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Inventor(s)

Kang; Hee Gyoung

Pouch Type Secondary Battery and Production Method Thereof

Abstract

Provided are the system and method of molding a gas collection portion of a battery pouch, and more particularly, the system and method of molding a gas collection portion to collect gas in a portion where an electrode tab welding portion of a battery pouch is disposed. In the system and method of molding the gas collection portion of the battery pouch according to the present disclosure, the electrode tab welding portion may also be molded when the battery pouch is molded, and the gas generated in the battery cell may thus be collected in a space formed between the pouch inclined surfaces, thereby preventing or delaying venting of the battery pouch.

Inventors: Kang; Hee Gyoung (Daejeon, KR)

Applicant: SK On Co., Ltd. (Seoul, KR)

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a continuation of U.S. patent application Ser. No. 17/084,545, filed on Oct. 29, 2020, and claims priority to Korean Patent Application No. 10-2019-0137381 filed Oct. 31, 2019, the disclosures of which are hereby incorporated by reference in their entirety.

TECHNICAL FIELD

[0002] The following disclosure relates to a pouch type secondary battery and a production method thereof, and more particularly, to a pouch type secondary battery having an expandable gas collection space, and a production method thereof.

BACKGROUND

[0003] As a portable wireless device such as a mobile phone or a laptop becomes lighter and multi-functional, there is a rapidly increasing demand for a secondary battery as its energy source. In particular, research on a lithium secondary battery having high energy density and discharge voltage has been actively conducted, commercialized and widely used. In addition, the secondary battery is spotlighted as a power source for an electric vehicle, which is proposed as a solution to environmental pollution caused by a prior gasoline vehicle, a diesel vehicle or the like, that uses a fossil fuel.

[0004] However, when the secondary battery is overcharged or short-circuited, a large amount of gas may be generated in the secondary battery. If pressure in the secondary battery is increased due to the generated gas, sealing of a battery pouch may be released and cause an explosion or fire. If a battery cell in the battery pouch includes a highly reactive material, the secondary battery may be less safe, and may have a shorter lifespan due to deterioration caused by the gas generation.

[0005] Accordingly, there has been research actively conducted on a method of preventing venting of a pouch type secondary battery or delaying occurrence of the venting due to the gas generation as much as possible by allowing the battery pouch to have a gas collection portion formed therein to collect the gas generated in the battery cell.

RELATED ART DOCUMENT

[Patent Document]

[0006] Japanese Patent Publication No. 4591923 (Sep. 24, 2010)

SUMMARY

[0007] An embodiment of the present disclosure is directed to providing a pouch type secondary battery capable of preventing venting of the secondary battery or delaying occurrence time of the venting by molding a battery pouch to have an additional gas collection portion having a curve allowing a surface of its predetermined portion to be stretched and thereby maximizing a space in which gas generated in a battery cell may be collected.

[0008] Another embodiment of the present disclosure is directed to providing a pouch type secondary battery capable of utilizing the most of its unsealed area by being produced to have an additional gas collection portion formed in a tab welding portion where an electrode tab welding area, which is the unsealed area, is located.

[0009] Still another embodiment of the present disclosure is directed to providing a pouch type secondary battery having a curved surface capable of collecting gas as much as possible and maintaining a predetermined shape during its expansion.

[0010] Yet another embodiment of the present disclosure is directed to providing a production method of producing such a pouch type secondary battery and a pouch case thereof.

[0011] In one general aspect, a pouch type secondary battery includes: a battery cell including a

positive plate, a negative plate, a separator, and positive and negative electrode tabs that protrude; and a pouch case having the battery cell disposed therein, wherein the pouch case includes: a battery cell accommodation space accommodating the battery cell; a sealing portion formed by sealing the pouch case around an outer periphery of the battery cell accommodation space; a tab welding surface formed in a portion where the positive electrode tab and the negative electrode tab are disposed inside the sealing portion and the pouch case is not sealed; and a pouch inclined surface formed between the battery cell accommodation space and the tab welding surface, and the tab welding surface is wrinkled by being molded to have a predetermined curve.

[0012] The predetermined curve of the tab welding surface may be formed in a shape of a curved or bent surface having a predetermined curvature.

[0013] The curved or bent surface of the tab welding surface may be formed in a fractal shape in which a curved or bent surface of a smaller pitch is repeated.

[0014] The pouch inclined surface may be wrinkled by being molded to have a predetermined curve.

[0015] The predetermined curve of the pouch inclined surface may be formed in a shape of a curved or bent surface having a predetermined curvature.

[0016] The curved or bent surface of the pouch inclined surface may be formed in a fractal shape in which a curved or bent surface of a smaller pitch is repeated.

[0017] In another general aspect, a production method of a pouch type secondary battery includes: a pouch case preparing step of preparing the plate-shaped pouch case; a mold preparing step of preparing the mold having a battery cell accommodation space molding portion, a sealing portion molding portion, a pouch inclined surface molding portion and a tab welding surface molding portion, the tab welding surface molding portion being formed to have a predetermined curve; a pouch case molding step of pressing the plate-shaped pouch case into the mold in a shape of the mold to obtain an upper pouch and a lower pouch; a battery cell accommodating step of accommodating the battery cell in a battery cell accommodation space formed by coupling the upper pouch and the lower pouch to each other; a vacuum-compressing step of making the inside of the battery pouch in which the battery cell is accommodated into a vacuum state; and a sealing step of sealing a sealing portion of the upper pouch and a sealing portion of the lower pouch together to make the battery pouch to into a sealed state.

[0018] The tab welding surface of the battery pouch, molded to have the predetermined curve, may have a predetermined wrinkle by performing the vacuum-compressing step.

[0019] The predetermined curve of the tab welding surface may be formed in a shape of a curved or bent surface having a predetermined curvature.

[0020] The curved or bent surface of the tab welding surface may be formed in a fractal shape in which a curved or bent surface of a smaller pitch is repeated.

[0021] The pouch inclined surface molding portion may have a predetermined curve.

[0022] The pouch inclined surface of the battery pouch, molded to have the predetermined curve, may have a predetermined wrinkle by performing the vacuum-compressing step.

[0023] The predetermined curve of the pouch inclined surface may be formed in a shape of a curved or bent surface having a predetermined curvature.

[0024] The curved or bent surface of the pouch inclined surface may be formed in a fractal shape in which a curved or bent surface of a smaller pitch is repeated.

[0025] In another general aspect, a pouch case includes: a battery cell accommodation space accommodating a battery cell; a sealing portion formed by sealing the pouch case around an outer periphery of the battery cell accommodation space; a tab welding surface formed in a portion where a positive electrode tab and a negative electrode tab are disposed inside the sealing portion and the pouch case is not sealed; and a pouch inclined surface formed between the battery cell accommodation space and the tab welding surface, wherein the tab welding surface is molded to have a predetermined curve.

[0026] The predetermined curve of the tab welding surface may be formed in a shape of a curved or bent surface having a predetermined curvature.

[0027] The curved or bent surface of the tab welding surface may be formed in a fractal shape in which a curved or bent surface of a smaller pitch is repeated.

[0028] The pouch inclined surface may be molded to have a predetermined curve.

[0029] The predetermined curve of the pouch inclined surface may be formed in a shape of a curved or bent surface having a predetermined curvature.

[0030] The curved or bent surface of the pouch inclined surface may be formed in a fractal shape in which a curved or bent surface of a smaller pitch is repeated.

[0031] Other features and aspects are apparent from the following detailed description, the drawings and the claims.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0032] FIGS. **1A** and **1B** are plan views respectively showing a pouch case of the present disclosure.

[0033] FIG. **2** is a plan view showing a state before the pouch case and electrode assembly of the present disclosure are sealed together.

[0034] FIG. **3** is an exploded perspective view of a pouch type secondary battery of the present disclosure.

[0035] FIGS. **4A** and **4B** are cross-sectional views respectively showing states before and after venting occurs in a prior pouch type secondary battery.

[0036] FIGS. **5A**, **5B** and **5C** are cross-sectional views respectively showing states before, soon after, and a while after the venting occurs in a pouch type secondary battery of the present disclosure.

[0037] FIG. **6** is a flowchart showing a production method of a pouch type secondary battery according to the present disclosure.

[0038] FIGS. **7A-7B** are conceptual diagrams showing one embodiment of a mold for producing a pouch case and a molded pouch case according to the present disclosure.

[0039] FIGS. **8A-8B** are conceptual diagrams showing another embodiment of a mold for producing a pouch case and a molded pouch case according to the present disclosure.

[0040] FIGS. **9A-9B** are conceptual diagrams showing another embodiment of a mold for producing a pouch case and a molded pouch case according to the present disclosure.

[0041] FIGS. **10A-10B** are conceptual diagrams showing another embodiment of a mold for producing a pouch case and a molded pouch case according to the present disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

[0042] Hereinafter, embodiments of the present disclosure are described in detail with reference to the accompanying drawings.

[0043] FIGS. **1A** and **1B** are plan views respectively showing a state before a pouch case **200** of the present disclosure is sealed. A pouch type secondary battery **1000** of the present disclosure may be completed by disposing a battery cell C in the pouch case **200** having an inner space accommodating the battery cell C, folding the pouch case **200** in half, and then sealing surfaces of the pouch case in contact with each other together.

[0044] Here, the battery cell C of the present disclosure may include a jelly roll including a positive plate, a negative plate and a separator, and an electrode tab T including positive and negative electrode tabs. The pouch case **200** may include: a battery cell accommodation space **210** accommodating the battery cell C; a sealing portion **220** formed by sealing the pouch case **200** around an outer periphery of the battery cell accommodation space **210**; a tab welding surface **240**

formed in a portion where the positive electrode tab or the negative electrode tab is disposed inside the sealing portion **220** and the pouch case is not sealed; and a pouch inclined surface **230** formed between the battery cell accommodation space **210** and the tab welding surface **240**. A tab film TF may be added to the portion where the sealing portion **220** and the electrode tab T are in contact with each other, and the tab welding surface **240** may be disposed in a tab welding portion TW where the electrode tab T is welded to the jelly roll.

[0045] When viewing cross sections of the battery cell accommodation space **210**, the sealing portion **220**, the pouch inclined surface **230** and the tab welding surface **240**, of the pouch case **200**, taken along the line X-X' of FIG. 1A, the battery cell accommodation space **210** may be formed to be concave to a predetermined depth, the pouch inclined surface **230** may connect the sealing portion **220** and a bottom of the battery cell accommodation space **210** at an angle with each other, and the tab welding surface **240** may be molded to have a predetermined depth like the battery cell accommodation space **210** and a predetermined curve, as shown in FIG. 1B. An additional gas collection portion capable of collecting and accommodating generated gas may be formed by molding the tab welding surface **240** to be concave to the predetermined depth as described above.

[0046] FIG. 2 is a plan view showing a state before the pouch case and electrode assembly of the present disclosure are sealed together, and shows a state in which the battery cell is disposed on the pouch case described above. It is possible to protect the electrode tab T when the pouch case and electrode assembly of the present disclosure are sealed together by disposing the tab welding surface **240** of the pouch case in a position corresponding to the tab welding portion TW of the electrode tab T and disposing the tab film TF in a position corresponding to the sealing portion **220** of the pouch case. In this manner, the present disclosure may delay the occurrence of venting by collecting and accommodating the gas using an unsealed area at a rear end of the tab film TF disposed to protect the electrode tab T.

[0047] FIG. 3 is an exploded perspective view of a pouch type secondary battery of the present disclosure. Referring to FIG. 3, as described above, the pouch type secondary battery **1000** of the present disclosure may be formed to accommodate the battery cell C including the electrode tab T; the sealing portion **220** may be formed to seal the surfaces of the pouch case together, in which its upper and lower portions are in contact with each other; the pouch inclined surface **230** may be formed on a portion, in which the sealing portion **220** and the bottom of the battery cell accommodation space **210** are connected to each other, to correspond to a portion where the electrode tab T is extended to the outside; and the tab welding surface **240** may be disposed at one end of the pouch inclined surface **230**. In a step of molding the tab welding surface **240**, the tab welding surface **240** may be curved to the predetermined depth, and in a step of sealing the pouch case after the battery cell C is accommodated therein, the opposite surfaces of the pouch case may be maintained to be attached to each other in a state in which a wrinkle is formed thereon through vacuum compression, thereby forming a gas collection space collecting and accommodating the gas by spreading the wrinkle when the gas is generated in the battery cell C.

[0048] Next, the description describes a principle of the pouch type secondary battery **1000** of the present disclosure to delay the occurrence of venting with reference to FIGS. 4A to 5C. FIGS. 4A and 4B are cross-sectional views respectively showing states before and after venting occurs in a prior pouch type secondary battery. The prior pouch type secondary battery may have one battery pouch **20** formed by coupling an upper pouch **20a** and a lower pouch **20b** to each other, and a portion where the electrode tab T of the battery cell C is extended from and welded to the jelly roll in a space between a pouch inclined surface **23** of the upper pouch **20a** and a pouch inclined surface **23** of the lower pouch **20b**. Here, in the pouch case where the gas is generated in the battery cell C due to aging of the battery or the like, the gas may be gradually collected in the space between the pouch inclined surface **23** of the upper pouch **20a** and the pouch inclined surface **23** of the lower pouch **20b**, and when the pressure in the space is greater than or equal to its threshold, a venting phenomenon may occur in which the sealing of the battery pouch **20** is released.

[0049] FIGS. 5A, 5B and 5C are cross-sectional views respectively showing states before, soon after, and a while after the venting occurs in a pouch type secondary battery **1000** of the present disclosure. The pouch type secondary battery **1000** of the present disclosure may have one battery pouch formed by coupling an upper pouch **201** and a lower pouch **202** to each other, and gas collection surfaces **231** and **232** formed by wrinkling the opposite surfaces of the upper pouch **201** and the lower pouch **202** through the vacuum compression. Unlike the prior pouch type secondary battery, when the gas is generated in the battery cell C in the pouch type secondary battery of the present disclosure, the tab welding surface **240** disposed on one end of the pouch inclined surface **230** and molded in advance to be curved to have a predetermined shape and depth may be unfolded first due to the pressure of the gas, and the unfolded space may thus form a space capable of collecting the generated gas. Accordingly, even if the gas is generated in the battery cell C, a larger amount of gas may be collected than in the prior art, thereby preventing or delaying the venting phenomenon of the battery pouch **200**. Meanwhile, when more gas is generated late after the venting occurs, the tab welding surface **240** and the pouch inclined surface **230** may be spread together as shown in FIG. 5C, and the much larger amount of gas may thus be collected than in the prior art. Here, the pouch inclined surface **230** may also be formed in advance to have a curve of a predetermined shape and length, and the pouch inclined surface **230** may thus be formed to have more collection space. To form various types of curves on the pouch inclined surface **230** is described in more detail below.

[0050] FIG. 6 is a flowchart showing a production method of a pouch type secondary battery according to an embodiment of the present disclosure. As shown in FIG. 6, a pouch case preparing step (S**100**) may first be performed by preparing a plate-shaped pouch case **200**.

[0051] Next, a mold preparing step (S**200**) may be performed by preparing the mold having a battery cell accommodation space molding portion **110**, a sealing portion molding portion **120**, a pouch inclined surface molding portion **130** and a tab welding surface molding portion **140**. As described above, the pouch inclined surface molding portion **130** and/or the tab welding surface molding portion **140** may be curved, and here, the curve of the pouch inclined surface molding portion **130** and the tab welding surface molding portion **140** may be formed in a shape of a curved or bent surface.

[0052] A pouch case molding step (S**300**) may be performed by pressing the plate-shaped pouch case **200** into a mold **100** in a shape of the mold when the plate-shaped pouch case **200** and the mold **100** are prepared. The plate-shaped pouch case **200** molded in the molding of the pouch case (S**300**) may be an upper pouch **201** or a lower pouch **202**, and one battery pouch may be formed by coupling the upper pouch **201** and the lower pouch **202** to each other.

[0053] Next, a battery cell accommodating step (S**400**) may be performed by accommodating a battery cell C in a battery cell accommodation space **210** formed by coupling the upper pouch **201** and the lower pouch **202** to each other, and a vacuum-compressing step (S**500**) may be performed by making a space between the upper pouch **201** and the lower pouch **202**, i.e. the inside of the battery pouch, into a vacuum state. As described above, the pouch inclined surface **230** and/or the tab welding surface **240** of the present disclosure may be curved, have a longer surface length than a prior art, and thus be wrinkled when the inside of the battery pouch is in the vacuum state.

[0054] Finally, a sealing step (S**600**) may be performed by sealing a sealing portion **221** of the upper pouch **201** and a sealing portion **222** of the lower pouch **202** together to make the battery pouch into a sealed state. In this manner, a pouch type secondary battery **1000** of the present disclosure may be completed.

[0055] FIGS. 7A to 10B respectively show various embodiments of a mold and a molded pouch case for producing the pouch type secondary battery according to the present disclosure. FIGS. 7A to 10B show the types of curves formed on the pouch inclined surface **230** for convenience, but various types of curves may also be formed on the tab welding surface **240** by the same method.

[0056] Referring to FIG. 7A, a mold **100a** may include: a battery cell accommodation space

molding portion **110** for accommodating a battery cell C; a sealing portion molding portion **120** for sealing a battery pouch **200a** after the battery cell C is accommodated; and a pouch inclined surface molding portion **130a** formed between an edge of the battery cell accommodation space molding portion **110** and an edge of the sealing portion molding portion **120**. As described above, a prior mold inclined surface **13** is flat, however, the pouch inclined surface molding portion **130a** of the present disclosure may be formed in a shape of a curved surface convex downward based on a reference surface G.

[0057] Accordingly, the plate-shaped pouch case **200** pressed into the mold **100a** and molded in a shape of the mold may include: the sealing portion **220**, the battery cell accommodation space **210**, and a pouch inclined surface **230a** formed between an edge of the sealing portion **220** and an edge of the battery cell accommodation space **210**, and the pouch inclined surface **230a** may be formed on the upper pouch **201** and the lower pouch **202**, which form the battery pouch **200** together. Here, the pouch inclined surface **230a** may also be molded in the shape of a curved surface convex downward like the pouch inclined surface molding portion **130a**.

[0058] As described above, one battery pouch **200** may be formed by coupling the upper pouch **201** and the lower pouch **202** to each other, and a portion where each of the electrode tabs T of the battery cell C is extended from and welded to the jelly roll may be disposed in a space between the pouch inclined surface **231** of the upper pouch **201** and the pouch inclined surface **232** of the lower pouch **202**, and when the gas is generated in the battery cell C, the gas may be collected in the space between the pouch inclined surface **231** of the upper pouch **201** and the pouch inclined surface **232** of the lower pouch **202**. Therefore, when the gas is generated in the battery cell C, a larger amount of gas may be collected than in the prior art because the pouch inclined surface **230a** of the present disclosure formed in the convex curved surface has a wider cross-sectional area than the flat pouch inclined surface **23** of the prior art, thereby preventing or delaying the venting phenomenon of the battery pouch **200a**.

[0059] FIG. 7B shows that a pouch inclined surface molding portion **130b** of a mold **100b** is formed in a shape of a curved surface based on the reference surface G, and is formed in a waveform. Accordingly, a battery pouch **200b** molded in a shape of the mold **100b** may also may accommodate the larger amount of gas and delay the venting longer by having a pouch inclined surface **230b** formed in the waveform and a longer length of the inclined surface.

[0060] FIGS. 8A and 8B each show an embodiment in which a pouch inclined surface is formed in a curved surface, and a curved surface having a smaller curvature is formed on the curved surface. The inclined surface may be formed in a fractal structure having self-similarity, may form the fractal structure having geometrical self-similarity thereon, and may thus form a maximum collection space with a predetermined order in a condition of a complex irregular external force such as molding, vacuum compression and expansion.

[0061] FIG. 8A shows that a pouch inclined surface molding portion **130c** of a mold **100c** is formed in the shape of a curved surface convex downward based on the reference surface G, and the curved surface has a smaller curvature repeatedly formed thereon. FIG. 8B shows that a pouch inclined surface molding portion **130d** of a mold **100d** may be formed in a waveform, and may have a smaller curvature repeatedly formed thereon. Accordingly, battery pouches **200c** and **200d** respectively molded in shapes of the molds may have pouch inclined surfaces **230c** and **230d** each formed in the curved surface or the waveform, and the pouch inclined surfaces **230c** and **230d** may each have the smaller curvature repeatedly formed thereon.

[0062] FIGS. 9A and 9B each show an embodiment in which the pouch inclined surface is formed in a bent surface. For example, a pouch inclined surface molding portion **130e** may have a shape of a bent surface which is bent once as shown in FIG. 9A, and a pouch inclined surface molding portion **130f** may have a shape of a bent surface which is bent twice as shown in FIG. 9B.

Accordingly, battery pouches **200e** and **200f** respectively molded in shapes of the molds may have pouch inclined surfaces **230e** and **230f**, each of which is bent once or twice. As described above,

when the pouch inclined surface is molded to be bent, it is possible to predict the shrinkage or expansion of the pouch inclined surface in advance in the condition of external force such as the molding, vacuum compression and expansion, and it is thus possible to more accurately design the position and volume of the gas collection portion. Meanwhile, the number of bent portions may be further increased as needed.

[0063] FIGS. **10A** and **10B** respectively show other embodiments in which a pouch inclined surface is formed in a bent surface. As shown in FIG. **10A**, a pouch inclined surface molding portion **130i** of a mold **100i** may be formed to have bent portions respectively disposed above and below the reference surface G, in which each bent cross section of the bent portions may have a trapezoid shape instead of a triangular shape. Accordingly, a battery pouch **200i** molded in a shape of the mold may have a pouch inclined surface **230i** having bent cross sections each molded in the trapezoidal shape instead of the triangular shape, thereby securing more volume and extending the venting delay time when the pouch inclined surface is expanded.

[0064] In addition, as shown in FIG. **10B**, the bent surface may also have a geometrical fractal structure, and a pouch inclined surface molding portion **130g** of a mold **100g** may be formed in a bent fractal structure. Accordingly, a pouch inclined surface **230g** may have the bent fractal structure.

[0065] The pouch type secondary battery of the present disclosure adopting the above configuration may maximize the space in which the gas generated in the battery cell is collected by using the expandable collection space, thereby preventing the venting or delaying the occurrence time of the venting.

[0066] In addition, the present disclosure may collect the generated gas as much as possible through the shape of the curved surface, and may maintain the overall shape of the battery cell when the pouch is expanded by the gas.

[0067] The present disclosure is not to be construed as being limited to the above-mentioned embodiments. The present disclosure may be applied to various fields and may be variously modified by those skilled in the art without departing from the scope of the present disclosure claimed in the claims. Therefore, it is obvious to those skilled in the art that these alterations and modifications fall in the scope of the present disclosure.

Claims

1. A pouch-type secondary battery comprising: a battery cell including a positive electrode tab and a negative electrode tab; and a pouch exterior having the battery cell disposed therein, wherein the pouch exterior includes: a sealing portion formed around an outer periphery of a battery cell accommodation space where the battery cell is accommodated, the sealing portion being sealed; a tab welding surface formed inside the sealing portion at a portion where the positive electrode tab and the negative electrode tab are located, the tab welding surface not being sealed; and a pouch inclined surface formed between the battery cell accommodation space and the tab welding surface, wherein at least one of the tab welding surface or the pouch inclined surface includes a wrinkle with a predetermined curvature.
2. The pouch-type secondary battery according to claim 1, wherein the positive electrode tab and the negative electrode tab protrude from one or both sides of the battery cell, and wherein the wrinkle with a predetermined curvature is formed in a direction perpendicular to the protruding direction of the positive electrode tab and the negative electrode tab.
3. The pouch-type secondary battery according to claim 2, wherein when gas is generated in the battery cell, the tab welding surface or the pouch inclined surface unfolds to collect the gas.
4. The pouch-type secondary battery according to claim 3, wherein the predetermined wrinkle is formed as a curved surface with a predetermined curvature or a bent surface.
5. The pouch-type secondary battery according to claim 4, wherein the predetermined wrinkle has a

fractal shape in which a curved surface or bent surface with a smaller pitch is repeatedly formed.

6. A pouch case comprising: a battery cell accommodation space for accommodating a battery cell including a positive electrode tab and a negative electrode tab; a sealing portion in which opposing sides are sealed together; a tab welding surface formed inside the sealing portion at a position where the positive electrode tab and the negative electrode tab are located, wherein the opposing sides are not sealed; and a pouch inclined surface formed between the battery cell accommodation space and the tab welding surface, wherein at least one of the tab welding surface and the pouch inclined surface includes a wrinkle with a predetermined curvature.

7. The pouch case according to claim 6, wherein the wrinkle with a predetermined curvature formed on the tab welding surface has a curvature in a direction perpendicular to the protruding direction of the positive electrode tab and the negative electrode tab of the battery cell.
