

(51) International Patent Classification:
H01L 33/00 (2010.01)(21) International Application Number:
PCT/CN2014/079876(22) International Filing Date:
13 June 2014 (13.06.2014)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicants: **DOW CORNING CORPORATION** [US/US]; 2200 West Salzburg Road, Midland, Michigan 48686-0994 (US). **DOW CORNING (CHINA) HOLDING CO., LTD.** [CN/CN]; 1077 Zhangjiang Road, Zhangjiang Hi-Tech Park, Shanghai 201203 (CN).(72) Inventors: **ZOU, Lu**; Building 25, Room 504, No. 271 East Huanlin Road, Pudong, Shanghai 200123 (CN). **KIM, Hongsub S.**; 210-601, Ricenz Apt, Jamsil 2-dong, Songpa-gu, Seoul 138-911 (KR). **LARSON, Kent R.**; 4328 N Ehlers Rd, Midland, Michigan 48642 (US). **MORRIS, Nathan**; 819 Roeser St, Freeland, Michigan 48623 (US).(74) Agent: **AFD CHINA INTELLECTUAL PROPERTY LAW OFFICE**; Suite B 1601A, 8 Xue Qing Rd., Haidian, Beijing 100192 (CN).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

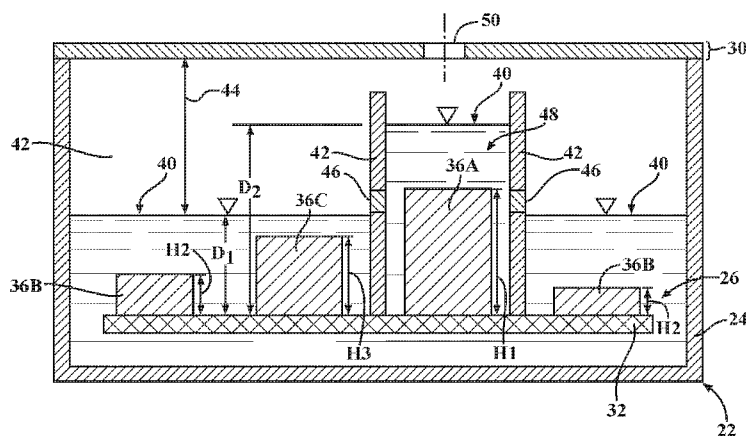
— of inventorship (Rule 4.17(iv))

Published:

— with international search report (Art. 21(3))

(54) Title: ELECTRICAL DEVICE INCLUDING AN INSERT

FIG. 3



(57) Abstract: An electrical device includes a housing having at least one wall defining a cavity. A circuitry substrate is disposed within the cavity with at least one electronic component disposed on and extending from the circuitry substrate. A pottant is disposed within the cavity for encasing the circuitry substrate and the electronic component within the cavity. An insert disposed within the cavity and displacing the pottant for minimizing an amount of the pottant required to encase the circuitry substrate and the electronic component. A method of manufacturing the electrical device is also disclosed.

ELECTRICAL DEVICE INCLUDING AN INSERT

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The subject invention relates to an electrical device including an insert.

2. Description of the Related Art

[0002] Conventional electrical devices, such as light emitting devices (LEDs), typically include a housing defining a cavity. The conventional electrical devices include a circuitry substrate disposed within the cavity with at least one electronic component connected to the circuitry substrate. A pottant is typically disposed within the cavity to completely and uniformly fill the cavity not occupied by the circuitry substrate or the electronic component. The pottant encases the electronic component to protect the electronic component from the environmental elements. However, as the pottant thermally expands within the cavity, the pottant exerts thermal stress on the circuitry substrate and the electronic component, which is undesirable because such stresses can lead to failure of the circuitry substrate and the electronic component. Therefore, it is desirable to reduce the thermal stress of the pottant acting on the circuitry substrate and the electronic component to extend the life of the electrical device.

SUMMARY OF THE INVENTION

[0003] An electrical device includes a housing having at least one wall defining a cavity. A circuitry substrate is disposed within the cavity with at least one electronic component disposed on and extending from the circuitry substrate. A pottant is disposed within the cavity for encasing the circuitry substrate and the electronic component within the cavity. An insert is disposed within the cavity and displacing the pottant for minimizing an amount of the pottant required to encase the circuitry substrate and the electronic component. A method of manufacturing the electrical device is also disclosed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] Other advantages of the present invention will be readily appreciated, as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

[0005] Figure 1 is a cross-sectional view of an LED lamp as a suitable example of an electrical device;

[0006] Figure 2 is a cross-sectional view of an LED luminaries as a suitable example of the electrical device;

[0007] Figure 3 is a cross-sectional view of the housing with the insert disposed on the circuitry substrate;

[0008] Figure 4 is a top view of the housing with the insert disposed on the circuitry substrate showing a void defines by the insert with the insert surrounding the electronic component;

[0009] Figure 5 is a cross-sectional view of the housing with the insert disposed on the circuitry substrate and surrounding taller and intermediate electronic components;

[0010] Figure 6 is a cross-sectional view of the housing with the insert disposed on the circuitry substrate and surrounding the shorter electronic component; and

[0011] Figure 7 is a cross-sectional view of the housing showing the insert extending between the circuitry substrate and the housing.

DETAILED DESCRIPTION

[0012] The present invention relates to a electrical device 20. Referring to the Figures, wherein like numerals indicate like or corresponding parts throughout the several views, suitable examples of the electrical device 20 are generally shown in Figures 1 and 2. The electrical device 20 shown in each of Figures 1-2 are schematic representations. The electrical device 20 may be selected from the group of light emitting devices (LED), which include light emitting diodes and light emitting chips, LED lamps (Figure 1), LED luminaries (Figure 2), LED converters, and junction boxes. The electrical device 20 may be used with a photovoltaic panel. For example, the electrical device 20 may be directly mounted behind the photovoltaic panel for increasing the efficiency of conversion.

[0013] Figure 3 is a schematic representation of a housing 22 common to different electrical devices 20, including the electrical devices 20 described above. As such, any variations or alternative embodiments shown in Figures 4-7 are equally applicable to any electrical device 20.

[0014] Referring to Figure 3, the housing 22 of the electrical device 20 has at least one wall 24 defining a cavity 26. In at least one embodiment, the housing 22 includes a base portion 28 defining the cavity 26 and a lid 30 coupled to the base portion 28 for covering the cavity 26. The lid 30 is moveable between a closed position where the lid 30 covers the cavity 26 and an open position where the lid 30 at least partially exposes the cavity 26 for providing access to the cavity 26.

[0015] Referring again to Figures 1-3, the electrical device 20 also comprises a circuitry substrate 32 disposed within the cavity 26. Typically, the circuitry substrate 32 is selected from the group of printed circuit boards, flexible stripes, films, ceramic boards, and combinations thereof. However, any acceptable circuitry substrate 32 could be used. The circuitry substrate 32 may be connected to wires 34 (best shown in Figure 2) for transmitting an electrical current to and from the circuitry substrate 32.

[0016] The electrical device 20 further comprises at least one electronic component 36 disposed on and extending from the circuitry substrate 32. It is to be appreciated that the electrical device 20 may include a plurality of electronic components 36. Generally, when the plurality of electronic components 36 are present, the electronic components 36 are connected to each other either directly or through the circuitry substrate 32. The electronic component 36 may be any suitable component. For example, the electronic component 36 may be selected from the group of LED chips, LED drivers, LED diodes, capacitors, MOV's, inductors, transistors, transformers, resistors, IC's, relays, and combinations thereof. As best shown in Figures 1 and 2, the electrical device 20 may include a lens 38 coupled to the housing 22 adjacent the electronic component 36 for allowing light to pass through the housing 22.

[0017] As best shown in Figure 3, the electronic component 36 disposed on the circuitry substrate 32 has a height that is measured perpendicular from the circuitry substrate 32. When the plurality of electronic components 36 are present, each of the electronic components 36 can have a different height. For example, taller electronic components 36A have a first height H1 that is greater than a second height H2 of shorter electronic components 36B. The terms taller and shorter as used herein are relative terms used to compare the height of two different electronic components 36. Each of the electronic components 36 disposed on the circuitry substrate 32 may have different heights. For example, one of the electronic component 36 may be referred to an intermediate electronic component 36C and have a third height H3 which is greater than the second height H2 of the shorter electronic component 36B but smaller than the first height H1 of the taller electronic component 36A.

[0018] Generally, electronic components 36 with the same or similar heights are grouped adjacent each other on the circuitry substrate 32. There is no particular height differences that would define a "similar" height, and the electronic components 36 may be grouped together in any desirable configuration. Said differently, the grouping of the electronic components 36 by height may be dictated by the layout and design of the electronic component.

[0019] The cavity 26 of the housing 22 has a starting volume. The circuitry substrate 32 and the electronic components 36 occupy a portion of the starting volume of the cavity 26. As such, the cavity 26 has a remaining volume, which represents the volume of the cavity 26 not occupied by the circuitry substrate 32 and the electronic components 36.

[0020] A pottant 40 is disposed within the cavity 26 and encases the circuitry substrate 32 and the electronic components 36 within the cavity 26. The pottant 40 protects that circuitry substrate 32 and the electronic components 36 from the environmental elements. However, the pottant 40 typically does not fill the entire remaining volume of the cavity 26.

[0021] The pottant 40 comprises a material, which is typically thermally conductive and it is suitable for protection of electrical and/or electronic components 36 of the electrical device 20 from the elements. For example, the pottant 40 may be a polymer composition. The pottant 40 may comprise curable material and/or a non-curable material. When the curable material is used, the curable material is not flammable such that the curable material passes UL 94 V-1 flammability rating or better once cured.

[0022] When the material of the pottant 40 is the polymer composition, the polymer 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 suitable pottant 40s are commercially available 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.

[0023] An insert 42 is also disposed within the cavity 26 and displaces the pottant 40 such that the insert 42 minimizes an amount of the pottant 40 required to encase the circuitry substrate 32 and the electronic components 36. Said differently, the insert 42 occupies a portion of the remaining volume of the cavity 26 thereby limiting the available volume for the pottant 40 to occupy.

[0024] As shown in Figure 3, in at least one embodiment, the insert 42 allows for an uneven level of the pottant 40 within the cavity 26 to ensure the taller electronic components 36A are fully incased in the pottant 40 without having the waste of excess pottant 40 above the shorter electronic components 36B. For example, the insert 42 is positioned within the cavity 26 so that the pottant 40 fully covers each of the electronic components 36 according to the heights of the electronic components 36, but the pottant 40 does not completely fill the remaining volume of the cavity 26 between the electronic component and the lid 30 of the housing 22. Said differently, the pottant 40 disposed within the cavity 26 above the shorter electronic

components 36B defines a first depth D1 that leave a gap 44 between the pottant 40 and the housing 22 while the pottant 40 above the taller electronic components 36A defines a second depth D2 that is larger than the first depth D1 to completely cover the taller electronic components 36A. The second depth D2 of the pottant 40 may be equal to the space between circuitry substrate 32 and the housing 22 such that at least of portion of the cavity 26 is considered to be filled by the pottant 40. The difference between the first depth D1 and the second depth D2 of the pottant 40 results in the uneven level of the pottant 40 within the cavity 26 thereby reducing the amount of pottant 40 required.

[0025] The insert 42 may be disposed adjacent the circuitry substrate 32 opposite the electronic components 36. In such an embodiment, the insert 42 only takes up a portion of the volume of the cavity 26 without affecting the depth of the pottant 40 above the electronic components 36.

[0026] The insert 42 reduces the amount of the pottant 40 required to encase the circuitry substrate 32 and the electronic components 36. Typically, the presence of the insert 42 reduces the amount of the pottant 40 needed to effectively protect the circuitry substrate 32 and the electronic components 36 by of from about 10, more typically of from about 35, and even more typically of from about 50 percent as compared to conventional electrical devices 20 without the insert 42 present and completely fill the remaining volume of the cavity 26 of the housing 22 with pottant 40.

[0027] The reduction in the amount of pottant 40 is advantageous for reducing the cost of pottant 40 necessary to protect the circuitry substrate 32 and the electronic components 36. Additionally, the space between the pottant 40 and the housing 22 above the shorter electronic components 36B allows the pottant 40 to thermally expand thereby relieving the shorter electronic components 36B from the thermal stress. Furthermore, the reduction of the amount of pottant 40 reduces a weight of the electrical device 20, which can reduce the mechanical support required to support the electrical device 20, thus allowing for more cost reduction as well as reducing the mechanical stress of any structure supporting the electrical device 20. The insert 42 allows for a single potting process that provides protection of both sides of the circuitry substrate 32 and a terminal of the circuitry substrate 32 does not need to be masked.

[0028] The insert 42 may comprise a material different from the material of the pottant 40. Additionally, the material of the insert 42 may be compressible for allowing thermal expansion of the pottant 40. Furthermore, the material of the insert 42 may also be expandable to account for thermal contraction of the pottant 40. The material of the insert 42 may be

thermally conductive or thermally insulative for controlling the thermal expansion of the pottant 40. Allowing thermal expansion of the pottant 40 within the cavity 26 reduces the thermal stress acting on the circuitry substrate 32 and the electronic components 36, which can extend a life of the circuitry substrate 32 and the electronic components 36. Typically, the thermal stress of the electrical device 20 is reduced by of from about 75, more typically of from about 85, and even more typically of from about 93 percent compared to electrical devices 20 that have a cavity 26 completely filled with pottant 40.

[0029] The insert 42 may be made of any material that is rigid enough to hold it essentially in a vertical position relative to the circuitry substrate 32. Alternatively, the insert 42 can be made from a material that is not self-supporting. The material of the insert 42 may comprise cellulose- or lignin-based material, such as paper, which may be treated with surface coating materials. The insert 42 is preferably made from such material that the insert 42 has a lifetime longer than or equal to the lifetime of the electrical device 20, i.e. 25 years or more. The insert 42 is preferably electrically insulating (i.e. not electrically conductive) so that it would not interfere with normal operation of the electrical device 20 in which the insert 42 is placed. The insert 42 may not contain components that would inhibit curing of the pottant 40. For example, the insert 42 may not contain phosphoric acid and derivative materials.

[0030] The material of the insert 42 may be any polymeric solid or porous material. For example, the insert 42 may comprise a thermoplastic and/or thermoset material. Typically, the material of the insert 42 is selected from the group of polyurethane, polyolefin, ethylene vinyl acetate, silicone, organopolysiloxane, polyisobutylene, polybutadiene, epoxy, polychloroprene, melamine, polyimide, polyester, polyether, polyvinyl chloride, and combinations thereof.

[0031] The material of the insert 42 can be a foam with the foam defining a plurality of cells in the foam with at least 50% of the cells closed for minimizing infiltration of the pottant 40 into the foam. The foam can be either formed in place or prefabricated. For example, blocks of prefabricated foam can be insert 42ed into the cavity 26 as the insert 42. Additionally, the foam can be granular foam. However, it is to be appreciated that the material of the insert 42 can be a non-compressible thermoplastic material, particularly when the electrical device 20 is the LED lamps and LED luminaries.

[0032] When the material of the insert 42 is the foam, the foam material is flexible and requires low pressure to deform, expand, and contract. For example, the foam material may be elastomeric. The foam material may be selected from the group of polyurethane foam, silicone foam, polystyrene foam, and combinations thereof. Additionally, when the material of

the insert 42 is the foam, the cells may be closed to prevent penetration of the pottant 40 through the insert 42, or the cells may be open or partially open so long as the penetration of uncured pottant 40 is slow enough so that the pottant 40 does not migrate through the insert 42 before the pottant 40 is cured. Such slow penetration may be achieved if the cell size is small and/or a distance that the pottant 40 must travels to migrate through the insert 42 is sufficiently long and the pottant 40 has sufficient viscosity that time it would take for the uncured pottant 40 to travel from one side of the insert 42 to the other side of the insert 42 is greater than the time that it takes for the pottant 40 to cure after the pottant 40 has been dispensed into the housing 22.

[0033] The insert 42 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 insert 42 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.

[0034] With reference to Figure 3, the insert 42 may include a reinforcing element 46 for increasing the rigidity of the insert 42. When employed, the reinforcing element 46 may be selected from the group of frames, meshes, foils, films made of metal or plastic, scaffolds, pillars, poles, and combinations of any two or more thereof for increasing a strength of said insert 42. The reinforcing element 46 may be included within the insert 42. For example, the insert 42 may be formed around a mesh material. Alternatively, the reinforcing element 46 may be disposed along the insert 42, such as a foam backed tape. The reinforcing element 46 may be permanent, or may be temporarily placed while the pottant 40 is uncured and is removable when the pottant 40 is cured.

[0035] As shown in Figures 1 and 3, the insert 42 is spaced from a portion of the circuitry substrate 32 for allowing the pottant 40 to flow around the insert 42 to encase the circuitry substrate 32 not contacted by the insert 42 during manufacturing of the electrical device 20.

[0036] As shown in Figure 3 and 5-7, the insert 42 may be disposed on the circuitry substrate 32 adjacent the electronic components 36 with the insert 42 extending from the circuitry substrate 32. In such an embodiment, the insert 42 is typically perpendicular to the circuitry substrate 32. However, the insert 42 may be at an angle relative to the circuitry substrate 32.

[0037] When the insert 42 is disposed on the circuitry substrate 32, the insert 42 may define a void 48 with at least one of the electronic components 36 disposed within the void 48. Said differently, the insert 42 surrounds at least one of the electronic components 36. For example,

the insert 42 may surround a perimeter of the taller electronic components 36A such that the taller electronic components 36A are disposed within the void 48. As such, the shorter electronic components 36B would typically be outside the void 48. However, it is to be appreciated that some of the shorter electronic components 36B may also be disposed within the void 48 of the insert 42 depending on the desired configuration of the electronic components 36 on the circuitry substrate 32, as shown in Figure 6.

[0038] The pottant 40 is disposed within the void 48 of the insert 42 to cover the electronic components 36. The pottant 40 used within the void 48 of the insert 42 may be same or different than the pottant 40 used outside the insert 42. It may be advantageous to match the thermal capacity of a pottant 40 to the electrical or electronic components 36 in a particular enclosed space. The housing 22 may define a hole 50 for allowing the pottant 40 to be disposed within the void 48 of the insert 42. As such, when present, the hole 50 is typically aligned with the void 48.

[0039] The insert 42 provides a barrier for allowing the depth of the pottant 40 inside the void 48 of the insert 42 to vary from the depth of the pottant 40 outside the void 48. Therefore, the insert 42 allows for the uneven depth of the pottant 40 within the cavity 26 to account for the taller and shorter electronic components 36B. The insert 42 may be disposed on the circuitry substrate 32 in any configuration as long as the insert 42 creates the void 48 wherein the pottant 40 is retained within the void 48 without migrating outside the insert 42. Additionally, the insert 42 may be coupled to the housing 22 and contact the circuitry substrate 32 without the insert being coupled to the circuitry substrate 32. For example, when the housing 22 includes a lid 30, the insert 42 may be coupled to the lid 30 and contact the circuitry substrate 32 when the lid 30 is in the closed position.

[0040] Typically, the second depth D2 of the pottant 40 is within the void 48 of the insert 42 and the first depth D1 of the pottant 40 is outside the void 48 of the insert 42. However, as shown in Figure 6, it is to be appreciated that the insert 42 may be used to surround the shorter electronic components 36B such that the first depth D1 of the pottant 40 would be within the void 48 and the second depth D2 of the pottant 40 would be outside the void 48. As such, the height of the insert 42, when the insert 42 defines the void 48 is greater than the second depth D2 of the pottant 40. Additionally, the height of the insert 42 may be such that the insert 42 extends from the circuitry substrate 32 to the house, sidewall 24A, and/or lid 30, as shown in Figure 7.

[0041] Additionally, as shown in Figures 4 and 5, the electrical device 20 may include more than one insert 42. When the insert 42 is made from two or more components, the components may be attached to each other or the components may be spaced from each other. Furthermore, the insert 42 may form a variety of shapes. For example, the insert 42 may 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 faces of the insert 42 may be flat or curved. Alternatively, the insert 42 may be constructed from two or more components. An exterior surface of the insert 42 in contact with the pottant 40 could be smooth or non-smooth (jagged, corrugated, or the like) to increase the surface area of the insert 42 and increase the bond between the pottant 40 and the insert 42.

[0042] The insert 42 may be coupled to the circuitry substrate 32 in any suitable fashion. For example, a fastening element may be used to couple the insert 42 to the circuitry substrate 32. When employed, the fastening element may be selected from the group of adhesives, adhesive tape, pressure sensitive adhesive, cyanoacrylate, urethane glue, sealants, hook and loop fasteners, hinges, friction fit, fasteners, magnets, gaskets, and combinations thereof. Also, the circuitry substrate 32 may be specifically designed for use with the insert 42 when the insert 42 is disposed on the circuitry substrate 32. For example, the circuitry substrate 32 may define grooves and/or receiving hole 50s for the insert 42 to be placed in and attached.

[0043] A method of manufacturing the electrical device 20 is described below. The method includes the step of disposing the circuitry substrate 32 with the electronic components 36 disposed thereon within the cavity 26 of the housing 22. The insert 42 is then coupled to the circuitry substrate 32 within the cavity 26 of the housing 22.

[0044] The pottant 40 is then dispensed into the cavity 26 of the housing 22 such that the pottant 40 contacts the insert 42 and encases the circuitry substrate 32 and the electronic components 36. The pottant 40 may be dispensed into the cavity 26 before or after the lid 30 of the case is placed into the closed position. When the lid 30 is in place, the pottant 40 may be dispensed into the cavity 26 and/or the void 48 of the insert 42 through the hole 50 defined by the lid 30. Alternatively, the housing 22 itself may define the hole 50 for allowing the pottant 40 to be dispensed into the cavity 26 and/or the void 48 of the insert 42. The pottant 40 is then cured to obtain the electrical device 20.

EXAMPLE

[0045] A first comparative test is performed to determine the thermal stress relief provided by the insert 42 within the housing 22. A first test container is provided. The first test container defines a cavity having a volume. The volume of the cavity of the first test container is filled with a pottant comprising silicone. The pottant of the first test container is cured at about 25 degrees Celsius. The first test container and the pottant is heated to about 80 degrees Celsius. The thermal stress of the first test container was determined to be about 1.6 psi/degree Celsius.

[0046] A second test container is provided. The second test container defines a cavity having a volume. Half of the volume of the cavity of the second test container is filled with a pottant comprising silicone. The pottant of the second test container is cured at about 25 degrees Celsius. The second test container and the pottant is heated to about 80 degrees Celsius. The thermal stress of the second test container was determined to be about 0.6 psi/degree Celsius.

[0047] A third test container is provided. The third test container defines a cavity having a volume. An insert is disposed within the cavity of the third test container. The insert occupies about 3.2 percent of the volume of the third test container. The remaining volume of the third test container is filled with a pottant comprising silicone. The pottant of the third test container is cured at about 25 degrees Celsius. The third test container and the pottant is heated to about 80 degrees Celsius. The thermal stress of the third test container was determined to be about 0.4 psi/degree Celsius.

[0048] As a result of the first comparative test, it was determined that the third test container with the insert disposed therein had about a 75 percent reduction of the thermal stress compared to the first test container and about a 33 percent reduction of the thermal stress compared to the second test container. Therefore, the inclusion of the insert within the third test container resulting in a significant reduction of the thermal stress of the test containers.

[0049] A second comparative test is performed to determine the thermal stress relief provided by the insert 42 within the housing 22. A fourth test container is provided. The fourth test container defines a cavity having a volume. The volume of the cavity of the fourth test container is filled with a pottant comprising polyurethane. The pottant of the fourth test container is cured at about 25 degrees Celsius. The fourth test container and the pottant is heated to about 80 degrees Celsius. The thermal stress of the fourth test container was determined to be about 4.1 psi/degree Celsius.

[0050] A fifth test container is provided. The fifth test container defines a cavity having a volume. Half of the volume of the cavity of the fifth test container is filled with a pottant comprising polyurethane. The pottant of the fifth test container is cured at about 25 degrees Celsius. The fifth test container and the pottant is heated to about 80 degrees Celsius. The thermal stress of the fifth test container was determined to be about 1.6 psi/degree Celsius.

[0051] A sixth test container is provided. The sixth test container defines a cavity having a volume. An insert is disposed within the cavity of the sixth test container. The insert occupies about 3.2 percent of the volume of the sixth test container. The remaining volume of the sixth test container is filled with a pottant comprising polyurethane. The pottant of the sixth test container is cured at about 25 degrees Celsius. The sixth test container and the pottant is heated to about 80 degrees Celsius. The thermal stress of the sixth test container was determined to be about 0.4 psi/degree Celsius.

[0052] As a result of the second comparative test, it was determined that the sixth test container with the insert disposed therein had about a 90 percent reduction of the thermal stress compared to the fourth test container and about a 75 percent reduction of the thermal stress compared to the fifth test container. Therefore, the inclusion of the insert within the sixth test container resulting in a significant reduction of the thermal stress of the test containers.

[0053] While the invention has been described with reference to exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.

CLAIMS

What is claimed is:

1. An electrical device comprising:
a housing having at least one wall defining a cavity;
5 a circuitry substrate disposed within said cavity;
at least one electronic component disposed on and extending from said circuitry substrate;
a pottant disposed within said cavity and encasing said circuitry substrate and said
electronic component within said cavity; and
an insert disposed within said cavity and coupled to said circuitry substrate with said
10 insert displacing said pottant such that said insert minimizes an amount of said pottant required to
encase said circuitry substrate and said electronic component.
2. An electrical device as set forth in claim 1 wherein said insert comprises a material
different from a material of said pottant.
3. An electrical device as set forth in claim 2 wherein said material of said insert is
15 compressible for allowing for thermal expansion of said pottant.
4. An electrical device as set forth in claim 4 wherein said material of said insert is selected
from the group of polyurethane, polyolefin, ethylene vinyl acetate, silicone, organopolysiloxane,
polyisobutylene, polybutadiene, epoxy, polychloroprene, melamine, polyimide, polyester,
polyether, polyvinyl chloride, and combinations thereof.
- 20 5. An electrical device as set forth in claim 4 wherein said material of said insert is a foam.
6. An electrical device as set forth in claim 5 wherein said foam defines a plurality of cells
in said foam with at least 50% of said cells closed for minimizing infiltration of said pottant into said
foam.
7. An electrical device as set forth in any one of the proceeding claims wherein said insert
25 includes a reinforcing element for increasing a strength of said insert.
8. An electrical device as set forth in claim 7 wherein said reinforcing element is selected
from the group of frames, meshes, foils, films made of metal or plastic, scaffolds, pillars, poles,
and combinations thereof.
9. An electrical device as set forth in any one of the proceeding claims wherein said insert
30 is spaced from said circuitry substrate for allowing said pottant to flow around said insert to encase
said circuitry substrate during manufacturing of said electrical device.
10. An electrical device as set forth in any one of the proceeding claims wherein said insert

is disposed on said circuitry substrate adjacent said electronic component with said insert extending from said circuitry substrate.

35 11. An electrical device as set forth in any one of the proceeding claims wherein said insert defines a void with said at least one electronic component disposed within said void of said insert such that said insert surrounds said at least one electronic component.

 12. An electrical device as set forth in claim 11 wherein said housing defines a hole for allowing said pottant to be disposed within said void of said insert.

40

13. A method of manufacturing a electrical device comprising the steps of:

- a) disposing a circuitry substrate having at least one electronic component disposed thereon within a cavity of a housing of the electrical device;
- b) coupling an insert to the circuitry substrate within the cavity of the housing;
- 45 c) dispensing a pottant into the cavity of the housing such that the pottant contacts the insert and encases the circuitry substrate and the electronic component; and
- d) curing the pottant to obtain the electrical device.

14. A method of manufacturing an electrical device as set forth in claims 1-12, said
50 method comprising the steps of:

- a) disposing a circuitry substrate having at least one electronic component disposed thereon within a cavity of a housing of the electrical device;
- b) coupling an insert to the circuitry substrate within the cavity of the housing;
- c) dispensing a pottant into the cavity of the housing such that the pottant contacts the
55 insert and encases the circuitry substrate and the electronic component; and
- d) curing the pottant to obtain the electrical device.

FIG. 1

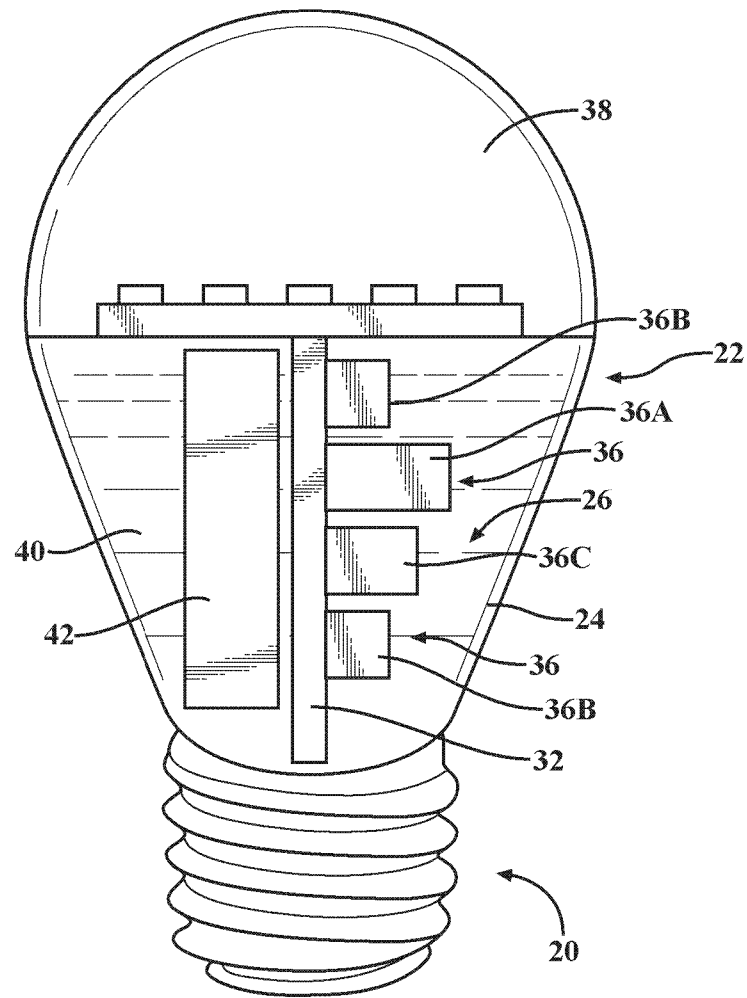


FIG. 2

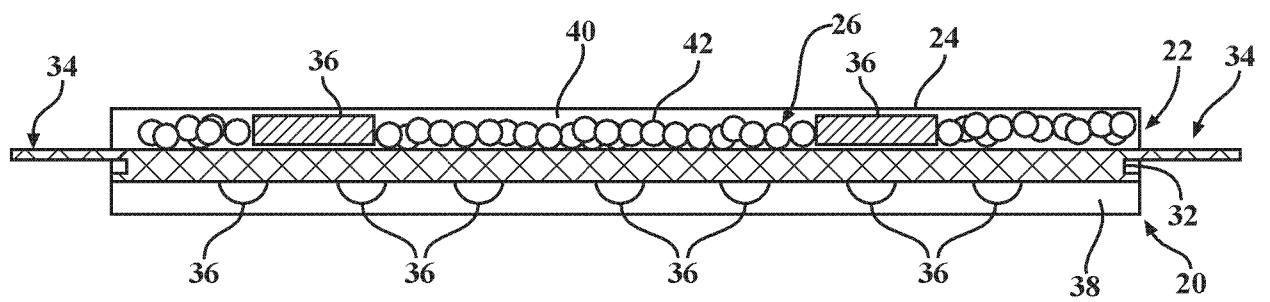


FIG. 3

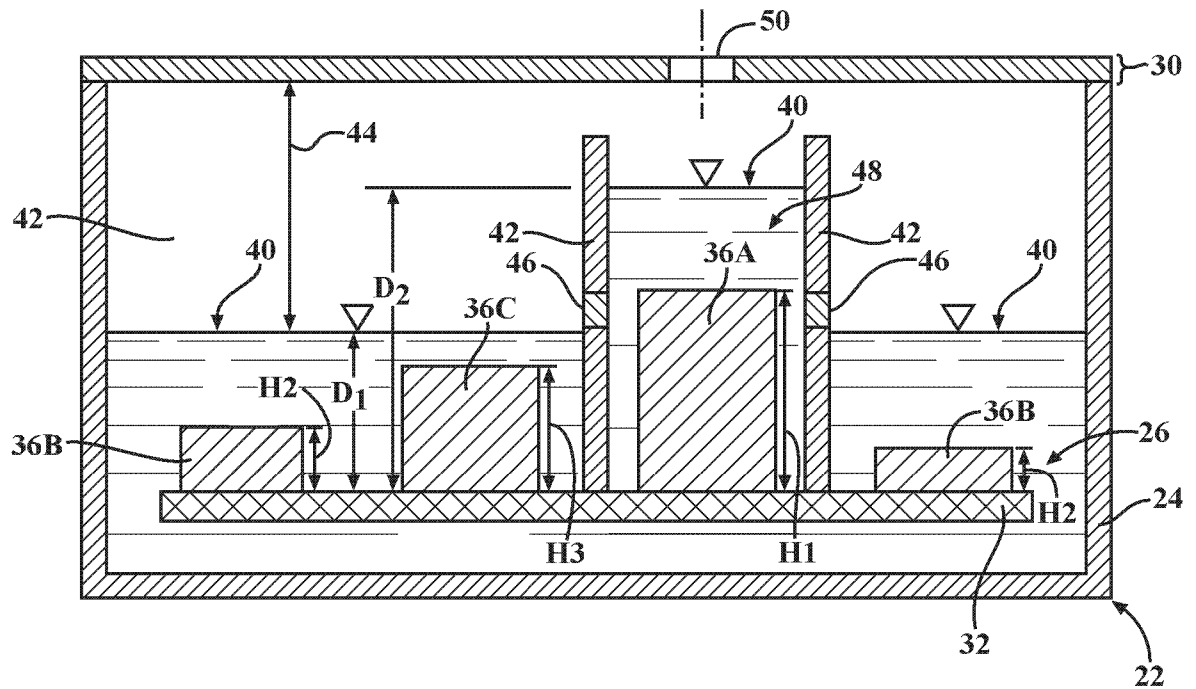


FIG. 4

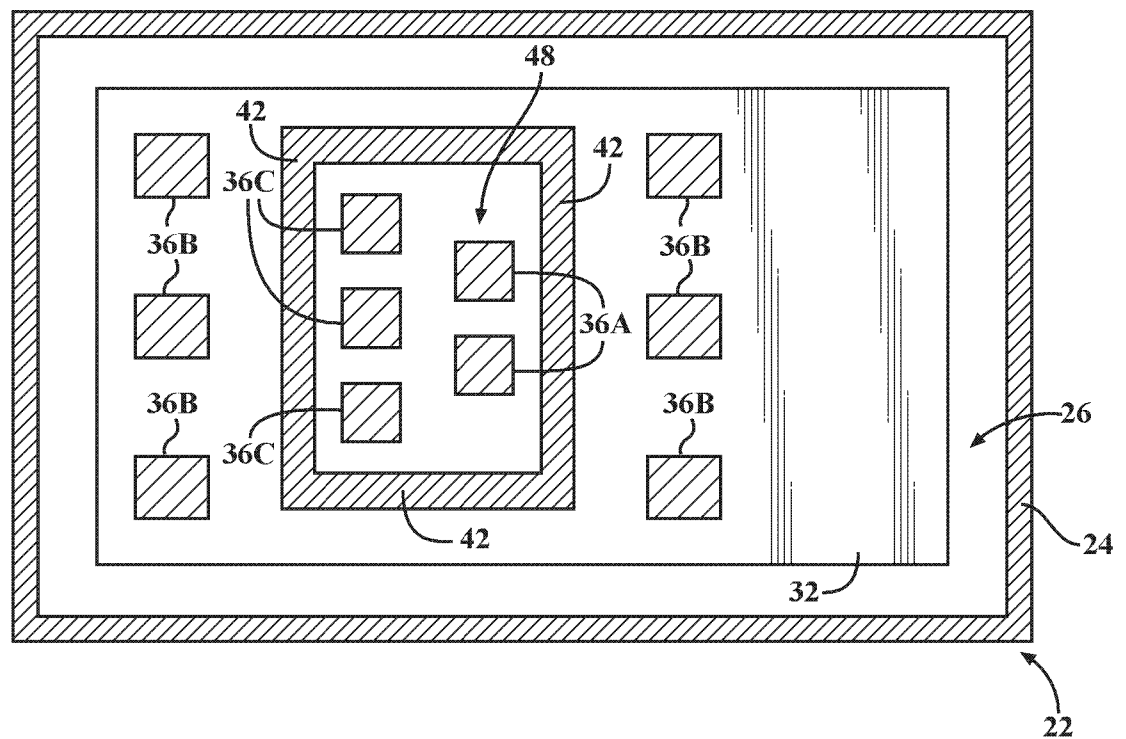


FIG. 5

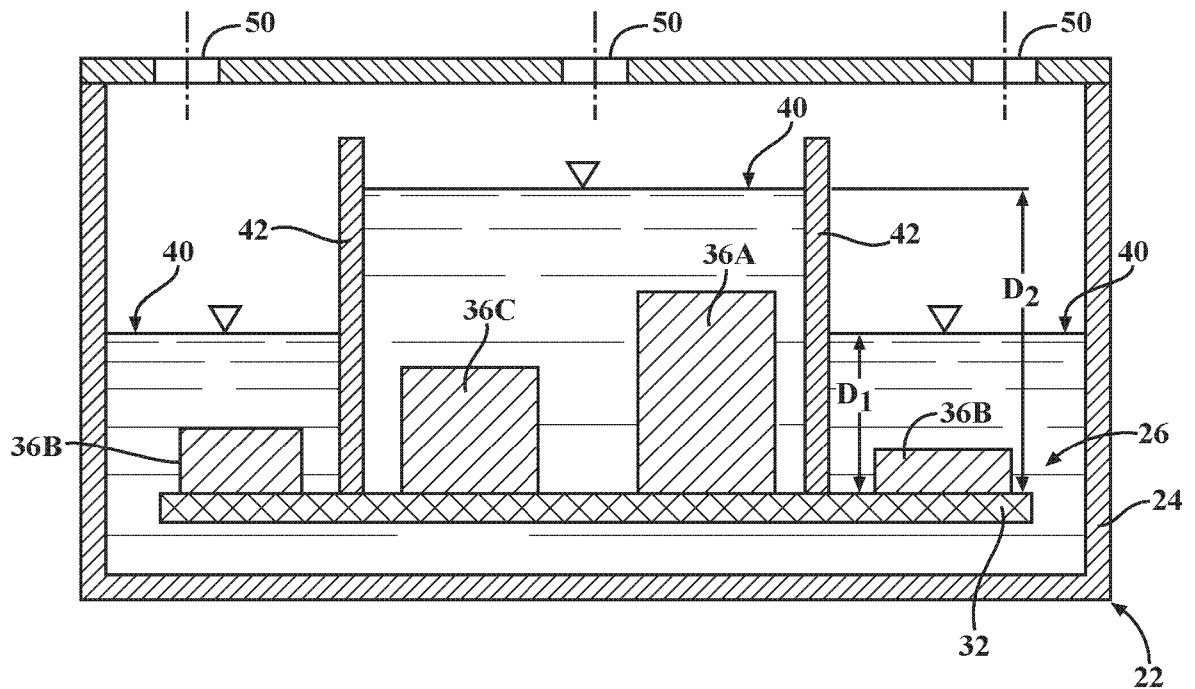
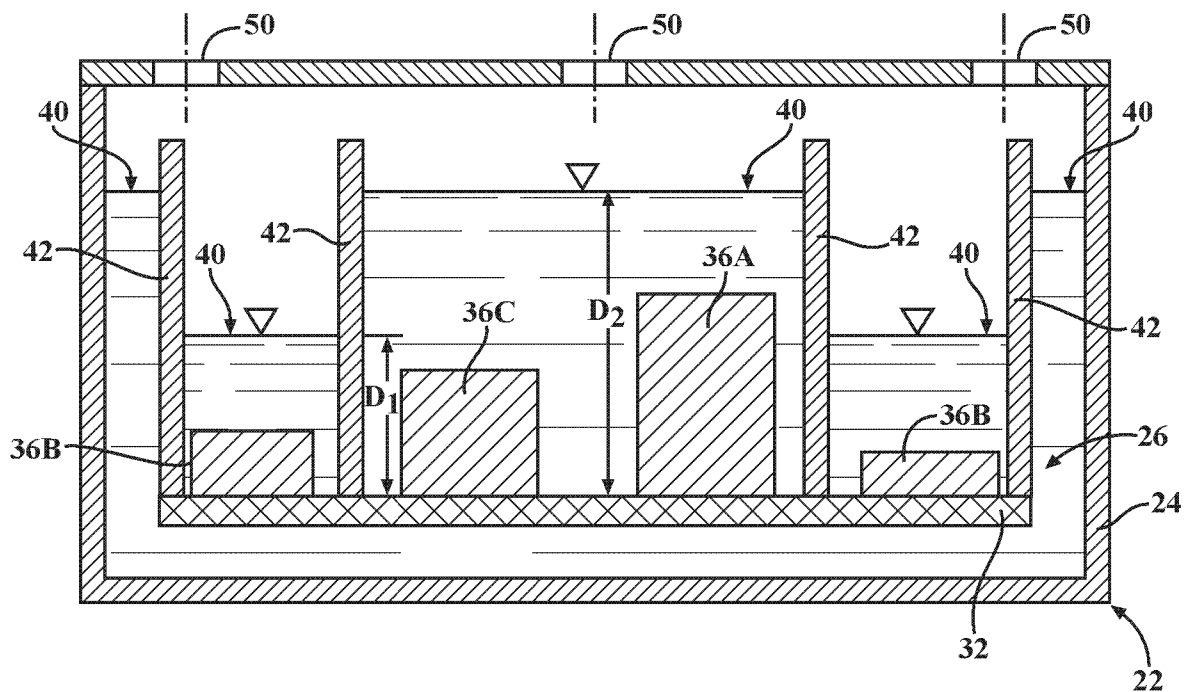


FIG. 6



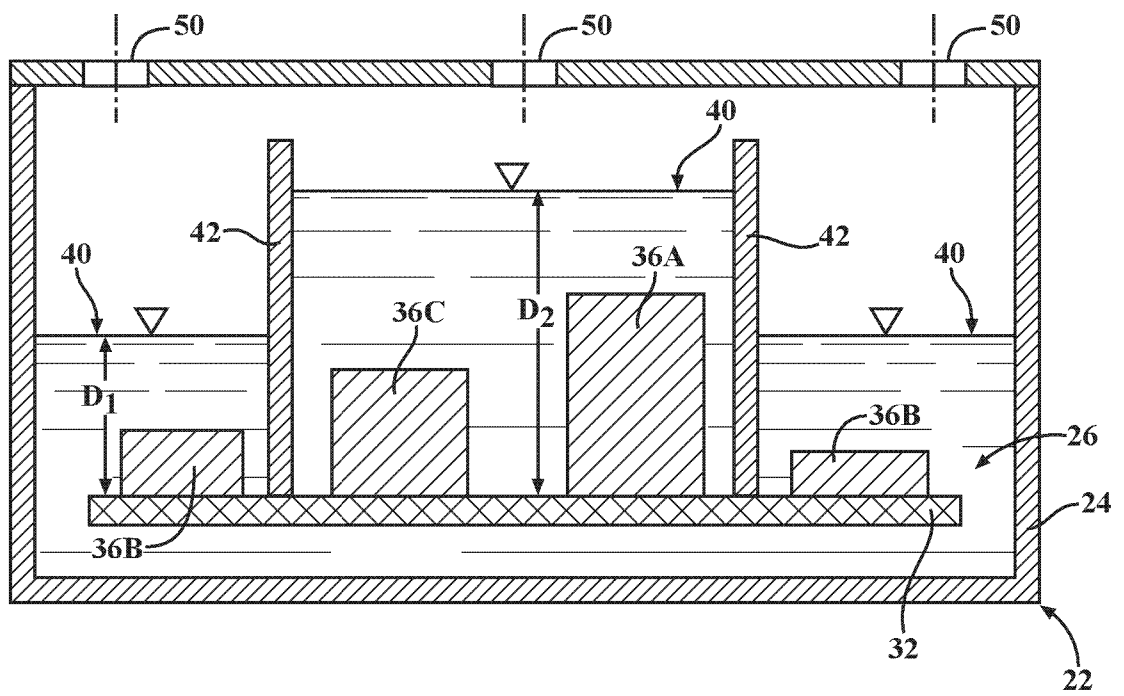


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2014/079876

A. CLASSIFICATION OF SUBJECT MATTER

H01L 33/00(2010.01)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)

H01L; F21V

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)

CNPAT,CNXTX,CNKI,EPODOC,WPI: LED, THERMAL, STRESS, TEMPERATURE, SEPARAT???, ISOLAT???, MINIMIZ???, DECREAS???, REDUC???, POT???, INSERT, HEIGHT, DEPTH

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 101958390 A (LI, GANG) 26 January 2011 (2011-01-26) description, paragraphs [0042] to [0052] and figures 1-3	1-14
A	CN 101867008 A (RESEARCH INSTITUTE OF SUN YAT SEN UNIVERSITY IN FOSHAN) 20 October 2010 (2010-10-20) the whole document	1-14
A	JP 2003273407 A (SHARP K.K.) 26 September 2003 (2003-09-26) the whole document	1-14
A	US 2008031009 A1 (CITIZEN ELECTRONICS CO., LTD.) 07 February 2008 (2008-02-07) the whole document	1-14



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

16 December 2014

Date of mailing of the international search report

30 December 2014

Name and mailing address of the ISA/CN

STATE INTELLECTUAL PROPERTY OFFICE OF THE
P.R.CHINA(ISA/CN)
6,Xitucheng Rd., Jimen Bridge, Haidian District, Beijing
100088 China

Authorized officer

HUANG,Shan

Facsimile No. (86-10)62019451

Telephone No. (86-10)62413762

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2014/079876

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	101958390	A	26 January 2011	Non e			
CN	101867008	A	20 October 2010	CN	101867008	B	21 November 2012
JP	2003273407	A	26 September 2003	US	2003227030	A1	11 December 2003
				JP	3973457	B2	12 September 2007
				CN	1445870	A	01 October 2003
US	2008031009	A1	07 February 2008	JP	2007227530	A	06 September 2007
				JP	5268082	B2	21 August 2013
				DE	102007006171	A1	06 September 2007
				CN	101026216	A	29 August 2007