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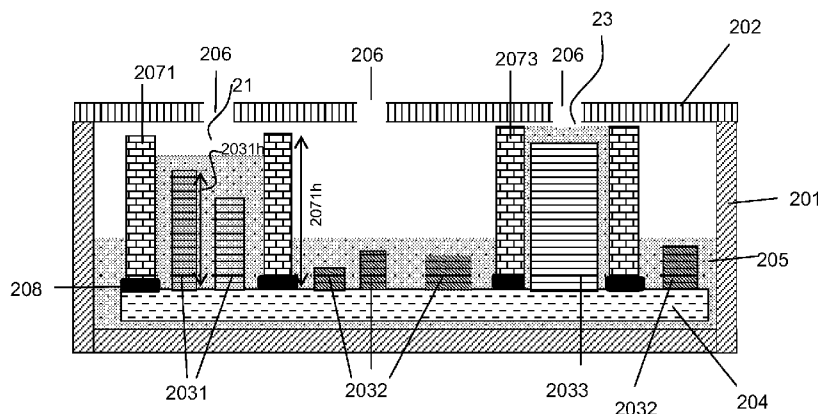


Figure 2a: View from the side

(57) Abstract: Power devices comprising partitions are provided wherein the partitions create enclosed spaces to allow sectioned potting of the components of such devices.



SECTIONED POTTING IN POWER CONVERTERS

BACKGROUND OF THE INVENTION

[0001] Power converters and inverters find use in multiple power management applications. In particular, micro-inverters and power optimizers are critical components used in photovoltaic systems.

[0002] A power optimizer is a DC-to-DC converter technology developed to maximize energy throughput for optimal power harvest from photovoltaic or wind turbine systems. A power optimizer is a simple structure, comprising only capacitor(s) and converter modules, without an inverter module. The power optimizers may be small, typically having a dimension of less than 300 (width) X 200 (height) X 100 (depth) mm, and preferably less than 250, 200, 150, or even 100 mm in width, less than 150, 100, 70, or even 50 mm in height, and less than 70, 50, 30, or even 15 mm in depth. In these small power optimizers, the volume of a case housing power optimizer components is typically less than 3 liters, 2, 1, 0.75, 0.5, or even less than 0.25 liter.

[0003] A micro-inverter is a subset of power converters, most often used with photovoltaic panels, but it may have other applications. A micro-inverter basically combines a power optimizer with a small inverter in a single case and is used on every panel in a photovoltaic system, while the power optimizer leaves the inverter in a separate box and uses only one inverter for the entire array of panels. In its use with a photovoltaic panel, a micro-inverter is located directly adjacent to and is disposed in electrical communication with a photovoltaic panel and is often integrated into the structure of a photovoltaic panel. Each micro-inverter obtains optimum power from the panel to which it is electrically connected by performing maximum power point tracking for its electrically connected panel. Micro-inverters are small in size, compared to size of conventional inverters, micro-inverters typically having a dimension of less than 500 (width) X 300 (height) X 100 (depth) millimeters (mm), and preferably less than 250, 200, 150, or even 100 mm in width, less than 150, 100, 70, or even 50 mm in height, and less than 80, 70, 50, 30, or even 15 mm in depth. The volume of a case housing micro-inverter components is typically less than 3 liters, 2, 1, 0.75, 0.5, or even less than 0.25 liter. Micro-inverters differ from conventional inverters in that due to their suitability to handle smaller amount of electricity at a lower voltage, heat generation by the micro-inverter is less than heat generation by a conventional inverter.

[0004] Because of their typical co-location with photovoltaic panels, micro-inverters require a more robust protection from environmental elements such as water, moisture, varying temperature and ultraviolet light and other radiation. Micro-inverters have high reliability requirements including thermal management and environmental protection to survive outdoor usage exposed to elements. The current leading micro-inverter & power optimizer companies provide 25 years of warranty for their product, and thermal conductive pottants filling these devices are critical materials to achieve this protection. A micro-inverter is described in, for example, U.S. Pat. No. 7796412, the entirety of which is herein incorporated by reference.

[0005] Like numerals indicate like parts throughout the Figures. Figure 1 is a schematic of a generic prior art power converter. Briefly, a power converter 100 comprises a case 101 and a lid 102 typically made of metallic and other durable materials, within which an electronic printed circuit board (PCB) 104 bearing electrical components 103 is operably placed. For the purpose of this application, electrical components 103 are a set of one or more capacitors to stabilize incoming electricity, one or more converter modules comprising a transformer for increasing the voltage of the incoming electricity, operably connected by a silicon-controlled rectifier to the inverter modules comprising one or more inductors and other parts to enable stable power conversion and inversion. The identity of each part of the electrical components 103 is not shown in the figures.

[0006] In addition to the components described above, a power converter also comprises one or more heat sinks for managing generated heat. In a prior art power converter, the entire PCB with electronic and electrical components is encased in a pottant 105, typically dispensed into the case 101 through a hole 106, to protect the electronic components from the environmental elements. In a typical power converter, relative to the PCB on which electrical and electronic components are located, the heights of the components vary. As indicated in Figure 1, prior art power converters are fully filled with a pottant material.

[0007] In prior art power converters, heat-dissipating pottants are used to fill the entire void space within the power converters to protect the components from the environment and prolong the useful life of the device. However, we realized the pottant exerts thermal stress on the components of the power converters. Reducing the stress would further prolong the life of the converters.

BRIEF SUMMARY OF THE INVENTION

[0008] This invention pertains to a method for protecting components of an electronic device using a reduced amount of pottant, and to the electronic device manufactured by such method. An embodiment of such method is particularly useful for a small-scale power inverter or converter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Figure 1 is a schematic of a generic prior art power converter.

[0010] Figure 2 is a schematic of a power converter with sectioned potting arrangement using pressure sensitive adhesive to anchor partitions.

[0011] Figure 3 is a schematic of a power converter with sectioned potting using an attachment means to anchor partitions.

DETAILED DESCRIPTION OF THE INVENTION

[0012] The term “power converter” is used in this application to mean an electronic device comprising one or more semiconductor modules and electrical components for converting (1) direct current (DC) to stronger DC, i.e. a power optimizer, (2) DC to alternating current (AC), i.e. an inverter, or (3) AC to DC, e.g. a light emitting diode (LED) module.

[0013] The present invention is directed to a power converter of any type or size, but in particular embodiments, the present invention is directed to a small-scale power optimizer or micro-inverter, not limited to but typically used with a photovoltaic panel, typically directly mounted behind a photovoltaic panel so that each panel is directly served by its own power converter and thus increasing the efficiency of conversion. The present invention is also directed to an LED module or photovoltaic panel comprising the small-scale power optimizer or micro-inverter.

[0014] Power converter of the present invention. The present application is directed to an invention pertaining to a power converter device comprising: a printed circuit board (PCB) having at least one region; electronic and electric components on the PCB, such components operably connected among themselves for converting electric power; one or more partitions, each partition having an edge; and a pottant, wherein each partition at its edge is in contact with the PCB so that the at least one region of the PCB is surrounded by the one or more the partitions to form one or more enclosures, each

enclosure defining an enclosed space above a different region of the PCB and being open only at the side opposite of the PCB, each such region of the PCB supporting one or more electronic or electrical components, each such enclosed space being at least partially filled with the pottant so that the pottant completely encases all electronic or electrical components located in the region, and the PCB is completely covered by the pottant in portions of the PCB that are not surrounded by the partitions, wherein above at least one region of the PCB there is a void above the pottant covering the electronic or electrical components in at least one region of the PCB.

[0015] The power converter of the present invention is structured so that a pottant fully covers each of the electronic or electrical components according to the heights of such components, but need not completely fill the void space between the top of an electronic or electrical component and the lid of the power converter. In a typical power converter, electrical and electronic components affixed on a PCB vary in their heights as measured perpendicular to the PCB. However, more than one component having a height same or similar to each other are on the PCB and some of such similar-height components are located adjacent to each other. In an embodiment of the present invention, such components of similar heights are grouped together and surrounded by a partition of a height that exceeds the heights of the components and that are not permeable to a pottant. A pottant is then dispensed within the enclosed space created by the surrounding partition to fully cover the components therein. Compared to a prior art power converter, where the pottant uniformly fills the case and reaches the lid, in the inventive embodiments, the pottant filling an enclosed space which contains components of small heights would cover the components and leave a void space above. Put differently, the amount of the pottant needed to cover the components in one space would vary not only by the area of the PCB within the enclosed space but also according to the height of the components in that enclosed space.

[0016] To illustrate, the components may be grouped in different height clusters, Group A, Group B, and Group C. Group A are the tallest components, and include transformers and capacitors. Group B are mid-height components, and include inductors, resistors and other electrical and electronic components. Group C are the lowest components, such as surface mounted device (SMD) and integrated circuit (IC) chips. The grouping of heights and the number of clusters of components may be selected as necessary and as dictated by the layout and design of the power converter, but typically there are two, three, or four groups of heights, and one, two, three, four, or five clusters. The partitions may be placed in any configuration as long as a partition creates an

enclosed space wherein an amount of pottant is retained without migrating to outside the closed area before the pottant is cured.

[0017] There is no particular height differences that would define a “similar” height, and one may group any components at one’s convenience. However, as a non-limiting example, where the tallest component of a first group is shorter than the shortest component of a second group, the difference between the tallest component of the first group and the shortest component of the second group may be 3 to 5 mm. A typical height of micro-inverters and small power converter components and an exemplary grouping are as follows:

Grouping of Components by similar height	Component and approximate height
Below 2.5 mm	SMD resistor, from about 0.5 mm to about 1mm; IC chips, from about 0.5 mm to about 1.5 mm; chip resistor, from about 0.5 to about 1.5 mm; SMD inductor, from about 1.5 mm to about 2.5 mm; SMD capacitor, from about 2 to about 3 mm.
Between 3 to 5 mm	SMD diode, from about 3 to about 5 mm; silicon controlled rectifier, from about 3 to about 5 mm; optoisolator, from about 3 to about 5 mm.
Between 5 to 10 mm	inductor, from about 5 mm to about 10 mm.
Between 10 to 15 mm	SMD transistor, from about 10 mm to about 15 mm; plastic film capacitor, from about 12 mm to about 15 mm; resistors, from about 10 mm to about 15 mm.
Above 15 mm	Electric capacitor, from about 15 mm to about 20 mm; transformer, from about 15 mm to about 25 mm.

[0018] An embodiment of the present invention is illustrated in Figure 2. In Figure 2, Figure 2a is a schematic of a side view of a power converter, looking parallel to the edge of a PCB 204. A power converter comprises a case 201 that encases PCB 204, on which electric or electronic components are operably connected, and lid 202. The partition 2071 surrounds a cluster of components 2031 and have a height 2071h larger than

height 2031h of the tallest of the components within the partitioned section. A pottant 205 is introduced to enclosed space 21 through a port 206 in lid 202 so that the components 2031 are completely covered by the pottant, and a void (not indicated) remains above pottant 205 in section 21. Put differently, the depth of pottant 205 in section 21 is larger than height 2031h and smaller than height 2071h of partition 2071. Partition 2073 creates a second enclosed space 23 where components 2033 are located. A second amount of pottant 205 is dispensed into section 23 so that the components 2033 are completely covered by the pottant 205 up to lid 202. A third cluster of components (not shown), if any, may be surrounded by a third partition (not shown), and similarly encased in pottant 205. When a sufficient number of clusters is identified and covered by the pottant 205 in a similar manner, PCB 204 and the shortest components 2032 such as SMD and IC chips are covered by introducing sufficient amount of pottant 205 to fill any space below and surrounding PCB 204, and to cover the lowest components, and a void (not indicated) remains above pottant 205 that covers components 2032.

[0019] Figure 2b is a schematic of a view of a power converter from the top, looking down to the face of PCB 204 (not visible). Each rectangle or square 2031, 2032, or 2033 represents a component. Components 2031 are of similar height to each other. Components 2032 are of similar height to each other. Components 2033 are of similar height to each other. Partitions 2071 and 2073 are attached to PCB 204 preferably without a space between the edges (not indicated) of partitions 2071 and 2073 and PCB 204, but may comprise some space as long as pottant 205 in its uncured does not migrate out of the space before it is cured in place. Each of partition 2071 and 2073 surround a different cluster of components of similar heights, such cluster being components 2031 or 2033. Partition 2071 creates a enclosed space 21, the bottom of which is demarcated by PCB 204 and wherein components 2031 are located. Similarly, partitions 2073 create a closed section 23 of PCB 204 wherein components 2033 are located.

[0020] A partition may be constructed from one piece of supported material to form a cylindrical shape without any corners, or may have corners so that there are three, four, five, six, seven, eight, or more faces. The partitions' faces may be flat or curved. Alternatively, partitions may be constructed from two or more than two pieces and may be attached to each other by any means of attachment when placed on a PCB for the inventive purpose. A partition is typically positioned essentially perpendicular to the PCB, but may have other angles relative to the PCB. A partition also may have a sufficient height so that the shortest part of a partition surrounding a set of components has a

height that exceeds the height of the tallest components of the set by 1, 2, 3, 4, 5, or more millimeters. The partition may reach to the top edge of the case, touching the lid, but may not exceed the height of the vertical sides of the case.

[0021] Part of a partition surrounding an enclosed space may form part of another partition surrounding another enclosed space. In such a case, such part of the partition stands between two enclosed spaces.

[0022] A partition may be made of any material that is rigid enough to hold its essentially vertical position relative to the PCB when secured to the PCB. Alternatively, a partition is made of a material that is not self-supporting, but may be supported by a support means such as a frame, scaffold, pillars or poles. For example, the partition may contain or attach to mesh, foil or film made of metal or plastic inside which could provide sufficient supporting force. Such support means may be permanent, or may be temporarily placed while a pottant is uncured and is removed when the pottant is cured. Each piece of the partition may be flexible or non-flexible. The partition may be solid, or may have a porous structure. When the partition has a porous structure, the pores may be closed and do not allow penetration of a pottant through the partition, or the pores may be open or partially open so long as the penetration of uncured pottant is slow enough so that the pottant does not leak through the partition before it is cured. Such slow penetration may be achieved if the pore size is small and/or the distance that the pottant travels to penetrate the partition is sufficiently long and the pottant has sufficient viscosity that the amount of time it would take for the uncured pottant to travel from one side of the partition to the other side of the partition is greater than the amount of time that the pottant cures after it has been dispensed into the power converter device where the partition is placed. Any polymeric solid or porous materials may be used to make a partition, including polyurethane, organopolysiloxane, polyisobutylene, polybutadiene, or a copolymer of any two or more of the monomers (e.g., polyisocyanate/polyol, PDMS D5, isobutylene, 1,3-butadiene) or oligomers used to form repeat units any of the foregoing. A partition may also be prepared from cellulose- or lignin-based material, such as paper, which may be treated with surface coating materials. The partition is preferably made from such material that has a lifetime longer than or equal to the lifetime of the power converter device, i.e. 25 years or more. The partition is preferably electrically insulating (i.e. not electrically conductive) so that it would not interfere with normal operation of a power converter device in which the partition is placed. The partition may not contain components that would inhibit curing of a pottant. For example, it may not contain phosphoric acid and derivative materials.

[0023] The partition may be of any thickness as long as the characteristics described in the paragraph immediately preceding this paragraph are satisfied. On the other hand, the partition may not be so thick as to interfere with the layout of the components, or to unnecessarily add to the size of the device. In a typical embodiment, a partition is 0.1, 0.5, 1, 2, or 3 mm thick for micro-inverter and other small sized device. In another embodiment, a partition may be up to 10 mm for a larger power converter.

[0024] A partition may be constructed by any conventional means suitable for the material from which it is made. Polymeric materials may be cast, molded, sprayed, or formed into the final form of the partition by any means where starting monomeric or uncured materials of the polymeric materials are processed into the polymer. Partitions may be sliced or shaped from larger solid or panel.

[0025] A partition may be secured to the PCB board by any means. A pressure sensitive adhesive (PSA) may be applied to the edge of the partition which is proximal to the PCB board, so that the partition may be pressed onto and adhered to the PCB. An illustration of such means of attachment is shown in the schematic of Figure 2, wherein the PSA 208 is shown. Partition 2071 may be attached by PSA, double-sided tape, or any type of adhesive between itself and PCB. Figure 3a is a view from the side and Figure 3b is a view from the top of an embodiment of the present invention with a support means supporting a partition. As shown in Figure 3, as an alternative to solely attaching a partition directly to the PCB, a support means 309 with an attachment appendix on the end proximal to PCB 304, may be attached to a partition 3071, for example. Support means 309 may be embedded in partition 3071 as shown in Figure 3. Alternatively, a support means may be attached to the exterior of a partition by adhesive. Partition 3071 is attached to PCB 309 by attaching support means 309 instead of or in addition to attaching partition 3071 itself. Support means 309 may be attached to PCB using an adhesive or by friction fit by embedding it into the partition, to support the partition. Support means 309 may also be welded to PCB 304. The support means may be a stick or a narrow board, and made of same or different materials as the partition. Support means 309 may have an externally screw-threaded fastener such as a screw at the end proximal to PCB 304 and attached to PCB 304 by the screw.

[0026] A PCB may be specifically designed for use with partitions of the present invention so that it would have grooves and/or receiving holes for the partitions to be placed and attached. A PCB may be constructed with a receiving structure for a support means, such as an indented area or a hole to match the size and shape of the cross-

section of a support means and a receiving thread for a screw-threaded part of a support means. The layout of the PCB may take into consideration the positions of partitions and may group components of similar heights together.

[0027] In this manner, the amount of the pottant needed to effectively protect the components of a power converter is expected to be 10, 20, 30, 40 or even 50% less than a prior art power converter lacking the one or more partitions. Such reduction is advantageous for reducing the amount and thus the cost of pottants necessary to protect the power converters, but also because the space above the shorter components allows for the thermal expansion of the pottant, relieving the shorter components from the thermal stress. The reduction of the pottant amount also reduces the weight of the converters, requiring less mechanical support for the converter, thus allowing for more cost reduction as well as reducing the mechanical stress of any structure supporting the thermal converters.

[0028] Pottant used for each enclosed space may be same or different. It may be advantageous to match the thermal capacity of a pottant to the electrical or electronic component in a particular enclosed space.

[0029] Pottant composition. A polymer composition useful as a pottant of the present invention may be of any pottant currently in use with a converter. It is preferably be thermally conductive and it is suitable for protection of electrical and/or electronic components of the power converter from the elements. If a curable material is used, the cured composition is not flammable. By "not flammable" it is meant that it passes UL 94 V-1 flammability rating or better. The cured composition preferably passes UL 94 V-1 at thickness equal to or less than 4 mm, preferably thickness equal to or less than 2 mm.

[0030] The polymer comprising the polymer composition may be a polyurethane, an organopolysiloxane, polyisobutylene, polybutadiene, or a copolymer of the monomers or oligomers comprising any of the foregoing. A preferred polymer is an organopolysiloxane. Examples of pottants include commercially available compositions such as Dow Corning Sylgard® 160, Sylgard® 170, CN-8760, Shin Etsu KET 132, Beginor Besil 340 for organopolysiloxane based compositions, and EFI polymer 30222/40020, Epic resin S7202-04 for polyurethane based compositions.

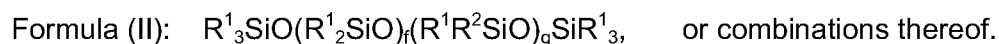
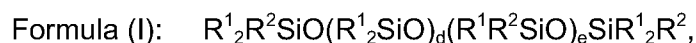
[0031] An exemplary organopolysiloxane composition useful for practicing the present invention is a cured material of a curable composition comprising an

organopolysiloxane, a curing agent, and a catalyst. Examples of such organopolysiloxane may be found in PCT application PCT/CN12/076460.

[0032] Component (A) is an organopolysiloxane having an average of at least 0.5, more typically two or more, silicon-bonded alkenyl group(s) per individual polymer molecule, and may be a single kind of polymer, or a mixture of two or more kinds. Component (A) may be linear (including a cyclic structure) or branched.

[0033] Component (A) may be further defined as an organoalkylpolysiloxane. The silicon-bonded alkenyl groups of the (A) organopolysiloxane are not particularly limited, and examples of suitable alkenyl groups are vinyl, allyl, butenyl, pentenyl, and hexenyl groups. Each alkenyl group may be the same or different and each may be independently selected from all others. Each alkenyl group may be terminal or pendant, and both may be found in the organoalkylpolysiloxane of (A). Vinyl groups are preferred.

[0034] In various embodiments, Component (A) may comprise the following formulae:



[0035] In formulae (I) and (II), each R^1 is independently a monovalent organic group free of aliphatic unsaturation and each R^2 is independently an aliphatically unsaturated organic group. R^1 includes, but is not limited to, alkyl groups having any one of 1 to 10 carbon atoms, e.g. methyl; ethyl; isomers of: propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl; cycloalkyl groups such as cyclopentyl and cyclohexyl; and aryl groups such as phenyl, tolyl, xylyl, benzyl, and 2-phenylethyl. Each R^2 is independently an aliphatically unsaturated monovalent organic group, exemplified by alkenyl groups such as vinyl, allyl, butenyl, pentenyl, hexenyl, or heptenyl groups. R^2 may include halogen atoms or halogen groups.

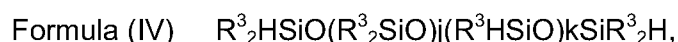
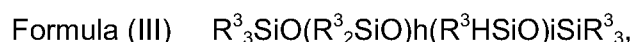
[0036] Subscript "d" typically has an average value of at least 1, but may have a value ranging from 0.1 to 2000. Subscripts "e" and "f" each may be 0 or a positive number. Alternatively, subscript "e" may have an average value ranging from 0 to 2000. Subscript "g" has an average value of at least 1, and more typically, at least 2. Alternatively, subscript "g" may have an average value ranging from 1 to 2000.

[0037] In various embodiments, Component (A) is further defined as an alkenyldialkylsilyl end-blocked polydialkylsiloxane. In particular, the polydialkylsiloxane may be further defined as: polydimethylsiloxane (PDMS); a methyl (3,3,3-trifluoropropyl)

polysiloxane; a copolymer of a methylvinylsiloxane and a dimethylsiloxane; a copolymer of a methyl (3,3,3-trifluoropropyl) siloxane and a dimethylsiloxane; a copolymer of a methylphenylvinylsiloxane and a dimethylsiloxane; or an organosiloxane copolymer composed of siloxane units represented by the following formulae: $(\text{CH}_3)_3\text{SiO}_{1/2}$, $(\text{CH}_3)_2(\text{CH}_2=\text{CH})\text{SiO}_{1/2}$, $\text{CH}_3\text{SiO}_{3/2}$, $(\text{CH}_3)_2\text{SiO}_{2/2}$. Each of these polymers is end-blocked, i.e. capped at one or both molecular terminals, by dimethylvinylsiloxy groups or methylphenylvinylsiloxy groups or silanol groups. The aforementioned siloxanes may include phenyl instead of methyl in some amount.

[0038] Component (B) is a cross-linker having an average of at least 2, 3, or more than 3 silicon-bonded hydrogen atoms per molecule and may comprise a silane or a siloxane, such as a polyorganosiloxane. The silicon-bonded hydrogen atoms may be terminal or pendant. Component (B) may also contain substituted or non-substituted monovalent hydrocarbon groups. Examples of suitable non-substituted monovalent hydrocarbon groups include alkyl groups having any one of between 1 and 10 carbon atoms e.g. methyl; ethyl; isomers of propyl, butyl, pentyl, hexyl, heptyl, octyl groups; cyclopentyl, cyclohexyl, or similar cycloalkyl groups; phenyl, tolyl, xylyl, or similar aryl groups; benzyl, phenethyl, or similar aralkyl groups; or 3,3,3-trifluoropropyl, 3-chloropropyl, or similar halogenated alkyl group. Preferable are alkyl, in particular, methyl groups.

[0039] Component (B) may also include siloxane units including, but not limited to, $\text{HR}^3_2\text{SiO}_{1/2}$, $\text{R}^3_3\text{SiO}_{1/2}$, $\text{HR}^3\text{SiO}_{2/2}$, $\text{R}^3_2\text{SiO}_{2/2}$, $\text{R}^3\text{SiO}_{3/2}$, and $\text{SiO}_{4/2}$ units, wherein each R^3 is independently selected from monovalent organic groups free of aliphatic unsaturation as described in the preceding paragraph. In various embodiments, the (B) cross-linker includes or is a compound of the formulae:



or a combination thereof.

[0040] In formulae (III) and (IV) above, subscripts "h" "j" and "k" each has an average value ranging from 0 to 2000, and subscript "i" has an average value ranging from 2 to 2000. Each R^3 is independently a monovalent organic group. Suitable monovalent organic groups include alkyl groups having 1 to 20, 1 to 15, 1 to 10, 5 to 20, 5 to 15, or 5 to 10 carbon atoms, such as methyl; ethyl; isomers of: propyl, butyl, pentyl, octyl, decyl, undecyl, dodecyl, and octadecyl; cycloalkyl such as cyclopentyl and cyclohexyl; alkenyl

such as vinyl, allyl, butenyl, and hexenyl; alkynyl such as ethynyl, propynyl, and butynyl; and aryl such as phenyl, tolyl, xylyl, benzyl, and 2-phenylethyl.

[0041] Component (B) may alternatively be further defined as: a methylhydrogen polysiloxane or a copolymer of a methylhydrogensiloxane and a dimethylsiloxane, either of which is capped at one or both molecular terminals with trimethylsiloxy groups, dimethylhydrogensiloxy groups or a combination thereof; a cyclic methylhydrogenpolysiloxane; and/or an organosiloxane composed of siloxane units represented by: $(\text{CH}_3)_3\text{SiO}_{1/2}$, $(\text{CH}_3)_2\text{HSiO}_{1/2}$, and $\text{SiO}_{4/2}$; tetra(dimethylhydrogensiloxy) silane, or methyl-tri(dimethylhydrogensiloxy) silane, or a dimethylpolysiloxane capped at one or both molecular terminals with any combination of the above-mentioned groups as long as at least one of these groups contains a silicon-bonded hydrogen atom.

[0042] It is also contemplated that Component (B) may be or include a combination of two or more organohydrogenpolysiloxanes that differ in at least one of the following properties: structure, average molecular weight, viscosity, siloxane units, and sequence. Component (B) may also include a silane. Dimethylhydrogensiloxy-terminated poly dimethylsiloxanes having relatively low degrees of polymerization (DP) (e.g., DP ranging from 3 to 100) are commonly referred to as chain extenders, and a portion of Component (B) may be or include a chain extender. In one embodiment, Component (B) is free of halogen atoms. In another embodiment, Component (B) includes one or more halogen atoms per molecule. It is contemplated that the gel, as a whole, may be free of halogen atoms.

[0043] The cross-linker of (B) may have a linear, a branched, or a partially branched linear, cyclic, dendrite, or resinous molecular structure.

[0044] The molar ratio of silicon-bonded alkenyl in component (A) to silicon bonded hydrogen in component (B), expressed herein as the SiH:Vi ratio, influences the physical property of a cured material of component (A) and component (B). In the present invention, the SiH:Vi ratio is 0.1 to less than 1.5. When the SiH:Vi ratio is less than 0.1, the composition is difficult to cure completely. On the other hand, when the SiH:Vi ratio is 1.5 or greater, the reduced softness and the increased pressure that the cured polymer exerts on the components of a power converter device are undesirable. Preferably, the SiH:Vi ratio is 0.1 to 1.2, more particularly 0.1 to 1.0, and more particularly 0.3 to 0.7.

[0045] Component (C) is a catalyst and is not particularly limited and may be any known in the art. In one embodiment, Component (C) includes a platinum group metal

selected from platinum, rhodium, ruthenium, palladium, osmium or iridium, organometallic compounds thereof, or combinations thereof. In another embodiment, Component (C) is further defined as a fine platinum metal powder, platinum black, platinum dichloride, platinum tetrachloride; chloroplatinic acid, alcohol-modified chloroplatinic acid, chloroplatinic acid hexahydrate; and complexes of such compounds, such as platinum complexes of olefins, platinum complexes of carbonyls, platinum complexes of alkenylsiloxanes, e.g. 1,3-divinyltetramethyldisiloxane, platinum complexes of low molecular weight organopolysiloxanes, for example 1,3-diethenyl-1,1,3,3 – tetramethyldisiloxane, complexes of chloroplatinic acid with β -diketones, complexes of chloroplatinic acid with olefins, and complexes of chloroplatinic acid with 1,3-divinyltetramethyldisiloxane.

[0046] Typically, Component (C) is present/utilized in an amount of from 0.01 to 1,000 ppm, alternatively 0.1 to 500 ppm alternatively 1 to 500 ppm, alternatively 2 to 200, alternatively 5 to 150 ppm, based on the total weight of (A) and (B).

[0047] In the embodiments of the present invention, any of the polymers described above may be used and combined with (D) one or more filler(s).

[0048] Component (D) is a filler or combination of fillers. These fillers may be heat conducting and/or non-conducting, reinforcing and/or non-reinforcing, flame retardant and/or non-flame retardant. Fillers may be dried and/or chemically pre-treated or not dried and/or chemically pre-treated. Examples of typical fillers include but are not limited to any one or any combination of; ground quartz (silica powder), precipitated silica, fumed silica, aluminum trihydrate (ground or precipitated), magnesium dihydrate (ground or precipitated), or alumina.

[0049] Thermally conductive fillers are known in the art, see for example, U.S. Patent 6,169,142 (col. 4, lines 7-33). Component (D) may comprise an inorganic filler, a meltable filler, or a combination thereof. Inorganic fillers are exemplified by onyx; aluminum trihydrate, metal oxides such as aluminum oxide, beryllium oxide, magnesium oxide, and zinc oxide; nitrides such as aluminum nitride and boron nitride; carbides such as silicon carbide and tungsten carbide; barium titanate, carbon fibers, diamond, graphite, magnesium hydroxide, and a combination thereof.

[0050] Component (D) may be a single thermally conductive filler or a combination of two or more thermally conductive fillers that differ in at least one property such as particle shape, average particle size, particle size distribution, and type of filler. In certain

embodiments, it may be desirable to combine a first thermally conductive filler having a larger average particle size with a second thermally conductive filler, which may be of the same or different material as the first filler, having a smaller average particle size in a proportion meeting the closest packing theory distribution curve. Use of a first filler having a larger average particle size and a second filler having a smaller average particle size than the first filler may improve packing efficiency, may reduce viscosity, and may enhance heat transfer.

[0051] The shape of the thermally conductive filler particles is not specifically restricted; however, rounded or spherical particles may prevent viscosity increase to an undesirable level upon high loading of the thermally conductive filler in the composition. The average particle size of the thermally conductive filler will depend on various factors including the type of thermally conductive filler selected for component (D) and the exact amount added to the curable composition, as well as the bondline thickness of the device in which the cured product of the composition will be used. In some particular instances, the thermally conductive filler may have an average particle size ranging from 0.1 micrometer to 80 micrometers, alternatively 0.1 micrometer to 50 micrometers, and alternatively 0.1 micrometer to 10 micrometers.

[0052] Thermally conductive fillers are commercially available. For example, meltable fillers may be obtained from Indium Corporation of America, Utica, N.Y., U.S.A.; Arconium, Providence, R.I., U.S.A.; and AIM Solder, Cranston, R.I., U.S.A. Aluminum fillers are commercially available, for example, from Toyal America, Inc. of Naperville, Illinois, U.S.A. and Valimet Inc., of Stockton, California, U.S.A. Silver filler is commercially available from Metalor Technologies U.S.A. Corp. of Attleboro, Massachusetts, U.S.A. Zinc oxides, such as zinc oxides having trademarks KADOX® and XX®, are commercially available from Zinc Corporation of America of Monaca, Pennsylvania, U.S.A. Further, CB-A20S and Al-43-Me are aluminum oxide fillers of differing particle sizes commercially available from Showa-Denko, and AA-04, AA-2, and AA 18 are aluminum oxide fillers commercially available from Sumitomo Chemical Company. Boron nitride filler is commercially available from Momenive Corporation, Cleveland, Ohio, U.S.A.

[0053] The filler may be, or may function as a flame retardant. Flame retardants are known in the art. Examples of known flame retardants are carbon black, fused or fumed silica, silica gel, esters of phosphoric acid, phosphinates, polyphosphonates or copolyphosphonates, melamine, metal salts, hydroxides and oxides, alumina hydrates,

metal borates, etc. and combinations thereof. Certain silicones, silanes and silsesquioxanes may also be used as flame retardants. When hydrosilylation-cured polyorganosiloxanes are used as soft tacky gels of this invention, flame retardants containing phosphorus, sulfur or nitrogen atoms are generally avoided to minimize the chance of interfering with curing. See, for example, Kashiwagi and Gilman, the Fire Retardancy of Polymeric Materials, pp 353-389 (2000) hereby incorporated by reference.

[0054] The (D) filler(s) is/are dispersed in component (A) and may be dispersed in (B) to (F). The dispersion may be heat-treated, dried, or chemically treated. Optional components (E) and (F), described below, may or may not interact or react with the filler(s). The overall level of (D) filler(s) based on total weight of (A) and (B) will be the minimum amount needed to achieve the desired function, and may be more than 5, 10, 20, 30, 40, or 50 wt%.

[0055] The curable prepolymers, i.e. monomers or oligomers; and in case of silicone compositions, component (A), (B), and (C); and component (D) are mixed. The composition cures to a soft, tacky thermally conductive cured silicone product, which may be colorless and transparent or colorless and semi-transparent, or having a color.

[0056] The composition may further comprise optional components.

[0057] Component (E), a silicone fluid, may be added. Component (E) may be alternatively described as only one of, or as a mixture of, a functional silicone fluid and/or a non-functional silicone fluid. In one embodiment, (E) is further defined as a polydimethylsiloxane, which is not functional. In another embodiment, (E) is further defined as a vinyl functional polydimethylsiloxane. The terminology "functional silicone fluid" typically describes that the fluid is functionalized to react in a hydrosilylation reaction, i.e., include unsaturated groups and/or Si-H groups. However, it is contemplated that the fluid may include one or more additional functional groups in addition to, or in the absence of, one or more unsaturated and/or Si-H groups. In various non-limiting embodiments, (E) is as described in one or more of U.S. Pat. Nos. 6,020,409; 4,374,967; and/or 6,001,918, each of which is expressly incorporated herein by reference. (E) is not particularly limited to any structure or viscosity.

[0058] In one embodiment, (E) is a functional silicone fluid and reacts with (A) and/or (B) in the presence of (C) and (D). Said differently, the hydrosilylation reaction product may be further defined as the hydrosilylation reaction product of (A), (B), and (E) the functional silicone fluid wherein (A), (B), and (E) react via hydrosilylation in the presence

of (C) and (D). In another embodiment, (A) and (B) react via hydrosilylation in the presence of (C), (D), and (E) a non-functional silicone fluid.

[0059] One or more of (A)-(E) may be combined together to form a mixture and the mixture may further react with remaining components of (A) – (E) to form the gel, with (E) being an optional component in either the mixture or as a remaining component. In other words, any combination of one or more (A)-(E) may react with any other combination of one or more of (A)-(E) so long as the gel is formed.

[0060] The pottant composition may comprise other optional components. The mixture, or any one or more of (A)-(E) may be independently combined with, treated with, or reacted with one or more additives. The additional Component may be selected from the group consisting of (F) filler treating agent, (G) an adhesion promoter, (H) a solvent or diluent, (I) a surfactant, (J) an acid acceptor, (K) a hydrosilylation stabilizer, and a combination thereof.

[0061] Component (F) is a filler treating agent. The filler(s) for component (D) may optionally be surface treated with component (F) a treating agent. Treating agents and treating methods are known in the art, see for example, U.S. Patent 6,169,142 (col. 4, line 42 to col. 5, line 2).

[0062] The amount of component (F) may vary depending on various factors including the type and amounts of fillers selected for components (D) and whether the filler is treated with component (F) in situ or before being combined with other components of the composition. However, the composition may comprise an amount ranging from 0.1 % to 2 % of component (F).

[0063] The component (F) may comprise an alkoxysilane having the formula: $R^6_mSi(OR^7)_{(4-m)}$, where subscript m is 1, 2, or 3 in any proportion within a particular component (F). Alternatively, subscript m in a particular component (F) may be 1 for all molecules, 2 for all molecules, or 3 for all molecules. Each R^6 is independently a monovalent organic group, such as a hydrocarbon group of 1 to 50 carbon atoms, alternatively 6 to 18 carbon atoms. R^6 is exemplified by alkyl groups such as hexyl, octyl, dodecyl, tetradecyl, hexadecyl, and octadecyl; and aromatic groups such as benzyl, phenyl and phenylethyl. R^6 can be saturated or unsaturated, branched or unbranched, and unsubstituted. R^6 can be saturated, unbranched, and unsubstituted.

[0064] Each R^7 may be an unsubstituted, saturated hydrocarbon group of 1 to 4 carbon atoms, alternatively 1 to 2 carbon atoms. Alkoxysilanes for component (H) are

exemplified by hexyltrimethoxysilane, octyltriethoxysilane, decyltrimethoxysilane, dodecyltrimethoxysilane, tetradecyltrimethoxysilane, phenyltrimethoxysilane, phenylethyltrimethoxysilane, octadecyltrimethoxysilane, octadecyltriethoxysilane, and a combination thereof.

[0065] Alkoxy-functional oligosiloxanes can also be used as treatment agents. Alkoxy- functional oligosiloxanes and methods for their preparation are known in the art, see for example, EP 1101167 A2. For example, suitable alkoxy-functional oligosiloxanes include those of the formula $(R^8O)_nSi(OSiR^9R^{10})_{(4-n)}$. In this formula, subscript n is 1, 2, or 3, alternatively n is 3. Each R^8 can be an alkyl group. Each R^9 can be independently selected from saturated and unsaturated monovalent hydrocarbon groups of 1 to 10 carbon atoms. Each R^{10} can be a saturated or unsaturated monovalent hydrocarbon group having at least 11 carbon atoms.

[0066] Metal fillers can be treated with alkylthiols such as octadecyl mercaptan and others, and fatty acids such as oleic acid, stearic acid, titanates, titanate coupling agents, zirconate coupling agents, and a combination thereof.

[0067] Treatment agents for alumina or passivated aluminum nitride may include alkoxysilyl functional alkylmethyl polysiloxanes (e.g., partial hydrolysis condensate of $R^{11}O R^{12}_p Si(OR^{13})_{(4-o-p)}$ or cohydrolysis condensates or mixtures), or similar materials where the hydrolyzable group may comprise silazane, acyloxy or oximo. In all of these, a group tethered to Si, such as R^{11} in the formula above, is a long chain unsaturated monovalent hydrocarbon or monovalent aromatic-functional hydrocarbon. Each R^{12} is independently a monovalent hydrocarbon group, and each R^{13} is independently a monovalent hydrocarbon group of 1 to 4 carbon atoms. In the formula above, subscript o is 1, 2, or 3 and subscript p is 0, 1, or 2, with the proviso that "o + p" i.e. the sum of "o" and "p" is 1, 2, or 3. Treatment agents may also be polyorganosiloxanes and may include those of the formula $R^{16}_3 Si(OSiR^{17})_r OSi(OR^{18})_3$ where R^{16} , R^{17} , and R^{18} are each independently a monovalent alkyl group, e.g. methyl group, and subscript "r" is 1 to 200. One skilled in the art could optimize a specific treatment to aid dispersion of the filler without undue experimentation.

[0068] Component (G) is an adhesion promoter. Suitable adhesion promoters may comprise alkoxysilanes of the formula $R^{14}_q Si(OR^{15})_{(4-q)}$, where subscript q is 1, 2, or 3, alternatively q is 3. Each R^{14} is independently a monovalent organofunctional group. R^{14} can be an epoxyfunctional group such as glycidoxypentyl or (epoxycyclohexyl)ethyl, an amino functional group such as aminoethylaminopentyl or aminopentyl, a

methacryloxypropyl, or an unsaturated organic group. Each R^{15} is independently an unsubstituted, saturated hydrocarbon group of at least 1 carbon atom. R^{15} may have 1 to 4 carbon atoms, alternatively 1 to 2 carbon atoms. R^{15} is exemplified by methyl, ethyl, n-propyl, and iso-propyl.

[0069] Examples of suitable adhesion promoters include glycidoxypropyltrimethoxysilane and a combination of glycidoxypropyltrimethoxysilane with an aluminum chelate or zirconium chelate. Examples of adhesion promoters for hydro silylation curable compositions may be found in U.S. Patent 4,087,585 and U.S. Patent 5,194,649. The curable composition may comprise 0.5 % to 5 % of adhesion promoter based on the weight of the composition.

[0070] Component (H), a solvent or a diluent, can be added during preparation of the composition, for example, to aid mixing and delivery. All or a portion of component (H) may optionally be removed after the composition is prepared.

[0071] Component (I) is a surfactant. Suitable surfactants include silicone polyethers, ethylene oxide polymers, propylene oxide polymers, copolymers of ethylene oxide and propylene oxide, other non-ionic surfactants, and combinations thereof. The composition may comprise up to 0.05 % of the surfactant based on the weight of the composition.

[0072] Component (J) is an acid acceptor. Suitable acid acceptors include magnesium oxide, calcium oxide, and combinations thereof. The composition may comprise up to 2 % of component (J) based on the weight of the composition.

[0073] Component (K) is a hydrosilylation stabilizer to prevent premature curing of the curable composition. In order to adjust speed of curing and to improve handling of the composition under industrial conditions, the composition may be further combined with an alkyne alcohol, enyne compound, benzotriazole, amines such as tetramethyl ethylenediamine, dialkyl fumarates, dialkenyl fumarates, dialkoxyalkyl fumarates, maleates such as diallyl maleate, and a combination thereof. Alternatively, the stabilizer may comprise an acetylenic alcohol. The following are specific examples of such compounds: such as 2-methyl-3-butyne-2-ol, 3-methyl-1-butyne-3-ol, 3,5-dimethyl-1-hexyne-3-ol, 2-phenyl-3-butyne-2-ol, 3-phenyl-1-butyne-3-ol, 1-ethynyl-1-cyclohexanol, 1,1-dimethyl-2-propynyl(oxy)trimethylsilane, methyl(tris(1,1-dimethyl-2-propynyloxy))silane, or similar acetylene-type compounds; 3-methyl-3-penten-1-yne, 3,5-dimethyl-3-hexen-1-yne, or similar en-yne compounds; Other additives may comprise hydrazine-based compounds, phosphines-based compounds, mercaptane-based compounds,

cycloalkenylsiloxanes such as methylvinylcyclotetrasiloxanes such as 1,3,5,7-tetramethyl-1,3,5,7-tetravinyl cyclotetrasiloxane, 1,3,5,7-tetramethyl-1,3,5,7-tetrahexenyl cyclotetrasiloxane, benzotriazole, or similar triazols. The content of such inhibitors in the hydrosilylation-curable thermoconductive silicone elastomer composition may be within the range of 0.0001 to 5 parts by weight per 100 parts by weight of component (A). Suitable hydro silylation cure inhibitors are disclosed by, for example, U.S. Patents 3,445,420; 3,989,667; 4,584,361; and 5,036,117.

[0074] One skilled in the art would recognize when selecting components for the composition described above, there may be overlap between types of components because certain Components described herein may have more than one function. For example, certain alkoxysilanes may be useful as filler treating agents and as adhesion promoters, and certain plasticizers such as fatty acid esters may also be useful as filler treating agents. One skilled in the art would be able to distinguish among and select appropriate components, and amounts thereof, based on various factors including the intended use of the composition and whether the composition will be prepared as a one-part or multiple-part composition.

[0075] The composition can be prepared by a method comprising combining all components by any convenient means such as mixing at ambient or elevated temperature. When the composition is prepared at elevated temperature, the temperature during preparation is less than the curing temperature of the composition.

[0076] The method may include the steps of providing components (A) - (D) (and optionally (E)), and the steps of combining one or more of (A)-(E) together. The components (A) to (D) and optionally (E) may be combined and offered as one ready-to-use part (one-part) or divided into two parts that would need to be combined before application (two-part). In the case of a two-part system, there is no limitation to the mix ratio, and the mix ratio may be one-to-one or unequal. The method may also include the steps of curing or partially curing, via a hydrosilylation reaction, (A) and (B), in the presence of (C) and (D) and optionally (E). This curing may take place without use of heat, or alternatively via heating. It is also contemplated that (A) and (B) may react with or cure with or in the presence of one or more of the aforementioned additives or other monomers or polymers previously described.

[0077] When component (F) is present, the composition may optionally be prepared by surface treating component (D) (and component (F), if present) with component (G) and thereafter mixing the product thereof with the other components of the composition.

Alternatively, the composition may be prepared as a multiple part composition, for example, when component (K) is absent or when the composition will be stored for a long period of time before use. In the multiple part composition, the crosslinker and catalyst are stored in separate parts, and the parts are combined shortly before use of the composition. For example, a two part curable silicone composition may be prepared by combining components comprising base polymer, catalyst, thermally conductive filler and plasticizer, and one or more additional components in a base part by any convenient means such as mixing. A curing agent part may be prepared by combining components comprising crosslinker, base polymer, thermally conductive filler and plasticizer, and one or more additional components by any convenient means such as mixing. The components may be combined at ambient or elevated temperature, depending on the cure mechanism selected. When a two part curable silicone composition is used, the weight ratio of amounts of base to curing agent may range from 1:1 to 50:1; any ratio within this range may be selected as suitable based on the convenience. One skilled in the art would be able to prepare a curable composition without undue experimentation.

[0078] Method. The disclosure also provides a method of forming the electronic article. The method comprises providing a printed circuit board (PCB); electronic and electric components on the PCB, such components operably connected for converting electric power; one or more partitions; and a pottant; operably assembling electric and electronic components and a PCB for converting electric power to obtain an assembled converter component; placing the assembled converter component into a case; operably attaching one or more partitions to the PCB by an adhesive or an attachment means to form an enclosed space that is open only at the side opposite of the PCB; dispensing a pottant into the enclosed space to completely encase all electric and electronic components in the enclosed space; and curing the pottant.

[0079] More specifically, a pottant useful for this invention may be prepared by any suitable means, including conventional means, of preparing such curable polymer, but in particular, the curable soft tacky gel described herein may be formed by the aforementioned steps of forming the gel. Prior to dispensing into the case, the uncured pottant composition is sufficiently degassed to remove air from the uncured fluid and all parts are mixed. Degassing and mixing may be done by a commercially available mixer-dispenser.

[0080] The pottant may be dispensed into the partitioned enclosed space before or after a lid of the case is placed to close the case. If the pottant is dispensed before the lid

is placed, it is dispensed from the top of the section that is open, to cover all components within the surrounded block, and from above the areas of the PCB not surrounded by the partitions so that the pottant fills any space below and around the PCB and covers the lowest components, then the lid is placed to close the case. For the pottant to be dispensed after the lid is placed, the lid has one or more dispensing hole that corresponds to each of the location of the enclosed space surrounded by the partitions, and the pottant is dispensed into the enclosed space from the dispensing hole.

[0081] It should be appreciated by those of skill in the art that the techniques disclosed herein represent techniques discovered by the inventor to function well in the practice of the invention, and thus can be considered to constitute preferred modes for its practice. However, those of skill in the art should, in light of the present disclosure, appreciate that many changes can be made in the specific embodiments which are disclosed and still obtain a like or similar result without departing from the spirit and scope of the invention. All percentages are in wt. %.

We claim:

1. A power converter device comprising:
 - a printed circuit board (PCB) having at least one region;
 - electronic and electric components on the PCB, such components operably connected to each other for converting electric power;
 - one or more partitions, each partition having an edge; and
 - a pottant,wherein each partition at its edge is in contact with the PCB so that the at least one region of the PCB is surrounded by the one or more the partitions to form one or more enclosures, each enclosure defining an enclosed space above a different region of the PCB and being open only at the side opposite of the PCB, each such region of the PCB supporting one or more electronic or electrical components, each such enclosed space being at least partially filled with the pottant so that the pottant completely encases all electronic or electrical components located in the region, and the PCB is completely covered by the pottant in portions of the PCB that are not surrounded by the partitions, wherein above at least one region of the PCB there is a void above the pottant covering the electronic or electrical components in at least one region of the PCB.
2. The power converter device according to claim 1, wherein the partition is attached to the PCB by an attachment means.
3. The power converter device according to claim 2, wherein the attachment means is an adhesive.
4. The power converter device according to claim 3 wherein the adhesive is a pressure sensitive adhesive.
5. The power converter device according to claim 1, wherein the partition further comprises a support means.
6. The power converter device according to claim 5, wherein the partition is attached to the PCB through the support means.
7. The power converter device according to claim 5, wherein the partition is attached to the PCB by an attachment means and through the support means.
8. The power converter device according to any one of the foregoing claims, wherein the partition comprises a polyurethane, an organopolysiloxane, a polyisobutylene, or a copolymer thereof.
9. The power converter device according to claim 1 that is a junction box, a micro-inverter, a power optimizer or a light-emitting diode converter.

10. A photovoltaic apparatus comprising the power converter device according to claim 6.
11. A method of manufacturing a power device, the method comprising the steps of:
 - a) Operably assembling electric and electronic components and a printed circuit board (PCB) for converting electric power to obtain a first assembled converter component, the PCB having at least one (two??) region;
 - b) Operably attaching one or more partitions, each having an edge, to the PCB of the assembled converter component by an attachment means for attaching each edge to the PCB to form one or more enclosures defining one or more enclosed spaces, each of which is open only at the side opposite of the PCB to obtain a second assembled converter component;
 - c) Placing the second assembled converter component into a case;
 - d) Dispensing a pottant into each enclosed space of the second assembled converter component to completely encase all electric and electronic components in the enclosed space;
 - e) Dispensing the pottant to completely encase the remaining portion of the PCB of the second assembled converter component; and
 - f) Curing the pottant to obtain the power device, wherein above at least one region of the PCB there is a void above the pottant covering the electronic or electrical components in at least one region of the PCB.

Figure 1 Prior art

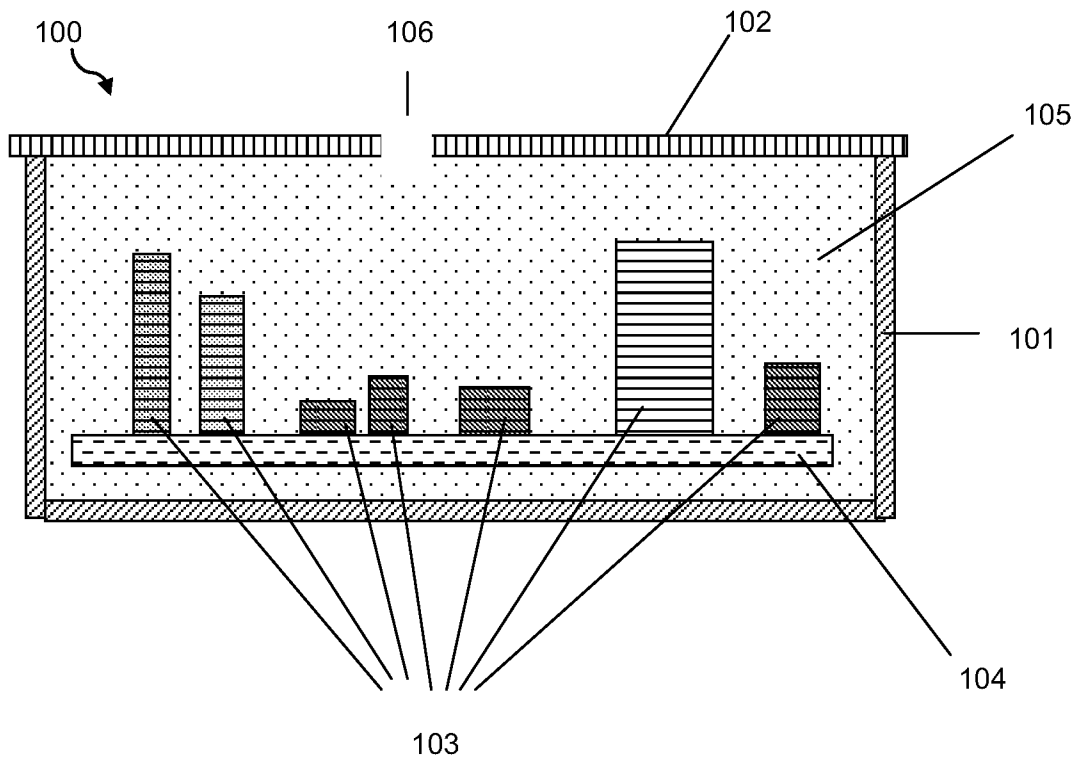


Figure 2

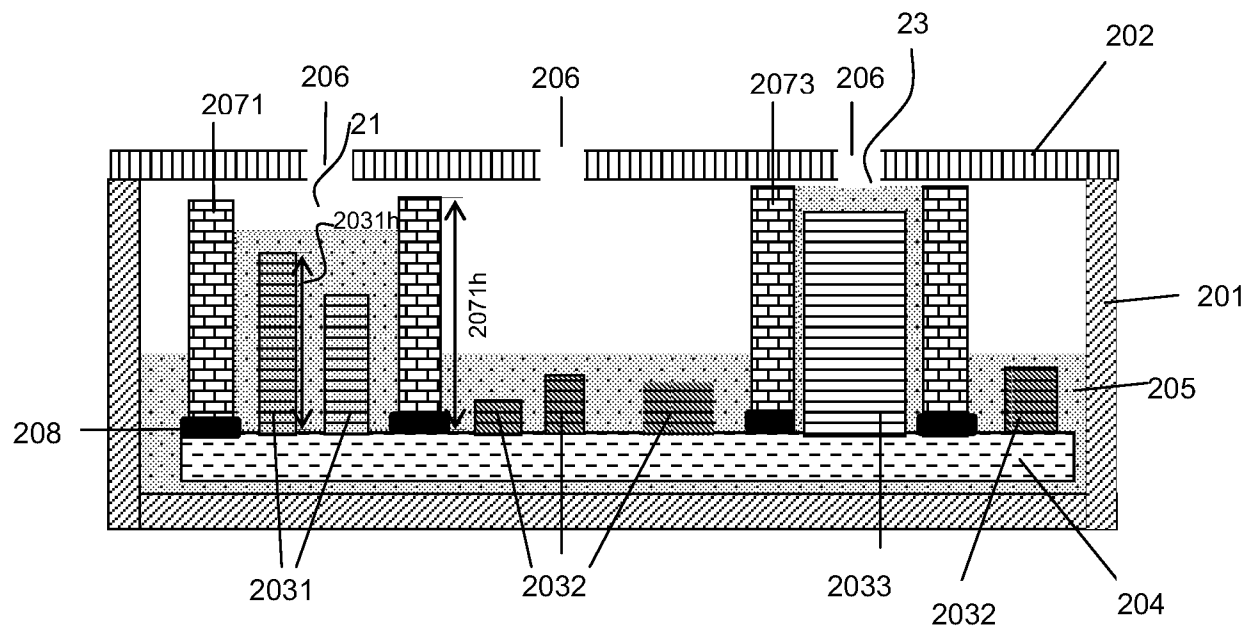


Figure 2a: View from the side

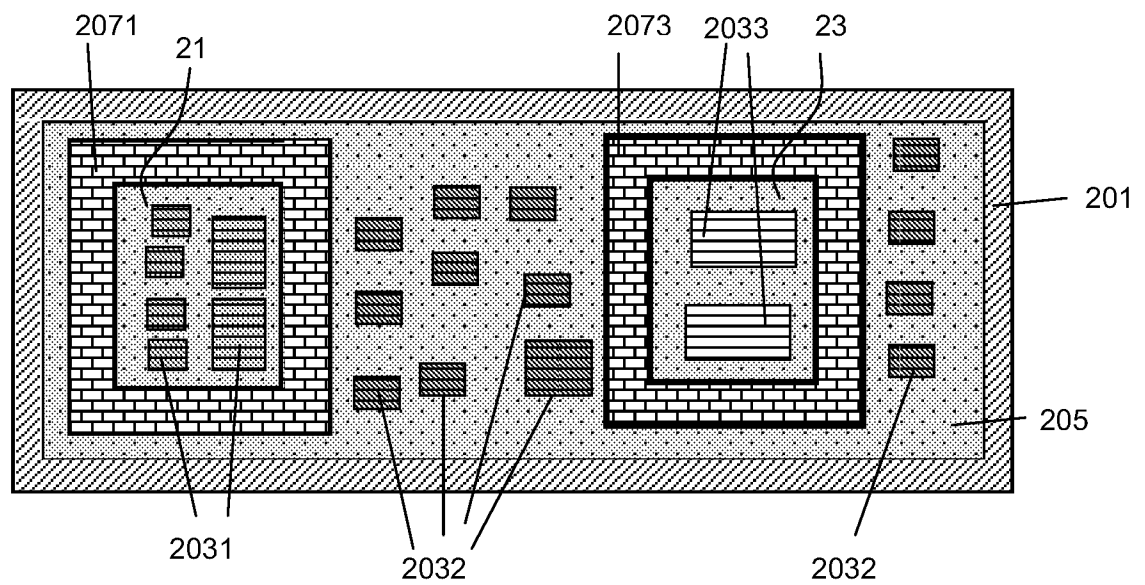


Figure 2b: View from the top

Figure 3

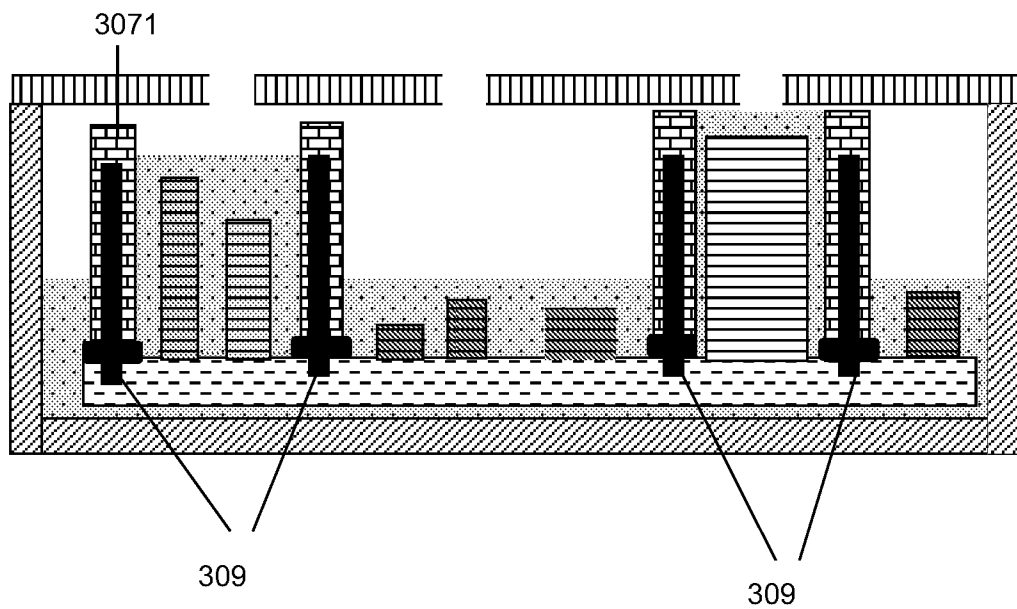


Figure 3a: View from the side

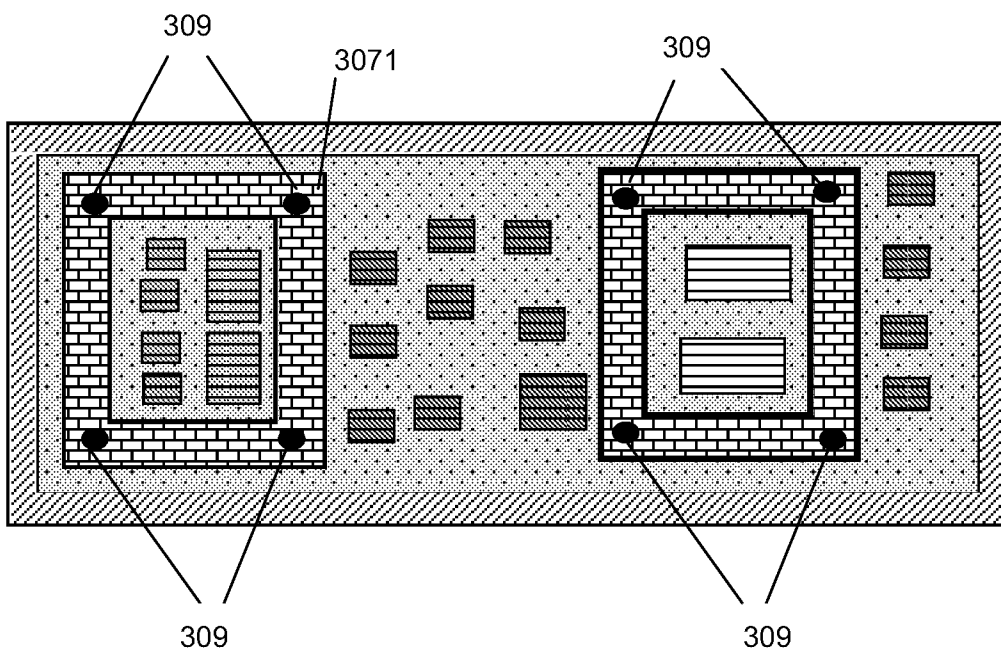


Figure 3b: View from the top

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2014/073952

A. CLASSIFICATION OF SUBJECT MATTER		
H05K 7/20(2006.01)i; H02M 1/00(2007.01)i; H02S 40/30(2014.01)i		
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)		
H05K; H02M; 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)		
CNABS;CNKI;EPODOC;WPI:POWER W CONVERTER?,POWER, (CIRCUIT W BOARD) OR (CIRCUIT W SUBSTRATE) OR PCB OR (WIRING W BOARD) OR (WIRING W SUBSTRATE), POTTANT OR RESIN OR ENCAPSULANT OR SEALANT, DEVICE? OR COMPONENT? OR ELEMENT? OR CHIP?, PARTITION? OR INSOLAT + OR CASE?, (HEAT W SINK) OR HEATSINK OR (HEAT W SPREAD+), HIGH+, HEAT OR THERMAL, SPACE? OR VOID		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 203406769 U (DOW CORNING CHINA HOLDING CO., LTD. ET AL.) 22 January 2014 (2014-01-22) description, paragraphs [0013]-[0087], claims 1 to 10 and figures 2a and 3a	1-11
A	EP 1182768 A2 (VLT CORP.) 27 February 2002 (2002-02-27) the whole document	1-11
A	JP 2010080931 A (KYOCERA CORP.) 08 April 2010 (2010-04-08) the whole document	1-11
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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PCT/CN2014/073952

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