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United States Patent Application Publication 20250260121
Kind Code A1
Publication Date August 14, 2025
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THERMAL RUNAWAY MITIGATION BATTERY MODULE

Abstract

Embodiments include a battery module having a first battery cell, a neighboring second battery cell, and insulating members positioned on opposing sides of the first battery cell. The battery module also includes a battery module enclosure surrounded by an external environment and configured to house each of the first battery cell, the neighboring second battery cell, and the insulating members and a module cover mounted to the battery module enclosure and including a vent feature configured to expel high-temperature gases from the first battery cell into the external environment, to thereby minimize transfer of the high-temperature gases from the first battery cell to the neighboring second battery cell and control propagation of a thermal runaway event in the battery module. The insulating members include tapered portions disposed between the first battery cell and the vent feature.

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Family ID: **96499332**

Appl. No.: **18/440318**

Filed: **February 13, 2024**

Publication Classification

Int. Cl.: **H01M50/358** (20210101); **B60L50/64** (20190101); **H01M10/658** (20140101); **H01M50/204** (20210101); **H01M50/271** (20210101); **H01M50/342** (20210101)

U.S. Cl.:

CPC **H01M50/358** (20210101); **B60L50/64** (20190201); **H01M10/658** (20150401); **H01M50/204** (20210101); **H01M50/271** (20210101); **H01M50/3425** (20210101); H01M2220/20 (20130101)

Background/Summary

[0001] The present disclosure relates to a battery module configured to remove heat and mitigate a thermal event.

[0002] A battery module or array may include a plurality of battery cells in relatively close proximity to one another. Batteries may be broadly classified into primary and secondary batteries. Primary batteries, also referred to as disposable batteries, are intended to be used until depleted, after which they are simply replaced with new batteries. Secondary batteries, more commonly referred to as rechargeable batteries, employ specific chemistries permitting such batteries to be repeatedly recharged and reused, therefore offering economic, environmental, and ease-of-use benefits compared to disposable batteries.

[0003] Rechargeable batteries may be used to power such diverse items as toys, consumer electronics, and motor vehicles. Particular chemistries of rechargeable batteries, such as lithium-ion cells, as well as external factors, may cause internal reaction rates generating significant amounts of thermal energy. Such chemical reactions may cause more heat to be generated by the batteries than is effectively withdrawn. Exposure of a battery cell to elevated temperatures over prolonged periods may cause the cell to experience a thermal runaway event. Accordingly, a thermal runaway event starting within an individual cell may lead to the heat spreading to adjacent cells in the module and affect the entire battery array.

SUMMARY

[0004] In one exemplary embodiment, a battery module is provided. The battery module includes a first battery cell, a neighboring second battery cell, and insulating members positioned on opposing sides of the first battery cell and a battery module enclosure surrounded by an external environment and configured to house each of the first battery cell, the neighboring second battery cell, and the insulating members. The battery module also includes a module cover mounted to the battery module enclosure and including a vent feature configured to expel high-temperature gases from the first battery cell into the external environment, to thereby minimize transfer of the high-temperature gases from the first battery cell to the neighboring second battery cell and control propagation of a thermal event in the battery module. The insulating members include tapered portions disposed between the first battery cell and the vent feature, the tapered portions being configured to direct the high-temperature gases from the first battery cell away from the neighboring second battery cell and towards the vent feature.

[0005] In addition to the one or more features described herein the vent feature includes exhaust openings configured to expel the high-temperature gases from the first battery cell.

[0006] In addition to the one or more features described herein the at least one of the exhaust openings has a reverse scoop shape configured to direct the high-temperature gases away from the neighboring second battery cell.

[0007] In addition to the one or more features described herein the vent feature includes liner segments configured to cover the exhaust openings and be blown off the exhaust openings by the high-temperature gases to thereby expel the high-temperature gases from the first battery cell to the external environment.

[0008] In addition to the one or more features described herein the liner segments are glued to the battery module cover.

[0009] In addition to the one or more features described herein the liner segments are constructed from mica.

[0010] In addition to the one or more features described herein the insulating members are constructed from mica.

[0011] In addition to the one or more features described herein further including a thermal barrier disposed adjacent to the insulating members.

[0012] In addition to the one or more features described herein the insulating members include a body portion that extends along a height of the first battery cell.

[0013] In addition to the one or more features described herein the at least part of the tapered portions of the insulating members overlap each other and are configured to deform and to contact the vent feature in response to the high-temperature gases being expelled from the first battery cell.

[0014] In one exemplary embodiment, a motor vehicle is provided. The motor vehicle includes a power-source configured to generate power-source torque and a battery module configured to supply electrical energy to the power-source. The battery module includes a first battery cell, a neighboring second battery cell, and insulating members positioned on opposing sides of the first battery cell and a battery module enclosure surrounded by an external environment and configured to house each of the first battery cell, the neighboring second battery cell, and the insulating members. The battery module also includes a module cover mounted to the battery module enclosure and including a vent feature configured to expel high-temperature gases from the first battery cell into the external environment, to thereby minimize transfer of the high-temperature gases from the first battery cell to the neighboring second battery cell and control propagation of a thermal event in the battery module. The insulating members include tapered portions disposed between the first battery cell and the vent feature, the tapered portions being configured to direct the high-temperature gases from the first battery cell away from the neighboring second battery cell and towards the vent feature.

[0015] In addition to the one or more features described herein the vent feature includes exhaust openings configured to expel the high-temperature gases from the first battery cell.

[0016] In addition to the one or more features described herein the at least one of the exhaust openings has a reverse scoop shape configured to direct the high-temperature gases away from the neighboring second battery cell.

[0017] In addition to the one or more features described herein the vent feature includes liner segments configured to cover the exhaust openings and be blown off the exhaust openings by the high-temperature gases to thereby expel the high-temperature gases from the first battery cell to the external environment.

[0018] In addition to the one or more features described herein the liner segments are glued to the battery module cover.

[0019] In addition to the one or more features described herein the liner segments are constructed from mica.

[0020] In addition to the one or more features described herein the insulating members are constructed from mica.

[0021] In addition to the one or more features described herein further including a thermal barrier disposed adjacent to the insulating members.

[0022] In addition to the one or more features described herein the insulating members include a body portion that extends along a height of the first battery cell.

[0023] In addition to the one or more features described herein the at least part of the tapered portions of the insulating members overlap each other and are configured to deform and to contact

the vent feature in response to the high-temperature gases being expelled from the first battery cell.
[0024] The above features and advantages, and other features and advantages of the disclosure are readily apparent from the following detailed description when taken in connection with the accompanying drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0025] Other features, advantages, and details appear, by way of example only, in the following detailed description, the detailed description referring to the drawings in which:
[0026] FIG. **1** is a schematic top view of an embodiment of a motor vehicle employing multiple power sources and a battery system having battery cells arranged in module(s) configured to generate and store electrical energy;
[0027] FIG. **2** is a schematic perspective view of the battery module shown in FIG. **1**, having a battery module enclosure and a battery module cover with exhaust openings, according to an embodiment of the disclosure;
[0028] FIG. **3** is a schematic perspective view of the battery module shown in FIG. **1**, having a battery module enclosure and a battery module cover with exhaust openings, wherein the battery module cover includes liner segments covering the exhaust openings, according to an embodiment of the disclosure;
[0029] FIG. **4** is a schematic cross-sectional plan view of the battery module shown in FIG. **2** taken at line **4-4**, having the battery module cover with channels engaging and nesting insulating members, according to an embodiment of the disclosure;
[0030] FIG. **5** is a schematic cross-sectional plan view of the battery module shown in FIG. **2**, having resilient sealing elements positioned between insulating members and the battery module cover, the resilient sealing elements having channels engaging and nesting insulating members, according to an embodiment of the disclosure;
[0031] FIG. **6** is a schematic close-up view of a particular section of the battery module shown in FIG. **5**, depicting a cross-section of the resilient sealing element, according to an embodiment of the disclosure; and
[0032] FIG. **7** is a schematic cross-sectional plan view of the battery module shown in FIG. **2**, having the battery module cover with channels engaging and nesting insulating members, according to an embodiment of the disclosure.
DETAILED DESCRIPTION
[0033] The following description is merely exemplary in nature and is not intended to limit the present disclosure, its application or uses. Various embodiments of the disclosure are described herein with reference to the related drawings. Alternative embodiments of the disclosure can be devised without departing from the scope of the claims. Various connections and positional relationships (e.g., over, below, adjacent, etc.) are set forth between elements in the following description and in the drawings.
[0034] These connections and/or positional relationships, unless specified otherwise, can be direct or indirect, and the present disclosure is not intended to be limiting in this respect. Accordingly, a coupling of entities can refer to either a direct or an indirect coupling, and a positional relationship between entities can be a direct or indirect positional relationship.
[0035] Referring to FIG. **1**, a motor vehicle **10** having a powertrain **12** is depicted. The vehicle **10** may include, but not be limited to, a commercial vehicle, industrial vehicle, passenger vehicle, aircraft, watercraft, train, or the like. It is also contemplated that the vehicle **10** may be a mobile platform, such as an airplane, all-terrain vehicle (ATV), boat, personal movement apparatus, robot, and the like to accomplish the purposes of this disclosure. The powertrain **12** includes a power-

source **14** configured to generate a power-source torque T for propulsion of the vehicle **10** via driven wheels **16** relative to a road surface **18**. The power-source **14** is depicted as an electric motor-generator.

[0036] As shown in FIG. **1**, the powertrain **12** may also include an additional power-source **20**, such as an internal combustion engine. The power-sources **14** and **20** may act in concert to power the vehicle **10**. The vehicle **10** additionally includes an electronic controller **22** and a battery system **24** configured to generate and store electrical energy through heat-producing electro-chemical reactions for supplying the electrical energy to the power-sources **14** and **20**. The electronic controller **22** may be a central processing unit (CPU) that regulates various functions of the vehicle **10**, or a powertrain control module (PCM) configured to control the powertrain **12** to generate a predetermined amount of power-source torque T. The battery system **24** may be connected to the power-sources **14** and **20**, the electronic controller **22**, as well as other vehicle systems via a high-voltage BUS **25**. Although the battery system **24** is described herein primarily with respect to a vehicle environment, nothing precludes the subject battery system from being employed to power other, non-automotive systems.

[0037] As shown in FIGS. **2-5**, the battery system **24** may include one or more sections, such as a battery array or module **26**. As shown in FIG. **2**, the battery module **26** includes a plurality of battery cells, such as a first battery cell **28-1** and a neighboring, directly adjacent, second battery cell **28-2**, each extending generally upward, (i.e., in the Z direction), as seen in FIGS. **2-5**. Although one module **26** and two battery cells **28-1**, **28-2** are shown, nothing precludes the battery system **24** from having a greater number of such modules and battery cells. The battery module **26** also includes a thermal barrier **30** arranged between the first battery cell **28-1** and the second battery cell **28-2**. The thermal barrier **30** may be constructed from a high-temperature polymer foam with a stiffening substructure. The thermal barrier **30** is specifically configured to limit the amount of thermal energy transfer between the neighboring battery cells **28-1**, **28-2** during battery module **26** operation.

[0038] As shown in FIG. **4**, the battery module **26** also includes insulating members **31**, which includes a first portion **31-1** and a second portion **31-2**. In exemplary embodiments, the insulating members **31** are at least partially disposed between the battery cells **28** and the barrier **30**. The insulating members **31** include a first portion **31-1**, also referred to herein as a body portion, and a second portion **31-2**, also referred to herein as a tapered portion. The first portion **31-1** of the insulating member **31** is disposed between battery cells **28-1**, **28-2** and thermal barrier **30** and extends along the height of the battery cells **28-1**, **28-2** in the Z direction. The second portion **31-2** of the insulating member **31** is disposed above the battery cells **28**. In exemplary embodiments, the second portion **31-2** has a tapered shape that is configured to direct gases generated during a thermal event towards an exhaust opening **46-1**. In exemplary embodiments, insulating member **31** may, for example, be constructed from mica for the subject material's resistance to elevated temperatures.

[0039] In exemplary embodiments, the second portions **31-2** of the insulating members **31** disposed adjacent to the battery cell **28-1** are configured to direct hot gasses expelled from the battery cell **28-1** away from the battery cell **28-2**. In one embodiment, at least a portion of the second portions **31-2** of the insulating members **31** disposed adjacent to the battery cell **28-1** are configured to deform when exposed to the hot gasses expelled from the battery cell **28-1**. For example, as shown in FIG. **5**, the second portions **31-2** of the insulating members **31** are configured to deform to contact exhaust opening **46-1** to thereby form a channel to direct the flow of the hot gasses expelled from the battery cell **28-1**.

[0040] As shown in FIGS. **2-5**, the battery module **26** also includes a heat sink **32**. The heat sink **32** is generally positioned below and in direct contact with each of the battery cells **28** to absorb thermal energy from the first and second battery cells. As shown, the heat sink **32** may be in direct physical contact with the first and second battery cells **28-1**, **28-2**. The heat sink **32** may be configured as a coolant plate having a plurality of coolant channels, shown as respective first and second coolant channels **34-1** and **34-2** in FIG. **4**. The coolant channels **34-1**, **34-2** are configured to circulate a coolant **36** (shown in FIG. **2**) and thereby remove thermal energy from battery cells **28** while the battery module **26** generates/stores electrical energy. As shown in FIG. **4**, the first coolant channel **34-1** may be arranged proximate to the first battery cell **28-1** and the second coolant channel **34-2** may be arranged proximate to the second battery cell **28-2**.

[0041] Generally, during normal operation of the module **26**, the thermal barrier **30** is effective in absorbing thermal energy released by the first and second cells **28-1**, **28-2** and facilitating the transfer of the thermal energy to the heat sink **32**. However, during extreme conditions, such as during a thermal event (identified via numeral **44** in FIG. **4**), the amount of thermal energy released by the cell undergoing the event will typically saturate the thermal barrier **30** and exceed its capacity to absorb and efficiently transfer heat to the heat sink **32**. As a result, excess thermal energy will typically be transferred between the neighboring cells **28-1**, **28-2**, leading to propagation of a thermal runaway through the battery module **26**. The term "thermal runaway event" generally refers to an uncontrolled increase in temperature in a battery system. During a thermal runaway event, the generation of heat within a battery system or a battery cell exceeds the dissipation of heat, thus leading to a further increase in temperature. A thermal runaway event may be triggered by various conditions, including a short circuit within the cell, improper cell use, physical abuse, manufacturing defects, or exposure of the cell to extreme external temperatures.

[0042] As shown in FIGS. **2-5**, the battery module **26** also includes a battery module enclosure **38** surrounded by an environment external to the battery module enclosure or ambient environment **40**. The battery module enclosure **38** is configured to house each of the first battery cell **28-1**, the second battery cell **28-2**, the thermal barrier **30**, and the heat sink **32**. As shown in FIG. **2**, the battery module enclosure **38** includes lateral walls, **38-1**, **38-2**, **38-3**, **38-4**, as well as a floor **38-5** mounting or incorporating the heat sink **32**. The battery module **26** also includes a battery module cover **42** generally positioned above the battery cells **28** and attached to the lateral walls **38-1**, **38-2**, **38-3**, **38-4** of the battery module enclosure **38**. For example, in the event the first battery cell **28-1** experiences thermal runaway, the excess gases generated by such an event would give rise to highly elevated internal pressures having a tendency to distort the battery module cover **42** and permit the gases to pass over or leak around the thermal barrier **30** to the neighboring second battery cell **28-2**. Such leakage of high-temperature gases would increase the likelihood of the thermal runaway in the battery module **26** from the first battery cell **28-1** to the second battery cell **28-2**, thereby generating a chain reaction and affecting the entire battery module.

[0043] As shown, the battery module cover **42** is arranged in an X-Y plane, substantially parallel to the heat sink **32**, and generally perpendicular to the first and second battery cells **28-1**, **28-2**. The battery module cover **42** is mounted to the battery module enclosure **38** and includes vent features **46** configured to expel high-temperature gases from one of the first and second battery cell **28-1**, **28-2**. The vent features **46** are additionally configured to divert, (i.e., deflect or reroute), the high-temperature gases away from the second battery cell **28-2** directly to the ambient environment **40**. The battery module cover **42** is thereby configured to minimize the transfer of the high-temperature gases from one of the first and second battery cell **28-1**, **28-2**, to the other of the two cells and control propagation of a thermal runaway event **44** in the battery module **26**. Although either the first battery cell **28-1** or the second battery cell **28-2** may generate high-temperature gases due to the thermal event **44**, the present disclosure will specifically focus on an exemplary case when the first battery cell generates the subject gases.

[0044] In one embodiment, as shown in FIG. **2**, the vent feature **46** may include an array of exhaust openings, depicted as a first set of exhaust openings **46-1** corresponding to the first battery cell **28-1** and a second set of exhaust openings **46-2** corresponding to the second battery cell **28-2**. The battery module cover **42** may be formed, such as stamped, from mild steel with the exhaust openings **46-1**, **46-2** formed into the battery module cover. The exhaust openings **46-1**, **46-2** are arranged relative to the first and second battery cells **28-1**, **28-2** such that the exhaust openings expel rising high-temperature gases from the uppermost/highest level within the battery module enclosure **38**. Particularly, the exhaust openings **46-1** are configured to operate in the manner of a chimney to expel the high-temperature gases **48** from the first battery cell **28-1** undergoing the thermal runaway event **44** and divert the high-temperature gases away from the second battery cell **28-2** by providing a direct path to the ambient environment **40**.

[0045] In one embodiment, as shown in FIG. **2**, the exhaust openings **46-1**, **46-2** may have a reverse scoop shape **49** configured to direct the high-temperature gases **48** generated by the first battery cell **28-1** away from the second battery cell **28-2**. The reverse scoop shape **49** may be specifically configured to direct the high-temperature gases **48** at an angle greater than 90 and smaller than 180 degrees relative to the cover X-Y plane. The array of vent openings, such as having the first and second exhaust openings **46-1**, **46-2**, with the subject reverse scoop shape **49** may be generally defined as having a directional "cheese grater" profile relative to the environment **40**. The reverse scoop shape **49** of the exhaust openings may be formed, e.g., stamped, directly into the structure of the battery module cover **42**.

[0046] In one embodiment, as shown in FIG. **3**, the battery module **26** includes a liner layer **50** affixed to the battery module cover **42**. The liner layer **50** includes a plurality of blow-off segments **51** configured to cover respective exhaust openings, (e.g., the first exhaust opening **46-1** and the second exhaust opening **46-2**). The blow-off segments **51** are specifically configured to be either partially or entirely blown off the exhaust opening **46-1** via the pressure from the high-temperature gases **48**. For example, the blow-off segments **51** may have perforated edges to facilitate their separation from the liner layer **50**. Such uncovering of the exhaust opening **46-1** by the high-temperature gases **48** will permit the battery module cover **42** to expel the high-temperature gases **48** from the battery cell **28-1** to the ambient environment **40**. The liner layer **50** may, for example, be constructed from mica for the subject material's resistance to elevated temperatures and be glued to the battery module cover **42** over the vent features **46**. The glue employed to attach the liner segments **50** may be specifically selected to maintain attachment of the liner segments to the battery module cover **42** under normal module operating conditions and give way under high gas pressure during a thermal runaway.

[0047] As shown in FIGS. **5** and **6**, the vent feature **46** may additionally include resilient elements **52**. Each resilient element **52** may be positioned between the respective thermal barrier **30** and the battery module cover **42**. The resilient elements **52** may be constructed from a heat-resistant flexible material, such as silicon. The resilient elements **52** are specifically configured to maintain contact with a portion of the insulating member **31** under pressure from the high-temperature gases generated by the battery cells **28-1**, **28-2**. In exemplary embodiments, the resilient elements **52** are configured to control the movement or deformation of the insulating member **31** due to the pressure from the high-temperature gases generated by the battery cells **28-1**, **28-2**. The resilient sealing elements **52** thereby facilitate the expelling of, for example, the high-temperature gases **48** from the first battery cell **28-1** to the ambient environment **40** through the exhaust openings **46-1**.

[0048] FIG. **6** is a close-up view of section **6** shown in FIG. **5**. As illustrated in FIG. **6**, each resilient element **52** may include, (i.e., define), a channel **54** configured to engage and nest the thermal barrier **30**. Such construction of the interface between the resilient element **52** and the thermal barrier **30** is intended to minimize deformation of the subject insulating member(s) **31** under pressure, such as from high-temperature gases **48**. Each resilient element **52** may further include lateral sections **56-1** and **56-2** arranged distally from the channel **54**. The lateral sections **56-1** and **56-2** are configured to maintain contact with the battery module cover under pressure from the high-temperature gases, such as the gases **48**, to thereby minimize transfer or leakage of the subject gases between the first and second battery cells **28-1**, **28-2**. Alternatively, as shown in FIG. **4**, the channel(s) **54** may be incorporated directly into the battery module cover **42** to engage and nest the thermal barrier(s) **30** to maintain separation between the respective battery cells, e.g., the first and second battery cells **28-1**, **28-2**, and minimize deformation of the respective insulating member(s) **31** under increased pressures.

[0049] Overall, during operation of the battery module **26**, the vent feature **46** is configured to automatically transfer directly to the ambient environment excess thermal energy generated by a thermal runaway event in a particular battery cell of the battery module. Such transfer of the excess thermal energy out of the battery module **26** is intended to control propagation of thermal runaway to other, neighboring cells in the battery module. Specifically, the battery module **26** includes insulting members **31** that are configured to direct the flow of high-temperature gasses **48** generated by a battery cell during a thermal runaway event **44**. In addition, the vent feature **46** may include exhaust openings. (e.g., **46-1**, **46-2**), and supporting structures to minimize the transfer of high-temperature gases from the battery cell undergoing the thermal runaway to a neighboring battery cell, thereby facilitating the transfer of such gases to the ambient environment **40**. Thus, the insulting members **31** and the vent features **46** are particularly effective in mitigating the propagation of a thermal runaway between individual battery cells within the battery module **26**, without requiring additional external hardware or controls.

[0050] In one embodiment, as shown in FIG. **7**, the second portion **31-2** of the insulating members **31** disposed on the opposite sides of the battery cells **28** are configured to at least partially overlap one another. In one embodiment, the second portion **31-2** of the insulating members **31** disposed on the opposite sides of the battery cells **28** may be in contact with one another. In another embodiment, an air gap may be present between the overlapping sections of the second portion **31-2** of the insulating members **31** disposed on the opposite sides of the battery cells **28**. In exemplary embodiments, at least a portion of the second portions **31-2** of the insulating members **31** disposed adjacent to the battery cell **28-1** are configured to deform when exposed to the hot gasses expelled from the battery cell **28-1**. For example, as shown in FIG. **5**, the second portions **31-2** of the insulating members **31** are configured to deform to contact exhaust opening **46-1** to thereby form a channel to direct the flow of the hot gasses expelled from the battery cell **28-1**.

[0051] The terms “a” and “an” do not denote a limitation of quantity, but rather denote the presence of at least one of the referenced item. The term “or” means “and/or” unless clearly indicated otherwise by context. Reference throughout the specification to “an aspect”, means that a particular element (e.g., feature, structure, step, or characteristic) described in connection with the aspect is included in at least one aspect described herein, and may or may not be present in other aspects. In addition, it is to be understood that the described elements may be combined in any suitable manner in the various aspects.

[0052] When an element such as a layer, film, region, or substrate is referred to as being “on” another element, it can be directly on the other element or intervening elements may also be present. In contrast, when an element is referred to as being “directly on” another element, there are no intervening elements present.

[0053] Unless specified to the contrary herein, all test standards are the most recent standard in effect as of the filing date of this application, or, if priority is claimed, the filing date of the earliest priority application in which the test standard appears.

[0054] Unless defined otherwise, technical and scientific terms used herein have the same meaning as is commonly understood by one of skill in the art to which this disclosure belongs.

[0055] While the above disclosure has been described with reference to exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from its scope. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the disclosure without departing from the essential scope thereof. Therefore, it is intended that the present disclosure not be limited to the particular embodiments disclosed, but will include all embodiments falling within the scope thereof.

Claims

1. A battery module comprising: a first battery cell, a neighboring second battery cell, and insulating members positioned on opposing sides of the first battery cell; a battery module enclosure surrounded by an external environment and configured to house each of the first battery cell, the neighboring second battery cell, and the insulating members; and a module cover mounted to the battery module enclosure and including a vent feature configured to expel high-temperature gases from the first battery cell into the external environment, to thereby minimize transfer of the high-temperature gases from the first battery cell to the neighboring second battery cell and control propagation of a thermal event in the battery module, wherein the insulating members include tapered portions disposed between the first battery cell and the vent feature, the tapered portions being configured to direct the high-temperature gases from the first battery cell away from the neighboring second battery cell and towards the vent feature.
2. The battery module of claim 1, wherein the vent feature includes exhaust openings configured to expel the high-temperature gases from the first battery cell.
3. The battery module of claim 2, wherein at least one of the exhaust openings has a reverse scoop shape configured to direct the high-temperature gases away from the neighboring second battery cell.
4. The battery module of claim 2, wherein the vent feature includes liner segments configured to cover the exhaust openings and be blown off the exhaust openings by the high-temperature gases to thereby expel the high-temperature gases from the first battery cell to the external environment.
5. The battery module of claim 4, wherein the liner segments are glued to the battery module cover.
6. The battery module of claim 4, wherein the liner segments are constructed from mica.
7. The battery module of claim 1, wherein the insulating members are constructed from mica.
8. The battery module of claim 1, further comprising a thermal barrier disposed adjacent to the insulating members.
9. The battery module of claim 1, wherein the insulating members include a body portion that extends along a height of the first battery cell.
10. The battery module of claim 1, wherein at least part of the tapered portions of the insulating members overlap each other and are configured to deform and to contact the vent feature in response to the high-temperature gases being expelled from the first battery cell.
11. A motor vehicle comprising: a power-source configured to generate power-source torque; and a battery module configured to supply electrical energy to the power-source, the battery module including: a first battery cell, a neighboring second battery cell, and insulating members positioned on opposing sides of the first battery cell; a battery module enclosure surrounded by an external environment and configured to house each of the first battery cell, the neighboring second battery cell, and the insulating members; and a module cover mounted to the battery module enclosure and including a vent feature configured to expel high-temperature gases from the first battery cell into the external environment, to thereby minimize transfer of the high-temperature gases from the first battery cell to the neighboring second battery cell and control propagation of a thermal event in the battery module, wherein the insulating members include tapered portions disposed between the first battery cell and the vent feature, the tapered portions being configured to direct the high-temperature gases from the first battery cell away from the neighboring second battery cell and towards the vent feature.
12. The motor vehicle of claim 11, wherein the vent feature includes exhaust openings configured to expel the high-temperature gases from the first battery cell.
13. The motor vehicle of claim 12, wherein at least one of the exhaust openings has a reverse scoop shape configured to direct the high-temperature gases away from the neighboring second battery cell.

14. The motor vehicle of claim 12, wherein the vent feature includes liner segments configured to cover the exhaust openings and be blown off the exhaust openings by the high-temperature gases to thereby expel the high-temperature gases from the first battery cell to the external environment.
15. The motor vehicle of claim 14, wherein the liner segments are glued to the battery module cover.
16. The motor vehicle of claim 14, wherein the liner segments are constructed from mica.
17. The motor vehicle of claim 11, wherein the insulating members are constructed from mica.
18. The motor vehicle of claim 11, further comprising a thermal barrier disposed adjacent to the insulating members.
19. The motor vehicle of claim 11, wherein the insulating members include a body portion that extends along a height of the first battery cell.
20. The motor vehicle of claim 11, wherein at least part of the tapered portions of the insulating members overlap each other and are configured to deform and to contact the vent feature in response to the high-temperature gases being expelled from the first battery cell.