the heat transfer component 130 and provided for assembly with other components, such as the electronic component 120 and the other of the substrate and the heat transfer component. In another example, the barrier 150 with an adhesive can be pre-attached to the substrate 110 about the electronic component 120 and provided for assembly with other components, such as the heat transfer component. Pre-attaching the barrier 150 to a component can reduce assembly costs.

[0034] In one aspect, the barrier 150 can comprise a hardened portion of the viscous TIM 140. For example, a viscous TIM for facilitating heat transfer between two components can include a viscous thermal grease and a hardenable polymer or other curable material. The polymer or curable material can form a hardened structure when cured or exposed to a hardening agent. Thus, a hardened or cured portion of the TIM can form the barrier 150 about at least a portion of the periphery 142 of the viscous TIM 140. The hardenable polymer or curable material can be hardened or cured by any suitable mechanism, such as exposure to UV light and/or oxygen, although these examples are not meant to be limiting. Thus, a viscous TIM having a hardenable or curable material can be dispensed and applied before assembly of the heat generating electronic component 120 and the heat transfer component 130. Once the heat generating electronic component 120 and the heat transfer component 130 have been assembled, an outer or exposed portion of the TIM can be cured or hardened to form the barrier 150, which in this case is a non-flowing hardened portion of the TIM forming a dam about the

periphery 142 of the viscous TIM 140. Within the barrier 150 formed by the hardened outer portion of the TIM, the viscous TIM 140 can remain uncured or unhardened and therefore fully functional as a TIM between the electronic component 120 and the heat transfer component 130.

- 5 **[0035]** Utilizing the barrier 150 as disclosed herein can facilitate use of any suitable viscous TIM that can provide an acceptable level of thermal performance. With no structural obstructions provided by the barrier 150 between the electronic component 120 and the heat transfer component 130, the presence of the barrier 150 does not negatively impact heat transfer
10 between the components. The barrier 150 can therefore be effectively utilized in any suitable application, including high power, high heat applications.

- [0036]** FIG. 3 illustrates an electronic device heat transfer or cooling system 200 in accordance with another example of the present disclosure. The system 200 is similar in many respects to the system 100 discussed above. For example,
15 the system 200 includes a substrate 210, a heat generating electronic component 220, a heat transfer component 230, a viscous TIM 240, and a barrier 250. In this case, the substrate 210 (i.e. a first substrate) can be coupled to another substrate 260 (i.e. a second substrate), such as a primary circuit board or motherboard. The first substrate 210 can be coupled to the second
20 substrate 260 in any suitable manner, such as with solder balls 261. The heat transfer component 230 can be configured for use with only the electronic component 220 or configured for more generalized use, such as providing a heat sink for multiple components (not shown) mounted on the second substrate 260. The heat transfer component 230 may or may not be coupled to
25 the first substrate 210 and/or the second substrate 260.

- [0037]** FIG. 4 illustrates an electronic device heat transfer or cooling system 300 in accordance with another example of the present disclosure. The system 300 is similar to the system 200. The system 300 includes a substrate 310, a heat generating electronic component 320, a heat transfer component 330, a viscous
30 TIM 340, and a barrier 350. The substrate 310 (i.e. a first substrate) is also coupled to another substrate 360 (i.e. a second substrate), such as a primary

circuit board or motherboard, via solder balls 361. In this case, the heat transfer component 330 is coupled to the second substrate 360 via mounts 362, 363.

[0038] FIG. 5 illustrates an electronic device heat transfer or cooling system 400 in accordance with another example of the present disclosure. As with other examples, the system 400 includes a substrate 410, a heat generating electronic component 420, a heat transfer component 430, a viscous TIM 440, and a barrier 450. In this case, the system 400 is configured as an electronic device package. Thus, the heat transfer component 430 can be configured as an integrated heat spreader or sink that is coupled to the substrate 410.

[0039] FIG. 6 illustrates an electronic device heat transfer or cooling system 500 in accordance with another example of the present disclosure. The system 500 includes a substrate 510 (i.e. a first substrate), a heat generating electronic component 520a, a heat transfer component 530a, a viscous TIM 540a, and a barrier 550a. Collectively, these components can be configured as an electronic device package that is mounted on a substrate 560 (i.e. a second substrate), such as a primary circuit board or motherboard, via solder balls 561. In this example, the system 500 can include another heat transfer component 530b (e.g., a heat spreader or a heat sink) to remove heat from the heat transfer component 530a (e.g., a heat spreader). As with the viscous TIM 540a in a bond line 541a between the electronic component 520a and the heat transfer component 530a, a viscous TIM 540b can be utilized to fill and eliminate gaps at a bond line 541b or interface area between the heat transfer component 530a and the heat transfer component 530b to provide a heat transfer pathway between the components to improve heat transfer performance. The principles disclosed herein can be utilized to maintain the viscous TIM 540b between the heat transfer component 530a and the heat transfer component 530b. Accordingly, the system 500 can include a barrier 550b, as described hereinabove, disposed about the viscous TIM 540b to maintain the viscous TIM within a confined location in proximity to the heat transfer component 530a. The heat transfer component 530b can be coupled to the second substrate 560 via mounts 562, 563, or to the first substrate 510 (as indicated at 512, 513).

[0040] One or more other components 570, such as a processor, a memory device, a heat sink, a radio, a slot, and/or a port, can be coupled to the second substrate 560. Such components 570 as desired can be operably coupled to the heat transfer component 530b, as described herein, to cool the components.

5 **[0041]** FIG. 7 illustrates a computing system 601 in accordance with an example of the present disclosure. In general, the computing system 601 can include a heat transfer or cooling system 600 as disclosed herein. In one example, the computing system 601 can include the heat transfer system 600 configured as an electronic device package (see, e.g., FIG. 5), and a motherboard 660. In
10 one aspect, the computing system 601 can also include a processor 681, a memory device 682, a radio 683, a heat sink 684, a port 685, a slot, or any other suitable device, which can be operably coupled to the motherboard 660. The computing system 601 can comprise any type of computing system, such as a desktop computer, a laptop computer, a tablet computer, a smartphone, a
15 server, etc.

Examples

[0042] The following examples pertain to further embodiments.

[0043] In one example there is provided, an electronic device heat transfer system comprising: a substrate; a heat transfer component; a heat-generating
20 electronic component coupled to the substrate between the substrate and the heat transfer component; a viscous TIM providing a heat transfer pathway between the electronic component and the heat transfer component; and a barrier about at least a portion of a periphery of the viscous TIM to maintain the viscous TIM within a confined location in proximity to the electronic component,
25 with the TIM being uninterrupted by the barrier within the periphery.

[0044] In one example of an electronic device heat transfer system, the barrier is continuous about the periphery of the viscous TIM.

[0045] In one example of an electronic device heat transfer system, the barrier is a gasket.

30 **[0046]** In one example of an electronic device heat transfer system, the gasket

and the viscous TIM are distinct from one another.

[0047] In one example of an electronic device heat transfer system, the gasket is an EMI gasket.

[0048] In one example of an electronic device heat transfer system, the barrier
5 comprises a hardened portion of the viscous TIM.

[0049] In one example of an electronic device heat transfer system, the viscous TIM includes a curable material and the hardened portion is created by curing the curable material.

[0050] In one example of an electronic device heat transfer system, the curable
10 material is an ultraviolet (UV) light curable material.

[0051] In one example of an electronic device heat transfer system, the barrier contacts both the substrate and the heat transfer component and extends therebetween.

[0052] In one example of an electronic device heat transfer system, the barrier is
15 coupled to the substrate, the heat transfer component, or both the substrate and the heat transfer component.

[0053] In one example of an electronic device heat transfer system, the heat transfer component is coupled to the substrate.

[0054] In one example of an electronic device heat transfer system, the
20 substrate is coupled to a motherboard.

[0055] In one example of an electronic device heat transfer system, the heat transfer component is coupled to the motherboard.

[0056] In one example of an electronic device heat transfer system, the heat transfer component comprises a heat spreader.

[0057] In one example of an electronic device heat transfer system, the heat
25 transfer component comprises a heat sink.

[0058] In one example of an electronic device heat transfer system, the electronic component comprises a processor.

[0059] In one example of an electronic device heat transfer system, the electronic

device heat transfer system can further comprise a second heat transfer component, a second viscous TIM to facilitate heat transfer between the first heat transfer component and the second heat transfer component, and a second barrier about at least a portion of a second periphery of the second TIM to maintain the second viscous TIM within the second periphery. The second viscous TIM is uninterrupted by the second barrier within the second periphery.

[0060] In one example of an electronic device heat transfer system, the second barrier is continuous about the second periphery of the second viscous TIM.

[0061] In one example of an electronic device heat transfer system, the second barrier comprises a gasket.

[0062] In one example of an electronic device heat transfer system, the gasket and the second viscous TIM are distinct from one another.

[0063] In one embodiment, the gasket is an EMI gasket.

[0064] In one example of an electronic device heat transfer system, the second barrier comprises a hardened portion of the second viscous TIM.

[0065] In one example of an electronic device heat transfer system, the second viscous TIM includes a curable material and the hardened portion is created by curing the curable material.

[0066] In one example of an electronic device heat transfer system, the curable material is an ultraviolet (UV) light curable material.

[0067] In one example of an electronic device heat transfer system, the second barrier extends between the substrate and the second heat transfer component.

[0068] In one example of an electronic device heat transfer system, the second heat transfer component is coupled to the substrate.

[0069] In one example of an electronic device heat transfer system, the second heat transfer component is coupled to a motherboard.

[0070] In one example of an electronic device heat transfer system, the second heat transfer component comprises a heat spreader.

[0071] In one example of an electronic device heat transfer system, the second heat transfer component comprises a heat sink.

[0072] In one example there is provided, an electronic device cooling system comprising: a substrate or a heat transfer component, and a barrier configured to engage either the substrate or the heat transfer component, or both at a location associated with a heat transfer pathway, the barrier being formable
5 about at least a portion of a periphery of a viscous TIM in the pathway to maintain the viscous TIM within said periphery and the viscous TIM being uninterrupted by the barrier within the periphery.

[0073] In one example of an electronic device cooling system, the barrier is continuous about the periphery of the viscous TIM.

10 **[0074]** In one example of an electronic device cooling system, the barrier comprises a gasket.

[0075] In one example of an electronic device cooling system, the gasket and the viscous TIM are distinct from one another.

15 **[0076]** In one example of an electronic device cooling system, the gasket is an EMI gasket.

[0077] In one example of an electronic device cooling system, the electronic device cooling system comprises both the substrate and the heat transfer component, and the barrier is extendable therebetween.

20 **[0078]** In one example of an electronic device cooling system, the heat transfer component comprises a heat spreader.

[0079] In one example of an electronic device cooling system, the heat transfer component comprises a heat sink.

[0080] In one example of an electronic device cooling system, the heat transfer pathway includes a heat-generating electronic component.

25 **[0081]** In one example of an electronic device cooling system, the heat-generating electronic component comprises a processor.

[0082] In one example there is provided, a computing system comprising a motherboard and an electronic device package as disclosed herein, mounted on the motherboard.

[0083] In one example of a computing system, the computing system further comprises a processor, a memory device, a heat sink, a radio, a slot, a port, or a combination thereof operably coupled to the motherboard.

5 **[0084]** In one example of a computing system, the computing system comprises a desktop computer, a laptop computer, a tablet computer, a smartphone, a server, or a combination thereof.

10 **[0085]** In one example there is provided, a viscous TIM for facilitating heat transfer between two components comprising: a viscous thermal grease and a hardenable polymer, with the polymer forming a hardened structure when exposed to a hardening agent.

[0086] In one example of a viscous TIM for facilitating heat transfer, the hardened structure forms a barrier about at least a portion of a periphery of the TIM.

[0087] In one example of a viscous TIM for facilitating heat transfer, the barrier is continuous about the periphery of the TIM.

15 **[0088]** In one example of a viscous TIM for facilitating heat transfer, the polymer is hardenable by exposure to UV light.

[0089] In one example of a viscous TIM for facilitating heat transfer, the polymer is hardenable by exposure to oxygen.

20 **[0090]** In one example there is provided, a method for minimizing migration of a viscous TIM away from a predetermined location in a heat transfer pathway of an electronic device comprising: disposing the viscous TIM in the predetermined location; and forming a barrier about at least a portion of a periphery of the viscous TIM, with the viscous TIM being uninterrupted by the barrier within the periphery.

25 **[0091]** In one example of a method for minimizing migration of a viscous TIM, the predetermined location includes a heat-generating electronic component.

[0092] In one example of a method for minimizing migration of a viscous TIM, the predetermined location is bounded by a first layer component and a second layer component.

30 **[0093]** In one example of a method for minimizing migration of a viscous TIM,

the first layer component is a substrate and the second layer component is a heat transfer component.

[0094] In one example of a method for minimizing migration of a viscous TIM, the substrate is a motherboard.

- 5 **[0095]** In one example of a method for minimizing migration of a viscous TIM, the first and second layer components are heat transfer components.

[0096] In one example of a method for minimizing migration of a viscous TIM, the barrier contacts both the first and second layer components and extends therebetween.

- 10 **[0097]** In one example of a method for minimizing migration of a viscous TIM, forming the barrier comprises disposing a gasket about the viscous TIM.

[0098] In one example of a method for minimizing migration of a viscous TIM, the gasket is an EMI gasket.

- 15 **[0099]** In one example of a method for minimizing migration of a viscous TIM, forming the barrier comprises hardening a peripheral portion of the viscous TIM.

[00100] In one example of a method for minimizing migration of a viscous TIM, hardening a peripheral portion of the viscous TIM comprises exposing the peripheral portion of the TIM to a hardening agent.

- 20 **[00101]** In one example of a method for minimizing migration of a viscous TIM, hardening agent is UV light.

[00102] In one example of a method for minimizing migration of a viscous TIM, hardening agent is oxygen.

- 25 **[00103]** In one example there is provided, a method for maintaining heat transfer efficiency of a heat transfer pathway in an electronic device comprising: disposing a viscous TIM in a heat transfer pathway between a first layer component and a second layer component of the electronic device; and minimizing migration of the viscous TIM out of the heat transfer pathway by locating a barrier about at least a portion of a periphery of the viscous TIM, with the viscous TIM being uninterrupted by the barrier within the periphery.

- 30 **[00104]** In one example of a method for maintaining heat transfer efficiency of

a heat transfer pathway, the barrier is continuous about the periphery of the viscous TIM.

[00105] In one example of a method for maintaining heat transfer efficiency of a heat transfer pathway, the barrier comprises a gasket.

- 5 **[00106]** In one example of a method for maintaining heat transfer efficiency of a heat transfer pathway, the gasket is an EMI gasket.

[00107] In one example of a method for maintaining heat transfer efficiency of a heat transfer pathway, the barrier comprises a hardened peripheral portion of the TIM.

- 10 **[00108]** In one example of a method for maintaining heat transfer efficiency of a heat transfer pathway, the hardened peripheral portion of the TIM is hardened by a hardening agent.

[00109] In one example of a method for maintaining heat transfer efficiency of a heat transfer pathway, the hardening agent is UV light.

- 15 **[00110]** In one example of a method for maintaining heat transfer efficiency of a heat transfer pathway, the hardening agent is oxygen.

[00111] In one example of a method for maintaining heat transfer efficiency of a heat transfer pathway, a heat-generating electronic component initiates movement of heat energy along the heat transfer pathway.

- 20 **[00112]** In one example of a method for maintaining heat transfer efficiency of a heat transfer pathway, the electronic component comprises a processor.

[00113] In one example of a method for maintaining heat transfer efficiency of a heat transfer pathway, the first layer component is a substrate and the second layer component is a heat transfer component.

- 25 **[00114]** In one example of a method for maintaining heat transfer efficiency of a heat transfer pathway, the substrate is a motherboard.

[00115] In one example of a method for maintaining heat transfer efficiency of a heat transfer pathway, the first and second layer components are heat transfer components.

[00116] In one example there is provided, a method of making an electronic device package can comprising: coupling a heat-generating electronic component to a substrate; associating a heat spreader with the electronic component; disposing a viscous TIM between the electronic component and the heat spreader to facilitate heat transfer between the electronic component and the heat spreader; and forming a barrier about at least a portion of a periphery of the viscous TIM to maintain the viscous TIM within the periphery, with the viscous TIM being uninterrupted by the barrier within the periphery.

[00117] In one example of a method of making an electronic device package, the barrier comprises a gasket.

[00118] In one example of a method of making an electronic device package, forming the barrier comprises disposing the gasket about the viscous TIM.

[00119] In one example of a method of making an electronic device package, the barrier comprises a hardened portion of the viscous TIM.

[00120] In one example of a method of making an electronic device package, forming the barrier comprises hardening a peripheral portion of the viscous TIM.

[00121] In one example of a method of making an electronic device package, hardening a peripheral portion of the viscous TIM comprises exposing the peripheral portion to UV light.

[00122] In one example of a method of making an electronic device package, hardening a peripheral portion of the viscous TIM comprises exposing the peripheral portion to oxygen.

[00123] In one example of a method of making an electronic device package, the heat-generating electronic component comprises a processor.

[00124] Circuitry used in electronic components or devices (e.g. a die) of an electronic device package can include hardware, firmware, program code, executable code, computer instructions, and/or software. Electronic components and devices can include a non-transitory computer readable storage medium which can be a computer readable storage medium that does not include signal. In the case of program code execution on programmable

computers, the computing devices recited herein may include a processor, a storage medium readable by the processor (including volatile and non-volatile memory and/or storage elements), at least one input device, and at least one output device. Volatile and non-volatile memory and/or storage elements may
5 be a RAM, EPROM, flash drive, optical drive, magnetic hard drive, solid state drive, or other medium for storing electronic data. Node and wireless devices may also include a transceiver module, a counter module, a processing module, and/or a clock module or timer module. One or more programs that may implement or utilize any techniques described herein may use an application
10 programming interface (API), reusable controls, and the like. Such programs may be implemented in a high level procedural or object oriented programming language to communicate with a computer system. However, the program(s) may be implemented in assembly or machine language, if desired. In any case, the language may be a compiled or interpreted language, and combined with
15 hardware implementations.

[00125] Furthermore, the described features, structures, or characteristics may be combined in any suitable manner in one or more embodiments. In this description, numerous specific details are provided, such as examples of layouts, distances, network examples, etc. One skilled in the relevant art will
20 recognize, however, that many variations are possible without one or more of the specific details, or with other methods, components, layouts, measurements, etc. In other instances, well-known structures, materials, or operations are not shown or described in detail but are considered well within the scope of the disclosure.

[00126] While the forgoing examples are illustrative of the specific embodiments in one or more particular applications, it will be apparent to those of ordinary skill in the art that numerous modifications in form, usage and details of implementation can be made without departing from the principles and concepts articulated herein. Accordingly, no limitation is intended thereby.

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Claims

What is claimed is:

1. An electronic device heat transfer system, comprising:
5 a substrate;
a heat transfer component;
a heat-generating electronic component coupled to the substrate
between the substrate and the heat transfer component;
a viscous thermal interface material (TIM) providing a heat transfer
10 pathway between the electronic component and the heat transfer
component; and
a barrier about at least a portion of a periphery of the viscous TIM to
maintain the viscous TIM within a confined location in proximity to
the heat-generating electronic component, wherein the TIM is
15 uninterrupted by the barrier within the periphery.
2. The electronic device heat transfer system of claim 1, wherein the barrier
is continuous about the periphery of the viscous TIM.
- 20 3. The electronic device heat transfer system of claim 1, wherein the barrier
is a gasket.
4. The electronic device heat transfer system of claim 3, wherein the gasket
and the viscous TIM are distinct from one another.
- 25 5. The electronic device heat transfer system of claim 4, wherein the gasket
is an electromagnetic interference (EMI) gasket.
6. The electronic device heat transfer system of claim 1, wherein the barrier
30 comprises a hardened portion of the viscous TIM.

7. The electronic device heat transfer system of claim 6, wherein the viscous TIM includes a curable material and the hardened portion is created by curing the curable material.
- 5 8. The electronic device heat transfer system of claim 7, wherein the curable material is an ultraviolet (UV) light curable material.
9. The electronic device heat transfer system of claim 1, wherein the barrier contacts both the substrate and the heat transfer component and extends
10 therebetween.
10. The electronic device heat transfer system of claim 1, wherein the barrier is coupled to the substrate, the heat transfer component, or both the substrate and the heat transfer component.
- 15 11. The electronic device heat transfer system of claim 1, wherein the heat transfer component is coupled to the substrate.
12. The electronic device heat transfer system of claim 1, wherein the
20 substrate is coupled to a motherboard.
13. The electronic device heat transfer system of claim 12, wherein the heat transfer component is coupled to the motherboard.
- 25 14. The electronic device heat transfer system of claim 1, wherein the heat transfer component comprises a heat spreader.
15. The electronic device heat transfer system of claim 1, wherein the heat transfer component comprises a heat sink.
- 30 16. The electronic device heat transfer system of claim 1, wherein the electronic component comprises a processor.

17. The electronic device heat transfer system of claim 1, further comprising:
a second heat transfer component;
a second viscous TIM to facilitate heat transfer between the first heat
5 transfer component and the second heat transfer component; and
a second barrier about at least a portion of a second periphery of the
second TIM to maintain the second viscous TIM within the second
periphery, wherein the second viscous TIM is uninterrupted by the
second barrier within the second periphery.
- 10 18. The electronic device heat transfer system of claim 17, wherein the
second barrier is continuous about the second periphery of the second viscous
TIM.
- 15 19. The electronic device heat transfer system of claim 17, wherein the
second barrier comprises a gasket.
- 20 20. The electronic device heat transfer system of claim 19, wherein the
gasket and the second viscous TIM are distinct from one another.
21. The electronic device heat transfer system of claim 20, wherein the
gasket is an electromagnetic interference (EMI) gasket.
22. The electronic device heat transfer system of claim 17, wherein the
25 second barrier comprises a hardened portion of the second viscous TIM.
23. The electronic device heat transfer system of claim 22, wherein the
second viscous TIM includes a curable material and the hardened portion is
created by curing the curable material.
- 30 24. The electronic device heat transfer system of claim 23, wherein the
curable material is an ultraviolet (UV) light curable material.

25. The electronic device heat transfer system of claim 17, wherein the second barrier extends between the substrate and the second heat transfer component.

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26. The electronic device heat transfer system of claim 17, wherein the second heat transfer component is coupled to the substrate.

27. The electronic device heat transfer system of claim 17, wherein the
10 second heat transfer component is coupled to a motherboard.

28. The electronic device heat transfer system of claim 17, wherein the second heat transfer component comprises a heat spreader.

15 29. The electronic device heat transfer system of claim 17, wherein the second heat transfer component comprises a heat sink.

30. An electronic device cooling system, comprising:
a substrate or a heat transfer component; and
20 a barrier configured to engage either the substrate or the heat transfer component, or both at a location associated with a heat transfer pathway, the barrier being formable about at least a portion of a periphery of a viscous thermal interface material (TIM) in the pathway to maintain the viscous TIM within said periphery,
25 wherein the viscous TIM is uninterrupted by the barrier within the periphery.

31. The electronic device cooling system of claim 30, wherein the barrier is continuous about the periphery of the viscous TIM.

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32. The electronic device cooling system of claim 29, wherein the barrier comprises a gasket.

33. The electronic device cooling system of claim 32, wherein the gasket and the viscous TIM are distinct from one another.

5 34. The electronic device cooling system of claim 33, wherein the gasket is an electromagnetic interference (EMI) gasket.

35. The electronic device cooling system of claim 30, wherein the system comprises both the substrate and the heat transfer component, and the barrier
10 is extendable therebetween.

36. The electronic device cooling system of claim 30, wherein the heat transfer component comprises a heat spreader.

15 37. The electronic device cooling system of claim 30, wherein the heat transfer component comprises a heat sink.

38. The electronic device cooling system of claim 30, wherein the heat transfer pathway includes a heat-generating electronic component.
20

39. The electronic device cooling system of claim 38, wherein the heat-generating electronic component comprises a processor.

40. A computing system, comprising:
25 a motherboard; and
an electronic device heat transfer system as recited in any one of claims 1-29, mounted on the motherboard.

41. The computing system of claim 40, further comprising a processor, a
30 memory device, a heat sink, a radio, a slot, a port, or a combination thereof operably coupled to the motherboard.

42. The computing system of claim 41, wherein the computing system comprises a desktop computer, a laptop computer, a tablet computer, a smartphone, a server, or a combination thereof.

- 5 43. A viscous thermal interface material (TIM) for facilitating heat transfer between two components, comprising:
- a viscous thermal grease; and
 - a hardenable polymer, said polymer forming a hardened structure when exposed to a hardening agent.

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44. The TIM of claim 43, wherein the hardened structure forms a barrier about at least a portion of a periphery of the TIM.

- 15 45. The TIM of claim 44, wherein the barrier is continuous about the periphery of the TIM.

46. The TIM of claim 43, wherein the polymer is hardenable by exposure to UV light.

- 20 47. The TIM of claim 43, wherein the polymer is hardenable by exposure to oxygen.

- 25 48. A method for minimizing migration of a viscous thermal interface material (TIM) away from a predetermined location in a heat transfer pathway of an electronic device, comprising:
- disposing the viscous TIM in the predetermined location; and
 - forming a barrier about at least a portion of a periphery of the viscous TIM, wherein the viscous TIM is uninterrupted by the barrier within the periphery.

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49. The method of claim 48, wherein the predetermined location includes a heat-generating electronic component.

50. The method of claim 48, wherein the predetermined location is bounded by a first layer component and a second layer component.
- 5 51. The method of claim 50, wherein the first layer component is a substrate and the second layer component is a heat transfer component.
52. The method of claim 51, wherein the substrate is a motherboard.
- 10 53. The method of claim 50, wherein the first and second layer components are heat transfer components.
54. The method of claim 50, wherein the barrier contacts both the first and second layer components and extends therebetween.
- 15 55. The method of claim 48, wherein forming the barrier comprises disposing a gasket about the viscous TIM.
56. The method of claim 55, wherein the gasket is an electromagnetic
20 interface (EMI) gasket.
57. The method of claim 48, wherein forming the barrier comprises hardening a peripheral portion of the viscous TIM.
- 25 58. The method of claim 57, wherein hardening a peripheral portion of the viscous TIM comprises exposing the peripheral portion of the TIM to a hardening agent.
59. The method of claim 58, wherein hardening agent is UV light.
- 30 60. The method of claim 58, wherein hardening agent is oxygen.

61. A method for maintaining heat transfer efficiency of a heat transfer pathway in an electronic device, comprising:
- 5 disposing a viscous thermal interface material (TIM) in a heat transfer pathway between a first layer component and a second layer component of the electronic device; and
- minimizing migration of the viscous TIM out of the heat transfer pathway by locating a barrier about at least a portion of a periphery of the viscous TIM, wherein the viscous TIM is uninterrupted by the barrier within the periphery.
- 10 62. The method of claim 61, wherein the barrier is continuous about the periphery of the viscous TIM.
63. The method of claim 61, wherein the barrier comprises a gasket.
- 15 64. The method of claim 63, wherein the gasket is an electromagnetic interference (EMI) gasket.
65. The method of claim 61, wherein the barrier comprises a hardened peripheral portion of the TIM.
- 20 66. The method of claim 65, wherein the hardened peripheral portion of the TIM is hardened by a hardening agent.
- 25 67. The method of claim 66, wherein the hardening agent is UV light.
68. The method of claim 66, wherein the hardening agent is oxygen.
69. The method of claim 61, wherein a heat-generating electronic component
- 30 initiates movement of heat energy along the heat transfer pathway.

70. The method of claim 69, wherein the electronic component comprises a processor.

71. The method of claim 61, wherein the first layer component is a substrate
5 and the second layer component is a heat transfer component.

72. The method of claim 71, wherein the substrate is a motherboard.

73. The method of claim 61, wherein the first and second layer components
10 are heat transfer components.

74. A method of making an electronic device package, comprising:
coupling a heat-generating electronic component to a substrate;
associating a heat spreader with the electronic component;
15 disposing a viscous thermal interface material (TIM) between the
electronic component and the heat spreader to facilitate heat
transfer between the electronic component and the heat spreader;
and
forming a barrier about at least a portion of a periphery of the viscous
20 TIM to maintain the viscous TIM within the periphery, wherein the
viscous TIM is uninterrupted by the barrier within the periphery.

75. The method of claim 74, wherein the barrier comprises a gasket.

25 76. The method of claim 75, wherein forming the barrier comprises disposing
the gasket about the viscous TIM.

77. The method of claim 74, wherein the barrier comprises a hardened
portion of the viscous TIM.

30 78. The method of claim 77, wherein forming the barrier comprises
hardening a peripheral portion of the viscous TIM.

79. The method of claim 78, wherein hardening a peripheral portion of the viscous TIM comprises exposing the peripheral portion to UV light.

5 80. The method of claim 78, wherein hardening a peripheral portion of the viscous TIM comprises exposing the peripheral portion to oxygen.

81. The method of claim 74, wherein the heat-generating electronic component comprises a processor.

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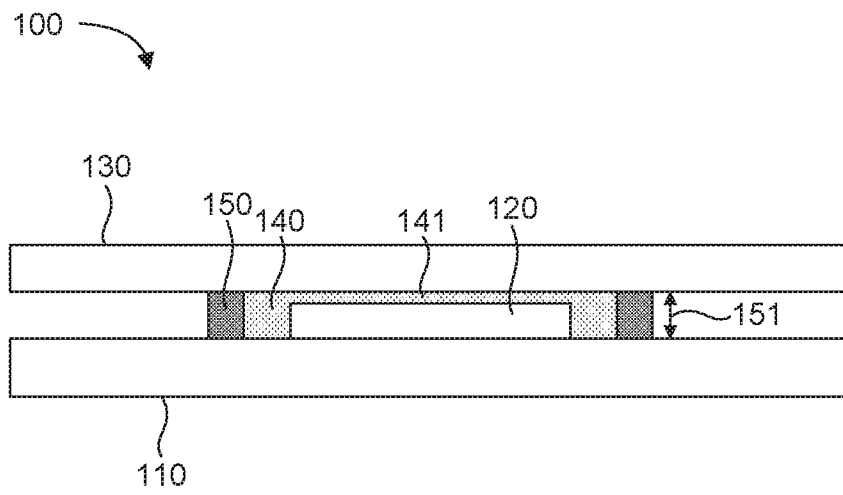


FIG. 1

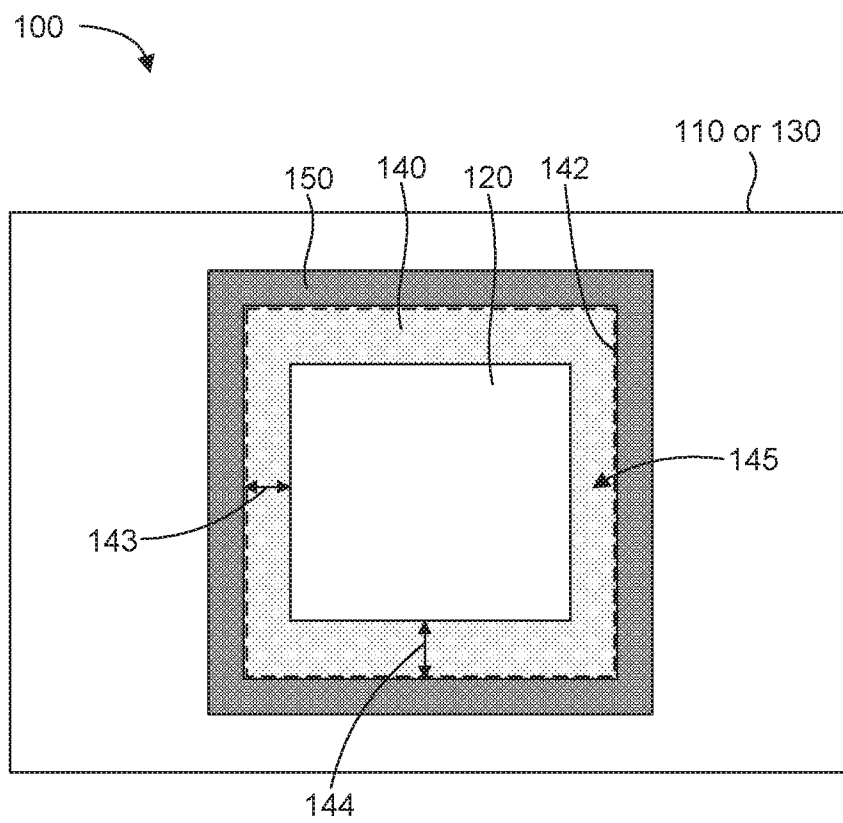


FIG. 2

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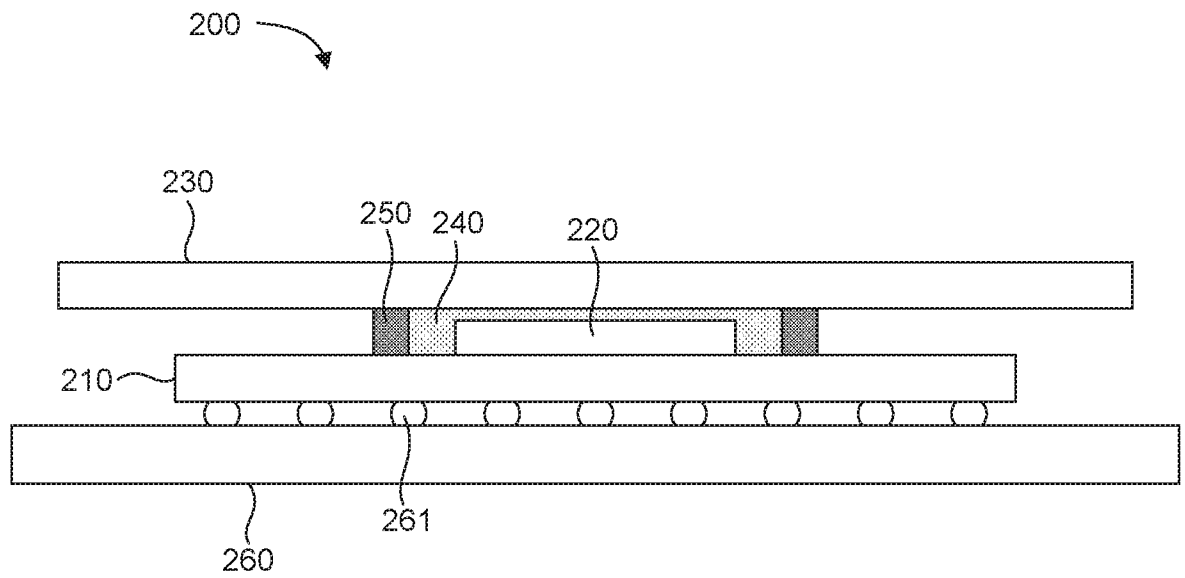


FIG. 3

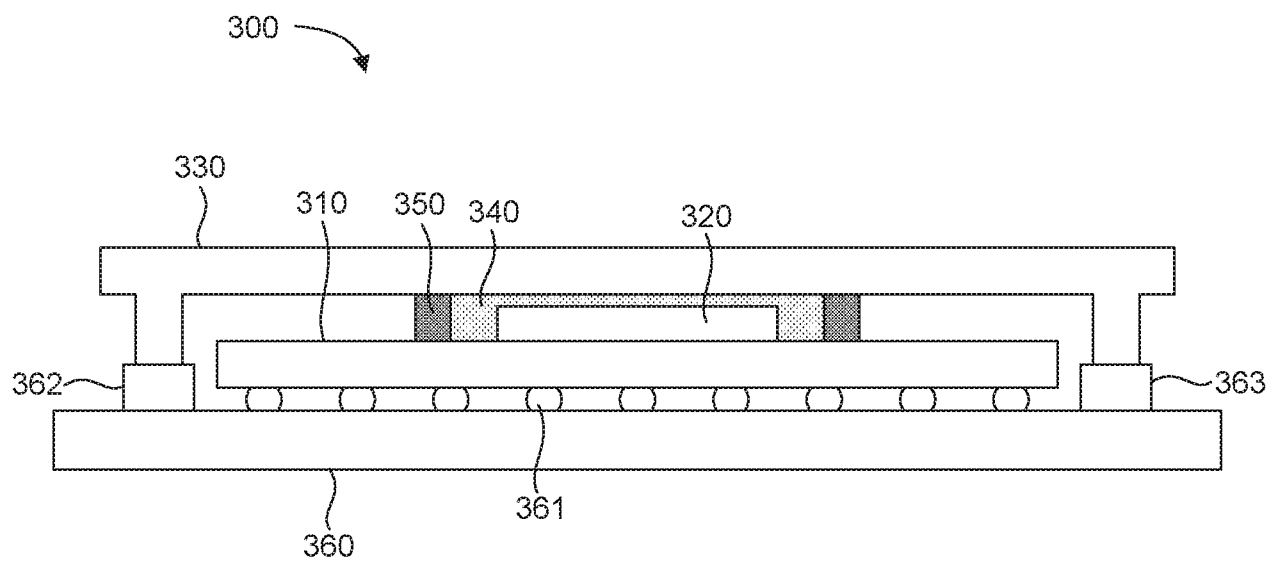


FIG. 4

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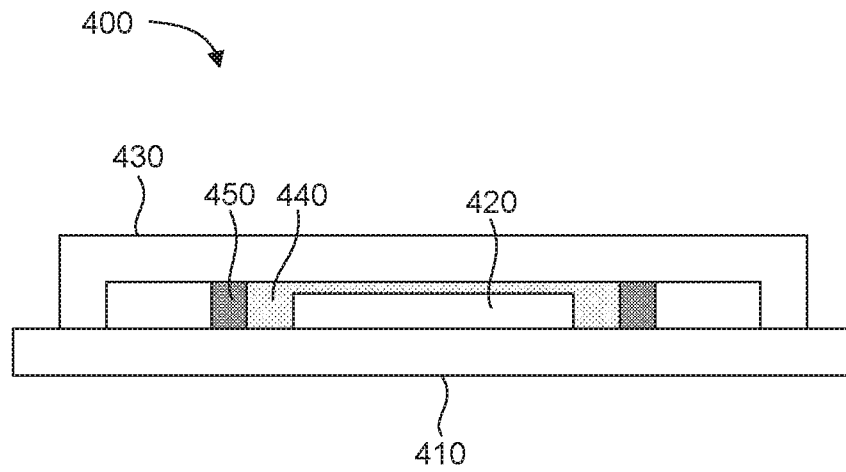


FIG. 5

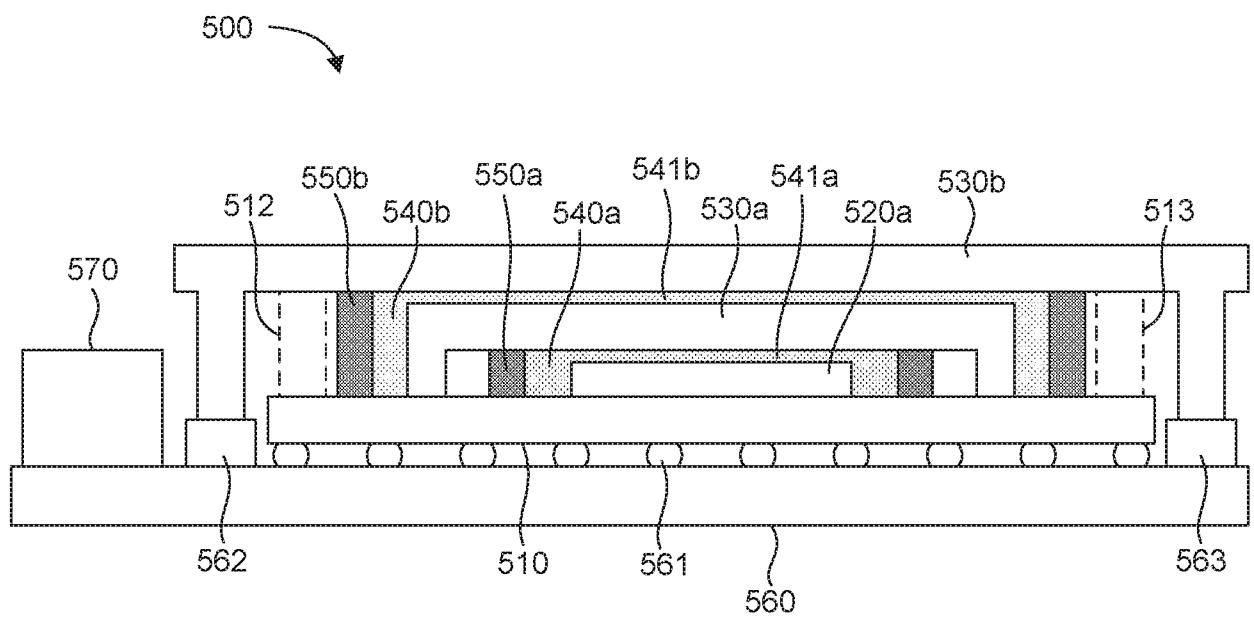


FIG. 6

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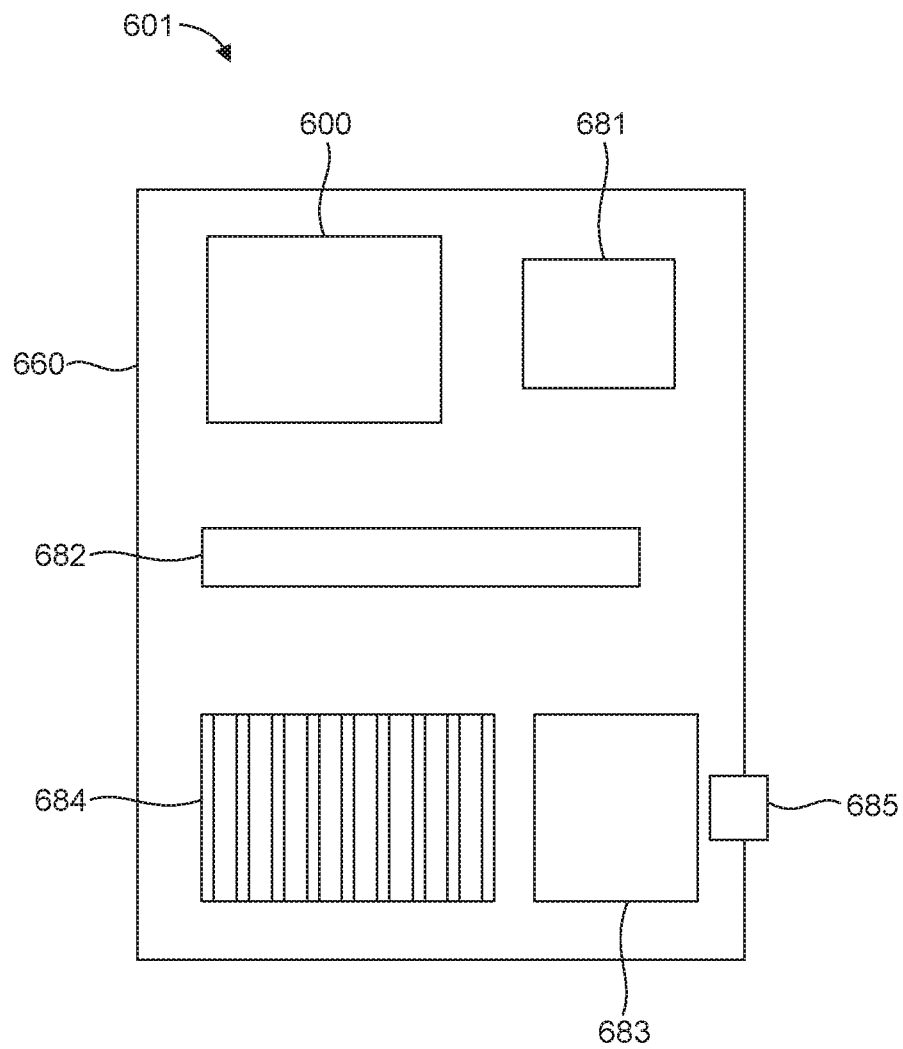


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2016/063753

A. CLASSIFICATION OF SUBJECT MATTER

INV. H01L23/42

ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2006/118925 A1 (MACRIS CHRIS [US] ET AL) 8 June 2006 (2006-06-08)	1-4, 10-20, 25-33, 35-42, 48-55, 61-63, 69-76,81 9
A	paragraph [0002] paragraph [0057] - paragraph [0063] paragraph [0068] - paragraph [0069] paragraph [0080] figures 4A-4D, 6A,6B,7A,7B,16 ----- -/-	



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

9 March 2017

Date of mailing of the international search report

10/05/2017

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
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Authorized officer

Keller, Jan

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2016/063753

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2012/098119 A1 (REFAI-AHMED GAMAL [CA] ET AL) 26 April 2012 (2012-04-26)	1-4, 9-16, 30-33, 35-42, 48-55, 61-63, 69-76,81
A	paragraph [0001] - paragraph [0010] paragraph [0024] - paragraph [0031] paragraph [0033] figures 1-3,5 -----	17-20, 25-29

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/063753

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-4, 9-20, 25-33, 35-42, 48-55, 61-63, 69-76, 81

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-4, 9-20, 25-33, 35-42, 48-55, 61-63, 69-76, 81

Electronic device heat transfer system, electronic device cooling system, method of minimizing migration of viscous TIM, method for maintaining heat transfer efficiency, method of making an electronic device package, comprising a viscous TIM and a gasket.

2. claims: 5, 21, 34, 56, 64

Electronic device heat transfer system, electronic device cooling system, method of minimizing migration of viscous TIM, method for maintaining heat transfer efficiency, comprising an gasket which is an EMI shield.

3. claims: 6-8, 22-24, 43-47, 57-60, 65-68, 77-80

Electronic device heat transfer system, viscous TIM, method of minimizing migration of viscous TIM, method for maintaining heat transfer efficiency, method of making an electronic device package, comprising an gasket which is a hardened portion of the viscous TIM.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2016/063753

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2006118925	A1	08-06-2006	NONE

US 2012098119	A1	26-04-2012	NONE
