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BATTERY THERMAL EVENT DETECTION AND SUPPRESSION

Abstract

A suppression system is described. The suppression system includes a container having an internal space arranged to receive a battery, and an event monitor. The container includes one or more bags that include a suppression material. The one or more bags are arranged to discharge the suppression material at least to the internal space of the container based on one or more parameters and one or more control signals. The discharged suppression material is usable to control a battery event. The event monitor includes one or more sensors configured to measure the one or more parameters, which are transmittable by the event monitor to a monitoring device and trigger the one or more control signals.

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Background/Summary

TECHNICAL FIELD

[0001] This disclosure relates to batteries and in particular to event detection, alerting and suppression in batteries such as, for example, Lithium-Ion (Li-Ion) batteries.

BACKGROUND

[0002] Batteries are an essential part of many devices, including motor vehicles. Historically, motor vehicles were equipped with a single battery, e.g., a lead acid battery, used to both start the vehicle's motor as well as to power the other systems of the vehicle, e.g., charging system, operation while running, lighting, accessories, etc. More recently, electric vehicles and hybrid gasoline/electric vehicles (collectively referred to herein as electric vehicles or EVs), rely on one or more Li-Ion batteries to provide energy to power electric motors that cause the vehicle's wheels to move and to also power the other systems of the vehicle. While batteries such as Li-Ion batteries provide large storage and powering capacities, some battery technologies, such as Li-Ion batteries, are susceptible scenarios that result in rapidly escalating internal thermal temperatures, sometimes referred to as “thermal runaway”. This condition occurs when the amount of heat generated by a battery exceeds the amount of heat that can be dissipated to the surroundings. As the battery heats, the situation worsens and accelerates. This can be a result of poor cooling, improper charging, battery failure and/or damage. Failure to detect such thermal runaway conditions can lead to fire, explosion and other undesirable consequences.

[0003] Of particular concern is the situation where a Li-Ion battery in a vehicle experiences a thermal runaway condition. In this scenario, the driver may not know that the condition is occurring, and driving under such conditions can lead to an accident if a battery or batteries catch fire, explode, etc. Similarly, a Li-Ion battery powered vehicle that is in an accident can have a battery damaged during the accident, leading to a thermal runaway condition and possible fire or explosion.

[0004] As another example, a battery may need to be shipped from one location to another, such as for recycling, new installation, etc. In such cases, failure to detect and address a thermal event, such as a thermal runaway event, can be dangerous and lead to injury of those involved with the shipping and/or damage to the shipping company's equipment.

SUMMARY

[0005] Some embodiments advantageously provide a method and system for detecting a thermal event, such as a thermal runaway event, alerting the occurrence of the event and/or then initiating one or more actions to suppress the thermal event.

[0006] According to one aspect, a suppression system is described. The suppression system includes a container having an internal space arranged to receive a battery, and an event monitor. The container includes one or more bags that include a suppression material. The one or more bags are arranged to discharge the suppression material at least to the internal space of the container based on one or more parameters and one or more control signals. The discharged suppression material is usable to control a battery event. The event monitor includes one or more sensors configured to measure the one or more parameters, which are transmittable by the event monitor to a monitoring device and trigger the one or more control signals.

[0007] In some embodiments, the one or more bags comprise one or both of a first bag and a

second bag. The one or more parameters comprise a first parameter, and the container comprises a valve coupled to the first bag and configured to open when the first parameter reaches or exceeds a first parameter threshold to discharge the suppression material of the first bag. The one or more parameters comprise a second parameter, and the container comprises a pin arranged to puncture the second bag when the second parameter reaches or exceeds a second parameter threshold to discharge the suppression material of the second bag.

[0008] In some other embodiments, the suppression material of the first bag and the second bag are discharged during a first discharge stage and a second discharge stage, respectively, based on the one or more parameters.

[0009] In some embodiments, one or more of the valve is configured to receive a first control signal of the one or more control signals that triggers the valve to open to discharge the suppression material of the first bag; the opening of the valve is associated with a first exposure period in which the discharged suppression material is exposed to the battery; the pin is configured receive a second control signal of the one or more control signals that triggers the pin to puncture the second bag to discharge the suppression material of the second bag; and the puncturing of the second bag is associated with a second exposure period in which the discharged suppression material is exposed to the battery.

[0010] In some other embodiments, the container comprises an exhaust port arranged to receive a third control signal of the one or more control signals that triggers the exhaust port to control a release of the discharged suppression material from the internal space. The release of the discharged suppression material is controlled by one or more of opening the exhaust port, closing the exhaust port, throttling the exhaust port based on the one or more parameters.

[0011] In some embodiments, the controlling of the release of the discharged suppression material by the exhaust port controls a third exposure period in which the discharged suppression material is exposed to the battery.

[0012] In some other embodiments, the suppression system further comprises first processing circuitry and a first communication interface. One or both of the first processing circuitry is configured to determine the one or more control signals based on the one or more parameters, and the first communication interface is configured to receive the one or more control signals based on the one or more parameters.

[0013] In some embodiments, the event monitor further comprises a second communication interface configured to transmit the measured one or more parameters. The transmission of the measured one or more parameters triggers transmission of the one or more control signals.

[0014] In some other embodiments, the suppression material is arranged to flow through the internal space and absorb heat from one or more of the battery, the internal space, and the container.

[0015] In some embodiments, one or more of the one or more parameters include one or more of a battery temperature, a pressure associated with the internal space, and a presence of the suppression material; the battery event is a thermal runaway event; and the discharged suppression material controls the thermal runaway event.

[0016] According to another aspect, a system comprising a suppression system, an event monitor, and a monitoring device. The suppression system includes a container having an internal space arranged to receive a battery. The container includes one or more bags including a suppression material. The one or more bags are arranged to discharge the suppression material at least to the internal space of the container based on one or more parameters and one or more control signals. The discharged suppression material is usable to control a battery event. The event monitor includes one or more sensors configured to measure the one or more parameters. The measured one or more parameters are transmittable by the event monitor to the monitoring device and triggering the one or more control signals. The monitoring device is in communication with the event monitor and includes a user interface configured to display the one or more parameters.

[0017] In some embodiments, on or more of the suppression system comprises first processing circuitry configured to trigger the discharge of the suppression material of at least one of the one or more bags; the event monitor comprises second processing circuitry in communication with the one or more sensors and is configured to cause transmission of a message comprising the one or more parameters to the monitoring device; the monitoring device comprises third processing circuitry configured to one or more of receive the message; determine the battery event has occurred or a likelihood that the event will occur within a predetermined period of time based on one or both of the one or more parameters and a differential of the one or more parameters; and cause transmission of the one or more control signals to the suppression system to trigger the discharge of the suppression material of at least one of the one or more bags based on the determination that the battery event has occurred or the likelihood that the event will occur within the predetermined period of time. In some other embodiments, the one or more bags comprise one or both of a first bag, where the one or more parameters comprise a first parameter, and the container comprises a valve coupled to the first bag and configured to open when the first parameter reaches or exceeds a first parameter threshold to discharge the suppression material of the first bag; and a second bag. The one or more parameters comprise a second parameter, and the container comprises a pin arranged to puncture the second bag when the second parameter reaches or exceeds a second parameter threshold to discharge the suppression material of the second bag.

[0018] In some embodiments, the suppression material of the first bag and the second bag are discharged during a first discharge stage and a second discharge stage, respectively, based on the one or more parameters.

[0019] In some other embodiments, one or more of the valve is configured to receive a first control signal of the one or more control signals that triggers the valve to open to discharge the suppression material of the first bag; the opening of the valve is associated with a first exposure period in which the discharged suppression material is exposed to the battery; the pin is configured receive a second control signal of the one or more control signals that triggers the pin to puncture the second bag to discharge the suppression material of the second bag; and the puncturing of the second bag is associated with a second exposure period in which the discharged suppression material is exposed to the battery.

[0020] In some embodiments, the container comprises an exhaust port arranged to receive a third control signal of the one or more control signals that triggers the exhaust port to control a release of the discharged suppression material from the internal space. The release of the discharged suppression material is controlled by one or more of opening the exhaust port, closing the exhaust port, throttling the exhaust port based on the one or more parameters.

[0021] In some other embodiments, the controlling of the release of the discharged suppression material by the exhaust port controls a third exposure period in which the discharged suppression material is exposed to the battery.

[0022] In some embodiments, the suppression material is arranged to flow through the internal space and absorb heat from one or more of the battery, the internal space, and the container.

[0023] In some other embodiments, the system further comprises a fan configured to receive a fourth control signal of the one or more control signals, and the third processing circuitry is further configured to cause transmission of the fourth control signal triggering the fan to be energized and to extract discharged suppression material from the system.

[0024] In some embodiments, one or more of the one or more parameters include one or more of a battery temperature, a pressure associated with the internal space, a presence of the suppression material; the battery event is a thermal runaway event; and the discharged suppression material controls the thermal runaway event at least by causing the battery temperature to be less than a predetermined temperature threshold.

[0025] According to an aspect, a method in a system comprising a container, one or more bags, and a monitoring device is described. The container comprises an internal space and being arranged to receive a battery in the internal space and the one or more bags. The one or more bags comprise a suppression material usable for controlling a battery event. The monitoring device comprises a user interface. The method comprises measuring one or more parameters associated with the battery, transmitting the one or more parameters for displaying in the user interface, and triggering a discharge of the suppression material at least to the internal space of the container based on the one or more parameters and one or more control signals.

[0026] In some embodiments, the method further comprises transmitting a message comprising the one or more parameters to the monitoring device; determining the battery event has occurred or a likelihood that the event will occur within a predetermined period of time based on one or both of the one or more parameters and a differential of the one or more parameters; and receiving from the monitoring device the one or more control signals to trigger the discharge of the suppression material of at least one of the one or more bags based on the determination that the battery event has occurred or the likelihood that the event will occur within the predetermined period of time.

[0027] In some other embodiments, the one or more bags comprise one or both of a first bag and a second bag. The one or more parameters comprise a first parameter and a second parameter. The container comprises one or both of a valve coupled to the first bag and a pin arranged to puncture the second bag. The method further comprises one or both of opening the valve when the first parameter reaches or exceeds a first parameter threshold to discharge the suppression material of the first bag and puncturing the second bag when the second parameter reaches or exceeds a second parameter threshold to discharge the suppression material of the second bag.

[0028] In some embodiments, the method comprises discharging the suppression material of the first bag and the second bag during a first discharge stage and a second discharge stage, respectively, based on the one or more parameters.

[0029] In some other embodiments, one or more of the method further comprises receiving a first control signal of the one or more control signals, opening the valve to discharge the suppression material of the first bag based on the first control signal, receiving a second control signal of the one or more control signals, and triggering the pin to puncture the second bag to discharge the suppression material of the second bag based on the second control signal; the opening of the valve is associated with a first exposure period in which the discharged suppression material is exposed to the battery; and the puncturing of the second bag is associated with a second exposure period in which the discharged suppression material is exposed to the battery.

[0030] In some embodiments, the container comprises an exhaust port arranged to receive a third control signal of the one or more control signals, and the method further comprises receiving a third control signal and triggering the exhaust port to control a release of the discharged suppression material from the internal space based on the third control signal. The release of the discharged suppression material is controlled by one or more of opening the exhaust port, closing the exhaust port, throttling the exhaust port based on the one or more parameters.

[0031] In some other embodiments, the controlling of the release of the discharged suppression material by the exhaust port controls a third exposure period in which the discharged suppression material is exposed to the battery.

[0032] In some embodiments, the suppression material is arranged to flow through the internal space and absorb heat from one or more of the battery, the internal space, and the container.

[0033] In some other embodiments, the system further comprises a fan configured to receive a fourth control signal of the one or more control signals, and the method further comprises transmitting the fourth control signal and energizing the fan based on the fourth control signal to extract the discharged suppression material from the system.

[0034] In some embodiments one or more of the one or more parameters include one or more of a battery temperature, a pressure associated with the internal space, a presence of the suppression material; the battery event is a thermal runaway event; and the discharged suppression material controls the thermal runaway event at least by causing the battery temperature to be less than a predetermined temperature threshold.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0035] A more complete understanding of embodiments described herein, and the attendant advantages and features thereof, will be more readily understood by reference to the following detailed description when considered in conjunction with the accompanying drawings wherein:

[0036] FIG. **1** is a block diagram of an example system constructed in accordance with the principles of present disclosure;

[0037] FIG. **2** is another block diagram of the example system constructed in accordance with the principles of present disclosure;

[0038] FIG. **3** is a suppression system comprising a container constructed in accordance with the principles of present disclosure;

[0039] FIG. **4** is an example system constructed in accordance with the principles of present disclosure; and

[0040] FIG. **5** is a flowchart of an example process in accordance with the principles of present disclosure.

DETAILED DESCRIPTION

[0041] Before describing in detail exemplary embodiments, it is noted that the embodiments reside primarily in combinations of apparatus components and processing steps related to a battery event (e.g., thermal event) monitoring, detection and suppression system. In some embodiments, the system is implemented with one or more Li-Ion batteries, although embodiments are not limited solely to Li-Ion batteries. Accordingly, the system and method components have been represented where appropriate by conventional symbols in the drawings, showing only those specific details that are pertinent to understanding the embodiments of the present disclosure so as not to obscure the disclosure with details that will be readily apparent to those of ordinary skill in the art having the benefit of the description herein.

[0042] As used herein, relational terms, such as “first” and “second,” “top” and “bottom,” and the like, may be used solely to distinguish one entity or element from another entity or element without necessarily requiring or implying any physical or logical relationship or order between such entities or elements. The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the concepts described herein. As used herein, the singular forms “a”, “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises,” “comprising,” “includes” and/or “including” when used herein, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0043] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure belongs. It will be further understood that terms used herein should be interpreted as having a meaning that is consistent with their meaning in the context of this specification and the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0044] In embodiments described herein, the joining term, “in communication with” and the like, may be used to indicate electrical or data communication, which may be accomplished by physical contact, induction, electromagnetic radiation, radio signaling, infrared signaling or optical signaling, for example. One having ordinary skill in the art will appreciate that multiple components may interoperate and modifications and variations are possible of achieving the electrical and data communication.

[0045] Referring now to the drawing figures in which like reference numbers refer to like elements, there is shown in FIGS. **1** and **2**, a battery thermal event monitoring, detection and suppression system **10** constructed in accordance with the principles of the present disclosure. In some embodiments, system **10** may include a battery **12**, for example a Li-Ion battery, which includes an event monitor **14** . . . . A suppression system **16** is coupled to, or in proximity to one or more batteries **12** such that the suppression system **16** can thermally suppress a thermal event in battery **12** when triggered. Although only one suppression system **16** and one battery **12** are shown, it is understood that more than one battery **12** and suppression system **16** can be implemented. Event monitor **14** may be in proximity to, within, or coupled to suppression system **16** (e.g., a container of suppression system **16**). Further, system **10** may also include one or more monitoring devices **18**.
[0046] Monitoring device **18** is in communication with event monitor **14** and/or suppression system **16**. In some embodiments the communication is wireless and may be based on a known wireless communication protocol such as Wi-Fi, cellular, BLUETOOTH, and the like.
[0047] In some embodiments, battery **12** (having event monitor **14**) and suppression system **16** may be included in (or include) a single package, e.g., shipping box, such as a shipping box used to ship the battery **12** to a recycling center. Such a box may be shipped empty to the person who is going to return the battery **12** for recycling. For example, the outbound box may include the suppression system **16** and an internal space to put the battery **12** into the box such that, when the box is sealed, the suppression system **16** ends up in contact with or in close enough proximity to battery **12** to allow suppression system **16** to address a detected thermal event in battery **12**.
[0048] In operation, a driver of the shipping vehicle or an operator associated with the shipping company may use monitoring device **18** to be alerted of an event associated with a battery **12** being monitored by an event monitor **14**. If a predetermined parameter threshold (e.g., temperate threshold) is reached, monitoring device **18** can alert the user and/or trigger suppression system **16** to activate in order to perform one or more actions (e.g., cool battery **12**). Suppression system **16** can cool battery **12** via technologies such as dispensing cooling and/or fire suppression chemicals, cooled air, and the like. In some embodiments, the suppression system **16** may be arranged to suppress thermal events for Li-Ion batteries of up to 2.5 kWh or more.
[0049] FIG. **2** is a more detailed block diagram of the elements of FIG. **1**. The system **10** includes an event monitor **14**, suppression system **16** and monitoring device **18**. In some embodiments, event monitor **14** may be incorporated within or affixed to battery **12** and/or suppression system **16**. Although one of each element is shown, it is understood that more than one of each element can be implemented. An event monitor **14** can be formed as an integrated circuit and or small package and implemented to monitor one or more components (e.g., cells) of battery **12**. Event monitor **14** may include processing circuitry **20**, sensor **22**, communication interface **24** and software **26**. The processing circuitry **20** may include a processor and a memory (not shown). In particular, in addition to or instead of a processor, such as a central processing unit, and memory, the processing circuitry **20** may comprise integrated circuitry for processing and/or control, e.g., one or more processors and/or processor cores and/or FPGAs (Field Programmable Gate Array) and/or ASICs (Application Specific Integrated Circuitry) adapted to execute instructions. The processor may be configured to access (e.g., write to and/or read from) the memory, which may comprise any kind of volatile and/or nonvolatile memory, e.g., cache and/or buffer memory and/or RAM (Random Access Memory) and/or ROM (Read-Only Memory) and/or optical memory and/or EPROM (Erasable Programmable Read-Only Memory). Further, memory may be configured as a storage device.
[0050] Event monitor **14** may include a sensor **22** or other device used to measure one or more parameters. For example, sensor **22** may be a temperature sensor configured to measure temperature (e.g., of battery **12**, or of a portion of battery **12** such as a battery cell, exhaust of the battery **12**, etc.), a pressure sensor to measure pressure (e.g., to detect a pressure increase as a result of a discharge of suppression material **32**), a suppression material detection sensor configured to

detect presence of a material (e.g., to detect that the material has been discharged), or any other kind of sensor. Sensor **22** can be periodically read by processing circuitry **20**. Event monitor **14** may include communication interface **24** enabling it to communicate directly/indirectly with any component/device of system **10**. For example, communication interface **24** may be configured for setting up and maintaining at least a wireless/wired connection with any component/device of system **10** such as suppression system **16** and/or monitoring device **18**. The communication interface **30** may be formed as or may include, for example, one or more RF transmitters, one or more RF receivers, and/or one or more RF transceivers.

[0051] Event monitor **14** further has software **26** (which may include a software application) stored internally in, for example, memory. Software **26** may include any software/program configured to perform the steps/processes of the present disclosure, e.g., measuring temperature and reporting the temperature to monitoring device **18** and/or triggering suppression system **16**. In some embodiments, the event monitor **14** can have a predetermined maximum temperature or rate of temperature increase at which event monitor **14** may itself trigger (directly, or indirectly) suppression system **16** to cool battery **12**.

[0052] The processing circuitry **20** may be configured to control any of methods and/or processes described herein and/or to cause such methods, and/or processes to be performed, e.g., by event monitor **14**. The memory is configured to store data and/or files such as thermal data and/or other information/data described herein. In some embodiments, the software **26** may include instructions that, when executed by the processing circuitry **20**, causes the processor and/or processing circuitry **20** to perform the processes described herein with respect to premises event monitor **14**.

[0053] The system **10** further includes suppression system **16** including hardware **28**. The hardware **28** may include suppression material **32** and processing circuitry **36**. Suppression material **32** may be any chemical or arrangement that can be used to actively cool battery **12** when dispensed/discharged and/or is exposed to (e.g., comes in contact with, is in proximity to) the battery during an exposure period (i.e., a time duration in which the suppression material is exposed to the battery **12**). The processing circuitry **36** may include a processor **38** and a memory **40**. In particular, in addition to or instead of a processor, such as a central processing unit, and memory, the processing circuitry **36** may comprise integrated circuitry for processing and/or control, e.g., one or more processors and/or processor cores and/or FPGAs (Field Programmable Gate Array) and/or ASICs (Application Specific Integrated Circuitry) adapted to execute instructions. The processor **38** may be configured to access (e.g., write to and/or read from) the memory **40**, which may comprise any kind of volatile and/or nonvolatile memory, e.g., cache and/or buffer memory and/or RAM (Random Access Memory) and/or ROM (Read-Only Memory) and/or optical memory and/or EPROM (Erasable Programmable Read-Only Memory). Further, memory **40** may be configured as a storage device.

[0054] Hardware **28** of suppression system **16** may include communication interface **30** enabling it to communicate directly/indirectly with any component/device of system **10**. For example, communication interface **30** may be configured for setting up and maintaining at least a wireless/wired connection with any component/device of system **10** such as event monitor **14** and/or remote monitoring device **18**. The communication interface **30** may be formed as or may include, for example, one or more RF transmitters, one or more RF receivers, and/or one or more RF transceivers. Suppression system **16** may include its own power source, e.g., battery, (not shown) to allow performance of the functions described herein.

[0055] Suppression system **16** further has software **42** (which may include software application **46**) stored internally in, for example, memory **40**, or stored in external memory (e.g., database, storage array, network storage device, etc.) accessible by the suppression system **16** via an external connection. Software application **46** may include any software/program configured to perform the steps/processes of the present disclosure, e.g., triggering the release of suppression material **32**. Further, software application **46** may run and/or be included directly as part of software **42** and/or the suppression system **16**. Software application **46** may be virtualized and/or running outside the suppression system **16** and/or any of the components of the suppression system **16** such that a trigger signal is provided to cause the release of suppression material **32** when triggered to do so.

[0056] The processing circuitry **36** may be configured to control any of methods and/or processes described herein and/or to cause such methods, and/or processes to be performed, e.g., by the suppression system **16**. Processor **38** corresponds to one or more processors **38** for performing the suppression system **16** functions described herein. The memory **40** is configured to store data and/or files, e.g., data/information generated by suppression unit **50** and/or other information described herein. In some embodiments, the software **42** may include instructions that, when executed by the processor **38** and/or processing circuitry **36**, causes the processor **38** and/or processing circuitry **36** to perform the processes described herein with respect to the suppression system **16**. For example, processing circuitry **36** of the suppression system **16** may include suppression unit **50** used to analyze date received from monitoring device **18** and/or event monitor **14** to trigger the release of suppression material **32**. Further, processing circuitry **36** may include control unit **52** which may be configured to receive one or more inputs, and or produce one or more outputs (e.g., control signals) usable to control one or more components of system **10** (e.g., valves, pins, etc.)

[0057] The system **10** further includes monitoring device **18** including hardware **58**. Monitoring device **18** can be any portable device such as a smart phone, tablet, laptop, etc., such as may be carried by the driver of a shipping vehicle carrying batteries **12**, or the operator of a vehicle having batteries **12**. Monitoring device **18** can also be any computing device, e.g., desktop computer, server, located at a monitoring center that is in communication with event monitor **14** and/or suppression system **16**. The processing circuitry **66** may include a processor **68** and a memory **70**. In particular, in addition to or instead of a processor, such as a central processing unit, and memory, the processing circuitry **66** may comprise integrated circuitry for processing and/or control, e.g., one or more processors and/or processor cores and/or FPGAs (Field Programmable Gate Array) and/or ASICs (Application Specific Integrated Circuitry) adapted to execute instructions. The processor **68** may be configured to access (e.g., write to and/or read from) the memory **70**, which may comprise any kind of volatile and/or nonvolatile memory, e.g., cache and/or buffer memory and/or RAM (Random Access Memory) and/or ROM (Read-Only Memory) and/or optical memory and/or EPROM (Erasable Programmable Read-Only Memory). Further, memory **70** may be configured as a storage device.

[0058] Hardware **58** of monitoring device **18** may include communication interface **60** enabling it to communicate directly/indirectly with any component/device of system **10**. For example, communication interface **60** may be configured for setting up and maintaining at least a wireless/wired connection with any component/device of system **10** such as event monitor **14** and/or suppression system **16**. The communication interface **60** may be formed as or may include, for example, one or more RF transmitters, one or more RF receivers, and/or one or more RF transceivers. Monitoring device **18** may include its own power source, e.g., battery, to allow performance of the functions described herein.

[0059] Monitoring device **18** further has software **82** (which may include software application **86**) stored internally in, for example, memory **70**, or stored in external memory (e.g., database, storage array, network storage device, etc.) accessible by the monitoring device **18** via an external connection. Software application **86** may include any software/program configured to perform the steps/processes of the present disclosure, e.g., monitoring parameter readings (e.g., temperature readings) received from event monitor **14**, and generating and sending a message to suppression system **16** to cause the release of suppression material **32**. Further, software application **86** may run and/or be included directly as part of software **82** and/or the monitoring device **18**. Software application **86** may be virtualized and/or run outside the monitoring device **18** and/or any of the components of the monitoring device **18** such that a message is generated to cause the release of suppression material **32**. Software application **86** may also include user interface **88** which operates to run a display (not shown) of monitoring device **18** to show data such as thermal data received from event monitor **14** to the user and/or to allow the user to cause the transmission of a message to suppression system **16** to release suppression material **32**. In some embodiments, the user interface can show in indication that a pre-determined parameter (e.g., temperature) and/or rate of a parameter (e.g., rate of temperature) change within battery **12** has been reached and that processing circuitry **66** has automatically generated and transmitted a message to suppression system **16** triggering the release of suppression material **32**.

[0060] The processing circuitry **66** may be configured to control any of methods and/or processes described herein and/or to cause such methods, and/or processes to be performed, e.g., by the monitoring device **18**. Processor **68** corresponds to one or more processors **68** for performing the suppression system **16** functions described herein. The memory **70** is configured to store data and/or files, e.g., data/information generated by analysis/alert engine **74** and/or other information described herein. In some embodiments, the software **82** may include instructions that, when executed by the processor **68** and/or processing circuitry **66**, causes the processor **68** and/or processing circuitry **66** to perform the processes described herein with respect to the monitoring device **18**. For example, processing circuitry **66** of the monitoring device **18** may include analysis/alert engine **74** used to analyze data received from event monitor **14** and/or suppression system **16** regarding parameters associated with battery **12** (e.g., temperature and/or rate of temperature change) such as to trigger the release of suppression material **32** and/or to receive confirmation from suppression system **16** that suppression material **32** has been released. Further, processing circuitry **66** may include control unit **76** which may be configured to receive one or more inputs, and or produce one or more outputs (e.g., control signals) usable to control one or more components of system **10** (e.g., extractors, fans, etc.)

[0061] In some embodiments, the display of monitoring device **18** can indicate the battery **12** temperature in color, such as blue for a temperature that does not exceed a predetermined value (to indicate a normal battery temperature) and red for a temperature that exceeds a predetermined value (to indicate an abnormal battery temperature). Alarm icons can also be provided on the display of monitoring device **18**, where different colors are used to indicate the absence or presence of an alarm (thermal event) condition. A vibration alert can also be provided to a user (monitoring device **18** can be equipped with a vibration element) when a thermal event is detected.

[0062] In sum, in operation, event monitor **14** monitors the parameters (e.g., temperature) of battery **12** (and/or internal space, container, etc.). The parameters such as temperature and/or rate of change of temperature and/or indication that either of these exceeds a predetermined value is provided to monitoring device **18** and/or suppression system **16**. Monitoring device **18** receives the parameters from event monitor **14** and provides that information to a user, such as via a display. For example, if a thermal event is detected, e.g., temperature and/or rate of temperature change exceeds a predetermined value(s), monitoring device **18** sends a message to suppression system **16** to trigger the release of suppression material **32** over the battery **12** to thereby cause a reduction in the temperature of battery **12** and/or to avoid/suppress fire, explosion, etc.

[0063] As discussed above, suppression system **16** can be included in a packaging arrangement to allow batteries **12** to be shipped back to a manufacturer/recycler for safe recycling.

[0064] FIG. **3** shows an example suppression system **16**. In this nonlimiting example, suppression system **16** comprises a container **100** (and/or event monitor **14**). Container **100** comprises a container cover **101** and a container housing **103**. Container cover **101** may be coupled to container housing **103**, e.g., container cover **101** is releasably coupled to container housing such as to allow: (A) container **100** to be opened (by removing container cover **101**); (B) battery **12** to be inserted in container housing **103**; and (C) container **100** to be closed (by coupling container cover **101** to container housing **103**). In some embodiments, after battery **12** is placed in container **100**, container cover **101** is releasably sealed to container housing **103** such as to ship battery **12** to a recycling center. Event monitor **14** may be in proximity to, within, or coupled to container **100** of suppression system **16**. Event monitor **14** may be configured to measure one or more parameters associated with the battery **12** and/or container **100** to detect one or more events such as a thermal runaway event.

[0065] FIG. **4** shows an example system **10** according to one or more embodiments of the present disclosure. System **10** may comprise event monitor **14** and/or suppression system **16** and/or monitoring device **18**. Suppression system **16** may comprise a container **100** arranged to receive, in internal space **102**, a battery **12** and be sealed such as for shipping battery **12** to a recycling facility or to the battery manufacturer. Event monitor **14** may be in proximity to, within, or coupled (removably or permanently) to container **100** of suppression system **16**. Container **100** may comprise one or more bags **104** (i.e., containers) arranged to contain suppression material **32**. In a nonlimiting example, container **100** may comprise a bag **104***a*, **104***b*, and **104***c*. Each bag **104** may contain, and be arranged to release, suppression material **32** using one or more release mechanisms. Bag **104***a* may comprise bag seal **105**. Bag seal **105** may be arranged to seal bag **104***a* such as to contain suppression material **32** within bag **104***a* when predetermined conditions are met. Bag seal **105** may further be arranged to open when the predetermined conditions are exceeded. For example, bag seal **105** may be arranged to open when a temperature associated with the bag **104***a* and/or with battery **12** and/or internal space **102** (e.g., a gas within the internal space) exceeds a predetermined parameter threshold (e.g., temperature threshold). When bag seal **105** opens suppression material **32** is discharged to internal space **102** (as discharged suppression material **34**).

[0066] In some embodiments, bag **104***b* may be coupled to a valve **106** (and/or actuator). Valve **106** may be configured to receive a control signal **108** (e.g., from event monitor **14**, suppression system **16**, monitoring device **18**) that triggers valve **106** to open and/or close (and/or throttle) valve **106**. When valve **106** is open (and/or is throttling) suppression material **32** is discharged to internal space **102** (as discharged suppression material **34**). In addition, container **100** may comprise pin **110** (and/or actuator) which may be arranged to travel in a first direction toward bag **104***c* such as to puncture bag **104***c* and to travel in a second direction (e.g., opposite the first direction) to retract pin **110**, e.g., to allow suppression material **32** to be discharged (as discharged suppression material **34**) to internal space **102** from punctured bag **104***c* (e.g., via a puncture on the bag caused by pin **110**). Pin **110** may be configured to receive a control signal **112** (e.g., from event monitor **14**, suppression system **16**, monitoring device **18**) to trigger pin **110** to travel and puncture bag **104***c*.

[0067] The discharged suppression material **34** may be arranged to flow within internal space and/or control a battery event, e.g., by absorbing heat such as emanated from battery **12** (and/or any other component of battery **12**). For example, discharged suppression material **34** may physically contact battery **12** and provide a heat exchange function to cool down the battery **12** to a predetermined threshold. Further, container **100** may be sealed, where container **100** comprises a container cover **101** and a container housing **103** sealed to the container cover **101**. Container **100** may further comprise one or more exhaust ports **114** which may be configured to open, close, or throttle such as to control contact time between discharged suppression material **34** (within internal space **102**) and battery **12**, e.g., based on a control signal **120**.

[0068] Although bags **104***a*, **104***b*, and **104***c* are shown, the present disclosure is not limited as such, e.g., container **100** may comprise any quantity and/or types of bags **104**. In some embodiments, the placement of bags **104** with respect to battery **12** (and its components) may be determined by the type, size, specifications of battery **12** (or battery components), suppression material characteristics, container characteristics, shipping information, recycling requirements, etc.

[0069] In a nonlimiting example, event monitor **14** comprises one or more sensors **22** (e.g., sensors **22***a*, **22***b*, **22***c*). Further, battery **12** may comprise exhaust port **116** which may be arranged to be in fluid communication with any other component of battery **12** such as a battery housing internal space, battery cells, battery management system, etc. Sensor **22***a* (e.g., temperature sensor, thermocouple, etc.) may be coupled to exhaust port **116** of battery **12** and may be configured to measure a parameter (e.g., temperature) of a gas present and/or leaving and/or entering exhaust port **116**, e.g., to measure the temperature of the battery **12**. Sensor **22***b* (e.g., another temperature sensor, thermocouple, etc.) may be coupled to one or more components of battery **12** (E.g., battery housing, cells) and measure a parameter (e.g., temperature) of the battery **12**. Further, sensor **22***c* may be configured to measure a parameter associated with internal space **102** (e.g., a temperature or pressure of a gas within internal space **102**, presence of a predetermined gas).

[0070] In another nonlimiting example, event monitor **14** (e.g., via one or more sensors **22**) may be configured to determine that a parameter associated with battery **12** has reached or exceeded a parameter threshold (e.g., temperature threshold). Event monitor **14** may be configured to transmit a message to monitoring device **18** (and/or suppression system **16**) where the message comprising parameter values, thresholds, and an indication indicating that the determined parameter has exceeded the parameter threshold. Monitoring device **18** may be configured to receive the message and use the parameter values, thresholds, and/or indication to determine whether an event associated with battery **12** (e.g., such a thermal event) has occurred or has a likelihood of occurring in a predetermined period of time. For example, monitoring device **18** may determine that a parameter (e.g., temperature) has reached or exceeded a parameter threshold. That is, monitoring device **18** may determine that an event has occurred. Monitoring device **18** may also determine a parameter differential (e.g., parameter at time 2 (p2)−parameter at time 1 (p1) and/or be used to determine a parameter differential over a period of time (t) (e.g., (p2−p1)/t. In addition, monitoring device **18** may be configured to determine a plurality of parameter values in time (e.g., a mathematical curve with respect to time).

[0071] Further, monitoring device **18** may be configured to determine that any one of the parameters, parameter values, parameter differentials, plurality of parameter values correspond to a battery event or condition (e.g., normal battery condition or an abnormal battery condition such as a thermal runaway). For example, monitoring device may receive one or more messages from event monitor **14** comprising data such as parameter values (e.g., temperature values) and determine a parameter differential (e.g., temperature rise per unit of time) and the determine that the parameter differential corresponds to an abnormal event has occurred or is likely to occur in battery **12** as the parameter differential exceeds a tolerance value when compared to a parameter differential that corresponds to a normal event.

[0072] Similarly, monitoring device **18** may be configured to compare a first curve (e.g., function, plot, mathematical curve, etc.) comprising a plurality of parameter values (e.g., sampled by event monitor **14**) to a second curve, where the first curve corresponds to a normal state of battery **12** over time, and the second curve corresponds to an abnormal state of battery **12** over time. The comparison of curves may comprise determining a degree of similarity or deviation between the two curves (or portions thereof) to determine whether an abnormal state has occurred or is likely to occur.

[0073] In some embodiments, monitoring device **18** may be configured to transmit one or more control signals such as control signals **108**, **112** to trigger the discharge of suppression material **32** (e.g., as discharged suppression material **34**) to internal space **102** to cool down battery **12**. Exhaust port **114** may be configured as a check valve (or any other valve controlled by monitoring device **18**) to control the release of discharged suppression material **34** to the exterior of container **100**. Monitoring device **18** may be further configured to detect that suppression material **32** has been discharged (e.g., based on information associated with a position of valve **106**, pin **110**, presence of discharged suppression material **34** (detected by sensor **22***c*), parameter values, etc.) and be configured to transmit a control signal **122** to fan **118** (e.g., extractor) arranged to extract discharged suppression material **34** to the exterior of system **10**. In some embodiments, fan **118** may be arranged to extract battery gases (e.g., via exhaust ports **116**, **114**) such as based on a detection of a type of gas sensed by sensor **22**. In some other embodiments, exhaust port **114** is ducted directly to the exterior and configure to release discharged suppression material **34** to the exterior, e.g., without the use of fan **118**.

[0074] In another example, an owner of battery **12** decides to ship battery **12** for recycling. Battery **12** is inserted in container **100** (e.g., battery shipping container), which comprises one or more bags **104** (which may comprise one or more of bags **104** arranged as bag **104***a*, one or more bags **104** arranged as **104***b*, and/or one or more bags **104** arranged as bag **104***c*). Container **100** is releasably sealed (e.g., container cover is sealed to the container housing) and comprises exhaust port **114** (e.g., initially closed). That is, the inserted battery **12** is stored within internal space **102** of container **100**. Sensor **22***a* of event monitor **14** measures the temperature of gas present in exhaust port **116** of battery **12** and/or sensor **22***b* measures the temperature of the bottom of the housing of battery **12**. At time t1, a first temperature (T1) is measured by sensor **22***a*, which is consistent with a normal state of the battery **12**. However, during shipping, e.g., time t2, the internal temperature of battery **12** increases at a first rate, e.g., corresponding to an impending thermal runaway event. Sensor **22***a* measures a second temperature (T2) at t2. Event monitor **14** transmits the measured temperatures to monitoring device **18**, which determines a temperature differential per unit of time, i.e., (T2−T1)/(t2−t1), and compares the temperature differential with a base line value (e.g., associated with a normal event of battery **12**) to determine whether suppression material **32** is to be discharged.

[0075] When container **100** comprises one or more bags arranged as bag **104**, suppression material **32** is discharged by reaching the second temperature (i.e., triggers bag seal **105** to open). When container **100** comprises one or more bags arranged as either one of bags **104**, **104***c*, the discharge of suppression material **32** may be triggered by monitoring device **18**. That is, when the temperature differential per unit of time exceeds a predetermine threshold (e.g., associated with a current or impending thermal runaway event, monitoring device **18** transmits a control signal **108** or a control signal **112** to trigger the discharge of suppression material **32** (as discharged suppression material **34**).

[0076] The presence of discharged suppression material **34** in internal space **102** may be detected by sensor **22***c*, and an indication of the presence of the discharged suppression material **34** may be transmitted monitoring device **18**. The indication may be used as a confirmation of the discharge and to control presence time of the discharged suppression material **34** in internal space **102** (and/or contact with battery **12**). For example, the time that the discharged suppression material **34** is in contact with battery **12** may be controlled by monitoring device **18** (and/or suppression system **16**) and by changing the state of exhaust port **114** (e.g., closed, open, throttling). A closed exhaust port **114** may be used to extend the time that the discharged suppression material is in the internal space **102**. An open exhaust port **114** may be used to expedite the release of the discharged suppression material **34** from the internal space **102**. A throttling exhaust port **114** may be used to dynamically adjust the time that the discharged suppression material **34** is in contact with battery **12**. The state of exhaust port **114** may be based on other parameters such as characteristics of the battery **12**, suppression material **32**, internal space **102**, shipping conditions, etc.

[0077] Further, fan **118** may be energized by sending a control signal **122** to fan **118** based on information associated with control signals **108**, **112**, **120**, presence detected by sensor **22***c*, temperatures measured by sensors **22***a*, **22***b*, etc. In addition, information corresponding to any of the parameters measured by sensors **22**, control signals **108**, **112**, **120**, **122**, position or state corresponding to valve **106**, pin **110**, etc. may be displayed via user interface **88** shown in FIG. **2** to alert the driver of the truck where the battery **12** is being shipped. In some embodiments, user interface **88** may be used to manually trigger the release of suppression material **32**.

[0078] In some embodiments, bags **104** are opened at different times (i.e., the bags are caused to discharge suppression material at different discharge stages) based on the measured parameters. For example, the first bag **104***a* may be opened at a first temperature (e.g., at a first time), and based on further measurements of temperature, the monitoring device **18** may determine that additional suppression material **32** may need to be discharged by the second bag **104***b* to further cool down the battery **12**. Thus, monitoring device **18** triggers the second bag **104***b* to open at a second time. Similarly, the monitoring device **18** may determine that still more suppression material **32** may need to be discharged by the third bag **104***c* to cool down the battery **12**. In such case, monitoring device **18** triggers the third bag **104***c* to open at a third time. That is, the times at which the discharge of suppression material **32** is discharged may be different and/or determined based on or more factors such as suppression material characteristics, battery characteristics, internal space characteristics, container characteristics, historical data and/or measurements (e.g., battery parameters), etc.

[0079] In some other embodiments, similar steps may be performed when battery **12** is being used in a vehicle, aircraft, infrastructure, etc.

[0080] In some embodiments, container **100** is closed (e.g., without being sealed) such that when suppression material **32** is discharged, the discharged suppression material **34** can be released to the exterior of container **100** by forcing its way between the container cover and housing out to the exterior (e.g., exhaust port **114** not being used). For example, container **100** may be closed by zipping the cover to its housing, where the discharged suppression material **34** may be released to the exterior via openings in the zipper and other openings between the container cover **101** and container housing **103**.

[0081] In some embodiments, discharged suppression material **34** flows through one or more ducts to predetermined locations of battery **12**, e.g., locations (e.g., cells) that are determined as having an increase in temperature, predetermined locations (e.g., cells) where thermal runaways are more likely to occur, etc.

[0082] FIG. **5** shows a flowchart of an example process (e.g., implemented in system **10**). The system comprises a container **100**, one or more bags **104**, and a monitoring device **18**. The container **100** comprises an internal space **102** and being arranged to receive a battery **12** in the internal space **102** and the one or more bags **104**. The one or more bags **104** comprise a suppression material **32** usable for controlling a battery event. The monitoring device **18** comprises a user interface **88**. The method comprises measuring (Block S**100**) one or more parameters associated with the battery **12**, transmitting (Block S**102**) the one or more parameters for displaying in the user interface **88**, and triggering (Block S**104**) a discharge of the suppression material **32** at least to the internal space **102** of the container **100** based on the one or more parameters and one or more control signals.

[0083] In some embodiments, the method further comprises transmitting a message comprising the one or more parameters to the monitoring device **18**; determining the battery event has occurred or a likelihood that the event will occur within a predetermined period of time based on one or both of the one or more parameters and a differential of the one or more parameters; and receiving from the monitoring device **18** the one or more control signals to trigger the discharge of the suppression material **32** of at least one of the one or more bags **104** based on the determination that the battery event has occurred or the likelihood that the event will occur within the predetermined period of time.

[0084] In some other embodiments, the one or more bags **104** comprise one or both of a first bag **104***a* and a second bag **104***b*. The one or more parameters comprise a first parameter and a second parameter. The container **100** comprises one or both of a valve **106** coupled to the first bag **104***a* and a pin arranged to puncture the second bag **104***b*. The method further comprises one or both of opening the valve **106** when the first parameter reaches or exceeds a first parameter threshold to discharge the suppression material **32** of the first bag **104***a* and puncturing the second bag **104***b* when the second parameter reaches or exceeds a second parameter threshold to discharge the suppression material **32** of the second bag **104***b*.

[0085] In some embodiments, the method comprises discharging the suppression material **32** of the first bag **104***a* and the second bag **104***b* during a first discharge stage and a second discharge stage,

respectively, based on the one or more parameters.
[0086] In some other embodiments, one or more of the method further comprises receiving a first control signal **108** of the one or more control signals, opening the valve **106** to discharge the suppression material **32** of the first bag **104***a* based on the first control signal **108**, receiving a second control signal **112** of the one or more control signals, and triggering the pin to puncture the second bag **104***b* to discharge the suppression material **32** of the second bag **104***b* based on the second control signal **112**; the opening of the valve **106** is associated with a first exposure period in which the discharged suppression material **34** is exposed to the battery **12**; and the puncturing of the second bag **104***b* is associated with a second exposure period in which the discharged suppression material **34** is exposed to the battery **12**.
[0087] In some embodiments, the container **100** comprises an exhaust port arranged to receive a third control signal **120** of the one or more control signals, and the method further comprises receiving a third control signal **120** and triggering the exhaust port to control a release of the discharged suppression material **34** from the internal space **102** based on the third control signal **120**. The release of the discharged suppression material **34** is controlled by one or more of opening the exhaust port, closing the exhaust port, throttling the exhaust port based on the one or more parameters.
[0088] In some other embodiments, the controlling of the release of the discharged suppression material **34** by the exhaust port controls a third exposure period in which the discharged suppression material **34** is exposed to the battery **12**.
[0089] In some embodiments, the suppression material **32** is arranged to flow through the internal space **102** and absorb heat from one or more of the battery **12**, the internal space **102**, and the container **100**.
[0090] In some other embodiments, the system further comprises a fan **118** configured to receive a fourth control signal **122** of the one or more control signals, and the method further comprises transmitting the fourth control signal **122** and energizing the fan **118** based on the fourth control signal **122** to extract the discharged suppression material **34** from the system.
[0091] In some embodiments one or more of the one or more parameters include one or more of a battery temperature, a pressure associated with the internal space **102**, a presence of the suppression material **32**; the battery event is a thermal runaway event; and the discharged suppression material **34** controls the thermal runaway event at least by causing the battery temperature to be less than a predetermined temperature threshold.
[0092] One or more embodiments of the present disclosure are beneficial at least because a state such as a thermal runaway associated with battery **12** can be detected and one or more actions performed to address the state, e.g., by automatically releasing suppression material **32** to cool down battery **12** and prevent or control potential damage and injury.
[0093] It is understood that all specification values shown and described herein are non-limiting examples for implementations of batteries **10** and cells **14** constructed in accordance with the principles of the disclosure provided herein. It will be appreciated by persons skilled in the art that the present embodiments are not limited to what has been particularly shown and described herein above. In addition, unless mention was made above to the contrary, it should be noted that all of the accompanying drawings are not to scale. A variety of modifications and variations are possible in light of the above teachings and following claims.

Claims

1. A suppression system comprising: a container having an internal space arranged to receive a battery, the container comprising: one or more bags comprising a suppression material, the one or more bags being arranged to discharge the suppression material at least to the internal space of the container based on one or more parameters and one or more control signals, the discharged suppression material being usable to control a battery event; and an event monitor comprising one or more sensors configured to measure the one or more parameters, the measured one or more parameters being transmittable by the event monitor to a monitoring device and triggering the one or more control signals.

2. The suppression system of claim 1, wherein the one or more bags comprise one or both of: a first bag, the one or more parameters comprise a first parameter, and the container comprises a valve coupled to the first bag and configured to open when the first parameter reaches or exceeds a first parameter threshold to discharge the suppression material of the first bag; and a second bag, the one or more parameters comprise a second parameter, and the container comprises a pin arranged to puncture the second bag when the second parameter reaches or exceeds a second parameter threshold to discharge the suppression material of the second bag.

3. The suppression system of claim 2, wherein the suppression material of the first bag and the second bag are discharged during a first discharge stage and a second discharge stage, respectively, based on the one or more parameters.

4. The suppression system of claim 2, wherein one or more of: the valve is configured to receive a first control signal of the one or more control signals that triggers the valve to open to discharge the suppression material of the first bag; the opening of the valve is associated with a first exposure period in which the discharged suppression material is exposed to the battery; the pin is configured receive a second control signal of the one or more control signals that triggers the pin to puncture the second bag to discharge the suppression material of the second bag; and the puncturing of the second bag is associated with a second exposure period in which the discharged suppression material is exposed to the battery.

5. The suppression system of claim 1, wherein the container comprises an exhaust port arranged to receive a third control signal of the one or more control signals that triggers the exhaust port to control a release of the discharged suppression material from the internal space, the release of the discharged suppression material being controlled by one or more of opening the exhaust port, closing the exhaust port, throttling the exhaust port based on the one or more parameters.

6. The suppression system of claim 5, wherein the controlling of the release of the discharged suppression material by the exhaust port controls a third exposure period in which the discharged suppression material is exposed to the battery.

7. The suppression system of claim 1, wherein the suppression system further comprises first processing circuitry and a first communication interface, one or both of: the first processing circuitry being configured to determine the one or more control signals based on the one or more parameters; and the first communication interface being configured to receive the one or more control signals based on the one or more parameters.

8. The suppression system of claim 1, wherein the event monitor further comprises a second communication interface configured to transmit the measured one or more parameters, the transmission of the measured one or more parameters triggering transmission of the one or more control signals.

9. The suppression system of claim 1, wherein the suppression material is arranged to flow through the internal space and absorb heat from one or more of the battery, the internal space, and the container.

10. The suppression system of claim 1, wherein one or more of: the one or more parameters include one or more of a battery temperature, a pressure associated with the internal space, and a presence of the suppression material; the battery event is a thermal runaway event; and the discharged suppression material controls the thermal runaway event.

11. A system comprising: a suppression system comprising: a container having an internal space arranged to receive a battery, the container comprising: one or more bags comprising a suppression material, the one or more bags being arranged to discharge the suppression material at least to the internal space of the container based on one or more parameters and one or more control signals, the discharged suppression material being usable to control a battery event; an event monitor comprising: one or more sensors configured to measure the one or more parameters, the measured one or more parameters being transmittable by the event monitor to a monitoring device and triggering the one or more control signals; and the monitoring device in communication with the event monitor and comprising: a user interface configured to display the one or more parameters.

12. The system of claim 11, wherein one or more of: the suppression system comprises first processing circuitry configured to: trigger the discharge of the suppression material of at least one of the one or more bags; the event monitor comprises second processing circuitry in communication with the one or more sensors and being configured to: cause transmission of a message comprising the one or more parameters to the monitoring device; the monitoring device comprises third processing circuitry configured to one or more of: receive the message; determine the battery event has occurred or a likelihood that the event will occur within a predetermined period of time based on one or both of the one or more parameters and a differential of the one or more parameters; and cause transmission of the one or more control signals to the suppression system to trigger the discharge of the suppression material of at least one of the one or more bags based on the determination that the battery event has occurred or the likelihood that the event will occur within the predetermined period of time.

13. The system of claim 11, wherein the one or more bags comprise one or both of: a first bag, the one or more parameters comprise a first parameter, and the container comprises a valve coupled to the first bag and configured to open when the first parameter reaches or exceeds a first parameter threshold to discharge the suppression material of the first bag; and a second bag, the one or more parameters comprise a second parameter, and the container comprises a pin arranged to puncture the second bag when the second parameter reaches or exceeds a second parameter threshold to discharge the suppression material of the second bag.

14. The system of claim 13, wherein the suppression material of the first bag and the second bag are discharged during a first discharge stage and a second discharge stage, respectively, based on the one or more parameters.

15. The system of claim 13, wherein one or more of: the valve is configured to receive a first control signal of the one or more control signals that triggers the valve to open to discharge the suppression material of the first bag; the opening of the valve is associated with a first exposure period in which the discharged suppression material is exposed to the battery; the pin is configured receive a second control signal of the one or more control signals that triggers the pin to puncture the second bag to discharge the suppression material of the second bag; and the puncturing of the second bag is associated with a second exposure period in which the discharged suppression material is exposed to the battery.

16. The system of claim 11, wherein the container comprises an exhaust port arranged to receive a third control signal of the one or more control signals that triggers the exhaust port to control a release of the discharged suppression material from the internal space, the release of the discharged suppression material being controlled by one or more of opening the exhaust port, closing the exhaust port, throttling the exhaust port based on the one or more parameters.

17. The system of claim 16, wherein the controlling of the release of the discharged suppression material by the exhaust port controls a third exposure period in which the discharged suppression material is exposed to the battery.

18. The system of claim 11, wherein the suppression material is arranged to flow through the internal space and absorb heat from one or more of the battery, the internal space, and the container.

19. The system of claim 11, wherein the system further comprises a fan configured to receive a fourth control signal of the one or more control signals, and the third processing circuitry is further configured to: cause transmission of the fourth control signal triggering the fan to be energized and to extract discharged suppression material from the system.

20. The system of claim 11, wherein one or more of: the one or more parameters include one or more of a battery temperature, a pressure associated with the internal space, a presence of the suppression material; the battery event is a thermal runaway event; and the discharged suppression material controls the thermal runaway event at least by causing the battery temperature to be less than a predetermined temperature threshold.

21.-**30**. (canceled)