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MODULAR ELECTRONIC COMPONENT ENCLOSURE

Abstract

Aspects of the subject disclosure relate to an enclosure for one or more electrical components for a battery pack. The enclosure may be configured to mechanically and electrically couple to an energy volume of the battery pack. The enclosure may include an access panel. The access panel may be formed from a solid insulating structure configured to at least partially cover the one or more electrical components, and a conductive layer on a surface of the solid insulating structure. The enclosure may be a modular enclosure that can be used to provide electrical connection to any of various energy volumes including batteries or battery cells of any of various cell chemistries.

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATION(S) [0001] The present application is a continuation of U.S. patent application Ser. No. 18/583,769 entitled "MODULAR ELECTRONIC COMPONENT ENCLOSURE", filed Feb. 21, 2024, the entirety of which is incorporated herein for reference. [0002] Batteries are often used as a source of power, including as a source of power for electric vehicles that include wheels that are driven by an electric motor that receives power from the battery. [0003] Aspects of the subject technology can help to improve the efficiency, serviceability, reliability, and/or range of electric vehicles, which can help to mitigate climate change by reducing greenhouse gas emissions.

SUMMARY
[0004] Aspects of the subject technology relate to a modular electronic component enclosure for a battery pack. For example, power electronics for a battery pack (e.g., having a pack frame that encloses one or more battery cells) may be housed in a separate enclosure at the rear of the battery pack. The electronic components in the separate enclosure may be serviceable by removing an access panel of the enclosure (e.g., from under a rear seat of the vehicle). The enclosure can be formed (e.g., primarily) from plastic or other insulating materials to reduce the mass and weight of the enclosure, and may be lined or coated with a conductive material, such as a foil, a coating, or a resin, to provide electromagnetic interference (EMI) protection and/or electromagnetic compatibility (EMC) properties. The enclosure may also include one or more metal layers and/or features, on or attached to a bottom plate of the enclosure, for grounding purposes. The enclosure may be modular, for mechanical and/or electrical connection to any of various energy volumes for any of various battery packs.
[0005] In accordance with aspects of the subject technology, an apparatus is provided that includes an enclosure for one or more electrical components for a battery pack. The enclosure may be configured to mechanically and electrically couple to an energy volume of the battery pack. The enclosure may include an access panel formed from a solid insulating structure configured to at least partially cover the one or more electrical components; and a conductive layer on a surface of the solid insulating structure. The surface of the solid insulating structure may include an interior surface of the solid insulating structure. The conductive layer may include at least one of: a foil, a coating, or a resin. The enclosure may also include a tray configured for mounting the one or more electrical components thereto. The tray and the access panel may be configured to at least partially enclose the one or more electrical components.
[0006] The tray may include a solid insulating tray, and the enclosure may also include at least one grounding structure coupled to the solid insulating tray. The at least one grounding structure may include a metal, and the solid insulating tray may be overmolded on the metal. The solid insulating tray may include a plurality of molded features configured for retaining the one or more electrical components. The enclosure may also include a solid insulating tub disposed between the tray and the access panel. The access panel and the tray may be configured to be attached to the solid insulating tub, and the solid insulating tub may include an additional conductive layer on a surface of the solid insulating tub. The solid insulating tub may include a plurality of ribs configured to provide structural rigidity to the solid insulating tub.
[0007] The tray may include an outer surface having a first portion configured to interface with a

frame of the energy volume of the battery pack, and a second portion configured to overhang the frame of the energy volume of the battery pack. The tray may include one or more first openings in the first portion of the outer surface for accommodating one or more high voltage connectors to one or more battery cells within the frame of the energy volume, and one or more second openings in the second portion of the outer surface for accommodating one or more high voltage output connectors coupled to the one or more electrical components. The tray may include one or more third openings in the second portion, the one or more third openings configured to accommodate one or more coolant ports for the enclosure. The solid insulating tub may include a ledge for mounting a flange of one of the one or more electrical components.

[0008] The tray may include a solid insulting tray, a conductive layer on an interior surface of the tray, and molded metal on an exterior surface of the tray, and the enclosure may also include a retention structure that includes a plurality of molded features configured for retaining the one or more electrical components.

[0009] The tray may include a metal tray, and the enclosure may also include a retention structure that includes a plurality of molded features configured for retaining the one or more electrical components. The enclosure may also include a tray that includes a solid insulating structure configured for mounting the one or more electrical components thereto. The access panel may be configured to attach directly to the tray to at least partially enclose the one or more electrical components. The enclosure may also include a retention structure that includes a plurality of molded features configured for retaining the one or more electrical components within the enclosure formed by the solid insulating structure and the access panel.

[0010] In accordance with other aspects of the disclosure, a vehicle may be provided that includes a battery pack, the battery pack including an enclosure for one or more electrical components for the battery pack, the enclosure configured to mechanically and electrically couple to an energy volume of the battery pack. The enclosure may include an access panel formed from a solid insulating structure configured to at least partially cover the one or more electrical components; and a conductive layer on a surface of the solid insulating structure.

[0011] The enclosure may also include a mid-structure that includes a solid insulating structure, a conductive layer on an interior surface of the solid insulating structure, and ribbing configured to provide structural impact resistance for the enclosure. The enclosure may also include a bottom panel, the bottom panel and the access panel configured to attach to the mid-structure to form the enclosure. The enclosure may also include a support structure configured to attach to a frame of the battery pack and to an overhang on the bottom panel to provide structural impact resistance for the vehicle.

[0012] The mid-structure may also include a sealing feature for sealingly attaching the enclosure to a body structure of the vehicle. The bottom panel may also include a plurality of seals for sealing a plurality of high voltage ports between the enclosure and the battery pack.

[0013] In accordance with other aspects of the disclosure, a method of assembling a vehicle may be provided, the method including: attaching one or more electrical components to a solid insulating tray having at least one grounding structure thereon; mounting a solid insulating tub having a conductive layer to the solid insulating tray; attaching one or more additional electrical components to the solid insulating tub; forming an enclosure for the one or more electrical components and the one or more additional electrical components by attaching an access panel to the solid insulating tub; attaching the enclosure to a frame for an energy volume for a battery pack; and attaching the enclosure and the frame to one or more body structures of the vehicle.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Certain features of the subject technology are set forth in the appended claims. However, for purpose of explanation, several embodiments of the subject technology are set forth in the following figures.

[0015] FIGS. **1**A and **1**B illustrate schematic perspective side views of example implementations of a vehicle having a battery pack in accordance with one or more implementations.

[0016] FIG. **1**C illustrates a schematic perspective view of a building having a battery pack in accordance with one or more implementations.

[0017] FIG. **2**A illustrates a schematic perspective view of a battery pack in accordance with one or more implementations.

[0018] FIG. **2**B illustrates schematic perspective views of various battery modules that may be included in a battery pack in accordance with one or more implementations.

[0019] FIG. **2**C illustrates a cross-sectional end view of a battery cell in accordance with one or more implementations.

[0020] FIG. **2**D illustrates a cross-sectional perspective view of a cylindrical battery cell in accordance with one or more implementations.

[0021] FIG. **2**E illustrates a cross-sectional perspective view of a prismatic battery cell in accordance with one or more implementations.

[0022] FIG. **2**F illustrates a cross-sectional perspective view of a pouch battery cell in accordance with one or more implementations.

[0023] FIG. **3** illustrates a schematic cross-sectional side view of a battery pack in accordance with one or more implementations.

[0024] FIG. **4** illustrates a top perspective view of a portion of a battery pack in accordance with one or more implementations.

[0025] FIG. **5** illustrates an exploded perspective view of a modular enclosure for one or more electrical components for a battery pack in accordance with one or more implementations.

[0026] FIG. **6** illustrates a bottom perspective view of a subassembly of a modular enclosure for one or more electrical components for a battery pack in accordance with one or more implementations.

[0027] FIG. **7**A illustrates a bottom perspective view of a modular enclosure for one or more electrical components for a battery pack in accordance with one or more implementations.

[0028] FIG. **7**B illustrates a perspective view of an assembly for high and low voltage feedthrough for a modular enclosure in accordance with one or more implementations.

[0029] FIG. **7**C illustrates an exploded perspective view of the assembly of FIG. **7**B in accordance with one or more implementations.

[0030] FIG. **7**D illustrates a top view of the assembly of FIG. **7**B in accordance with one or more implementations.

[0031] FIG. **7**E illustrates a top perspective view of another implementation of an assembly for high and low voltage feedthrough for a modular enclosure, with a top housing removed, in accordance with one or more implementations.

[0032] FIG. **7**F illustrates a top perspective view of a portion of the assembly of FIG. **7**E with the top housing installed, in accordance with one or more implementations.

[0033] FIG. **8** illustrates a cross-sectional side view of a modular enclosure for one or more electrical components for a battery pack in accordance with one or more implementations.

[0034] FIG. **9** illustrates a cross-sectional side view of a tray for a modular enclosure for one or more electrical components for a battery pack in accordance with one or more implementations.

[0035] FIG. **10** illustrates a cross-sectional side perspective view of a portion of a battery pack having a modular enclosure for one or more electrical components for the battery pack in accordance with one or more implementations.

[0036] FIG. **11** illustrates a bottom perspective view of a portion of a battery pack having a modular enclosure for one or more electrical components for the battery pack in accordance with one or more implementations.
[0037] FIG. **12** illustrates a top perspective view of a modular enclosure coupled to a body structure of a vehicle in accordance with one or more implementations.
[0038] FIG. **13** illustrates a bottom view of a modular enclosure coupled to a body structure of a vehicle in accordance with one or more implementations.
[0039] FIG. **14** illustrates an exploded perspective view of another example modular enclosure for one or more electrical components for a battery pack in accordance with one or more implementations.
[0040] FIG. **15** illustrates an exploded perspective view yet another example modular enclosure for one or more electrical components for a battery pack in accordance with one or more implementations.
[0041] FIG. **16** illustrates an exploded perspective view still another example modular enclosure for one or more electrical components for a battery pack in accordance with one or more implementations.
[0042] FIG. **17** illustrates a flow chart of illustrative operations that may be performed for assembling a vehicle in accordance with one or more implementations.

DETAILED DESCRIPTION

[0043] The detailed description set forth below is intended as a description of various configurations of the subject technology and is not intended to represent the only configurations in which the subject technology can be practiced. The appended drawings are incorporated herein and constitute a part of the detailed description. The detailed description includes specific details for the purpose of providing a thorough understanding of the subject technology. However, the subject technology is not limited to the specific details set forth herein and can be practiced using one or more other implementations. In one or more implementations, structures and components are shown in block diagram form in order to avoid obscuring the concepts of the subject technology.
[0044] Aspects of the subject technology described herein relate to a modular electronic component enclosure for battery packs. The modular electronic component enclosure may include an enclosure body that encloses one or more electrical and/or electronic components for distributing power from an energy volume of a battery pack. The modular electronic component enclosure may be mechanically and electrically couplable to the energy volume of any of various battery packs having various sizes and/or having battery cells of various cell chemistries. In accordance with one or more implementations of the subject technology, the modular electronic component enclosure may be formed primarily from solid lightweight and/or insulating materials, and may include conductive layers and/or elements for managing electromagnetic interference (EMI), electromagnetic compatibility (EMC,) and/or grounding properties.
[0045] FIG. **1**A is a diagram illustrating an example implementation of a moveable apparatus as described herein. In the example of FIG. **1**A, a moveable apparatus is implemented as a vehicle **100**. As shown, the vehicle **100** may include one or more battery packs, such as battery pack **110**. The battery pack **110** may be coupled to one or more electrical systems of the vehicle **100** to provide power to the electrical systems.
[0046] In one or more implementations, the vehicle **100** may be an electric vehicle having one or more electric motors that drive the wheels **102** of the vehicle using electric power from the battery pack **110**. In one or more implementations, the vehicle **100** may also, or alternatively, include one or more chemically powered engines, such as a gas-powered engine or a fuel cell powered motor. For example, electric vehicles can be fully electric or partially electric (e.g., hybrid or plug-in hybrid.
[0047] In the example of FIG. **1**A, the vehicle **100** is implemented as a truck (e.g., a pickup truck) having a battery pack **110**. As shown, the battery pack **110** may include one or more battery

modules **115**, which may include one or more battery cells **120**. As shown in FIG. **1**A, the battery pack **110** may also, or alternatively, include one or more battery cells **120** mounted directly in the battery pack **110** (e.g., in a cell-to-pack configuration). In one or more implementations, the battery pack **110** may be provided without any battery modules **115** and with the battery cells **120** mounted directly in the battery pack **110** (e.g., in a cell-to-pack configuration) and/or in other battery units that are installed in the battery pack **110**. A vehicle battery pack can include multiple energy storage devices that can be arranged into such as battery modules or battery units. A battery unit or module can include an assembly of cells that can be combined with other elements (e.g., structural frame, thermal management devices) that can protect the assembly of cells from heat, shock and/or vibrations.

[0048] For example, the battery cell **120** can be included a battery, a battery unit, a battery module and/or a battery pack to power components of the vehicle **100**. For example, a battery cell housing of the battery cell **120** can be disposed in the battery module **115**, the battery pack **110**, a battery array, or other battery unit installed in the vehicle **100**.

[0049] As discussed in further detail hereinafter, the battery cells **120** may be provided with a battery cell housing that can be provided with any of various outer shapes. The battery cell housing may be a rigid housing in some implementations (e.g., for cylindrical or prismatic battery cells). The battery cell housing may also, or alternatively, be formed as a pouch or other flexible or malleable housing for the battery cell in some implementations. In various other implementations, the battery cell housing can be provided with any other suitable outer shape, such as a triangular outer shape, a square outer shape, a rectangular outer shape, a pentagonal outer shape, a hexagonal outer shape, or any other suitable outer shape. In some implementations, the battery pack **110** may not include modules (e.g., the battery pack may be module-free). For example, the battery pack **110** can have a module-free or cell-to-pack configuration in which the battery cells **120** are arranged directly into the battery pack **110** without assembly into a battery module **115**. In one or more implementations, the vehicle **100** may include one or more busbars, electrical connectors, or other charge collecting, current collecting, and/or coupling components to provide electrical power from the battery pack **110** to various systems or components of the vehicle **100**. In one or more implementations, the vehicle **100** may include control circuitry such as a power stage circuit that can be used to convert DC power from the battery pack **110** into AC power for one or more components and/or systems of the vehicle (e.g., including one or more power outlets of the vehicle and/or the motor(s) that drive the wheels **102** of the vehicle). The power stage circuit can be provided as part of the battery pack **110** or separately from the battery pack **110** within the vehicle **100**. The vehicle **100** may have a front end **131** and a rear end **133**.

[0050] The example of FIG. **1**A in which the vehicle **100** is implemented as a pickup truck having a truck bed at the rear portion thereof is merely illustrative. For example, FIG. **1**B illustrates another implementation in which the vehicle **100** including the battery pack **110** is implemented as a sport utility vehicle (SUV), such as an electric sport utility vehicle. In the example of FIG. **1**B, the vehicle **100** including the battery pack **110** may include a cargo storage area that is enclosed within the vehicle **100** (e.g., behind a row of seats within a cabin of the vehicle). In other implementations, the vehicle **100** may be implemented as another type of electric truck, an electric delivery van, an electric automobile, an electric car, an electric motorcycle, an electric scooter, an electric bicycle, an electric passenger vehicle, an electric passenger or commercial truck, a hybrid vehicle, an aircraft, a watercraft, and/or any other movable apparatus having a battery pack **110** (e.g., a battery pack or other battery unit that powers the propulsion or drive components of the moveable apparatus).

[0051] In one or more implementations, a battery pack such as the battery pack **110**, a battery module **115**, a battery cell **120**, and/or any other battery unit as described herein may also, or alternatively, be implemented as an electrical power supply and/or energy storage system in a building, such as a residential home or commercial building. For example, FIG. **1**C illustrates an example in which a battery pack **110** is implemented in a building **180**. For example, the building **180** may be a residential building, a commercial building, or any other building. As shown, in one or more implementations, a battery pack **110** may be mounted to a wall of the building **180**.

[0052] As shown, the battery **110**A that is installed in the building **180** may be couplable to the battery pack **110** in the vehicle **100**, such as via: a cable/connector **106** that can be connected to the charging port **130** of the vehicle **100**, electric vehicle supply equipment **170** (EVSE), a power stage circuit **172**, and/or a cable/connector **174**. For example, the cable/connector **106** may be coupled to the EVSE **170**, which may be coupled to the battery **110**A via the power stage circuit **172**, and/or may be coupled to an external power source **190**. In this way, either the external power source **190** or the battery **110**A that is installed in the building **180** may be used as an external power source to charge the battery pack **110** in the vehicle **100** in some use cases. In some examples, the battery **110**A that is installed in the building **180** may also, or alternatively, be coupled (e.g., via a cable/connector **174**, the power stage circuit **172**, and the EVSE **170**) to the external power source **190**. For example, the external power source **190** may be a solar power source, a wind power source, and/or an electrical grid of a city, town, or other geographic region (e.g., electrical grid that is powered by a remote power plant). During, for example, times when the battery pack **110** in the vehicle **100** is not coupled to the battery **110**A that is installed in the building **180**, the battery **110**A that is installed in the building **180** can be coupled (e.g., using the power stage circuit **172** for the building **180**) to the external power source **190** to charge up and store electrical energy. In some use cases, this stored electrical energy in the battery **110**A that is installed in the building **180** can later be used to charge the battery pack **110** in the vehicle **100** (e.g., during times when solar power or wind power is not available, in the case of a regional or local power outage for the building **180**, and/or during a period of high rates for access to the electrical grid).

[0053] In one or more implementations, the power stage circuit **172** may electrically couple the battery **110**A that is installed in the building **180** to an electrical system of the building **180**. For example, the power stage circuit **172** may convert DC power from the battery **110**A into AC power for one or more loads in the building **180**. For example, the battery **110**A that is installed in the building **180** may be used to power one or more lights, lamps, appliances, fans, heaters, air conditioners, and/or any other electrical components or electrical loads in the building **180** (e.g., via one or more electrical outlets that are coupled to the battery **110**A that is installed in the building **180**). For example, the power stage circuit **172** may include control circuitry that is operable to switchably couple the battery **110**A between the external power source **190** and one or more electrical outlets and/or other electrical loads in the electrical system of the building **180**. In one or more implementations, the vehicle **100** may include a power stage circuit (not shown in FIG. **1**C) that can be used to convert power received from the electric vehicle supply equipment **170** to DC power that is used to power/charge the battery pack **110** of the vehicle **100**, and/or to convert DC power from the battery pack **110** into AC power for one or more electrical systems, components, and/or loads of the vehicle **100**.

[0054] In one or more use cases, the battery **110**A that is installed in the building **180** may be used as a source of electrical power for the building **180**, such as during times when solar power or wind power is not available, in the case of a regional or local power outage for the building **180**, and/or during a period of high rates for access to the electrical grid (as examples). In one or more other use cases, the battery pack **110** that is installed in the vehicle may be used to charge the battery **110**A that is installed in the building **180** and/or to power the electrical system of the building **180** (e.g., in a use case in which the battery **110**A that is installed in the building **180** is low on or out of stored energy and in which solar power or wind power is not available, a regional or local power outage occurs for the building **180**, and/or a period of high rates for access to the electrical grid occurs (as examples)).

[0055] FIG. **2**A depicts an example battery pack **110**, in accordance with one or more implementations. As shown, the battery pack **110** may include a battery pack frame **205** (e.g., a battery pack housing or pack frame). For example, the battery pack frame **205** may house or enclose an energy volume **207** for the battery pack **110**, the energy volume **207** including one or more battery modules **115** and/or one or more battery cells **120**, and/or other battery pack components. In one or more implementations, the battery pack frame **205** may include or form a shielding structure on an outer surface thereof (e.g., a bottom thereof and/or underneath one or more battery module **115**, battery units, batteries, and/or battery cells **120**) to protect the battery module **115**, battery units, batteries, and/or battery cells **120** from external conditions (e.g., if the battery pack **110** is installed in a vehicle **100** and the vehicle **100** is driven over rough terrain, such as off-road terrain, trenches, rocks, rivers, streams, etc.).

[0056] Battery pack **110** may include, within the energy volume **207** and the battery pack frame **205**, multiple battery cells **120** (e.g., directly installed within the battery pack **110**, or within batteries, battery units, and/or battery modules **115** as described herein) and/or battery modules **115**, and one or more conductive coupling elements for coupling a voltage generated by the battery cells **120** to a power-consuming component, such as the vehicle **100** and/or an electrical system of a building **180**. For example, the conductive coupling elements may include internal connectors and/or contactors that couple together multiple battery cells **120**, battery units, batteries, and/or multiple battery modules **115** within the battery pack frame **205** to generate a desired output voltage for the battery pack **110**.

[0057] As shown, the battery pack **110** may also include a modular enclosure **290** (e.g., a modular electronic component enclosure or a modular electrical component enclosure) mounted to the battery pack frame **205**. In one or more implementations, the modular enclosure **290** may include one or more of the conductive coupling elements for routing power from the battery cells **120** and/or battery modules **115** within the pack frame **205** (e.g., within the energy volume **207**) to one or more external connection ports, such as electrical contact **203** (e.g., a high voltage terminal, port, or connector). For example, an electrical cable or harness may be connected between the electrical contact **203** and an electrical system of the vehicle **100** or the building **180**, to provide electrical power to the vehicle **100** or the building **180**. The battery pack frame **205** may have a front end **267** and a rear end **269**. In one or more implementations, when the battery pack **110** is installed in the vehicle **100**, the battery pack **110** may be arranged with the front end **267** closer to the front end **131** of the vehicle and the rear end **269** closer to the rear end **133** of the vehicle. As shown, the modular enclosure **290** may be mounted to the pack frame **205** at or near the rear end **269** in one or more implementations.

[0058] In one or more implementations, the battery pack **110** may include one or more additional features, such as thermal control structures (e.g., cooling lines and/or plates and/or heating lines and/or plates). For example, thermal control structures may couple thermal control structures and/or fluids to the battery modules **115**, battery units, batteries, and/or battery cells **120** within the battery pack frame **205**, such as by distributing fluid through the battery pack **110**.

[0059] For example, the thermal control structures may form a part of a thermal/temperature control or heat exchange system that includes one or more thermal components such as plates or bladders that are disposed in thermal contact with one or more battery modules **115** and/or battery cells **120** disposed within the battery pack frame **205**. For example, a thermal component may be positioned in contact with one or more battery modules **115**, battery units, batteries, and/or battery cells **120** within the battery pack frame **205**. In one or more implementations, the battery pack **110** may include one or multiple thermal control structures and/or other thermal components for each of several top and bottom battery module pairs. As shown, the battery pack **110** may include an electrical contact **203** (e.g., a high voltage connector or port) by which an external load (e.g., the vehicle **100** or an electrical system of the building **180**) may be electrically coupled to the battery modules and/or battery cells in the battery pack **110**.

[0060] FIG. **2**B depicts various examples of battery modules **115** that may be disposed in the battery pack **110** (e.g., within the battery pack frame **205** of FIG. **2**A). In the example of FIG. **2**B, a battery module **115**A is shown that includes a battery module housing **223** having a rectangular cuboid shape with a length that is substantially similar to its width. In this example, the battery module **115**A includes multiple battery cells **120** implemented as cylindrical battery cells. In this example, the battery module **115**A includes rows and columns of cylindrical battery cells that are coupled together by an interconnect structure **200** (e.g., a current connector assembly or CCA). For example, the interconnect structure **200** may couple together the positive terminals of the battery cells **120**, and/or couple together the negative battery terminals of the battery cells **120**. As shown, the battery module **115**A may include a charge collector or bus bar **202**. For example, the bus bar **202** may be electrically coupled to the interconnect structure **200** to collect the charge generated by the battery cells **120** to provide a high voltage output from the battery module **115**A.

[0061] FIG. **2**B also shows a battery module **115**B having an elongate shape, in which the length of the battery module housing **223** (e.g., extending along a direction from a front end of the battery pack **110** to a rear end of the battery pack **110** when the battery module **115**B is installed in the battery pack **110**) is substantially greater than a width (e.g., in a transverse direction to the direction from the front end of the battery pack **110** to the rear end of the battery pack **110** when the battery module **115**B is installed in the battery pack **110**) of the battery module housing **223**. For example, one or more battery modules **115**B may span the entire front-to-back length of a battery pack within the battery pack frame **205**. As shown, the battery module **115**B may also include a bus bar **202** electrically coupled to the interconnect structure **200**. For example, the bus bar **202** may be electrically coupled to the interconnect structure **200** to collect the charge generated by the battery cells **120** to provide a high voltage output from the battery module **115**B.

[0062] In the implementations of battery module **115**A and battery module **115**B, the battery cells **120** are implemented as cylindrical battery cells. However, in other implementations, a battery module may include battery cells having other form factors, such as a battery cells having a right prismatic outer shape (e.g., a prismatic cell), or a pouch cell implementation of a battery cell. As an example, FIG. **2**B also shows a battery module **115**C having a battery module housing **223** having a rectangular cuboid shape with a length that is substantially similar to its width and including multiple battery cells **120** implemented as prismatic battery cells. In this example, the battery module **115**C includes rows and columns of prismatic battery cells that are coupled together by an interconnect structure **200** (e.g., a current collector assembly or CCA). For example, the interconnect structure **200** may couple together the positive terminals of the battery cells **120** and/or couple together the negative battery terminals of the battery cells **120**. As shown, the battery module **115**C may include a charge collector or bus bar **202**. For example, the bus bar **202** may be electrically coupled to the interconnect structure **200** to collect the charge generated by the battery cells **120** to provide a high voltage output from the battery module **115**C.

[0063] FIG. **2**B also shows a battery module **115**D including prismatic battery cells and having an elongate shape, in which the length of the battery module housing **223** (e.g., extending along a direction from a front end of the battery pack **110** to a rear end of the battery pack **110** when the battery module **115**D is installed in the battery pack **110**) is substantially greater than a width (e.g., in a transverse direction to the direction from the front end of the battery pack **110** to the rear end of the battery pack **110** when the battery module **115**D is installed in the battery pack **110**) of the battery module housing **223**. For example, one or more battery modules **115**D having prismatic battery cells may span the entire front-to-back length of a battery pack within the battery pack frame **205**. As shown, the battery module **115**D may also include a bus bar **202** electrically coupled to the interconnect structure **200**. For example, the bus bar **202** may be electrically coupled to the interconnect structure **200** to collect the charge generated by the battery cells **120** to provide a high voltage output from the battery module **115**D.

[0064] As another example, FIG. **2**B also shows a battery module **115**E having a battery module housing **223** having a rectangular cuboid shape with a length that is substantially similar to its width and including multiple battery cells **120** implemented as pouch battery cells. In this example,

the battery module **115**C includes rows and columns of pouch battery cells that are coupled together by an interconnect structure **200** (e.g., a current collector assembly or CCA). For example, the interconnect structure **200** may couple together the positive terminals of the battery cells **120** and couple together the negative battery terminals of the battery cells **120**. As shown, the battery module **115**E may include a charge collector or bus bar **202**. For example, the bus bar **202** may be electrically coupled to the interconnect structure **200** to collect the charge generated by the battery cells **120** to provide a high voltage output from the battery module **115**E.
[0065] FIG. **2**B also shows a battery module **115**F including pouch battery cells and having an elongate shape in which the length of the battery module housing **223** (e.g., extending along a direction from a front end of the battery pack **110** to a rear end of the battery pack **110** when the battery module **115**E is installed in the battery pack **110**) is substantially greater than a width (e.g., in a transverse direction to the direction from the front end of the battery pack **110** to the rear end of the battery pack **110** when the battery module **115**E is installed in the battery pack **110**) of the battery module housing **223**. For example, one or more battery modules **115**E having pouch battery cells may span the entire front-to-back length of a battery pack within the battery pack frame **205**. As shown, the battery module **115**E may also include a bus bar **202** electrically coupled to the interconnect structure **200**. For example, the bus bar **202** may be electrically coupled to the interconnect structure **200** to collect the charge generated by the battery cells **120** to provide a high voltage output from the battery module **115**E.
[0066] In various implementations, a battery pack **110** may be provided with one or more of any of the battery modules **115**A, **115**B, **115**C, **115**D, **115**E, and **115**F. In one or more other implementations, a battery pack **110** may be provided without battery modules **115** (e.g., in a cell-to-pack implementation).
[0067] In one or more implementations, multiple battery modules **115** in any of the implementations of FIG. **2**B may be coupled (e.g., in series) to a current collector of the battery pack **110**. In one or more implementations, the current collector may be coupled, via a high voltage harness, to one or more external connectors (e.g., electrical contact **203**) on the battery pack **110**. In one or more implementations, the battery pack **110** may be provided without any battery modules **115**. For example, the battery pack **110** may have a cell-to-pack configuration in which battery cells **120** are arranged directly into the battery pack **110** without assembly into a battery module **115** (e.g., without including a separate battery module housing **223**). For example, the battery pack **110** (e.g., the battery pack frame **205**) may include or define a plurality of structures for positioning of the battery cells **120** directly within the battery pack frame **205**.
[0068] FIG. **2**C illustrates a cross-sectional end view of a portion of a battery cell **120**. As shown in FIG. **2**C, a battery cell **120** may include an anode **208**, an electrolyte **210**, and a cathode **212**. As shown, the anode **208** may include or be electrically coupled to a first current collector **206** (e.g., a metal layer such as a layer of copper foil or other metal foil). As shown, the cathode **212** may include or be electrically coupled to a second current collector **214** (e.g., a metal layer such as a layer of aluminum foil or other metal foil). As shown, the battery cell **120** may include a first terminal **216** (e.g., a negative terminal) coupled to the anode **208** (e.g., via the first current collector **206**) and a second terminal **218** (e.g., a positive terminal) coupled to the cathode (e.g., via the second current collector **214**). In various implementations, the electrolyte **210** may be a liquid electrolyte layer or a solid electrolyte layer. In one or more implementations (e.g., implementations in which the electrolyte **210** is a liquid electrolyte layer), the battery cell **120** may include a separator layer **220** that separates the anode **208** from the cathode **212**. In one or more implementations in which the electrolyte **210** is a solid electrolyte layer, the solid electrolyte layer may act as both separator layer and an electrolyte layer.
[0069] In one or more implementations, the battery cell **120** may be implemented as a lithium ion battery cell in which the anode **208** is formed from a carbonaceous material (e.g., graphite or silicon-carbon). In these implementations, lithium ions can move from the anode **208**, through the

electrolyte **210**, to the cathode **212** during discharge of the battery cell **120** (e.g., and through the electrolyte **210** from the cathode **212** to the anode **208** during charging of the battery cell **120**). For example, the anode **208** may be formed from a graphite material that is coated on a copper foil corresponding to the first current collector **206**. In these lithium ion implementations, the cathode **212** may be formed from one or more metal oxides (e.g., a lithium cobalt oxide, a lithium manganese oxide, a lithium nickel manganese cobalt oxide (NMC), or the like) and/or a lithium iron phosphate. As shown, the battery cell **120** may include a separator layer **220** that separates the anode **208** from the cathode **212**. In an implementation in which the battery cell **120** is implemented as a lithium-ion battery cell, the electrolyte **210** may include a lithium salt in an organic solvent. The separator layer **220** may be formed from one or more insulating materials (e.g., a polymer such as polyethylene, polypropylene, polyolefin, and/or polyamide, or other insulating materials such as rubber, glass, cellulose or the like). The separator layer **220** may prevent contact between the anode **208** and the cathode **212**, and may be permeable to the electrolyte **210** and/or ions within the electrolyte **210**. In one or more implementations, the battery cell **120** may be implemented as a lithium polymer battery cell having a dry solid polymer electrolyte and/or a gel polymer electrolyte.

[0070] Although some examples are described herein in which the battery cells **120** are implemented as lithium-ion battery cells, some or all of the battery cells **120** in a battery module **115**, battery pack **110**, or other battery or battery unit may be implemented using other battery cell technologies, such as nickel-metal hydride battery cells, sodium ion battery cells, lead-acid battery cells, and/or ultracapacitor cells. For example, in a nickel-metal hydride battery cell, the anode **208** may be formed from a hydrogen-absorbing alloy and the cathode **212** may be formed from a nickel oxide-hydroxide. In the example of a nickel-metal hydride battery cell, the electrolyte **210** may be formed from an aqueous potassium hydroxide in one or more examples.

[0071] The battery cell **120** may be implemented as a lithium sulfur battery cell in one or more other implementations. For example, in a lithium sulfur battery cell, the anode **208** may be formed at least in part from lithium, the cathode **212** may be formed from at least in part form sulfur, and the electrolyte **210** may be formed from a cyclic ether, a short-chain ether, a glycol ether, an ionic liquid, a super-saturated salt-solvent mixture, a polymer-gelled organic media, a solid polymer, a solid inorganic glass, and/or other suitable electrolyte materials.

[0072] In various implementations, the anode **208**, the electrolyte **210**, and the cathode **212** of FIG. **2**C can be packaged into a battery cell housing having any of various shapes, and/or sizes, and/or formed from any of various suitable materials. For example, battery cells **120** can have a cylindrical, rectangular, square, cubic, flat, pouch, elongated, or prismatic outer shape. As depicted in FIG. **2**D, for example, a battery cell such as the battery cell **120** may be implemented as a cylindrical cell. In the example of FIG. **2**D, the battery cell **120** includes a cell housing **215** having a cylindrical outer shape. For example, the anode **208**, the electrolyte **210**, and the cathode **212** may be rolled into one or more substantially cylindrical windings **221**. As shown, one or more windings **221** of the anode **208**, the electrolyte **210**, and the cathode **212** (e.g., and/or one or more separator layers such as separator layer **220**) may be disposed within the cell housing **215**. For example, a separator layer may be disposed between adjacent ones of the windings **221**. However, the cylindrical cell implementation of FIG. **2**D is merely illustrative, and other implementations of the battery cells **120** are contemplated.

[0073] For example, FIG. **2**E illustrates an example in which the battery cell **120** is implemented as a prismatic cell. As shown in FIG. **2**E, the battery cell **120** may have a cell housing **215** having a right prismatic outer shape. As shown, one or more layers of the anode **208**, the cathode **212**, and the electrolyte **210** disposed therebetween may be disposed (e.g., with separator materials between the layers) within the cell housing **215** having the right prismatic shape. As examples, multiple layer of the anode **208**, electrolyte **210**, and cathode **212** can be stacked (e.g., with separator materials between each layer), or a single layer of the anode **208**, electrolyte **210**, and cathode **212** can be formed into a flattened spiral shape and provided in the cell housing **215** having the right prismatic shape. In the implementation of FIG. **2**E, the cell housing **215** has a relatively thick cross-sectional width **217** and is formed from a rigid material. For example, the cell housing **215** in the implementation of FIG. **2**E may be formed from a welded, stamped, deep drawn, and/or impact extruded metal sheet, such as a welded, stamped, deep drawn, and/or impact extruded aluminum sheet. For example, the cross-sectional width **217** of the cell housing **215** of FIG. **2**E may be as much as, or more than 1 millimeter (mm) to provide a rigid housing for the prismatic battery cell. In one or more implementations, the first terminal **216** and the second terminal **218** in the prismatic cell implementation of FIG. **2**E may be formed from a feedthrough conductor that is insulated from the cell housing **215** (e.g., a glass to metal feedthrough) as the conductor passes through to cell housing **215** to expose the first terminal **216** and the second terminal **218** outside the cell housing **215** (e.g., for contact with an interconnect structure **200** of FIG. **2**B). However, this implementation of FIG. **2**E is also illustrative and yet other implementations of the battery cell **120** are contemplated.

[0074] For example, FIG. **2**F illustrates an example in which the battery cell **120** is implemented as a pouch cell. As shown in FIG. **2**F, one or more layers of the anode **208**, the cathode **212**, and the electrolyte **210** disposed therebetween may be disposed (e.g., with separator materials between the layers) within the cell housing **215** that forms a flexible or malleable pouch housing. In the implementation of FIG. **2**F, the cell housing **215** has a relatively thin cross-sectional width **219**. For example, the cell housing **215** in the implementation of FIG. **2**F may be formed from a flexible or malleable material (e.g., a foil, such as a metal foil, or film, such as an aluminum-coated plastic film). For example, the cross-sectional width **219** of the cell housing **215** of FIG. **2**F may be as low as, or less than 0.1 mm, 0.05 mm, 0.02 mm, or 0.01 mm to provide flexible or malleable housing for the pouch battery cell. In one or more implementations, the first terminal **216** and the second terminal **218** in the pouch cell implementation of FIG. **2**F may be formed from conductive tabs (e.g., foil tabs) that are coupled (e.g., welded) to the anode **208** and the cathode **212** respectively, and sealed to the pouch that forms the cell housing **215** in these implementations. In the examples of FIGS. **2**C, **2**E, and **2**F, the first terminal **216** and the second terminal **218** are formed on the same side (e.g., a top side) of the battery cell **120**. However, this is merely illustrative and, in other implementations, the first terminal **216** and the second terminal **218** may formed on two different sides (e.g., opposing sides, such as a top side and a bottom side) of the battery cell **120**. The first terminal **216** and the second terminal **218** may be formed on a same side or difference sides of the cylindrical cell of FIG. **2**D in various implementations.

[0075] In one or more implementations, a battery module **115**, a battery pack **110**, a battery unit, or any other battery may include some battery cells **120** that are implemented as solid-state battery cells and other battery cells **120** that are implemented with liquid electrolytes for lithium-ion or other battery cells having liquid electrolytes. One or more of the battery cells **120** may be included a battery module **115** or a battery pack **110**, such as to provide an electrical power supply for components of the vehicle **100**, the building **180**, or any other electrically powered component or device. The cell housing **215** of the battery cell **120** can be disposed in the battery module **115**, the battery pack **110**, or installed in any of the vehicle **100**, the building **180**, or any other electrically powered component or device.

[0076] FIG. **3** illustrates a schematic cross-sectional side view of a battery pack in accordance with one or more implementations of the subject technology. As shown in FIG. **3**, the battery pack **110** may include the energy volume **207**, and the enclosure **290**. As shown, the energy volume **207** may include the pack frame **205** and one or more battery modules **115** and/or battery cells **120** therewithin. The enclosure **290** may enclose, or house, one or more electrical components **304** for the battery pack **110**. For example, the enclosure **290** may be configured to mechanically and electrically couple to the energy volume **207** of the battery pack **110**. For example, the electrical components **304** (e.g., a high voltage distribution bus, one or more other electrical and/or electronic components, and/or the like) that are disposed within the enclosure **290** may be configured to route power (e.g., a high voltage output) from the battery modules **115** and/or battery cells **120** within the energy volume **207** to one or more ports on the enclosure, such as the electrical contact **203**.

[0077] In one or more implementations, the enclosure **290** may include an access panel **300**. The access panel **300** may include a solid insulating structure **301** configured to at least partially cover the electrical components **304**, and a conductive layer **302** on a surface of the solid insulating structure **301**. The solid insulating structure **301** may be formed from any solid insulating material including, as examples, plastic or reinforced plastic. In some implementations, the solid insulating structure **301** may include, or be replaced with, one or more conductive materials, such as magnesium.

[0078] In the example of FIG. **3**, the surface of the solid insulating structure **301** that includes the conductive layer **302** is an interior surface of the solid insulating structure **301**. However, in one or more other implementations, the conductive layer **302** may be provided on an outer surface of the solid insulating structure **301**. In various implementations, the conductive layer **302** may be formed from a foil (e.g., a metal foil, such as an aluminum foil, compressed onto the surface), a coating (e.g., a metal coating, such as a coating formed using a vapor deposition process), or a resin (e.g., an EMI compliant resin). By forming the solid insulating structure from an insulating material with a conductive coating (or from a lighter conductive material, such as magnesium), the mass of the enclosure **290** can be reduced (e.g., relative to providing a full metal enclosure, such as a steel or aluminum enclosure, or relative to increasing the side of the pack frame **205** to enclose the electrical components), while meeting EMI and EMC specifications. This reduced mass can increase the range of an electric vehicle in which the battery pack **110** is implemented.

[0079] In the example of FIG. **3**, an energy volume housing for the energy volume **207** includes the pack frame **205** and a lid **307** that enclose the battery modules **115** and/or battery cells **120**. As shown, the lid **307** may be attached to the pack frame **205** by one or more fasteners **312**, and a seal **316** may be provided between the lid **307** and the pack frame **205** to seal the interior of the energy volume **207** from the external environment (e.g., from liquid ingress).

[0080] As shown, the enclosure **290** may be removably attached to the energy volume **207** (e.g., to the pack frame **205** and/or the lid **307**). In the example of FIG. **3**, the enclosure **290** is attached to the energy volume **207** by fasteners **310** (e.g., bolts) that pass through portions of the access panel **300** into the lid **307** and/or the pack frame **205**. A seal **314** may be provided between the enclosure **290** and the energy volume **207** (e.g., between the enclosure **290** and the lid **307** and/or the pack frame **205**). Because the electrical components **304** are provided in an enclosure **290** that is removably attachable to the energy volume **207**, the enclosure and its electrical components **304** can be installed, serviced, and/or leak checked separately from the battery modules **115** and/or battery cell **120**, without affecting EMI/EMC, grounding, and structural performance. For example, the enclosure **290** and its electrical components **304** may be assembled and tested separately for electrical and leak checks.

[0081] Providing an enclosure **290** for the electrical components **304** that is removably attachable to the energy volume **207** allows the enclosure to be modular, and useable (e.g., for voltage distribution) with any of various different types of energy volume, regardless of cell chemistry of the battery cells **120** therein or the size of the battery pack frame **205**. The enclosure **209** may be scaled up or down depending on the magnitude of force and/or EMI specifications for a particular battery pack. Advantages of providing the enclosure **290** can include having a single electronic box that is pre-assembled with different configurations depending on the type of the vehicle and/or the chemistry of the cell technology used in the battery packs.

[0082] The enclosure **290** may provide benefits for serviceability of the battery pack **110**, and/or a vehicle in which the battery pack **110** is implemented. For example, as shown in FIG. **3**, the access panel **300** may be removed (e.g., by removing the fasteners **310**), allowing access to the electrical components **304** without opening the energy volume **207** (e.g., without opening the lid **307** or otherwise exposing the battery modules **115** and/or battery cells **120**). In one or more implementations, the battery pack **110** may be installed in the vehicle **100** such that the enclosure **290** is disposed beneath a seat (e.g., a rear seat) of the vehicle. In this way, the electrical components **304** may be serviceable from within the passenger compartment of the vehicle (e.g., by removing or displacing a bottom cushion assembly of the rear seat and removing or opening the access panel **300**).

[0083] In one or more implementations, the enclosure **290** provides a single enclosure for the electrical components **304** of the battery pack **110**, and acts as a shield for EMI/EMC. In one or more implementations, the enclosure **290** is provided in a modular form that can be connected to energy volumes of various sizes and that include battery cells of any of various cell chemistries.

[0084] In the example of FIG. **3**, a portion of the enclosure **290** is disposed on the lid **307**, and a portion of the enclosure **290** overhangs the end of the lid **307**. For example, a portion of the enclosure **290** may be located outward of the seal **316** between the lid and the pack frame **205**. In this example, the enclosure **290** may be sealingly attached to the energy volume **207**, such as by providing a seal **314** between the access panel **300** and the lid **307**, and a seal **315** between the access panel **300** and the pack frame **205**. In the example of FIG. **3**, the electrical contact **203** (e.g., a high voltage port) is disposed on the portion of the enclosure **290** that overhangs the end of the lid **307**. As shown, a grounding structure **306** may be attached to the pack frame **205** and/or the access panel **300**, to provide grounding for the electrical contact **203** and/or the electrical components **304**. In the example of FIG. **3**, the grounding structure **306** is formed from a metal plate that is fastened to the pack frame **205** and/or the access panel **300** using one or more fasteners **308**. However, this is merely illustrative, and in other implementations, a grounding structure for the enclosure **290** may be formed in other ways, such as by a metal overmold on a portion of the enclosure **290**, as described in further detail hereinafter.

[0085] In the example of FIG. **3**, the enclosure **290** is formed from a single solid insulating structure **301** with a conductive layer **302**. However, this arrangement of the enclosure **290** is merely illustrative, and other implementations of the enclosure **290** are contemplated herein. For example, FIG. **4** shows another exemplary implementation of the enclosure **290**. In the example of FIG. **4**, the enclosure **290** is attached to the pack frame **205**. In this example, rather than attaching the access panel **300** directly to the pack frame **205**, the access panel **300** is attached to a solid insulating tub **400**. As shown, the solid insulating tub **400** may include a seal **404**. The seal **404** may be configured, for example, to interface with a body structure of a vehicle, such as vehicle **100**. In this way, the seal **404** may sealingly separate the access panel **300** from a portion of the vehicle that can be exposed to environmental conditions (e.g., from an underside of the vehicle). In this way, the access panel **300** may be located in a “dry zone” of the vehicle **100**.

[0086] In the example of FIG. **4**, the access panel **300** includes an opening **402**. As shown, the opening **402** may provide access to one or more additional connectors or ports for the battery pack **110**, such as one or more connectors **291** (e.g., electrical ports, terminals, and/or contacts). For example, the connector(s) **291** may be low-voltage connectors to a low-voltage source within the enclosure **290**. The access panel **300** may be removed (e.g., by detaching the access panel **300** from the solid insulating tub **400**) to provide access (e.g., for servicing) one or more other electrical components **304**, within the enclosure **209**, that are not visible in FIG. **4**. The access panel **300** may be removed from the enclosure **290** without detaching the solid insulating tub **400** from the pack frame **205**.

[0087] FIG. **5** illustrates an exploded perspective view of the enclosure **290**, in accordance with one or more implementations. As shown in FIG. **5**, the access panel **300** may be provided with one or more openings **402** (e.g., for providing access to one or more connectors **291** or other connections to the electrical components **304**). As shown, the solid insulating tub **400** may form a peripheral wall **501** for the enclosure **290**. The solid insulating tub **400** may be provided with a conductive layer **508** on a surface thereof. In the example of FIG. **5**, the conductive layer **508** is formed on an interior surface of the solid insulating tub. However, in one or more other implementations, the conductive layer **508** may be formed on an exterior surface of the solid insulating tub.

[0088] In various implementations, the conductive layer **508** may be formed from a foil (e.g., a metal foil, such as an aluminum foil, compressed onto the surface), a coating (e.g., a metal coating, such as a coating formed using a vapor deposition process), or a resin (e.g., an EMI compliant resin). By forming the solid insulating tub **400** from an insulating material with a conductive layer **508** (or from a lighter metal, such as magnesium), the mass of the enclosure **290** can be reduced (e.g., relative to providing a full metal enclosure, such as a steel or aluminum enclosure, or relative to increasing the side of the pack frame **205** to enclose the electrical components), while meeting EMI and EMC specifications. This reduced mass can increase the range of an electric vehicle in which the battery pack **110** is implemented. The solid insulating tub **400** may include one or more ribs **504** (e.g., on the peripheral wall **501**). The ribs **504** may be configured to provide structural rigidity to the solid insulating tub. In this way, the enclosure **290** may be provided with a structural rigidity, and can be integrated as a structural component of a vehicle, such as the vehicle **100**, in one or more implementations. A groove **511** may be provided on a surface (e.g., a top surface) of the peripheral wall **501** of the solid insulating tub **400**. For example, the groove **511** may be configured to receive (e.g., to be filled with) a sealing material for forming the seal **404** of FIG. **4**.

[0089] As shown in FIG. **5**, the enclosure **290** may also include a tray **500**. The tray **500** may be configured for mounting one or more of the electrical components **304** thereto, and the tray **500** and the access panel **300** may be configured to at least partially enclose the electrical components **304**. As shown, the solid insulating tub **400** may be disposed between the tray **500** and the access panel **300**. For example, the access panel **300** and the tray **500** may be attached to the solid insulating tub **400** (e.g., to opposing sides, such as top and bottom sides, of the solid insulating tub **400**). In one or more implementations, the tray **500** may include one or more features **506** (e.g., molded features, such as channels, sub-walls, brackets, etc.). For example, the features **506** may be configured for retaining, supporting, securing, or mounting one or more of the electrical components **304** (e.g., including cables, busbars, etc.). In the example of FIG. **5**, the tray **500** is a molded structure (e.g., an insulating structure, such as a molded plastic structure), and the features **506** are integral molded features of the molded structure.

[0090] As illustrated in FIG. **5**, the access panel **300** may be attached to the solid insulating tub **400**, such as by fasteners **505** (e.g., bolts, screws, or other fasteners) around the periphery of the access panel **300**. The tray **500** may be attached to the solid insulating tub **400**, such as by fasteners **502** (e.g., bolts, screws, or other fasteners) around the periphery of the tray **500**. Providing a separate solid insulating tub **400** between the tray **500** and the access panel **300** may facilitate installation of the electrical components **304** into the enclosure **290** (e.g., by providing additional space and flexibility for installing some of the electrical components **304** on the tray prior to attaching the solid insulating tub **400** to the tray **500**).

[0091] FIG. **6** illustrates a bottom perspective view of a subassembly of the enclosure **209**, in which the solid insulating tub **400** is attached to the access panel **300**. In the bottom view of FIG. **6**, the openings **402**, as well as the conductive layer **302** on the interior surface of the access panel **300** and the conductive layer **508** on the interior surface of the solid insulating tub **400** can be seen. The solid insulating tub **400** may include a bottom surface **600**, at least a portion of which is configured to interface with the tray **500**. The bottom surface **600** of the solid insulating tub **400** may include one or more features **602** (e.g., protrusions and/or openings) that are configured for attachment of the solid insulating tub **400** (and thereby the enclosure **290**) to a body structure of a vehicle, such as vehicle **100**.

[0092] FIG. **7**A illustrates a bottom perspective view of the enclosure **290** of FIG. **5** in accordance with one or more implementations. In the example of FIG. **7**A, a bottom surface of the tray **500** can be seen. As shown, the tray **500** may be formed from a solid insulating tray **700** that is overmolded onto a grounding structure **702**. For example, the grounding structure **702** may include a metal layer over which a moldable material (e.g., plastic) is overmolded to form the solid insulating tray **700** with the metal layer molded thereto.

[0093] In one or more implementations, the tray **500** may include an outer surface (e.g., the bottom surface that is visible in FIG. 7A) having a first portion **704** that is configured to interface with a frame (e.g., pack frame **205**) of the energy volume **207** of the battery pack **110**, and a second portion **706** that is configured to overhang the frame of the energy volume **207** of the battery pack. As shown, the tray **500** may include one or more first openings **710** in the first portion **704** of the outer surface. For example, the first openings **710** may be configured for accommodating one or more high voltage and/or low voltage feedthroughs between the enclosure **290** and the energy volume **207**. For example, as shown in FIG. 7A, one or more high voltage terminals, such as a high voltage terminal **720** (e.g., a negative high voltage terminal, such as a cylindrical negative high voltage terminal) and a high voltage terminal **722** (e.g., a positive high voltage terminal, such as a cylindrical positive high voltage terminal) may be provided in each of the openings **710** to couple one or more high voltage sources within the energy volume **207** to one or more of the electrical components **304** within the enclosure **290**. Although not visible in FIG. 7A, one or more low-voltage connectors may also be provided for feedthrough between the energy volume **207** and the enclosure **290** (as described in further detail hereinafter). The tray **500** may include one or more second openings **708** in the second portion **706** of the outer surface. The second openings **708** may be configured for accommodating one or more high voltage output connectors coupled to the one or more electrical components **304**. The tray **500** may also include one or more third openings **712** in the second portion **706**. The one or more third openings **712** may be configured to accommodate one or more coolant ports for the enclosure **290**.

[0094] FIG. 7B illustrates an example implementation of an assembly **730** that may be provided within the enclosure **290** to allow high voltage (HV) bussing and low voltage (LV) signals to pass through a sealed interface between the energy volume **207** and the enclosure **290**. As shown, the assembly **730** may include a seal **734** that extends around the HV terminal **720** and the HV terminal **720**. For example, the seal **734** may be pressed against an internal surface of the tray **500** to provide an internal seal, within the enclosure **290**, around an opening **710** in which the assembly **730** is mounted (e.g., to position the HV terminals **720** and **722** as HV feedthroughs within the opening **710**). As shown, a low voltage connector **732** may also be provided within the seal **734**. For example, the low voltage connector **732** may be implemented as a multi-pin (e.g., eight-pin) connector that is molded into the housing **738** at a location within the seal **734**. When the enclosure **290** is mounted to the pack frame **205**, the HV terminals **720** and **722** may be coupled with a high voltage source within the energy volume **207** and configured to route power from the high voltage source within the energy volume **207** to high voltage components within the enclosure **290**. When the enclosure **290** is mounted to the pack frame **205**, the LV connector **732** may be coupled, via an opening **710** in the tray **500**, to a cable within the energy volume **207** and may be configured to route low voltage signals between the enclosure **290** and the energy volume **207**. For example, in one or more implementations, a low-voltage cable within the enclosure **290** may be connected to a low voltage connector **736** that includes pins that are electrically coupled to the pins of the low voltage connector **732**.

[0095] As shown, the seal **734** may be mounted to and/or extend from a housing **738** of the assembly **730**. As shown, one or high voltage contacts **740** may extend from the housing **738** and may be electrically coupled to the HV terminal **720**. The HV contacts **740** may be coupled one or more high voltage electrical components within the enclosure **290**. One or high voltage contacts **742** may extend from the housing **738** and may be electrically coupled to the HV terminal **722**. The HV contacts **742** may be coupled one or more high voltage electrical components within the enclosure **290**.

[0096] FIG. 7C illustrates an exploded perspective view of the assembly **730** of FIG. 7B. As shown in FIG. 7B, the housing **738** of the assembly **730** may include a top housing **738**T and a bottom

housing **738**B. The top housing **738**T and the bottom housing **738**B may cooperate to enclose a busbar **750** and a busbar **752** of the assembly **730**. HV contacts **740** and/or HV contacts **742** may be formed, for example, from one or more foils or other metal layers welded to the busbars **750** and **752**, respectively. As shown, the busbar **750** may electrically connect the high voltage contacts **740** to the high voltage terminal **720**. The busbar **752** may connect the high voltage contacts **742** to the high voltage terminal **722**. For example, HV contacts **740** and/or HV contacts **742** may be formed, for example, from one or more foils (e.g., 0.6 mm thick welding foils) or other metal layers welded to the busbars **750** and **752**, respectively.
[0097] In one or more implementations, the electrical joint between the foils and the busbars may have a resistance of less than 20 μΩ. In one or more implementations, the electrical joint between the cylindrical terminals (e.g., HV terminals **720** and **722**) and the busbars may have a resistance of less than 20 μΩ. In one or more implementations, the foils, the busbars, and the terminals may support a continuous current of as much as, or more than, 250-300A. As shown, the top housing **738**T may include the low voltage connector **732**, the low voltage connector **736**, and a feature (e.g., a groove **760**) configured to receive the seal **734**. In the example of FIG. **7**C, pins **766** of the low voltage connector **736** can be seen.
[0098] FIG. **7**C also illustrates how the assembly **730** may include one or more scaling features (e.g., O-rings **754**) configured to seal the high voltage terminal **720** and the high voltage terminal **722** to an internal surface of the top housing **738**T. For example, the top housing **738**T may include an extension **762** and an extension **764** that are configured to receive, respectively, the high voltage terminal **720** (e.g., with an O-ring **754**) and the high voltage terminal **722** (e.g., with an O-ring **754**). As shown, the assembly **730** may also include one or more touch protectors **758** (e.g., IPXXB touch protectors) for the high voltage terminal **720** and the high voltage terminal **722**. In one or more implementations, a threaded insert **756** may be provided within each of the cylindrical high voltage terminals for securing a touch protector **758** to that terminal. FIG. **7**D illustrates a top view of the assembly **730** of FIGS. **7**B and **7**C, in which a cable **772** is connected to the low voltage connector **736** (e.g., via a mating connector **770** for the low voltage connector). Pins **774** of the low voltage connector **732** are also visible in FIG. **7**D. In this way, the assembly **730** may provide signal paths for multiple (e.g., eight, less than eight, or more than eight) low voltage communication signals to be passed through between the energy volume **207** and the enclosure **290**.
[0099] In the examples of FIGS. **7**B-**7**D, the low voltage connector **732** is implemented using molded-in connector pins (e.g., pins **774**) inside the top housing **738**T. However, this is merely illustrative, and other implementations of the low voltage connector are contemplated. For example, FIG. **7**E illustrates another implementation of the assembly **730** (with the top housing **738**T removed for clarity) in which the low voltage connector **732** is implemented using connector pins **782** directly mounted onto a stiffener with a flex circuit **780**. As shown, in FIG. **7**F, when the top housing **738**T is installed, the connector pins **782** and the flex circuit **780** may be assembled between the top housing **738**T and the bottom housing **738**B, and the connector pins **782** may be accessible via an opening **784** in the top housing **738**T. In this example, the top housing **738**T and the bottom housing **738**B may provide a retention, location, channel, and/or routing path for the flex circuit **780**.
[0100] In the examples of FIGS. **7**B-**7**F, the assembly **730** provides three seals, including two O-rings **754** around the terminals **720** and **722**, and one lid seal (e.g., seal **734**). These seals may prevent ingress of liquid or other debris from the external environment from entering the enclosure **290** or the pack frame **205** via the openings **710**. In one or more implementations, these seals may each meet IP69 seal standards, may be formed from polyurethane, epoxy, acrylic, and/or silicone adhesives (as examples), may be configured to maintain a seal in temperatures of between −40° C. and 100° C., and/or may have a maximum leak rate of 3 SCCM at −0.5 PSIG under all tolerance conditions. The seal **734** may have a Z-tolerance to the tray **500** of +/−2 mm, a nominal Z-space

available of 4 mm, a lid flatness tolerance of 1 mm, and a maximum seal compression force of 12 kgf, in one or more implementations. In one or more implementations, the assembly **730** may have a width of between 200 mm and 400 mm, a length of between 50 mm and 170 mm, and/or a height of between 25 mm and 50 mm.

[0101] FIG. **8** illustrates a cross-sectional side view of the enclosure of FIG. **4**, with the electrical components **304** installed therein and the access panel **300** removed. As shown, the solid insulating tub **400** may include a ledge **805**. The ledge **805** may be configured for mounting a flange **806** of one of the electrical components **304**. By mounting the one of the electrical components **304** to the ledge **805**, a gap **807** may be provided between the one of the electrical components **304** and the tray **500**. One or more additional electrical components **304** (e.g., including cables, busbars, etc.) and/or one or more thermal features (e.g., cold plates, fluid lines, etc.) may be mounted within the gap **807** (e.g., mounted to the mounting features **506** on the tray **500**). FIG. **8** also shows how the enclosure **290** may include one or more sealing features **802** configured to provide a seal around the high-voltage connectors to the energy volume **207**. FIG. **8** also illustrates how the second portion **706** of the tray **500** may have a shape that is configured to overhang an edge of the pack frame **205**, and how the electrical contact **203** (e.g., a high-voltage output connector) may be provided on the second portion **706**.

[0102] FIG. **9** illustrates a cross-sectional view of a portion of the tray **500**. In the example of FIG. **9** it can be seen that the grounding structure **702** may be formed from a relatively thin layer of conductive material (e.g., metal) over which the solid insulating tray **700** can be overmolded. FIG. **10** illustrates a cross-sectional side perspective view of the battery pack **110** including the enclosure **290** of FIG. **8**. In the example of FIG. **10**, the enclosure **290** is attached to the pack frame **205** of the energy volume **207**, and the access panel **300** installed. In this example, the ribbing **504** on the solid insulating tub **400** can be seen. In this example, the battery pack **110** also includes a support structure **1000**. For example, the support structure **1000** may be configured to attach to the pack frame **205** of the battery pack **110** and to the second portion **706** of the tray that overhangs the end of the pack frame **205**. For example, the support structure **1000** may help to provide additional structural impact resistance for the battery pack **110** and/or the vehicle **100**.

[0103] FIG. **11** illustrates a bottom perspective view of a portion of the battery pack **110** of FIG. **10**, showing the second portion **706** of the tray **500** with various connectors attached thereto. For example, the electrical contact **203** and/or one or more other high-voltage connectors **1100** and/or low-voltage connectors **1104** that provide various voltages from the battery cells **120** within the energy volume **207** can be provided on the second portion **706** of the tray **500** that overhangs the edge of the pack frame **205**. As shown, one or more fluid ports, such as a fluid port **1102** (e.g., a coolant port), may also be provided on the second portion **706** of the tray **500** that overhangs the edge of the pack frame **205**. The fluid port **1102** and/or one or more other fluid ports on the portion **706** of the tray **500**, may provide coolant inlet ports and/or coolant outlet ports for a cooling fluid to pass into and out of the enclosure **290** to cool one or more of the electrical components **304** disposed therein. FIG. **11** also shows how multiple support structures **1000** can be provided to support the overhanging portion of the enclosure **290** on the pack frame **205**, and to strengthen the overall structure of the battery pack **110** and/or the vehicle **100**.

[0104] In one or more implementations, the electrical contact(s) **203**, the fluid port(s) **1102**, the support structure(s) **1000**, and the second portion **706** of the tray may be disposed in a "wet zone" of the vehicle **100**. For example, the wet zone may be located outside of the seal **404** shown in FIG. **4**.

[0105] As illustrated by FIGS. **3-11**, the enclosure **290** may provide a modular, serviceable, grounded package that allows electrical component checks (e.g., checks and/or tests of electrical components **304**, such as battery management system (BMS), contactors, the high voltage terminals **720** and **722**, the low voltage connectors **732** and **736**, the high-voltage connectors **1100**, and/or the low-voltage connectors **1104**) and/or thermal checks (e.g., by cycling coolant through the enclosure **290** via one or more fluid ports **1102**) separately from the energy volume **207**. For example, coolant cycling, testing that contactors open and close, testing that the BMS is functioning and/or software is updated can be performed on the enclosure **290** separately from the energy volume **207** (e.g., separate from tests and/or checks of the energy volume **207** and/or while the enclosure **290** is physically separated from the energy volume **207**, such as prior to attachment of the enclosure **290** to the pack frame **110**). As illustrated by FIGS. **3-11**, the enclosure **290** may provide a modular, serviceable, grounded package that provides high-voltage, low-voltage, and thermal feedthroughs to external connectors/ports.

[0106] In one or more implementations, assembling a vehicle including the battery pack **110** disclosed herein may include attaching the enclosure **290** to the pack frame **205** (e.g., and thus the energy volume **207**), and then installing the battery pack **110** with the enclosure **290** attached thereto into the vehicle. For example, the enclosure **290** may be inserted into an opening in a body structure **1200** of the vehicle, as shown in FIG. **12**. Inserting the enclosure **290** into the opening in the body structure **1200** may compress the seal **404** of FIG. **4** against an underside (not visible in FIG. **12**) of the body structure **1200**. For example, the body structure **1200** may be a body structure to which one or more seats (e.g., a rear seat) of the vehicle **100** may be mounted. As shown, a portion of the enclosure **290** that extends through the body structure **1200** may include the access panel **300**, and the connector(s) **291** that are accessible through the openings **402** in the access panel **300**. Due to the seal between the body structure **1200** and the seal **404** on the solid insulating body **400**, the portion of the enclosure **290** that extends through the opening in the body structure **1200** may be in a “dry zone” of the vehicle **100**.

[0107] In one or more implementations, a rear seat of the vehicle **100** may be mounted to the body structure **1200**. The rear seat of the vehicle may include a removable cushion assembly that covers the access panel **300** and the connector **291** of the enclosure **290**. The cushion assembly of the rear seat may be removed to provide access to the connector **291** and/or to the access panel **300** (e.g., which may also be removed for servicing of components within the enclosure **290**).

[0108] FIG. **13** illustrates a bottom view of the enclosure **290** and body structure **1200** of FIG. **12**. As illustrated in the bottom view of FIG. **13**, the solid insulating tub **400** may abut the body structure **1200**. In this arrangement, the bottom surface of the tray **500**, which may include the openings **710**, **708**, and **712** may be formed in a “wet zone” of the vehicle, outside of the seal **404** on the solid insulating tub **400**. For example, bolts through the features **602** on the solid insulating tub **400** may be used to attach the solid insulating tub, and thereby the enclosure **290**, to the body structure **1200**.

[0109] Example implementations of a modular enclosure **290** for a battery pack **110** have been described herein in connection with, for example, FIGS. **2**A and **3-12**. However, these implementations of the enclosure **290** are merely illustrative, and other implementations of the enclosure are contemplated herein.

[0110] For example, FIG. **14** illustrates another implementation of the enclosure **290**, in which the tray **500** includes the solid insulating tray **700** and a conductive layer **1402** (e.g., a conductive foil, a molded metal structure, a conductive plate, a conductive resin, or a conductive coating) on an interior surface of the solid insulating tray **700**. In this implementation, the tray **500** may also include the grounding structure **702** (e.g., a molded metal) on an exterior surface of the tray (e.g., as in the examples of FIGS. **7**, **9**, and **13**). In this example, the enclosure **290** may also include a retention structure **1404**. For example, the retention structure **1404** may include one or more molded features **1405** (e.g., similar to the molded features **506** of FIG. **5**, but formed on a separate retention structure from the tray **500**) configured for retaining, supporting, securing, or otherwise holding or guiding one or more of the electrical components **304** (e.g., electrical components **304** disposed in the gap **807** of FIG. **8**). The implementation of FIG. **14** may provide additional grounding for the enclosure **290**, but may prevent the molded features **506** from being formed on the tray **500** itself. The molded features **1405** on the retention structure **1404** may replace the molded features **506**.

[0111] As another example, FIG. **15** illustrates another implementation of the enclosure **290**, in which the tray **500** is formed from a metal tray **1502**. In this example, the enclosure **290** may also include the retention structure **1404** including the molded features **1405** (e.g., configured for retaining one or more of the electrical components **304**). For example, the retention structure **1404** may be attached to the metal tray **1502**. As another example, FIG. **16** illustrates another implementation of the enclosure **290**, in which one or more features of the solid insulating tub **400** are integrated into the tray **500** (e.g., in a deep tray implementation of the tray **500**). For example, as shown in FIG. **16**, in one or more implementations, the tray **500** may include a solid insulating structure **1600** that is configured for mounting the one or more electrical components thereto, and the access panel **300** may be configured to attach directly to the tray **500** (e.g., to the solid insulating structure **1600**) to at least partially enclose the electrical components **304**.

[0112] For example, the solid insulating structure **1600** may be overmolded on a grounding structure **702** (e.g., as in the examples of FIGS. **7**, **9**, and **13**) and may include a ledge **1602** for mounting one or more of the electronic components **304**. For example, the ledge **1602** may be configured to support the flange **806** shown in FIG. **8**, such that a gap similar to the gap **807** is formed between the electrical component **304** having the flange **806** and a floor of the solid insulating tray **1600**. In the example of FIG. **16**, the enclosure **290** also includes the retention structure **1404** having the molded features **1405** (e.g., configured for retaining one or more electrical components **304** within the enclosure formed by the solid insulating structure **1600** and the access panel **300**). In the example of FIG. **16**, the solid insulating tray **1600** may include a surface, such as surface **1604**, that is configured to sealingly abut a vehicle structure, such as the body structure **1200** of FIGS. **12** and **13**. When servicing of one or more electrical components **304** within the enclosure **290** is desired, the access panel **300** may be detached from the solid insulating tray **1600** to provide access to the electrical components **304** mounted on the solid insulating tray **1600**.

[0113] As illustrated by FIGS. **1**A-**16**, in one or more implementations, a vehicle **100** may be provided with a battery pack **110** that includes an enclosure **290** for one or more electrical components **304** for the battery pack **110**, in which the enclosure is configured to mechanically and electrically couple to an energy volume **207** of the battery pack **110**. The enclosure **290** may include an access panel **300** formed from a solid insulating structure **301** configured to at least partially cover the one or more electrical components, and a conductive layer **302** on a surface of the solid insulating structure. The enclosure may also include a mid-structure (e.g., solid insulating tub **400**) that includes a solid insulating structure **507**, a conductive layer **508** on an interior surface of the solid insulating structure **507**, and ribbing **504** configured to provide structural impact resistance for the enclosure. The enclosure **290** may also include a bottom panel (e.g., tray **500**). The bottom panel and the access panel may be configured to attach to the mid-structure to form the enclosure **290**. The battery pack **110** and/or the enclosure **290** may also include one or more support structures **1000** that are configured to attach to a frame (e.g., pack frame **205**) of the battery pack **110** and to an overhang (e.g., second portion **706**) on the bottom panel to provide structural impact resistance for the vehicle. In one or more implementations, the mid-structure (e.g., solid insulating tub **400**) may also include a scaling feature (e.g., a groove **511** and/or a seal **404**) for sealingly attaching the enclosure **290** to a body structure **1200** of the vehicle **100**. The bottom panel (e.g., tray **500**) may also include a plurality of seals **802** for sealingly protecting a plurality of high voltage ports between the enclosure **290** and the battery pack **110** (e.g., the energy volume of the battery pack **110**).

[0114] FIG. **17** illustrates a flow diagram of an example process **1700** that may be performed for assembling a vehicle, in accordance with implementations of the subject technology. For explanatory purposes, the process **1700** is primarily described herein with reference to the vehicle **100** and enclosure **290** of FIGS. **1**A-**16**. However, the process **1700** is not limited to the vehicle **100** and enclosure **290**, and one or more blocks (or operations) of the process **1700** may be performed by or with one or more other structural components of other devices, systems, or moveable apparatuses. Further for explanatory purposes, some of the blocks of the process **1700** are described herein as occurring in serial, or linearly. However, multiple blocks of the process **1700** may occur in parallel. In addition, the blocks of the process **1700** need not be performed in the order shown and/or one or more blocks of the process **1700** need not be performed and/or can be replaced by other operations.

[0115] As illustrated in FIG. **17**, at block **1702**, one or more electrical components (e.g., electrical components **304**, such as a high voltage distribution box, cables, busbars, etc.) may be attached to a solid insulating tray (e.g., tray **500**, solid insulating tray **700**, and/or solid insulating tray **1600**) having at least one grounding structure (e.g., grounding structure **702**) thereon.

[0116] At block **1704**, a solid insulating tub (e.g., solid insulating tub **400**) having a conductive layer (e.g., conductive layer **508**) may be mounted to the solid insulating tray (e.g., using fasteners **502** or other fasteners).

[0117] At block **1706**, one or more additional electrical components (e.g., an electrical component **304** having a flange **806**) may be mounted to the solid insulating tub.

[0118] At block **1708**, an enclosure **290** for the one or more electrical components and the one or more additional electrical components may be formed by attaching an access panel (e.g., access panel **300**) to the solid insulating tub (e.g., using fasteners **505**). The access panel may include one or more openings (e.g., openings **402**) for accessing one or more ports (e.g., connectors **291**) while the access panel is attached to the solid insulating tub.

[0119] At block **1710**, the enclosure may be attached to a frame (e.g., pack frame **205**) for an energy volume (e.g., energy volume **207**) for a battery pack (e.g., battery pack **110**). Attaching the enclosure to the frame of the energy volume may include mechanically and electrically coupling the enclosure to the frame of the energy volume. For example, mechanically coupling the enclosure to the frame of the energy volume may include bolting the enclosure to the frame (e.g., using bolts that pass through the solid insulating tub and/or the tray) and/or forming one or more seals (e.g., seals **802**) between the enclosure and the frame. For example, electrically coupling the enclosure to the frame of the energy volume may include electrically coupling the electrical components within the enclosure to one or more high-voltage contacts on the frame that are electrically coupled to one or more battery cells and/or battery modules within the frame.

[0120] At block **1712**, the enclosure and the frame may be attached to one or more body structures (e.g., body structure **1200**) of the vehicle. Attaching the enclosure and the frame to the body structure may include bolting the enclosure to the body structure via the solid insulating tub. Attaching the enclosure and the frame to the body structure may include compressing a scal (e.g., seal **404**) on the solid insulating tub against the body structure. Attaching the enclosure and the frame to the body structure may include attaching (e.g., bolting) the frame to the body structure and/or another body structure at one or more locations separate from the enclosure.

[0121] In one or more implementations, a method of servicing a vehicle may also be provided. The method of servicing the vehicle may include removing an access panel (e.g., access panel **300**) of an enclosure (e.g., enclosure **290**) of a battery pack (e.g., battery pack **110**) while the battery pack is installed in the vehicle; and servicing (e.g., removing, replacing, and/or repairing) one or more electrical components (e.g., electrical components **304**) within the enclosure via an opening formed by removing the access panel, while the battery pack is installed in the vehicle. In one or more implementations, a portion (e.g., a cushion or cushion assembly) of a seat (e.g., a rear seat) of the vehicle may be removed to provide access to the access panel, for removing the access panel.

[0122] Aspects of the subject technology can help improve the reliability and/or range of electric vehicles. This can help facilitate the functioning of and/or proliferation of electric vehicles, which can positively impact the climate by reducing greenhouse gas emissions.

[0123] A reference to an element in the singular is not intended to mean one and only one unless specifically so stated, but rather one or more. For example, “a” module may refer to one or more modules. An element proceeded by “a,” “an,” “the,” or “said” does not, without further constraints, preclude the existence of additional same elements.

[0124] Headings and subheadings, if any, are used for convenience only and do not limit the invention. The word exemplary is used to mean serving as an example or illustration. To the extent that the term include, have, or the like is used, such term is intended to be inclusive in a manner similar to the term comprise as comprise is interpreted when employed as a transitional word in a claim. Relational terms such as first and second and the like may be used to distinguish one entity or action from another without necessarily requiring or implying any actual such relationship or order between such entities or actions.

[0125] Phrases such as an aspect, the aspect, another aspect, some aspects, one or more aspects, an implementation, the implementation, another implementation, some implementations, one or more implementations, an embodiment, the embodiment, another embodiment, some embodiments, one or more embodiments, a configuration, the configuration, another configuration, some configurations, one or more configurations, the subject technology, the disclosure, the present disclosure, other variations thereof and alike are for convenience and do not imply that a disclosure relating to such phrase(s) is essential to the subject technology or that such disclosure applies to all configurations of the subject technology. A disclosure relating to such phrase(s) may apply to all configurations, or one or more configurations. A disclosure relating to such phrase(s) may provide one or more examples. A phrase such as an aspect or some aspects may refer to one or more aspects and vice versa, and this applies similarly to other foregoing phrases.

[0126] A phrase “at least one of” preceding a series of items, with the terms “and” or “or” to separate any of the items, modifies the list as a whole, rather than each member of the list. The phrase “at least one of” does not require selection of at least one item; rather, the phrase allows a meaning that includes at least one of any one of the items, and/or at least one of any combination of the items, and/or at least one of each of the items. By way of example, each of the phrases “at least one of A, B, and C” or “at least one of A, B, or C” refers to only A, only B, or only C; any combination of A, B, and C; and/or at least one of each of A, B, and C.

[0127] It is understood that the specific order or hierarchy of steps, operations, or processes disclosed is an illustration of exemplary approaches. Unless explicitly stated otherwise, it is understood that the specific order or hierarchy of steps, operations, or processes may be performed in different order. Some of the steps, operations, or processes may be performed simultaneously. The accompanying method claims, if any, present elements of the various steps, operations or processes in a sample order, and are not meant to be limited to the specific order or hierarchy presented. These may be performed in serial, linearly, in parallel or in different order. It should be understood that the described instructions, operations, and systems can generally be integrated together in a single software/hardware product or packaged into multiple software/hardware products.

[0128] In one aspect, a term coupled or the like may refer to being directly coupled. In another aspect, a term coupled or the like may refer to being indirectly coupled.

[0129] Terms such as top, bottom, front, rear, side, horizontal, vertical, and the like refer to an arbitrary frame of reference, rather than to the ordinary gravitational frame of reference.

[0130] Thus, such a term may extend upwardly, downwardly, diagonally, or horizontally in a gravitational frame of reference.

[0131] The disclosure is provided to enable any person skilled in the art to practice the various aspects described herein. In some instances, well-known structures and components are shown in block diagram form in order to avoid obscuring the concepts of the subject technology. The disclosure provides various examples of the subject technology, and the subject technology is not limited to these examples. Various modifications to these aspects will be readily apparent to those skilled in the art, and the principles described herein may be applied to other aspects.

[0132] All structural and functional equivalents to the elements of the various aspects described throughout the disclosure that are known or later come to be known to those of ordinary skill in the art are expressly incorporated herein by reference and are intended to be encompassed by the claims. Moreover, nothing disclosed herein is intended to be dedicated to the public regardless of whether such disclosure is explicitly recited in the claims. No claim element is to be construed under the provisions of 35 U.S.C. § 112 (f), unless the element is expressly recited using the phrase “means for” or, in the case of a method claim, the element is recited using the phrase “step for”.
[0133] Those of skill in the art would appreciate that the various illustrative blocks, modules, elements, components, methods, and algorithms described herein may be implemented as hardware, electronic hardware, computer software, or combinations thereof. To illustrate this interchangeability of hardware and software, various illustrative blocks, modules, elements, components, methods, and algorithms have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application. Various components and blocks may be arranged differently (e.g., arranged in a different order, or partitioned in a different way) all without departing from the scope of the subject technology.
[0134] The title, background, brief description of the drawings, abstract, and drawings are hereby incorporated into the disclosure and are provided as illustrative examples of the disclosure, not as restrictive descriptions. It is submitted with the understanding that they will not be used to limit the scope or meaning of the claims. In addition, in the detailed description, it can be seen that the description provides illustrative examples and the various features are grouped together in various implementations for the purpose of streamlining the disclosure. The method of disclosure is not to be interpreted as reflecting an intention that the claimed subject matter requires more features than are expressly recited in each claim. Rather, as the claims reflect, inventive subject matter lies in less than all features of a single disclosed configuration or operation. The claims are hereby incorporated into the detailed description, with each claim standing on its own as a separately claimed subject matter.
[0135] The claims are not intended to be limited to the aspects described herein, but are to be accorded the full scope consistent with the language of the claims and to encompass all legal equivalents. Notwithstanding, none of the claims are intended to embrace subject matter that fails to satisfy the requirements of the applicable patent law, nor should they be interpreted in such a way.

Claims

1. An apparatus, comprising: an enclosure for one or more electrical components for a battery pack, wherein the enclosure is configured to mechanically and electrically couple to an energy volume of the battery pack, and wherein the enclosure comprises: a tray, wherein the tray is configured to at least partially enclose the one or more electrical components, wherein the tray comprises a metal tray; and a retention structure comprising a plurality of molded features configured for retaining the one or more electrical components.
2. The apparatus of claim 1, further comprising at least one thermal feature mounted to the tray.
3. The apparatus of claim 2, wherein the tray comprises at least one feature, and wherein the at least one thermal feature is mounted to the at least one feature of the tray.
4. The apparatus of claim 3, wherein the at least one thermal feature is mounted within a gap between the one or more electrical components and the tray.
5. The apparatus of claim 2, wherein the tray comprises an outer surface having a first portion configured to interface with a frame of the energy volume of the battery pack, and a second portion configured to overhang the frame of the energy volume of the battery pack.

6. The apparatus of claim 5, wherein the tray comprises: one or more first openings in the first portion of the outer surface for accommodating one or more high voltage feedthroughs and one or more low voltage feedthroughs to the energy volume; and one or more second openings in the second portion of the outer surface for accommodating one or more high voltage output connectors coupled to the one or more electrical components.
7. The apparatus of claim 6, wherein: the tray further comprises one or more third openings in the second portion, the one or more third openings configured to accommodate one or more coolant ports for the enclosure; the one or more electrical components comprise an assembly having first and second high voltage terminals and at least one low voltage connector; and the assembly is configured to position the first and second high voltage terminals as the one or more high voltage feedthroughs, and the at least one low voltage connector as the one or more low voltage feedthroughs, within the one or more first openings.
8. The apparatus of claim 1, wherein the one or more electrical components comprise high voltage power electronics and one or more battery pack contactors.
9. The apparatus of claim 1, further comprising an access panel, and wherein the access panel and the tray are configured to at least partially enclose the one or more electrical components that are retained by the retention structure.
10. An apparatus, comprising: a metal tray for an enclosure that is configured to mechanically and electrically couple to an energy volume of a battery pack, wherein the metal tray is configured to at least partially enclose one or more electrical components and to support a retention structure comprising a plurality of molded features configured for retaining the one or more electrical components.
11. The apparatus of claim 10, wherein the metal tray comprises at least one feature configured to be mounted to at least one thermal feature within the enclosure.
12. The apparatus of claim 10, wherein the metal tray comprises an outer surface having a first portion configured to interface with a frame of the energy volume of the battery pack, and a second portion configured to overhang the frame of the energy volume of the battery pack.
13. The apparatus of claim 12, wherein the metal tray comprises: one or more first openings in the first portion of the outer surface for accommodating one or more high voltage feedthroughs and one or more low voltage feedthroughs to the energy volume; and one or more second openings in the second portion of the outer surface for accommodating one or more high voltage output connectors coupled to the one or more electrical components.
14. The apparatus of claim 13, wherein: the metal tray further comprises one or more third openings in the second portion, the one or more third openings configured to accommodate one or more coolant ports for the enclosure; the one or more electrical components comprise an assembly having first and second high voltage terminals and at least one low voltage connector; and the assembly is configured to position the first and second high voltage terminals as the one or more high voltage feedthroughs, and the at least one low voltage connector as the one or more low voltage feedthroughs, within the one or more first openings.
15. The apparatus of claim 10, wherein the one or more electrical components comprise high voltage power electronics and one or more battery pack contactors.
16. A battery pack, comprising: a metal tray for an enclosure that is configured to mechanically and electrically couple to an energy volume housing of an energy volume of the battery pack, wherein the metal tray is configured to at least partially enclose one or more electrical components and to support a retention structure comprising a plurality of molded features configured for retaining the one or more electrical components.
17. The battery pack of claim 16, further comprising: the energy volume housing; and the enclosure, wherein the metal tray is mechanically and electrically coupled to the energy volume housing.
18. The battery pack of claim 17, further comprising a plurality of battery subassemblies within the

energy volume housing, the plurality of battery subassemblies electrically coupled to the electrical components via one or more openings in the metal tray.

19. The battery pack of claim 16, wherein the battery pack is implemented in an electric vehicle.

20. The battery pack of claim 16, wherein the metal tray comprises: an outer surface having a first portion configured to interface with the energy volume housing of the energy volume of the battery pack, and a second portion configured to overhang the energy volume housing of the energy volume of the battery pack; one or more first openings in the first portion of the outer surface for accommodating one or more high voltage feedthroughs and one or more low voltage feedthroughs to the energy volume; one or more second openings in the second portion of the outer surface for accommodating one or more high voltage output connectors coupled to the one or more electrical components; and one or more third openings in the second portion, the one or more third openings configured to accommodate one or more coolant ports for the enclosure, and wherein: the one or more electrical components comprise an assembly having first and second high voltage terminals and at least one low voltage connector; the assembly is configured to position the first and second high voltage terminals as the one or more high voltage feedthroughs, and the at least one low voltage connector as the one or more low voltage feedthroughs, within the one or more first openings; and the one or more electrical components comprise high voltage power electronics and one or more battery pack contactors.
