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(54) **FLEXIBLE ELECTRODE ASSEMBLY AND RECHARGEABLE BATTERY INCLUDING THE SAME**

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(57) **ABSTRACT**

A rechargeable battery according to some embodiments includes a first electrode assembly including a first positive electrode and a first negative electrode disposed with a separator therebetween; and a second electrode assembly including a second positive electrode and a second negative electrode disposed with the separator therebetween. The first positive electrode and the second negative electrode may be alternately arranged in a matrix structure on one surface of the separator, the first negative electrode and the second positive electrode may be alternately arranged in a matrix structure on the other surface of the separator, and the separator may include a bendable bent portion disposed between rows or columns of the matrix structure.

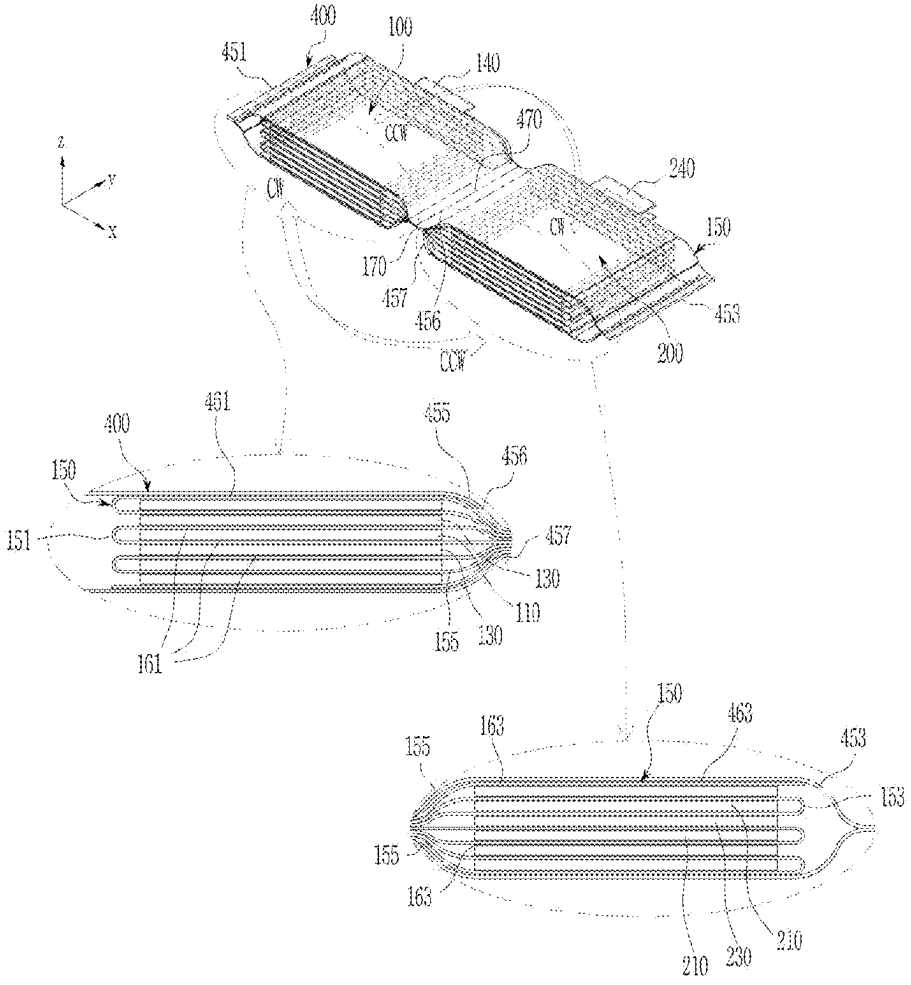
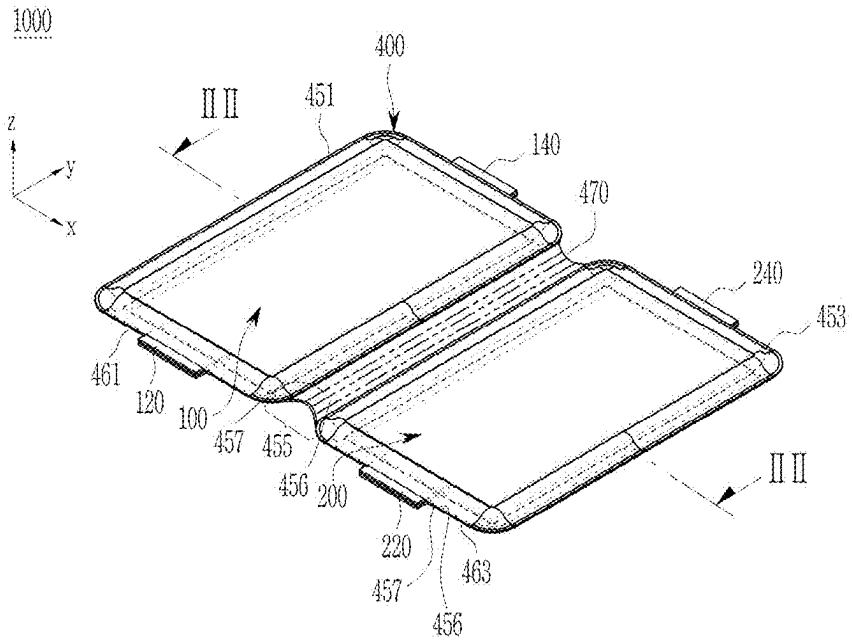


FIG. 1


1000
400
II
II
451
140
470
240
453
z
y
x
461
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100
457
455
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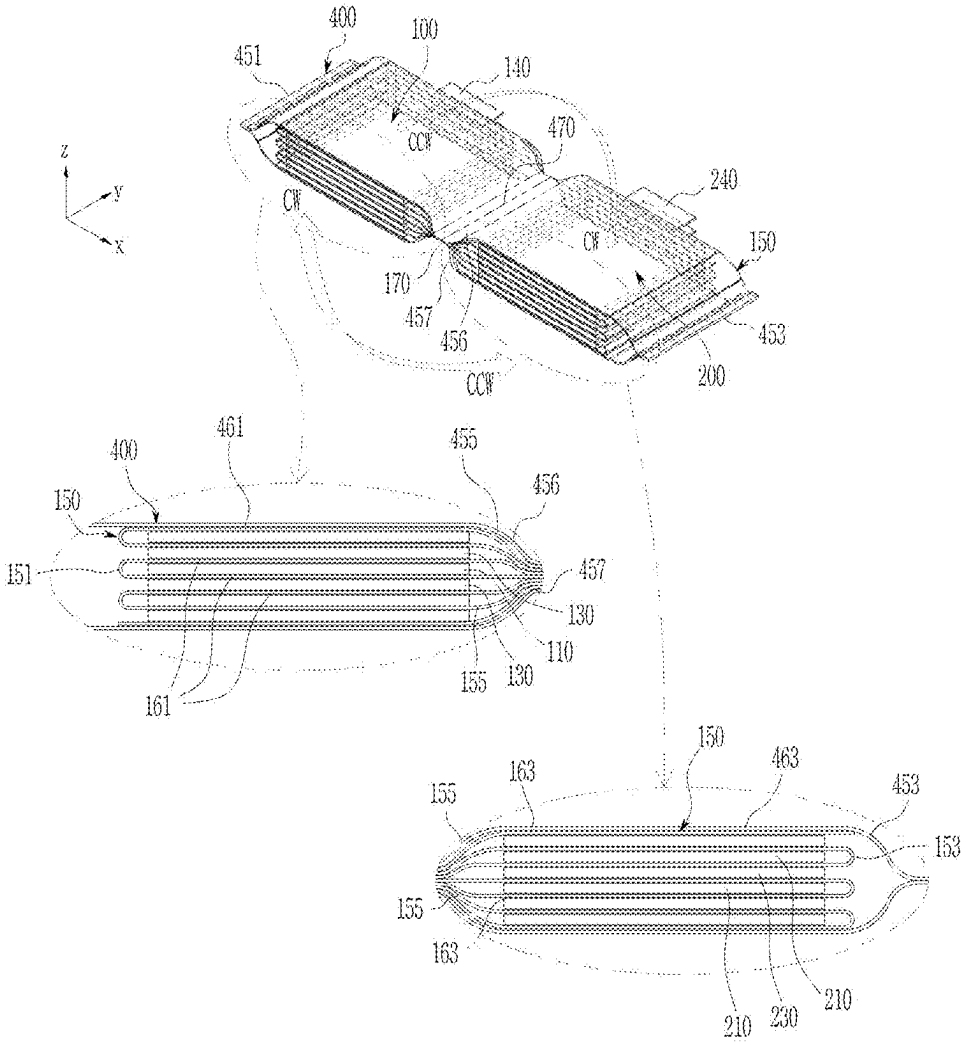
200
220
457
463
456
II
II

FIG. 2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451
140
470
CCW
CW
240
150
170
457
456
453
200
CCW
z
y
x
461
455
400
456
150
151
457
130
110
155
130
161
150
463
163
155
453
153
155
163
210
230
210

FIG. 3A

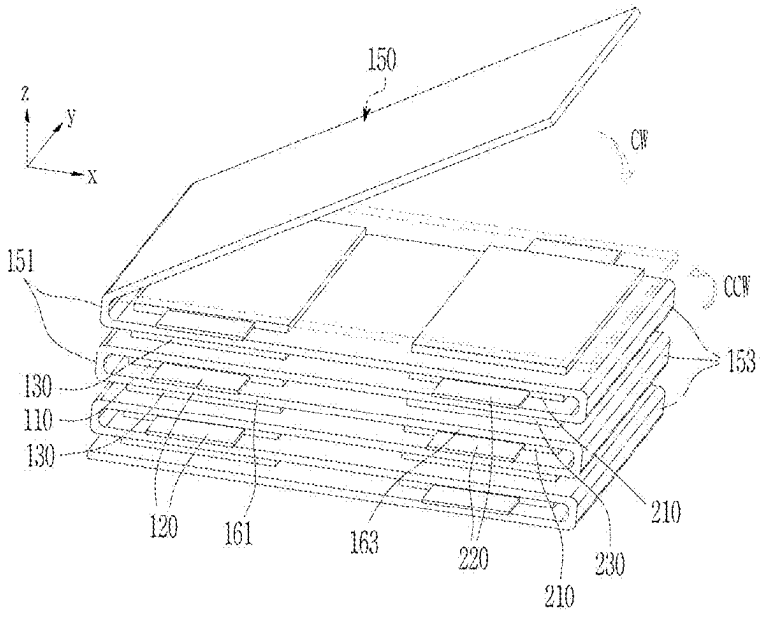


FIG. 3B

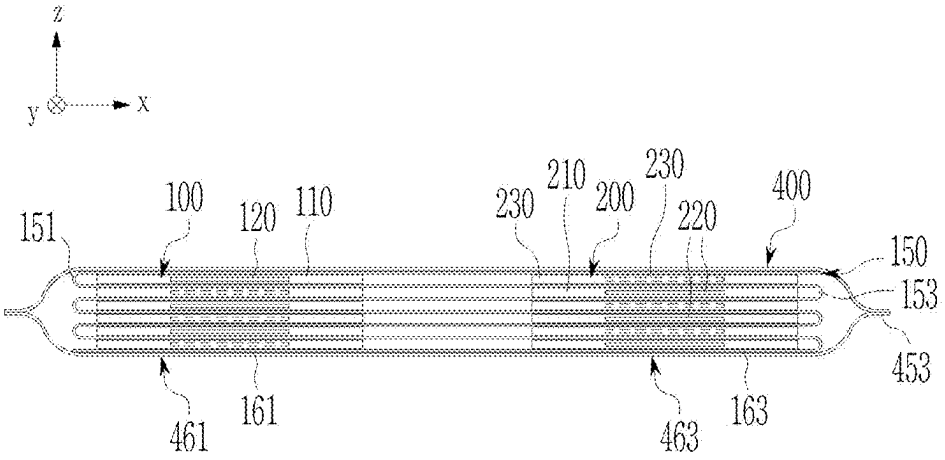
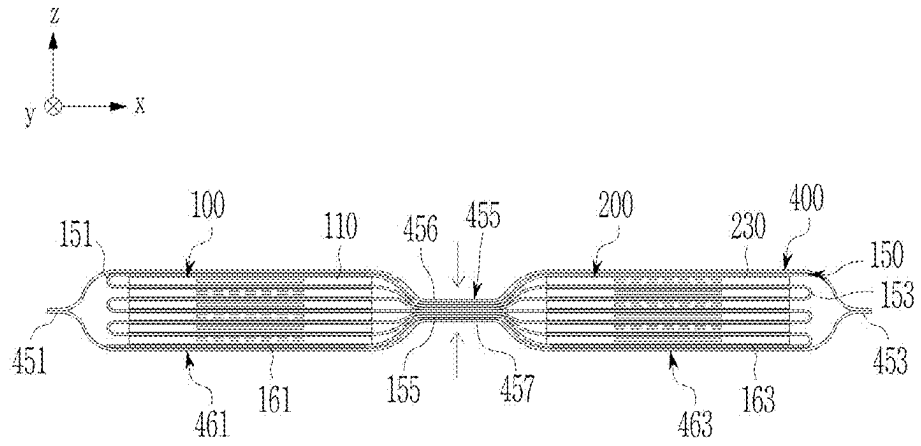

z
y
x
151
100
120
110
230
210
200
230
220
400
150
153
453
461
161
463
163

FIG. 3C


z
y
x
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110
456
455
200
230
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461
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463
163

FIG. 4

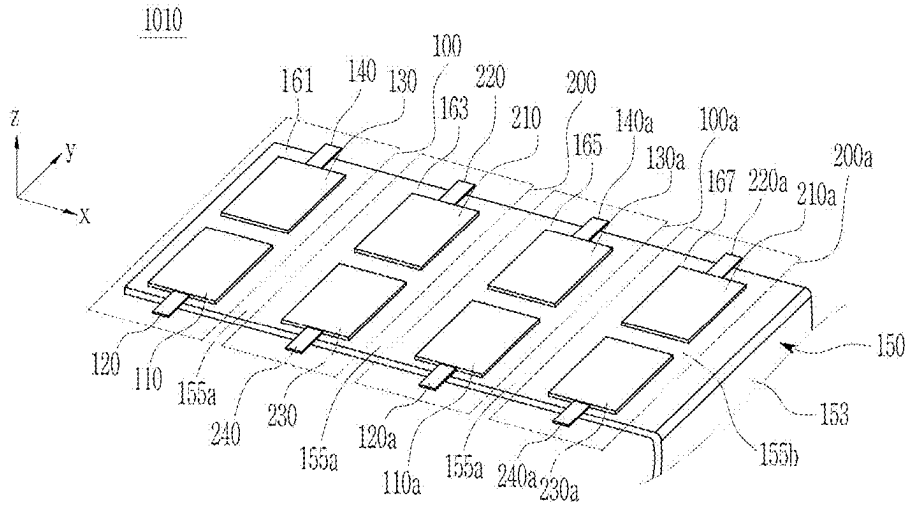
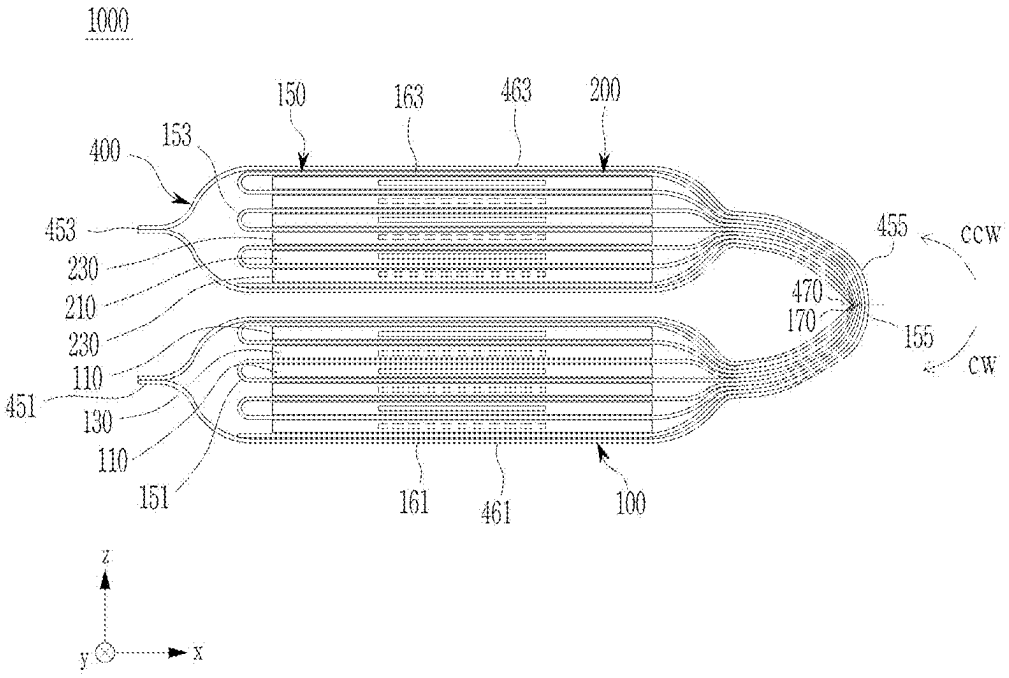

1010
100
161
140
130
220
200
163
210
140a
100a
165
130a
200a
167
220a
210a
z
y
x
150
120
110
155a
240
230
153
120a
155a
155b
110a
155a
240a
230a

FIG. 5


1000
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153
453
230
210
230
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130
110
151
161
461
100
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ccw
470
170
155
cw
z
y
x

FIG. 6

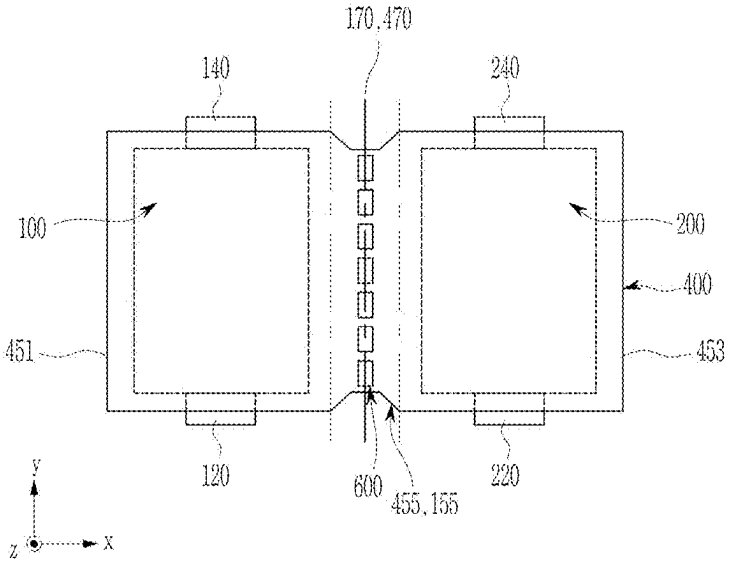


FIG. 7A

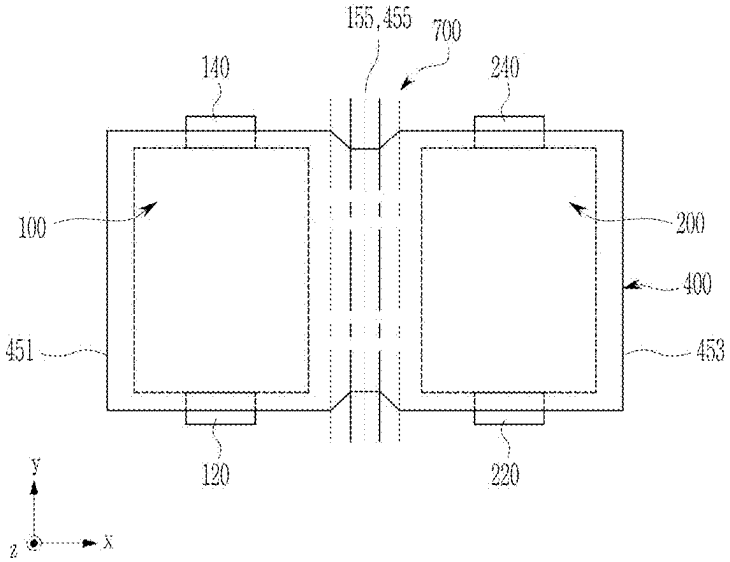
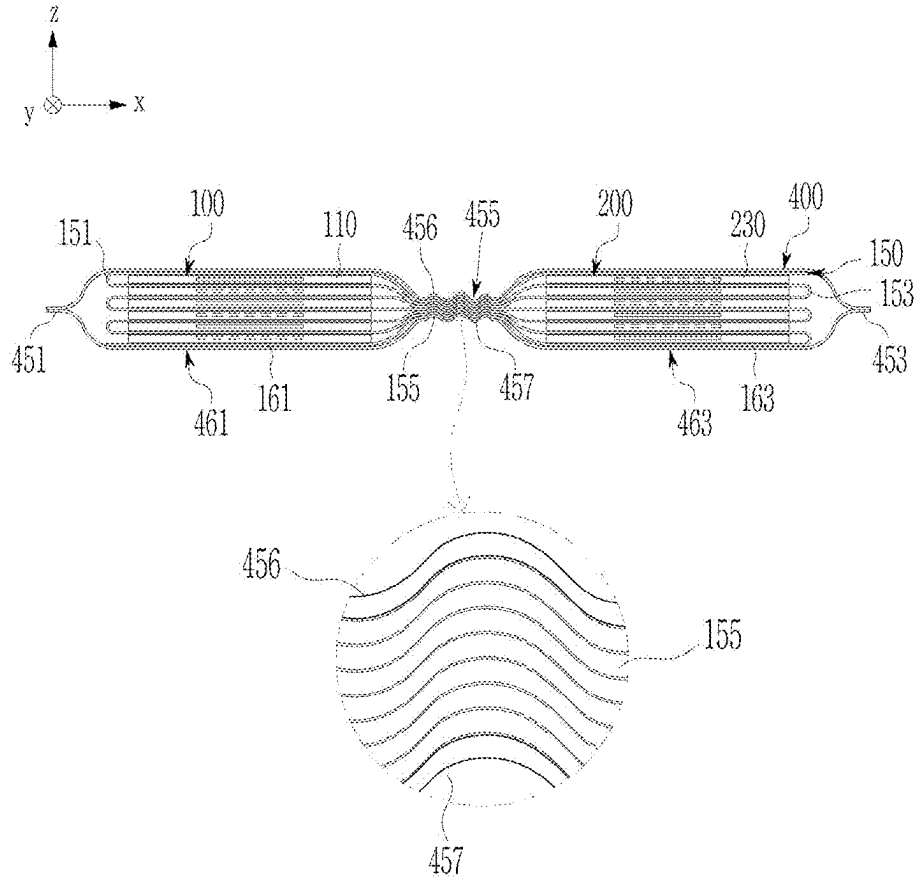


FIG. 7B


z
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456
155
457

FIG. 8

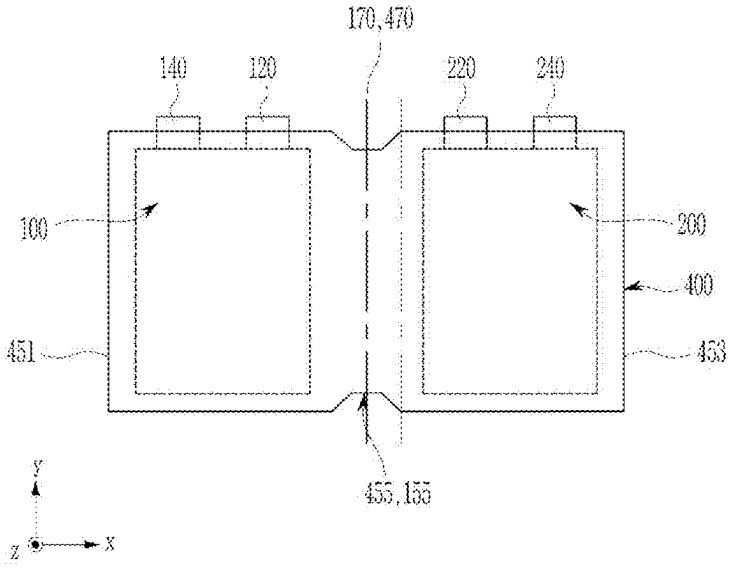


FIG. 9

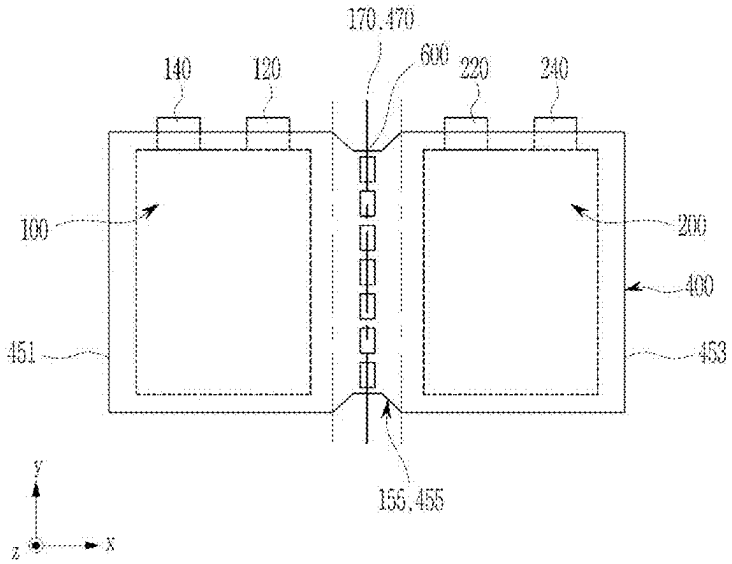


FIG. 10A

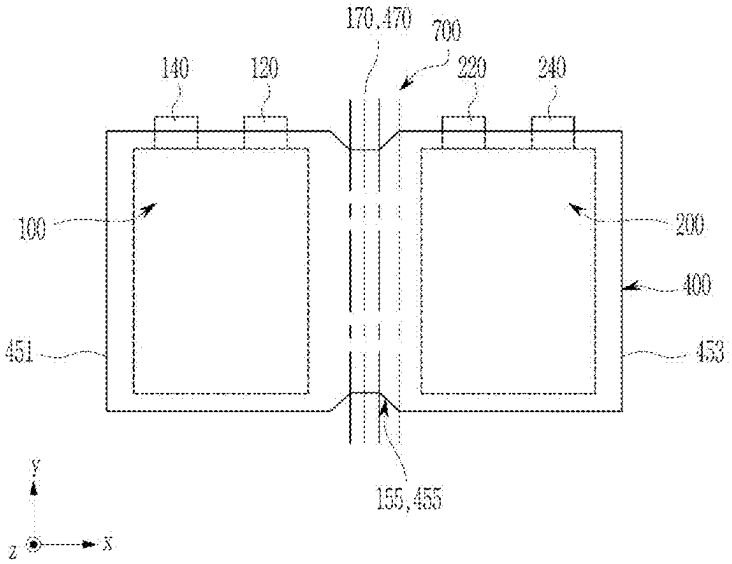
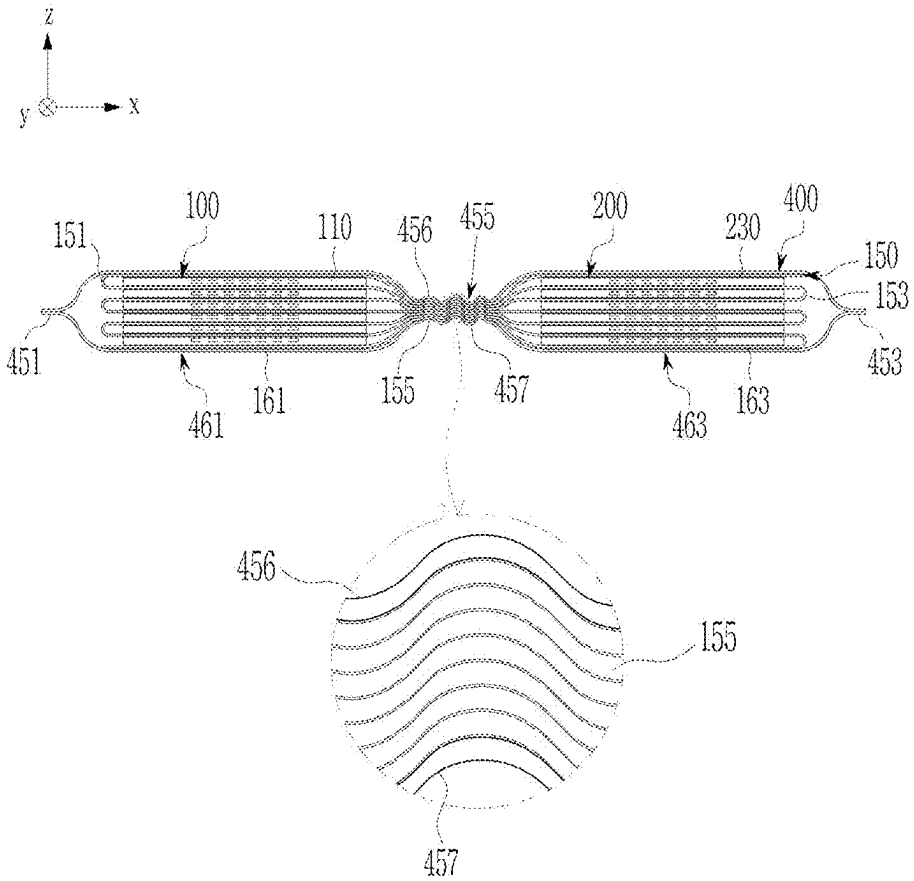


FIG. 10B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100
151
110
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455
200
230
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150
153
451
453
461
161
155
457
463
163
456
155
457

FIG. 11A

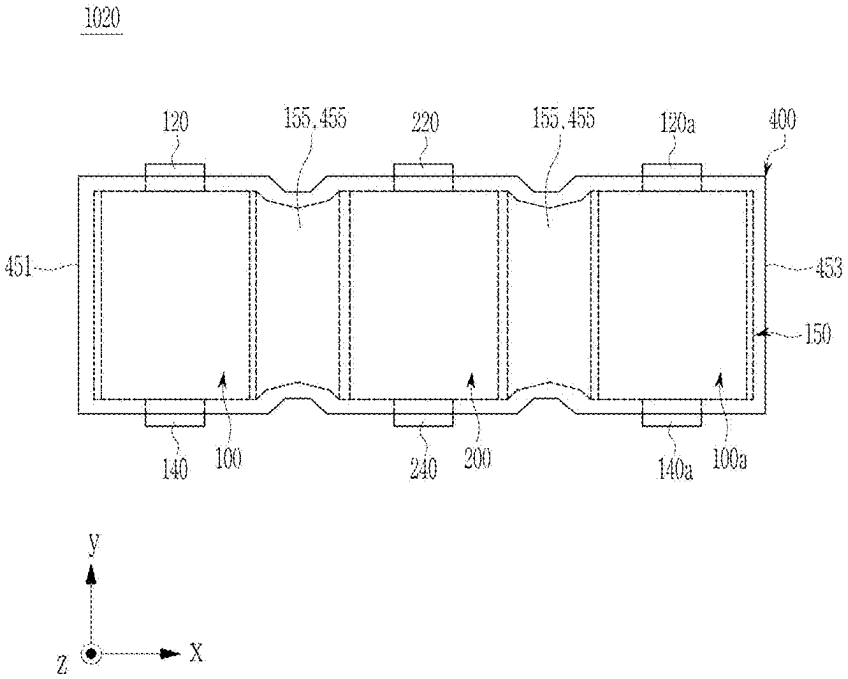
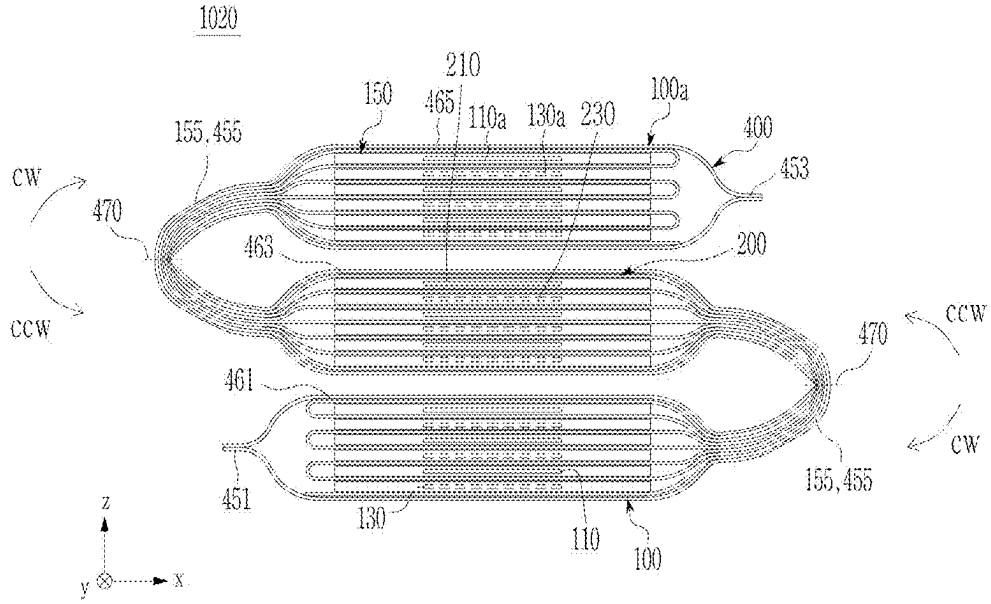

1020
120
155,455
220
155,455
120a
400
451
453
150
140
100
240
200
140a
100a
y
z
X

FIG. 11B


1020
210
150
465
110a
130a
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400
155,455
453
CW
470
463
200
CCW
CCW
470
461
CW
155,455
451
130
110
100
z
y
x

FLEXIBLE ELECTRODE ASSEMBLY AND RECHARGEABLE BATTERY INCLUDING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This present application claims priority to and the benefit under 35 U.S.C. § 119(a)-(d) of Korean Patent Application No. 10-2024-0025352, filed on Feb. 21, 2024, in the Korean Intellectual Property Office, the entire disclosure of which is incorporated herein by reference.

FIELD

[0002] The present disclosure relates to a flexible electrode assembly and a rechargeable battery including the same.

BACKGROUND

[0003] Unlike primary batteries, secondary batteries (rechargeable batteries) are repeatedly charged and discharged batteries. Small-capacity rechargeable batteries can be used in small, portable electronic devices, such as mobile phones, laptop computers, and camcorders. High-capacity and high-density rechargeable batteries have been used as power sources for driving motors in hybrid and electric vehicles or for energy storage.

[0004] The aforementioned information disclosed in the technology that forms the background of the present disclosure is only intended to improve understanding of the background of the present disclosure, and therefore may include information that does not constitute related art.

SUMMARY

[0005] According to some embodiments, the present disclosure provides an electrode assembly that may be deformed and a rechargeable battery including the same.

[0006] However, the technical problems to be solved by the present disclosure are not limited to the problems described herein, and other problems not mentioned may be clearly understood by those skilled in the art from the description of the disclosure described below.

[0007] According to some embodiments, a rechargeable battery includes: a first electrode assembly including a first positive electrode and a first negative electrode disposed with a separator therebetween; and a second electrode assembly including a second positive electrode and a second negative electrode disposed with the separator therebetween. The first positive electrode and the second negative electrode may be alternately arranged in a matrix structure on one surface of the separator, the first negative electrode and the second positive electrode may be alternately arranged in a matrix structure on the other surface of the separator, and the separator may include a bendable bent portion disposed between rows or columns of the matrix structure.

[0008] The first positive electrode and first negative electrode of the first electrode assembly may be alternately stacked in one direction, the second positive electrode and second negative electrode of the second electrode assembly may be alternately stacked in the one direction, and the first electrode assembly and the second electrode assembly may be separated by the bent portion.

[0009] A pivot line for bending or folding the first electrode assembly or the second electrode assembly may be provided at the bent portion.

[0010] The rechargeable battery may include one or more additional electrode assemblies.

[0011] The separator may have a continuous sheet shape.

[0012] The bent portion may include a first bent portion and a second bent portion arranged in a zigzag shape and a third bent portion disposed between the first bent portion and the second bent portion.

[0013] One or more openings may be provided in the third bent portion.

[0014] A wrinkle portion including a concave portion and a convex portion may be provided in the third bent portion.

[0015] A first positive electrode tab connected to the first positive electrode and a second positive electrode tab connected to the second positive electrode may protrude in the same direction, a first negative electrode tab connected to the first negative electrode and a second negative electrode tab connected to the second negative electrode may protrude in the same direction, and protruding directions of the first positive electrode tab and the second positive electrode tab may be opposite to protruding directions of the first negative electrode tab and the second negative electrode tab.

[0016] A first positive electrode tab connected to the first positive electrode and a second positive electrode tab connected to the second positive electrode may protrude in the same direction, a first negative electrode tab connected to the first negative electrode and a second negative electrode tab connected to the second negative electrode may protrude in the same direction, and protruding directions of the first positive electrode tab and the second positive electrode tab may be the same as protruding directions of the first negative electrode tab and the second negative electrode tab.

[0017] The rechargeable battery may further include: a pouch in which the first electrode assembly and the second electrode assembly are accommodated, wherein the pouch may include a foldable region bendable between rows or columns of the matrix structure to be a folded region.

[0018] The pouch may further include: a first electrode assembly accommodating portion accommodating the first electrode assembly; and a second electrode assembly accommodating portion accommodating the second electrode assembly, and the first electrode assembly accommodating portion and the second electrode assembly accommodating portion may be connected by the folded region

[0019] The bent portion may include first and second bent portions arranged in a zigzag shape; and a third bent portion disposed between the first bent portion and the second bent portion, wherein the third bent portion and the folded region may be thermally compressed.

[0020] According to other embodiments, a rechargeable battery includes: a separator including a first bent portion, a second bent portion, a third bent portion disposed between the first bent portion and the second bent portion, a plurality of first separation portions connected to the first bent portion and the third bent portion, and a plurality of second separation portions connected to the second bent portion and the third bent portion, wherein a first positive electrode and a first negative electrode of a first electrode assembly are separately disposed between the plurality of first separation portions, a second positive electrode and a second negative electrode of a second electrode assembly are separately disposed between the plurality of second separation por-

tions, the first bent portion is connected to one side of the first separation portion and has a bent shape so that the first positive electrode or the first negative electrode is surrounded by the first separation portion, the second bent portion is connected to one side of the second separation portion and has a bent shape so that the second positive electrode or the second negative electrode is surrounded by the second separation portion, and the third bent portion is connected to the other side disposed opposite to the one side of the first separation portion and to the other side disposed opposite to the one side of the second separation portion.

[0021] According to other embodiments, a method of manufacturing a rechargeable battery includes: alternately disposing a first electrode of each of the different electrode assemblies in a matrix structure on one surface of a continuous sheet-shaped separator; bending the continuous sheet-shaped separator in a direction of wrapping each first electrode to cover each first electrode with the separator; alternately disposing a second electrode of each of the different assemblies at each first electrode on the other surface of the continuous sheet-shaped separator; bending the continuous sheet-shaped separator in a direction covering each second electrode to cover each second electrode with the continuous sheet-shaped separator; and pressing the continuous sheet-shaped separator so that the different electrode assemblies are stacked by bent portions formed between rows or columns of the matrix structure.

[0022] According to some embodiments of the present disclosure, since the separator and the pouch include a plurality of bent portions, the flexible electrode assembly that may be stacked in various shapes and the rechargeable battery including the same may be provided.

[0023] According to some embodiments of the present disclosure, the electrode assembly and the rechargeable battery including the same may be stacked in various forms, so that a rechargeable battery accommodation space in a product may be utilized to the maximum.

[0024] According to some embodiments of the present disclosure, the rate of the rechargeable battery manufacturing process may be improved because the existing manufacturing process may be utilized as is.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] The drawings accompanying this specification illustrate embodiments of the present disclosure and serve to further understand the technical idea of the present disclosure together with the detailed description of the disclosure described below, so the present disclosure should not be construed as being limited to only the matters described in such drawings.

[0026] FIG. **1** is a perspective view illustrating a rechargeable battery according to some embodiments of the present disclosure.

[0027] FIG. **2** is a partially cross-sectional perspective view taken along line II-II shown in FIG. **1**.

[0028] FIG. **3**A is a perspective view illustrating a stacking process during the rechargeable battery manufacturing process according to some embodiments of the present disclosure.

[0029] FIG. **3**B is a schematic diagram illustrating a pouch process during the rechargeable battery manufacturing process according to some embodiments of the present disclosure.

[0030] FIG. **3**C is a schematic diagram illustrating a sealing and pressing process during the rechargeable battery manufacturing process according to some embodiments of the present disclosure.

[0031] FIG. **4** is a diagram illustrating the matrix structure of electrodes in at least one embodiment of the present disclosure.

[0032] FIG. **5** is a front view illustrating a third bent portion and a folded region in a bent state in the rechargeable battery according to the embodiments of FIGS. **1** to **3**.

[0033] FIG. **6** is a plan view illustrating an opening formed in the third bent portion and the folded region of a rechargeable battery according to some embodiments of the present disclosure.

[0034] FIG. **7**A is a plan view illustrating a state in which wrinkles are formed in the third bent portion and folded region of a rechargeable battery according to some embodiments of the present disclosure.

[0035] FIG. **7**B is a front view illustrating a state in which wrinkles are formed in the third bent portion and folded region of a rechargeable battery according to some embodiments of the present disclosure.

[0036] FIG. **8** is a plan view illustrating a state in which a tab of a first electrode and a tab of a second electrode of the rechargeable battery according to some embodiments of the present disclosure are in the same direction.

[0037] FIG. **9** is a plan view illustrating a state in which the tab of the first electrode and the tab of the second electrode of the rechargeable battery according to some embodiments of the present disclosure are in the same direction and an opening is formed in the third bent portion.

[0038] FIG. **10**A is a plan view illustrating a state in which the tab of the first electrode and the second electrode of a rechargeable battery according to some embodiments of the present disclosure are in the same direction and a wrinkle is formed in the third bent portion.

[0039] FIG. **10**B is a front view illustrating a state in which the tab of the first electrode and the second electrode of a rechargeable battery according to some embodiments of the present disclosure are in the same direction and a wrinkle is formed in the third bent portion.

[0040] FIG. **11**A is a plan view illustrating a rechargeable battery further including a third electrode assembly as an additional electrode assembly in the rechargeable battery according to the embodiments of FIGS. **1** to **3**.

[0041] FIG. **11**B is a diagram illustrating a state in which the first electrode assembly, the second electrode assembly, and the third electrode assembly of FIG. **11**A are stacked.

DETAILED DESCRIPTION

[0042] Hereinafter, embodiments of the present disclosure are described in detail with reference to the accompanying drawings. Prior to this, the terms or words used in this specification and claims should not be construed as being limited to their usual or dictionary meanings, and should be construed as meanings and concepts consistent with the technical idea of the present disclosure based on the principle that the inventor may appropriately define the concept of terms in order to describe his or her invention in the best way. Accordingly, the embodiments described in this specification and the configurations shown in the drawings are only some of the most preferred and/or exemplary embodiments of the present disclosure and do not represent the entire technical idea of the present disclosure. Therefore, it

should be understood that there may be various equivalents and variations that may replace them that may exist at the time of filing the present application.

[0043] In addition, when used herein, "comprise, include," and/or "comprising, including" specify the presence of mentioned features, numbers, steps, operations, members, elements, and/or groups thereof and does not exclude the presence or addition of one or more other shapes, numbers, operations, members, elements and/or groups.

[0044] In addition, in order to facilitate understanding of the disclosure, the accompanying drawings are not drawn to scale and the dimensions of some components may be exaggerated. In addition, the same components in different embodiments may be given the same reference numbers.

[0045] The statement that two objects of comparison are 'the same' means that they are 'substantially the same.'

[0046] Therefore, 'substantially the same' may include a deviation that is considered low in the art, for example, a deviation less than 5%. In addition, uniformity of a parameter in a certain region may refer to uniformity from an average perspective.

[0047] Although first, second, etc. are used to describe various components, these components are of course not limited by these terms. These terms are only used to distinguish one component from another component, and unless specifically stated to the contrary, a first component may also be a second component. In more detail, although the terms first, second, third, etc. may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. This term is used to distinguish one element, component, region, layer, or cross-section from another element, component, region, layer, or cross-section. Accordingly, a first element, component, region, layer, or section discussed below may be named a second element, component, region, layer, or section without departing from the teachings of the example embodiments.

[0048] Throughout the specification, unless otherwise stated, each component may be singular or plural.

[0049] The arrangement of any component on an "upper portion (or lower portion)" of a component or "above (or below)" a component may refer to not only that any component is disposed in contact with an upper surface (or a lower surface) of the component but also that another component is interposed between the component and any component disposed on (or under) the component.

[0050] In addition, when a component is described as "on," "connected to," or "coupled to" another component, those components may be directly connected to each other. However, it should be understood that other components may be "interposed" between each component or that each component may be "connected," "coupled," or "connected" through other components.

[0051] As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. In addition, the use of "may" when describing embodiments of the present disclosure relates to "one or more embodiments of the present disclosure."

[0052] Expressions, such as "one or more," and "one or more" preceding a list of elements, modify the entire list of elements and do not modify individual elements of the list

[0053] Throughout the specification, when referring to "A and/or B", it means A, B, or A and B, unless specifically stated to the contrary, and when referring to "C to D", it means that it is C or more and D or less unless specifically stated to the contrary.

[0054] When a phrase, such as "at least one of A, B and C", "at least one of A, B or C", "at least one selected from the group consisting of A, B and C" and "at least one selected from A, B and C" is used to specify a list of elements A, B, and C, the phrase may refer to any and all suitable combinations.

[0055] The term "use" may be considered to be synonymous with the term "utilize."

[0056] As used herein, the terms "substantially," "about," and similar terms are used as terms of approximation rather than terms of degree and are to consider inherent variations in measured or calculated values as would be recognized by a person of ordinary skill in the art.

[0057] For ease of description, spatial relative terms "beneath," "below," "lower," "above," "upper," etc. are used to describe the relationship of one element or feature to another element(s) or feature(s) as shown in the drawings. The spatially relative position will be understood to encompass different directions of a device in use or operation in addition to the direction depicted in the figures. For example, if a device in the drawing is turned over, elements described as located "below" or "in a lower portion of" other elements are understood to be "above" or "in an upper portion of" other elements. Therefore, the term "below" may encompass both upward and downward directions.

[0058] The terms used in this specification are for describing embodiments of the present disclosure and are not intended to limit the disclosure as discussed above.

[0059] In recent years, with the rapid expansion of the market for smartphones, tablet PCs, and wearable products, the need for bendable or foldable, that is, flexible, rechargeable batteries has emerged.

[0060] The design of electronic devices using rechargeable batteries has also changed in accordance with the preferences of consumers who want a variety of products day by day. Accordingly, there is a need for rechargeable batteries to be designed in accordance with the design of the electronic device to which the rechargeable battery is applied.

[0061] FIG. **1** is a perspective view illustrating a rechargeable battery **1000** according to some embodiments of the present disclosure. FIG. **2** is a cross-sectional view taken along line II II-II II in FIG. **1**.

[0062] Referring to FIGS. **1** and **2**, a rechargeable battery **1000** includes a plurality of electrode assemblies **100** and **200** and a container or pouch **400**, hereinafter referred to as a pouch for convenience, accommodating the plurality of electrode assemblies **100** and **200**. The rechargeable battery **1000**, according to the present embodiments, includes a first electrode assembly **100** and a second electrode assembly **200**, that is, two electrode assemblies.

[0063] Each electrode assembly **100** or **200** includes at least one first electrode **110** and **210**, at least one second electrode **130** and **230**, and a separator **150**. At least one first electrode **110** and **210** is connected to first electrode tabs **120** and **220**, respectively. At least one second electrode **130** and **230** is connected to second electrode tabs **140** and **240**, respectively.

[0064] The first electrodes **110** and **210** may be a positive electrode or a negative electrode, and the second electrodes **130** and **230** may also be a positive electrode or a negative

electrode. The first electrode **110** of the first electrode assembly **100** and the first electrode **210** of the second electrode assembly **200** may be electrodes having the same polarity, and the second electrode **130** of the first electrode assembly **100** and the second electrode **230** of the second electrode assembly **200** may be electrodes having the same polarity.

[0065] For example, when the first electrode **110** of the first electrode assembly **100** is a first negative electrode, the first electrode **210** of the second electrode assembly **200** may be a second negative electrode, and when the second electrode **130** of the first electrode assembly **100** is a first positive electrode, the second electrode **230** of the second electrode assembly **200** may be a second positive electrode. When the second electrode **130** of the first electrode assembly **100** is a first negative electrode, the second electrode **230** of the second electrode assembly **200** may be a second negative electrode, and when the first electrode **110** of the first electrode assembly **100** is a first positive electrode, the first electrode **210** of the second electrode assembly **200** may be a second positive electrode.

[0066] However, the first electrodes **110** and **210** and the second electrodes **130** and **230** do not have the same polarity. For example, when the first electrodes **110** and **210** are positive electrodes, the second electrodes **130** and **230** may be negative electrodes, and when the first electrodes **110** and **210** are negative electrodes, the second electrodes **130** and **230** may be positive electrodes.

[0067] In the x-y-z coordinate axes shown in FIGS. **1** and **2** (the same are applied to other drawings described below), the x-axis may be a major side direction of the rechargeable battery **1000** or a minor side direction of the first electrodes **110** and **210** and the second electrodes **130** and **230**. The y-axis may be a direction perpendicular to the x-axis and may be a minor side direction of the rechargeable battery **1000** or a major side direction of the first electrodes **110** and **210** and the second electrodes **130** and **230**. Moreover, the y-axis may be a direction in which the electrode tabs **120**, **140**, **220**, and **240** of the first electrode assembly **100** and the second electrode assembly **200** respectively protrude. The z-axis is a direction perpendicular to both the x-axis and the y-axis and may be a width direction of the rechargeable battery **1000**, the first electrodes **110** and **210**, and the second electrodes **210** and **230**.

[0068] Both electrode assemblies **100** and **200** may be arranged to be spaced apart on the same plane. For example, the two electrode assemblies **100** and **200** may be arranged side by side on the x-y plane at a certain interval along the x-axis. For example, the positive electrode assemblies **100** and **200** may be arranged in a matrix structure on the x-y plane. In the present embodiments, the positive electrode assemblies **100** and **200** may be arranged in a 1×2 matrix structure on the x-y plane.

[0069] As shown in FIG. **2**, the first electrode **110** and the second electrode **130** of the first electrode assembly **100** are alternately stacked in the z-axis direction. That is, the first electrode **110** and the second electrode **130** of the first electrode assembly **100** are alternately stacked. The first electrode **210** and the second electrode **230** of the second electrode assembly **200** may also be stacked in the same manner. However, the first electrode **210** and the second electrode **230** of the second electrode assembly **200** may alternate with the first electrode **110** and the second electrode **130** of the first electrode assembly **100** in a stacking order.

[0070] For example, when the first electrode **110** is disposed at the top of the first electrode assembly **100** based on FIGS. **1** and **2**, the first electrode tab **120** of the first electrode **110** protrudes in the −y axis direction (forward direction based on FIG. **1**), and the second electrode **230** is disposed at the top of the second electrode assembly **200**, so that the second electrode tab **240** of the second electrode **230** protrudes in the +y axis direction (rearward direction based on FIG. **1**). Here, the protruding directions of the first electrode tab **120** and the second electrode tab **240** may be the same. That is, in the rechargeable battery according to the present disclosure, the protruding directions of the electrode tab(s) of the first electrode(s) and the electrode tab(s) of the second electrode(s) are not limited.

[0071] The pouch **400** includes a first tip portion **451**, a second tip portion **453**, a folded region **455**, and a plurality of accommodating portions **461** and **463**. A first electrode assembly accommodating portion **461** and a second electrode assembly accommodating portion **463** are respectively accommodated in the plurality of accommodating portions **461** and **463**. The accommodating portions included in the pouch **400** are not limited thereto and may further include a third electrode assembly accommodating portion (not shown).

[0072] The first electrode assembly accommodating portion **461** may be arranged in a matrix structure together with the second electrode assembly accommodating portion **463**. For example, the first electrode assembly accommodating portion **461** and the second electrode assembly accommodating portion **463** may be arranged in a 1×2 matrix structure.

[0073] The first tip portion **451** is disposed on one side of the first electrode assembly accommodating portion **461**, and the folded region **455** is disposed on the other side of the first electrode assembly accommodating portion **461**. In addition, the second tip portion **453** is disposed on one side of the second electrode assembly accommodating portion **463**, and the folded region **455** is disposed on the other side. Due to this, the first electrode assembly accommodating portion **461** and the second electrode assembly accommodating portion **463** may be connected by the folded region **455**.

[0074] The first tip portion **451** and the second tip portion **453** may be located in directions facing each other. For example, the first tip portion **451** and the second tip portion **453** may be located in opposite directions with the folded region **455** interposed therebetween along the x-axis.

[0075] The folded region **455** may be located between the first electrode assembly accommodating portion **461** and the second electrode assembly accommodating portion **463**. For example, the folded region **455** may be located between the first electrode assembly accommodating portion **461** and the second electrode assembly accommodating portion **463** arranged in the 1×2 matrix structure. In other words, the folded region **455** may be located between columns in the 1×2 matrix structure. The folded region **455** may be bendable between rows or columns of the matrix structure.

[0076] The folded region **455** is formed so that the first electrode assembly accommodating portion **461** and the first electrode assembly **100** accommodated therein or the second electrode assembly accommodating portion **463** and the

second electrode assembly **200** accommodated therein are rotated clockwise (CW) or rotated counterclockwise (CCW) to be bent or folded. For example, in the electrode assembly having a 1×2 matrix structure, as a portion between the columns is bent, the first electrode assembly accommodating portion **461** and the first electrode assembly **100** accommodated therein or the second electrode assembly accommodating portion **463** and the second electrode assembly **200** accommodated therein may be bent or folded clockwise (CW) or counterclockwise (CCW).

[0077] A first surface **456** and a second surface **457** of the pouch **400** disposed in the folded region **455** may be spaced apart or bonded to each other in the z-axis direction. The separator **150** may be located between the first surface **456** and the second surface **457**. For example, a third bent portion **155**, which is one of the bent portions included in the separator **150**, may be located between the first surface **456** and the second surface **457**. The bent portion of the separator **150** is described below.

[0078] The first surface **456** and the second surface **457** may be concave in a direction perpendicular to the plane where the two electrode assemblies **100** and **200** are disposed. For example, the second surface **457** may have a concave shape in the +z-axis direction, and the first surface **456** may have a concave shape in the −z-axis direction. In some embodiments, the concave shape includes shapes, such as squares and semicircles, but is not limited thereto. As the first surface **456** and the second surface **457** of the folded region **455** have a concave shape, the first electrode assembly **100** or the second electrode assembly **200** may be bent or folded more easily based on the folded region **455**.

[0079] The folded region **455** may include a pivot line **470**. The pivot line **470** may be formed along the y-axis at a central point including the exact center of the folded region **455**. The pivot line **470** may be provided at a folded region **455**. For example, the pivot line **470** may be formed along the y-axis at a central point including the exact center between columns of the 1×2 matrix structure. In the present embodiments, the pivot line **470** is provided at the exact center of the folded region **455**. Due to the pivot line **470**, the first electrode assembly **100** or the second electrode assembly **200** may be bent or folded based on the pivot line **470** as a starting point.

[0080] Referring to FIG. **2**, the first electrode assembly **100** includes first electrodes **110** and second electrodes **130** that are alternately stacked. For example, the first electrode **110** and the second electrode **130** are alternately stacked. In the present embodiments, the first electrode **110** and the second electrode **130** are alternately stacked in the z-axis direction (up-down direction in FIG. **2**). The separator **150** may be interposed between the first electrode **110** and the second electrode **130**. This arrangement of the first electrode **110** and the second electrode **130** may also be applied to the second electrode assembly **200**. The second electrode **130** of the first electrode assembly **100** may be alternately disposed at the first electrode **110** on the other surface of the separator **150**.

[0081] The separator **150** may be configured in the shape of a single continuous sheet. Of course, the shape of the separator **150** is not limited thereto. As shown in FIG. **2**, the separator **150** includes a plurality of bent portions **151**, **153**, and **155**, a plurality of first electrode assembly separation portions **161**, and a plurality of second electrode assembly separation portions **163**. The first electrode assembly **100** and second electrode assembly **200** may be separated by a bent portion **155**.

[0082] The first electrode **110** of the first electrode assembly **100** and the second electrode **230** of the second electrode assembly **200** may be disposed on one surface of the separator **150**, and the second electrode **130** of the first electrode assembly **100** and the first electrode **210** of the second electrode assembly **200** may be disposed on the other surface of the separator **150**.

[0083] For example, the first electrode **110** of the first electrode assembly **100** may be disposed on one surface of the first electrode assembly separation portion **161**, and the second electrode **230** of the second electrode assembly **200** may be disposed on one surface of the second electrode assembly separation portion **163**. That is, the first electrode **110** and the second electrode **230** may be arranged in a 1×2 matrix structure on one surface of the separator.

[0084] In this case, the second electrode **130** of the first electrode assembly **100** may be disposed on the other surface of the first electrode assembly separation portion **161** (the surface facing the one surface), and the first electrode **210** of the second electrode assembly **200** may be disposed on the other surface of the second electrode assembly separation portion **163**. That is, the second electrode **130** and the first electrode **210** may be arranged in a 1×2 matrix structure on the other surface of the second electrode assembly separation portion **163**.

[0085] However, the first electrodes **110** and **210** or the second electrodes **130** and **230** may not be disposed on the other surface of the first electrode assembly separation portion **161** and the second electrode assembly separation portion **163** located at the top or bottom of each of the first electrode assembly **100** and the second electrode assembly **200**.

[0086] The plurality of bent portions **151**, **153**, and **155** include a first bent portion **151**, a second bent portion **153**, and a third bent portion **155**. The first bent portion **151** is connected to one side of the first electrode assembly separation portion **161** and to one side of the first electrode assembly separation portion **161** adjacent on the z-axis. Adjacent first electrode assembly separation portions **161** may be connected through the first bent portion **151**. The third bent portion **155** is connected to the other side of the first electrode assembly separation portion **161**.

[0087] The first bent portion **151** may be formed by bending the separator **150** in a direction of wrapping the first electrode **110** interposed between a pair of adjacent first electrode assembly separation portions **161** on the z-axis in the rechargeable battery **1000** stacking process to be described below. A shape of the first bent portion **151** may be a curved surface (e.g., C shape) or a non-curved surface (e.g., [shape), but the shape of the first bent portion **151** is not limited thereto. In the present embodiments, the first bent portion **151** is described as being bent in a direction of wrapping the first electrode **110**, but it is not limited thereto and may wrap the second electrode **130**. The electrodes **110**, **130** may be surrounded by the first bent portion **151**.

[0088] The second electrode assembly **200** also includes the first electrodes **210** and the second electrodes **230** that are alternately stacked. For example, the first electrode **210** and the second electrode **230** are alternately stacked in the z-direction. The second bent portion **153** is connected to one side of the second electrode assembly separation portion

163, and the third bent portion **155** is connected to the other side of the second electrode assembly separation portion **163**.

[0089] The second bent portion **153** is connected to one side of one second electrode assembly separation portion **163** and to one side of the second electrode assembly separation portion **163** adjacent on the z-axis. Accordingly, adjacent first electrode assembly separation portions **163** may be connected through the second bent portion **153**.

[0090] In the rechargeable battery **1000** stacking process, which will be described below, the second bent portion **153** may also be formed by bending the separator **150** in a direction of wrapping the first electrode **210** interposed between a pair of adjacent second electrode assembly separation portions **163** on the z-axis. The shape of the second bent portion **153** may be a curved surface (e.g., ⊂ shape) or a non-curved surface (e.g., [shape), but the shape of the second bent portion **153** is not limited thereto. In the present embodiments, the second bent portion **153** is described as being bent in the direction wrapping the first electrode **210**, but the second bent portion **153** is not limited thereto and may wrap the second electrode **230**.

[0091] However, in some embodiments, when the first bent portion **151** is formed to be bent in a direction of wrapping the first electrode **110**, the second bent portion **153** is also formed to be bent only in a direction of wrapping the first electrode **210**. Meanwhile, when the first bent portion **151** is formed to be bent in the direction of wrapping the second electrode **130**, the second bent portion **153** is also formed to be bent only in the direction of wrapping the second electrode **230**.

[0092] The first bent portion **151** and the second bent portion **153** are formed along the y-axis direction (forward and backward directions based on FIG. **2**) and are located in opposite directions with respect to the y-axis with the third bent portion **155** therebetween. The first bent portion **151** and the second bent portion **153** do not exist on the same plane. The so-called first bent portion **151** and the second bent portion **153** may be arranged in a zigzag shape.

[0093] The third bent portion **155** may be located between the first electrode assembly separation portion **161** and the second electrode assembly separation portion **163**. Specifically, the third bent portion **155** may be located between columns in a 1×2 matrix structure.

[0094] The third bent portion **155** may have a concave shape in a direction perpendicular to the plane where the two electrode assemblies **100** and **200** are disposed. For example, the third bent portion **155** may have a concave shape in the +z-axis or −z-axis direction. In other words, the third bent portion **155** may have a concave shape to correspond to the shapes of the first surface **456** and the second surface **457** of the pouch **400** having a concave shape. Due to this, the third bent portion **155** may be accommodated between the first surface **456** and the second surface **457** of the pouch **400**.

[0095] The plurality of third bent portions **155** may overlap each other or may be partially in close contact with each other to be accommodated in a space between the first surface **456** and the second surface **457**. When the plurality of third bent portions **155** are viewed as a whole, the third bent portions **155** group may have a concave shape in a direction perpendicular to the plane (x-y plane based on FIG. **2**) on which both positive electrode assemblies **100** and **200** are disposed.

[0096] For example, a portion of the third bent portion **155** close to the first surface **456** of the pouch **400** may have a concave shape in the +z-axis direction and another portion of the third bent portion **155** may have a concave shape in the −z-axis direction. In some embodiments, the concave shape includes a shape, such as a square and semicircle, but is not limited thereto. Since the third bent portion **155** has a concave shape, the first electrode assembly **100** or the second electrode assembly **200** may be bent or folded more easily.

[0097] The third bent portion **155** may include a pivot line **170**. For example, the pivot line **170** may be formed along the y-axis in the central portion including the exact center of the third bent portion **155**. In other words, the pivot line **170** may be formed along the y-axis at a central point including the exact center between columns of a 1×2 matrix structure. In the present embodiments, the pivot line **170** is provided at the exact center of the third bent portion **155**. The first electrode assembly **100** or the second electrode assembly **200** may be bent or folded based on the pivot line **170** as a starting point.

[0098] Through the third bent portion **155** and the folded region **455** of the aforementioned configuration, the first electrode assembly **100** or the second electrode assembly **200** may rotate clockwise (CW) or counterclockwise (CCW), respectively, based on the pivot lines **170** and **470** within a range of 180 degrees to be bent or folded. For example, the first electrode assembly **100** or the second electrode assembly **200** may rotate in the direction of the arrow shown in FIG. **2** with respect to the pivot lines **170** and **470**, that is, clockwise (CW) or counterclockwise (CCW).

[0099] For example, when the second electrode assembly **200** rotates counterclockwise (CCW), the second electrode assembly **200** is stacked on the first electrode assembly **100**, and the third bent portion **155** and the pivot line **170** are located in the +x direction (rightward direction based on FIG. **2**) based on both electrode assemblies **100** and **200**. In addition, when the first electrode assembly **100** rotates counterclockwise (CCW), the second electrode assembly **200** is stacked on the first electrode assembly **100**, and the third bent portion **155** and the pivot line **170** is located in the −x direction (leftward direction based on FIG. **2**) based on both electrode assemblies **100** and **200**.

[0100] When the second electrode assembly **200** rotates clockwise (CW), the first electrode assembly **100** is stacked on the second electrode assembly **200**, and the third bent portion **155** and the pivot line **170** are located in the +x direction (rightward direction based on FIG. **2**) based on both electrode assemblies **100** and **200**. In addition, when the first electrode assembly **100** rotates clockwise (CW), the first electrode assembly **100** is stacked on the second electrode assembly **200**, and the third bent portion **155** and the pivot line **170** are located in the −x direction (leftward direction based on FIG. **2**) based on both electrode assemblies **100** and **200**.

[0101] FIGS. **3**A to **3**C are diagrams illustrating a manufacturing process of the rechargeable battery **1000** according to some embodiments of the present disclosure. FIG. **3**A is a perspective view illustrating a stacking process during the manufacturing process of the rechargeable battery **1000** according to some embodiments of the present disclosure. FIG. **3**B is a schematic diagram illustrating a pouch process during the manufacturing process of the rechargeable battery **1000** according to some embodiments of the present disclo-

sure. FIG. **3**C is a schematic diagram illustrating sealing and pressing processes during the manufacturing process of the rechargeable battery **1000** according to some embodiments of the present disclosure.

[0102] Referring to FIG. **3**A, the first electrode **110** of the first electrode assembly **100** and the second electrode **230** of the second electrode assembly **200** are disposed on one surface of the first and second electrode assembly separation portions **161** and **163** of the separator **150** alternately in a matrix structure. For example, the first electrode **110** and the second electrode **230** are alternately arranged in a 1×2 matrix structure. On the other surface of the first and second electrode assembly separation portions **161** and **163** of the separator **150**, the second electrode **130** of the first electrode assembly **100** and the first electrode **210** of the second electrode assembly **200** are alternately arranged in a matrix structure. For example, the second electrode **130** and the first electrode **210** are alternately arranged in a 1×2 matrix structure.

[0103] In a state in which the first electrode **110** of the first electrode assembly **100** and the second electrode **230** of the second electrode assembly **200** are disposed on one surface of the first and second electrode assembly separation portions **161** and **163**, the separator **150** may be bent in the direction (CW) of wrapping them (e.g., to cover each electrode **110**, **230** with the separator **150**). In this case, the first bent portion **151** is formed on one side of the first electrode assembly separation portion **161**. In other words, the first bent portion **151** is formed in a direction opposite to the second electrode assembly separation portion **163**.

[0104] In addition, in a case in which the second electrode **130** of the first electrode assembly **100** and the first electrode **210** of the second electrode assembly **200** are arranged on the other side of the first and second electrode assembly separation portions **161** and **163**, when the separator **150** is bent in the direction (CCW) of wrapping them, the second bent portion **153** is formed on one side of the second electrode assembly separation portion **163**.

[0105] Accordingly, the first bent portion **151** and the second bent portion **153** are disposed in the mutually opposite direction with the first electrode assembly **100** and the second electrode assembly **200** therebetween in the y-axis direction (forward and backward directions with respect to FIG. **2**). Here, the first bent portion **151** and the second bent portion **153** do not exist on the same plane.

[0106] A section between the first electrode assembly separation portion **161** and the second electrode assembly separation portion **163** may be formed as the third bent portion **155** by a pressing process of FIG. **3**C, which will be described below. For example, the third bent portion **155** may be formed between the first electrode **110** and the second electrode **130** of the first electrode assembly **100** and between the first electrode **210** and the second electrode **230** of the second electrode assembly **200**. In other words, the third bent portion **155** may be located between columns in a 1×2 matrix structure.

[0107] Referring to FIG. **3**B, the pouch **400** may wrap both the first electrode assembly **100** and the second electrode assembly **200**. Specifically, the pouch **400** may wrap both the upper and lower surfaces of the first electrode assembly **100** and the second electrode assembly **200**.

[0108] Referring to FIG. **3**C, while the first electrode assembly **100** and the second electrode assembly **200** are accommodated in the pouch **400**, the pouch **400** may be pressed in a direction in which the pouch **400** is sealed and stacked (z axis based on FIG. **3**C). When the pressing process is completed, a corresponding section of the pouch **400** between the first electrode assembly accommodating portion **461** and the second electrode assembly accommodating portion **463** may be formed as the folded region **455**. That is, the folded region **455** may be formed between columns in a 1×2 matrix structure. Moreover, by the pressing process, the separator **150** is heat-compressed in the corresponding section of the separator **150** between the first electrode assembly separation portion **161** and the second electrode assembly separation portion **163** to form a third bent portion. It may be formed as third bent portion **155**. That is, the third bent portion **155** may be formed between columns in a 1×2 matrix structure. In addition, the pouch portion of the section of the pouch **400** corresponding to the area between the first electrode assembly accommodating portion **461** and the second electrode assembly accommodating portion **463** of the pouch may be thermally compressed to the third bent portion **155** according to the pressing process to be formed as the folded region **455**. The third bent portion and folded region may therefore be thermally compressed.

[0109] Accordingly, the third bent portion **155** and the folded region **455** may connect the first electrode assembly separation portion **161** and the second electrode assembly separation portion **163** and the first electrode assembly accommodating portion **461** and the second electrode assembly accommodating portion **463**, respectively. The first electrode assembly accommodating portion **461** and the first electrode assembly **100** or the second electrode assembly accommodating portion **463** and the second electrode assembly **200** may be folded through the third bent portion **155** and the folded region **455**, respectively.

[0110] The rechargeable battery **1000** of the embodiments manufactured in this manner may be manufactured using rechargeable battery manufacturing processes and devices of related technology. The rechargeable battery **1000** of the embodiments can stack the electrode assemblies **100**, **200** by merely changing the stacking method while using existing equipment.

[0111] Accordingly, when manufacturing the rechargeable battery **1000** according to some embodiments of the present disclosure, there is no need to buy new equipment, which can result in cost savings. By placing a plurality of electrodes on each surface of the separator **150**, more electrodes can be included in a single electrode assembly compared to conventional stacking methods, thus saving time in producing electrode assemblies of the same capacity.

[0112] Therefore, manufacturing costs and time may be saved when manufacturing the rechargeable battery **1000** according to the embodiments.

[0113] FIG. **4** is a diagram illustrating a matrix structure of electrodes according to some embodiments of the present disclosure.

[0114] The matrix structure refers to a structure of at least one first electrode and at least one second electrode being arranged in an m×n matrix. That is, the matrix structure may refer to a structure in which the first electrode and the second electrode are arranged along the same x-axis line to form one row and are arranged along the same y-axis line to form one column.

[0115] In addition, the matrix structure refers to a structure in which at least one first electrode and at least one second

electrode are alternately arranged at regular intervals. For example, on the same plane, the second electrodes are arranged at regular intervals above and below and/or to the left and right of the first electrodes (up and down in the y-axis direction and left and right in the x-axis direction based on FIG. **4**), and the first electrodes are arranged at regular intervals above and below and/or left and right of the second electrodes in the same manner.

[0116] FIG. **4** shows an example embodiment of the present disclosure adopting a 2×4 matrix structure. Referring to FIG. **4**, a rechargeable battery **1010** includes a first electrode assembly **100**, a second electrode assembly **200**, a third electrode assembly **100***a*, and a fourth electrode assembly **200***a*.

[0117] The first electrodes **110**, **210**, **110***a*, and **210***a* and the second electrodes **130**, **230**, **130***a*, and **230***a* of the respective electrode assemblies **100**, **200**, **100***a*, and **200***a* are arranged on one surface of the electrode assembly separation portions **161**, **163**, **165**, and **167** of the separator **150** respectively corresponding to the electrode assemblies **100**, **200**, **100***a*, and **200***a*.

[0118] For example, the first electrode **110** and the second electrode **130** of the first electrode assembly **100** are disposed on one surface of the first electrode assembly separation portion **161**, the first electrode **210** and the second electrode **230** of the second electrode assembly **200** are disposed on one surface of the second electrode assembly separation portion **163**, the first electrode **110***a* and the second electrode **130***a* of the third electrode assembly **100***a* are disposed on one surface of the third electrode assembly separation portion **165**, and the first electrode **210***a* and the second electrode **230***a* of the fourth electrode assembly **200***a* are disposed on one surface of the fourth electrode assembly separation portion **167**. Here, the positive electrode and negative electrode disposed on one surface of any one of the electrode assembly separation portions **161**, **163**, **165**, and **167** form the same row.

[0119] In addition, in the first row of the matrix structure, the first electrode **110** of the first electrode assembly **100**, the second electrode **230** of the second electrode assembly **200**, the first electrode **110***a* of the third electrode assembly **100***a*, and the second electrode **230***a* of the fourth electrode assembly **200***a* are disposed, and in the second row of the matrix structure, the second electrode **130** of the first electrode assembly **100**, the first electrode **210** of the second electrode assembly **200**, the second electrode **130***a* of the third electrode assembly **100***a*, and the first electrode **210***a* of the fourth electrode assembly **200***a* are disposed.

[0120] Here, the tabs of electrodes located in the same row protrude in the same direction. For example, the electrode tabs **120**, **240**, **120***a*, and **240***a* of the electrodes **110**, **230**, **110***a*, and **230***a* located in the first row protrude in the-y-axis direction, and the electrode tabs **140**, **220**, **140***a*, and **220***a* of the electrodes **130**, **210**, **130***a*, and **210***a* located in the second row protrude in the +y-axis direction.

[0121] As described above in relation to the embodiments of FIGS. **3**A to **3**C, the separator **150** may be bent to wrap the electrodes, and electrodes respectively corresponding to the electrode assemblies are arranged on the other surface of the bent separator **150**.

[0122] The separator **150** includes a plurality of folded regions **155***a* that may be bent between columns and folded regions **155***b* that may be bent between rows by the aforementioned sealing and pressing processes. The separator **150** may include a bendable bent portion disposed between rows or columns of the matrix structure. The first electrode assembly **100**, the second electrode assembly **200**, the third electrode assembly **100***a*, and the fourth electrode assembly **200***a* are each rotatable through the plurality of folded regions **155***a* and **155***b*. The different electrode assemblies **100**, **200** may be stacked by bent portions formed between rows or columns of the matrix structure.

[0123] Based on FIG. **4**, when the first electrode assembly **100** and the third electrode assembly **100***a* are considered odd-numbered electrode assemblies, the second electrode assembly **200** and the fourth electrode assembly **200***a* may be considered even-numbered electrode assemblies.

[0124] As described above, when the electrodes of each electrode assembly are disposed on the bent separator **150**, the stacking order of the first electrodes **110** and **110***a* and the second electrodes **130** and **130***a* of the odd-numbered electrode assemblies **100** and **100***a* may be the same. In addition, the stacking order of the first electrodes **210** and **210***a* and the second electrodes **230** and **230***a* of the even-numbered electrode assemblies **200** and **200***a* may also be the same.

[0125] Meanwhile, the order in which the first electrodes **110** and **110***a* and the second electrodes **130** and **130***a* of the odd-numbered electrode assemblies **100** and **100***a* are stacked may be the opposite to the order in which the first electrodes **210** and **210***a* and the second electrodes **230** and **230***a* of the even-numbered electrode assemblies **200** and **200***a* are stacked.

[0126] For example, the stacking order of the first electrode **110***a* and the second electrode **130***a* of the third electrode assembly **100***a* may be the opposite to the stacking order of the first electrode **210** and the second electrode **230** of the second electrode assembly **200** and may also be opposite to the stacking order of the first electrode **210***a* and the second electrode **230***a* of the fourth electrode assembly **200***a*.

[0127] FIG. **5** is a diagram illustrating a state in which the third bent portion **155** and the folded region **455** are bent in the rechargeable battery **1000** according to the embodiments of FIGS. **1** to **3**.

[0128] Referring to FIG. **5**, the third bent portion **155** of the separator **150** and the folded region **455** of the pouch **400** may be bent, and when the third bent portion **155** and the folded region **455** are bent, the first electrode assembly **100** or the second electrode assembly **200** may rotate.

[0129] For example, when the second electrode assembly **200** rotates counterclockwise (CCW), the second electrode assembly **200** is stacked on the first electrode assembly **100**, and the third bent portion **155** and the pivot lines **170** and **470** are located in the +x direction (rightward direction in FIG. **2**) with respect to both electrode assemblies **100** and **200**. In addition, when the first electrode assembly **100** rotates counterclockwise (CCW), the second electrode assembly **200** is stacked on the first electrode assembly **100**, and the third bent portion **155** and the pivot lines **170** and **470** are located in the −x direction (leftward direction in FIG. **2**) with respect to both electrode assemblies **100** and **200**.

[0130] When the second electrode assembly **200** rotates clockwise (CW), the first electrode assembly **100** is stacked on the second electrode assembly **200**, and the third bent portion **155** and the pivot lines **170** and **470** are located in the +x direction (rightward direction in FIG. **2**) with respect to

both electrode assemblies **100** and **200**. In addition, when the first electrode assembly **100** rotates clockwise (CW), the first electrode assembly **100** is stacked on the second electrode assembly **200**, and the third bent portion **155** and the pivot lines **170** and **470** are located in the −x direction (leftward direction in FIG. **2**) with respect to both electrode assemblies **100** and **200**.

[0131] Since the third bent portion **155** and the folded region **455** may be bent, the rechargeable battery **1000** according to the present embodiments may be miniaturized and may be configured to be easily inserted into small devices, foldable and bendable devices, etc.

[0132] FIG. **6** is a plan view illustrating a state in which an opening **600** is formed in the third bent portion **155** and the folded region **455** of the rechargeable battery **1000** according to some embodiments of the present disclosure. FIG. **7**A is a plan view illustrating a state in which a wrinkle portion **700** is formed in the third bent portion **155** and the folded region **455** of the rechargeable battery **1000** according to some embodiments of the present disclosure. FIG. **7**B is a front view illustrating the state in which the wrinkle portion **700** is formed in the third bent portion **155** and the folded region **455** of the rechargeable battery **1000** according to some embodiments of the present disclosure.

[0133] Referring to FIG. **6**, a plurality of openings **600** may be formed in the third bent portion **155** and the folded region **455**. For example, the opening **600** may be formed at the pivot line **170** of the third bent portion **155** and the pivot line **470** of the folded region **455**. A plurality of openings **600** may be provided at random intervals in the z-axis direction. The shape of the opening **600** can include a circle, square, triangle, etc., and is not limited to a certain shape. When the opening **600** is formed in the third bent portion **155** and the folded region **455**, the flexibility of the third bent portion **155** and the folded region **455** may be expanded so that bending of the third bent portion **155** and the folded region **455** may become easier.

[0134] Referring to FIGS. **7**A and **7**B, the wrinkle portion **700** may be formed in the third bent portion **155** and the folded region **455**. The wrinkle portion **700** may include a plurality of concave portions and a plurality of convex portions in the z-axis direction. When the wrinkle portion **700** is formed in the third bent portion **155** and the folded region **455**, the flexibility of the third bent portion **155** and the folded region **455** may be expanded so that they may be bent more easily.

[0135] FIG. **8** is a plan view showing a state in which the direction of the tab **120** of the first electrode **110** of the first electrode assembly **100** of the rechargeable battery **1000** according to some embodiments of the present disclosure and the direction of the tab **140** of the second electrode **130** of the first electrode assembly **100** are the same, and the direction of the tab **220** of the first electrode **210** of the second electrode assembly **200** and the direction of the tap **240** of the second electrode **230** of the second electrode assembly **200** are the same.

[0136] FIG. **9** is a plan view illustrating a state in which the opening **600** is formed in the third bent portion **155** and the folded region **455** of the rechargeable battery **1000** of FIG. **8**. FIG. **10**A is a plan view illustrating in which the wrinkle portion **700** is adopted in the third bent portion **155** of the separator **150** of the rechargeable battery **1000** of FIG. **8** and the folded region **455**. FIG. **10**B is a front view illustrating in which the wrinkle portion **700** is adopted in the third bent portion **155** of the separator **150** of the rechargeable battery **1000** of FIG. **8** and the folded region **455**.

[0137] Referring to FIGS. **8** to **10**B, in the rechargeable battery **1000** according to some embodiments of the present disclosure, the tabs **120** and **220** of the first electrodes **110** and **210** and the tabs **140** and **240** of the second electrodes **130** and **230** may be manufactured to have the same direction. At this time, the opening **600** or the wrinkle portion **700** may be provided in the third bent portion **155** and the folded region **455**. In this case, due to the expansion of the flexibility of the third bent portion **155** and the folded region **455**, the third bent portion **155** and the folded region **455** may be more easily bent or folded. In other embodiments, both the opening **600** and the wrinkle portion **700** may be provided in the third bent portion **155** and the folded region **455**.

[0138] FIG. **11**A is a plan view illustrating a rechargeable battery **1020** that further includes a third electrode assembly **100***a* as an additional electrode assembly in addition to the first electrode assembly **100** and the second electrode assembly **200** of the embodiments of FIGS. **1** to **3**. FIG. **11**B is a cross-sectional view illustrating a state in which the first electrode assembly **100**, the second electrode assembly **200**, and the third electrode assembly **100***a* of FIG. **11**A are stacked.

[0139] Referring to FIGS. **11**A and **11**B, the rechargeable battery **1020** includes three electrode assemblies **100**, **200**, and **100***a* and a pouch **400** in which the electrode assemblies **100**, **200**, and **100***a* are accommodated.

[0140] The electrode assemblies **100**, **200**, and **100***a* respectively include first electrodes **110**, **210**, and **110***a*, second electrodes **130**, **230**, and **130***a*, and a separator **150**. The first electrodes **110**, **210**, and **110***a* are respectively connected to the first electrode tabs **120**, **220**, and **120***a*. The second electrodes **130**, **230**, and **130***a* are respectively connected to the second electrode tabs **140**, **240**, and **140***a*.

[0141] The plurality of electrode assemblies **100**, **200**, and **100***a* may be arranged to be spaced apart from each other on the same plane. The plurality of electrode assemblies **100**, **200**, and **100***a* may be arranged side by side on the x-y plane and spaced apart at a certain distance along the x-axis. For example, the plurality of electrode assemblies **100**, **200**, and **100***a* may be arranged in a matrix structure on the x-y plane. In the present embodiments, a plurality of electrode assemblies **100**, **200**, and **100***a* may be arranged in a 1×3 matrix structure on the x-y plane.

[0142] The pouch **400** may include the first tip portion **451**, the second tip portion **453**, the folded region **455**, and a plurality of accommodating portions **461**, **463**, and **465**. The plurality of accommodating portions **461**, **463**, and **465** include a first electrode assembly accommodating portion **461**, a second electrode assembly accommodating portion **463**, and a third electrode assembly accommodating portion **465**.

[0143] The first tip portion **451** may be connected to one side of the first electrode assembly accommodating portion **461**, and the folded region **455** may be connected to the other side of the first electrode assembly accommodating portion **461**. The second tip portion **453** may be connected to one side of the third electrode assembly accommodating portion **465**, and the folded region **455** may be connected to the other side. The folded region **455** may be connected to both sides of the second electrode assembly accommodating portion

463. That is, the first electrode assembly accommodating portion **461**, the second electrode assembly accommodating portion **463**, and the third electrode assembly accommodating portion **465** may be connected by the folded region(s) **455**.

[0144] The folded region **455** may be located between the first electrode assembly accommodating portion **461** and the second electrode assembly accommodating portion **463** and between the second electrode assembly accommodating portion **463** and the third electrode assembly accommodating portion **465**. In other words, the folded region **455** may be located between the first electrode assembly accommodating portion **461** and the second electrode assembly accommodating portion **463** and between the second electrode assembly accommodating portion **463** and the third electrode assembly accommodating portion **465** arranged in a 1×3 matrix structure. In other words, the folded region **455** may be located between columns in a 1×3 matrix structure.

[0145] The folded region **455** may include the pivot line **470** (see e.g., FIG. **11**B). For example, the pivot line **470** may be formed along the y-axis in the central portion including the exact center of the folded region **455**. In other words, the pivot line **470** may be formed along the y-axis in the central portion including the exact center between columns of the 1×3 matrix structure. Accordingly, the first electrode assembly **100**, the second electrode assembly **200**, or the third electrode assembly **100***a* may be bent or folded based on the pivot line **470** as a starting point.

[0146] As the folded region **455** is configured to be bent or folded in this manner, the first electrode assembly accommodating portion **461** and the first electrode assembly **100** accommodated therein, the second electrode assembly accommodating portion **463** and the second electrode assembly **200** accommodated therein, or the third electrode assembly accommodating portion **465** and the third electrode assembly **100***a* accommodated therein may be folded clockwise (CW) or counterclockwise (CCW).

[0147] In other words, as the columns of the 1×3 matrix structure are bent, the first electrode assembly accommodating portion **461** and the first electrode assembly **100** accommodated therein, the second electrode assembly accommodating portion **463** and the second electrode assembly **200** accommodated therein, or the third electrode assembly accommodating portion **465** and the third electrode assembly **100***a* accommodated therein may be folded clockwise (CW) or counterclockwise (CCW).

[0148] For example, when the second electrode assembly **200** rotates counterclockwise (CCW) to be folded, the second electrode assembly **200** is stacked on the first electrode assembly **100**, and the third bent portion **155** and the pivot line **470** are located in the +x direction (rightward direction in FIG. **11**B) based on both electrode assemblies **100** and **200**.

[0149] In this state, when the third electrode assembly **100***a* rotates clockwise (CW) to be folded, the third electrode assembly **100***a* is stacked on the second electrode assembly **200**, and the third bent portion **155** and the pivot line **470** may be located in the −x direction (leftward direction in FIG. **2**) based on both electrode assemblies **200** and **100***a*.

[0150] The plurality of electrode assemblies **100**, **200**, and **100***a* may be folded in various manners, and the folding direction is not limited thereto. In this manner, when the plurality of electrode assemblies **100**, **200**, and **100***a* are stacked in one rechargeable battery cell, a manufacturing rate may be expected to be improved due to simplification of the process and a large amount of energy may be stored in a small volume. That is, the energy density may be increased.

[0151] Although it is described that the rechargeable battery includes three electrode assemblies in the depicted embodiment of FIGS. **11**A and **11**B, the rechargeable battery of the present disclosure is not limited thereto. For example, a rechargeable battery may be configured to include the first electrode assembly **100**, the second electrode assembly **200**, and the fourth electrode assembly **200***a* as an additional electrode assembly, and a rechargeable battery may be configured to include the first electrode assembly **100**, the second electrode assembly **200** and the third electrode assembly **100***a* and the fourth electrode assembly **200***a* as additional electrode assemblies. Of course, a rechargeable battery may be configured by further including additional electrode assemblies. Moreover, the arrangement order of each electrode assembly may be appropriately adjusted for the configuration of a rechargeable battery.

[0152] In this manner, when a rechargeable battery is formed by stacking a plurality of electrode assemblies **100**, **200**, **100***a*, and **200***a*, a manufacturing rate may be expected be improved due to simplification of the process and a large amount of energy may be stored in a small volume. That is, the energy density may be increased.

[0153] Meanwhile, in some embodiments of the present disclosure, a compound capable of reversible intercalation and deintercalation of lithium (lithiated intercalation compound) may be used as a positive electrode active material constituting a positive electrode active material layer of a positive electrode. For example, one or more types of composite oxides of lithium and a metal selected from cobalt, manganese, nickel, and combinations thereof may be used.

[0154] The composite oxide may be a lithium transition metal composite oxide and may include, for example, lithium nickel-based oxide, lithium cobalt-based oxide, lithium manganese-based oxide, lithium iron phosphate-based compound, cobalt-free nickel-manganese-based oxide, or combinations thereof.

[0155] As an example, a compound represented by any of the following formulas may be used. $Li_aA_{1-b}X_bO_{2-c}D_c$(0.90≤a≤1.8, 0≤b≤0.5, 0≤c≤0.05); $Li_aMn_{2-b}X_bO_{4-c}D_c$(0.90≤a≤1.8, 0≤b≤0.5, 0≤c≤0.05); $Li_aNi_{1-b-c}Co_bX_cO_{2-\alpha}D_\alpha$(0.90≤a≤1.8, 0≤b≤0.5, 0≤c≤0.5, 0<α<2); $Li_aNi_{1-b-c}Mn_bX_cO_{2-\alpha}D_\alpha$(0.90≤a≤1.8, 0≤b≤0.5, 0≤c≤0.5, 0<α<2); $Li_aNi_bCo_cL^1{}_dG_eO_2$(0.90≤a≤1.8, 0≤b≤0.9, 0≤c≤0.5, 0≤d≤0.5, 0≤e≤0.1); $Li_aNiG_bO_2$(0.90≤a≤1.8, 0.001≤b≤0.1); $Li_aCoG_bO_2$(0.90≤a≤1.8, 0.001≤b≤0.1); $Li_aMn_{1-b}G_bO_2$(0.90≤a≤1.8, 0.001≤b≤0.1); $Li_aMn_2G_bO_4$(0.90≤a≤1.8, 0.001≤b≤0.1); $Li_aMn_{1-g}G_gPO_4$(0.90≤a≤1.8, 0≤g≤0.5); $Li_{(3-f)}Fe_2(PO_4)_3$(0≤f≤2); Li_aFePO_4(0.90≤a≤1.8).

[0156] In the above formulas: A is Ni, Co, Mn, or combination thereof; X is Al, Ni, Co, Mn, Cr, Fe, Mg, Sr, V, a rare earth element, or combination thereof; D is O, F, S, P, or combination thereof; G is Al, Cr, Mn, Fe, Mg, La, Ce, Sr, V, or combination thereof; and L^1 is Mn, Al, or combination thereof.

[0157] The positive electrode according to some embodiments may include a positive electrode current collector in

which a positive active material layer is disposed, and the positive active material layer may further include a binder and/or a conductive material.

[0158] The content of the positive electrode active material may be 90 wt % to 99.5 wt % based on 100 wt % of the positive electrode active material layer, and the content of the binder and the conductive material may be 0.5 wt % to 5 wt %, respectively, based on 100 wt % of the positive electrode active material layer.

[0159] Aluminum (Al) may be used as the positive electrode current collector, but is not limited thereto.

[0160] In some embodiments of the present disclosure, a negative electrode active material constituting the negative electrode active material layer of the negative electrode includes a material capable of reversible lithium-ion intercalation/deintercalation, lithium metal, an alloy of lithium metal, a material capable of lithium doping/dedoping, or a transition metal oxide.

[0161] The material capable of reversible lithium-ion intercalation/deintercalation may be a carbon-based negative electrode active material and may include, for example, crystalline carbon, amorphous carbon, or combination thereof. Examples of the crystalline carbon include graphite, such as natural graphite or artificial graphite, and examples of the amorphous carbon include soft carbon or hard carbon, mesophase pitch carbide, calcined coke, etc.

[0162] A Si-based negative electrode active material or a Sn-based negative electrode active material may be used as the material capable of doping/dedoping lithium. The Si-based negative electrode active material may be silicon, silicon-carbon composite, SiOx ($0<x<2$), Si-based alloy, or combination thereof.

[0163] The silicon-carbon composite may be a composite of silicon and amorphous carbon. According to some embodiments, the silicon-carbon composite may be in the form of silicon particles and amorphous carbon coated on the surface of the silicon particles.

[0164] The silicon-carbon composite may further include crystalline carbon. For example, the silicon-carbon composite may include a core including crystalline carbon and silicon particles and an amorphous carbon coating layer located on the surface of the core.

[0165] The negative electrode according to some embodiments includes a negative electrode current collector in which the negative electrode active material layer is disposed, and the negative electrode active material layer may further include a binder and/or a conductive material.

[0166] For example, the negative electrode active material layer may include 90% to 99 wt % of the negative electrode active material, 0.5% to 5 wt % of the binder, and 0% to 5 wt % of the conductive material.

[0167] The binder may be a non-aqueous binder, an aqueous binder, a dry binder, or combination thereof. When an aqueous binder is used as the negative electrode binder, the negative electrode binder may further include a cellulose-based compound capable of imparting viscosity.

[0168] The negative electrode current collector may be selected from copper foil, nickel foil, stainless steel foil, titanium foil, nickel foam, copper foam, a polymer substrate coated with a conductive metal, and combination thereof.

[0169] The electrolyte solution for a lithium rechargeable battery may include a non-aqueous organic solvent and a lithium salt.

[0170] The non-aqueous organic solvent may serve as a medium through which ions involved in an electrochemical reaction of the battery may move.

[0171] The non-aqueous organic solvent may be a carbonate-based, ester-based, ether-based, ketone-based, or alcohol-based solvent, an aprotic solvent, or combination thereof, and may be used alone or in a mixture of two or more types.

[0172] In addition, in the case of using a carbonate-based solvent, a mixture of cyclic carbonate and chain carbonate may be used.

[0173] Depending on the type of lithium rechargeable battery, a separator may exist between the positive and negative electrodes, such as described herein. As the separator, polyethylene, polypropylene, polyvinylidene fluoride, or a multilayer film of two or more layers thereof may be used.

[0174] The separator may include a porous substrate and a coating layer including an organic material, an inorganic material, or combination thereof located on one or both sides of the porous substrate.

[0175] The organic material may include a polyvinylidene fluoride-based double antibody or a (meth)acrylic-based polymer.

[0176] The inorganic material may include inorganic particles selected from Al_2O_3, SiO_2, TiO_2, SnO_2, CeO_2, MgO, NiO, CaO, GaO, ZnO, ZrO_2, Y_2O_3, $SrTiO_3$, $BaTiO_3$, $Mg(OH)_2$, boehmite, and combination thereof, but is not limited thereto.

[0177] The organic material and the inorganic material may be mixed in a single coating layer or may exist in a laminated form of a coating layer including an organic material and a coating layer including an inorganic material.

[0178] Although the present disclosure has been described with exemplary embodiments and drawings, the present disclosure is not limited thereto, and various modifications and variations may be made by those skilled in the art to which the present disclosure pertains within the scope of equivalence of the patent claims.

What is claimed is:

1. A rechargeable battery comprising:

a first electrode assembly comprising a first positive electrode and a first negative electrode disposed with a separator therebetween; and

a second electrode assembly comprising a second positive electrode and a second negative electrode disposed with the separator therebetween,

wherein the first positive electrode and the second negative electrode are alternately arranged in a matrix structure on one surface of the separator,

the first negative electrode and the second positive electrode are alternately arranged in a matrix structure on the other surface of the separator, and

the separator comprises a bendable bent portion disposed between rows or columns of the matrix structure.

2. The rechargeable battery as claimed in claim **1**, wherein:

the first positive electrode and first negative electrode of the first electrode assembly are alternately stacked in one direction,

the second positive electrode and second negative electrode of the second electrode assembly are alternately stacked in the one direction, and

the first electrode assembly and the second electrode assembly are separated by the bendable bent portion.

3. The rechargeable battery as claimed in claim **1**, wherein:

a pivot line for bending or folding the first electrode assembly or the second electrode assembly is provided at the bendable bent portion.

4. The rechargeable battery as claimed in claim **1**, wherein:

the rechargeable battery comprises one or more additional electrode assemblies.

5. The rechargeable battery as claimed in claim **1**, wherein:

the separator has a continuous sheet shape.

6. The rechargeable battery as claimed in claim **5**, wherein the bendable bent portion comprises:

a first bent portion and a second bent portion arranged in a zigzag shape; and

a third bent portion disposed between the first bent portion and the second bent portion.

7. The rechargeable battery as claimed in claim **6**, wherein:

one or more openings are provided in the third bent portion.

8. The rechargeable battery as claimed in claim **6**, wherein:

a wrinkle portion comprising a concave portion and a convex portion is provided in the third bent portion.

9. The rechargeable battery as claimed in claim **1**, wherein:

a first positive electrode tab connected to the first positive electrode and a second positive electrode tab connected to the second positive electrode protrude in a same first direction,

a first negative electrode tab connected to the first negative electrode and a second negative electrode tab connected to the second negative electrode protrude in a same second direction, and

the same first direction of the first positive electrode tab and the second positive electrode tab is opposite to the same second direction of the first negative electrode tab and the second negative electrode tab.

10. The rechargeable battery as claimed in claim **1**, wherein:

a first positive electrode tab connected to the first positive electrode and a second positive electrode tab connected to the second positive electrode protrude in a same first direction,

a first negative electrode tab connected to the first negative electrode and a second negative electrode tab connected to the second negative electrode protrude in a same second direction, and

the same first direction of the first positive electrode tab and the second positive electrode tab is a same direction as the same second direction of the first negative electrode tab and the second negative electrode tab.

11. The rechargeable battery as claimed in claim **1**, further comprising:

a pouch accommodating the first electrode assembly and the second electrode assembly,

wherein the pouch comprises a foldable region that is bendable between rows or columns of the matrix structure to be a folded region.

12. The rechargeable battery as claimed in claim **11**, wherein:

the pouch further comprises:

a first electrode assembly accommodating portion accommodating the first electrode assembly; and

a second electrode assembly accommodating portion accommodating the second electrode assembly,

wherein the first electrode assembly accommodating portion and the second electrode assembly accommodating portion are connected by the folded region.

13. The rechargeable battery as claimed in claim **12**, wherein:

the bendable bent portion comprises:

first and second bent portions arranged in a zigzag shape; and

a third bent portion disposed between the first bent portion and the second bent portion,

wherein the third bent portion and the folded region are thermally compressed.

14. A rechargeable battery comprising:

a separator comprising a first bent portion, a second bent portion, a third bent portion disposed between the first bent portion and the second bent portion, a plurality of first separation portions connected to the first bent portion and the third bent portion, and a plurality of second separation portions connected to the second bent portion and the third bent portion,

wherein a first positive electrode and a first negative electrode of a first electrode assembly are separately disposed between the plurality of first separation portions,

a second positive electrode and a second negative electrode of a second electrode assembly are separately disposed between the plurality of second separation portions,

the first bent portion is connected to one side of the first separation portion and has a bent shape so that the first positive electrode or the first negative electrode is surrounded by the first separation portion,

the second bent portion is connected to one side of the second separation portion and has a bent shape so that the second positive electrode or the second negative electrode is surrounded by the second separation portion, and

the third bent portion is connected to the other side disposed opposite to the one side of the first separation portion and to the other side disposed opposite to the one side of the second separation portion.

15. A method of manufacturing a rechargeable battery, the method comprising:

alternately disposing a first electrode of each of different electrode assemblies in a matrix structure on one surface of a continuous sheet-shaped separator;

bending the continuous sheet-shaped separator in a direction of wrapping each first electrode to cover each first electrode with the continuous sheet-shaped separator;

alternately disposing a second electrode of each of the different assemblies at each first electrode on the other surface of the continuous sheet-shaped separator;

bending the continuous sheet-shaped separator in a direction covering each second electrode to cover each second electrode with the continuous sheet-shaped separator; and

pressing the continuous sheet-shaped separator so that the different electrode assemblies are stacked by bent portions formed between rows or columns of the matrix structure.

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