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(54) Title: AN ENERGY STORAGE CELL

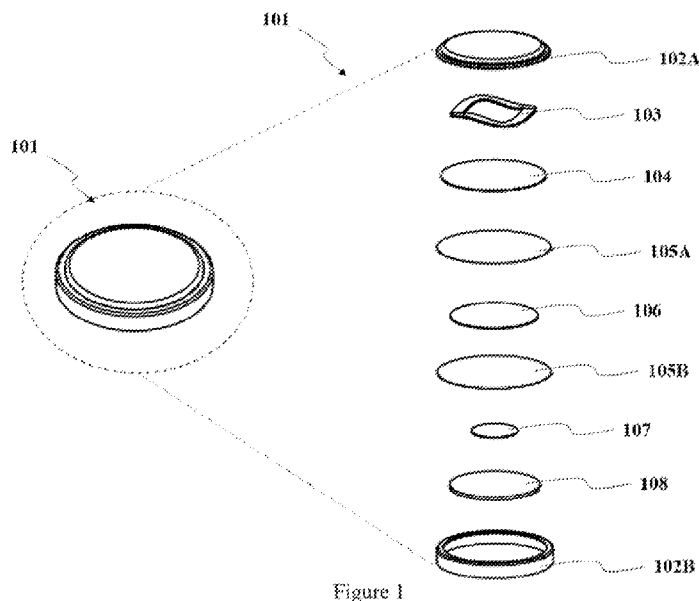


Figure 1

(57) Abstract: The present invention is related to an energy storage cell (101, 201) comprising an anode (104, 205), a cathode (107, 202), two or more separator (105, 203), and an intermittent electrode sheet (106, 204). The separator (105, 203) being disposed of between said intermittent electrode sheet (106, 204) and at least one of said anode (104, 205) and said cathode (107, 202). The intermittent electrode sheet (106, 204) being coated by predetermined material on both upper and bottom side surface to reduce the capacity loss. According to the above configuration, the intermittent electrode sheet (106, 204) increases the availability of lithium ions during cell operation. More specifically, the intermittent electrode (106, 204) serves as an additional Li⁺ (lithium ion) source which reduces the capacity loss. This improves the coulombic efficiency.

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RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM,
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AN ENERGY STORAGE CELL

TECHNICAL FIELD

[0001] The present subject matter relates to an energy storage cell. More particularly, to an energy storage cell for a powered device or product.

5

BACKGROUND

[0002] Existing research in battery technology is directed to rechargeable batteries, such as sealed, starved electrolyte, lead/acid batteries, are commonly used as power sources in different applications, such as, vehicles and the like. However, the lead-acid batteries are heavy, bulky, and have short cycle life, short calendar life, and low turn
10 around efficiency, resulting in limitations in applications.

[0003] Thus, in order to overcome problems associated with conventional energy storage devices including the lead-acid batteries, lithium-ion battery has emerged as a preferred solution which provides an ideal system for high energy-density applications, improved rate capability, and safety. Further, the rechargeable energy
15 storage devices - lithium-ion batteries exhibit one or more beneficial characteristics which makes it useable on powered devices. First, for safety reasons, the lithium-ion battery is constructed of all solid components while still being flexible and compact. Secondly, the energy storage device including the lithium-ion battery exhibits similar conductivity characteristics to primary batteries with liquid electrolytes, i.e., deliver
20 high power and energy density with low rates of self-discharge. Thirdly, the energy storage device as the lithium-ion battery is readily manufacturable in a manner that it is both reliable and cost-efficient. Finally, the energy storage device including the lithium-ion battery is able to maintain a necessary minimum level of conductivity at sub-ambient temperatures.

25 [0004] In a known structure for an energy storage device, one or more energy storage cells including lithium-ion battery cells are disposed in at least one holder structure in series and parallel combinations using at least one interconnecting structure. The interconnecting structure is adapted for electrically interconnecting the energy storage cells with a battery management system (hereinafter "BMS"). An

output voltage and an output current generated by the energy storage device is transmitted to one or more electronic and electrical components configured to be powered by the energy storage device via end connections after being monitored and regulated by the BMS.

- 5 [0005] The above information disclosed in this Background section is only for enhancement of understanding of the background of the disclosure and therefore it may contain information that does not form the prior art that is already known in this country to a person of ordinary skill in the art.

10

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The present invention is described with reference to an exemplary embodiment of a cell of Lithium-ion battery. The same numbers are used throughout the drawings to reference like features and components. Further, the inventive features of the invention are set forth in the appended claims.

- 15 [0007] Non-limiting and non-exhaustive embodiments of the invention are described with reference to the following figures, wherein like reference numerals refer to like parts throughout the various views unless otherwise specified. It should be appreciated that the following figures may not be drawn to scale.

[0008] Descriptions of certain details and implementations follow, including a
20 description of the figures, which may depict some or all of the embodiments described below, as well as a discussion of other potential embodiments or implementations of the inventive concepts presented herein. An overview of embodiments of the invention is provided below, followed by a more detailed description with reference to the drawings.

- 25 [0009] **Figure 1** illustrates a perspective view and an exploded view of an energy storage cell (101, 201), as per embodiment, in accordance with one example of the present subject matter.

[00010] **Figure 2** illustrates a perspective view and an exploded view of an energy storage cell (101, 201), as per alternative embodiment, in accordance with one example
30 of the present subject matter.

[00011] **Figure 3a** illustrates a graphical representation depicting the difference between total charge capacity and total discharge capacity for the conventional energy storage cell.

[00012] **Figure 3b** illustrates a graphical representation depicting the difference
5 between total charge capacity and total discharge capacity for the coin type energy storage cell (101) as per embodiment, in accordance with one example of the present subject matter.

[00013] **Figure 3c** illustrates a graphical representation depicting the difference
10 between total charge capacity and total discharge capacity for the pouch type energy storage cell (201), as per embodiment, in accordance with one example of the present subject matter.

DETAILED DESCRIPTION

[00014] In the following description, numerous details are set forth to provide a
15 thorough understanding of the embodiments. One skilled in the relevant art will recognize, however, that the techniques described herein can be practiced without one or more of the specific details, or with other methods, components, materials, etc. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring certain aspects.

20 [00015] Typically, the high costs of fossil-based fuel and its impact on pollution is leading to research and development of renewable energy storage technologies. Various energy storage devices include a fuel cell, lithium-ion batteries. Fuel cell is an electrochemical device that generates electricity on reaction between a fuel, i.e., hydrogen and oxygen. Pure oxygen or air containing a large amount of oxygen reacts
25 with pure hydrogen or a fuel containing a large amount of hydrogen in the fuel cell. Hydrogen may be generated by reforming a hydrocarbon fuel, such as methanol. The fuel is channeled through a flow field plate to an anode on one side of a proton exchange membrane in the fuel cell and oxygen is channeled through another flow field plate to the cathode on another side of the proton exchange membrane.
30 Electrochemical reactions occur at the anode and the cathode to produce electricity, water, and heat. In addition, the fuel cells have a long-lasting service life and high

energy density as compared to the conventional storage batteries. Different type of fuel cells includes a High temperature Proton exchange member fuel cell (hereinafter HTPEM FC) and Low temperature proton exchange member fuel cell (hereinafter LTPEM FC). The HTPEM FC works at high temperatures and LTPEMFC works at normal temperature. The heaters are essential for HTPEM FC and humidifiers for LTPEM. A fuel cell system controller controls the preheating, operation and shutdown of HTPEM FC stack. HTPEM FC has to be heated to its operating temperature before starting. This preheating is done by the heaters attached to the stack and the stack temperature is controlled by a closed loop PI controller. Once the operating temperature is attained, the reactants are supplied, hydrogen at anode and air at cathode side. Flow of hydrogen is regulated at the inlet by solenoid valve and at the outlet by proportional valve. The proportional valve is operated in such a way that it maximizes the hydrogen utilization and power by optimal purging. At cathode side, air intake is controlled by a variable speed blower. The blower speed is controlled with an adaptive feed forward PI controller for maintaining proper stoichiometric ratio of air to hydrogen and operating temperature. To shut down the system, at first the load and hydrogen supply will be disconnected and the blower will be operated at maximum speed to cool down the stack to a safe temperature. The bleeder circuit maintains the open circuit voltage of the stack within the safe limits. However, fuel cells are expensive to manufacture due to high cost of catalyst and hydrogen is expensive to produce and not widely available. To this end, lithium-ion batteries are one of the promising technologies. It is used as rechargeable batteries for electronics, transportation and grid storage.

[00016] However, it is observed that the useful life of the battery is limited by the battery aging process. The battery loses its energy storage capacity with use and time. The battery aging depends on an individual battery's application and usage pattern. Temperature is one of the most important operating factors. More specifically, lithium-ion batteries are widely used in laptop and other electronic gadgets. The lithium-ion battery age significantly when exposed to elevated temperature when operating and while charging. Further, it is observed rarely electronic gadgets like laptop are disconnected from the charger. Therefore, it is a common phenomenon the lithium-ion

battery loses much of its capacity. Additionally, the marketable feature of fast charge increases the temperature of the batteries significantly as the current batteries require a relatively long time to recharge. However, fast charging increases battery degradation and performance deterioration due to increased temperature in the
5 batteries

[00017] It is known in the prior art to limit temperature rise in batteries by circulating a liquid to the battery which is thermally conductive and electrically insulator. The liquid is stored in the liquid container and whenever the battery stops discharging, the BMS will allow liquid to flow into the battery through a valve V1/ pump. The liquid
10 flows around the heated cells and comes to contact with the casing which can dissipate the heat out. More specifically, while charging/discharging of battery if the battery temperature rises to 60 degree celsius, the BMS will open the valve V1 and circulates the fluid around the cells to bring down the temperature so as to avoid thermal runaway. The liquid is circulated back to the container once the battery reaches
15 atmospheric temperature. In this case the BMS will allow the flow of liquid from battery to the container by opening a valve V2. This way the temperature can be controlled inside battery so as to get more life. However, said system requires plurality of control valves, pump and complex algorithm. Moreover, the system it is observed said system is not effective and still the temperature tends to rise. Further, this
20 increased temperature leads to capacity loss in the lithium-based batteries. The three main reasons for the loss of capacity in the lithium-based batteries are due to loss of recyclable Li⁺ (lithium ion), loss of active material, and structural change of the active material. The loss of active material occurs due to its dissolution into electrocyclic either as a result of parasitic reactions, exposure of cell to high temperature operation
25 or wear and tear of the electrode surface as a result of repeated cycling. Prolonged cycling also results in the structural deformation of the active materials which effects the battery capacity either by trapping some of the recycle Li⁺ inside its interstitials which can no longer be extracted or structural changes which can no longer intercalate Li⁺ into them. The capacity loss occurring as a result of all the above-mentioned
30 causes cannot be compensated for during the battery operation. To address said issues it is known in the prior art to increases the capacity of the batteries more than required

capacity by providing a grace in case of capacity loss. However, this significantly increases the size, weight, and cost of the battery.

[00018] Therefore, it is a challenge for design engineers to develop an efficient battery with improved battery life and to reduce the impact of fast charging which is
5 counterintuitive in nature as the fast charging significantly increases the battery temperature and expedites the life cycle aging.

[00019] Therefore, there is a need to provide an improved lithium ion-based battery for a powered device or product overcoming all the above problems & trade-offs as well as overcoming problems of the known art.

10 [00020] It is an object of the present invention to improve the life of lithium-based battery.

[00021] It is another objective of the present invention to reduce the capacity loss of the lithium-based battery and to reduce its the charging time.

[00022] To this end, the present invention discloses an energy storage cell.
15 comprising an anode, a cathode, two or more separator, and an intermittent electrode sheet. The separator being disposed of between said intermittent electrode sheet and at least one of said anode and said cathode. As per an aspect of the present invention, said intermittent electrode sheet being coated by predetermined material on both upper and bottom side surface to reduce the capacity loss.

20 [00023] According to the above configuration, one of the advantages of the present invention is that the intermittent electrode increases the availability of lithium ions during cell operation. More specifically, the intermittent electrode serves as an additional Li^+ (lithium ion) source which reduces the capacity loss. This improves the charge- discharge efficiency and coulombic efficiency i.e., achieve higher total
25 discharge capacity as compared to charge capacity.

[00024] As per one embodiment of the present invention, said two or more separator include an anode separator and a cathode separator, wherein said cathode separator being sandwiched between said cathode and said intermittent electrode sheet.

[00025] As per another embodiment of the present invention, said anode separator
30 being sandwiched between said anode and said intermittent electrode sheet.

- [00026] As per yet another embodiment of the present invention, said anode comprises an anode active material coated onto at least one side of an anode current collector film, said anode active material composition includes silica-graphite (SiO₂-C).
- 5 [00027] As per one embodiment of the present invention, said anode current collector film being made up of copper.
- [00028] As per another embodiment of the present invention, said cathode comprises a cathode active material, wherein said cathode active material coated on a cathode current collector film, wherein said cathode active material is made up of at least one
- 10 of said Lithium Nickel Manganese Cobalt Oxide, Lithium Nickel Cobalt Aluminum Oxide, Lithium Manganese Oxide, Lithium Iron Phosphate, Lithium Cobalt Oxide.
- [00029] As per yet another embodiment of the present invention, said cathode current collector film is made up of aluminum.
- [00030] As per one embodiment of the present invention, said intermittent electrode
- 15 sheet is configured with predetermined thickness from 100 microns to 1000 microns.
- [00031] As per one embodiment, the energy storage cell includes a coin type energy storage cell.
- [00032] As per alternative embodiment of the present invention, said energy storage cell includes a pouch type energy storage cell.
- 20 [00033] As per one implantation of the present invention, a battery pack comprises a battery module, said battery module includes one or more energy storage cell as described above.
- [00034] The present subject matter is further described with reference to accompanying figures. It should be noted that the description and figures merely
- 25 illustrate the principles of the present subject matter. Various arrangements may be devised that, although not explicitly described or shown herein, encompass the principles of the present subject matter. Moreover, all statements herein reciting principles, aspects, and examples of the present subject matter, as well as specific examples thereof, are intended to encompass equivalents thereof.
- 30 [00035] The foregoing disclosure is not intended to limit the present disclosure to the precise forms or particular fields of use disclosed. As such, it is contemplated that

various alternate embodiments and/or modifications to the present disclosure, whether explicitly described or implied herein, are possible in light of the disclosure. Having thus described embodiments of the present disclosure, a person of ordinary skill in the art will recognize that changes may be made in form and detail without departing from
5 the scope of the present disclosure. Thus, the present disclosure is limited only by the claims.

[00036] In the foregoing specification, the disclosure has been described with reference to specific embodiments. However, as one skilled in the art will appreciate, various embodiments disclosed herein can be modified or otherwise implemented in
10 various other ways without departing from the spirit and scope of the disclosure. Accordingly, this description is to be considered as illustrative and is for the purpose of teaching those skilled in the art the manner of making and using various embodiments of the disclosure. It is to be understood that the forms of the disclosure herein shown and described are to be taken as representative embodiments. Equivalent
15 elements, materials, processes or steps may be substituted for those representatively illustrated and described herein. Moreover, certain features of the disclosure may be utilized independently of the use of other features, all as would be apparent to one skilled in the art after having the benefit of this description of the disclosure. Expressions such as “including”, “comprising”, “incorporating”, “consisting of”,
20 “have”, “is” used to describe and claim the present disclosure are intended to be construed in a non-exclusive manner, namely allowing for items, components or elements not explicitly described also to be present. Reference to the singular is also to be construed to relate to the plural.

[00037] Further, various embodiments disclosed herein are to be taken in the
25 illustrative and explanatory sense, and should in no way be construed as limiting of the present disclosure. All joinder references (e.g., attached, affixed, coupled, connected, etc.) are only used to aid the reader's understanding of the present disclosure, and may not create limitations, particularly as to the position, orientation, or use of the systems and/or methods disclosed herein. Therefore, joinder references,
30 if any, are to be construed broadly. Moreover, such joinder references do not necessarily infer that two elements are directly connected to each other.

[00038] Additionally, all numerical terms, such as, but not limited to, “first”, “second”, “third”, “primary”, “secondary”, “main” or any other ordinary and/or numerical terms, should also be taken only as identifiers, to assist the reader's understanding of the various elements, embodiments, variations and/or modifications of the present disclosure, and may not create any limitations, particularly as to the order, or preference, of any element, embodiment, variation and/or modification relative to, or over, another element, embodiment, variation and/or modification.

[00039] It will also be appreciated that one or more of the elements depicted in the drawings/figures can also be implemented in a more separated or integrated manner, or even removed or rendered as inoperable in certain cases, as is useful in accordance with a particular application. Additionally, any signal hatches in the drawings/figures should be considered only as exemplary, and not limiting, unless otherwise specifically specified.

[00040] The embodiments of the present invention will now be described in detail with reference to the accompanying drawings.

[00041] **Figure 1** illustrates a perspective view and an exploded view of a coin type energy storage cell (101), as per embodiment, in accordance with one example of the present subject matter. The coin type energy storage cell (101), includes an anode (104), a cathode (107), two or more separator (105A, 105B), a spacer (108), a spring (103), and an intermittent electrode sheet (106). The anode (104) comprises an anode active material coated onto the anode current collector film (not shown). The anode active material composition includes graphite and silica. (SiO₂-C). The anode current collector film (not shown) is made up of copper. The cathode (107) includes a cathode active material coated on to the cathode collector film (not shown). The cathode active material includes at one of said lithium nickel manganese cobalt oxide, Lithium Nickel Cobalt Aluminum Oxide, Lithium Manganese Oxide, Lithium Iron Phosphate, Lithium Cobalt Oxide are used as cathode materials of lithium-ion cell. As per preferred embodiment, said cathode (107) is coated with Lithium nickel cobalt magnesium oxide. More specifically, cathode (107) is coated with Li (Ni_{0.8}Co_{0.1}Mn_{0.1}) O₂ which improves the energy density of the said coin type electrochemical cells (101) which provides greater storage capacity. The cathode current collector film (not

shown) is made up of Aluminum. The two or more separator (105) includes said anode side separator (105A) and said cathode side separator (105B). The separator (105) is a physical barrier to prevent contact between anode (104) and cathode (107) and thus avoids short circuiting the coin type energy storage cell (101). The cathode separator
5 (105B) is sandwiched between said cathode (107) and said intermittent electrode sheet (106). The anode separator (105A) being sandwiched between said anode (104) and said intermittent electrode sheet (106). The spacer (108) being sandwiched between the second end casing (102B) and the cathode (107). Further, the spring (103) being sandwiched between the anode (104) and said first end casing (102A). The first end
10 casing (105A) and the second end casing (105B) are cast on metal foils that provide electronic connection to the external circuit, and being circumferentially attached to each other. The intermittent electrode sheet (106) being coated on both upper side surface (not shown) and bottom side surface (not shown) to reduce the capacity loss. The upper side surface (not shown) and bottom side surface (not shown) being coated
15 with a predetermined material. The predetermined material includes lithium titanate. As per preferred embodiment, the intermittent electrode sheet (106) has predetermined thickness from 100 microns to 1 milli meter.

[00042] **Figure 2** illustrates a perspective view and an exploded view of a pouch type energy storage cell (201), as per alternative embodiment, in accordance with one
20 example of the present subject matter. The pouch type energy storage cell (201) includes an anode (205), a cathode (202), two or more separator (203), and an intermittent electrode sheet (204). The two or more separator (203) includes said anode side separator (203A) and said anode side separator (203B). The cathode separator (203) sandwiched between said cathode (202) and said intermittent electrode sheet
25 (204). The anode separator (203A) being sandwiched between said anode (205) and said intermittent electrode (204). As per illustrated embodiment, the pouch type energy storage cell (201) being configured to have at least one terminal which arises out of said anode (205) and said cathode (202).

[00043] **Figure 3a** illustrates a graphical representation depicting the difference
30 between total charge capacity and total discharge capacity for the conventional energy storage cell. **Figure 3b** illustrates a graphical representation depicting the difference

between total charge capacity and total discharge capacity for the coin type energy storage cell (101) as per embodiment, in accordance with one example of the present subject matter. **Figure 3c** illustrates a graphical representation depicting the difference between total charge capacity and total discharge capacity for the pouch type energy storage cell (201), as per embodiment, in accordance with one example of the present subject matter. For sake of brevity, Figure 3a, 3b, and 3c will be discussed together. Preferably, the vertical axis signifies the electric capacity in milliamp hours (mAh) and the horizontal axis signifies the number of cycles. Each cycle includes a charge and a discharge. During charging and discharging the ions shuffles between the cathode and the anode. More specifically, during charging the ions flow from the cathode to the anode. However, during discharge the ions flow from the anode to the cathode through the separator. In other words, the anode undergoes oxidation i.e., loss of electrons, and cathode undergo reduction i.e., gain of electrons. The curve C represent total discharge capacity and curve D represents total charge capacity in a conventional energy storage cell. The curve A represents total discharge capacity and curve B represents total charge capacity in coin type cell. Further, the curve A' represents total discharge capacity and curve B' represents total charge capacity in pouch type cell. As shown in the graph, for each cycle the conventional energy storage cell having less total discharge capacity than the total charge capacity. However, as per present invention the proposed coin type energy storage cell and the pouch type energy storage cell having higher total discharge capacity than the total charge capacity which improves the coulombic efficiency. The coulombic efficiency defined as $Q_{\text{Discharge}}/Q_{\text{Charge}} \times 100$. Importantly, the improved coulombic efficiency indicates an improved battery cycle life. As per one embodiment, the intermittent electrode sheet supplies Li^+ ions during cell operation which balances the lost Li^+ content which improves the cell performance as well as its longevity. As per one embodiment, Li^+ ion moves from intermittent electrode sheet positioned closer to the cathode and the anode which enables fast charging.

[00044] The above-described embodiments, and particularly any “preferred” embodiments, are possible examples of implementations and merely set forth for a clear understanding of the principles of the invention. It will be apparent to those

skilled in the art that changes in form, connection, and detail may be made therein without departing from the spirit and scope of the invention.

List of Reference

5

101- Coin type cell	15 108- Spacer
102A - First end casing	201- Pouch type cell
102B - Second end casing	201A - Anode terminal
103- Spring	201B - Cathode terminal
10 104- Anode	202 - Cathode
105A - Anode Separator	20 203A - Anode Separator
105B - Cathode Separator	203B - Cathode Separator
106- Intermittent electrode	204 - Intermittent electrode
107- Cathode	205 - Anode

We Claim:

1. An energy storage cell (101, 201), comprising
an anode (104, 205);
a cathode (107, 202);
5 two or more separator (105, 203); and
an intermittent electrode sheet (106, 204),
wherein said separator (105, 203) being disposed of between
said intermittent electrode sheet (106, 204) and at least one of said
anode (104, 205) and said cathode (107, 202).
10
2. The energy storage cell (101, 201) as claimed in claim 1, wherein said two or
more separator (105, 203) includes an anode separator (105A, 203A) and a
cathode separator (105B, 203B), wherein said cathode separator (105B,
203B) being sandwiched between said cathode (107, 202) and said
15 intermittent electrode sheet (106, 204).
3. The energy storage cell (101, 201) as claimed in claim 1, wherein said anode
separator (105A, 203A) being sandwiched between said anode (104, 205) and
said intermittent electrode sheet (106, 204).
20
4. The energy storage cell (101, 201) as claimed in claim 1, wherein said anode
(104, 205) comprises an anode active material coated onto at least one side of
an anode current collector film, said anode active material composition
25 includes silica-graphite (SiO₂-C).
5. The energy storage cell (101, 201) as claimed in claim 4, wherein said anode
current collector film being made up of copper.
- 30 6. The energy storage cell (101, 201) as claimed in claim 1, wherein said cathode
(107, 202) comprises a cathode active material, wherein said cathode active

material coated on a cathode current collector film, wherein said cathode active material is made up of at least at one of said Lithium Nickel Manganese Cobalt Oxide, Lithium Nickel Cobalt Aluminum Oxide, Lithium Manganese Oxide, Lithium Iron Phosphate, Lithium Cobalt Oxide.

5

7. The energy storage cell **(101, 201)** as claimed in claim 6, wherein said cathode current collector film is made up of aluminum.

10 8. The energy storage cell **(101, 201)** as claimed in claim 1, wherein said intermittent electrode sheet **(106, 204)** being coated by predetermined material on both upper and bottom side surface to reduce the capacity loss.

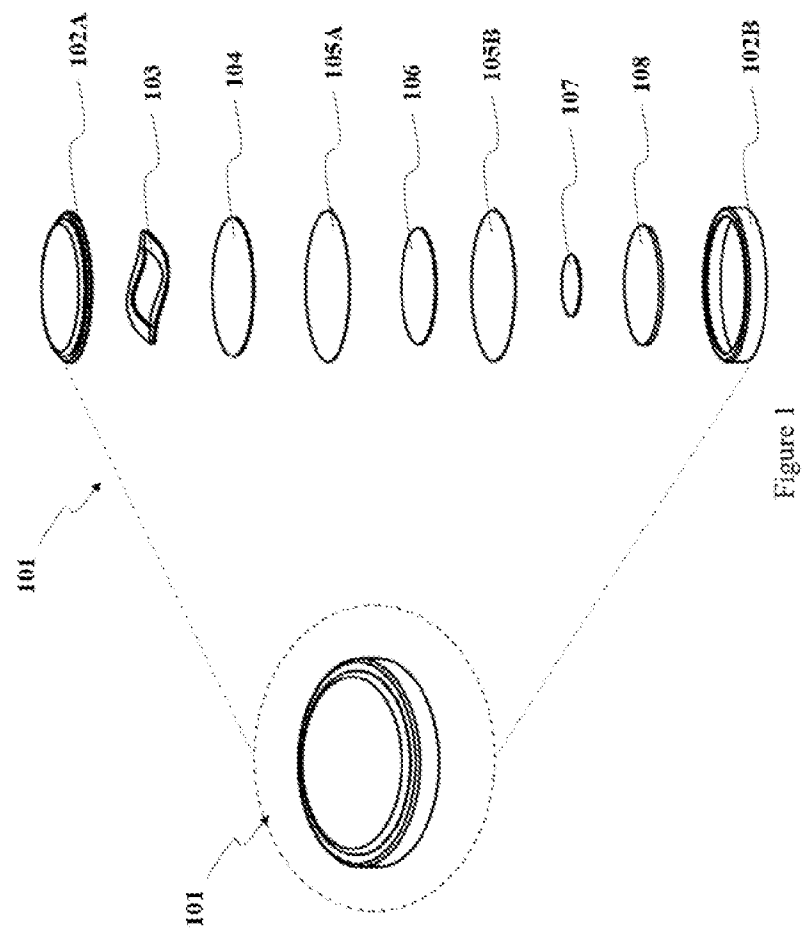
15 9. The energy storage cell **(101, 201)** as claimed in claim 1, wherein said intermittent electrode sheet **(106, 204)** is configured with predetermined thickness from 100 microns to 1000 microns.

10. The energy storage cell **(201)** as claimed in claim 1, wherein at least one terminal arises out of said anode **(205)** and said cathode **(202)**.

20

11. The energy storage cell **(101, 201)** as claimed in claim 1, wherein said energy storage cell **(101, 201)** includes at least one of a coin type energy storage cell **(101)** and a pouch type energy storage cell **(201)**.

25 12. A battery pack comprises a battery module, said battery module includes one or more energy storage cell as claimed in any of the preceding claims.



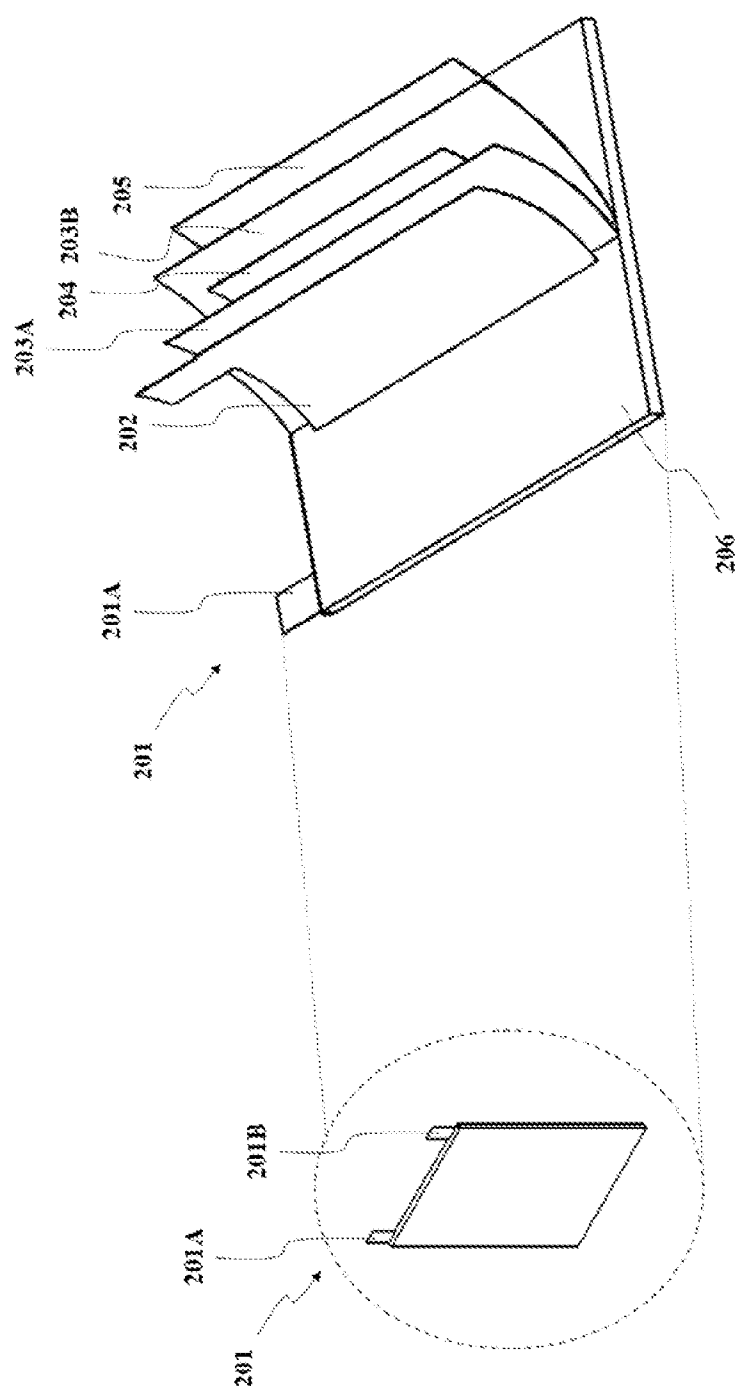
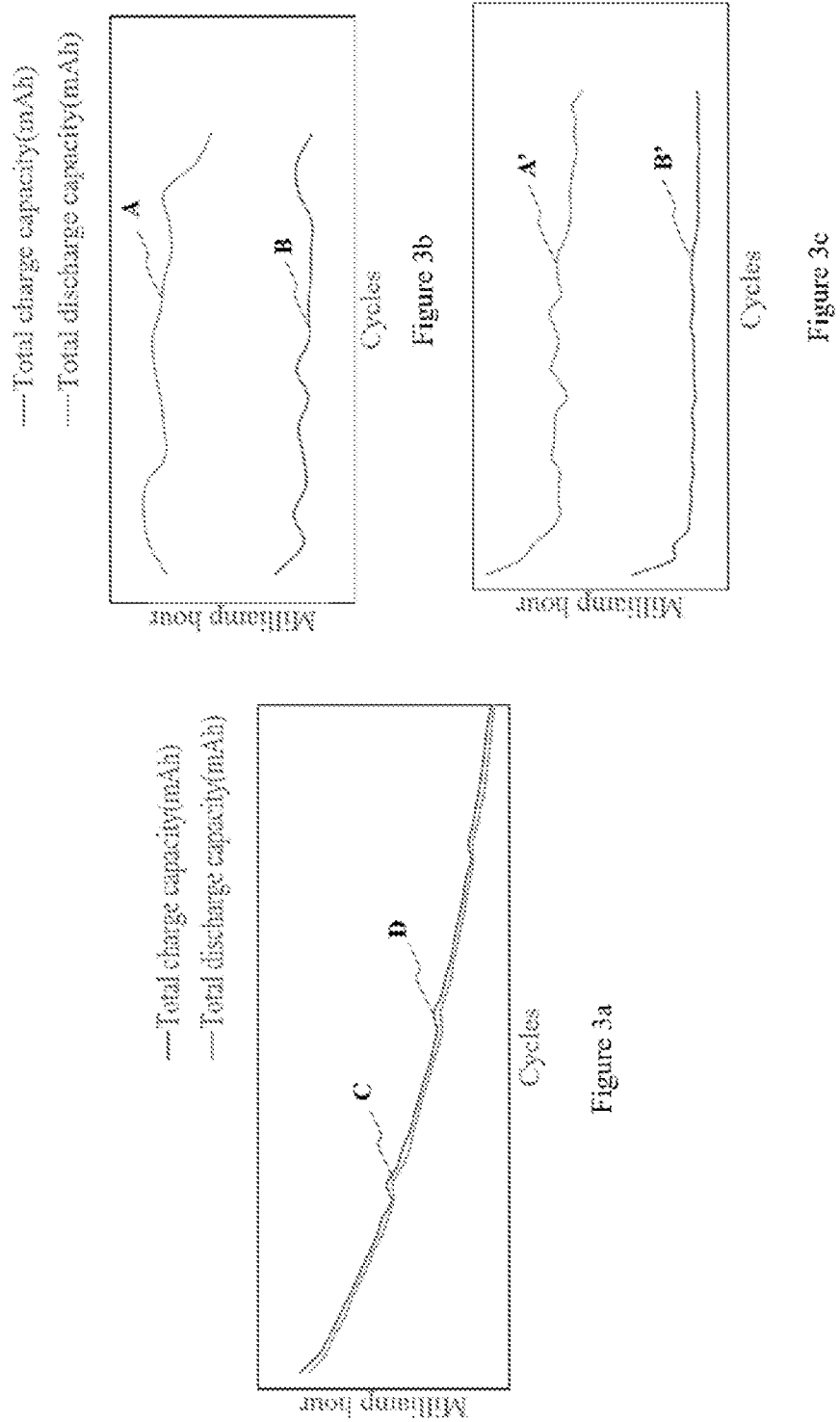


Figure 2



INTERNATIONAL SEARCH REPORT

International application No
PCT/IN2022/050260

A. CLASSIFICATION OF SUBJECT MATTER INV. H01M4/13 H01M4/38 H01M4/485 H01M4/505 H01M4/525 H01M4/58 H01M4/587 H01M10/0525 H01M50/105 H01M50/109 ADD. According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) H01M Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 882 012 A1 (TOYOTA MOTOR CO LTD [JP]) 10 June 2015 (2015-06-10) paragraphs [0018], [0022], [0086] - [0088], [0090]; figures 1-8 -----	1-3, 5-7, 9-12
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