A BUS BAR FOR A BATTERY MODULE, A BATTERY PACK AND A METHOD OF MANUFACTURING THE SAME

FIELD OF INVENTION

[0001] The present invention relates to the field of battery packs. Particularly, the present invention relates to a bus bar for a battery module. The present invention also relates to a battery module and a battery pack comprising such bus bars and a method of manufacturing a bus bar according to battery pack requirements.

BACKGROUND OF THE INVENTION

[0002] The subject matter discussed in the background section should not be assumed to be prior art merely because of its mention in the background section. Similarly, a problem mentioned in the background section or associated with the subject matter of the background section should not be assumed to have been previously recognized in the prior art. The subject matter in the background section merely represents different approaches, which in and of themselves may correspond to implementations of the claimed technology.

[0003] In common practice, a battery pack comprises of a plurality of battery modules each of which is comprised of a plurality of electrochemical cells such as lithium ion cells or the like. General known methods of electrically connecting these cells in a battery module is by using a bus bar. Each battery cell is connected via a terminal of the bus bar to collectively form a battery module. The terminals may be arranged in rows to form a bus bar, making it easier to connect electrically. The electrochemical cells may be connected in series or parallel through these terminals as per the battery pack requirements.

[0004] Generally, battery packs using cylindrical cells make electrical connections to the tops and the bottoms of the cells i.e. two-sided connection using techniques which may include laser welding. The welding techniques frequently used for connecting these battery cells are resistance spot, ultrasonic or laser beam welding, and the like. These techniques differ with respect to the characteristics based on the properties and geometry based on the contact.

[0005] When a cell is charged or discharged, it generates heat which causes the temperature of the cell to rise. In a few cases, the temperature rise is abnormal and may cause an explosion. Also, operating cells at elevated temperature reduces the performance and life of the battery.

Further, due to the two-sided connection, an increased thermal resistance is observed on both sides of the cell. This reduces the effectiveness of thermal management i.e. lower heat dissipation and also increases the weight of thermal management setup. Also, this two-sided connection needs voltage and temperature sense wires connection on both sides of the pack which makes it difficult in wire routing.

[0006] Another problem with the two-sided connection of cells, is that the wire connections are provided on both of the sider of the cells and therefore there is difficulty in wire routing. There is therefore a need to improve the ease in wire routing of voltage and temperature sensing.

[0007] Therefore, there is a need for a bus bar for electrically connecting batteries which is capable of removing heat generated by it as quickly as possible. There is also a need for a bus bar for a battery module wherein there is less or ease in wire routing.

OBJECT OF THE INVENTION

[0008] A general objective of the present invention is to provide an efficient bus bar for a battery module with increased heat dissipation and remove the heat generated by the cell as quickly as possible.

[0009] Another objective of the present invention is to provide a bus bar for a battery module capable of providing a single sided connection of the top of the cell.

[0010] Yet another objective of the present invention is to provide a bus bar for a battery module capable of using the negative terminal of the cell only for thermal management.

[0011] Yet another objective of the present invention is to provide a bus bar for a battery module with efficient space utilization, reduced number of wire connections and reduced battery pack assembly time.

[0012] Yet another objective of the present invention is to provide a method for manufacturing a bus bar for a battery module.

[0013] Yet another objective of the present invention is to provide a battery module and a battery pack comprising a bus bar.

[0014] Yet another objective of the present invention is to provide a fusible busbar for isolating module from a bad cell in the event of a short-circuit.

SUMMARY OF THE INVENTION

[0015] The summary is provided to introduce aspects related to an electrical energy storage system. Other aspects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

[0016] In an embodiment, the present invention provides a bus bar, comprising a plurality of first contact portions on a first side of the bus bar, and a plurality of second contact portions on a second side of the bus bar. The bus bar is arranged in a battery pack. The battery pack includes a plurality of batteries connected in series and parallel configuration. The plurality of the first contact portions are configured to connect to negative terminals of the plurality of battery cells on the first side, and the plurality of second contact portions configured to connect to positive terminals of the plurality of battery cells on the second side.

[0017] In an embodiment, the first contact portion is arc-shaped and the second contact portion is ring-shaped.

[0018] In an embodiment, the first contact portion of the bus bar is the arc shaped to dissipate heat.

[0019] In an embodiment, the bus bar is welded to the terminals of the battery cells using a laser power source.

[0020] In an embodiment, the single-sided connection is done by wire routing for voltage and temperature sensing.

[0021] In an embodiment, a thermally conductive and electrically insulative polymer material is applied to a bottom surface of each battery cell to remove the air gap between the battery cell and heat sink.

[0022] In an embodiment, a material of the bus bar includes a high-conductivity metal such as copper, nickel, or aluminum.

[0023] In an embodiment, the bus bar is electrically connected to a battery pack, wherein the battery pack comprises a plurality of battery modules.

[0024] In an embodiment, the battery module comprises the plurality of battery cells.

[0025] Other aspects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] The accompanying drawings constitute a part of the description and are used to provide further understanding of the present disclosure. The drawings illustrate exemplary embodiments of the present disclosure and, together with the description, serve to explain the principles of the present disclosure.

[0027] **Fig. 1** illustrates a schematic representation of a bus bar for a battery module and battery pack, in accordance with an embodiment of the present invention;

[0028] **Fig. 2** illustrates a schematic representation of the battery pack, in accordance with an embodiment of the present invention; and

[0029] **Fig. 3** illustrates a flow chart the bus bar verification, in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0030] The description set forth below in connection with the appended drawings is intended as a description of various embodiments of the present disclosure and is not intended to represent the only embodiments in which the present disclosure may be practiced. Each embodiment described in this disclosure is provided merely as an example or illustration of the present disclosure, and should not necessarily be construed as preferred or advantageous over other embodiments. The description includes specific details for the purpose of providing a thorough understanding of the present disclosure. However, it will be apparent to those skilled in the art that the present disclosure may be practiced without these specific details.

[0031] Exemplary embodiments now will be described with reference to the accompanying drawings. The disclosure may, however, be embodied in many different forms and should not

be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey its scope to those skilled in the art. The terminology used in the detailed description of the particular exemplary embodiments illustrated in the accompanying drawings is not intended to be limiting. In the drawings, like numbers refer to like elements.

[0032] It is to be noted, however, that the reference numerals used herein illustrate only typical embodiments of the present subject matter, and are therefore, not to be considered for limiting its scope, for the subject matter may admit to other equally effective embodiments.

[0033] The specification may refer to "an", "another", "one" or "some" embodiment(s) in several locations.

[0034] This does not necessarily imply that each such reference is to the same embodiment(s), or that the feature only applies to a single embodiment. Single features of different embodiments may also be combined to provide other embodiments.

[0035] As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless expressly stated otherwise. It will be further understood that the terms "includes", "comprises", "including" 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. It will be understood that when an element is referred to as being "connected" or "coupled" to another element, it can be directly connected or coupled to the other element or intervening elements may be present. Furthermore, "connected" or "coupled" as used herein may include operatively connected or coupled. As used herein, the term "and/or" includes any and all combinations and arrangements of one or more of the associated listed items.

[0036] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skills in the art to which this disclosure pertains. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0037] The detailed description includes specific details for the purpose of providing a thorough understanding of the present disclosure. However, it will be apparent to those skilled in the art that the present disclosure may be practiced without these specific details.

[0038] The present invention relates to bus bar for a battery module. The battery module essentially comprises of a plurality of cells arranged together to form a battery module. These cells are placed in an electrical connection using a bus bar connected to the battery terminals. Busbars are essential to an electric vehicle since they carry out the process of distribution of power from the individual cells as well as the battery pack to the motors. A battery pack comprises of plurality of such battery module welded together with busbars.

[0039] Fig. 1 illustrates a schematic representation of a bus bar according to an embodiment of the invention. The present invention provides for a bus bar which is capable of proving a single sided connection with a battery cell. The bus bar (1) comprises a plurality of first contact portions (10) and a plurality of second contact portions (20). The first contact portions (10) are present on a first side (30) of the bus bar (1), and the second contact portions (20) are present on a second side (40) of the bus bar (1). In an embodiment, each of the first contact portion (10) of the bus bar (1) is connected to a negative terminal of a battery cell and each of the second contact portion (20) of the bus bar (1) is connected to the positive terminal of the other battery cell and so on to form a connection in series. In an embodiment, the first contact portion (10) of the bus bar (1) is in an arc shape, and the second contact portion (20) of the bus bar (1) is in a ring shape.

[0040] In a preferred embodiment, the negative terminal and the positive terminal of the battery cell are provided on the same side i.e. top side of the cell. In an embodiment, the cell is a cylindrical cell with a positive terminal as a cap and the negative terminal as a rim of the cell. The first contact portion (10) of the bus bar (1) is connected to the negative rim of the cell, and the second contact portion (20) of the bus bar (1) connected to the positive cap of the other cell, and so on.

[0041] In an embodiment, the heat generated in the cell is dissipated through the negative terminal connected to the first contact portion of the bus bar. That is, the negative terminal of the cells is purely used for thermal management of the cell i.e. to increase heat dissipation of the heat generated by the cells connected to the bus bar.

[0042] In another embodiment, the positive and negative terminals of the cells are connected to the bus bar using laser source welding. In another embodiment, a customized busbar is designed according to the battery pack requirements, the required cell arrangement and electrical path of the battery pack.

[0043] The single bus bar (1), according to an embodiment, is capable of connecting a plurality of cells in parallel of one group, in series, with a plurality of cells in parallel of another group. In a preferred embodiment, the single bus bar (1) makes a parallel connection for at least eight cells of one group as shown in Fig. 1. Such an arrangement of the bus bar increases effectiveness in space utilization. Also, since all the busbar connections are present on the single side of the module, tab connections for voltage sensing are also made on the top side of the pack using the same laser source. This eliminates the number of assembly stations and robots in the assembly line as well and also decreases the battery pack assembly time.

[0044] **Fig. 2** illustrates a schematic representation of the battery pack, in accordance with an embodiment of the present invention. In an embodiment, the bus bar (1) is arranged in a battery pack (200), the battery pack (200) includes a plurality of batteries connected in series and parallel configuration. The plurality of batteries includes a first set of batteries (202) connected in parallel and a second set of batteries (204) connected in parallel. The first set of batteries (202) are connected in parallel through a positive bus bar (206), and the second set of batteries (204) are connected in parallel through a negative bus bar (208). The first set of batteries (202) are connected with the second set of batteries (204) through the bus bar (1) in series connection.

[0045] The negative bus bar (208) may include a plurality of negative sense tape (210) to couple the second set of batteries (204) of the battery pack (200). The positive bus bar (206) may include a plurality of positive sense tape (212) to couple the first set of batteries (202) of the battery pack (200). In an embodiment, the negative sense tape (210) may be correspond to the first contact portion of bus bar (1) and the positive sense tape (212) may be correspond to the second contact portion of the bus bar (1), as illustrated in Fig 1.

[0046] For example, let's take a 100V EV battery pack with 28 cells connected in parallel (each cell provides 3.6V nominal). To connect the cells in series, each cell's positive terminal needs to be connected to the negative terminal of the next cell using busbars. In an embodiment, the busbars would be made of material selected from at least one of copper/nickel/aluminium and could be single-sided welded to each terminal. In a single-sided welded busbar design, the

busbar is welded to the positive or negative terminal of each cell on only one side, reducing weight and complexity. The weld ensures that the connection is stable and secure, even under the thermal cycling conditions of an EV battery pack.

[0047] In an embodiment, a battery cell from the plurality of batteries is a cylindrical cell with the positive terminal as a cap shaped terminal and the negative terminal as a rim of the cell. The cells or batteries may be primary or rechargeable batteries. More preferably, rechargeable batteries can be used to store and supply power in various applications. Exemplary rechargeable batteries include lead acid, nickel cadmium (NiCd), nickel metal hydride (NiMH), lithium ion (Li ion), and lithium ion polymer (Li ion polymer). More preferably, lithium-ion batteries which are used to drive vehicles at least partially, for example, such batteries can be used in electric vehicles and hybrid vehicles.

[0048] The bus bar (1) is connected with the first contact portion (10) connected to the negative rim of the battery cell and the second contact portion (20) connected to the positive cap of the battery cell. In a cylindrical cell construction, the axial bulk thermal conductivity of lithium ion cell is almost ten times higher than radial thermal conductivity. Thus, in order to remove heat from the lateral surface of the cell, the area of contact with the heat sink of the battery pack must be more. Considering space and weight restrictions, heat removal from terminals in axial direction is optimal. By the cell construction, the negative terminal of the cell is the entire cylindrical body and positive terminal is the cap of the cell. Therefore, it is beneficial that heat generated by the be removed quickly from the negative terminal for following reasons:

a) More surface area of the negative terminal at bottom of the cell;

b) More thermal resistance in the positive terminal direction because of safety elements such as Current Interrupt Device (CID), vent disk.

[0049] According to an embodiment, the heat generated in the battery cell is dissipated through the negative terminal connected to the first contact portion of the bus bar. That is, the negative terminal of the cells is purely used for thermal management of the cell i.e. to increase heat dissipation of the heat generated by the cells connected to the bus bar.

[0050] For example, during operation, EV battery packs generate heat due to the flow of current. The busbars, which carry high currents, must be designed to handle this heat effectively. The single-sided welded busbar helps by providing a low-resistance connection,

which minimizes heat generation. Additionally, the design and material selection of the busbars play an essential role in ensuring the overall thermal management of the battery pack. For heat dissipation of the busbar, it needs to have sufficient cross-sectional area to handle the high currents without overheating. In some cases, busbars may have additional cooling features, such as heat sinks or channels for coolant to pass through, to keep the battery pack at optimal temperatures

[0051] In same embodiment, a thermally conductive and electrically insulative polymer material is applied on the bottom surface of each of the battery cell to remove the air gap between the cell and the heat sink, which is the metal enclosure of the battery pack.

[0052] According to the embodiment, the positive and negative terminals of the cells are connected to the bus bar using laser power source welding. Using laser power, the number of rejections or rate of rejection in single side welding is reduced. A customized busbar is designed according to the battery pack requirements, the required cell arrangement and electrical path of the battery pack.

[0053] In another embodiment, a battery module includes a plurality of bus bars connecting one group of plurality of parallel cells, in series, with another group of plurality of parallel cells. A battery pack is composed of a plurality of battery modules connected with each other through the bus bars (1).

[0054] In another embodiment, the fusible busbar (1) is configured to disconnect a bad cell from the plurality of cells. When a cell goes bad, it creates a short circuit path for the remaining parallelly connected plurality of cells. This causes a very high amount of current to flow which may melt the fusible busbar that link the bad cell to the other plurality of parallelly connected cells. This fusible busbar also saves the battery in the event of external short circuit by disconnecting the plurality of cells. Thus, avoiding the flow of high current through the cells.

[0055] Fig. 3 illustrates a flow chart the bus bar verification, in accordance with an embodiment of the present invention. In an embodiment, the verification of the bus bar may include various steps:

[0056] At step 300, a cell is welded in series and in parallel connection.

[0057] At step 302, the module level internal resistance test [IR] for each cell is performed.

[0058] At step 304, it is verified that the internal resistance [IR] result meets acceptance criteria and then move forward for the next stage.

[0059] At step 306, if it is determined that the internal resistance [IR] is equal to a total harmonic (TH) distortion, then at step 308, welded cell module is connected to the electronic or resistive load and shall apply the battery maximum current to the module for 30 seconds of duration. However, if it is determined that internal resistance [IR] is not equal to a threshold (TH), then the module shall go into re-work stage and the process will be repeated until test is passed.

[0060] At step 310, High Rate Discharge (HRD) is performed. A high rate discharge (HRD) test is a quality check that assesses a battery's reliability by discharging it at a high current for a short time.

[0061] At step 312, if the cell delta is below threshold, then the test is failed. Otherwise, if the cell delta is equal to threshold, then the test is considered as passed.

[0062] At step 314, the battery module's welding tape or interconnection between cells shall be verified. The process shall be repeated until the module meets with acceptance criteria.

[0063] The present invention provides a single-sided welded bus bar system for battery packs, offering significant technical advancements in manufacturing efficiency, thermal management, and electrical performance. By enabling single-sided connections, the design simplifies assembly, reduces material usage, and minimizes the complexity of welding processes, thereby lowering production costs and improving scalability. The integration of high-conductivity materials such as copper or aluminium enhances electrical efficiency, while the curved negative terminal contact portions improve mechanical stability and reliable connectivity. Additionally, the design optimizes thermal dissipation by allowing heat to be efficiently transferred away from battery terminals, reducing the risk of thermal runaway. The inclusion of voltage sensing points and a fusible link further enhances safety, enabling real-time monitoring and protection against overcurrent conditions. This novel approach leads to a more compact, lightweight, and robust battery pack suitable for high-performance applications such as electric vehicles, renewable energy storage, and industrial power systems.

[0064] The figures of the disclosure are provided to illustrate some examples of the disclosure described. The figures are not to limit the scope of the depicted embodiments or the appended

claims. Aspects of the disclosure are described herein with reference to the disclosure to example embodiments for illustration. It should be understood that specific details, relationships, and method are set forth to provide a full understanding of the example embodiments. One of ordinary skill in the art recognize the example embodiments can be practiced without one or more specific details and/or with other methods.

[0065] Similarly, while operations are depicted in the drawings in a particular order, this should not be understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results. In certain circumstances, multitasking and parallel processing may be advantageous. Moreover, the separation of various system components in the embodiments described above should not be understood as requiring such separation in all embodiments, and it should be understood that the described program components and systems can generally be integrated together in a single software product or packaged into multiple software products.

[0066] It is to be understood that the disclosure is not to be limited to the specific embodiments disclosed, and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation, unless described otherwise.

We claim:

1. A bus bar (1), comprising:

a plurality of first contact portions (10) on a first side of the bus bar;

a plurality of second contact portions (20) on a second side of the bus bar,

wherein the bus bar (1) is electrically connected to a battery pack, the battery pack includes a plurality of battery cells connected in series and parallel configuration,

wherein the plurality of the first contact portions (10) are configured to connect to negative terminals of the plurality of battery cells on the first side, and the plurality of second contact portions (20) configured to connect to positive terminals of the plurality of battery cells on the second side.

2. The bus bar (1) of claim 1, wherein the first contact portion (10) is arc-shaped.

3. The bus bar (1) of claim 1, wherein the second contact portion (20) is ring-shaped.

4. The bus bar (1) of claim 2, wherein the first contact portion (10) of the bus bar is the arc shaped to dissipate heat.

5. The bus bar (1) of claim 1, wherein the bus bar (1) is welded to the terminals of the plurality of the battery cells using a laser power source.

6. The bus bar (1) of claim 1, wherein single-sided connection is done by wire routing for voltage and temperature sensing.

7. The bus bar (1) of claim 1, wherein a material of the bus bar includes a high-conductivity metal such as copper, nickel, or aluminium.