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SECONDARY BATTERY

Abstract

In this secondary battery, in a direction perpendicular to a first sealing plate, a surface of a first region on the first sealing plate side protrudes to the first sealing plate side with respect to each of a surface of a second region on the first sealing plate side and a surface of a third region on the first sealing plate side, and in a direction perpendicular to the first sealing plate, in a surface of a second current collecting member on an electrode assembly side, a fourth region is provided with a recess recessed to the first sealing plate side with respect to each of a fifth region and a sixth region, and at least a portion of the first region is disposed in the recess.

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS
[0001] This nonprovisional application is based on Japanese Patent Application No. 2024-021238 filed on Feb. 15, 2024 with the Japan Patent Office, the entire contents of which are hereby incorporated by reference.
BACKGROUND OF THE INVENTION
Field of the Invention
[0002] The present technology relates to a secondary battery.
Description of the Background Art
[0003] Japanese Patent No. 4537353 discloses a prismatic battery in which a positive electrode terminal is provided on a side surface on one side and a negative electrode terminal is provided at an end portion on the other side in a battery case.
SUMMARY OF THE INVENTION
[0004] A secondary battery having a higher volume energy density and higher reliability has been required, and there is room for further improvement in terms of a structure of a current collecting portion and an assembling method.
[0005] An object of the present technology is to provide a secondary battery having higher volume energy density and higher reliability.
[0006] The present technology provides the following secondary battery. [0007] [1] A secondary battery comprising: an electrode assembly including a first electrode and a second electrode having a polarity different from a polarity of the first electrode; a case main body provided with a first opening; a first sealing plate that seals the first opening; a first electrode tab electrically connected to the first electrode; a first current collecting member electrically connected to the first electrode tab; a second current collecting member joined to the first current collecting member; and a first electrode terminal electrically connected to the second current collecting member and provided on the first sealing plate, wherein the first current collecting member includes a first region, a second region, and a third region, the first region is disposed between the second region and the third region, the second current collecting member includes a fourth region, a fifth region, and a sixth region, the fourth region is disposed between the fifth region and the sixth region, the first electrode tab is connected to the first region, in a direction perpendicular to the first sealing plate, a surface of the first region on the first sealing plate side protrudes to the first sealing plate side with respect to each of a surface of the second region on the first sealing plate side and a surface of the third region on the first sealing plate side, and in the direction perpendicular to the first sealing plate, in a surface of the second current collecting member on the electrode assembly side, the fourth region is provided with a recess recessed to the first sealing plate side with respect to each of the fifth region and the sixth region, and at least a portion of the first region is disposed in the recess. [0008] [2] The secondary battery according to [1], wherein a first abutment region in which the second region and the fifth region are in abutment with each other is formed, and a second abutment region is formed at at least one of a position between the first region and the fourth region and a position between the third region and the sixth region, the second abutment region being a region in which corresponding ones of the first region, the fourth region, the third region, and the sixth region are in abutment with each other. [0009] [3] The secondary battery according to [2], wherein a joining portion at which the first current collecting member and the second current collecting member are joined to each other is provided at an end portion of the first abutment region. [0010] [4] The secondary battery according to [3], wherein a first clearance is present in a vicinity of an end portion of the first abutment region opposite to the end portion at which the joining portion is formed. [0011] [5] The secondary battery according to any one of [2] to [4], wherein the second

abutment region is formed between the third region and the sixth region. [0012] [6] The secondary battery according to any one of [1] to [5], wherein a thickness of the fourth region is smaller than each of a thickness of the fifth region and a thickness of the sixth region. [0013] [7] The secondary battery according to any one of [1] to [6], wherein a portion of the first current collecting member to which the first electrode tab is connected is present close to the third region with respect to the second region. [0014] [8] The secondary battery according to any one of [1] to [7], wherein an end portion of the third region protrudes outward with respect to an end portion of the sixth region in a long-side direction of the first sealing plate.
[0015] The foregoing and other objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0016] FIG. **1** is a front view showing a configuration of a secondary battery according to an embodiment.
[0017] FIG. **2** is a diagram showing a state in which the secondary battery shown in FIG. **1** is viewed in a direction of arrow II.
[0018] FIG. **3** is a diagram showing a state in which the secondary battery shown in FIG. **1** is viewed in a direction of arrow III.
[0019] FIG. **4** is a diagram showing a state in which the secondary battery shown in FIG. **1** is viewed in a direction of arrow IV.
[0020] FIG. **5** is a diagram showing a state in which the secondary battery shown in FIG. **1** is viewed in a direction of arrow V.
[0021] FIG. **6** is a front cross sectional view of the secondary battery shown in FIG. **1**.
[0022] FIG. **7** is a cross sectional view of a negative electrode plate.
[0023] FIG. **8** is a front view showing the negative electrode plate.
[0024] FIG. **9** is a cross sectional view of a positive electrode plate.
[0025] FIG. **10** is a front view showing the positive electrode plate.
[0026] FIG. **11** is a cross sectional view of the secondary battery shown in FIG. **1** along XI-XI.
[0027] FIG. **12** is a cross sectional view of the secondary battery shown in FIG. **1** along XII-XII.
[0028] FIG. **13** is a flowchart showing a method of manufacturing a secondary battery according to one embodiment.
[0029] FIG. **14** is a perspective view showing a state before two electrode assemblies included in the secondary battery according to one embodiment are overlapped with each other.
[0030] FIG. **15** is a cross sectional view of each of the electrode assemblies and current collectors shown in FIG. **14** along XV-XV.
[0031] FIG. **16** is a perspective view showing a state of attaching a holder and a spacer to the electrode assembly.
[0032] FIG. **17** is a perspective view showing a state of attaching a sealing plate to the current collectors on the negative electrode side.
[0033] FIG. **18** is a cross sectional view of each of the electrode assemblies and the current collectors shown in FIG. **17** along XVIII-XVIII.
[0034] FIG. **19** is a first perspective view showing an implementation of the spacer.
[0035] FIG. **20** is a second perspective view showing the implementation of the spacer.
[0036] FIG. **21** is a side view showing a positional relation between the spacer and an insulating sheet.
[0037] FIG. **22** is a perspective view showing a state of inserting the electrode assemblies into a

case main body.
[0038] FIG. **23** is a perspective view showing a state of attaching a sealing plate to the current collectors on the positive electrode side.
[0039] FIG. **24** is a cross sectional view of each of the electrode assemblies and the current collectors shown in FIG. **23** along XXIV-XXIV.
[0040] FIG. **25** is a perspective view showing a configuration of the secondary battery.
[0041] FIG. **26** is a side view showing only a negative-electrode-side connection structure on the first sealing plate side.
[0042] FIG. **27** is a longitudinal cross sectional view showing only the negative-electrode-side connection structure other than a negative electrode tab group and the electrode assemblies.
[0043] FIG. **28** is a perspective view showing a state before fixing the sealing plate to the case main body.
[0044] FIG. **29** is a first perspective view showing another implementation of a joining portion of the current collector.
[0045] FIG. **30** is a second perspective view showing the other implementation of the joining portion of the current collector.
[0046] FIG. **31** is a third perspective view showing the other implementation of the joining portion of the current collector.
[0047] FIG. **32** is a fourth perspective view showing the other implementation of the joining portion of the current collector.
[0048] FIG. **33** is a fifth perspective view showing the other implementation of the joining portion of the current collector.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0049] Hereinafter, embodiments of the present technology will be described. It should be noted that the same or corresponding portions are denoted by the same reference characters, and may not be described repeatedly.
[0050] In the embodiments described below, when reference is made to number, amount, and the like, the scope of the present technology is not necessarily limited to the number, amount, and the like unless otherwise stated particularly. Further, in the embodiments described below, each component is not necessarily essential to the present technology unless otherwise stated particularly. Further, the present technology is not limited to one that necessarily exhibits all the functions and effects stated in the present embodiment.
[0051] In the present specification, the terms “comprise”, “include”, and “have” are open-end terms. That is, when a certain configuration is included, a configuration other than the foregoing configuration may or may not be included.
[0052] In the present specification, when geometric terms and terms representing positional/directional relations are used, for example, when terms such as “parallel”, “orthogonal”, “obliquely at 45°”, “coaxial”, and “along” are used, these terms permit manufacturing errors or slight fluctuations. In the present specification, when terms representing relative positional relations such as “upper side” and “lower side” are used, each of these terms is used to indicate a relative positional relation in one state, and the relative positional relation may be reversed or turned at any angle in accordance with an installation direction of each mechanism (for example, the entire mechanism is reversed upside down).
[0053] In the present specification, the term “secondary battery” is not limited to a lithium ion battery, and may include other secondary batteries such as a nickel-metal hydride battery and a sodium-ion battery. In the present specification, the term “electrode” may collectively represent a positive electrode and a negative electrode.
[0054] In the figures, when an electrode assembly included in the secondary battery is a stacked type electrode assembly, an X direction is defined as a long-side direction of a stacked surface, whereas when the electrode assembly is a wound type electrode assembly, the X direction is

defined as a direction along a winding axis thereof. Further, a Y direction is defined as a short-side direction of the electrode assembly when viewed in the X direction, and a Z direction is defined as a long-side direction of the electrode assembly when viewed in the X direction. In order to facilitate understanding of the invention, the size of each configuration in the figures may be illustrated to be changed from its actual size.

[0055] In the specification of the present application, the first direction (X direction) may be referred to as a "width direction" of each of the secondary battery, the electrode assembly, and the case main body, the second direction (Z direction) may be referred to as a "height direction" of the secondary battery or the case main body, and the third direction (Y direction) may be referred to as a "thickness direction" of the secondary battery or the case main body.

Embodiment: Overall Configuration of Battery

[0056] FIG. **1** is a front view of a secondary battery **1** according to the present embodiment. FIGS. **2** to **5** are diagrams showing states of secondary battery **1** shown in FIG. **1** when viewed in directions of arrows II, III, IV, and V respectively. FIG. **6** is a front cross sectional view of secondary battery **1** shown in FIG. **1**.

[0057] Secondary battery **1** can be mounted on a battery electric vehicle (BEV), a plug-in hybrid electric vehicle (PHEV), a hybrid electric vehicle (HEV), or the like. It should be noted that the purpose of use of secondary battery **1** is not limited to the use on a vehicle.

[0058] As shown in FIGS. **1** to **6**, secondary battery **1** includes a case **100**, an electrode assembly **200**, electrode terminals **300**, and current collectors **400**. Case **100** includes a case main body **110**, a sealing plate **120** (first sealing plate), and a sealing plate **130** (second sealing plate).

[0059] When forming a battery assembly including secondary battery **1**, a plurality of secondary batteries **1** are stacked in the thickness direction of each of the plurality of secondary batteries **1**. Secondary batteries **1** stacked may be restrained in the stacking direction (Y direction) by a restraint member to form a battery module, or the battery assembly may be directly supported by a side surface of a case of a battery pack without using the restraint member.

[0060] Case main body **110** is constituted of a member having a tubular shape, preferably, a prismatic tubular shape. Thus, secondary battery **1** having a prismatic shape is obtained. Case main body **110** is composed of a metal. Specifically, case main body **110** is composed of aluminum, an aluminum alloy, iron, an iron alloy, or the like.

[0061] As shown in FIGS. **1** and **2**, sealing plate **120** (first wall) and sealing plate **130** (second wall) are provided at respective end portions of the case main body. Case main body **110** can be formed to have a prismatic tubular shape in, for example, the following manner: end sides of a plate-shaped member having been bent are brought into abutment with each other (joining portion **115** illustrated in FIG. **2**) and are joined together (for example, laser welding). Each of the corners of the "prismatic tubular shape" may have a shape with a curvature. Moreover, the secondary battery in the present technology is not necessarily limited to the prismatic secondary battery.

[0062] In the present embodiment, case main body **110** is formed to be longer in the width direction (X direction) of secondary battery **1** than in each of the thickness direction (Y direction) and the height direction (Z direction) of secondary battery **1**. The size (width) of case main body **110** in the X direction is preferably about 30 cm or more. In this way, secondary battery **1** can be formed to have a relatively large size (high capacity). The size (height) of case main body **110** in the Z direction is preferably about 20 cm or less, more preferably about 15 cm or less, and further preferably about 10 cm or less. Thus, (low-height) secondary battery **1** having a relatively low height can be formed, thus resulting in improved ease of mounting on a vehicle, for example.

[0063] Case main body **110** includes a pair of first side surface portions **111** and a pair of second side surface portions **112**. The pair of first side surface portions **111** constitute parts of the side surfaces of case **100**. The pair of second side surface portions **112** constitute the bottom surface portion and upper surface portion of case **100**. The pair of first side surface portions **111** and the pair of second side surface portions **112** are provided to intersect each other. The pair of first side

surface portions **111** and the pair of second side surface portions **112** are connected at their respective end portions. Each of the pair of first side surface portions **111** desirably has an area larger than that of each of the pair of second side surface portions **112**.

[0064] As shown in FIG. **5**, a gas-discharge valve **150** is provided in one second side surface portion **112**A of the pair of second side surface portions **112**. Gas-discharge valve **150** extends in the width direction (X direction) of secondary battery **1**. Gas-discharge valve **150** extends from the center of case main body **110** in the X direction to such an extent that gas-discharge valve **150** does not reach both ends of case main body **110** in the X direction. The shape of gas-discharge valve **150** can be changed appropriately.

[0065] The thickness of the plate-shaped member in gas-discharge valve **150** is thinner than the thickness of the plate-shaped member of case main body **110** other than gas-discharge valve **150**. Thus, when the pressure in case **100** becomes equal to or more than a predetermined value, gas-discharge valve **150** is fractured prior to the other portions of case main body **110**, thereby discharging the gas in case **100** to the outside.

[0066] As shown in FIG. **2**, joining portion **115** is formed at the other second side surface portion **112**B of the pair of second side surface portions **112**. Joining portion **115** extends in the width direction (X direction) of secondary battery **1**. At joining portion **115**, the end sides of the plate-shaped member of case main body **110** are joined to each other.

[0067] As shown in FIG. **3**, an opening **113** (first opening) is provided at an end portion of case main body **110** on a first side in the first direction (X direction). Opening **113** is sealed by sealing plate **120**. Joining portion **115** is formed at opening **113** so as to seal opening **113**. Each of opening **113** and sealing plate **120** has a substantially rectangular shape in which the Y direction corresponds to its short-side direction and the Z direction corresponds to its long-side direction. The substantially rectangular shape includes a rectangular shape or a generally rectangular shape such as a rectangular shape having corners each with a curvature.

[0068] Sealing plate **120** (first sealing plate) is provided with a negative electrode terminal **301**. The position of negative electrode terminal **301** can be appropriately changed.

[0069] As shown in FIG. **4**, an opening **114** (second opening) is provided at an end portion of case main body **110** on a second side opposite to the first side in the first direction (X direction). That is, opening **114** is located at an end portion opposite to opening **113**, and openings **113** and **114** face each other. Opening **114** is sealed by sealing plate **130**. Joining portion **115** is formed at opening **114** so as to seal opening **114**. Each of opening **114** and sealing plate **130** has a substantially rectangular shape in which the Y direction corresponds to its short-side direction and the Z direction corresponds to its long-side direction.

[0070] Sealing plate **130** (second sealing plate) is provided with a positive electrode terminal **302** and an injection hole **134**. The positions of positive electrode terminal **302** and injection hole **134** can be appropriately changed.

[0071] Each of sealing plate **120** and sealing plate **130** is composed of a metal. Specifically, each of sealing plate **120** and sealing plate **130** is composed of aluminum, an aluminum alloy, iron, an iron alloy, or the like.

[0072] Negative electrode terminal **301** (first electrode terminal) is electrically connected to a negative electrode of electrode assembly **200**. Negative electrode terminal **301** is attached to sealing plate **120**, i.e., case **100**.

[0073] Positive electrode terminal **302** (second electrode terminal) is electrically connected to a positive electrode of electrode assembly **200**. Positive electrode terminal **302** is attached to sealing plate **130**, i.e., case **100**.

[0074] Negative electrode terminal **301** is composed of a conductive material (more specifically, a metal), and can be composed of copper, a copper alloy, or the like, for example. A portion or layer composed of aluminum or an aluminum alloy may be provided at a portion of an outer surface of negative electrode terminal **301**.

[0075] Positive electrode terminal **302** is composed of a conductive material (more specifically, a metal), and can be composed of aluminum, an aluminum alloy, or the like, for example.
[0076] Injection hole **134** is sealed by a sealing member (not shown). As the sealing member, for example, a blind rivet or another metal member can be used.
[0077] Electrode assembly **200** is an electrode assembly having a flat shape and having a below-described positive electrode plate and a below-described negative electrode plate stacked on each other. Specifically, electrode assembly **200** is a stacked type electrode assembly in which a plurality of positive electrode plates and a plurality of negative electrode plates are alternately stacked with below-described separators **800** being interposed therebetween. However, in the present specification, the "electrode assembly" is not limited to the stacked type electrode assembly, and may be a wound type electrode assembly in which a strip-shaped positive electrode plate and a strip-shaped negative electrode plate are wound together with a strip-shaped separator being interposed therebetween. The separator can be constituted of, for example, a microporous membrane composed of polyolefin. When the electrode assembly is the stacked type electrode assembly including the plurality of positive electrode plates and the plurality of negative electrode plates, positive electrode tabs provided on the positive electrode plates may be stacked to form a positive electrode tab group, and negative electrode tabs provided on the negative electrode plates may be stacked to form a negative electrode tab group.
[0078] As shown in FIG. **6**, case **100** accommodates electrode assembly **200**. FIG. **6** illustrates a first electrode assembly **201** described below. First electrode assembly **201** is accommodated in case **100** such that the long-side direction thereof is parallel to the X direction.
[0079] Specifically, one or a plurality of the stacked type electrode assemblies and an electrolyte solution (electrolyte) (not shown) are accommodated inside a below-described insulating sheet **700** disposed in case **100**. As the electrolyte solution (non-aqueous electrolyte solution), it is possible to use, for example, a solution obtained by dissolving LiPF.sub.6 at a concentration of 1.2 mol/L in a non-aqueous solvent obtained by mixing ethylene carbonate (EC), ethyl methyl carbonate (EMC), and dimethyl carbonate (DMC) at a volume ratio (25° C.) of 30:30:40. Instead of the electrolyte solution, a solid electrolyte may be used.
[0080] First electrode assembly **201** includes a main body portion having a substantially rectangular shape, a negative electrode tab group **220** (first electrode tab group), and a positive electrode tab group **250** (second electrode tab group).
[0081] The main body portion is constituted of a below-described negative electrode plate **210** and a below-described positive electrode plate **240**. Negative electrode tab group **220** is located at an end portion of first electrode assembly **201** on the first side with respect to the main body portion thereof in the first direction (X direction). The first side in the present embodiment is the sealing plate **120** side. Positive electrode tab group **250** is located at an end portion of first electrode assembly **201** on the second side with respect to the main body portion thereof in the first direction (X direction). The second side in the present embodiment is the sealing plate **130** side.
[0082] Each of negative electrode tab group **220** and positive electrode tab group **250** is formed to protrude from a central portion of electrode assembly **200** toward sealing plate **120** or sealing plate **130**.
[0083] Current collectors **400** include a negative electrode current collector **400**A and a positive electrode current collector **400**B. Each of negative electrode current collector **400**A and positive electrode current collector **400**B is constituted of a plate-shaped member. Electrode assembly **200** is electrically connected to negative electrode terminal **301** and positive electrode terminal **302** through current collectors **400**.
[0084] Negative electrode current collector **400**A is disposed on sealing plate **120** with an insulating member composed of a resin being interposed therebetween. Negative electrode current collector **400**A is electrically connected to negative electrode tab group **220** and negative electrode terminal **301**. Negative electrode current collector **400**A is composed of a conductive material

(more specifically, a metal), and can be composed of copper, a copper alloy, or the like, for example. Details of negative electrode current collector **400**A will be described later.

[0085] Positive electrode current collector **400**B is disposed on sealing plate **130** with an insulating member composed of a resin being interposed therebetween. Positive electrode current collector **400**B is electrically connected to positive electrode tab group **250** and positive electrode terminal **302**. Positive electrode current collector **400**B is composed of a conductive material (more specifically, a metal), and can be composed of aluminum, an aluminum alloy, or the like, for example. Positive electrode tab group **250** may be electrically connected to sealing plate **130** directly or via positive electrode current collector **400**B. In this case, sealing plate **130** may serve as positive electrode terminal **302**. Details of positive electrode current collector **400**B will be described later.

Configuration of Electrode Assembly **200**

[0086] FIG. **7** is a cross sectional view of negative electrode plate **210** (cross sectional view along VII-VII in FIG. **8**), and FIG. **8** is a front view showing negative electrode plate **210**.

[0087] As shown in FIG. **8**, a negative electrode tab **230** (first electrode tab) constituted of a negative electrode core body **211** is provided at one end portion, in the width direction, of negative electrode plate **210**. When negative electrode plates **210** are stacked, a plurality of negative electrode tabs **230** are stacked to form negative electrode tab group **220**. The length of each of the plurality of negative electrode tabs **230** in the plurality of negative electrode plates **210** in the protruding direction is appropriately adjusted in consideration of the state in which negative electrode tab group **220** is connected to negative electrode current collector **400**A. The shape of negative electrode tab **230** is not limited to the one illustrated in FIG. **7**.

[0088] FIG. **9** is a cross sectional view of positive electrode plate **240** (cross sectional view along IX-IX in FIG. **10**), and FIG. **10** is a front view showing positive electrode plate **240**.

[0089] As shown in FIG. **10**, a positive electrode tab **260** (second electrode tab) constituted of a positive electrode core body **241** is provided at one end portion, in the width direction, of positive electrode plate **240** formed. When positive electrode plates **240** are stacked, a plurality of positive electrode tabs **260** are stacked to form positive electrode tab group **250**. The length of each of positive electrode tabs **260** in the plurality of positive electrode plates **240** in the protruding direction is appropriately adjusted in consideration of the state in which positive electrode tab group **250** is connected to positive electrode current collector **400**B. The shape of positive electrode tab **260** is not limited to the one illustrated in FIG. **10**.

[0090] A positive electrode protective layer **243** is provided at the root of positive electrode tab **260**. Positive electrode protective layer **243** may not necessarily be provided at the root of positive electrode tab **260**.

[0091] In a typical example, the thickness of (one) negative electrode tab **230** is smaller than the thickness of (one) positive electrode tab **260**. In this case, the thickness of negative electrode tab group **220** is smaller than the thickness of positive electrode tab group **250**.

Connection Structure between Electrode Assembly **200** and Current Collector **400**

[0092] FIG. **11** is a cross sectional view of the secondary battery shown in FIG. **1** along XI-XI. As shown in FIG. **11**, electrode assembly **200** includes first electrode assembly **201** and a second electrode assembly **202**. Each of first electrode assembly **201** and second electrode assembly **202** includes a positive electrode (second electrode) and a negative electrode (first electrode). Electrode assembly **200** may be constituted of three or more electrode assemblies.

[0093] Electrode assembly **200** is formed by overlapping first electrode assembly **201** and second electrode assembly **202** with each other. First electrode assembly **201** and second electrode assembly **202** are arranged side by side in the thickness direction (Y direction) of each of first electrode assembly **201** and second electrode assembly **202**.

[0094] First electrode assembly **201** includes negative electrode tab group **220**. Negative electrode tab group **220** is electrically connected to one current collector **410** (negative electrode current

collector) at its first end portion **205** in the X direction. Second electrode assembly **202** includes a negative electrode tab group **270**. Negative electrode tab group **270** is electrically connected to the other current collector **410** (negative electrode current collector) at its third end portion **207** in the X direction.

[0095] Negative electrode tab group **220** has a curved portion **221** and a tip portion **222**. Curved portion **221** is a portion at which negative electrode tab group **220** is curved on the side, on which the first electrode is connected, with respect to tip portion **222**. Tip portion **222** is a portion located at an end portion of negative electrode tab group **220** on the side opposite to the side on which the first electrode is connected.

[0096] Negative electrode tab group **270** has a curved portion **271** and a tip portion **272**. Curved portion **271** is a portion at which negative electrode tab group **270** is curved on the side, on which the first electrode is connected, with respect to tip portion **272**. Tip portion **272** is a portion located at an end portion of negative electrode tab group **270** on the side opposite to the side on which the first electrode is connected.

[0097] Negative electrode tab group **220** and negative electrode tab group **270** are curved in opposite directions such that tip portions **222**, **272** are close to each other. Tip portions **222**, **272** are separated from each other in the present embodiment; however, it is not limited to this configuration, and tip portions **222**, **272** may be in contact with each other.

[0098] Negative electrode current collector **400**A electrically connects negative electrode terminal **301** to negative electrode tab group **220** and negative electrode tab group **270**. Negative electrode current collector **400**A in the present embodiment is connected to negative electrode terminal **301** between electrode assembly **200** and sealing plate **120**.

[0099] Negative electrode current collector **400**A includes two current collectors **410** (first current collecting member) and a current collector **430** (second current collecting member).

[0100] Each of current collectors **410** is a plate-shaped member. Current collector **410** has a long-side direction in the Z direction and a short-side direction in the Y direction. Current collector **430** is a plate-shaped member. Current collector **430** has a long-side direction in the Z direction and a short-side direction in the Y direction. Current collector **410** and current collector **430** are arranged side by side in parallel in the X direction. In this way, current collector **410** and current collector **430** are constituted of separate components.

[0101] Negative electrode tab group **220** is joined to one current collector **410** at a joining location **411** (see FIG. **14**) described later. Negative electrode tab group **270** is joined to the other current collector **410** at a joining location **411** (see FIG. **14**) described later. Each of joining locations **411** may be formed by ultrasonic welding, resistance welding, laser welding, swaging, or the like, for example. In the present embodiment, negative electrode tab group **220** and one current collector **410** are joined by ultrasonic joining, and negative electrode tab group **270** and the other current collector **410** are joined by ultrasonic joining, for example.

[0102] Current collector **430** is joined to each of one current collector **410** and the other current collector **410** at a joining location (not shown) located at its end portion in the Z direction. Current collector **430** is connected to negative electrode terminal **301**. The connection between current collector **430** and negative electrode terminal **301** may be formed by swaging and/or welding, for example.

[0103] Negative electrode terminal **301** is located on the outer side with respect to sealing plate **120**. Negative electrode terminal **301** is connected to a plate-shaped member **303**. It should be noted that negative electrode terminal **301** preferably includes a region **301***a* composed of copper or a copper alloy and a region **301***b* composed of aluminum or an aluminum alloy, and region **301***a* composed of copper or a copper alloy is preferably connected to current collector **430**.

[0104] Plate-shaped member **303** is located on the outer side with respect to sealing plate **120**. Plate-shaped member **303** is disposed along sealing plate **120**. Plate-shaped member **303** has electric conductivity. Plate-shaped member **303** is disposed to secure an area of connection with a

bus bar or the like that electrically connects secondary battery **1** and another secondary battery adjacent thereto. The connection between negative electrode terminal **301** and plate-shaped member **303** can be formed by, for example, laser welding or the like.

[0105] An insulating member **510** is disposed between plate-shaped member **303** and sealing plate **120**. An insulating member **520** is disposed between negative electrode terminal **301** and sealing plate **120**. An insulating member **530** is disposed between current collector **430** and sealing plate **120**.

[0106] It should be noted that negative electrode terminal **301** may be electrically connected to sealing plate **120**. Further, sealing plate **120** may function as negative electrode terminal **301**.

[0107] A below-described spacer **600** (first spacer) is disposed between sealing plate **120** and the main body portion (negative electrode tab group **220** is not included) of electrode assembly **200**. Spacer **600** is composed of a resin member having an insulating property. Negative electrode tab group **220** passes internal to spacer **600**, thereby protecting negative electrode tab group **220** by spacer **600**. It should be noted that it is also possible to employ a configuration in which spacer **600** (first spacer) is not provided.

[0108] Although a detailed structure of spacer **600** will be described later, spacer **600** is provided with a protrusion **616** protruding in the Y direction. With this protrusion **616** of spacer **600**, spacer **600** functions as a guide to facilitate curving of curved portions **221**, **271** when forming curved portions **221**, **271**.

[0109] Insulating sheet **700** (electrode assembly holder) composed of a resin is disposed between electrode assembly **200** and case main body **110**. Insulating sheet **700** may be composed of, for example, a resin. More specifically, the material of insulating sheet **700** is, for example, polypropylene (PP), polyethylene terephthalate (PET), polyphenylene sulfide (PPS), polyimide (PI), or polyolefin (PO).

[0110] FIG. **12** is a cross sectional view of the secondary battery shown in FIG. **1** along XII-XII. The connection structure between electrode assembly **200** and current collector **400** on the positive electrode side of secondary battery **1** according to the present embodiment is different from that of the configuration on the negative electrode side in the following point: a portion corresponding to one current collector **410** and the other current collector **410** on the negative electrode side is constituted of a single component.

[0111] First electrode assembly **201** includes positive electrode tab group **250**. Positive electrode tab group **250** is electrically connected to current collector **420** (positive electrode current collector) at its second end portion **206** in the X direction. Second electrode assembly **202** includes a positive electrode tab group **280**. Positive electrode tab group **280** is electrically connected to current collector **420** (positive electrode current collector) at its fourth end portion **208** in the X direction.

[0112] Positive electrode tab group **250** has a curved portion **251** and a tip portion **252**. Curved portion **251** is a portion at which positive electrode tab group **250** is curved on the side, on which the second electrode is connected, with respect to tip portion **252**. Tip portion **252** is a portion located at an end portion of positive electrode tab group **250** on the side opposite to the side on which the second electrode is connected.

[0113] Positive electrode tab group **280** has a curved portion **281** and a tip portion **282**. Curved portion **281** is a portion at which positive electrode tab group **280** is curved on the side, on which the second electrode is connected, with respect to tip portion **282**. Tip portion **282** is a portion located at an end portion of positive electrode tab group **280** on the side opposite to the side on which the second electrode is connected.

[0114] Positive electrode tab group **250** and positive electrode tab group **280** are curved in opposite directions such that tip portions **252**, **282** are close to each other. Tip portions **252**, **272** are separated from each other in the present embodiment; however, it is not limited to this configuration, and tip portions **252**, **282** may be in contact with each other.

[0115] Positive electrode current collector **400**B electrically connects positive electrode terminal

302 to positive electrode tab group **250** and positive electrode tab group **280**. Positive electrode current collector **400**B in the present embodiment is connected to positive electrode terminal **302** between electrode assembly **200** and sealing plate **130**.

[0116] Positive electrode current collector **400**B includes current collector **420** and a current collector **440**. Although a plate **460** is interposed as an insulating member between current collector **420** and current collector **440**, current collector **420** and current collector **440** are electrically joined to each other at a position different from the cross section shown in the figure.

[0117] Current collector **420** is a plate-shaped member. Current collector **420** has a long-side direction in the Z direction and a short-side direction in the Y direction. Current collector **420** is constituted of a single component in one piece.

[0118] Positive electrode tab group **250** and positive electrode tab group **280** are joined, at below-described joining locations **421** (see FIG. **14**), to current collector **420** constituted of the single component. Each of joining locations **421** may be formed by ultrasonic welding, resistance welding, laser welding, swaging, or the like, for example. In the present embodiment, positive electrode tab group **250** and positive electrode tab group **280** are joined to current collector **420** by ultrasonic joining, for example.

[0119] Current collector **440** is joined to current collector **420** at a joining location (not shown) located at its end portion in the Z direction. Current collector **440** is connected to positive electrode terminal **302**. The connection between current collector **440** and positive electrode terminal **302** may be formed by swaging and/or welding, for example.

[0120] Positive electrode terminal **302** is provided to be exposed to the outside of sealing plate **130** and reach current collector **440** of positive electrode current collector **400**B provided on the inner surface side of sealing plate **130**. Positive electrode terminal **302** is connected to a plate-shaped member **304**.

[0121] Plate-shaped member **304** is located on the outer side with respect to sealing plate **130**. Plate-shaped member **304** is disposed along sealing plate **130**. Plate-shaped member **304** has electric conductivity. Plate-shaped member **304** is disposed to secure an area of connection with a bus bar or the like that electrically connects secondary battery **1** and another secondary battery adjacent thereto. The connection between positive electrode terminal **302** and plate-shaped member **304** may be formed by, for example, laser welding or the like.

[0122] An insulating member **510** is disposed between plate-shaped member **304** and sealing plate **130**. An insulating member **520** is disposed between positive electrode terminal **302** and sealing plate **130**. An insulating member **470** is disposed between current collector **440** and sealing plate **130**.

[0123] It should be noted that positive electrode terminal **302** may be electrically connected to sealing plate **130**. Further, sealing plate **130** may function as positive electrode terminal **302**.

[0124] A spacer **600** (second spacer) is disposed between sealing plate **130** and the main body portion (positive electrode tab groups **250**, **280** are not included) of electrode assembly **200**. Spacer **600** is composed of a resin member having an insulating property. Since each of positive electrode tab groups **250**, **280** passes internal to spacer **600**, each of positive electrode tab groups **250**, **280** is protected by spacer **600**. It should be noted that it is also possible to employ a configuration in which spacer **600** (second spacer) is not provided.

[0125] Although a detailed structure of spacer **600** will be described later, spacer **600** is provided with a protrusion **616** protruding in the Y direction. With this protrusion **616** of spacer **600**, spacer **600** functions as a guide to facilitate curving of curved portions **251**, **281** when forming curved portions **251**, **281**.

[0126] Insulating sheet **700** (electrode assembly holder) composed of a resin as described above is disposed between electrode assembly **200** and case main body **110**.

Manufacturing Process for Secondary Battery **1**

[0127] Hereinafter, a method of manufacturing the secondary battery according to the present

embodiment will be described. FIG. **13** is a flowchart showing a method of manufacturing the secondary battery according to the first embodiment. FIG. **14** is a perspective view showing a state before two electrode assemblies included in the secondary battery according to the first embodiment are overlapped with each other. FIG. **15** is a cross sectional view of each of the electrode assemblies and the current collectors shown in FIG. **14** along XV-XV.

[0128] As shown in FIG. **13**, in the method of manufacturing the secondary battery according to the present embodiment, first, first electrode assembly **201** and second electrode assembly **202** are produced (step S**1**). Parts of the tips of negative electrode tab group **220**, positive electrode tab group **250**, negative electrode tab group **270**, and positive electrode tab group **280** are preferably cut such that they have the same tip length when bundled.

[0129] As shown in FIGS. **13** to **15**, after producing first electrode assembly **201** and second electrode assembly **202**, negative electrode tab group **220** is joined to one current collector **410** (step S**2**). Negative electrode tab group **220** is joined to one current collector **410** at joining location **411**. Next, negative electrode tab group **270** is joined to the other current collector **410** (step S**3**). Negative electrode tab group **270** is joined to the other current collector **410** at joining location **411**.

[0130] Next, first electrode assembly **201**, current collector **420**, and second electrode assembly **202** are disposed side by side in this order in the first direction (DR**1** direction). Positive electrode tab group **250** is disposed on one side with respect to current collector **420** in the first direction (DR**1** direction). Positive electrode tab group **250** and positive electrode tab group **280** are joined to current collector **420** with positive electrode tab group **280** being disposed on the other side with respect to current collector **420** in the first direction (DR**1** direction) (step S**4**). Positive electrode tab group **250** and positive electrode tab group **280** are joined to current collector **420** at joining locations **421**.

[0131] In the height direction of each of first electrode assembly **201** and second electrode assembly **202**, each of one current collector **410**, the other current collector **410** and current collector **420** is disposed on one side with respect to the center of each of first electrode assembly **201** and second electrode assembly **202**. Thus, each of the current collectors can be formed to be short, thereby reducing the size of the current collector.

[0132] Each of one current collector **410**, the other current collector **410**, and current collector **420** is not limited to this configuration. In the height direction of each of first electrode assembly **201** and second electrode assembly **202**, each of current collectors **410** and current collector **420** may be disposed at the center of a corresponding one of first electrode assembly **201** and second electrode assembly **202**. In this case, in the height direction of each of first electrode assembly **201** and second electrode assembly **202**, each of negative electrode tab group **220**, positive electrode tab group **250**, negative electrode tab group **270**, and positive electrode tab group **280** is disposed at the center of a corresponding one of first electrode assembly **201** and second electrode assembly **202** so as to correspond to a corresponding one of current collectors **410** and current collector **420**.

[0133] The order of the steps of joining current collectors **410** and current collector **420** to first electrode assembly **201** and second electrode assembly **202** is not limited to the one described above, and the order may be changed. Each of the respective steps of joining current collectors **410** to first electrode assembly **201** and second electrode assembly **202** is preferably performed before the below-described step of overlapping first electrode assembly **201** and second electrode assembly **202** with each other, and is preferably performed before the step of joining current collector **420** to first electrode assembly **201** and second electrode assembly **202**.

[0134] Next, after joining positive electrode tab group **250** and positive electrode tab group **280** to current collector **420**, positive electrode tab group **250** and positive electrode tab group **280** are bent in the thickness direction (direction orthogonal to the DR**1** direction in FIGS. **14** and **15**) of each of first electrode assembly **201** and second electrode assembly **202**, thereby overlapping first electrode assembly **201** and second electrode assembly **202** with each other (step S**5**). That is, first electrode assembly **201** and second electrode assembly **202** are collected together.

[0135] Regarding the expression “overlapping the first electrode assembly and the second electrode assembly with each other”, the first electrode assembly and the second electrode assembly may be overlapped with each other directly, or another member may be disposed between the first electrode assembly and the second electrode assembly. Further, the first electrode assembly and the second electrode assembly may or may not be fixed by a tape or the like. Further, the first electrode assembly, the current collector, and the second electrode assembly may not be disposed on a straight line in the first direction (DR**1** direction), and the first electrode assembly or the second electrode assembly may be inclined with respect to the current collector in the first direction (DR**1** direction).
[0136] Positive electrode tab group **250** and positive electrode tab group **280** are folded such that tip portions thereof face each other. Similarly, negative electrode tab group **220** and negative electrode tab group **270** are also folded such that tip portions thereof face each other.
[0137] Each of FIGS. **13** and **16** is a perspective view showing a state of attaching the holder and the spacer to the electrode assembly. As shown in FIG. **16**, next, spacer **600** and insulating sheet **700** are assembled to electrode assembly **200** (step S**6**).
[0138] Insulating sheet **700** does not necessarily need to cover a whole of the surfaces of electrode assembly **200**. Insulating sheet **700** preferably covers an area of about 50% or more, more preferably about 70% or more, of the outer surfaces of the electrode assembly. Insulating sheet **700** preferably covers a whole of at least four surfaces of the six surfaces of electrode assembly **200** having a substantially rectangular parallelepiped shape (flat shape) other than the two surfaces thereof on which negative electrode tab group **220** and positive electrode tab group **250** are formed respectively.
[0139] FIG. **17** is a perspective view showing a state of attaching sealing plate **120** to the current collectors on the negative electrode side. FIG. **18** is a cross sectional view of each of the electrode assemblies and the current collectors shown in FIG. **17** along XVIII-XVIII. FIGS. **19** and **20** are first and second perspective views each showing an implementation of spacer **600**, and FIG. **21** is a front view showing a positional relation between spacer **600** and insulating sheet **700**. It should be noted that in FIG. **18**, case main body **110** is not shown.
[0140] As shown in FIGS. **19** and **20**, spacer **600** is composed of a resin member having an insulating property. Spacer **600** includes: a first component **612** and a second component **614** each having three surrounding side walls; and a coupling wall **611** that couples one side wall of first component **612** and one side wall of second component **614** to each other. Protrusion **616** is provided on an inner side of coupling wall **611** so as to extend between first component **612** and second component **614** (in the Z direction).
[0141] First component **612** includes a first plate portion **617** provided to couple the three walls. First plate portion **617** is provided with a plurality of first through holes **617***s* each having an elliptical shape. The shape of each first through hole **617***s* and the number of first through holes **617***s* are appropriately selected, and are not limited to the shape and number shown. A first protrusion **612***p* protruding outward is provided in a region of first component **612** opposite to first plate portion **617** (side opposite to the electrode assembly).
[0142] Second component **614** includes a second plate portion **618** provided to couple the three walls. Second plate portion **618** is provided with a plurality of second through holes **618***s* each having an elliptical shape. The shape of each second through hole **618***s* and the number of second through holes **618***s* are appropriately selected, and are not limited to the shape and number shown. A second protrusion **614***p* protruding outward is provided in a region of second component **614** opposite to second plate portion **618** (side opposite to the electrode assembly).
[0143] Each of first plate portion **617** and second plate portion **618** described above is located on an end surface side of the electrode assembly. Each of these plate portions may be in abutment with the end surface of the electrode assembly, or when each of these plate portions is not in abutment with the end surface, the shortest distance to the electrode assembly is preferably 2 mm or less, and

is more preferably 1 mm or less. Further, since first through hole **617***s* and second through hole **618***s* are provided, when secondary battery **1** shown in FIG. **1** is placed with the Z direction corresponding to the upward direction (such a direction that opening **113** (first opening) and opening **114** (second opening) at the both ends of case main body **110** are arranged on the left and right), even if the electrolyte solution pushed out from the electrode assembly flows to outside of the through holes during charging (generally, the electrode plate is expanded), the electrolyte solution can be readily returned to inside of the electrode assembly during discharging (generally, the electrode plate is contracted).

[0144] The outer size of spacer **600** (each of the first spacer and the second spacer) is preferably smaller than the outer size of electrode assembly **200**. Since insulating sheet **700** is wound around electrode assembly **200** and is also wound around spacer **600**, insertability of electrode assembly **200** of case main body **110** can be improved by making the outer size of spacer **600** smaller than that of electrode assembly **200**.

[0145] As shown in FIG. **21**, when electrode assembly **200** is covered with insulating sheet **700**, spacer **600** is also preferably covered with insulating sheet **700**. In this case, each of the negative electrode tab group and the positive electrode tab group passes internal to spacer **600**, thereby protecting each of the negative electrode tab group and the positive electrode tab group by spacer **600**. Further, since spacer **600** is also covered with insulating sheet **700**, each of the negative electrode tab group and the positive electrode tab group is further protected. It should be noted that each of first protrusion **612***p* and second protrusion **614***p* provided in spacer **600** is desirably exposed from insulating sheet **700**.

[0146] As shown in FIGS. **13**, **17**, and **18**, one current collector **410** and the other current collector **410** are electrically connected to negative electrode terminal **301** via current collector **430** after joining negative electrode tab group **220** to current collector **410**, joining negative electrode tab group **270** to current collector **430**, and overlapping first electrode assembly **201** and second electrode assembly **202** with each other (step S**7**). It should be noted that step S**7** can be performed before step S**6**.

[0147] Specifically, negative electrode tab group **220** and negative electrode tab group **270** are folded such that tip portions **222**, **272** face each other.

[0148] Each of negative electrode terminal **301** and current collector **430** is attached to sealing plate **120** with an insulating member being interposed therebetween. Current collector **430** is brought into abutment with one current collector **410** and the other current collector **410** in the X direction. It should be noted that the connecting of plate-shaped member **303** to negative electrode terminal **301** may be performed at any timing. Current collector **430** is joined to one current collector **410** and the other current collector **410** by laser welding from between sealing plate **120** and insulating sheet **700**.

[0149] FIG. **22** is a perspective view showing a state of inserting the electrode assemblies into the case main body. As shown in FIGS. **13** and **22**, next, after overlapping first electrode assembly **201** and second electrode assembly **202** with each other, first electrode assembly **201** and second electrode assembly **202** are inserted into case main body **110** via opening **113** with the current collector **420** side being inserted first (step S**8**). On this occasion, at each of the end portions of first electrode assembly **201** and second electrode assembly **202** on the negative electrode tab **230** side, first electrode assembly **201** and second electrode assembly **202** may be inserted into case main body **110** with negative electrode active material layer **212** protruding to the negative electrode tab **230** side with respect to the end portion of positive electrode active material layer **242**.

[0150] Negative electrode tab group **220** and negative electrode tab group **270** are curved by bringing sealing plate **120** close to the main body portion of electrode assembly **200** (first electrode assembly **201** and second electrode assembly **202**). It should be noted that sealing plate **120** and case main body **110** are preferably brought close to each other by bringing sealing plate **120** close to the main body portion of electrode assembly **200** disposed in case main body **110**. As shown in

FIG. **11**, negative electrode tab group **220** and negative electrode tab group **270** are curved along the shape of spacer **600** such that the folded portions of curved portions **221**, **271** are close to case main body **110** in the Y direction.

[0151] After bringing sealing plate **120** into abutment with case main body **110**, sealing plate **120** is temporarily joined to case main body **110**. By the temporary joining, sealing plate **120** is partially joined to opening **113** of case main body **110**. Thus, sealing plate **120** is positioned with respect to case main body **110**.

[0152] When inserting electrode assembly **200** into case main body **110**, electrode assembly **200** may be pulled from the current collector **420** side, or may be pushed from each of the current collector **410** side and the current collector **430** side. When electrode assembly **200** is pressed from each of the current collector **410** side and the current collector **430** side, negative electrode tab group **220** and negative electrode tab group **270** can be curved at the same time.

[0153] FIG. **23** is a perspective view showing a state of attaching sealing plate **130** to the current collectors on the positive electrode side. FIG. **24** is a cross sectional view of each of the electrode assemblies and the current collectors shown in FIG. **23** along XXIII-XXIII. In FIG. **24**, case main body **110** is not shown.

[0154] As shown in FIGS. **13**, **22** and **23**, current collector **420** is electrically connected to positive electrode terminal **302** after inserting first electrode assembly **201** and second electrode assembly **202** into case main body **110** (step S**9**).

[0155] Specifically, each of positive electrode terminal **302** and current collector **450** is attached to sealing plate **130** with an insulating member being interposed therebetween. After inserting first electrode assembly **201** and second electrode assembly **202** into case main body **110**, current collector **450** is brought into abutment, in the X direction, with current collector **420** protruding from opening **114**. The connecting of plate-shaped member **304** to positive electrode terminal **302** may be performed at any timing.

[0156] As shown in FIG. **24**, positive electrode tab group **250** and positive electrode tab group **280** connected to current collector **420** are folded such that tip portions **252**, **282** face each other. From the state shown in FIG. **24**, sealing plate **130** is brought into abutment with case main body **110**. On this occasion, positive electrode tab group **250** and positive electrode tab group **280** are curved by bringing sealing plate **130** and the main body portion of electrode assembly **200** close to each other. As shown in FIG. **12**, positive electrode tab group **250** and positive electrode tab group **280** are curved along the shape of spacer **600** such that the folded portions of curved portions **251**, **281** are close to case main body **110** in the Y direction.

[0157] After sealing plate **130** is brought into abutment with case main body **110**, sealing plate **130** is temporarily welded to case main body **110**. By the temporary joining, sealing plate **130** is partially joined to opening **114** of case main body **110**. Thus, sealing plate **130** is positioned with respect to case main body **110**.

[0158] FIG. **25** is a perspective view showing the configuration of secondary battery **1**. As shown in FIGS. **13** and **25**, next, sealing plate **120** and sealing plate **130** are joined to case main body **110** (step S**10**). Sealing plate **120** seals opening **113** of case main body **110**, and sealing plate **130** seals opening **114** of case main body **110**. Thus, first electrode assembly **201** and second electrode assembly **202** are accommodated in case **100**.

[0159] After the above-described steps, an inspection such as a leakage inspection is performed (step S**11**). After the leakage inspection, secondary battery **1** is dried to remove moisture in case **100**. Then, the electrolyte solution is injected into case **100** through injection hole **134**. When injecting the electrolyte solution, case **100** is inclined with sealing plate **130** facing upward and sealing plate **120** facing downward, thereby injecting the electrolyte solution into case **100** via injection hole **134** of sealing plate **130**. Thereafter, charging is performed to result in release of gas. For performing the charging to result in release of gas, injection hole **134** may be temporarily sealed. Thereafter, injection hole **134** is sealed, thereby completing secondary battery **1**.

[0160] The order of the step of inserting electrode assembly **200** and the step of connecting the current collectors is not limited to the above-described example. For example, after only a portion of electrode assembly **200** is inserted into case main body **110** with the end portion of negative electrode active material layer **212** (second electrode active material layer) on the opening **113** side being disposed outside case main body **110** (first step), negative electrode terminal **301** (first electrode terminal) provided on sealing plate **120** (first sealing plate) and negative electrode tab groups **220**, **270** (first electrode tab) may be electrically connected to each other, and then electrode assembly **200** may be inserted into case main body **110** until the end portion of negative electrode active material layer **212** on the opening **113** side is disposed inside case main body **110** (second step). That is, negative electrode terminal **301** and electrode assembly **200** can be electrically connected to each other during the step of inserting electrode assembly **200** into case main body **110**.

[0161] In the present embodiment, since first electrode assembly **201** is provided with negative electrode tab group **220** and positive electrode tab group **250** and second electrode assembly **202** is provided with negative electrode tab group **270** and positive electrode tab group **280**, first electrode assembly **201** and second electrode assembly **202** can be configured to have separate electrode tabs.

[0162] With this configuration, the electrode tabs can be shortened as compared with a case where one collective electrode tab is formed by first electrode assembly **201** and second electrode assembly **202** and the electrode tab is bent.

[0163] As a result, the occupied volume of the electrode tabs can be reduced, thereby improving the energy density of secondary battery **1**. Further, in the configuration in which the separate electrode tabs are respectively provided for first electrode assembly **201** and second electrode assembly **202**, the electrode tabs are readily bent and the electrode tabs and the current collectors can be therefore readily joined as compared with the case where one collective electrode tab is formed by first electrode assembly **201** and second electrode assembly **202**, with the result that the secondary battery can be stably manufactured. In particular, since secondary battery **1** can be stably manufactured, reliability of the connection portion between each of the electrode tabs and each of the current collectors can be increased.

Specific Configurations of Current Collector **410** and Current Collector **430**

[0164] Next, a specific configuration of each of current collectors **410** (first current collecting member) and current collector **430** (second current collecting member) will be described with reference to FIGS. **26** to **28**. FIG. **26** is a side view showing only the negative-electrode-side connection structure on the sealing plate **120** (first sealing plate) side, FIG. **27** is a longitudinal cross sectional view showing only the negative-electrode-side connection structure other than negative electrode tab groups **220**, **270** and electrode assembly **200**, and FIG. **28** is a perspective view showing a state before fixing sealing plate **120** to case main body **110**.

[0165] Current collector **410** has a plate shape and includes a first region R**1**, a second region R**2**, and a third region R**3**. First region R**1** is disposed between second region R**2** and third region R**3**. It should be noted that negative electrode tab group **220**, **270** (first electrode tab) is connected to first region R**1**. It should be noted that second region R**2**, first region R**1**, and third region R**3** are preferably arranged in this order in the long-side direction of sealing plate **120**.

[0166] Current collector **430** has a plate shape and includes a fourth region R**4**, a fifth region R**5**, and a sixth region R**6**. Fourth region R**4** is disposed between fifth region R**5** and sixth region R**6**.

[0167] In current collector **410**, in the direction (X direction) perpendicular to sealing plate **120**, a surface of first region R**1** on the sealing plate **120** side protrudes to the sealing plate **120** side with respect to each of a surface of second region R**2** on the sealing plate **120** side and a surface of third region R**3** on the sealing plate **120** side.

[0168] A first chamfered portion RT**2** is provided at a tip portion of second region R**2** on the fifth region R**5** side, and a second chamfered portion RT**5** is provided at a tip portion of fifth region R**5**

on the second region R**2** side.
[0169] In the present embodiment, since the whole of first region R**1** protrudes to the sealing plate **120** side, a recess **410***p* is provided on the negative electrode tab group **220**, **270** side of first region R**1**. Thus, negative electrode tab group **220**, **270** is connected to recess **410***p* of first region R**1**. It should be noted that the negative electrode tab group **220**, **270** (first electrode tab) side of first region R**1** may be flat.
[0170] In current collector **430**, in the direction (X direction) perpendicular to sealing plate **120**, in the surface of current collector **430** on the electrode assembly **200** side, fourth region R**4** is provided with a recess **430***p* recessed to the sealing plate **120** side with respect to each of fifth region R**5** and sixth region R**6**.
[0171] The length (PL**1**) of recess **430***p* in the long-side direction (Z direction) is preferably larger than the length of the portion of first region R**1** protruding to the sealing plate **120** side in the long-side direction (Z direction). The length of the portion of first region R**1** protruding to the sealing plate **120** side in the long-side direction (Z direction) is preferably 70% or more, more preferably 80% or more, and further preferably 90% or more of the length (PL**1**) of recess **430***p* in the long-side direction (Z direction).
[0172] The first region of current collector **410** preferably has a protruding portion **410***q* protruding to the sealing plate **120** side, and protruding portion **410***q* preferably has a tip surface **410***q***1** located on the tip side in the protruding direction and outer side surfaces **410***q***2** located at both ends of tip surface **410***q***1** in the long-side direction thereof.
[0173] Recess **430***p* preferably has a bottom surface **430***p***1** and inner side surfaces **430***p***2** provided at both ends of bottom surface **430***p***1** in the long-side direction thereof. Tip surface **410***q***1** of protruding portion **410***q* and bottom surface **430***p***1** of recess **430***p* face each other and is in abutment with or in proximity to each other. The length (PL**11**) of tip surface **410***q***1** of protruding portion **410***q* of current collector **410** in the long-side direction (Z direction) is preferably 70% or more, more preferably 80% or more, and further preferably 90% or more of the length (PL**12**) of bottom surface **430***p***1** of recess **430***p* in the long-side direction (Z direction). It should be noted that the length of tip surface **410***q***1** is preferably less than 100% of bottom surface **430***p***1**.
[0174] In recess **430***p*, the length (PL**1**) of recess **430***p* in the long-side direction (Z direction) may be longer than the length (TL**1**) of each of negative electrode tab groups **220**, **270** (first electrode tab) in the long-side direction (Z direction). When each of negative electrode tab groups **220**, **270** (first electrode tab) is trapezoidal in shape, the length (length in the Z direction) of each of the regions of negative electrode tab groups **220**, **270** connected to current collectors **410** is defined as the length (TL**1**) of each of negative electrode tab groups **220**, **270**.
[0175] Further, referring to FIG. **11**, the length (PL**2**) of recess **430***p* in the short-side direction (Y direction) is preferably longer than the length (TL**2**), in the width direction (Y direction), of each of the portions of negative electrode tab groups **220**, **270** (first electrode tab) that are in abutment with current collectors **410**. It should be noted that the entire region of current collector **430** in the short-side direction is preferably recess **430***p*.
[0176] In a state in which current collector **410** and current collector **430** are overlapped with each other, at least a portion of first region R**1** of current collector **410** is preferably disposed in recess **430***p* of current collector **430**. Thus, current collector **410** can be positioned with respect to current collector **430**. As a result, current collector **410** and current collector **430** can be stably connected.
[0177] Preferably, in a state in which first region R**1** is disposed in recess **430***p*, a first clearance S**1** is provided on the second region side and a second clearance S**2** is provided on the third region side between first region R**1** and the inner side surface of recess **430***p*. With first clearance S**1** and second clearance S**2**, a slight positional deviation of first region R**1** in recess **430***p* can be absorbed, thereby facilitating positioning of first region R**1** with respect to recess **430***p*. It should be noted that only one of first clearance S**1** and second clearance S**2** may be provided.
[0178] Further, in the long-side direction (Z direction in FIG. **26**) of recess **430***p*, each of the width

of first clearance S**1** (portion of the clearance with the maximum width) and the width of second clearance S**2** (portion of the clearance with the maximum width) is preferably 5 mm or less, more preferably 3 mm or less, and further preferably 2 mm or less.

[0179] Further, a first abutment region TR**1** in which second region R**2** of current collector **410** and fifth region R**5** of current collector **430** are in abutment with each other may be formed, and a second abutment region TR**2** may be formed at at least one of a position between first region R**1** of current collector **410** and fourth region R**4** of current collector **430** and a position between third region R**3** of current collector **410** and sixth region R**6** of current collector **430**, second abutment region TR being a region in which corresponding ones of first region R**1**, fourth region R**4**, third region R**3**, and sixth region R**6** are in abutment with each other. Thus, current collector **410** and current collector **430** are more stably connected to each other.

[0180] In the present embodiment, second abutment region TR**2** is formed between third region R**3** and sixth region R**6**. With this configuration, an abutment state between current collector **410** and current collector **430** can be further stabilized. On this occasion, first region R**1** and fourth region R**4** can be avoided from being in abutment with each other. Thus, it is possible to suppress unsteadiness more effectively.

[0181] First region R**1** and fourth region R**4** may be in contact with each other, second region R**2** and fifth region R**5** may be in contact with each other, and third region R**3** and sixth region R**6** may be in contact with each other. With this configuration, positioning can be attained and unsteadiness can be suppressed.

[0182] The length of an abutment surface of first abutment region TR**1** at which second region R**2** and fifth region R**5** are in abutment with each other is preferably 1 mm or more, more preferably 2 mm or more, and further preferably 3 mm or more. It should be noted that first region R**1** and fourth region R**4** may constitute a proximity region (proximity surface). The proximity region means a state in which they are not in abutment with each other but there is substantially no clearance formed therebetween, and is, for example, 0.5 mm or less.

[0183] A joining portion SG**1** joined by welding WD is provided at an end portion (upper end portion in the figure) of first abutment region TR**1**. Since first abutment region TR**1** is provided, the end portion of first abutment region TR**1** can be stably welded. Further, after joining portion SG**1** is formed, occurrence of unsteadiness of first abutment region TR**1** can be suppressed even when a load is applied to first abutment region TR**1**.

[0184] For the welding, welding using a high energy radiation is preferable, and laser welding using laser light is more preferable. Thus, it is possible to form joining portion SG**1** with high reliability in joining. On this occasion, when the high energy radiation is applied from the side surface side (upper side in FIG. **26**) of each of current collector **410** and current collector **430**, first chamfered portion RT**2** at the tip portion of second region R**2** and second chamfered portion RT**5** at the tip portion of fifth region R**5** preferably form a V-shaped receiving portion because joining portion SG**1** can be readily formed. It should be noted that joining portion SG**1** may be formed between second region R**2** and fifth region R**5** through penetration welding by applying the high energy radiation to one region (current collector).

[0185] In the step of forming joining portion SG**1**, joining portion SG**1** can be formed in the following manner: after electrode assembly **200** is inserted into case main body **110**, the laser light is applied to the chamfered portion of at least one of current collector **410** and current collector **430** from between case main body **110** and sealing plate **120** in the step of joining current collector **410** and current collector **430**. It should be noted that the step of forming joining portion SG**1** is not limited to being performed at this timing.

[0186] Further, first clearance S**1** described above may be provided in the vicinity of the end portion of first abutment region TR**1** opposite to the end portion at which joining portion SG**1** is formed. By providing first clearance S**1**, heat generated when forming joining portion SG**1** can be suppressed from being transferred to each of the first region R**1** side and the fourth region R**4** side,

thereby stably forming joining portion SG**1**.

[0187] In current collector **430**, the thickness (t**4**) of fourth region R**4** is preferably smaller than each of the thickness (t**5**) of fifth region R**5** and the thickness (t**6**) of sixth region R**6**. The value of the thickness (t**4**) of fourth region R**4**/the thickness (t**5**) of fifth region R**5** is preferably about 0.3 to 0.8, for example. The value of the thickness (t**4**) of fourth region R**4**/the thickness (t**6**) of sixth region R**6** is preferably about 0.3 to 0.8, for example. The value of the thickness (t**1**) of first region R**1**/the thickness (t**2**) of second region R**2** is preferably about 0.8 to 1.2, for example. The value of the thickness (t**1**) of first region R**1**/the thickness (t**3**) of third region R**3** is preferably about 0.8 to 1.2, for example. Current collector **410** may be formed by bending a plate material.

[0188] A portion of current collector **410** to which each of negative electrode tab groups **220**, **270** is connected may be present close to third region R**3** (lower side in the figure) with respect to second region R**2**.

[0189] An end portion of third region R**3** may protrude (distance Pl in the figure) outward with respect to the end portion of sixth region R**6** in the long-side direction of sealing plate **120**.

Other Embodiments

[0190] Other implementations of second region R**2** of current collector **410** and fifth region R**5** of current collector **430** will be described with reference to FIGS. **29** to **33**. FIGS. **29** to **33** are first to fifth perspective views each showing another implementation of the joining portion between second region R**2** of current collector **410** and fifth region R**5** of current collector **430**.

[0191] In the implementation of the joining portion shown in FIG. **29**, fifth region R**5** of current collector **430** is provided to be separated from insulating member **530** as compared with the manner of joining as shown in FIG. **28**. Also in this implementation of the joining portion, the operation of joining second region R**2** and fifth region R**5** can be readily performed because joining portion SG**1** is oriented in the Z direction. Furthermore, since joining portion SG**1** is separated from insulating member **530**, insulating member **530** can be suppressed from being damaged due to an influence of heat.

[0192] In the implementation of the joining portion shown in FIG. **30**, second region R**2** of current collector **410** is bent perpendicularly to the electrode assembly **200** side, and fifth region R**5** of current collector **430** is also bent perpendicularly to the electrode assembly **200** side along second region R**2**. As a result, an overlapping region R**11** is provided between second region R**2** and fifth region R**5**, and joining portion SG**1** is formed in this region. With this implementation of the joining portion, the operation of joining second region R**2** and fifth region R**5** can be readily performed because joining portion SG**1** is oriented in the Z direction. Further, since joining portion SG**1** is separated from insulating member **530**, insulating member **530** can be suppressed from being damaged due to an influence of heat. Further, a formation area of joining portion SG**1** can be large.

[0193] In the implementation of the joining portion shown in FIG. **31**, second region R**2** of current collector **410** is bent to protrude to the electrode assembly **200** side, and fifth region R**5** of current collector **430** is also bent to the electrode assembly **200** side along second region R**2**. As a result, an overlapping region R**11** between second region R**2** and fifth region R**5** is provided to be inclined with respect to sealing plate **120**, and joining portion SG**1** is formed in this region R**11**. With this implementation of the joining portion, the operation of joining second region R**2** and fifth region R**5** can be readily performed because joining portion SG**1** is oriented obliquely with respect to the Z direction. Further, since joining portion SG**1** is separated from insulating member **530**, insulating member **530** can be suppressed from being damaged due to an influence of heat.

[0194] In the implementation of the joining portion shown in FIG. **32**, second region R**2** of current collector **410** is provided to extend in the Z direction so as to be located close to the electrode assembly **200** side with respect to first region R**1**, and fifth region R**5** of current collector **430** is also provided to extend in the Z direction along second region R**2**. Further, the end portion of fifth region R**5** is provided to protrude with respect to the end portion of second region R**2**. As a result,

joining portion SG**1** can be formed at fifth region R**5** protruding with respect to second region R**2**, with the result that the welding operation can be readily performed in an oblique direction. Further, since joining portion SG**1** is separated from insulating member **530**, insulating member **530** can be suppressed from being damaged due to an influence of heat.

[0195] In the implementation of the joining portion shown in FIG. **33**, second region R**2** of current collector **410** is provided with a first extension portion R**21** extending obliquely upward from its tip to the electrode assembly **200** side, fifth region R**5** of current collector **430** is separated from insulating member **530** so as to be in contact with second region R**2**, and the tip portion of fifth region R**5** is provided with a second extension portion R**51** bent toward insulating member **530**. As a result, a receiving portion having a V-shaped cross section is formed by first extension portion R**21** and second extension portion R**51**. Since the receiving portion is formed in this way, joining portion SG**1** can be formed in the receiving portion, with the result that the welding operation can be readily performed. Further, since joining portion SG**1** is separated from insulating member **530**, insulating member **530** can be suppressed from being damaged due to an influence of heat.

[0196] In each of the implementations disclosed in FIGS. **28** to **33**, the connecting of current collector **410** and current collector **430** may be performed before electrode assembly **200** is inserted into case main body **110**, or may be performed after at least a portion of electrode assembly **200** is inserted into case main body **110**.

[0197] Although the current collecting structure on the negative electrode side has been illustratively described in each of the above-described embodiments, the current collecting structure described in each of the above-described embodiments can be applied to the current collecting structure on the positive electrode side. Further, in each of the above-described embodiments, it has been illustratively described that two current collectors **410** are used on the negative electrode side; however, as with the positive electrode side, only one current collector **410** may be used. Further, current collector **410** and current collector **430** may be connected to each other before electrode assembly **200** is inserted into case main body **110**.

[0198] Although the embodiments of the present invention have been described and illustrated in detail, it is clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation. The scope of the present invention is defined by the terms of the claims, and is intended to include any modifications within the scope and meaning equivalent to the terms of the claims.

Claims

1. A secondary battery comprising: an electrode assembly including a first electrode and a second electrode having a polarity different from a polarity of the first electrode; a case main body provided with a first opening; a first sealing plate that seals the first opening; a first electrode tab electrically connected to the first electrode; a first current collecting member electrically connected to the first electrode tab; a second current collecting member joined to the first current collecting member; and a first electrode terminal electrically connected to the second current collecting member and provided on the first sealing plate, wherein the first current collecting member includes a first region, a second region, and a third region, the first region is disposed between the second region and the third region, the second current collecting member includes a fourth region, a fifth region, and a sixth region, the fourth region is disposed between the fifth region and the sixth region, the first electrode tab is connected to the first region, in a direction perpendicular to the first sealing plate, a surface of the first region on the first sealing plate side protrudes to the first sealing plate side with respect to each of a surface of the second region on the first sealing plate side and a surface of the third region on the first sealing plate side, and in the direction perpendicular to the first sealing plate, in a surface of the second current collecting member on the electrode assembly side, the fourth region is provided with a recess recessed to the first sealing

plate side with respect to each of the fifth region and the sixth region, and at least a portion of the first region is disposed in the recess.

2. The secondary battery according to claim 1, wherein a first abutment region in which the second region and the fifth region are in abutment with each other is formed, and a second abutment region is formed at at least one of a position between the first region and the fourth region and a position between the third region and the sixth region, the second abutment region being a region in which corresponding ones of the first region, the fourth region, the third region, and the sixth region are in abutment with each other.

3. The secondary battery according to claim 2, wherein a joining portion at which the first current collecting member and the second current collecting member are joined to each other is provided at an end portion of the first abutment region.

4. The secondary battery according to claim 3, wherein a first clearance is present in a vicinity of an end portion of the first abutment region opposite to the end portion at which the joining portion is formed.

5. The secondary battery according to claim 2, wherein the second abutment region is formed between the third region and the sixth region.

6. The secondary battery according to claim 1, wherein a thickness of the fourth region is smaller than each of a thickness of the fifth region and a thickness of the sixth region.

7. The secondary battery according to claim 1, wherein a portion of the first current collecting member to which the first electrode tab is connected is present close to the third region with respect to the second region.

8. The secondary battery according to claim 1, wherein an end portion of the third region protrudes outward with respect to an end portion of the sixth region in a long-side direction of the first scaling plate.