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United States Patent	12394860
Kind Code	B2
Date of Patent	August 19, 2025
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Secondary battery

Abstract

The present invention relates to a secondary battery capable of improving insulation safety. For example, the secondary battery includes: an electrode assembly; a case configured to accommodate the electrode assembly; and a cap assembly coupled to an upper portion of the case, wherein the cap assembly includes a cap-up, a safety vent installed below the cap-up and having a vent extension part extending to an upper side of the cap-up to surround an edge of the cap-up, and an insulation washer attached to upper portions of the vent extension part and the cap-up, and a welding area having a thickness less than that of surroundings is formed on the vent extension part.

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Appl. No.: **17/051718**

Filed (or PCT Filed): **April 15, 2019**

PCT No.: **PCT/KR2019/004491**

PCT Pub. No.: **WO2019/212164**

PCT Pub. Date: November 07, 2019

Prior Publication Data

Document Identifier	Publication Date
US 20210242528 A1	Aug. 05, 2021

Foreign Application Priority Data

KR	10-2018-0050596	May. 02, 2018

Publication Classification

Int. Cl.: **H01M50/342** (20210101); **H01M50/169** (20210101); **H01M50/578** (20210101); **H01M50/593** (20210101)

U.S. Cl.:

CPC **H01M50/342** (20210101); **H01M50/169** (20210101); **H01M50/578** (20210101); **H01M50/593** (20210101);

Field of Classification Search

CPC: H01M (50/342); H01M (50/578); H01M (50/169)

USPC: 429/82

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION(S)

(1) This application is a National Phase Patent Application of International Patent Application Number PCT/KR2019/004491, filed on Apr. 15, 2019, which claims priority of Korean Patent Application No. 10-2018-0050596, filed May 2, 2018. The entire contents of both of which are incorporated herein by reference.

TECHNICAL FIELD

(2) The present invention relates to a secondary battery.

BACKGROUND ART

(3) A secondary battery is a chargeable and dischargeable battery, unlike a primary battery that is not chargeable. Low-capacity secondary batteries are used in portable small electronic devices such as smart phones, feature phones, notebook computers, digital cameras, and camcorders, and large-capacity secondary batteries are widely used for a power source and power storage for driving a motor, such as hybrid vehicles, electric vehicles, and the like. Such lithium ion secondary batteries

may be classified into cylindrical, prismatic, and pouch-type secondary batteries.
(4) Particularly, a cylindrical lithium ion secondary battery generally includes a cylindrical electrode assembly, a cylindrical case to which the electrode assembly is coupled, an electrolyte injected into the inside of the case to enable movement of lithium ions, and a cap assembly coupled to one side of the case to prevent the electrolyte from leaking and preventing the electrode assembly from being separated.
(5) The above-described information disclosed in the technology that serves as the background of the present invention is only for improving understanding of the background of the present invention and thus may include information that does not constitute the related art.

DISCLOSURE OF THE INVENTION

Technical Problem

(6) The present invention provides a secondary battery capable of improving insulation safety.

Technical Solution

(7) A secondary battery according to the present invention includes: an electrode assembly; a case configured to accommodate the electrode assembly; and a cap assembly coupled to an upper portion of the case, wherein the cap assembly includes a cap-up, a safety vent installed below the cap-up and having a vent extension part extending to an upper side of the cap-up to surround an edge of the cap-up, and an insulation washer attached to upper portions of the vent extension part and the cap-up, and a welding area having a thickness less than that of surroundings is formed on the vent extension part.
(8) A portion of the safety vent and a portion of the cap-up may be melted by laser welding to form a welding bead, which protrudes upward, on the welding area.
(9) The welding bead may be spaced apart from the insulation washer.
(10) The vent extension part may include a first surface that is in contact with the cap-up and a second surface that is an opposite surface of the first surface and is in contact with the insulation washer, and the welding area may be defined by forming a groove having an opened end in the first surface.
(11) The cap-up may include a terminal part that protrudes upward, a coupling part which is disposed outside the terminal part and to which the safety vent is coupled, and a connection part configured to connect the terminal part to the coupling part, wherein the coupling part may include a first region extending from the connection part and a second region which is disposed outside the first region and has a thickness less than that of the first region and to which the vent extension part is coupled.
(12) The thickness of the first region may be equal to a sum of the thickness of the second region and a thickness of the vent extension part.
(13) The insulation washer may be seated on upper portions of the vent extension part and the first region.
(14) An oxide film may be formed on a surface of the insulation washer.
(15) The vent extension part may include a first surface that is in contact with the cap-up and a second surface that is an opposite surface of the first surface and is in contact with the insulation washer, and the welding area may be defined by forming a groove having an opened end in the second surface.
(16) The vent extension part may include a first surface that is in contact with the cap-up and a second surface that is an opposite surface of the first surface and is in contact with the insulation washer, and the welding area may be defined by forming a trench in the second surface.

Advantageous Effects

(17) In the secondary battery according to the embodiment of the present invention, the thin welding area may be formed in the safety vent to prevent the welding bead from being in contact with the insulation washer. Therefore, when the gasket is melted or damaged, the short circuit

between the cap assembly and the case may be prevented to improve the safety of the secondary battery.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. **1** is a cross-sectional view of a secondary battery according to an embodiment of the present invention.

(2) FIG. **2** is a cross-sectional view of a cap assembly in the secondary battery according to an embodiment of the present invention.

(3) FIG. **3** is an enlarged cross-sectional view illustrating a portion A of FIG. **2**.

(4) FIGS. **4**A to **4**D are cross-sectional views illustrating a method for forming a cap assembly.

(5) FIG. **5** is a cross-sectional view illustrating a welding area of a safety vent according to another embodiment of the present invention.

(6) FIG. **6** is a cross-sectional view illustrating a welding area of a safety vent according to further another embodiment of the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

(7) Preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings so that those skilled in the art can easily implement the present invention.

(8) Here, throughout the specification, parts having similar configurations and operations are denoted by the same reference numerals. Also, in this specification below, when any portion is referred to as being “connected” to another portion, it should be understood that the former can be “directly connected” to the latter, or “electrically connected” to the latter via an intervening member.

(9) FIG. **1** is a cross-sectional view of a secondary battery according to an embodiment of the present invention.

(10) Referring to FIG. **1**, a secondary battery **100** according to an embodiment of the present invention includes an electrode assembly **110**, a case **120**, a cap assembly **130**, and a gasket **190**.

(11) The electrode assembly **110** includes a first electrode **111**, a second electrode **112**, and a separator **113** interposed between the first electrode **111** and the second electrode **112**. The electrode assembly **110** may be formed by winding a stack of the first electrode **111**, the separator **113**, and the second electrode **112** in a jelly-roll form. The first electrode **111** may function as a positive electrode, and the second electrode **112** may function as a negative electrode. A first electrode tab **114** is connected to the cap assembly **130** in an upper portion of the electrode assembly **110**, and a second electrode tab **115** is connected to a bottom plate **122** of the case **120** in a lower portion of the electrode assembly **110**.

(12) The first electrode **111** is formed by applying a first electrode active material such as a transition metal oxide on a first electrode collector formed of metal foil such as aluminum foil. A first electrode non-coating portion that is not coated with a first electrode active material is formed on the first electrode **111**, and a first electrode tab **114** is attached to the first electrode non-coating portion. The first electrode tab **114** has one end, which is electrically connected to the first electrode **111**, and the other end, which protrudes upward from the electrode assembly **110** and is electrically connected to the cap assembly **130**.

(13) The second electrode **112** is formed by applying a second electrode active material such as graphite or carbon on a second electrode collector made of metal foil such as copper or nickel. A second electrode non-coating portion that is not coated with a second electrode active material is formed on the second electrode **112**, and a second electrode tab **115** is attached to the second electrode non-coating portion. The second electrode tab **115** has one end, which is electrically connected to the second electrode **112**, and the other end, which protrudes downward from the

electrode assembly **110** and is electrically connected to the bottom plate **122** of the case **120**.
(14) The separator **113** is disposed between the first electrode **111** and the second electrode **112** to prevent short circuit from occurring and allow lithium ions to be movable. The separator **113** may be formed of polyethylene, polypropylene, or a composite film of polyethylene and polypropylene.
(15) The case **120** includes a side plate **121**, which is a cylindrical body having a predetermined diameter to form a space in which the electrode assembly **110** is accommodated, and a bottom plate **122** that seals a lower portion of the side plate **121**. An upper opening of the case **120** is opened to be sealed after inserting the electrode assembly **110**. Also, a beading part **123** for preventing movement of the electrode assembly **110** is formed at an upper portion of the case **120**. Also, a crimping part **124** for fixing the cap assembly **130** and the gasket **190** is formed at the uppermost end of the case **120**. The crimping part **124** has a gasket **190** interposed therein and is formed to press the cap assembly **130**, thereby preventing the cap assembly **130** from being separated and preventing the electrolyte from leaking.
(16) FIG. **2** is a cross-sectional view of the cap assembly in the secondary battery according to an embodiment of the present invention.
(17) Referring to FIG. **2**, the cap assembly **130** includes a cap-up **140**, a safety vent **150**, an insulator **160**, a cap-down **170**, and an insulation washer **180**.
(18) The cap-up **140** is provided as a circular plate body and includes a terminal part **141** convexly formed at a center thereof, a coupling part **142** disposed on an outer circumference of the terminal part **141**, and a connection part **143** connecting the terminal part **141** and the coupling part **142** to each other. The terminal part **141** protrudes upward rather than the coupling part **142** to serve as a terminal electrically connected to an external circuit. The terminal part **141** is electrically connected to the first electrode tab **114** to function as, for example, a positive electrode. The coupling part **142** is disposed on the outer circumference of the terminal part **141**, and the safety vent **150** is coupled to the coupling part **142**. Also, the coupling part **142** includes a first region **142***a* disposed inside and connected to the connection part **143** and a second region **142***b* disposed outside the first region **142***a*. The second region **142***b* is formed to be thinner than a thickness of the first region **142***a*, and thus, a stepped portion occurs between the first region **142***a* and the second region **142***b*. A vent extension part **153** of the safety vent **150** is coupled to an upper portion of the second region **142***b*. Here, a sum of a thickness of the second region **142***b* and a thickness of the vent extension part **153** is formed to be equal to the thickness of the first region **142***a*. This is because the insulation washer **180** to be described later is stably seated on upper portions of the first region **142***a* of the cap-up **140** and the vent extension part **153**. The connection part **143** connects the terminal part **141** and the coupling part **142** to each other, and a gas discharge hole **143***a* is formed in the connection part **143**. The gas discharge hole **143***a* may be formed in plurality in the connection part **143** and provide a passage through which a gas generated inside the case **120** is discharged. Also, a portion of the gas discharge hole **143***a* may extend to the terminal part **141** and the coupling part **142**.
(19) The safety vent **150** is provided as a circular plate body corresponding to the cap-up **140** and is coupled to a lower portion of the cup-up **140**. A protrusion **151** protruding downward is formed at a center of the safety vent **150**. The safety vent **150** is electrically connected to the sub plate **175** fixed to a lower surface of the cap-down **170** by using the protrusion **151** passing through a through-hole **171** of the cap-down **170**. Here, the sub plate **175** and the protrusion **151** of the safety vent **150** may be welded through laser welding, ultrasonic welding, resistance welding, or an equivalent method thereof.
(20) Also, a notch **152** for guiding rupture of the safety vent **150** is formed on the outer circumference of the protrusion **151**. The safety vent **150** discharges the internal gas while blocking current when an abnormal internal pressure occurs in the case **120**. When the internal pressure of the safety vent **150** is equal to or greater than an operation pressure of the safety vent **150**, the protrusion **151** ascends upward by the gas discharged through the gas discharge hole **172** of the

cap-down **170** and thus is electrically separated from the sub plate **175**. Here, the sub plate **175** is electrically separated from the safety vent **150** while the welded portion of the protrusion **151** is torn. Also, when the internal pressure of the case **120** is greater than or equal to the rupturing pressure that is higher than the operation pressure of the safety vent **150**, the notch **152** is ruptured to prevent the secondary battery **100** from being exploded. The safety vent **150** may be made of aluminum (Al).

(21) The safety vent **150** is installed in close contact with the coupling part **142** at the lower portion of the cup-up **140**. Also, an edge of the safety vent **150** surrounds the cup-up **140** to extend to an upper side of the cup-up **140**. Here, the upward extending portion of the cap-up **140** is defined as a vent extension part **153**. Furthermore, an upper portion of the vent extension part **153** is welded using laser to fix the safety vent **150** to the cap-up **140**. A portion of the safety vent **150** and a portion of the cap-up **140** are melted by the laser welding to form a welding bead **155**. The welding method of the safety vent **150** and the cap-up **140** and the welding bead **155** will be described in more detail below.

(22) The insulator **160** is interposed between the safety vent **150** and the cap-down **170** to insulate the safety vent **150** and the cap-down **170** from each other. Particularly, the insulator **160** is provided in a ring shape and is interposed between an outer circumference of the safety vent **150** and an outer circumference of the cap-down **170**. The insulator **160** may be made of a resin material such as polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), or the like.

(23) The cap-down **170** is provided as a circular plate body. The through-hole **171** is formed in a center of the cap-down **170**, and the protrusion **151** of the safety vent **150** passes through the through-hole **171**. Also, the gas discharge hole **172** is formed at one side of the cap-down **170**, and a sub plate **175** is coupled to a lower portion of the cap-down **170**. The gas discharge hole **172** serves to discharge the internal gas when an excessive internal pressure is generated in the case **120**. Here, the protrusion **151** of the safety vent **150** may ascend by the gas discharged through the gas discharge hole **172**, and thus, the protrusion **151** may be separated from the sub plate **175**. The sub plate **175** is welded between the protrusion **151** of the safety vent **150**, which passes through the through-hole **171** of the cap-down **170**, and the first electrode tab **114**. Accordingly, the sub plate **175** electrically connects the first electrode tab **114** to the safety vent **150**.

(24) The insulation washer **180** is provided in a ring shape and is installed on the upper portions of the cap-up **140** and the safety vent **150**. Particularly, the insulation washer **180** is disposed on the upper portions of the first region **142***a* of the cap-up **140** and the vent extension part **153** of the safety vent **150**. Here, the insulation washer **180** may be attached to the upper portions of the cap-up **140** and the safety vent **150** through an adhesive member (not shown). The insulation washer **180** serves to prevent an electrical short-circuit between the cap assembly **110** and the case **120**. Particularly, the insulation washer **180** may prevent the cap assembly **110** and the case **120** from being short-circuited even if the gasket **190** disposed between the cap assembly **110** and the case **120** is melted or damaged. The insulation washer **180** may be formed by anodizing an aluminum sheet. Here, the anodizing is to oxidize a surface of a metal plate so as to form an oxide film. In general, the most representative material for anodizing is aluminum (Al). In addition, the anodizing may be performed on metal materials such as manganese (Mn), zinc (Zn), titanium (Ti), hafnium (Hf) and niobium (Nb). The oxide film is very hard, has excellent corrosion resistance and abrasion resistance, and is not melted at a high temperature. That is, an oxide film **181** is formed on a surface of the insulation washer **180**, and the oxide film **181** prevents an electrical short-circuit between the cap assembly **110** and the case **120**.

(25) The gasket **190** is installed in the upper opening of the case **120**. That is, the gasket **190** is assembled by being in close contact with the outer circumference of the cap-up **140**, the safety vent **150**, and the upper opening of the case **120**. The gasket **190** may be made of a resin material such as polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), or the like. The gasket

190 may electrically insulate the case **120** and the cap assembly **130** from each other.
(26) FIG. **3** is an enlarged cross-sectional view illustrating a portion A of FIG. **2**.
(27) As illustrated in FIG. **3**, the vent extension part **153** has a first surface **153***a* in contact with the cap-up **140** and a second surface **153***b* in contact with the insulation washer **180** on an opposite surface of the first surface **153***a*. Also, the vent extension part **153** includes a welding area **153***c* that is welded to the cap-up **140**. The welding area **153***c* is formed on an end of the vent extension part **153** and is disposed inside the safety vent **150**. That is, the welding area **153***c* is disposed at a portion adjacent to the first region **142***a* in the second region **142***b* of the cap-up **140**. Furthermore, a thickness of the welding area **153***c* is formed to be relatively thinner than a thickness of the peripheral vent extension part **153**. This is to prevent the welding bead **155** formed when welding the welding area **153***c* to the cap-up **140** from being in contact with the insulation washer **180**.
(28) The welding area **153***c* may be defined by forming a groove having an opened end in the first surface **153***a* of the vent extension part **153**. Accordingly, a stepped portion occurs between the vent extension part **153** and the welding area **153***c*, and a spaced space exists between the welding region **153***c* and the cap-up **140**. During the welding, the welding area **153***c* is pressed to be in close contact with the second region **142***b* of the cap-up **140**, and then, the safety vent **150** is fixed to the cap-up **140** by irradiating a laser onto the welding area **153***c*. A portion of the welding area **153***c* and a portion of the second region **142***b* are melted by the laser welding to form the welding bead **155**, and the welding bead **155** protrudes to the upper side of the welding area **153***c*. Here, since the thickness of the welding area **153***c* is relatively thin compared to the surroundings, the welding area **153***c* is not in contact with the insulation washer **180** disposed thereon. That is, the welding bead **155** is spaced apart from the insulation washer **180**. If the thickness of the welding area is not formed to be thin, the welding bead protrudes to an upper side of the vent extension part and is in contact with the insulation washer. The welding bead breaks the oxide film of the insulation washer by a pressure applied when the crimping part is formed to fix the cap assembly to the case. Accordingly, when the gasket is melted or damaged, the short circuit occurs between the cap assembly and the case. However, in the present invention, the welding bead **155** is not in contact with the insulation washer **180** by forming the welding area **153***c* having the thin thickness in the safety vent **150** to improve safety of the secondary battery **100**.
(29) Furthermore, the following experiment was conducted to confirm safety performance of the secondary battery according to the present invention.
(30) As in the present invention, a secondary battery, in which a welding bead is formed on a safety vent having a thin welding area through laser welding, and an insulation washer is attached to an upper portion of the welding bead, was prepared. Also, in Comparative Example, a secondary battery in which a welding bead is formed on a safety vent having the same thickness through laser welding, and an insulation washer is attached to an upper portion of the welding bead was prepared. It was confirmed whether the secondary batteries were electrically connected after short circuit. This process was repeated 6 times.
(31) The experimental results are summarized in Table 1 below.
(32) TABLE-US-00001 TABLE 1 AC-IR after Whether being electrically short circuit connected after short circuit The present Over Flow (∞) 0/6 invention Comparative 2~7 mΩ 6/6 Example
(33) As shown in Table 1, it was confirmed that the secondary batteries according to the present invention are not electrically connected after the short circuit in all the six experiments, and the secondary batteries according to Comparative Example are electrically connected after the short circuiting in all the six experiments. As described above, in the secondary battery according to the present invention, the welding area of the safety vent may have the thin thickness to prevent the welding bead and the insulation washer from being in contact with each other, thereby preventing the welding bead and the insulation washer from being electrically re-connected to each other and improving the safety of the secondary battery.
(34) FIGS. **4**A to **4**D are cross-sectional views illustrating a method for forming a cap assembly.

(35) A method for forming a cap assembly in a secondary battery according to the present invention will be described with reference to FIGS. **4**A to **4**D.
(36) First, as illustrated in FIG. **4**A, an insulator **160** and a safety vent **150** are sequentially seated on an upper portion of the cap-down **170**, and a sub plate **175** is welded to a protrusion **151** of the safety vent **150**, which is exposed through a through-hole of a cap-down **170**. Then, a cap-up **140** is seated on an upper portion of the safety vent **150**. Here, in order to seat the cap-up **150** on the upper portion of the safety vent **150**, the vent extension part **153** extends upward without being bent. Also, a welding area **153***c* is formed on an end of the vent extension part **153**. A groove having an open end is formed in an inner surface of the welding area **153***c*, that is, a first surface **153***a* facing the cap-up **140**, and thus, a thickness of the welding area **153***c* is thinner than that of the surroundings.
(37) Next, as illustrated in FIG. **4**B, the vent extension part **153** is bent to be in close contact with the upper portion of the cap-up **140**. Particularly, the vent extension part **153** is in contact with a second region **142***b* of a connection part **142** of the cap-up **140**.
(38) Next, as illustrated in FIG. **4**C, the welding area **153***c* is pressed to be in close contact with the second region **142***b* of the cap-up **140**, and the safety vent **150** is fixed to the cap-up **140** through laser welding. A welding bead **155** is formed on the welding area **153***c* through the laser welding. The welding bead **155** is formed by melting a portion of the safety vent **150** and a portion of the cap-up **140** and protrudes to an upper side of the welding area **153***c*.
(39) Then, as illustrated in FIG. **4**D, an insulation washer **180** is attached to the upper portions of the cap-up **140** and the safety vent **150**. Here, since the welding area **153***c* is formed to be thinner than the surroundings, the welding bead **155** formed on the welding area **153***c* is not in contact with the insulation washer **180**. As described above, the cap assembly **130** is completed, and the completed cap assembly **130** may be coupled and/or fixed together with a gasket **1901** on an upper end of the case **120**.
(40) FIG. **5** is a cross-sectional view illustrating a welding area of a safety vent according to another embodiment of the present invention.
(41) Referring to FIG. **5**, a safety vent **150** is installed to be in close contact with a coupling part **142** below a cup-up **140** and includes a vent extension part **253** extending to an upper side of the cup-up **140**. The vent extension part **253** includes a first surface **253***a* in contact with the cap-up **140** and a second surface **253***b* in contact with an insulation washer **180** on a surface opposite to the first surface **253***a*. Also, the vent extension part **253** includes a welding area **253***c* that is welded to the cap-up **140**. The welding area **253***c* is formed on an end of the vent extension part **253** and is disposed inside the safety vent **150**. The welding area **253***c* may be defined by forming a groove having an opened end in the second surface **253***b* of the vent extension part **253**. As described above, when the welding area **253***c* is defined by forming a groove having an open end in the second surface **253***b* of the vent extension part **253**, it is unnecessary to press the welding area **253***c* when the safety vent **150** and the cap-up **140** are welded to each other.
(42) FIG. **6** is a cross-sectional view illustrating a welding area of a safety vent according to further another embodiment of the present invention.
(43) Referring to FIG. **6**, a safety vent **150** is installed to be in close contact with a coupling part **142** below a cup-up **140** and includes a vent extension part **353** extending to an upper side of a cup-up **140**. The vent extension part **353** has a first surface **353***a* in contact with the cap-up **140** and a second surface **153***b* in contact with an insulation washer **180** on an opposite surface of the first surface **353***a*. Also, the vent extension part **353** includes a welding area **353***c* that is welded to the cap-up **140**. The welding area **353***c* may be defined by forming a trench in the second surface **353***b* of the vent extension part **353**. As described above, when the welding area **253***c* is defined by forming the trench in the second surface **253***b* of the vent extension part **353**, it is unnecessary to press the welding area **353***c* when a safety vent **150** and a cap-up **140** are welded to each other.
(44) The above-mentioned embodiment is merely an embodiment of the secondary battery, and

thus, the present invention is not limited to the foregoing embodiment, and also it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present invention as defined by the following claims.

Claims

1. A secondary battery comprising: an electrode assembly; a case configured to accommodate the electrode assembly; and a cap assembly coupled to an upper portion of the case, wherein the cap assembly comprises a cap-up, a safety vent installed below the cap-up and having a vent extension part extending to an upper side of the cap-up to surround an edge of the cap-up, and an insulation washer contacting upper portions of both the vent extension part and the cap-up, a bottom surface of the insulation washer and the upper portions of the vent extension part and the cap-up enclosing an opening therebetween, the cap-up contacting the insulation washer, wherein a welding area having a thickness less than that of a first portion of the vent extension part is at an end of the vent extension part, wherein the vent extension part has an angled portion extending from the first portion of the vent extension part to the weld area at an angle relative to the insulation washer, the angled portion having a uniform thickness, and wherein a bottom surface of the vent extension part and an upper surface of the cap-up define a gap therebetween, the angled portion of the vent extension part overlapping the gap in a plan view, and the upper surface extending flatly under an entirety of the vent extension part and the gap.
2. The secondary battery of claim 1, wherein a portion of the safety vent and a portion of the cap-up are melted by laser welding to form a welding bead, which protrudes upward, on the welding area.
3. The secondary battery of claim 2, wherein the welding bead is spaced apart from the insulation washer.
4. The secondary battery of claim 1, wherein the vent extension part comprises a first surface that is in contact with the cap-up and a second surface that is an opposite surface of the first surface and is in contact with the insulation washer, and the welding area is defined by forming a groove having an opened end in the first surface.
5. The secondary battery of claim 1, wherein the cap-up comprises a terminal part that protrudes upward, a coupling part which is disposed outside the terminal part and to which the safety vent is coupled, and a connection part configured to connect the terminal part to the coupling part, wherein the coupling part comprises a first region extending from the connection part and a second region which is disposed outside the first region and has a thickness less than that of the first region and to which the vent extension part is coupled.
6. The secondary battery of claim 5, wherein the thickness of the first region is equal to a sum of the thickness of the second region and a thickness of the vent extension part.
7. The secondary battery of claim 5, wherein the insulation washer is seated on upper portions of the vent extension part and the first region.
8. The secondary battery of claim 1, wherein an oxide film is formed on a surface of the insulation washer.