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BATTERY DISCHARGE SYSTEM FOR END-OF-LIFE PROTECTION

Abstract

A system and method for discharging the battery cells of a battery pack for rendering the battery pack safe for shipping and disposal and preventing further use of the battery pack after reaching an end of life state. A discharge switching device is included in the battery pack and is configured to permanently transition from a first state to a second state. When the discharge switching device transitions to the second state, the stored voltage in the battery cells discharges through a voltage drain circuit that includes a power consuming load and a drain circuit. The transition of the discharge switching device to the second state prevents further charging of the battery cells in the battery pack. The transition of the discharge switching device can be controlled by a manual activation device and/or a battery management system of the battery pack.

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Background/Summary

BACKGROUND

[0001] The present disclosure generally relates to a battery discharge system for removing the charge on a battery pack for safe shipping and disposal. More specifically, the present disclosure relates to a battery discharge system that discharges a stored charge on the battery cells of a battery pack and prevents further charging of the battery cells so that the battery pack can no longer be used and can be safely shipped and disposed.

[0002] The increased use of battery powered devices across many fields of use, including in a hospital or healthcare environment, has resulted in an ever-increasing number of battery packs that must be disposed of after the useful life of the battery pack has ended. In some cases, battery packs that reach their end of life are shipped back to the battery or device manufacturer so that the battery or device manufacturer can study and analyze data that is stored on the battery management system (BMS) for the battery pack.

[0003] In other cases, when a battery pack becomes faulty or unstable, the defective battery pack is returned to either the device manufacturer or the battery pack manufacturer for study and investigation. Although field-based representatives for the device manufacturer may be able to pick up the faulty or expired battery packs and return the battery packs to a facility for analysis, it would be much more convenient for the battery packs to be shipped using commercial shipping companies.

[0004] Many commercial shipping companies will not accept battery packs for shipment, especially lithium-ion battery packs, based on the potential fire hazard these batteries present when there is a stored charge in the battery cells of the battery pack. Since commercial shipping companies will not accept the battery packs for shipment, the inventors of the present disclosure identified a need for a system to fully discharge the battery pack prior to shipment and possible disposal. Further, the inventors have identified a need for a battery pack that includes a system to not only discharge the battery pack but also prevent any further charging and present a visual indication of such action such that the battery pack will be accepted for shipment.

SUMMARY

[0005] This Summary is provided to introduce a selection of concepts that are further described below in the Detailed Description. This Summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used as an aid in limiting the scope of the claimed subject matter.

[0006] In one embodiment, a system is provided that is able to discharge the battery cells of a battery pack to make the battery pack safe for shipping and disposal while also preventing further charging and discharging of the battery pack. The system in accordance with an exemplary embodiment of the present disclosure includes an activation device that is used to trigger the discharge of the battery cells in the battery pack prior to shipment and to render the battery pack incapable of retaining a charge. In an exemplary embodiment of the present disclosure, the activation device can include a manually operated engagement device and the battery management system of the battery pack. In other embodiments, the manually operated engagement device can be eliminated and the battery management system would trigger the discharge of the battery cells.

[0007] The system further includes a discharge switching device that is operable to permanently transition from a first state to a second state. The transition from the first state to the second state is controlled and triggered by the activation device. In an exemplary embodiment, the discharge

switching device is a chemical fuse that permanently transitions from a first state (closed) to a second state (open).
[0008] A voltage drain circuit is connected to the positive end of the battery cells and provides a discharge path for the stored voltage on the battery cells when the voltage drain circuit is in an operational state. In an exemplary embodiment, the voltage drain circuit include both a power consuming load and drain switching device, such as a MOSFET. When the drain switching device is closed, the battery cells are able to discharge through the power consuming load. When the drain switching device is open, the power consuming load is connected to an open circuit and the stored voltage on the battery cells cannot discharge through the power consuming load.
[0009] When the discharge switching device transitions to the second state, the discharge switching device allows the voltage drain circuit to provide a discharge path for the voltage on the battery cells. In this state, the voltage on the battery cells is nearly completely discharged so that the battery pack can be safely shipped and/or disposed. Further, when the discharge switching device is in the second state, the discharge path from the battery cells remains and the battery cells can no longer be charged. Thus, in an end of life state of the battery pack, the internal components of the battery pack, including the discharge switching device, prevents any further use of the battery pack.
[0010] Various other features, objects, and advantages of the invention will be made apparent from the following description taken together with the drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0011] The present disclosure is described with reference to the following Figures.
[0012] FIG. **1** is a circuit schematic diagram showing the system of the present disclosure to discharge the cells of a battery pack and disable charging;
[0013] FIG. **2** is a simplified circuit schematic showing the switching device in a first, closed state;
[0014] FIG. **3** is a simplified circuit schematic showing the switching device in a second, open state; and
[0015] FIG. **4** is a flow chart showing one exemplary method for operating the system of the present disclosure to render a battery pack ready for shipping.
DETAILED DESCRIPTION
[0016] The present inventors have recognized several problems with currently available battery management circuits for lithium-ion battery packs that are unable to fully ensure that the battery packs are protected from end user abuse. If a battery pack is used longer than the expected life of the battery, the battery pack may become unstable and could possibly cause damage. In addition, at the end of life of the battery pack, the present inventors have recognized a problem in not being able to fully discharge the battery cells so that the battery pack can be safely shipped. The present disclosure was developed by the inventors to completely disable the further use of the battery pack and to discharge the battery cells to a level that allows for safe shipping.
[0017] FIG. **1** illustrates a battery pack **10** constructed in accordance with the present disclosure. The battery pack **10** is designed as a self-contained unit that includes an enclosed housing and can be used to power a wide variety of equipment, such as but not limited to medical equipment. The battery pack **10** shown in FIG. **1** includes a pair of external contact terminals **12**, **14** that provide electrical connections for operating battery-powered equipment in a standard fashion. Although only two contact terminals **12**, **14** are shown in the embodiment of FIG. **1**, it should be understood that the battery pack **10** could include additional terminals depending upon the configuration of the battery pack **10** and the potential uses of the battery pack **10**.
[0018] In the embodiment shown, the battery pack **10** includes a battery cell block **16** that is connected between the positive contact terminal **12** and the negative contact terminal **14**. In the

embodiment shown, the battery cell block **16** includes a combination of individual battery cells **18** that are connected to each other to provide the available current and voltage for the battery pack **10**. In the embodiment shown, the battery cell block **16** includes three individual battery cells **18** that are connected in a parallel relationship. Although the individual battery cells **18** are shown in FIG. **1** as connected in parallel and including three separate cells **18**, it should be understood that the number of individual battery cells **18** and the connections between the battery cells **18** can vary depending upon the individual battery pack **10**. As an example, the battery cell block **16** could be a single battery cell **18** or could include multiple battery cells **18**. In an embodiment with multiple battery cells **18**, the battery cells **18** can be connected in series and/or parallel depending on the voltage and current requirements for the resulting battery pack **10**.

[0019] As is well known in battery pack management, the battery pack **10** includes a battery management system (BMS) **20** that is included in the outer housing for the battery pack **10** and operates to control the charging and discharging of the battery cell block **16**. In addition to controlling the charging and discharging of the battery cell block **16**, the BMS **20** also monitors the operation of the entire battery pack **10** and provides a point of communication between the equipment being operated and the battery pack **10**. The BMS **20** is a conventional integrated circuit that is readily available from a wide variety of different manufacturers, such as but not limited to Texas Instruments and Micron. The BMS **20** includes an integrated circuit that monitors the charging, discharging and operational parameters associated with the operation of the entire battery pack **10**.

[0020] In the embodiment shown, the battery cell block **16** includes a series of lithium-ion battery cells **18** that can be repeatedly charged and discharged to provide for a standard lifecycle for the entire battery pack **10**. The BMS **20** monitors the charging and discharging life of the battery cell block **16** and will disable further use of the battery pack when the battery pack reaches defined end of life parameters, which can be number of charging cycles, time in use or other specific parameters.

[0021] According to standard UL and IEC safety requirements, the BMS **20** operates to disable future charging or discharging cycles when the battery pack reaches an end-of-life (EOL) condition. Although the BMS **20** includes electronics that are designed to prevent future charging and discharging cycles of the battery cell block **16**, the BMS **20** is unable to ensure that the battery pack is protected from end user abuse, such as overriding the controls of the BMS **20** to continue to use the battery pack after the end of life as dictated by the battery manufacturer. In addition to preventing the charging and discharging of the battery cell block **16** due to end-of-life parameters, the BMS **20** can also prevent continued use of the battery pack **10** upon failure parameters and extreme fault conditions. Once again, although the BMS **20** includes programing and operating instructions to prevent use after reaching the end of life triggers, there is a possibility of end user abuse and thus overriding the operation of the BMS **20** during these fault conditions.

[0022] Therefore, the inventors of the present disclosure have identified a need to completely disable the use of the battery pack while also discharging any stored charge on the battery cell block **16** so that the battery pack **10** can be transported and shipped back to a manufacturer to recycle or investigate the cause of a defect that resulted in the BMS **20** preventing further use of the battery pack **10**.

[0023] In the embodiment shown in FIG. **1**, a discharge switching device **22** is added to the internal circuitry for the battery pack **10**. The discharge switching device **22** is shown in the embodiment of FIG. **1** as being controlled by an activation device **24**. The activation device **24** shown in the embodiment of FIG. **1** includes both the BMS **20** and a manually operated engagement device **26**. The manually operated engagement device **26** could be any type of device that can be engaged and operated by a user, such as but not limited to a push button, manually operated switch or other component. When a user operates the engagement device **26**, the engagement device **26** sends a signal or other type of indication to the BMS **20** such that the BMS **20** can trigger the operation of the discharge switching device **22**. In other embodiments, the engagement device **26** can be connected directly to the discharge switching device **22** without the need for the BMS **20** to generate an activation signal to control the operation of the discharge switching device **22**. In another alternate embodiment, the engagement device **26** can be eliminated and the triggering signal to the BMS **20** can be generated in other ways, such as by a wired or wireless signal delivered to the BMS **20**, such as through the connection between the equipment being powered by the battery pack **10** or an external communication device that communicates with the BMS **20**. In any case, the BMS **20** or the engagement device **26** deliver a triggering signal to the discharge switching device **22** to cause the discharge switching device **22** to change states.

[0024] In one exemplary embodiment of the present disclosure, the discharge switching device **22** is a chemical fuse that operates to permanently transition from a first state to a second state. The chemical fuse that can be utilized as the discharge switching device makes a permanent transition from the first state to the second state such that the state of the discharge switching device cannot be reversed. Although a chemical fuse is contemplated as being an exemplary embodiment of the discharge switching device **22**, it should be understood that different types of switching devices that permanently transition from a first state to a second state could be utilized while operating within the scope of the present disclosure. The permanent transition of the discharge switching device **22** from a first state to a second state prevents end user abuse since the discharge switching device cannot be overridden after the permanent transition from the first state to the second state.

[0025] As further shown in FIG. **1**, a control resistor **28** is shown positioned between the positive end **42** of the battery cell block **16** and the discharge switching device **22**. The resistance value of the control resistor **28** is selected to create the required voltage across the control resistor **28** as will be discussed in further detail below.

[0026] The internal circuitry of the battery pack **10** further includes a voltage drain circuit **30** that includes one of its terminals connected to a junction point between the control resistor **28** and the discharge switching device **22**. The voltage drain circuit **30** in the exemplary embodiment illustrated is a MOSFET that has the gate terminal **32** connected to one end of the control resistor **28** and the drain terminal **34** connected to a ground potential. The source terminal **36** of the MOSFET is connected to the positive terminal of the battery cell block **16** through a drain resistor **38**. Although a drain resistor **38** is shown in the embodiment, it should be understood that other different types of power consuming loads could be used in place of the drain resistor **38** while operating within the scope of the present disclosure.

[0027] In the exemplary embodiment illustrated, a visual indicator **40** is also located between the drain resistor **38** and the source terminal **36** of the MOSFET voltage drain circuit **30**. The indicator **40** is selected to be some type of phase change material that changes the state upon the application of current or voltage. The indicator **40** is located within the batter pack **10** such that the indicator is visible through the housing of the battery pack **10**. The indicator **40** is included in the battery pack to indicate to an end user that the discharge switching device **22** has been activated and the stored charge contained on the battery cell block **16** has been discharged, thereby indicating that the battery pack **10** is safe for shipment. The indicator **40** can be eliminated in other embodiments of the present disclosure, but it is desired to include some type of indication that the battery cell block **16** has been discharged to a safe level that allows for shipment of the battery pack **10**.

[0028] FIG. **2** is a simplified version of the circuitry shown in FIG. **1** and illustrates the operation of the internal circuitry within the battery pack **10** in a condition in which the discharge switching device **22** is in a first state. In the embodiment shown in FIG. **2**, the discharge switching device **22** is shown as a closed switch **44**. In an embodiment in which the discharge switching device **22** is a chemical fuse, the closed switch provides a direct path for current to flow through the discharge switching device. In this first state, the positive side **42** of the battery cell block **16** is connected to the control resistor **28**. In this configuration, the gate terminal **32** of the MOSFET voltage drain circuit **30** is directly connected to the drain terminal **34** through the discharge switching device **22** such that no voltage differential is established between the gate terminal **32** and the drain terminal **34**. In this condition, the voltage drain circuit **30** functions as an open switch and the battery cell block **16** will not be able to discharge through the drain resistor **38**. Thus, during normal operating conditions, the discharge switching device **22** is in the first state in which the switch element **44** is closed. Thus, during normal operating conditions, the additional circuitry added to the battery pack **10** allows the battery pack to operate in a normal manner and allows the battery management system **20** shown in FIG. **1** to control the discharge and charging of the battery cell block **16**.

[0029] When an end user or the BMS **20** identifies a desire or operating parameter that indicates the need to move the battery pack **10** to an end of life state, the end user can either activate the engagement device **26** or the BMS **20** will automatically initiate the end-of-life transition. During the end-of-life transition, the activation device **24** sends an activation signal to the discharge switching device **22** which causes the discharge switching device **22** to permanently transition from the first state (closed) to the second state (open) shown in FIG. **3**. In the second state shown, the switch element **44** moves or transitions to an open position. In the example in which the discharge switching device **22** is a chemical fuse, the chemical fuse opens and creates an open circuit as illustrated in FIG. **3**.

[0030] When the discharge switching device **22** transitions to the second state and presents an open circuit, the positive side **42** of the battery cell block **16** is provided with a current flow path through the control resistor **28**. The control resistor **28** is selected such that a gate voltage is created at the gate terminal **32** of the voltage drain circuit **30**. The size of the control resistor **28** is selected such that the developed voltage at the gate terminal **32** is sufficient such that the voltage drain circuit **30** (which is a MOSFET in the embodiment illustrated) acts as a closed circuit path that allows current to flow from the source terminal **36** to the drain terminal **34**. When the voltage drain circuit **30** is in this closed state, current flows through the drain resistor **38** and through the voltage drain circuit **30** to the ground potential. The drain resistor **38** is selected such that the drain resistor **38** consumes power from the battery cell block **16**. As discussed above, although one or more drain resistors **38** are shown in the exemplary embodiment, it is contemplated that other types of power consuming loads could be used in place of the drain resistor **38** shown in the Figures. In this way, the drain resistor **38** will continue to discharge the battery cell block **16** until the voltage at the positive side **42** is no longer sufficient to provide enough current through the control resistor **28** to keep the voltage drain circuit **30** active. In an embodiment in which the voltage drain circuit **30** is a MOSFET, the voltage at the gate terminal **32** must be above a specified level to keep the MOSFET operating as a closed circuit. The level of voltage on the battery cell block **16** when the control resistor **28** is no longer able to provide a large enough voltage at the gate terminal **32** is a level low enough to allow the entire battery pack **10** to be shipped. As an example, the battery cell block **16** will be discharged to a voltage level in the range of 0.7 to 2.0 volts (depending on the setting with the optional control resistor **45** to keep the cells over the MOSFET dropout voltage) before the voltage at the gate terminal **32** is too low to prevent any further discharge of the battery cell. This voltage is sufficiently low to allow the entire battery pack **10** to be shipped.

[0031] During the discharge of the battery cell block **16** through the drain resistor **38**, the indicator **40** will also be activated. As indicated previously, the indicator **40** is a state changing device that changes color or appearance when a voltage is applied to the indicator **40**. It is contemplated that the indicator **40** will change appearance and will not change the appearance back even when the battery cell block **16** is completely discharged. The indicator **40** thus provides a visual indication that the entire battery pack **10** has been discharged and is safe to be shipped and that the voltage on the battery cell block **16** is sufficiently low to be of any concern.

[0032] As indicated above, when the discharge switching device **22** is moved to the second state shown in FIG. **3**, the positive side **42** of the battery cell block **16** is connected to ground potential through the drain resistor **38** and the voltage drain circuit **30**. After the transition of the discharge switching device **22** to the second state, if the BMS **20** or any other circuitry is connected to attempt to re-charge the battery cell block **16**, any charge being applied to the battery **16** will immediately discharge through the voltage drain circuit **30** and the drain resistor **38**. In this manner, the permanent transition of the voltage drain circuit **30** will prevent the battery cell block **16** from ever holding a charge above the charge needed to turn on the voltage drain circuit **30** through the voltage applied at the gate terminal **32**.

[0033] Although the voltage drain circuit **30** shown in the preferred embodiment is described and discussed as being a MOSFET, it should be understood that other types of discharge circuits **30** could be utilized while operating within the scope of the present disclosure. The voltage drain circuit **30** is triggered by the transition of the discharge switching device **22** from the first state to the second state. Any type of device could be used as the voltage drain circuit **30** as long as the discharge circuit is triggered by the movement of the discharge switching device from the first state to the second state. Likewise, the discharge switching device **22** could be other types of switching elements as long as the discharge switching device transitions from the first state to the second state and cannot return back to the first state once the initial transition has taken place. In this manner, the discharge switching device **22** permanently transitions from the first state to the second state and cannot transition back from the second state to the first state.

[0034] FIG. **4** is a flow chart showing and describing one exemplary method for operating the system of the present disclosure with the understanding that other embodiments are contemplated as being within the scope of the present disclosure. The reference numbers in the description refer to the components of FIGS. **1-3** previously described.

[0035] As shown in step **60**, a voltage drain circuit **30** is included in the battery pack of the present disclosure. The voltage drain circuit **30** is connected to the positive terminal of the cell block **16** that includes the single or plurality of battery cells **18**. The voltage drain circuit **30** is designed to selectively discharge the battery cells of the cell block so that the battery pack can be more safely shipped upon reaching an end-of-life condition or upon a fault condition.

[0036] Upon reaching an end-of-life or fault condition, an activation device of the battery pack is manually activated or automatically activates as shown in step **62**. As described above, the activation device could be a manually operated device **26** or could be the battery monitoring system **20**. The activation device is operated to trigger the discharge of the voltage and current stored in the battery cells **18** so that the battery pack can be safely shipped.

[0037] Once the activation device is triggered in step **62**, the activation device causes a discharge switching device **22** to transition from a first steady state to a second state as shown by step **64**. In an exemplary embodiment, the transition from the first state to the second state in step **64** is a permanent transition that cannot be reversed. Thus, once the discharge switching device **22** transitions to the second state, the discharge switching device **22** cannot return to the first state. In one contemplated embodiment, the discharge switching device is a chemical fuse that physically transitions to the second state. In the second state, the chemical fuse presents an open circuit although other types of switching devices are contemplated.

[0038] Upon transition of the discharge switching device to the second state, the voltage drain circuit **30** is switched into a discharge state, as shown in step **66**. In the discharge state, the voltage drain circuit **30** connects the positive terminal of the battery cell block, and thus the battery cells in the battery cell block, to a discharge path. The discharge path can include a connection to a ground potential such that the stored voltage and current on the battery cells can be discharged to the ground potential. As described above, in one exemplary embodiment, the voltage drain circuit can include a switching device, such as a MOSFET, that can transition from an open state to a closed state.

[0039] In one contemplated embodiment, the voltage drain circuit can further include a drain resistor **38** positioned between the battery cell block and the switching device of the voltage drain circuit such that the voltage and current from the battery cells in the battery cell block are discharged through the drain resistor of the voltage drain circuit as shown by step **68**. In an embodiment in which the voltage drain circuit includes a MOSFET, the voltage drain circuit is able to discharge the battery cells to the voltage level required to keep the MOSFET in the closed state. This voltage level is very small and upon complete discharge, the battery pack will be safe for shipment.

[0040] As shown in step **70**, in one contemplated embodiment, a visual indicator can be activated to indicate that the battery cells of the battery pack have been discharged and that the battery pack is safe for shipment. The indicator **40** is a state changing device that changes color or appearance when a voltage is applied to the indicator **40**. It is contemplated that the indicator **40** will change appearance and will not change the appearance back even when the battery cell block **16** is completely discharged. The indicator **40** thus provides a visual indication that the entire battery pack **10** has been discharged and is safe to be shipped and that the voltage on the battery cell block **16** is sufficiently low to be of any concern.

[0041] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to make and use the invention. Certain terms have been used for brevity, clarity and understanding. No unnecessary limitations are to be inferred therefrom beyond the requirement of the prior art because such terms are used for descriptive purposes only and are intended to be broadly construed. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have features or structural elements that do not differ from the literal language of the claims, or if they include equivalent features or structural elements with insubstantial differences from the literal languages of the claims.

[0042] Unless otherwise specified or limited, the terms “mounted,” “connected,” “linked,” “supported,” and “coupled” and variations thereof are used broadly and encompass both direct and indirect mountings, connections, supports, and couplings. Further, unless otherwise specified or limited, “connected” and “coupled” are not restricted to physical or mechanical connections or couplings. As used herein, unless otherwise limited or defined, discussion of particular directions is provided by example only, with regard to particular embodiments or relevant illustrations. For example, discussion of “top,” “bottom,” “front,” “back,” “left” or “right” features is generally intended as a description only of the orientation of such features relative to a reference frame of a particular example or illustration. Correspondingly, for example, a “top” feature may sometimes be disposed below a “bottom” feature (and so on), depending on the position of the element and the frame of reference. Additionally, use of the words “first,” “second”, “third,” etc. is not intended to connote priority or importance, but merely to distinguish one of several similar elements or machines from another.

Claims

1. A system for rendering a battery pack safe for shipping or disposal, the system comprising: a voltage drain circuit connected to battery cells of the battery pack; a discharge switching device operable to transition from a first state to a second state, wherein the voltage drain circuit discharges the battery cells only when the discharge switching device is in the second state; and an activation device operable to cause the discharge switching device to transition from the first state to the second state.

2. The system of claim 1 wherein the discharge switching device permanently transitions from the first state to the second state based on the activation device.

3. The system of claim 2 wherein the discharge switching device is a chemical fuse that can transition from the first state to the second state only one time.

4. The system of claim 1 wherein the activation device includes a manually operated engagement device.

5. The system of claim 1 further comprising a power consuming load that is connected to ground through the voltage drain circuit when the discharge switching device is in the second state.
6. The system of claim 1 wherein the activation device includes a battery management system included in the battery pack.
7. The system of claim 6 wherein the battery management system transitions the discharge switching device to the second state when the battery pack is in a severe fault condition.
8. The system of claim 6 wherein the activation device includes a manually operated engagement device that communicates with the battery management system.
9. The system of claim 1 further comprising a visual indicator operable to indicate the state of the discharge switching device.
10. A system for rendering a battery pack including battery cells safe for shipping or disposal, the system comprising: a voltage drain circuit connected to a positive terminal of the battery cells; a discharge switching device operable to permanently transition from a first state to a second state, wherein the voltage drain circuit discharges the battery cells when the discharge switching device permanently transitions from the first state to the second state; and an activation device operable to cause the discharge switching device to transition from the first state to the second state.
11. The system of claim 10 wherein the discharge switching device prevents charging of the battery cells when the discharge switching device is in the second state.
12. The system of claim 11 wherein the discharge switching device is a chemical fuse.
13. The system of claim 10 wherein the activation device includes a manually operated engagement device.
14. The system of claim 10 further comprising a power consuming load that is connected to ground through the voltage drain circuit when the discharge switching device is in the second state.
15. The system of claim 10 further comprising a visual indicator operable to indicate the state of the discharge switching device.
16. A method of rendering a battery pack including battery cells safe for shipping or disposal, the method comprising the steps of: operating an activation device upon a decision to discharge the battery cells; transitioning a discharge switching device from a first state to a second state upon operation of the activation device, wherein the discharge switching device permanently transitions from the first state to the second state; and discharging the battery cells through a voltage drain circuit only when the discharge switching device is in the second state.
17. The method of claim 16 wherein the activation device includes a battery management system included in the battery pack.
18. The method of claim 16 wherein the discharge switching device is a chemical fuse.
19. The method of claim 16 further comprising the step of visually indicating the discharge of the battery cells through the voltage drain circuit.
20. The method of claim 16 wherein the voltage drain circuit includes a power consuming load and a switching device, wherein the switching device provides a discharge path from the battery cells through the power consuming load when the discharge switching device is in the second state.