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OVERMOLDED CURRENT COLLECTOR ASSEMBLY

Abstract

A current collector assembly (CCA) with an insulative structure is provided. A battery system can include the current collector assembly formed from the insulative structure. The current collector assembly can include a conductor layer at least partially encapsulated by the insulative structure. The current collector assembly can include a conductor array cut from the conductor layer. A first portion of the conductor array can contact a positive terminal of a first group of battery cells, and a second portion of the conductor array can contact a negative terminal of a second group of battery cells. The rib can be formed from the insulative structure of the current collector assembly.

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Background/Summary

CROSS-REFERENCE TO RELATED PATENT APPLICATIONS [0001] This application claims the benefit of and priority to U.S. patent application Ser. No. 18/438,784 filed Feb. 12, 2024, which is incorporated herein by reference in its entirety and for all purposes.

INTRODUCTION

[0002] Electric vehicles (EVs) can be powered using batteries that store energy to reduce greenhouse gas emissions. The batteries can include different components facilitating energy storage and distribution.

SUMMARY

[0003] This disclosure is generally directed to an insulative structure of a current collector assembly (CCA). A current collector assembly formed from multiple pieces of plastic can consume excessive materials, introduce additional manufacturing steps and duration of manufacturing, or impact the durability or longevity of the current collector assembly when used in a battery system that can support a physical load. Aspects of this technical solution can provide an insulative structure of a CCA that can improve the ability to scale manufacturing of CCAs, while resulting in a CCA with increased durability, longevity, or ability to be used in load-bearing applications. For example, using an insulative structure allows for the CCA to contain a single conductor layer at least partially encapsulated by the insulative structure. A conductor array of the conductor layer can include one portion of the CCA that can contact a positive terminal of a group of battery cells and another portion of the CCA that can contact a negative terminal of another group of cells. The insulative structure can have a rib formed on the insulative structure of the CCA.

[0004] An aspect of this disclosure can be directed to a battery system. The battery system can include a current collector assembly formed from an insulative structure. The current collector assembly can include a conductor layer at least partially encapsulated by the insulative structure. The current collector assembly can include a conductor array cut from the conductor. A first portion of the conductor array can contact a positive terminal of a first group of battery cells, and a second portion of the conductor array can contact a negative terminal of a second group of battery cells. The rib can be formed on the insulative structure of the current collector assembly.

[0005] An aspect of this disclosure can be directed to a method for creating a battery system. The method can include forming a current collector assembly from an insulative structure. The method can include at least partially encapsulating a conductor layer within the insulative structure. The method can include cutting, a conductor array of the conductor layer. A first portion of the conductor array can contact a positive terminal of a first group of battery cells and a second portion of the conductor array can contact a negative terminal of a second group of battery cells. The method can include forming a rib on the insulative structure of the current collector assembly. The rib can be formed on the insulative structure of the current collector assembly.

[0006] An aspect of this disclosure can be directed to an electric vehicle. The electric vehicle includes a battery system. The battery system can include a current collector assembly formed from an insulative structure. The current collector assembly can include a conductor layer at least partially encapsulated by the insulative structure. The current collector assembly can include a conductor array cut from the conductor layer. A first portion of the conductor array can contact a positive terminal of a first group of battery cells, and a second portion of the conductor array can contact a negative terminal of a second group of battery cells. The rib can be formed from the insulative structure of the current collector assembly.

[0007] These and other aspects and implementations are discussed in detail below. The foregoing information and the following detailed description include illustrative examples of various aspects and implementations and provide an overview or framework for understanding the nature and character of the claimed aspects and implementations. The drawings provide illustration and a further understanding of the various aspects and implementations and are incorporated in and constitute a part of this specification. The foregoing information and the following detailed description and drawings include illustrative examples and should not be considered as limiting.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0008] The accompanying drawings are not intended to be drawn to scale. Like reference numbers and designations in the various drawings indicate like elements. For purposes of clarity, not every component can be labeled in every drawing. In the drawings:
[0009] FIG. **1** depicts a top view of a current collector assembly.
[0010] FIG. **2**A depicts a top view of a conductor layer without a stamped conductor array.
[0011] FIG. **2**B depicts a top view of the conductor layer with a stamped conductor array.
[0012] FIG. **3** depicts a top view of the current collector assembly.
[0013] FIG. **4** depicts a rear-side view of the current collector assembly.
[0014] FIG. **5** depicts a rear-side view of the current collector assembly.
[0015] FIG. **6** depicts a rear-side view of the current collector assembly.
[0016] FIG. **7** depicts a side view of the current collector assembly.
[0017] FIG. **8** depicts a bottom view of the current collector assembly.
[0018] FIG. **9** depicts a side view of the current collector assembly.
[0019] FIG. **10** depicts an example of the current collector assembly.
[0020] FIG. **11** depicts a top view of the current collector assembly.
[0021] FIG. **12** depicts an exploded view of the current collector assembly.
[0022] FIG. **13** depicts an example electric vehicle.
[0023] FIG. **14**A depicts an example of one or more battery packs.
[0024] FIG. **14**B depicts an example of one or more battery modules.
[0025] FIG. **14**C depicts a cross sectional view of a battery cell.
[0026] FIG. **14**D depicts a cross sectional view of the battery cell.
[0027] FIG. **14**E depicts a cross sectional view of the battery cell.
[0028] FIG. **15** is a flow diagram illustrating an example method of forming the current collector assembly.
DETAILED DESCRIPTION
[0029] Following below are more detailed descriptions of various concepts related to, and implementations of, methods, apparatuses, and systems of integrating a current collector into a battery module assembly of an electric vehicle. The various concepts introduced above and discussed in greater detail below can be implemented in any of numerous ways.
[0030] This disclosure is generally directed to an insulative structure of a current collector assembly (CCA). A current collector assembly formed from multiple pieces can consume excessive materials, introduce additional manufacturing steps and duration of manufacturing, or impact the durability or longevity of the current collector assembly when used in a battery system that can support a physical load. Aspects of this technical solution can provide an insulative structure that can improve the ability to scale manufacturing of CCAs, while resulting in a CCA with increased durability, longevity, or ability to be used in load-bearing applications. For example, using an insulative structure in the CCA allows for the CCA to contain a single conductor layer. A conductor array can be stamped onto the conductor layer on one side of the insulative structure such that one

portion of the CCA can contact a positive terminal of a group of battery cells, and another portion of the CCA can contact a negative terminal of another group of cells. The insulative structure can have a rib formed to separate portions of the CCA.

[0031] This disclosure is generally directed to a solution for producing a current collector assembly for efficient manufacturing in high volume with a scalable process for integration of a current collector assembly with a battery system of an EV (e.g., an assembly of a battery pack or a module). An EV can store energy in a battery pack and can include interconnected battery modules. The battery pack or the battery modules can include battery cells which can be charged and discharged via current collectors of the battery modules. However, manufacturing and integrating current collectors into a battery assembly can be difficult and time consuming.

[0032] The present solution of this disclosure is generally directed to an insulative structure for a current collector assembly (CCA). The insulative structure of this disclosure can allow for the CCA's to be produced in high volume and create a scalable process. For example, using an insulative structure allows for the CCA to contain a single conductor layer removed from the polymeric or plastic insulative structure. A conductor array can be cut onto the conductor layer such that one portion of the CCA can contact a positive terminal of a group of battery cells, and another portion of the CCA can contact a negative terminal of another group of cells. The insulative structure can have a rib formed to separate portions of the CCA.

[0033] FIG. **1** depicts an example current collector assembly **100**, in accordance with implementations of this disclosure. The current collector assembly **100** can include one or more of a conductor layer **105**, a conductor array **110**, a rib **115**, a first portion **120**, an insulative structure **125**, or a second portion **135**. The currently collector assembly **100** can include an insulative structure **125**. The current collector assembly **100** can be formed from an insulative structure **125**. The insulative structure **125** can include plastic (e.g., thermoplastic material or thermoset material). The insulative structure **125** can encapsulate the current collector assembly in a manner that reduces manufacturing complexity, manufacturing resources, materials, or time to manufacture. This technology can provide a current collector assembly **100** with fewer components or pieces, while maintaining or improving functionality or structural integrity of the current collector. For example, the insulative structure **125** can be an overmold, which can reduce part assembly cost and part assembly sequences. The overmold of insulative structure **125** material can interface with one or more components of a battery system. Furthermore, the overmold of the insulative structure **125** can attenuate a frequency of vibration to constrain movement of the current collector assembly **100**. For example, using the overmold, the currently collector assembly **100** can have a frequency closer to the fundamental frequency when a force is applied on both sides of current collector assembly **100**, along a x-axis or a y-axis, to restrict the current collector assembly **100** from bending, twisting, and moving.

[0034] The current collector assembly **100** can include a conductor layer **105**. The conductor layer **105** can include a material to conduct electricity (e.g., gold, copper, aluminum, silver, or a combination of metallic metals). The materials of the conductor layer **105** can be designed, constructed, or selected to conduct electricity. For example, the materials of the conductor layer **105** can have a sufficient density of free electrons to allow for the transmission of electric current to provide power to one or more component of an electric vehicle, such as an electric motor or on-board computer system. The conductor can be formed by depositing the material onto a substrate following a process including at least one of physical vapor deposition, chemical vapor deposition, electroplating, chemical deposition, among others. The conductor layer **105** can provide an electrically conductive path for electricity to and from battery cells that can be housed within a battery module. Instead of injecting the conductor layer **105** into the insulative structure **125**, the conductor layer **105** can be partially encapsulated by the insulative structure **125**. The insulative structure **125** can encapsulate the conductor layer **105** by at least partially surrounding the conductor layer **105**, at least partially covering the conductor layer **105**, or at least partially enveloping the conductor layer **105**, for example. By partially encapsulating the conductor layer **105**, one or more terminals can be exposed at the top portion of the current collector assembly **100**. The conductor layer **105** can be coupled to the insulative structure **125** using an adhesive (e.g., glue). In some arrangements, the adhesive can be removed to separate the conductor layer **105** and the insulative structure **125**.

[0035] The conductor layer **105** can include a plurality of polygons or quadrilaterals (e.g., square, rhombus, or parallelograms) to form spaces for the battery cells. For example, the spaces for the battery cells can be a plurality of squares. In another example, the spaces of the battery cells can be a plurality of rhombi. The plurality of polygons or quadrilaterals can include a symmetrical or asymmetrical arrangement. For example, one space can be offset by 3 centimeters and at a 45-degree angle from the space adjacent to it. In some arrangements, each space can be aligned along a first axis.

[0036] The current collector assembly **100** can include a conductor array **110**. The conductor array **110** can include a pattern of conductive materials on the substate. The pattern of conductive materials can facilitate the flow of electrical current based on the conductor layer **105**. In some arrangements, the conductor array **110** can detect, identify, or facilitate measuring changes in temperature, current, or voltage and provide the changes to a voltage sensing harness. The conductor array **110** can be stamped in the insulative structure **125** to connect to one or more battery cells. The conductor array **110** can be cut from the conductor layer **105**. The first portion **120** of the conductor array **110** can refer to or include a portion of the conductor array **110** that contacts a positive terminal of a first group of battery cells. The second portion **135** of the conductor array **110** can refer to or include a portion of the conductor array **110** that contacts a negative terminal of a second group of battery cells. In some cases, the first portion **120** can contact a negative terminal, while the second portion **135** contacts the positive terminal. The insulative structure **125** can allow the conductor array **110** to maintain connection with each battery cell despite being stamped in some portions of the insulative structure **125**. The conductor array **110** can be stamped in the conductor layer **105** by a stamping tool (e.g., etching, copper foil stamping dies, conductive ink stamps, or circuit stamping dies).

[0037] The current collector assembly **100** can include a rib **115**. The rib **115** can be formed from the insulative structure **125** on a side of the of the insulative structure **125**. The rib **115** can be a raised or elevated ridge or strip of material (e.g., same material as the insulative structure **125** material, such as a polymeric or plastic). The rib **115** can provide structural support to the current collector assembly **100** by providing strength and rigidity. The rib **115** can distribute mechanical loads and prevent warping, bending, folding, or distorting of the insulative structure **125**. For example, a physical load can be placed on the current collector assembly **100**. The rib **115** can be in contact with at least a portion of the physical load and support the physical load. For example, the physical load can exert a force on the current collector assembly **100**, which the rib **115** can receive and distribute to balance or at least partially support the physical load.

[0038] The rib **115** can adjust to a plurality of heights for the first and second group of battery cells. For example, the first group of battery cells can have a height between three to five inches to properly arrange the battery cells which can have a height between six to ten inches. The rib **115** can include a pattern to interact with at least one of every cell or every couple of cells in the first group battery cells and the second group of battery cells. Furthermore, the rib **115** can extend along the entire dimension of the insulative structure **125**.

[0039] A first side of the insulative structure **125** can include the conductor array **110**, the rib **115**, the first portion **120**, the second portion **135**, brackets, edge holes, and holes. The first side of the insulative structure **125** can be formed to withstand a physical load that can cause warping, bending, or distorting of the insulative structure **125**. For example, a physical load can be place on the first side of the insulative structure **125** of the insulative structure **125**. The first side of the insulative structure **125** can interface with at least a portion of the physical load. Furthermore, the physical load can exert a force (e.g., force of gravity) on the first side of the insulative structure **125**. The first side of the insulative structure **125** can protect, guard, or prevent damages to the components within the current collector assembly **100**. For example, water may spill onto the current collector assembly **100** and the first side of the insulative structure **125** can drain the water by forcing the flow of water to an end of the first side of the insulative structure **125 125**. In some arrangements, the first side of the insulative structure **125** can be formed to interface with the lid. For example, the lid can contain dimensions to operatively coupled to the first side of the insulative structure **125**.

[0040] A second side of the insulative structure **125** can include the conductor layer **105**, the conductor array **110**, battery cells, a center spine, a flange, and a flame barrier. The second side of the insulative structure **125** can be opposite the first side of the insulative structure **125**. The second side of the insulative structure **125** can aid in heat dissipation of the battery cells by including openings (e.g., cell spaces) and having a non-conductive material. In some arrangements, the second side of the insulative structure **125** can interact with the flame barrier. For example, the flame barrier can align with the second side of the insulative structure **125** based on the placement of the battery cells. Furthermore, the second side of the insulative structure **125** can align the battery cells to be coupled to the flame barrier and the second side of the insulative structure **125** with a tolerance.

[0041] FIG. **2**A depicts an example of the conductor layer **105** in accordance with implementations. The view of the example conductor layer **105** depicted in FIG. **2**A is represents the conductor layer **105** prior to a conductor array **215** being stamped. The conductor layer **105** can include the unstamped conductor array **215**, multiple cell spaces **210**, and one or more terminals **205** at one end of the conductor layer **105**. Each cell space **210** can include dimensions to allow the battery cell to be held, placed, disposed or constrained within the cell space **210**. The terminal **205** can be a connection point of contact for electrical components (e.g., conductors, resistors, battery cells, inductors, among others). The terminal **205** can include a negative terminal to be a reference point for voltages of the battery cells in the current collector assembly **100**. The terminal **205** can include a positive terminal to enable a flow of current through the battery cells of the current collector assembly. The terminal **205** can be disposed, affixed or supported on the outer bottom surface of the current collector assembly **100**. The terminal **205** can be disposed, affixed, or supported by the insulative structure **125** of the current collector assembly **100**.

[0042] FIG. **2**B depicts an example conductor layer **105** that includes a stamped conductor array **220**, in accordance with implementations. The stamped conductor array **220** can include one or more component, material, or functionality of the conductor array **110** depicted in FIG. **1**.

[0043] FIG. **3** depicts an example current collector assembly **300**, in accordance with implementations. The current collector assembly **300** can include one or more component, material or functionality of current collector assembly **100** depicted in FIG. **1**. The current collector assembly **300** can include one or more of the conductor array **110**, the rib **115**, the first portion **120**, the second portion **135**, a hole **305**, a negative terminal **310**, a positive terminal **315**, or an edge hole **320**. The negative terminal **310** can refer to or include one or more component or functionality of the terminal **205** depicted in FIG. **2**A. The positive terminal **315** can refer to or include one or more component or functionality of the terminal **205** depicted in FIG. **2**A. The cell space **210** can be defined, established, or based on the current collector assembly **300**. In some arrangements, the cell space **210** can be defined by the conductor layer **105**.

[0044] The current collector assembly **300** can include one or more holes **305**. The holes **305** can be referred to or include an opening or a cavity. The insulative structure **125** can form the one or more holes **305** to interact with a lid. The lid can be a covering made of the same plastic material as the insulative structure **125**structure or include one or more different materials. The lid can aide in heat dissipation from the battery cells. The lid can provide structural support for the current collector assembly. The holes **305** can be formed in a plurality of circular shapes (e.g., circle, oval, ellipse) and sizes defined by the insulative structure **125**. For example, the size of the holes **305** can correspond and scale to a size of the insulative structure **125**. The holes **305** can contain a first hole **305** including a first dimensionality. The first dimensionality can help align the battery system with the lid along a first axis (e.g., X-Axis **325**, Y-Axis **330**) different from a second dimensionality of a second hole **305** in the holes **305**. The holes **305** can constrain the movement and rotation of the insulative structure **125** of the current collector assembly. For example, the holes **305** can allow the insulative structure **125** to move freely along the first axis (e.g., X-Axis **325**, Y-Axis **330**).

[0045] Each of the one or more holes **305** can be used as a two-way datum. In some arrangements, a datum can be a reference point to define the location of a plurality of materials, components, or functionality. In some arrangements, each of the one or more holes **305** can be used as a four-way datum. The two-way datum can prevent movement along a first axis (e.g., X-Axis **325**, Y-Axis **330**) on a plane. For example, one hole **305** can prevent movement along the X-Axis **325**, where movement is free along the Y-Axis **330**. In another example, one hole **305** can prevent movement along Y-Axis **330**, where movement is free along the X-Axis **325**. In some arrangements, each of the one or more holes **305** can be used as a four-way datum. The four-way datum can prevent movement along a first and second axis (e.g., +X-Axis **325**, −X-Axis **325**, +Y-Axis **330**, −Y-Axis **330**) on a plane. In some arrangements, the insulative structure **125** can include a cylindrical pin to determine the axis which may be constrained.

[0046] The insulative structure **125** can form an edge hole **320** coupled to an edge. The edge hole **320** can have different shapes (e.g., circle, oval, ellipse) and sizes. One edge hole **320** is depicted in FIG. **3**, but the current collector assembly **100** can include a plurality of edge holes **302**. Multiple edge holes **302** can interact with the lid of the current collector assembly **100**. In some arrangements, the current collector assembly **100** can include a side wall to cover battery cells. In some arrangements, the edge hole **320** can constrain the movement and rotation of the insulative structure **125**. In some arrangements, the edge hole **320** can have a depth corresponding to the height of the battery cells. The edge hole **320** can be a voltage harness routing grommet hole. In some arrangements, the edge hole **320** can support a voltage sense harness. For example, the edge hole **305** can be used to secure the voltage sense harness and limit the movement of the voltage sense harness within the current collector assembly **300**.

[0047] The lid can be secured, fastened, or screwed into the edge hole **320** of the insulative structure **125**. For example, the lid can contain one or more pins which extend the height of the battery cells of the current collector assembly **100**. The pins can have dimensions corresponding to the edge hole **320** and can interact with the edge hole **320**. The pins can be made of a material (e.g., steel, metal, plastic) to support a weight of the current collector assembly **100**. The edge hole **320** and the hole **305** can constrain movement along a different axis. For example, the hole **305** can constrain the movement of the insulative structure **125** along the Y-axis **330**, whereas the edge hole **320** can constrain the movement of the insulative structure **125** along the X-Axis **325**. Each of the edge holes **320** and the holes **305** in the plurality of edge holes **320** and holes **305** can constrain movement along a different axis. For example, each of the holes **305** can constrain the movement of the insulative structure **125** along the Y-axis **330**, whereas each of the edge hole **320** can constrain the movement of the insulative structure **125** along the X-Axis **325**.

[0048] Edge hole **320** and the holes **305** can include a tolerance. The tolerance can be the same for the entire opening or different, based on direction or orientation. For example, tolerance of an opening in one direction can be different than the tolerance of the opening in another direction. For example, an edge hole **320** can include an opening having a first tolerance along a direction of length of the opening and a second tolerance along a direction of width of the opening. Tolerance can include any size range defined based on the size of the opening, such as between 1% and 20% of the size of the opening. For example, tolerance can have up to 1% of the opening size, 2% of the opening size, 5% of the opening size, 10% of the opening size, 15% of the opening size, 20% of the opening size or more than 20% of the opening size. Tolerance can include any size range based on the size of the pin cross-section diameter size, such as between 1-200% of the pin cross-section diameter size. For instance, tolerance can include 1%, 10%, 30%, 50%, 1100%, 11150%, 200% or more than 200% of the cross-sectional diameter size of pin. Tolerances can differ along the length and the width of the opening. Tolerances can differ along any direction with respect to the center of the opening. Tolerances can allow for the pin to move when inserted into the opening by one distance in one direction and by another distance in another direction.

[0049] FIG. **4**, FIG. **5**, and FIG. **6** depict a current collector **400**, **500**, or **600** having multiple features in which a bracket **405** and a flange **410** of the insulative structure **100** can provide a structure for supporting the current collector assembly and other components (e.g., voltage sense harness or battery voltage tester). The current collector assembly **400** can include a plurality of brackets **405**, depending upon the dimensions of the insulative structure **125**. For example, an insulative structure **125** can have a length which requires a specific number of brackets **405**. The bracket **405** can include a bracket hole **505** to allow objects (e.g., harness, metal, rope, structural components, etc.). For example, the bracket **405** can have an aluminum fastener fed through the bracket hole **505** to maintain the current collector assembly **400** at an elevated height. In another example, a harness can pass through the bracket hole **505** of the bracket **405** to attach a component to the current collector assembly **400**. The bracket **405** can include the edge hole **302** to constrain the object fed through the bracket hole **505**. In some arrangements, a harness can be fed through the bracket hole **505** and the pin from the lid can apply a downward force on the harness by extending through the edge hole **320**. The bracket **405** can align the insulative structure **125** with other components (e.g., lid, metal) of the current collector assembly **400**.

[0050] The flange **410** can provide structure support to the current collector assembly **400**. The flange **410** can include a height adjustable to the battery cell size to protect the battery cells. For example, the flange **410** can have a height which extends to the height of the battery cells within the current collector assembly. The flange **410** can be formed from the materials of the insulative structure **125** defined by a use for the insulative structure **125**. For example, the flange **410** can include a pattern to match an organization of the battery cells in the current collector assembly **400**. The organization of the battery cells can correspond to other components (e.g., terminals, connectors, sensors, etc.) disposed throughout the current collector assembly **400**. For example, the organization of the battery cells can correspond to a busbar coupled to the first portion **120** and the second portion **135**, where the busbar is connected to a positive and negative terminal. The flange **410** can include a structural integrity to limit the free movement of the battery cells. For example, the pattern can be formed to allow the battery cells at the end of a row to have the battery cells movement restricted. The flange **410** can align the insulative structure **125** with one or more separator structures when loading the current collector assembly. The one or more separator structures can separate each battery cell in the plurality of battery cells in the current collector assembly **400**.

[0051] FIG. **7** depicts a side view of an example current collector assembly **700**. The current collector assembly **700** can include one or more component, material or functionality of the current collector assembly **100** depicted in FIG. **1**. The current collector assembly **700** can include or interface with battery cells **705**, flame barrier hole **710**, flame barrier **715**, a **720**, or a connector **725**. The connector **725** can be on the second portion **135** and the first portion **120**. The connector **725** can be used to connect to negative terminal on the second portion **135**. When connected to the negative terminal, current within the current collector assembly **700** can flow to the connector **725** to be grounded. The insulative structure **125** can provide the adequate dimensions for the connector **725** to attach to the negative terminal. Using the single piece of the insulative structure **125**, an operation for removing the space for the insulative structure **125** can be more inefficient and inexpensive because of the ease of removing portions of the insulative structure **125**. For example, if the connector **725** connects to the negative terminal, the battery cells on the second portion can be grounded. The connector **725** can be used to connect to the positive terminal on the first portion

120. When connected to the positive terminal, current can flow from the positive terminal to interact with each of the battery cells **705**.

[0052] The flange **410** of the insulative structure **125** can interact with the flame barrier **715**. In some arrangements, the flange **410** can locate where the battery cells **705** can be placed on the flame barrier **715**. For example, the flange **410** can constrain the battery cells **705** to align the flame barrier **715**. The flange **410** can be used to reduce error and maintain the tolerance. For example, the flange **410** can be used to constrain the battery cells **705** while the flame barrier **715** is aligned to maintain the tolerance necessary to construct the current collector assembly **100**. The flange **410** can reduce error by constraining the battery cells **705**, interacting with the flame barrier hole **710**, and aligning the flame barrier **715** with the insulative structure **125**. In some arrangements, the flange **410** can interact with the flame barrier hole **710** by allowing a securing mechanism (e.g., harness, fastener, rope, or metal) to attach to the flange **410** and constrain the flame barrier **715** to the insulative structure **125**. Tightening the securing mechanism can decrease the free movement of components within the current collector assembly (e.g., battery cells **705**, separator structure **720**). In some arrangements, the flange **410** can be used to calibrate the current collector assembly **700**. The calibration can include fastening the flange **410** and the battery cells **705**, securing the flame barrier **715** to the flange **410** using a securing mechanism, or aligning the battery cells **705** to the flame barrier **715** by the flange **410**.

[0053] The separator structure **720** can be coupled to the flame barrier **715** and the insulative structure **125**. The separator structure **720** can include a battery separator material. The battery separator material can vary depending upon the type of battery (e.g., Lithium-Ion, Lead-Acid, Alkaline, Nickel-Cadmium, etc.) to improve safety and thermal resistance in some arrangements. The battery separator material can include a non-conductive material (e.g., polyethylene or polypropylene), material made from polyvinyl chloride, non-woven fabrics, glass fiber, among others). The separator structure **720** can be defined by the intended use of the battery, design requirements, or the type of battery. The separator structure **720** can have dimensions to correspond with the insulative structure **125** to allow for the separation of battery cells **705**. The insulative structure **125** can include groves for the separator structure **720** to enter. The groves contain a shape to fit the separator structure **720** within a tolerance. For example, the groves can be within a 2% tolerance of the separator structure **720**. The single piece of the insulative structure **125** enables the separator structure **720** to maintain the position as it is woven through the battery cells. The separator structure **720** can have a height to be constrained between the flame barrier **715** and the insulative structure **125**.

[0054] FIG. **8** depicts a bottom view of an example current collector assembly **800**. The current collector assembly **800** can include one or more component, material or functionality of the current collector assembly **100** depicted in FIG. **1**. The insulative structure **125** can be coupled to the first portion **120**, the second portion **135**, the separator structure **720**, voltage sense harness **805**, a slot **810**, and the battery cells **705**. The single piece of the insulative structure **125** can reduce the number of conductor layers **105** in the current collector assembly **800**. For example, since the insulative structure **125** is single piece, the conductor layer **105** can have various arrangements not constrained by the wielding of two pieces.

[0055] FIG. **9** depicts a side view of a current collector assembly **900**. The current collector assembly **900** can include one or more component, material or functionality of the current collector assembly **100** depicted in FIG. **1**. The rib **115** can contain a center spine **905** coupled to a mechanical adhesive. The mechanical adhesive can be used to couple the lid to the current collector assembly **900**. The center spine **905** can be the same material as the insulative structure **125** and can extend to the height of the battery cells **705**. For example, the center spine **905** can be the same height at the battery cells **705** to maintain separation between the first and second group of battery cells **705**. In some arrangements, the center spine **905** can be the same length as the rib **115**. The center spine **905** can be used to locate the middle axis (e.g., Y axis **330**). Furthermore, the center spine **905** can be used to align the flame barrier **715** and the battery cells **705** because it is disposed along the Y-Axis **330** to form a “center line” for the current collector assembly. The center spine **905** can allow for removal of portions of the insulative structure **125** to be relative to the center spine **905**. For example, the center spice **905** can define a distance between the first and second groups of battery cells **705** to protect the battery cells **705**.

[0056] FIG. **10** depicts an example current collector assembly **1000**. The current collector assembly **1000** can include one or more component, material or functionality of the current collector assembly **100** depicted in FIG. **1**. The current collector assembly **1000** contains all components described herein. The insulative structure **125** can be formed by a trimming operation. The trimming operation can cut or remove excess material from a workpiece (e.g., plastic, metal, glass) The trimming operation can cut, remove or adjust material to form a desired shape, size or fit. Furthermore, the trimming operation can include finishing injection molded components to remove rough edges, flash, and excess material. For example, the trimming operation can cut a product to be a desired shape, and further can remove excess material from the product. By using the trimming operation, the flexibility of injection molding can be exploited to add geometry to the insulative structure **125**. Therefore, identical insulative structured **125** can be formed with each use of the trimming operation.

[0057] The insulative structure **125** enables many components to be coupled, welded, places, or structured by the single piece of the insulative structure **125**. The single piece enables the current collector assembly to have a single layer to house all the electrical components described herein (e.g., battery cells **705**). The insulative structure **125** can define how other components are aligned to restrict the movement of the battery cells **705** (e.g., separator structure **720**, conductor layer **105**, or flame barrier **715**). The current collector assembly can include a short wall **1005**. The short wall **1005** can be used to protect the components of the current collector assembly **1000**. For example, the short wall **1005** can protect the voltage sense harness **805**, one or more terminals, and the battery cells **705**. The first portion **120** and the second portion **135** can define the size and shape of the short wall **1005**. Furthermore, the short wall **1005** can be coupled to a side terminal holder **1010**. The side terminal holder **1010** can hold one or more terminals connected to the connectors **725**. The side terminal holder **1010** can be a non-conductive material to prevent electrical current leakage.

[0058] The voltage sense harness **805** can be coupled to the top of the insulative structure **125** of the current collector assembly **100** or to the bottom of the insulative structure **125** within the current collector assembly **100**. The voltage sense harness **805** can monitor the voltage at a critical point in an electrical system. For example, the volage sense harness **805** can monitor the voltage of the battery cells **705**. In some arrangements, the voltage sense harness **805** placed at the top of the current collector assembly **1000** can provide an accurate voltage measurement at a particular location on the current collector assembly. For example, the voltage sense harness **805** can measure the voltage of the battery cells **705** five rows from the positive connector **1015**. In some arrangements, the voltage sense harness **805** can measure the voltage of the battery cells **705** seven rows from the positive connectors **1015**.

[0059] FIG. **11** depicts an example top-side view current collector assembly **1100**. The current collector assembly **1100** can include one or more component, material or functionality of the current collector assembly **100** depicted in FIG. **1**. The current collector assembly **1100** can include one or more of the components described herein. For example, the current collector assembly **1100** can include a series busbar **1105** (referred to as first busbar **1105** herein) coupled to the positive portion **120** and the negative portion **135**. The first busbar **1105** can include a metallic material but is not limited to copper and aluminum. The metallic material can depend on the characteristics of the current collector assembly **1000**. For example, a first busbar **1105** can have an aluminum material to reduce the weight of the current collector assembly. In some arrangements, copper can be used due to the higher conductivity. In some arrangements, copper can be used to increase the longevity of the first busbar **1105**. In some arrangements, the first busbar **1105** can have a structure proportional to the height of the rib **115**. For example, if the rib **115** is 3.2 cm, the first busbar **1105** can have a displacement from the rib **115** of 4.2 cm.

[0060] The first busbar **1105** can maintain electrical current distribution in the current collector assembly **1000**. For example, the first busbar **1105** can control the flow of current from the positive portion **120** to the negative portion **135**. In some arrangements, the first busbar **1105** can interconnect the positive portion **120** and the negative portion **135**. The first busbar **1105** can control voltage in the current collector assembly **1100** by ensuring that a desired voltage is transferring between the positive portion **120** and the negative portion **135**. The desired voltage can be established by the voltage sense harness **805**. For example, the first busbar **1105** can transfer electrical current between the positive portion **120** and the negative portion **135** based on measurements of the voltage sense harness **805**.

[0061] The first busbar **1105** can be a centralized ground for the current collector assembly **1100**. The metallic material of the first busbar **1105** can provide a low-impedance path for the current to flow to ground. For example, the first busbar **1105** can transfer the current from the battery cells **705** to ground by controlling the flow of current from the positive portion **120** to the negative portion **135**. In some arrangements, the first busbar **1105** can protect the components of the current collector assembly **1100**. For example, the first busbar **1105** can reduce the possibility of an occurrence of fault currents in the current collector assembly **1100**.

[0062] FIG. **12** depicts an example exploded view of the current collector assembly **1200**. The current collector assembly **1200** can include one or more component, material or functionality of the current collector assembly **100** depicted in FIG. **1**. The current collector assembly **1200** contains all components described herein. The current collector assembly can include intercellular potting **1205**, a treehouse busbar **1210**, and a battery voltage tester **1215**.

[0063] The intercellular potting **1205** can include a plurality of separator structures **720** described herein. The intercellular potting **1205** can hold a group of battery cells **705**. The battery cells **705** can be part of a parallel group (such as parallel group configurations). The parallel group configurations can increase the total capacity of the battery system. The parallel group configurations can spread the current load across the battery cells **705**. The battery cells **705** can be part of a group of cells. For example, the current collector assembly **1200** can include one separator structure **720** that holds one group of battery cells **705**, two separator structures **720** that hold two groups of cells, three separator structures **720** that hold three groups of cells, or more.

[0064] The intercellular potting **1205** can comprise a material based on material properties such as thermal insulation or conductivity, structural strength, gravimetric density, ability to disperse heat, ability to resist combustion, or chemical resistance. For example, the material can be or include foam. The material can provide thermal management for the battery cells **705** in the current collector assembly **1200**. The material can control or regulate the temperature of the battery cells **705** in the current collector assembly **1200**. The material can insulate, dissipate, or redirect heat in the current collector assembly **1200**. Thermal management can prevent overheating, thermal degradation, or thermal runaway. Thermal management can increase safety.

[0065] The second busbar **1210** (which can include or be referred to as a treehouse busbar **1210** herein) can include materials, structure, and functionality similar to the first busbar **1105**. The second busbar **1210** can be coupled to the battery voltage tester **1215** and the voltage sense harness **805**. The battery voltage tester **1215** can access the state of charge of the battery cells **705** and further determine whether the battery cells **705** have sufficient voltage to operate the current collector assembly **1200**. For example, an interface can be couple to the battery voltage tester **1215** to display the state of charge of the battery cells **705**. The battery voltage tester **1215** and the voltage sense harness **805** can work together to provide accurate voltage measurements of the battery cells **705** of a current collector assembly. For example, the voltage sense harness **805** can continuously monitor the voltage of each battery cell **705** in the battery cells **705**. The real-time feedback can be transmitted to the battery voltage tester **1215** to provide the interface with a continuously updated measurement of the voltage of each battery cell **705** in the battery cells **705**. The combination of the voltage sense harness **805** and the battery voltage tester **1215** can provide convenience of on-the-spot voltage checks and the benefits of automated, continuous monitoring to ensure optimal performance and prevent potential issues.

[0066] FIG. **13** depicts an example cross-sectional view **1300** of an electric vehicle **1305** installed with at least one battery pack **1310**. Electric vehicles **1305** can include electric trucks, electric sport utility vehicles (SUVs), electric delivery vans, electric automobiles, electric cars, electric motorcycles, electric scooters, electric passenger vehicles, electric passenger or commercial trucks, hybrid vehicles, or other vehicles such as sea or air transport vehicles, planes, helicopters, submarines, boats, or drones, among other possibilities. The battery pack **1310** can also be used as an energy storage system to power a building, such as a residential home or commercial building. Electric vehicles **1305** can be fully electric or partially electric (e.g., plug-in hybrid) and further, electric vehicles **1305** can be fully autonomous, partially autonomous, or unmanned. Electric vehicles **1305** can also be human operated or non-autonomous. Electric vehicles **1305** such as electric trucks or automobiles can include on-board battery packs **1310**, battery modules **1315**, or battery cells **1320** to power the electric vehicles. The electric vehicle **1305** can include a chassis **1325** (e.g., a frame, internal frame, or support structure). The chassis **1325** can support various components of the electric vehicle **1305**. The chassis **1325** can span a front portion **1330** (e.g., a hood or bonnet portion), a body portion **1335**, and a rear portion **1340** (e.g., a trunk, payload, or boot portion) of the electric vehicle **1305**. The battery pack **1310** can be installed or placed within the electric vehicle **1305**. For example, the battery pack **1310** can be installed on the chassis **1325** of the electric vehicle **1305** within one or more of the front portions **1330**, the body portion **1335**, or the rear portion **1340**. The battery pack **1310** can include or connect with at least one busbar, e.g., a current collector element. The battery pack **1310** can include one or more component of the current collector assembly **100** depicted in FIG. **1**. The first busbar **1345** and the second busbar **1350** can include electrically conductive material to connect or otherwise electrically couple the battery modules **1315** or the battery cells **1320** with other electrical components of the electric vehicle **1305** to provide electrical power to various systems or components of the electric vehicle **1305**. The battery pack **1310** can connect with the current collector assembly **100**. For example, the conductor layer **105** of the current collector assembly **100** can electrically couple the battery cells **1320** or the battery modules **1350** other electrical components of the electric vehicle **1305** to provide electrical power to various systems or components of the electric vehicle **1305**.

[0067] FIG. **14**A depicts an example battery pack **1310**. Referring to FIG. **14**A, among others, the battery pack **1310** can provide power to electric vehicle **1305**. Battery packs **1310** can include any arrangement or network of electrical, electronic, mechanical or electromechanical devices to power a vehicle of any type, such as the electric vehicle **1305**. The battery pack **1310** can include at least one housing **1405**. The housing **1405** can include at least one battery module **1315** or at least one battery cell **1320**, as well as other battery pack components. The battery module **1315** can be or can include one or more groups of prismatic cells, cylindrical cells, pouch cells, or other form factors of battery cells **1320**. The housing **1405** can include a shield on the bottom or underneath the battery module **1315** to protect the battery module **1315** and/or cells **1320** from external conditions, for example if the electric vehicle **1305** is driven over rough terrains (e.g., off-road, trenches, rocks, etc.) The battery pack **1310** can include at least one cooling line **1410** that can distribute fluid through the battery pack **1310** as part of a thermal/temperature control or heat exchange system that can also include at least one thermal component (e.g., cold plate) **1415**. The thermal component **1415** can be positioned in relation to a top submodule and a bottom submodule, such as in between the top and bottom submodules, among other possibilities. The battery pack **1310** can include any number of thermal components **1415**. For example, there can be one or more thermal components **1415** per battery pack **1310**, or per battery module **1315**. At least one cooling line **1410** can be coupled with, part of, or independent from the thermal component **1415**.

[0068] FIG. **14**B depicts example battery modules **1315**, and FIGS. **14**C, **14**D and **14**E depict an example cross sectional view of a battery cell **1320**. The battery modules **1315** can include at least one submodule. For example, the battery modules **1315** can include at least one first (e.g., top) submodule **1420** or at least one second (e.g., bottom) submodule **1425**. At least one thermal component **1415** can be disposed between the top submodule **1420** and the bottom submodule **1425**. For example, one thermal component **1415** can be configured for heat exchange with one battery module **1315**. The thermal component **1415** can be disposed or thermally coupled between the top submodule **1420** and the bottom submodule **1425**. One thermal component **1415** can also be thermally coupled with more than one battery module **1315** (or more than two submodules **1420**, **1425**). The battery submodules **1420**, **1425** can collectively form one battery module **1315**. In some examples each submodule **1420**, **1425** can be considered as a complete battery module **1315**, rather than a submodule.

[0069] The battery modules **1315** can each include a plurality of battery cells **1320**. The battery modules **1315** can be disposed within the housing **1255** of the battery pack **1310**. The battery modules **1315** can include battery cells **1320** that are cylindrical cells or prismatic cells, for example. The battery module **1315** can operate as a modular unit of battery cells **1320**. For example, a battery module **1315** can collect current or electrical power from the battery cells **1320** that are included in the battery module **1315** and can provide the current or electrical power as output from the battery pack **1310**. The battery pack **1310** can include any number of battery modules **1315**. For example, the battery pack can have one, two, three, four, five, six, seven, eight, nine, ten, eleven, twelve or other number of battery modules **1315** disposed in the housing **1255**. It should also be noted that each battery module **1315** can include a top submodule **1420** and a bottom submodule **1425**, possibly with a thermal component **1415** in between the top submodule **1420** and the bottom submodule **1425**. The battery pack **1310** can include or define a plurality of areas for positioning of the battery module **1315** and/or cells **1320**. The battery modules **1315** can be square, rectangular, circular, triangular, symmetrical, or asymmetrical. In some examples, battery modules **1315** can be different shapes, such that some battery modules **1315** are rectangular but other battery modules **1315** are square shaped, among other possibilities. The battery module **1315** can include or define a plurality of slots, holders, or containers for a plurality of battery cells **1320**.

[0070] Battery cells **1320** have a variety of form factors, shapes, or sizes. For example, battery cells **1320** can have a cylindrical, rectangular, square, cubic, flat, pouch, elongated or prismatic form factor. As depicted in FIG. **14**C, for example, the battery cell **1320** can be cylindrical. As depicted in FIG. **14**D, for example, the battery cell **1320** can be prismatic. As depicted in FIG. **14**E, for example, the battery cell **1320** can include a pouch form factor. Battery cells **1320** can be assembled, for example, by inserting a winded or stacked electrode roll (e.g., a jelly roll) including electrolyte material into at least one battery cell housing **1430**. The electrolyte material, e.g., an ionically conductive fluid or other material, can support electrochemical reactions at the electrodes to generate, store, or provide electric power for the battery cell by allowing for the conduction of ions between a positive electrode and a negative electrode. The battery cell **1320** can include an electrolyte layer where the electrolyte layer can be or include solid electrolyte material that can conduct ions. For example, the solid electrolyte layer can conduct ions without receiving a separate liquid electrolyte material. The electrolyte material, e.g., an ionically conductive fluid or other material, can support conduction of ions between electrodes to generate or provide electric power for the battery cell **1320**. The housing **1430** can be of various shapes, including cylindrical or rectangular, for example. Electrical connections can be made between the electrolyte material and components of the battery cell **1320**. For example, electrical connections to the electrodes with at least some of the electrolyte material can be formed at two points or areas of the battery cell **1320**, for example to form a first polarity terminal **1435** (e.g., a positive or anode terminal) and a second polarity terminal **1440** (e.g., a negative or cathode terminal). The polarity terminals can be made from electrically conductive materials to carry electrical current from the battery cell **1320** to an electrical load, such as a component or system of the electric vehicle **1305**.

[0071] For example, the battery cell **1320** can include at least one lithium-ion battery cell. In lithium-ion battery cells, lithium ions can transfer between a positive electrode and a negative electrode during charging and discharging of the battery cell. For example, the battery cell anode can include lithium or graphite, and the battery cell cathode can include a lithium-based oxide material. The electrolyte material can be disposed in the battery cell **1320** to separate the anode and cathode from each other and to facilitate transfer of lithium ions between the anode and cathode. It should be noted that battery cell **1320** can also take the form of a solid-state battery cell developed using solid electrodes and solid electrolytes. Solid electrodes or electrolytes can be or include inorganic solid electrolyte materials (e.g., oxides, sulfides, phosphides, ceramics), solid polymer electrolyte materials, hybrid solid state electrolytes, or combinations thereof. In some embodiments, the solid electrolyte layer can include polyanionic or oxide-based electrolyte material (e.g., Lithium Superionic Conductors (LISICONs), Sodium Superionic Conductors (NASICONs), perovskites with formula A BO.sub.3 (A=Li, Ca, Sr, La, and B=Al, Ti), garnet-type with formula A.sub.3B.sub.2(XO.sub.4).sub.3 (A=Ca, Sr, Ba and X=Nb, Ta), lithium phosphorous oxy-nitride (LixPOyNz). In some embodiments, the solid electrolyte layer can include a glassy, ceramic and/or crystalline sulfide-based electrolyte (e.g., Li.sub.3PS.sub.4, Li.sub.2P.sub.3S.sub.13, Li.sub.2S—P.sub.2S.sub.5, LizS—B.sub.2S.sub.3, SnS—P.sub.2S.sub.5, LizS—SiS.sub.2, Li.sub.2S—P.sub.2S.sub.5, Li.sub.2S—GeS.sub.2, Li10GeP2S14) and/or sulfide-based lithium argyrodites with formula Li.sub.6PS.sub.5X (X=Cl, Br) like Li.sub.6PS.sub.5Cl). Furthermore, the solid electrolyte layer can include a polymer electrolyte material (e.g., a hybrid or pseudo-solid-state electrolyte), for example, polyacrylonitrile (PAN), polyethylene oxide (PEO), polymethyl-methacrylate (PMMA), and polyvinylidene fluoride (PVDF), among others.

[0072] The battery cell **1320** can be included in battery modules **1315** or battery packs **1310** to power components of the electric vehicle **1305**. The battery cell housing **1430** can be disposed in the battery module **1315**, the battery pack **1310**, or a battery array installed in the electric vehicle **1305**. The housing **1430** can be of any shape, such as cylindrical with a circular (e.g., as depicted in FIG. **2**C, among others), elliptical, or ovular base, among others. The shape of the housing **1430** can also be prismatic with a polygonal base, as shown in FIG. **2**D, among others. As shown in FIG. **2**E, among others, the housing **1430** can include a pouch form factor. The housing **1430** can include other form factors, such as a triangle, a square, a rectangle, a pentagon, and a hexagon, among others. In some embodiments, the battery pack can not include modules. For example, the battery pack can have a cell-to-pack configuration wherein battery cells are arranged directly into a battery pack without assembly into a module.

[0073] The housing **1430** of the battery cell **1320** can include one or more materials with various electrical conductivity or thermal conductivity, or a combination thereof. The electrically conductive and thermally conductive material for the housing **1430** of the battery cell **1320** can include a metallic material, such as aluminum, an aluminum alloy with copper, silicon, tin, magnesium, manganese, or zinc (e.g., aluminum 13000, 4000, or 5000 series), iron, an iron-carbon alloy (e.g., steel), silver, nickel, copper, and a copper alloy, among others. The electrically insulative and thermally conductive material for the housing **1430** of the battery cell **1320** can include a ceramic material (e.g., silicon nitride, silicon carbide, titanium carbide, zirconium dioxide, beryllium oxide, and among others) and a thermoplastic material (e.g., polyethylene, polypropylene, polystyrene, polyvinyl chloride, or nylon), among others. In examples where the housing **1430** of the battery cell **1320** is prismatic (e.g., as depicted in FIG. **2**D, among others) or cylindrical (e.g., as depicted in FIG. **2**C, among others), the housing **1430** can include a rigid or semi-rigid material such that the housing **1430** is rigid or semi-rigid (e.g., not easily deformed or manipulated into another shape or form factor). In examples where the housing **1430** includes a pouch form factor (e.g., as depicted in FIG. **2**E, among others), the housing **1430** can include a flexible, malleable, or non-rigid material such that the housing **1430** can be bent, deformed, manipulated into another form factor or shape.

[0074] The battery cell **1320** can include at least one anode layer **1445**, which can be disposed within the cavity **1450** defined by the housing **1430**. The anode layer **1445** can include a first redox potential. The anode layer **1445** can receive electrical current into the battery cell **1320** and output electrons during the operation of the battery cell **1320** (e.g., charging or discharging of the battery cell **1320**). The anode layer **1445** can include an active substance. The active substance can include, for example, an activated carbon or a material infused with conductive materials (e.g., artificial or natural Graphite, or blended), lithium titanate ($Li_4Ti_5O_{14}$), or a silicon-based material (e.g., silicon metal, oxide, carbide, pre-lithiated), or other lithium alloy anodes (Li—Mg, Li—Al, Li—Ag alloy etc.) or composite anodes consisting of lithium and carbon, silicon and carbon or other compounds. The active substance can include graphitic carbon (e.g., ordered or disordered carbon with sp**2** hybridization), Li metal anode, or a silicon-based carbon composite anode, or other lithium alloy anodes (Li—Mg, Li—Al, Li—Ag alloy etc.) or composite anodes consisting of lithium and carbon, silicon and carbon or other compounds. In some examples, an anode material can be formed within a current collector material. For example, an electrode can include a current collector (e.g., a copper foil) with an in situ-formed anode (e.g., Li metal) on a surface of the current collector facing the separator or solid-state electrolyte. In such examples, the assembled cell does not comprise an anode active material in an uncharged state.

[0075] The battery cell **1320** can include at least one cathode layer **1455** (e.g., a composite cathode layer compound cathode layer, a compound cathode, a composite cathode, or a cathode). The cathode layer **1455** can include a second redox potential that can be different than the first redox potential of the anode layer **1445**. The cathode layer **1455** can be disposed within the cavity **1450**. The cathode layer **1455** can output electrical current out from the battery cell **1320** and can receive electrons during the discharging of the battery cell **1320**. The cathode layer **1455** can also release lithium ions during the discharging of the battery cell **1320**. Conversely, the cathode layer **1455** can receive electrical current into the battery cell **1320** and can output electrons during the charging of the battery cell **1320**. The cathode layer **1455** can receive lithium ions during the charging of the battery cell **1320**.

[0076] The battery cell **1320** can include an electrolyte layer **1460** disposed within the cavity **1450**. The electrolyte layer **1460** can be arranged between the anode layer **1445** and the cathode layer **1455** to separate the anode layer **1445** and the cathode layer **1455**. The electrolyte layer **1460** can help transfer ions between the anode layer **1445** and the cathode layer **1455**. The electrolyte layer **1460** can transfer Li^+ cations from the anode layer **1445** to the cathode layer **1455** during the discharge operation of the battery cell **1320**. The electrolyte layer **1460** can transfer lithium ions from the cathode layer **1455** to the anode layer **1445** during the charge operation of the battery cell **1320**.

[0077] The redox potential of layers (e.g., the first redox potential of the anode layer **1445** or the second redox potential of the cathode layer **1455**) can vary based on a chemistry of the respective layer or a chemistry of the battery cell **1320**. For example, lithium-ion batteries can include an LFP (lithium iron phosphate) chemistry, an NMC (Nickel Manganese Cobalt) chemistry, an NCA (Nickel Cobalt Aluminum) chemistry, or an LCO (lithium cobalt oxide) chemistry for a cathode layer (e.g., the cathode layer **1455**). Lithium-ion batteries can include a graphite chemistry, a silicon-graphite chemistry, or a lithium metal chemistry for the anode layer (e.g., the anode layer **1445**).

[0078] For example, lithium-ion batteries can include an olivine phosphate ($LiMPO_4$, M=Fe and/or Co and/or Min and/or Ni)) chemistry, LISICON or NASICON Phosphates (Li3M2 (PO4)3 and LiMPO4Ox, M=Ti, V, Mn, Cr, and Zr), for example Lithium iron phosphate (LFP), Lithium iron manganese phosphate (LM FP), a layered oxides (LiMO2, M=Ni and/or Co and/or M n and/or

Fe and/or Al and/or M g) examples NMC (Nickel Manganese Cobalt) chemistry, an NCA (Nickel Cobalt Aluminum) chemistry, or an LCO (lithium cobalt oxide) chemistry for a cathode layer, Lithium rich layer oxides ($Li1+xM1-xO2$) (Ni, and/or Mn, and/or Co), (OLO or LMR), spinel ($LiMn2O4$) and high voltage spinels ($LiMn1.5Ni0.5O4$), disordered rock salt, Fluorophosphates $Li2FePO4F$ (M=Fe, Co, Ni) and Fluorosulfates $LiMSO4F$ (M=Co, Ni, Mn) (e.g., the cathode layer **1455**). Lithium-ion batteries can include a graphite chemistry, a silicon-graphite chemistry, or a lithium metal chemistry for the anode layer (e.g., the anode layer **1445**). For example, a cathode layer having an LFP chemistry can have a redox potential of 3.4 V vs. Li/Li.sup.+, while an anode layer having a graphite chemistry can have a 0.2 V vs. Li/Li.sup.+ redox potential.

[0079] Electrode layers can include anode active material or cathode active material, commonly in addition to a conductive carbon material, a binder, other additives as a coating on a current collector (metal foil). The chemical composition of the electrode layers can affect the redox potential of the electrode layers. For example, cathode layers (e.g., the cathode layer **1455**) can include medium to high-nickel content (50 to 80%, or equal to 80% Ni) lithium transition metal oxide, such as a particulate lithium nickel manganese cobalt oxide ("LiNMC"), a lithium nickel cobalt aluminum oxide ("LiNCA"), a lithium nickel manganese cobalt aluminum oxide ("LiNMCA"), or lithium metal phosphates like lithium iron phosphate ("LFP") and Lithium iron manganese phosphate ("LMFP"). Anode layers (e.g., the anode layer **1445**) can include conductive carbon materials such as graphite, carbon black, carbon nanotubes, and the like. A node layers can include Super P carbon black material, Ketjen Black, Acetylene Black, SWCNT, MWCNT, graphite, carbon nanofiber, or graphene, for example.

[0080] Electrode layers can also include chemical binding materials (e.g., binders). Binders can include polymeric materials such as polyvinylidene fluoride ("PVDF"), polyvinylpyrrolidone ("PVP"), styrene-butadiene or styrene-butadiene rubber ("SBR"), polytetrafluoroethylene ("PTFE") or carboxymethylcellulose ("CMC"). Binder materials can include agar-agar, alginate, amylose, Arabic gum, carrageenan, caseine, chitosan, cyclodextrines (carbonyl-beta), ethylene propylene diene monomer (EPDM) rubber, gelatine, gellan gum, guar gum, karaya gum, cellulose (natural), pectine, poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT-PSS), polyacrylic acid (PAA), poly (methyl acrylate) (PMA), poly(vinyl alcohol) (PVA), poly(vinyl acetate) (PVAc), polyacrylonitrile (PAN), polyisoprene (Plpr), polyaniline (PANi), polyethylene (PE), polyimide (PI), polystyrene (PS), polyurethane (PU), polyvinyl butyral (PVB), polyvinyl pyrrolidone (PVP), starch, styrene butadiene rubber (SBR), tara gum, tragacanth gum, fluorine acrylate (TRD202A), xanthan gum, or mixtures of any two or more thereof.

[0081] Current collector materials (e.g., a current collector foil to which an electrode active material is laminated to form a cathode layer or an anode layer) can include a metal material. For example, current collector materials can include aluminum, copper, nickel, titanium, stainless steel, or carbonaceous materials. The current collector material can be formed as a metal foil. For example, the current collector material can be an aluminum (Al) or copper (Cu) foil. The current collector material can be a metal alloy, made of Al, Cu, Ni, Fe, Ti, or combination thereof. The current collector material can be a metal foil coated with a carbon material, such as carbon-coated aluminum foil, carbon-coated copper foil, or other carbon-coated foil material.

[0082] The electrolyte layer **1460** can include or be made of a liquid electrolyte material. For example, the electrolyte layer **1460** can be or include at least one layer of polymeric material (e.g., polypropylene, polyethylene, or other material) that is wetted (e.g., is saturated with, is soaked with, receives) a liquid electrolyte substance. The liquid electrolyte material can include a lithium salt dissolved in a solvent. The lithium salt for the liquid electrolyte material for the electrolyte layer **1460** can include, for example, lithium tetrafluoroborate (LiBF.sub.4), lithium hexafluorophosphate (LiPF.sub.6), and lithium perchlorate (LiClO.sub.4), among others. The solvent can include, for example, dimethyl carbonate (DMC), ethylene carbonate (EC), and diethyl carbonate (DEC), among others. The electrolyte layer **1460** can include or be made of a solid electrolyte material, such as a ceramic electrolyte material, polymer electrolyte material, or a glassy electrolyte material, or among others, or any combination thereof.

[0083] In some embodiments, the solid electrolyte film can include at least one layer of a solid electrolyte. Solid electrolyte materials of the solid electrolyte layer can include inorganic solid electrolyte materials (e.g., oxides, sulfides, phosphides, ceramics), solid polymer electrolyte materials, hybrid solid state electrolytes, or combinations thereof. In some embodiments, the solid electrolyte layer can include polyanionic or oxide-based electrolyte material (e.g., Lithium Superionic Conductors (LISICONs), Sodium Superionic Conductors (NASICONs), perovskites with formula ABO3(A=Li, Ca, Sr, La, and B=Al, Ti), garnet-type with formula A3B2(XO4)3(A=Ca, Sr, Ba and X=Nb, Ta), lithium phosphorous oxy-nitride (LixPOyNz). In some embodiments, the solid electrolyte layer can include a glassy, ceramic and/or crystalline sulfide-based electrolyte (e.g., Li3PS4, Li7P3S13, Li2S—P255, Li2S—B 2S3, SnS—P2S5, Li2S—SiS2, Li2S—P2S5, Li2S—GeS2, Li10GeP2S14) and/or sulfide-based lithium argyrodites with formula Li6PS5X (X=Cl, Br) like Li6PS5Cl). Furthermore, the solid electrolyte layer can include a polymer electrolyte material (e.g., a hybrid or pseudo-solid-state electrolyte), for example, polyacrylonitrile (PAN), polyethylene oxide (PEO), polymethyl-methacrylate (PMMA), and polyvinylidene fluoride (PVDF), among others.

[0084] In examples where the electrolyte layer **1460** includes a liquid electrolyte material, the electrolyte layer **1460** can include a non-aqueous polar solvent. The non-aqueous polar solvent can include a carbonate such as ethylene carbonate, propylene carbonate, diethyl carbonate, ethyl methyl carbonate, dimethyl carbonate, or a mixture of any two or more thereof. The electrolyte layer **1460** can include at least one additive. The additives can be or include vinylidene carbonate, fluoroethylene carbonate, ethyl propionate, methyl propionate, methyl acetate, ethyl acetate, or a mixture of any two or more thereof. The electrolyte layer 1460 can include a lithium salt material. For example, the lithium salt can be lithium perchlorate, lithium hexafluorophosphate, lithium bis(fluorosulfonyl) imide, lithium bis trifluorosulfonyl) imide, or a mixture of any two or more thereof. The lithium salt can be present in the electrolyte layer 1460 from greater than 0 M to about 1.5 M.

[0085] FIG. **15** depicts a method **1500** to form, create, build, or manufacture a current collector assembly using an insulative structure (e.g., a single piece of insulative structure material, such as plastic, insulative structure **125**). The method **1500** can be performed by, using, or for a system **1000**, a battery pack **1310** or an EV **1305**. AtACT **1505**, the method **1500** can include encapsulating a conductor layer in the insulative structure. At ACT **1510**, the method **1500** can include cutting a conductor array of the conductor layer. At ACT **1515**, the method **1500** can include forming a plurality of holes from the insulative structure. At ACT **1520**, the method can include forming a rib on the insulative structure.

[0086] At ATC **1505**, the method **1500** can include at least partially encapsulating a conductor layer in the insulative structure. The conductor layer can be made of aluminum, copper, tin, or any other conductive material. The method **1500** can include forming the insulative structure as an overmold to attenuate a frequency of vibration to restrict movement the current collector assembly.

[0087] At ACT **1510**, the method **1500** can include cutting a conductor array of a conductor layer, a first portion of the conductor array to contact a positive terminal of a first group of battery cells, and a second portion of the conductor array to contact a negative terminal of a second group of battery cells. The method **1500** can include forming a plurality of cell spaces within the conductor array. The method **1500** can include aligning the plurality of cell spaces with openings in the insulative structure. The plurality of cell spaces can have a shape that is polygonal. The method **1500** can include forming an insulative structure by a trimming operation. The trimming operation involves using an injection molding machine to formulate the geometry of the insulative structure. The conductor layer can include a material to conduct electricity (e.g., gold, copper, aluminum, silver, combination of metallic metals). The materials have high density of free electrons to

transmit current. The conductor can be formed by depositing the material onto a substrate following a process including at least one of physical vapor deposition, chemical vapor deposition, electroplating, chemical deposition, among others. The method **1500** can include removing portions of the conductor layer to create space for a plurality of battery cells. The battery cells can include one or more materials with various electrical conductivity or thermal conductivity, or a combination thereof. The electrically conductive and thermally conductive material for a housing of the plurality of battery cells can include a metallic material, such as aluminum, an aluminum alloy with copper, silicon, tin, magnesium, manganese, or zinc (e.g., aluminum 13000, 4000, or 5000 series). The conductor array can include a pattern of conductive materials on the substrate. The pattern of conductive materials can facilitate the flow of electrical current based on the conductor layer. In some arrangements, the conductive array can detect changes in temperature, current, or voltage and provide the changes to a voltage sensing harness. The conductor array can be stamped in the insulative structure to connect to each battery cell in a plurality of battery cells.
[0088] At ACT **1515**, the method **1500** can include forming a first plurality of holes in the insulative structure on a second side of the current collector assembly that is opposite the side of the current collector assembly with the rib. The method **1500** can include aligning, the first plurality of holes with a second plurality of holes on a lower insulation barrier of the current collector assembly. The method **1500** can include forming a flange on the insulative structure. The flange is disposed along the first portion and the second portion of the insulative structure. The method **1500** can include aligning, by the flange, the insulative structure with a first row of battery cells in the first group of battery cells and a second row of battery cells in the second group of battery cells within the current collector assembly. The method **1500** can include constraining, by the flange, movement of the first row of battery and the second row of battery cells within the current collector assembly. The method **1500** can include attaching a voltage sense harness to a first side of the insulative structure, wherein side of the insulative structure is the first side. The method **1500** can include connecting the voltage sense harness to the first group of battery cells and the second group of battery cells.
[0089] At ACT **1520**, the method **1500** can include forming, a rib from the insulative structure, on a second side of the current collector assembly opposite the first side. The method **1500** can include forming a spine on the insulative structure. The spine can be connected to the rib. The method **1500** can include aligning, by the spine, the first group of battery cells and the second group of battery cells along the first portion and the second portion of the insulative structure. The method **1500** can include forming a plurality of brackets along the first portion and the second portion of the insulative structure. The method **1500** can include aligning by the plurality of brackets, the current collector assembly within the battery system. The method **1500** can include connecting one or more busbars to the first portion of the conductor array and the second portion of the conductor array. The method **1500** can include transferring, by the one or more busbars, current between the first portion of the conductor array and the second portion of the conductor array. The method **1500** can include the injection molding machine inspecting the insulative structure for defects and fixing any defects in the insulative structure using the trimming operation.
[0090] Example and non-limiting module implementation elements include sensors providing any value determined herein, sensors providing any value that is a precursor to a value determined herein, datalink or network hardware including communication chips, oscillating crystals, communication links, cables, twisted pair wiring, coaxial wiring, shielded wiring, transmitters, receivers, or transceivers, logic circuits, hard-wired logic circuits, reconfigurable logic circuits in a particular non-transient state configured according to the module specification, any actuator including at least an electrical, hydraulic, or pneumatic actuator, a solenoid, an op-amp, analog control elements (springs, filters, integrators, adders, dividers, gain elements), or digital control elements.
[0091] While operations are depicted in the drawings in a particular order, such operations are not

required to be performed in the particular order shown or in sequential order, and all illustrated operations are not required to be performed. A ctions described herein can be performed in a different order.

[0092] Having now described some illustrative implementations, it is apparent that the foregoing is illustrative and not limiting, having been presented by way of example. In particular, although many of the examples presented herein involve specific combinations of method acts or system elements, those acts and those elements can be combined in other ways to accomplish the same objectives. Acts, elements and features discussed in connection with one implementation are not intended to be excluded from a similar role in other implementations or implementations.

[0093] The phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of "including" "comprising" "having" "contained" "involving" "characterized by" "characterized in that" and variations thereof herein, is meant to encompass the items listed thereafter, equivalents thereof, and additional items, as well as alternate implementations consisting of the items listed thereafter exclusively. In one implementation, the systems and methods described herein consist of one, each combination of more than one, or all the described elements, acts, or components.

[0094] Any references to implementations or elements or acts of the systems and methods herein referred to in the singular can also embrace implementations including a plurality of these elements, and any references in plural to any implementation or element or act herein can also embrace implementations including only a single element. References in the singular or plural form are not intended to limit the presently disclosed systems or methods, their components, acts, or elements to single or plural configurations. References to any act or element being based on any information, act or element can include implementations where the act or element is based at least in part on any information, act, or element.

[0095] A ny implementation disclosed herein can be combined with any other implementation or embodiment, and references to "an implementation," "some implementations," "one implementation" or the like are not necessarily mutually exclusive and are intended to indicate that a particular feature, structure, or characteristic described in connection with the implementation can be included in at least one implementation or embodiment. Such terms as used herein are not necessarily all referring to the same implementation. A ny implementation can be combined with any other implementation, inclusively or exclusively, in any manner consistent with the aspects and implementations disclosed herein.

[0096] References to "or" can be construed as inclusive so that any terms described using "or" can indicate any of a single, more than one, and all the described terms. References to at least one of a conjunctive list of terms can be construed as an inclusive OR to indicate any of a single, more than one, and all the described terms. For example, a reference to "at least one of 'A' and 'B'" can include only 'A', only 'B', as well as both 'A' and 'B'. Such references used in conjunction with "comprising" or other open terminology can include additional items.

[0097] Where technical features in the drawings, detailed description or any claim are followed by reference signs, the reference signs have been included to increase the intelligibility of the drawings, detailed description, and claims. Accordingly, neither the reference signs nor their absence have any limiting effect on the scope of any claim elements.

[0098] Modifications of described elements and acts such as variations in sizes, dimensions, structures, shapes and proportions of the various elements, values of parameters, mounting arrangements, use of materials, colors, orientations can occur without materially departing from the teachings and advantages of the subject matter disclosed herein. For example, elements shown as integrally formed can be constructed of multiple parts or elements, the position of elements can be reversed or otherwise varied, and the nature or number of discrete elements or positions can be altered or varied. Other substitutions, modifications, changes and omissions can also be made in the design, operating conditions and arrangement of the disclosed elements and operations without departing from the scope of the present disclosure.

[0099] For example, descriptions of positive and negative electrical characteristics can be reversed. For example, negative busbar and a positive busbar can be reversed, as well as negative current collector and the positive current collector. Elements described as negative elements can instead be configured as positive elements and elements described as positive elements can instead by configured as negative elements. For example, elements described as having first polarity can instead have a second polarity, and elements described as having a second polarity can instead have a first polarity. Further relative parallel, perpendicular, vertical or other positioning or orientation descriptions include variations within +/−10% or +/−10 degrees of pure vertical, parallel or perpendicular positioning. References to “approximately,” “substantially” or other terms of degree include variations of +/−10% from the given measurement, unit, or range unless explicitly indicated otherwise. Coupled elements can be electrically, mechanically, or physically coupled with one another directly or with intervening elements. Scope of the systems and methods described herein is thus indicated by the appended claims, rather than the foregoing description, and changes that come within the meaning and range of equivalency of the claims are embraced therein.

Claims

1-20. (canceled)

21. A battery system, comprising: a conductor layer encapsulated by an insulative structure, wherein the conductor layer includes a plurality of cell spaces aligned along a first axis to expose one or more terminals of a plurality of battery cells within the insulative structure; an electrical component attached via a hole of the insulative structure, the electrical component to connect a first group of the plurality of battery cells and a second group of the plurality of battery cells along the first axis associated with the conductor layer; and intercellular potting within the plurality of cell spaces of the conductor layer to hold the first group of the plurality of battery cells and second group of the plurality of battery cells.

22. The battery system of claim 21, wherein the conductor layer comprises a conductor array, the conductor array comprises the plurality of cell spaces aligned with openings in the insulative structure, the opening to expose the one or more terminals of the plurality of battery cells.

23. The battery system of claim 22, wherein the conductor array includes a first portion and a second portion, the first portion of the conductor array to contact a positive terminal of the first group of battery cells, the second portion of the conductor array to contact a negative terminal of the second group of battery cells.

24. The battery system of claim 21, wherein the plurality of cell spaces of the conductor layer are in a polygonal shape.

25. The battery system of claim 21, wherein the electrical component is coupled to a portion of the insulative structure and monitors a voltage of the plurality of battery cells.

26. The battery system of claim 21, wherein the intercellular potting includes a plurality of separator structures to hold the first group of the plurality of battery cells and the second group of the plurality of battery cells.

27. The battery system of claim 21, wherein the insulative structure is configured to attenuate a frequency of vibration to restrict movement of the battery system.

28. A method comprising: encapsulating a conductor layer within the insulative structure, wherein the conductor layer includes a plurality of cell spaces to expose one or more terminals of a plurality of battery cells within the insulative structure, the plurality of cell spaces including in a first shape aligned along a first axis; attaching an electrical component via a hole of the insulative structure, the electrical component to connect a first group of the plurality of battery cells and a second group of the plurality of battery cells along the first axis associated with the conductor layer; and forming intercellular potting within the plurality of cell spaces of the conductor layer to hold the first group

of the plurality of battery cells and second group of the plurality of battery cells.
29. The method of claim 28, wherein the conductor layer comprises a conductor array, the conductor array comprises the plurality of cell spaces aligned with openings in the insulative structure, comprising: exposing, by the opening, the one or more terminals of the plurality of battery cells.
30. The method of claim 29, wherein the conductor array includes a first portion and a second portion, comprising: contacting, by the first portion of the conductor array, a positive terminal of the first group of battery cells; and contacting, by the second portion of the conductor array, a negative terminal of the second group of battery cells.
31. The method of claim 28, wherein the plurality of cell spaces of the conductor layer are in a polygonal shape.
32. The method of claim 28, wherein the electrical component is coupled to a portion of the insulative structure and monitors a voltage of the plurality of battery cells.
33. The method of claim 28, wherein the intercellular potting includes a plurality of separator structures, comprising: holding, by the plurality of separator structures, the first group of the plurality of battery cells and the second group of the plurality of battery cells.
34. The method of claim 28, comprising: attenuating, by the insulative structure, a frequency of vibration to restrict movement of the battery system.
35. An electric vehicle, comprising: a battery system comprising: a conductor layer encapsulated by an insulative structure, wherein the conductor layer includes a plurality of cell spaces aligned along a first axis to expose one or more terminals of a plurality of battery cells within the insulative structure; an electrical component attached via a hole of the insulative structure, the electrical component to connect a first group of the plurality of battery cells and a second group of the plurality of battery cells along the first axis associated with the conductor layer; and intercellular potting within the plurality of cell spaces of the conductor layer to hold the first group of the plurality of battery cells and second group of the plurality of battery cells.
36. The electric vehicle of claim 35, wherein the conductor layer comprises a conductor array, the conductor array comprises the plurality of cell spaces aligned with openings in the insulative structure, the opening to expose the one or more terminals of the plurality of battery cells.
37. The electric vehicle of claim 36, wherein the conductor array includes a first portion and a second portion, a first portion of the conductor array to contact a positive terminal of the first group of battery cells, and a second portion of the conductor array to contact a negative terminal of the second group of battery cells.
38. The electric vehicle of claim 35, wherein the plurality of cell spaces of the conductor layer are in a polygonal shape.
39. The electric vehicle of claim 35, wherein the electrical component is coupled to a portion of the insulative structure and monitors a voltage of the plurality of battery cells.
40. The electric vehicle of claim 35, wherein the intercellular potting includes a plurality of separator structures to hold the first group of the plurality of battery cells and the second group of the plurality of battery cells.