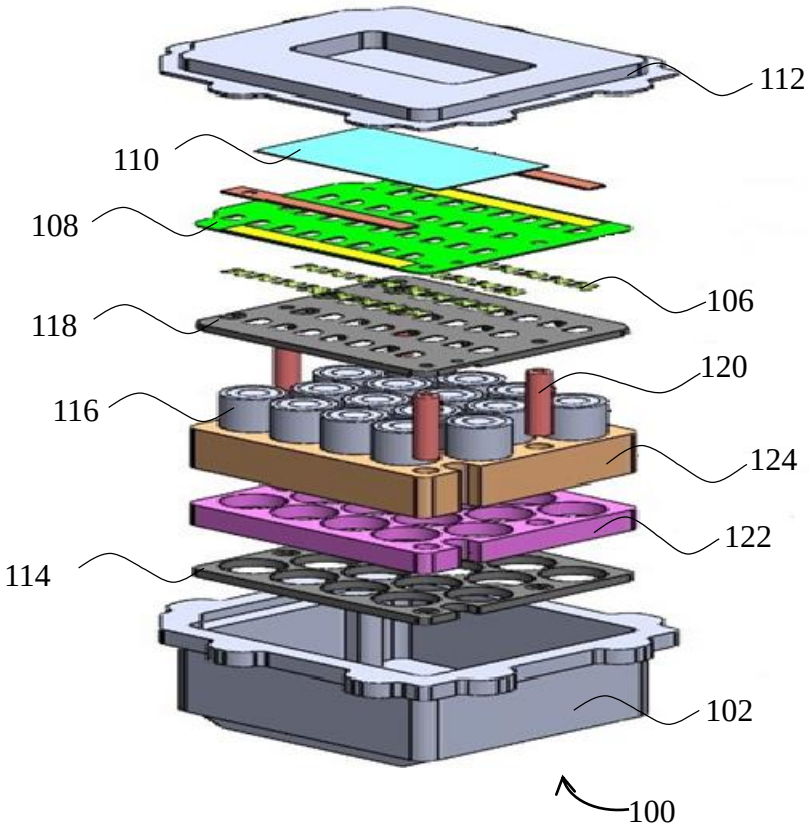


FIG. 1

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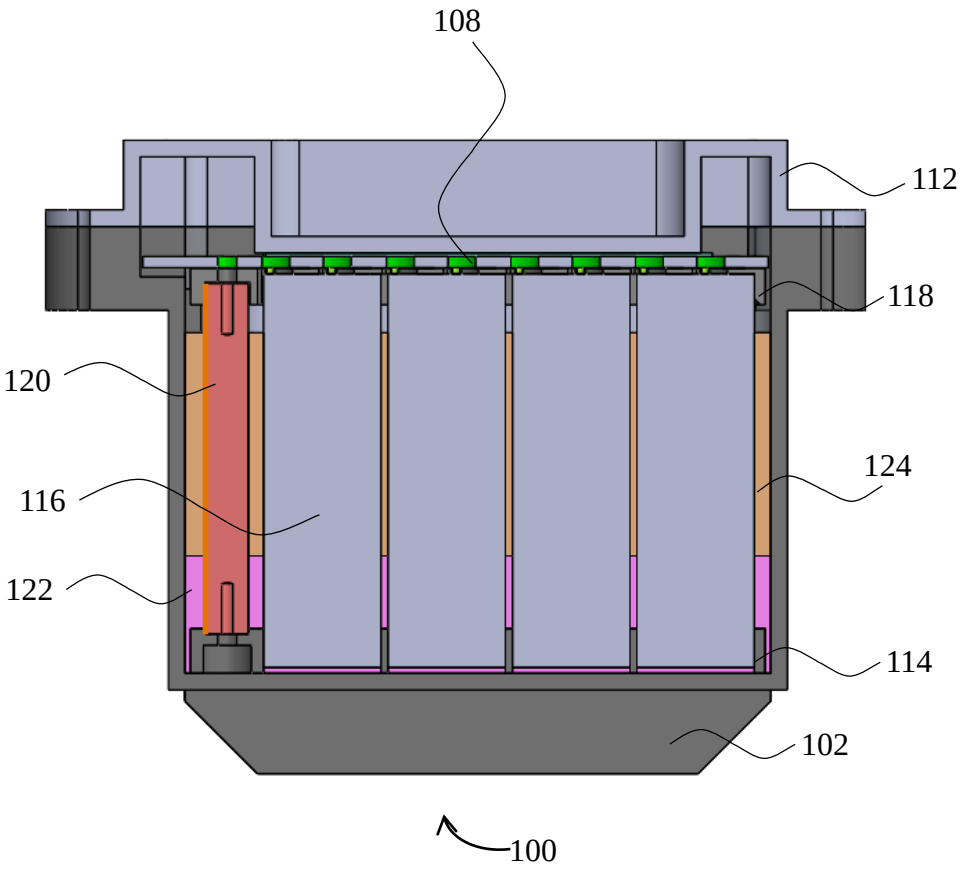


FIG. 2

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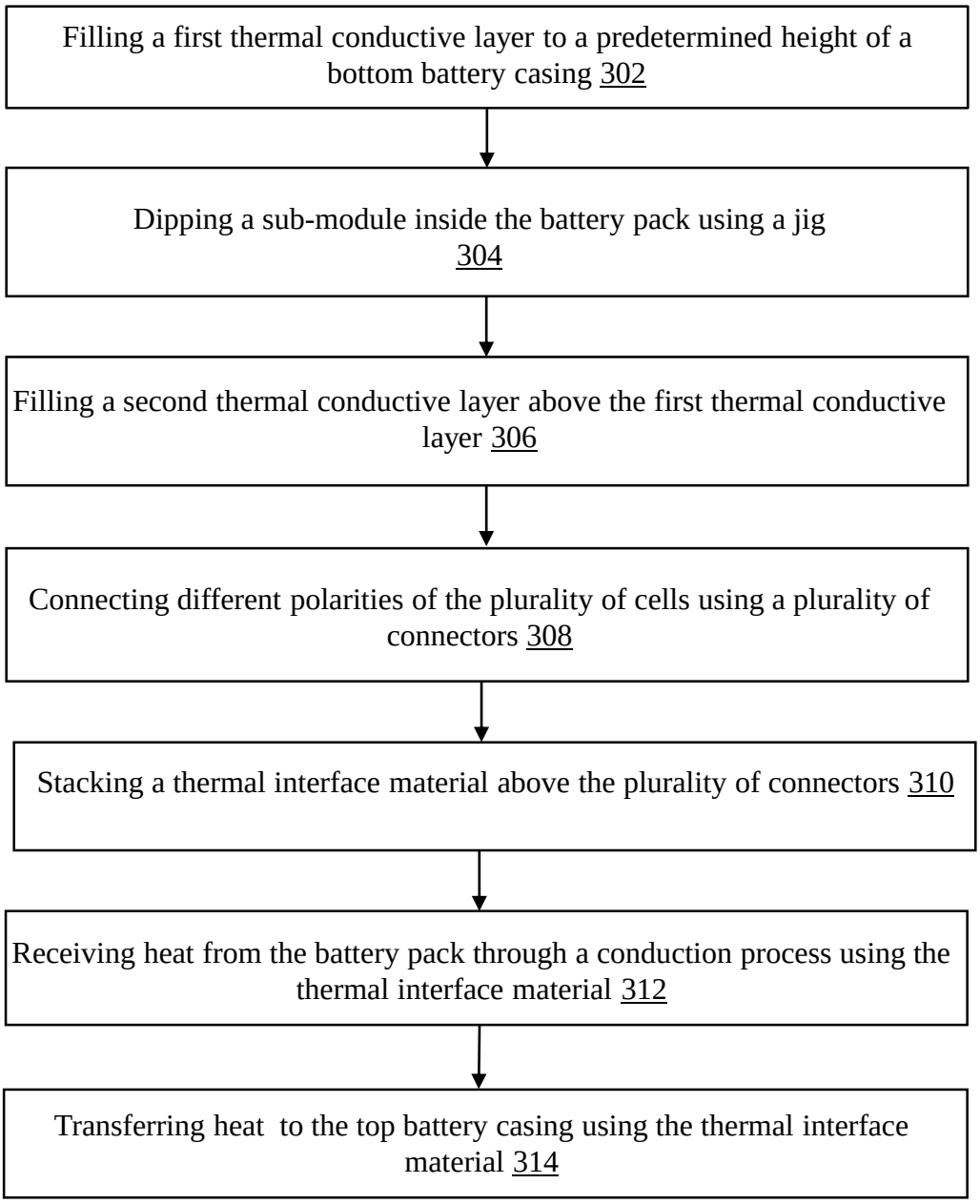


FIG. 3

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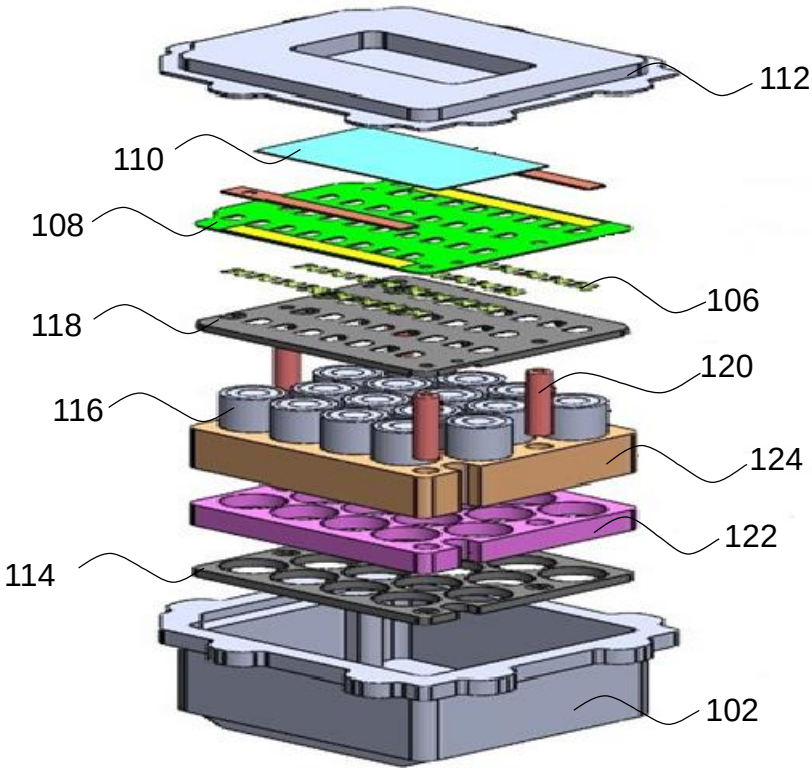


FIG. 1

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Pankaj Kumar
IN/PA- 1432
Patent Agent for the Applicant

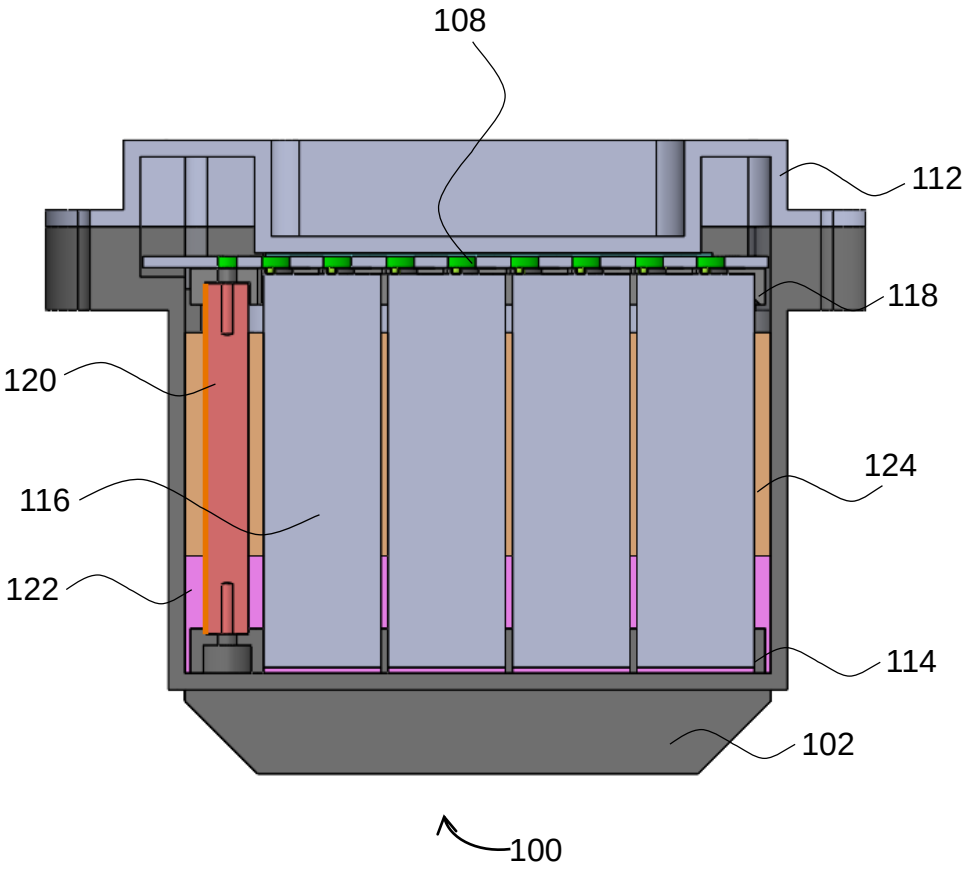


FIG. 2

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Pankaj Kumar
IN/PA- 1432
Patent Agent for the Applicant

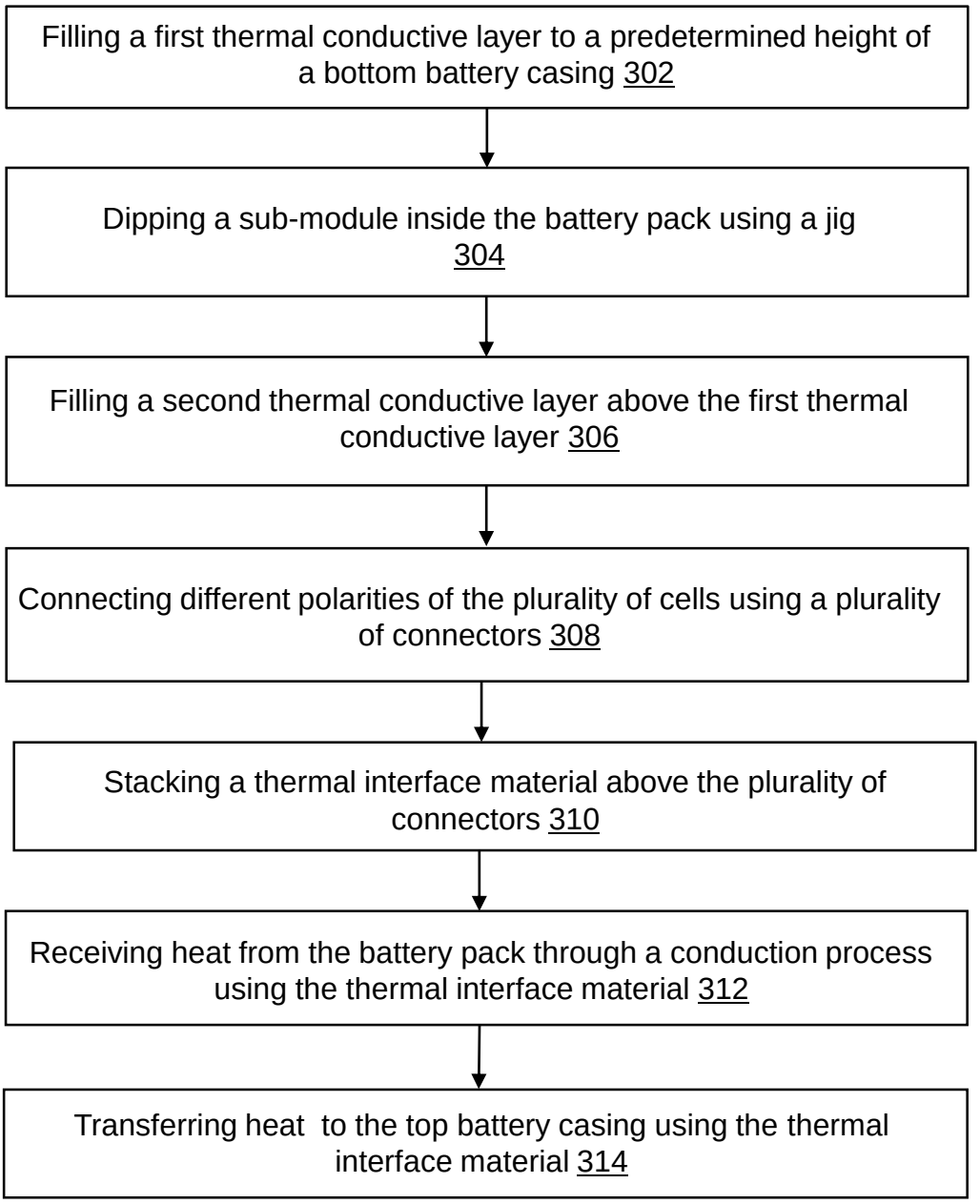


FIG. 3

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Pankaj Kumar
IN/PA- 1432
Patent Agent for the Applicant

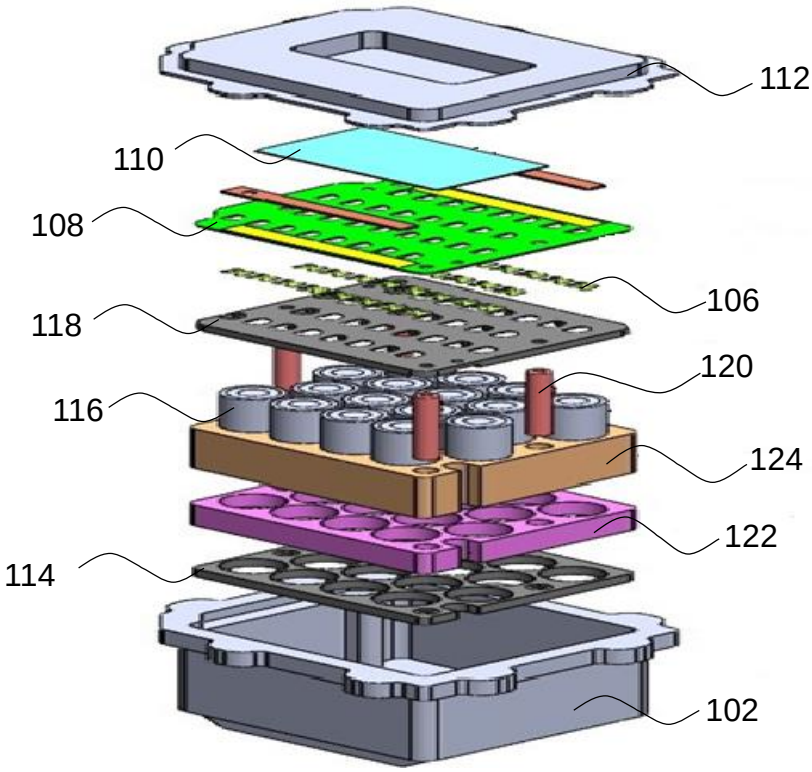


FIG. 1

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Pankaj Kumar
IN/PA- 1432
Patent Agent for the Applicant

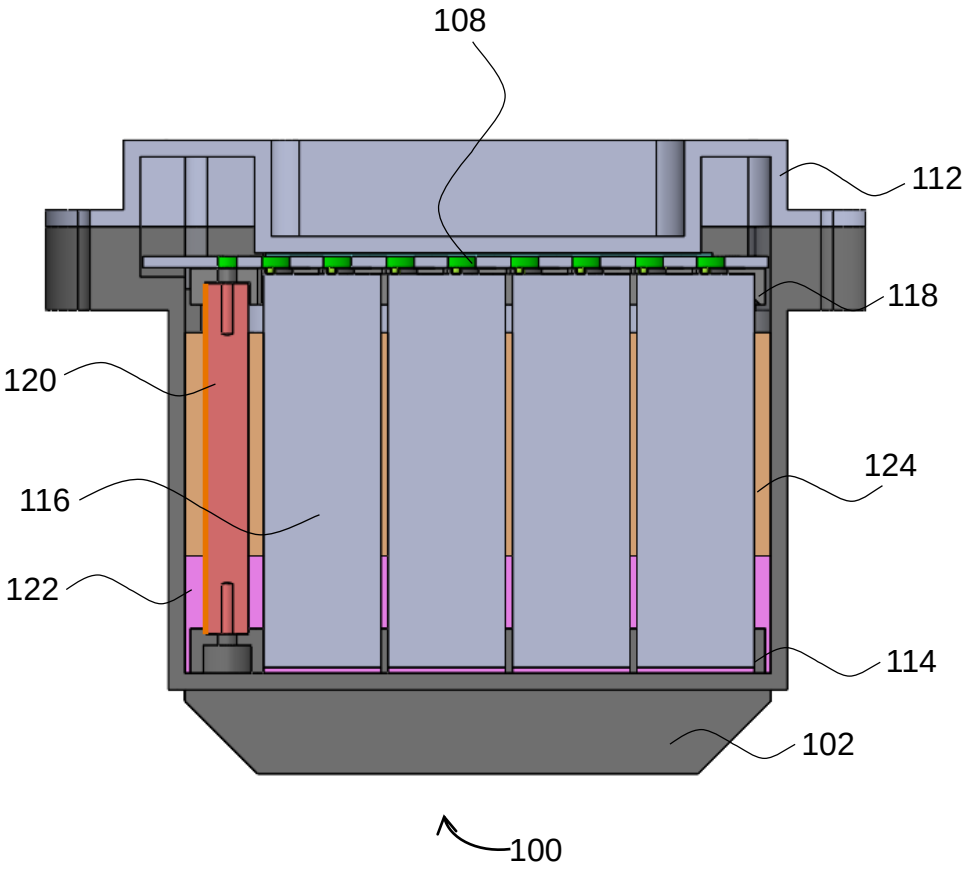


FIG. 2

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Pankaj Kumar
IN/PA- 1432
Patent Agent for the Applicant

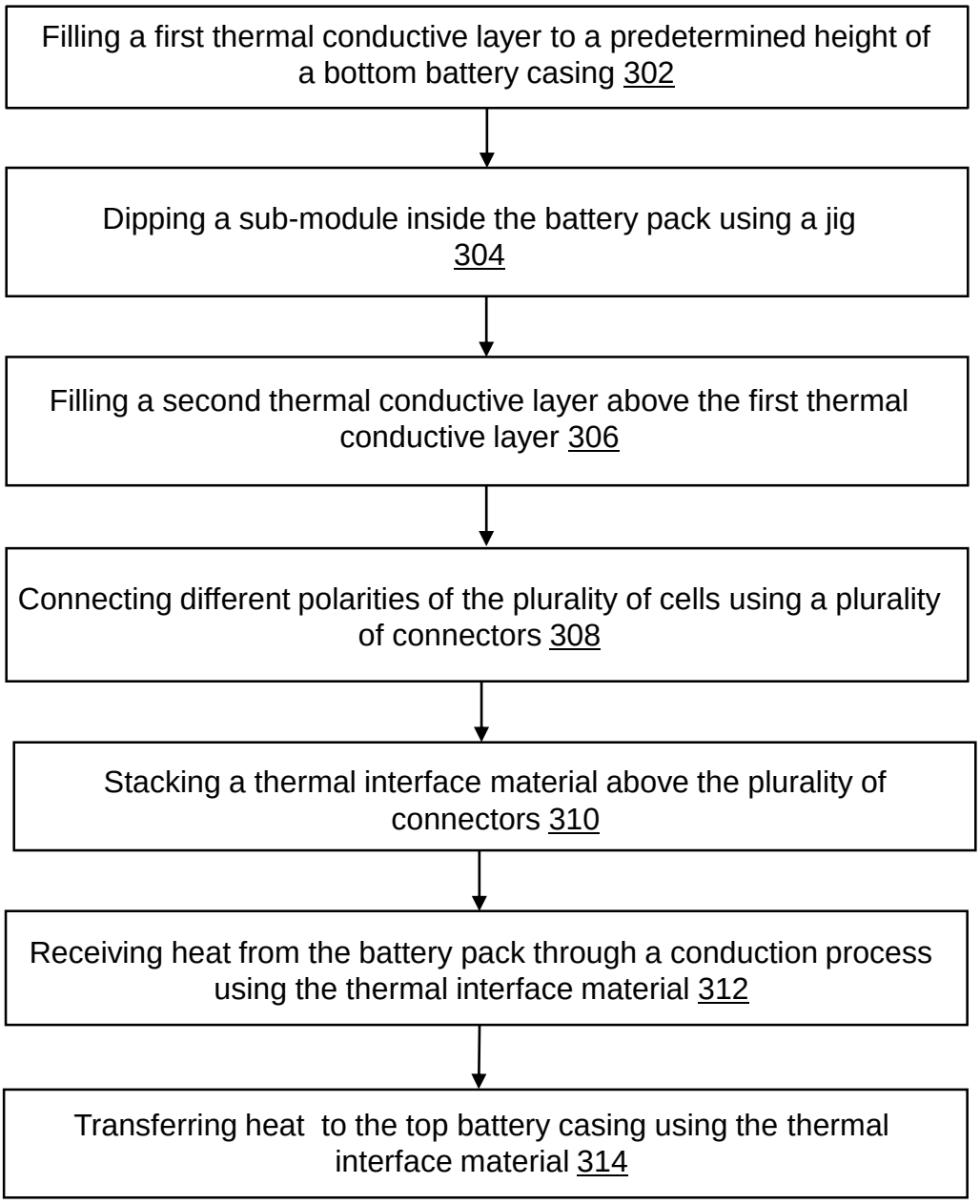


FIG. 3

Dated this on 4 Sep 2022

Pankaj Kumar
IN/PA- 1432
Patent Agent for the Applicant

FORM 2

The Patent Act 1970

(39 of 1970)

&

The Patent Rules, 2003

COMPLETE SPECIFICATION

(SEE SECTION 10 AND RULE 13)

“A BATTERY PACK AND METHOD FOR THERMAL MANAGEMENT”

Applicant	Nationality	Complete Address with pin code
Simpleenergy Private Limited	Indian	9th floor, Wing A, Survey No.2/2, North Gate Phase-2, Modern Asset, Venkatala Village, Yelahanka, Hobil, Bengaluru-560064 Karnataka

The following specification particularly describes and ascertains the nature of this invention and the manner in which it is to be performed: -

FIELD OF INVENTION

[0001] The present disclosure relates to electrical energy storage devices, and more particularly a battery pack including a plurality of cells and a method for thermal management. The present application is based on, and claims priority from an Indian Provisional Application Number **202241057085** filed on **05-10-2022**, the disclosure of which is hereby incorporated by reference herein.

BACKGROUND

[0002] A cell is a device that stores chemical energy and converts it to electrical energy. The chemical reactions in the cell involve the flow of electrons between an anode and a cathode, through an external circuit, so that the temperature level of the cell may increase, which will increase the temperature level of the battery pack. An atmospheric temperature is also the reason for the temperature hike in the battery pack. The performance of the battery pack/cell is affected heavily by temperature variations. In some cases, increased temperature levels may lead to thermal abuse, and thermal runaway in worst cases. So, it is very important to monitor and control the temperature level of the battery pack. Maintaining the temperature level of the battery pack with optimal temperature is a difficult task.

[0003] In a conventional method, many electric vehicle manufacturers come up with a coolant method and a natural heat transfer method, or a passive heat transfer method that reduces the temperature level of the cell and the battery pack, but this method is not efficient. At the same time, the coolant and the heat sink methods make the system big, complex, and expensive. In a recent method, many of the electric vehicle manufacturers used thermal conductive materials to reduce the temperature level of the cell and the battery pack. However, thermally conductive materials dissipate heat on the radial surface of the cells due to their dispensing position, but there is no option to dissipate heat generated at the axial surface of the cells. As we know, the heat energy produced in the cell is symmetric, but the high thermal conductivity is in the vertical axis, so the heat dissipation is more on the axial surface

compared to the radial surface. So, the conventional and the recent methods are not efficient in solving the above-mentioned issues of the battery pack.

[0004] Hence, there remains a need for an improved approach to providing a battery pack and therefore addressing the aforementioned issues.

SUMMARY

[0005] Accordingly, the embodiments herein disclose a battery pack. The battery pack includes a thermally conductive layer, a thermally insulative layer, and a sub-module. The thermally conductive layer is configured to spread across the battery pack and maintain equal space between a plurality of cells. The thermally conductive layer is filled to a predetermined height in a bottom battery casing. The thermally conductive layer faces the axial surface and the circumferential surface of the plurality of cells to absorb heat and transfer the heat to a plurality of fins. The thermally insulative layer is configured to prevent thermal runaway propagation and reduce shock and vibration. The thermally insulative layer is positioned on a top portion of the thermally conductive layer. The thermally insulative layer is configured to suppress fire during the thermal runaway of the plurality of cells. The sub-module includes a first cell holder, a second cell holder, and a plurality of cell holder sleeves. The first cell holder includes a plurality of cavities and is configured to hold the plurality of cells in a predetermined position. The first cell holder is configured to provide an equal space between the bottom battery casing and the bottom surface of the plurality of cells. The second cell holder is placed on a top portion of the plurality of cells and the thermally insulative layer and is configured to provide an equal space between the plurality of cells. The plurality of cell holder sleeves is configured to support and hold the first cell holder, and the second cell holder along with the plurality of cells.

[0006] In one embodiment, the thermally conductive layer includes a resin, a polymeric/non-polymeric material, a polyurethane, an epoxy, a dielectric, and a silicon.

[0007] In another embodiment, the thermally insulative layer includes a silicon foam, a foam, a polyurethane foam, a polyurethane, a polystyrene, a silicon, and a polyisocyanurate.

[0008] In yet another embodiment, the battery pack further includes an interconnector. The interconnector is positioned on a top portion of the sub-module and is configured to connect different polarities of the plurality of cells by using a plurality of connectors.

[0009] In yet another embodiment, the interconnector includes a PCB (Printed Circuit Board), and a current collector.

[0010] In yet another embodiment, the plurality of connectors includes feeders.

[0011] In yet another embodiment, the battery pack further includes a thermal interface material configured to receive heat which is generated from one or more terminals of the plurality of cells through the conduction process and transfer the heat to a top battery casing.

[0012] Accordingly, the embodiments herein disclose a method of thermal management in a battery pack. The method includes the following steps: (a) filing a thermally conductive layer to a predetermined height of a bottom battery casing; (b) dipping a sub-module into the battery pack using a jig, (i) the sub-module includes a first cell holder, a plurality of cells, a second cell holder, and a plurality of cell holder sleeves; (c) filing a thermally insulative layer on a top portion of the thermally conductive layer; (d) connecting, by an interconnector, different polarities of the plurality of cells by using a plurality of connectors; (e) stacking a thermal interface material on a top portion of the plurality of connectors; (f) receiving, by the thermal interface material, heat generated from the battery pack through a conduction process; and, (g) transferring, the thermal interface material transfers the heat to a top battery casing.

[0013] In one embodiment, the method further includes (a) placing the sub-module into the bottom battery casing of the battery pack; and (b) pouring the thermally

conductive layer to the predetermined height of the bottom battery casing of the battery pack, wherein the thermally conductive layer is poured in one or more locations of the battery pack.

[0014] In another embodiment, the thermally insulative layer includes a silicon foam, a foam, a polyurethane foam, a polyurethane, a polystyrene, a silicon, and a polyisocyanurate.

[0015] In yet another embodiment, the thermally conductive layer includes a resin, a polymeric/non-polymeric material, a polyurethane, an epoxy, a dielectric, and a silicon.

[0016] These and other aspects of the embodiments herein will be better appreciated and understood when considered in conjunction with the following description and the accompanying drawings. It should be understood, however, that the following descriptions, while indicating preferred embodiments and numerous specific details thereof, are given by way of illustration and not of limitation. Many changes and modifications may be made within the scope of the embodiments herein without departing from the invention thereof, and the embodiments herein include all such modifications.

BRIEF DESCRIPTION OF FIGURES

[0017] This invention is illustrated in the accompanying drawings, throughout which like reference letters indicate corresponding parts in the various figures. The embodiments herein will be better understood from the following description with reference to the drawings, in which:

[0018] FIG. 1 illustrates an exploded perspective view of a battery pack according to an embodiment as disclosed herein;

[0019] FIG. 2 illustrates a cross-sectional view of the battery pack according to an embodiment as disclosed herein; and

[0020] FIG. 3 is a flow diagram illustrating a method for thermal management of the battery pack according to an embodiment as disclosed herein.

DETAILED DESCRIPTION OF INVENTION

[0021] In the following description, for the purposes of explanation, various specific details are set forth in order to provide a thorough understanding of embodiments of the present disclosure. It will be apparent, however, that embodiments of the present disclosure may be practiced without these specific details. Several features described hereafter can each be used independently of one another or with any combination of other features. An individual feature may not address all of the problems discussed above or might address only some of the problems discussed above. Some of the problems discussed above might not be fully addressed by any of the features described herein.

[0022] The ensuing description provides exemplary embodiments only, and is not intended to limit the scope, applicability, or configuration of the disclosure. Rather, the ensuing description of the exemplary embodiments will provide those skilled in the art with an enabling description for implementing an exemplary embodiment. It should be understood that various changes may be made in the function and arrangement of elements without departing from the spirit and scope of the disclosure as set forth.

[0023] The word "exemplary" and/or "demonstrative" is used herein to mean serving as an example, instance, or illustration. For the avoidance of doubt, the subject matter disclosed herein is not limited by such examples. In addition, any aspect or design described herein as "exemplary" and/or "demonstrative" is not necessarily to be construed as preferred or advantageous over other aspects or designs, nor is it meant to preclude equivalent exemplary structures and techniques known to those of ordinary skill in the art. Furthermore, to the extent that the terms "includes," "has," "contains," and other similar words are used in either the detailed description or the claims, such terms are intended to be inclusive—in a manner similar to the term "comprising" as an open transition word—without precluding any additional or other elements.

[0024] Reference throughout this specification to “one embodiment” or “an embodiment” or “an instance” or “one instance” means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present disclosure. Thus, the appearances of the phrases “in one embodiment” or “in an embodiment” in various places throughout this specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

[0025] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the disclosure. As used herein, the singular forms “a”, “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises” and/or “comprising,” when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items.

[0026] The accompanying drawings are used to help easily understand various technical features and it should be understood that the embodiments presented herein are not limited by the accompanying drawings. As such, the present disclosure should be construed to extend to any alterations, equivalents and substitutes in addition to those which are particularly set out in the accompanying drawings. Although the terms first, second, etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are generally only used to distinguish one element from another.

[0027] Accordingly, the embodiments herein disclose a battery pack. The battery pack includes a thermally conductive layer, a thermally insulative layer, and a

sub-module. The thermally conductive layer is configured to spread across the battery pack and maintain equal space between a plurality of cells. The thermally conductive layer is filled to a predetermined height in a bottom battery casing. The thermally conductive layer faces the axial surface and the circumferential surface of the plurality of cells to absorb heat and transfer the heat to a plurality of fins. The thermally insulative layer is configured to prevent thermal runaway propagation and reduce shock and vibration. The thermally insulative layer is positioned on a top portion of the thermally conductive layer. The thermally insulative layer is configured to suppress fire during the thermal runaway of the plurality of cells. The sub-module includes a first cell holder, a second cell holder, and a plurality of cell holder sleeves. The first cell holder includes a plurality of cavities and is configured to hold the plurality of cells in a predetermined position. The first cell holder is configured to provide an equal space between the bottom battery casing and the bottom surface of the plurality of cells. The second cell holder is placed on a top portion of the plurality of cells and the thermally insulative layer and is configured to provide an equal space between the plurality of cells. The plurality of cell holder sleeves is configured to support and hold the first cell holder, and the second cell holder along with the plurality of cells.

[0028] Referring now to the drawings and more particularly to FIGS. 1 to 3, where similar reference characters denote corresponding features consistently throughout the figure, these are shown preferred embodiments.

[0029] FIG. 1 illustrates an exploded perspective view of a battery pack 100 according to an embodiment as disclosed herein. The battery pack 100 includes a bottom battery casing 102, a sub-module, a plurality of connectors 106, an interconnector 108, a thermal interface material 110, and a top battery casing 112. In one embodiment, the thermal interface material 110 may include, but not limited to, a thermal pad, a thermal paste, a silicon pad, a gap pad, a thermal grease, a thermal gap filler, and the like. In one embodiment, the interconnector 108 may include, but not limited to, a PCB (Printed Circuit Board), a current collector, and the like.

[0030] The sub-module further includes a first cell holder 114, a plurality of cells 116, a second cell holder 118, and a plurality of cell holder sleeves 120. The battery pack 100 further includes a plurality of fins. The battery pack 100 further includes a thermally conductive layer 122, and a thermally insulative layer 124. In one embodiment, the thermally conductive layer 122 may include, but not limited to, resin, a polymeric/non-polymeric material, a polyurethane, an epoxy, a dielectric, and a silicon.

[0031] The thermally conductive layer 122 may provide better structural stability and better structural rigidity to the sub-module. The thermally conductive layer 122 is configured to spread across the battery pack 100 and maintain equal space between the plurality of cells 116. The thermally conductive layer 122 retains position of the plurality of cells 116. The thermally conductive layer 122 increases durability of the plurality of cells 116. The thermally conductive layer 122 increases reliability and structural rigidity. Furthermore, the thermally conductive layer 122 provides electrical insulation between the plurality of cells 116, and the battery bottom casing 102. The thermally conductive layer 122 is filled to a predetermined height in the bottom battery casing 102.

[0032] The thermally conductive layer 122 further provides increased durability to the sub-module. The thermally conductive layer 122 transfers the heat from the plurality of cells 116 to a plurality of fins through the conduction process. The thermally conductive layer 122 further resists movements of the plurality of the cells 116 in the sub-module.

[0033] The thermally conductive layer 122 is configured to reduce the heat of the plurality of cells 116 by transferring the heat to the plurality of fins (not shown in the figures). As used herein, fin is defined as a surface that extends from an object to increase the rate of heat transfer to or from the environment by increasing convection. The plurality of fins positioned in outer walls of the top battery casing 112, and the bottom battery casing 102.

[0034] In one embodiment, the thermally conductive layer 122 is dispensed (as a liquid) in such a way that thermally conductive layer 122 is facing axial surface and circumferential surface of the plurality of cells 116 to absorb heat and transfer the heat to the plurality of fins, but in normal room temperature, the first thermal conductive layer 122 will be in solid state (as shown in Fig. 1). In one embodiment, the thermally conductive layer 122 is dipped in such a way that thermally conductive layer 122 is facing axial surface of the plurality of cells 116. The thermally conductive layer 122 spreads across the battery pack 100 and provides a predetermined space between the plurality of cells 116 and the bottom battery casing 102. The thermally insulative layer 122 is configured to reduce shock and vibration.

[0035] The thermally insulative layer 124 may include, but not limited to a thermal runaway mitigation material. In one embodiment, the thermally insulative layer 124 prevents thermal runaway propagation. In one embodiment, the thermal runaway mitigation material may include, but not limited to, a silicon foam, a foam, a polyurethane foam, a polyurethane, a polystyrene, a silicon, and a polyisocyanurate. The thermally insulative layer 124 may include, but not limited to, a low density thermal conductive material, and an electrically insulating material. The thermally insulative layer 124 is configured to reduce shock and vibration. The thermally insulative layer 124 may include a flame-retardant capacity. The thermally insulative layer 124 is configured to prevent thermal runaway/and reduce shock and vibration.

[0036] The bottom battery casing 102 is filled with the thermally conductive layer 122 to a predetermined height. In one embodiment, the predetermined height depends on heat generated by the plurality of cells 116, or the battery pack 100. The sub-module is dipped into the bottom battery casing 102 of the battery pack 100 which is filled with the thermal conductive layer 122. In one embodiment, the sub-module is dipped into the bottom battery casing 102 of the battery pack 100 using a jig.

[0037] The first cell holder 114 is positioned on the bottom portion of the sub-module. The first cell holder 114 includes a plurality of cavities and is configured to

hold the plurality of cells 116 in a predetermined position. In one embodiment, the first cell holder 114 may be a thermally conductive and electrically insulative material. In another embodiment, the first cell holder 114 may include, but not limited to, a synthetic polymer-based material, a non-synthetic polymer-based material, and a thermoset plastic material. In one embodiment, the plurality of cells 116 may include, but not limited to, nickel cadmium, alkaline, nickel metal hydride (NIMH), lithium-ion, nickel hydrogen, nickel-zinc, electro-chemical cells, and the like. The plurality of cells 116 are connected with the interconnector 108 to configure one or more connections between the one or more cells 116 are a series connection, a parallel connection, and a combination of a series and a parallel connection and the like.

[0038] The first cell holder 114 is configured to provide an equal space between the bottom battery casing 102 and the bottom surface of the plurality of cells 116. In one embodiment, the equal space between the bottom battery casing and the bottom surface of the plurality of cells 116 may depend, but not limited to, thermal behavior, structural stability, and electrical insulation of the plurality of cells. In addition to that, the equal space provides insulation by the thermally conductive layer 122. Further, the first cell holder 116 is configured to increase structural rigidity of the batter pack 100.

[0039] Once the sub-module is dipped into the bottom battery casing 102, the thermally insulative layer 124 is dispensed above the thermally conductive layer 122. The thermally insulative layer 124 is dispensed (as shown in FIG. 2). The thermally insulative layer 124 is placed on a top portion of the plurality of cells 116 and the thermally insulative layer 124 and is configured to provide an equal space between the plurality of cells 116 and reduce the heat of the plurality of cells 116. In one embodiment, the thermally insulative layer 124 is dispensed in such a way that the thermally insulative layer 124 covers the surface of the plurality of cells 116.

[0040] The plurality of cell holder sleeves 120 supports and holds the second cell holder 118, and the first cell holder 114 along with the plurality of cells 116. In one embodiment, the second cell holder 118 may include, but not limited to, a thermally

conductive material and an electrically insulative material. In another embodiment, the second cell holder 118 may include, but not limited to, a synthetic polymer-based material, a non-synthetic polymer-based material, and a thermoset plastic material. Further, the second cell holder 118 is configured to provide an equal space between the plurality of cells 116. In one embodiment, the second cell holder 118 is configured to provide structural rigidity to the battery pack 100. In another embodiment, the second cell holder 118 is configured to reduce shock and vibration.

[0041] The battery pack 100 further includes an interconnector 108. The interconnector 108 is positioned on a top portion of the sub-module. The interconnector 108 is configured to connect different polarities of the plurality of cells 116 by using the plurality of connectors 106. In one embodiment, the plurality of connectors 106 may be feeders. In another embodiment, the plurality of connectors 106 may include, but not limited to, a nickel stip.

[0042] The thermal interface material 108 is positioned on a top portion of the interconnector 108. Further, the thermal interface material 110 may include, but not limited to, an electrically insulative material. The thermal interface material 108 stacks above the plurality of connectors 106. In one embodiment, the thermal interface material 108 may include, but not limited to, a thermal pad, a thermal paste, a silicon pad, a gap pad, a thermal grease, a thermal gap filler, and the like. In one embodiment, the thermal interface material 108 may be applied above the plurality of connectors 106. In another embodiment, the thermal interface material 108 may be pasted above the plurality of connectors 106. In yet another embodiment, the thermal interface material 108 may be dispensed above the plurality of connectors 106.

[0043] The thermal interface material 110 is configured to receive the heat which is generated from the battery pack 100 through the conduction process. In one embodiment, the thermal interface material 110 is configured to receive the heat which is generated from one or more terminals of the plurality of cells 116 through the conduction process. The thermal interface material 110 is configured to transfer the

heat to the top battery casing 112. The thermal interface material 110 is compressed by the top battery casing 112 to transfer heat which is generated from the sub-module, and the interconnector 108. The top battery casing 112 is configured to close the battery pack 100 from the top.

[0044] FIG. 2 illustrates a cross sectional view of the battery pack 100 of FIG. 1 according to an embodiment as disclosed herein. The battery pack 100 includes the bottom battery casing 102, the sub module, the plurality of connectors 106, the interconnector 108, the thermal interface material 110, and the top battery casing 112. In one embodiment, the thermal interface material 110 may include, but not limited to, a thermal pad, a thermal paste, a silicon pad, a gap pad, a thermal grease, a thermal gap filler, and the like. The sub-module further includes the first cell holder 114, the plurality of cells 116, the second cell holder 118, and the plurality of cell holder sleeves 120.

[0045] The cross-sectional view of the battery pack 100 shows the thermally conductive layer 122 is filed to the predetermined height in the bottom battery casing 102. Further, the cross-sectional view of the battery pack 100 shows the sub-module is dipped inside the battery pack 100 using the jig. The thermally insulative layer 124 is filled above the thermally conductive layer 122.

[0046] Further, FIG. 2 shows that interconnector 108 connects different polarities of the plurality of cells by using the plurality of connectors 116. In one embodiment, the plurality of connectors 116 may be feeders. In another embodiment, the plurality of connectors 106 may include, but not limited to, a nickel stip.

[0047] In addition to that, the thermal interface material 108 is poisoned on a top portion of the interconnector 108. Further, the thermal interface material 108 may include, but not limited to, an electrically insulative material. In one embodiment, the thermal interface material 108 may include, but not limited to, a thermally conductive material.

[0048] The thermal interface material 108 stacks above the plurality of connectors 106. In one embodiment, the thermal interface material 108 may include, but not limited to, a thermal pad, a thermal paste, a silicon pad, a gap pad, a thermal grease, a thermal gap filler, and the like. In one embodiment, the thermal interface material 108 applies above the plurality of connectors 106. In another embodiment, the thermal interface material 108 pastes above the plurality of connectors 106. In yet another embodiment, the thermal interface material 108 dispenses above the plurality of connectors 106.

[0049] The thermal interface material 108 is configured to receive the heat generated from the battery pack 100 through the conduction process. In one embodiment, the thermal interface material 108 is configured to receive the heat which is generated from one or more terminals of the plurality of cells 116. The thermal interface material 110 is configured to transfer the heat to the top battery casing 112. The thermal interface material 110 and the top battery casing are connected with each other. The top battery casing 112 is configured to close the battery pack 100.

[0050] FIG. 3 is a flow diagram illustrating a method 300 for thermal management of the battery pack 100 according to an embodiment herein. At step 302, a thermally conductive layer 122 is filled to a predetermined height of a bottom battery casing 102. In one embodiment, the thermally conductive layer 122 may include, but not limited to, a resin, a polymeric/non-polymeric material, a polyurethane, an epoxy, and a silicon. The thermally conductive layer 122 may provide better structural stability, and a better structural rigidity to the sub-module. The thermally conductive layer 122 further provides an increased durability to the sub-module. The thermally conductive layer 122 transfers the heat from the plurality of cells 116 to the plurality of fins through the conduction process. The thermally conductive layer 122 further resists movements of the plurality of the cells 116 in the sub-module. The thermally conductive layer 122 is configured to reduce the heat of the plurality of cells 116 by

transferring the heat to the plurality of fins. The plurality of fins positioned in outer walls of the top battery casing 112, and the bottom battery casing 102.

[0051] In one embodiment, the thermally conductive layer 122 is dispensed in such a way that the thermally conductive layer 122 is facing an axial surface of the plurality of cells 116. In one embodiment, the thermally conductive layer 122 is dipped in such a way that the thermally conductive layer 122 is facing the axial surface of the plurality of cells 116.

[0052] At step 304, a sub-module is dipped inside the battery pack 100 using a jig. The sub-module is dipped into the bottom battery casing 102 of the battery pack 100 which is filled with the thermally conductive layer 122. The sub-module includes the first cell holder 114, the plurality of cells 116, the second cell holder 118, and the plurality of cell holder sleeves 120. The thermally insulative layer 122 is configured to reduce shock and vibration.

[0053] At step 306, a thermally insulative layer 124 is filled on a top portion of the thermally conductive layer 122. In one embodiment, the thermally insulative layer 124 may include, but not limited to, a silicon foam, a foam, a polyurethane foam, a polyurethane, a polystyrene, a silicon, and a polyisocyanurate. The thermally insulative layer 124 may include, but not limited to, a low-density thermal conductive material, and an electrically insulating material. The thermally insulative layer 124 is configured to reduce shock and vibration. The thermally insulative layer 124 may include a flame-retardant capacity. The thermally insulative layer 124 is configured to prevent thermal runaway/and reduce shock and vibration. The thermally insulative layer 124 is configured to reduce the heat of the plurality of cells 116. In one embodiment, the thermally insulative layer 124 is dispensed in such a way that the thermally insulative layer 124 covers the surface of the plurality of cells 116.

[0054] At step 308, the interconnector 108 is connected to different polarities of the plurality of cells 116 by using the plurality of connectors 106. In one embodiment, the plurality of connectors 116 may be feeders. In one embodiment, the

electrical connection may include, but not limited to, a series connection, a parallel connection, and a combination of a series and a parallel connection.

[0055] At step 310, a thermal interface material 108 is stacked on a top portion of the plurality of connectors 106. In one embodiment, the thermal interface material 108 may include, but not limited to, a thermal pad, a thermal paste, a silicon pad, a gap pad, a thermal grease, a thermal gap filler, and the like. In one embodiment, the thermal interface material may be applied above the plurality of connectors 106. In another embodiment, the thermal interface material may be pasted above the plurality of connectors 106. In yet another embodiment, the thermal interface material may be dispensed above the plurality of connectors 106.

[0056] At step 312, the thermal interface material 108 is received the heat which is generated from the battery pack 100 through the conduction process. In one embodiment, the thermal interface material 108 may include, but not limited to, an electrically insulative material. In one embodiment, the thermal interface material 108 may include, but not limited to, a thermal pad, a thermal paste, a silicon pad, a gap pad, a thermal grease, a thermal gap filler, and the like.

[0057] At step 314, the thermal interface material 110 is transferred the heat to the top battery casing 112. The thermal interface material 110 is positioned on a top portion of the sub-module. The thermal interface material 110 is compressed by the top battery casing 112 to transfer the heat, which is generated from the sub-module, and the interconnector 108.

[0058] The sub-module is placed into the bottom battery casing 102 of the battery pack 100. The thermally conductive layer 122 is poured to the predetermined height of the bottom battery casing 102 of the battery pack 100.

[0059] Improvements and modifications may be incorporated herein without deviating from the scope of the invention. The foregoing description of the specific embodiments will so fully reveal the general nature of the embodiments herein that others can, by applying current knowledge, readily modify and/or adapt for various

applications such specific embodiments without departing from the generic concept, and, therefore, such adaptations and modifications should and are intended to be comprehended within the meaning and range of equivalents of the disclosed embodiments. It is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation. Therefore, while the embodiments herein have been described in terms of preferred embodiments, those skilled in the art will recognize that the embodiments herein can be practiced with modification within the spirit and scope of the appended claims.

We claim:

1. A battery pack (100) comprising:

a thermally conductive layer (122) is configured to spread across the battery pack (100), and maintain an equal space between a plurality of cells (116), wherein the thermally conductive layer (122) is filled to a predetermined height in a bottom battery casing (102), wherein the thermally conductive layer (122) is facing an axial surface and a circumferential surface of the plurality of cells (116) to absorb heat and transfer the heat to a plurality of fins, wherein the plurality of fins positioned in the battery casing;

a thermally insulative layer (124) is configured to prevent thermal runaway, and reduce shock and vibration, wherein the thermally insulative layer (124) is positioned on a top portion of the thermally conductive layer (122), wherein the thermally insulative layer (124) is configured to suppress fire during thermal runaway of the plurality of cells (116); and

a sub-module comprises:

a first cell holder (114) comprises a plurality of cavities and is configured to hold the plurality of cells (116) in a predetermined position, wherein the first cell holder (114) is configured to provide an equal space between the bottom battery casing (102) and the bottom surface of the plurality of cells (116);

a second cell holder (118) is placed on top of the plurality of cells (116) and the thermally insulative layer (124) and is configured to provide an equal space between the plurality of cells (116); and

a plurality of cell holder sleeves (120) configured to support and hold the first cell holder (114), the second cell holder (118) along with the plurality of cells (116).

2. The battery pack (100) as claimed in claim **1**, wherein the thermally conductive layer (122) comprises a resin, a polymeric/non-polymeric material, a polyurethane, an epoxy, a dielectric, and a silicon.

3. The battery pack (100) as claimed in claim **1**, wherein the thermally insulative layer (124) comprises a silicon foam, a foam, a polyurethane foam, a polyurethane, a polystyrene, a silicon, and a polyisocyanurate.

4. The battery pack (100) as claimed in claim **1**, wherein the battery pack (100) further comprises an interconnector (108), wherein the interconnector (108) is positioned on top of the sub-module and is configured to connect different polarities of the plurality of cells (116) by using a plurality of connectors (106).

5. The battery pack (100) as claimed in claim **1**, wherein the interconnector (108) comprises a PCB (Printed Circuit Board), and a current collector.

6. The battery pack (100) as claimed in claim **1**, wherein the plurality of connectors (106) comprises feeders.

7. The battery pack (100) as claimed in claim **1**, wherein the battery pack (100) further comprises a thermal interface material (110) configured to receive heat generated from one or more terminals of the plurality of cells (116) through the conduction process and transfer the heat to a top battery casing (112).

8. A method (300) of thermal management in a battery pack (100) comprising,

filing a thermally conductive layer (122) to a predetermined height of a bottom battery casing (102);

dipping a sub-module into the battery pack (100) using a jig, wherein the sub-module comprises a first cell holder (114), a plurality of cells (116), a second cell holder (118), and a plurality of cell holder sleeves (120);

filing a thermally insulative layer (124) on top of the thermally conductive layer (122);

connecting, by an interconnector (108), different polarities of the plurality of cells (116) by using a plurality of connectors (106);

stacking a thermal interface material (110) on top of the plurality of connectors (106);

receiving, by the thermal interface material (110), heat generated from the battery pack (100) through a conduction process; and

transferring, the thermal interface material (110) transfers heat to a top battery casing (112).

9. The method (300) as claimed in claim **8**, wherein the method comprises:

placing the sub-module into the bottom battery casing (102) of the battery pack (100); and

pouring the thermally conductive layer (122) to the predetermined height of the bottom battery casing (102) of the battery pack (100), wherein the thermally conductive layer (122) is poured in one or more locations of the battery pack (100).

10. The method (300) as claimed in claim **8**, wherein the thermally insulative layer (124) comprises a silicon foam, a foam, a polyurethane foam, a polyurethane, a polystyrene, a silicon, and a polyisocyanurate.

11. The method (300) as claimed in claim **8**, wherein the thermally conductive layer (122) comprises a resin, a polymeric/non-polymeric material, a polyurethane, an epoxy, a dielectric, and a silicon.

Jaipur

for the applicant

3rd Oct'23

digitally signed by Pankaj Kumar

(Patent Agent No. INPA 1432)

ABSTRACT

“A BATTERY PACK AND METHOD FOR THERMAL MANAGEMENT”

Embodiments herein disclose a battery pack 100 and a method for thermal management. The battery pack 100 includes a bottom battery casing 102, a sub module, a plurality of connectors 106, an interconnector 108, a thermal interface material 110, and a top battery casing 112. The sub-module includes a first cell holder 114, a plurality of cells 116, a second cell holder 118, and a plurality of cell holder sleeves 120. The battery pack 100 includes a thermally conductive layer 122, and a thermally insulative layer 124. The bottom battery casing 102 is filled with the thermally conductive layer 122. The sub-module is dipped into the bottom battery casing 102. Once the sub-module is dipped in the bottom battery casing 102, the thermally insulative layer 124 is dispensed. The interconnector 108 connects different polarities of the plurality of cells 116 by using the plurality of connectors.