



DECLARATION OF TRANSLATOR

I, Suhua Liu, hereby declare as follows:

1. I personally performed the attached translation from Chinese into English of the patent number CN202905885U that is entitled “一种卷绕式结构的方形锂离子电池” in Chinese and "QUADRATE LITHIUM-ION BATTERY HAVING WINDING STRUCTURE" in English (also attached).

2. The attached translation is, to the best of my knowledge, a true, full and accurate translation of the attached Chinese document.

3. I am competent to perform this translation, because I have translated many patent applications for clients, such as new energy batteries, online games, autonomous driving, artificial intelligence, mower, etc., involving fields of: new energies, organic chemistry, artificial intelligence, electronic communication, etc.

4. I declare under the penalty of perjury under the laws of the United States that the foregoing is true and correct; and further declare that I am aware that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 1001 of Title 18 of the United States Code.

Dated: 3 February 2025

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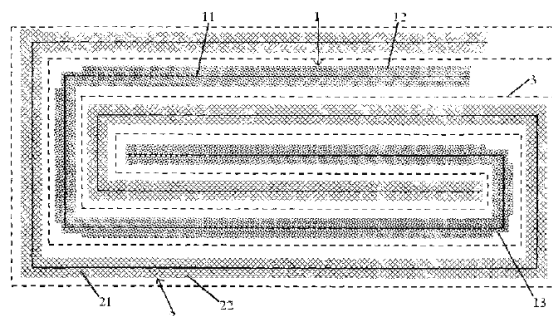
CLAIMS on 2 page, DESCRIPTION on 15 pages,
FIGURES on 2 pages

(54) Title of the utility model

PRISMATIC LITHIUM-ION BATTERY
HAVING WINDING STRUCTURE

(57) ABSTRACT

The present utility model belongs to the technical field of lithium-ion batteries, and particularly relates to a prismatic lithium-ion battery having a winding structure, comprising a positive electrode, a negative electrode, a separator, and an electrolyte solution. The positive electrode comprises a positive electrode current collector and a positive electrode material layer coated on the positive electrode current collector, a ratio of the thickness of the positive electrode material layer in the corner region of the positive electrode to the thickness of the positive electrode material layer in the body region of the positive electrode is smaller than or equal to 90%, and the length of the corner region in the winding direction is 0.5-4 times the thickness of the battery cell. Compared with the prior art, the present utility model optimizes the prismatic lithium-ion battery having the winding electrode structure, the thickness of the coated electrode material layer in the corner region of the electrode thereof is smaller than the thickness of the electrode material layer in the body region, thereby reducing the stress caused by electrode expansion during charging, discharging, and cycling of the battery, reducing the deformation rate of the battery, reducing the apparent thickness of the battery during cycling, increasing the energy density of the battery, and improving the battery performance.



PRISMATIC LITHIUM-ION BATTERY HAVING WINDING STRUCTURE

Technical Field

[0001] The present utility model belongs to the technical field of lithium-ion batteries, and particularly relates to a prismatic lithium-ion battery having a winding structure, particularly a prismatic lithium-ion battery having a winding structure that can reduce deformation rate.

Background

[0002] A prismatic battery has a regular shape and a controllable thickness, and can adapt to the trend of ultra-thin development of modern consumer electronics. Moreover, the prismatic battery has a larger specific surface area than a cylindrical battery, which is conducive to heat dissipation of a large-capacity battery. The prismatic structure is also conducive to assembly of large-scale batteries, and is therefore also adapted to large-scale energy storage applications, such as an automotive power battery and an energy storage battery. At present, the assembly of prismatic battery electrodes and separator assemblies mainly includes stacking and winding. The assembly of the prismatic battery by winding is conducive to automatic mechanical production, and improving production efficiency and product reliability.

[0003] However, compared with a battery having a stacked structure, the battery having a winding structure tends to deform during cycling, thereby increasing the battery thickness, reducing the volumetric energy density, deteriorating the interface between electrodes, and worsening the battery performance. An ideal prismatic battery should be an even square shape. Battery deformation refers to various phenomena that cause the battery to be uneven, for example, some parts of the battery are raised and the back is recessed, or some parts are recessed and the back is raised. The reason for this phenomenon is that electrode expansion during charge-discharge cycles of the battery having a winding structure causes non-uniform stress distribution at different positions inside the battery, so that the battery tends to deform; while for a battery having a stacked structure, electrode plates are independent, are stacked in parallel, and expand uniformly without stress distribution. Therefore, the stacked battery expands uniformly in the entire thickness direction without the deformation problem.

[0004] The electrode expansion during cycling includes lattice expansion of the electrode material during charging and discharging, electrode swelling by the electrolyte solution, electrode expansion caused by gradual release of the stress generated during electrode processing during cycling, and expansion caused by surface film growth of the electrode active material during cycling. In a stacked battery, various parts of the electrode plates expand uniformly. Moreover, the current collectors are not an entirety, and do not restrict each other. Therefore, during the electrode expansion, the entirety of the battery can expand uniformly, which does not tend to cause battery deformation. However, for the battery having a winding structure, the electrode plates are constrained by the current collectors and the separator during expansion, thereby resulting in non-uniform stress distribution inside the battery, and resulting in the battery deformation.

[0005] In view of this, it is really necessary to provide a prismatic lithium-ion battery having a winding structure that can solve the deformation problem.

Summary of the Utility Model

[0006] The objective of the present utility model is to: provide a prismatic lithium-ion battery having a winding structure that can solve the deformation problem in view of the defects of the prior art.

[0007] In order to achieve the above objective, the present utility model adopts the following technical solutions:

[0008] A prismatic lithium-ion battery having a winding structure comprises a battery cell, a packing bag configured to accommodate the battery cell, and an electrolyte solution infused in the packing bag, wherein the battery cell comprises a positive electrode, a negative electrode, and a separator spaced between the positive electrode and the negative electrode, the positive electrode comprises a positive electrode current collector and a positive electrode material layer coated on the positive electrode current collector, the negative electrode comprises a negative electrode current collector and a negative electrode material layer coated on the negative electrode current collector, a ratio of the thickness of the positive electrode material layer in the corner region of the positive electrode to the thickness of the positive electrode material layer in the body region of the

positive electrode is smaller than or equal to 90%, and the length of the corner region in the winding direction is 0.5-4 times the thickness of the battery cell. The corner region refers to a region of an electrode near its corner position. The length of the corner region in the winding direction is about 0.5-4 times the thickness of the battery cell, and is optimally 1-2 times the thickness of the battery cell. Too small length of the corner region can hardly function to inhibit the battery deformation, while too large length of the corner region may lead to the loss of energy density of the battery. Moreover, the corner region should be distributed as symmetrically as possible relative to the electrode corner position, and a length ratio of both sides of the corner region relative to the corner should be between 0.6 and 1.5, thereby resulting in uniform electrode distribution, and achieving a better result.

[0009] The body region refers to a region other than the corner region. During charging, discharging, and cycling of the battery assembled from electrodes having this optimized structure, a small stress is generated due to electrode expansion in the corner region of the winding structure, thereby alleviating the problem of non-uniform stress distribution, and reducing the deformation rate of the battery. It is found during implementation that when the thickness of the positive electrode material layer in the corner region is equivalent to 90% of the thickness of the electrode material layer in the body region of the positive electrode, the battery deformation is reduced.

[0010] As an improvement of the prismatic lithium-ion battery having a winding structure in the present utility model, a ratio of the thickness of the negative electrode material layer in the corner region of the negative electrode to the thickness of the negative electrode material layer in the body region of the negative electrode is smaller than or equal to 90%. In order to enable the thickness of the electrode layer coated in the corner region of the electrode (positive electrode or negative electrode) to be lower than the thickness of the electrode layer in the body region, the following implementations may be used:

[0011] a first implementation is coating once, and then taking out a certain amount of slurry from the corner region by, e.g., suction or adhesion, or reducing the thickness of the active coating by, e.g., grinding or removing after drying;

[0012] a second implementation is intermittently regulating the gap of the coating head and directly coating less slurry in the corner region; and

[0013] a third implementation is coating twice, that is, first coating the entirety with a layer, and then coating the body region without coating the corner region during the second coating;

[0014] wherein the first implementation and the second implementation are difficult to implement, and the third implementation is currently relatively simple and feasible.

[0015] As an improvement of the prismatic lithium-ion battery having a winding structure in the present utility model, the ratio of the thickness of the positive electrode material layer in the corner region of the positive electrode to the thickness of the positive electrode material layer in the body region of the positive electrode is smaller than or equal to 30%. In this case, the corner region has less active material, more space, and less electrode expansion; the battery expansion is mainly reflected in the body region, and there is almost no stress distribution inside the battery. In this case, the effect of electrode expansion on the battery is similar to the effect of electrode expansion on a stacked battery. The entirety of the battery expands in the thickness direction substantially without a deformation phenomenon.

[0016] As an improvement of the prismatic lithium-ion battery having a winding structure in the present utility model, the corner region of the positive electrode is a blank positive electrode current collector, which is a special case of the present utility model, that is, the corner region may also be uncoated with the electrode active material. In this case, the expansion of the battery during charge-discharge cycles is similar to the expansion behavior of the stacked battery, which has a good effect on reducing the deformation rate of the battery during cycling.

[0017] However, the exposed current collector tends to produce dendritic metal fragments at its edge. This fragment tends to puncture the separator and cause short circuit of the battery. Therefore, a protective layer needs to be applied to an uncoated region, to avoid short circuit caused by dendrites. This protective layer may be implemented by the following methods

[0018] method I is pasting adhesive tapes, using some chemically and electrochemically stable adhesive tapes to cover blank current collector regions;

[0019] method II is coating a polymer layer or a protective coating of inorganic particles/binder on blank current collector regions; and

[0020] method III is coating a conductive coating of conductive agent/binder on the current collectors.

[0021] A small region before and after the blank current collector can be covered by the first two methods, and the current collector can be coated prior to coating the active material by the latter method. The application in method I is complex, but has good protective effects; a high-precision coating machine is required in the method II; and the method III will cause losses of volumetric energy density, but can reduce the internal resistance of the battery, and is conducive to improving the power density. The methods can be flexibly selected during actual use. There are no special requirements for the adhesive tape in the method I, as long as it has certain strength, is capable of resisting puncture by metal particles, and maintains chemical and electrochemical stability in the battery system. There are no special requirements for inorganic particles in the method II, but they are required to be insoluble in the electrolyte solution and maintain chemical and electrochemical stability in the battery system, such as aluminum oxide, titanium dioxide, zirconium dioxide, magnesium oxide, aluminum phosphate, and zeolite. There are no special requirements for the polymers and binders in the methods II and III, as long as they maintain adhesiveness, and chemical and electrochemical stability in the battery system, such as butadiene-styrene copolymer, polyvinylidene fluoride, vinylidene fluoride-tetrafluoroethylene copolymer, calcium polyacrylate, polyester, or polyimide. The thickness of each of the adhesive tape, protective coating, and conductive coating should be larger than or equal to once as much as the thickness of the current collector, to meet basic protection requirements; and be smaller than or equal to three times as much as the thickness of the current collector, so that the blank region has a small thickness and can have designed effects.

[0022] As an improvement of the prismatic lithium-ion battery having a winding structure in the present utility model, the length of the corner region in the winding direction is 1-2 times the thickness of the battery cell.

[0023] For the battery having a winding structure, the circumference of the electrode increases with each additional layer from the inner layer to the outer layer of the binding structure. Therefore, as an optimized design, the length of the corner region in the winding direction increases with its position in the battery cell from the inside to the outside; the length of the corner region in each layer is 0.5-4 times as much as the thickness of the battery sandwiched by the current collectors on both sides of the corner, and is 1-2 times as much as the thickness of the battery cell sandwiched by the current collectors on both sides of the corner as per a more optimized design. This is not only conducive to maintaining the neat arrangement of the electrode plate body region, but also conducive to reducing the deformation rate with low energy density losses.

[0024] During an actual implementation, the positive electrode of the optimized structure can be used alone, or both the positive electrode and the negative electrode of the optimized structure can be used; and the negative electrode and the positive electrode can adopt, independent of each other, different degrees of small coating thickness or no coating of the electrode material layer. However, in order to avoid active metal lithium plating, the capacity of the negative electrode to accept lithium in any region must be higher than the capacity of the positive electrode to release lithium in a corresponding region. Therefore, the negative electrode having this optimized structure cannot be used alone, or a ratio of weight in the corner region of the negative electrode to weight in the body region of the negative electrode shall be higher than or equal to a ratio of weight in the corner region of the positive electrode to weight in the body region of the positive electrode.

[0025] Similarly, in order to avoid metal lithium plating, normal coating region of the negative electrode should exceed normal coating region of the positive electrode to avoid relative movement of positive and negative electrode positions during battery assembly and use, so as to avoid the the phenomenon that the negative electrode that is thin-coated or uncoated with the negative electrode material corresponds to thick-coated positive electrode which results in lithium plating. Depending on the production process of the battery and the size of the battery itself, the normal coating region of the negative electrode should exceed the normal coating region of the positive electrode by a width of 0.5 mm-10 mm.

[0026] The present utility model is applicable to a battery system with thickness expansion of the electrodes during electrode processing, charging-discharging, and cycling. There are no special requirements for the electrolyte solution, the separator, and the battery shell. There are no special requirements for the positive electrode active material. Lithium-transition metal composite oxide, lithium-transition metal phosphate, lithium-transition metal silicate, lithium-transition metal fluorosulfate, etc. can each be used as the positive electrode active material of the battery in the present utility model. There are no special requirements for the negative electrode material. A battery using a material with large lattice expansion during charging and discharging have more obvious advantages, such as graphite (particularly artificial graphite with high graphitization degree and natural graphite), silicon and silicon/carbon composite negative electrode material, SnCoC, or other alloy negative electrode materials.

[0027] Compared with the prior art, the present utility model optimizes the prismatic lithium-ion battery having the winding electrode structure, the thickness of the coated electrode material layer in the corner region of the electrode thereof is smaller than the thickness of the electrode material layer in the body region, thereby reducing the stress caused by electrode expansion during charging, discharging, and cycling of the battery, reducing the deformation rate of the battery, reducing the apparent thickness of the battery during cycling, increasing the energy density of the battery, and improving the battery performance.

Description of Drawings

[0028] The lithium-ion battery of the present utility model is described in detail below with reference to the drawings and embodiments, wherein

[0029] FIG. 1 is a schematic structural diagram of a winding prismatic battery according to Embodiments 1-5 of the present utility model;

[0030] FIG. 2 is a schematic structural diagram of a winding prismatic battery according to Embodiments 6-10 of the present utility model; and

[0031] FIG. 3 is a schematic structural diagram of a winding prismatic battery according to Embodiments 11-13 of the present utility model.

Detailed Description

[0032] The present utility model is described in further detail below with reference to embodiments and test results. However, the implementations of the present utility model are not limited to the embodiments.

[0033] As shown in FIG. 1, a prismatic lithium-ion battery having a winding structure in the present utility model comprises a battery cell, a packing bag configured to accommodate the battery cell, and an electrolyte solution infused in the packing bag, wherein the battery cell comprises a positive electrode 1, a negative electrode 2, and a separator 3 spaced between the positive electrode 1 and the negative electrode 2, the positive electrode 1 comprises a positive electrode current collector 11 and a positive electrode material layer 12 coated on the positive electrode current collector 11, the negative electrode 2 comprises a negative electrode current collector 21 and a negative electrode material layer 22 coated on the negative electrode current collector 21, a ratio of the thickness of the positive electrode material layer 12 in a corner region 13 of the positive electrode to the thickness of the positive electrode material layer 12 in the body region of the positive electrode is smaller than or equal to 90%, and the length of the corner region 13 of the positive electrode in the winding direction is 0.5-4 times the thickness of the battery cell.

[0034] As shown in FIG. 2, a ratio of the thickness of the negative electrode material layer 22 in a corner region 15 of the negative electrode to the thickness of the negative electrode material layer 22 in the body region of the negative electrode is smaller than or equal to 90%.

[0035] As shown in FIG. 3, the corner regions of the positive electrode 1 and the negative electrode 2 are blank positive electrode current collectors, that is, no active material layer is coated. In this case, in order to prevent the blank current collectors from puncturing the separator 3, a protective layer 14 is provided on the blank positive electrode current collectors in the corner region 13 of the positive electrode and the corner region 15 of the negative electrode. The protective layer 14 may be an adhesive tape, a protective coating, or a conductive coating, and the thickness of the protective layer 14 is 1-3 times that of the corresponding current collector.

[0036] Of course, although the figures of the present utility model only show that a region with a thickness smaller than the thickness of the corresponding electrode body region is provided on one side of the corner region of the positive electrode 1 and/or the negative electrode 2, it is obvious that a region with a thickness smaller than the thickness of the corresponding electrode body region may be further provided on the other side of the corner region of the positive electrode 1 and/or the negative electrode 2, or may be provided on each side of the corner region of the positive electrode 1 and/or the negative electrode 2.

[0037] Embodiment 1

[0038] Preparation of a positive electrode 1: 94 parts by weight of lithium cobalt oxide powder (LiCoO_2), 3 parts by weight of acetylene black, 3 parts by weight of polyvinylidene fluoride (PVDF), and an appropriate amount of nitrogen-methylpyrrolidone were dispersed by stirring using a high-speed mixer to form a uniform positive electrode slurry. Then, a method of coating twice and compaction twice was used: first, the slurry was coated on both sides of an aluminum foil current collector by continuous coating, the solvent was dried, then the positive electrode was compacted to a density of 3.8 g/cm^3 , and then a second layer was coated by gap coating with the gap width of the positive electrode being 2 times as much as the battery thickness, the coating width between every two adjacent gaps being the battery width in the winding direction minus the gap width, and the coating weight ratio of the corner region 13 to the body region of the positive electrode being as shown in Table 1. The electrode plate was cut to a suitable size to obtain a unit positive electrode 1.

[0039] Preparation of a negative electrode 2: 94 parts by weight of natural graphite powder, 1.5 parts by weight of acetylene black, 2.5 parts by weight of styrene butadiene rubber (emulsion with a solid content of about 50% and a dry material weight ratio of 2.5), 2 parts by weight of sodium carboxymethylcellulose, and an appropriate amount of water were dispersed by stirring using a high-speed mixer to form a uniform negative electrode slurry, wherein the styrene butadiene rubber emulsion was added in the last step after the slurry was fully dispersed, and the mixture was stirred slowly to prevent the emulsion from demulsification. This slurry was coated

on a copper foil current collector, the solvent was dried, the weight of the negative electrode coating per unit area on one side after drying was 8.86 mg/cm^2 , and then the other side was coated with the same weight. The electrode plate was compacted to a coating density of about 1.6 g/cm^3 after compaction; and the electrode plate was cut to a suitable size to obtain a unit negative electrode 2.

[0040] Electrolyte solution: Lithium hexafluorophosphate (LiPF_6) was dissolved in a mixed solvent with a weight ratio of ethylene carbonate:diethyl carbonate:ethyl methyl carbonate=1:1:1, so that the lithium salt concentration was 1 mole per liter, and vinylene carbonate was added as an additive, vinylene carbonate accounting for 3% of the weight of the electrolyte solution, thus obtaining the electrolyte solution.

[0041] Polypropylene porous membrane was selected as the separator 3.

[0042] Preparation of a lithium-ion secondary battery: The positive electrode 1, the separator 3, and the negative electrode 2 were wound to form an electrode assembly, and the separator 3 was located between the positive electrode 1 and the negative electrode 2. The resulting electrode assembly was transferred in a battery box bag. The electrolyte solution was injected into the battery box, which was then vacuum-packaged. The battery was charged to 50% SOC at a constant current of 0.05C, followed by vacuum degassing and secondary packaging, to complete the battery manufacturing.

[0043] Embodiments 2-13

[0044] The negative electrodes in Embodiments 2-5 were manufactured using the same method as that in Embodiment 1. The positive electrodes 1 in Embodiments 2-5, and the positive electrodes 1 and the negative electrodes 2 in Embodiments 6-10 were all implemented by coating twice and compaction twice. The coating statuses of the positive electrodes 1 and the negative electrodes 2 in Embodiments 2-13 are shown in Table 1. Specific operation processes of the coating twice and the compaction twice are as follows: after double-sided coating in a continuous manner, the positive electrode 1 was compacted to a density of 3.8 g/cm^3 , and the negative electrode 2 was compacted to a density of 1.5 g/cm^3 ; then a second layer was coated by gap coating with the gap width of the positive electrode 1 being 2 times as much as the battery thickness, the gap width of

the negative electrode 2 being 1.2 times as much as the battery thickness, and the coating width between every two adjacent gaps being the battery width in the winding direction minus the gap width. In all embodiments of the present utility model, the battery width in the winding direction is 200 mm, and the battery thickness is 5 mm. After the double-layer coating, a total weight of double-layer electrode coating in the double-layer coating region was 20.13 mg/cm^2 for the positive electrode 1 and 8.86 mg/cm^2 for the negative electrode 2. The electrodes were compacted such that an average density of electrode layers in the double-layer coating region was 4.1 g/cm^3 for the positive electrode 1 and 1.6 g/cm^3 for the negative electrode 2. The positive electrodes 1 and the negative electrodes 2 in Embodiments 11-13 were coated merely in an intermittent manner with gap coating size parameters the same as those in the above embodiments. The coating weight was 20.13 mg/cm^2 for the positive electrode 1 and 8.86 mg/cm^2 for the negative electrode 2. The electrodes were compacted such that the coating density was 4.1 g/cm^3 for the positive electrode 1 and 1.6 g/cm^3 for the negative electrode 2. Green glue with a thickness of 20 μm was applied to blank current collector regions of the electrodes. The operations in Embodiment 12 are the same as those in Embodiment 11 except that the blank current collector regions were coated with a protective coating. The protective coating comprises polyvinylidene fluoride and aluminum oxide, and has a thickness of 10 μm . The operations in Embodiment 13 are the same as those in Embodiment 11 except that the blank current collector regions were coated with a conductive coating prior to coating. The conductive coating is a butadiene-styrene copolymer layer.

[0045] With a center line of a gap region as a corner position for winding, the positive electrode 1, the separator 3, and the negative electrode 2 were wound to form an electrode assembly, and the separator 3 was located between the positive electrode 1 and the negative electrode 2. The resulting electrode assembly was transferred in a battery box bag. The battery was packaged, charged for a first time, degassed, and packaged for a second time according to the method in Embodiment 1 to complete the battery manufacturing.

[0046] Table 1: Coating weight in corner region of positive and negative electrodes, and ratio of coating thickness in corner region to coating thickness in body region after the electrode manufacturing in the embodiments

[0047]

Group No.	Coating weight in corner region (mg/cm ²)		After electrode manufacturing Coating thickness in corner region/coating thickness in body region	
	Negative electrode	Positive electrode	Negative electrode	Positive electrode
Embodiment 1		16.79	1	0.9
Embodiment 2		13.06	1	0.7
Embodiment 3		5.60	1	0.3
Embodiment 4		1.87	1	0.1
Embodiment 5		0.94	1	0.05
Embodiment 6	7.47	16.79	0.9	0.9
Embodiment 7	5.81	13.06	0.7	0.7
Embodiment 8	2.49	5.60	0.3	0.3
Embodiment 9	2.49	1.87	0.3	0.1
Embodiment 10	0.83	1.87	0.1	0.1
Embodiment 11	Uncoated	Uncoated	0	0
Embodiment 12	Uncoated	Uncoated	0	0
Embodiment 13	Uncoated	Uncoated	0	0

[0048] *Note: an electrode with a ratio of the thickness of the corner region to the thickness of the body region being 1 was a gapless region manufactured by single-layer continuous coating and cold pressing once; and an electrode with the ratio being 0 was manufactured by single-layer intermittent coating and cold pressing once, and the gap region was pasted with green glue or coated with a protective coating after cold pressing, or a conductive coating was coated on a blank current collector prior to coating.

[0049] Battery cycling expansion and deformation rate test:

[0050] The battery was charged to 4.2V at a constant current at a rate of 1C, then charged to a current of 0.05C at a constant voltage of 4.2V, and then discharged to 3.0V at a constant current at a rate of 1C. The battery was repeatedly charged and discharged 100 times. Then, the battery was charged to 4.2V at a constant current/constant voltage. The battery thickness distribution was measured by scanning with a laser thickness gauge to calculate the average thickness of the battery, which was denoted as T (100). The battery was clamped using two parallel flat plates with a

clamping force of 0.5 kgf. A distance between the two flat plates was used as a maximum thickness of the battery after 100 cycles, and denoted as $T(100, \max)$. $T(100, \max)/T(100)-1$ was used as a deformation rate of the battery after 100 cycles, and the result thereof is as shown in Table 2.

[0051] Under same test conditions, a deformation rate after 100 cycles of a battery manufactured from an electrode plate with same thickness in the corner region and the body region obtained by conventional continuous coating once was 2.46%.

[0052] Table 2: Deformation rate after 100 cycles of batteries in Embodiments 1-13

[0053]

Group No.	Coating thickness in corner region/coating thickness in body region		Battery deformation rate after 100 cycles
	Negative electrode	Positive electrode	
Embodiment 1	1	0.9	2.35%
Embodiment 2	1	0.7	2.23%
Embodiment 3	1	0.3	1.37%
Embodiment 4	1	0.1	1.25%
Embodiment 5	1	0.05	1.03%
Embodiment 6	0.9	0.9	2.27%
Embodiment 7	0.7	0.7	2.09%
Embodiment 8	0.3	0.3	0.86%
Embodiment 9	0.3	0.1	0.52%
Embodiment 10	0.1	0.1	0.56%
Embodiment 11	0	0	0.43%
Embodiment 12	0	0	0.53%
Embodiment 13	0	0	0.70%

[0054] As can be seen from Table 2, when a low electrode coating weight was used for the corner region 13 of the positive electrode, a ratio of coating thickness in the corner region 13 of the positive electrode to coating thickness in the body region of the positive electrode was reduced, or after both the ratio of the coating thickness in the corner region to the coating thickness in the electrode coating region of the positive electrode 1 and the ratio of the coating thickness in the corner region to the coating thickness in the electrode coating region of the negative electrode 2 were reduced, the battery deformation was significantly alleviated. When the coating thickness in the corner region 13 of the positive electrode was reduced to 0.9 of the thickness in the body region, the deformation rate can be reduced from 2.46% to 2.35%. When both the coating thickness in the corner region 13 of the positive electrode and that in the corner region 15 of the negative electrode

were reduced to 0.9 of the thickness in the body region of the corresponding electrode, the deformation rate can be reduced from 2.46% to 2.27%. When the coating thickness in the corner region was reduced to 0.3 or smaller of the thickness in the body region, the improvement effect was more obvious. For example, when the coating thickness in the corner region 13 of the positive electrode was 0.3 of the coating thickness in the body region, and the coating thickness in the corner region 15 of the negative electrode was 0.1 of the coating thickness in the body region, the deformation rate of the battery was only 0.52%, and the deformation degree was only one fifth of the deformation degree of a conventional battery.

[0055] During charging and discharging of the battery, the electrode plates will expand. The reasons for the expansion of the electrode plates include factors such as lattice expansion of the electrode material during charging and discharging, electrode swelling by the electrolyte solution, gradual release of the stress generated during electrode processing during cycling, and surface film growth of the electrode active material during cycling. In the winding prismatic battery of the prior art, the expansion of the electrode plates is restricted by the current collectors and the separator, and the expansion of the electrode plates will cause stress generation and non-uniform stress distribution inside the battery, thereby resulting in distortion and deformation of the battery structure. According to the technology of the present utility model, a thin coating layer in the corner of the winding structure can alleviate non-uniform stress distribution; and moreover, when the corner region is thin or is uncoated with the electrode layer, the corner region has a large space, which can make the expansion of the battery be similar to the expansion of the stacked battery, that is, the entirety expands in the thickness direction instead of local distortion, thereby alleviating the battery deformation.

[0056] According to the disclosure and teachings in the above specification, those skilled in the art to which the present utility model belongs can further make alterations and modifications to the above embodiments. Therefore, the present utility model is not limited to the embodiments disclosed and described above, and some modifications and alterations to the present utility model should also be encompassed within the scope of protection of the claims of the present utility

model. In addition, although some particular terms are used in the present specification, these terms are provided merely for ease of description, and do not constitute any limitation to the present utility model.

CLAIMS

1. A prismatic lithium-ion battery having a winding structure, comprising a battery cell, a packing bag configured to accommodate the battery cell, and an electrolyte solution infused in the packing bag, wherein the battery cell comprises a positive electrode, a negative electrode, and a separator spaced between the positive electrode and the negative electrode, the positive electrode comprises a positive electrode current collector and a positive electrode material layer coated on the positive electrode current collector, and the negative electrode comprises a negative electrode current collector and a negative electrode material layer coated on the negative electrode current collector, wherein a ratio of the thickness of the positive electrode material layer in the corner region of the positive electrode to the thickness of the positive electrode material layer in the body region of the positive electrode is smaller than or equal to 90%, and the length of the corner region in the winding direction is 0.5-4 times the thickness of the battery cell.

2. The prismatic lithium-ion battery having a winding structure according to claim 1, wherein a ratio of the thickness of the negative electrode material layer in the corner region of the negative electrode to the thickness of the negative electrode material layer in the body region of the negative electrode is smaller than or equal to 90%.

3. The prismatic lithium-ion battery having a winding structure according to claim 1, wherein the ratio of the thickness of the positive electrode material layer in the corner region of the positive electrode to the thickness of the positive electrode material layer in the body region of the positive electrode is smaller than or equal to 30%.

4. The prismatic lithium-ion battery having a winding structure according to claim 3, wherein the corner region of the positive electrode is a blank positive electrode current collector.

5. The prismatic lithium-ion battery having a winding structure according to claim 4, wherein the blank positive electrode current collector in the corner region is pasted with an adhesive tape, and the thickness of the adhesive tape is 1-3 times that of the positive electrode current collector.

6. The prismatic lithium-ion battery having a winding structure according to claim 4, wherein the blank positive electrode current collector in the corner region is coated with a protective coating.

7. The prismatic lithium-ion battery having a winding structure according to claim 6, wherein the thickness of the protective coating is 1-3 times that of the positive electrode current collector.

8. The prismatic lithium-ion battery having a winding structure according to claim 4, wherein the blank positive electrode current collector in the corner region is coated with a conductive coating.

9. The prismatic lithium-ion battery having a winding structure according to claim 8, wherein the thickness of the conductive coating is 1-3 times that of the positive electrode current collector.

10. The prismatic lithium-ion battery having a winding structure according to claim 1, wherein the length of the corner region in the winding direction is 1-2 times the thickness of the battery cell.

FIGURES

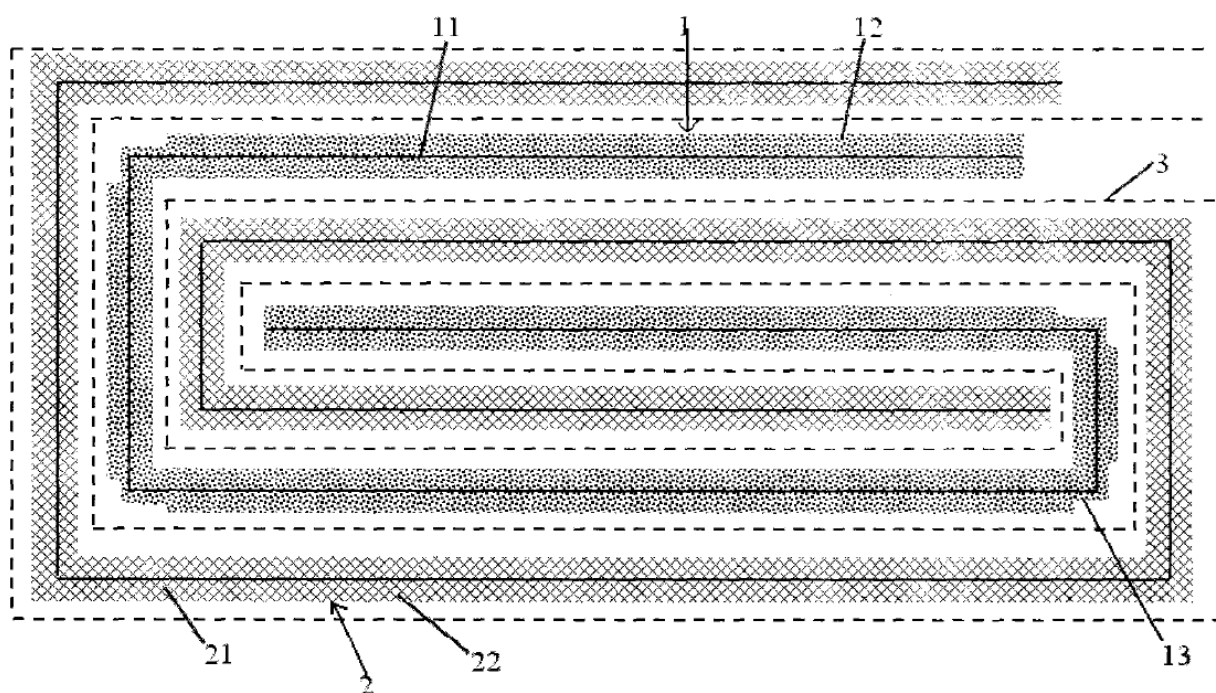


FIG. 1

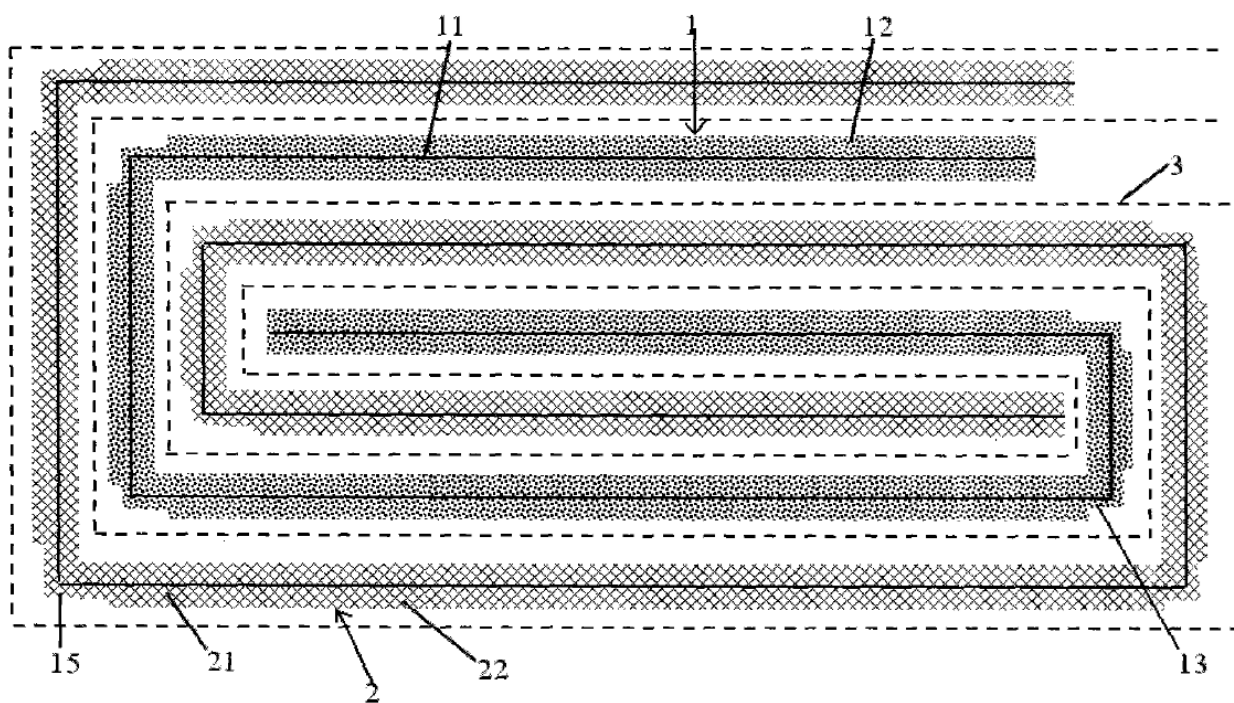
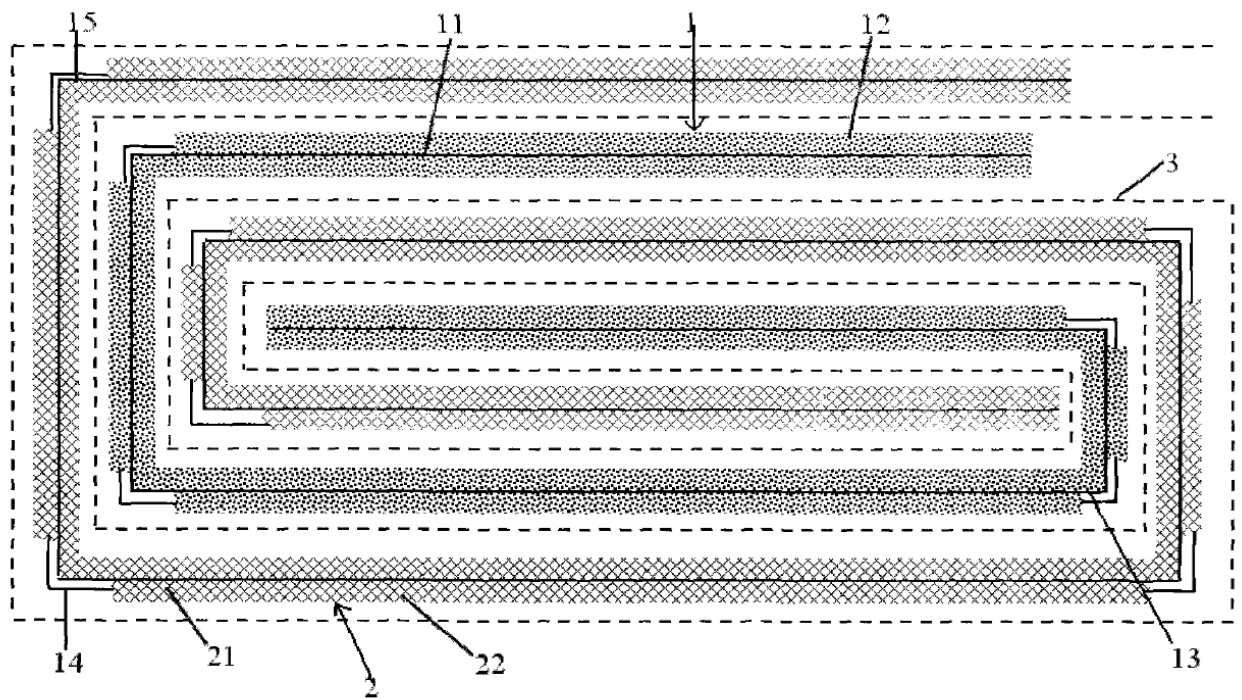


FIG. 2

**FIG. 3**



(12) 实用新型专利

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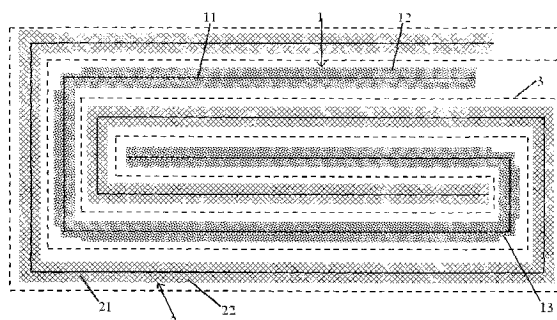
权利要求书1页 说明书7页 附图2页

(54) 实用新型名称

一种卷绕式结构的方形锂离子电池

(57) 摘要

本实用新型属于锂离子电池技术领域,尤其涉及一种卷绕式结构的方形锂离子电池,包括正极、负极、隔膜和电解液,正极包括正极集流体及涂布在正极集流体上的正极材料层,正极在转角区域的正极材料层的厚度与正极本体区域的正极材料层的厚度的比值小于等于 90%,转角区域在卷绕方向的长度为 0.5~4 个电芯厚度。相对于现有技术,本实用新型优化了电极结构的卷绕式方形锂离子电池,在其电极的转角区域,涂布的电极材料层厚度低于其本体区域的电极材料层厚度,以此降低电池在充放电及循环过程中因电极膨胀导致的应力,降低电池的变形率,减少电池循环过程的表现厚度,提高电池的能量密度,及改善电池性能。



1. 一种卷绕式结构的方形锂离子电池,包括电芯、用于容纳所述电芯的包装袋和灌注于所述包装袋内的电解液,所述电芯包括正极、负极和间隔于所述正极和负极之间的隔膜,所述正极包括正极集流体及涂布在正极集流体上的正极材料层,所述负极包括负极集流体及涂布在负极集流体上的负极材料层,其特征在于:所述正极在转角区域的正极材料层的厚度与正极本体区域的正极材料层的厚度的比值小于等于 90%,所述转角区域在卷绕方向的长度为 0.5 ~ 4 个电芯厚度。

2. 根据权利要求 1 所述的卷绕式结构的方形锂离子电池,其特征在于:所述负极在转角区域的负极材料层的厚度与负极本体区域的负极材料层的厚度的比值小于等于 90%。

3. 根据权利要求 1 所述的卷绕式结构的方形锂离子电池,其特征在于:所述正极在转角区域的正极材料层的厚度与正极本体区域的正极材料层的厚度的比值小于等于 30%。

4. 根据权利要求 3 所述的卷绕式结构的方形锂离子电池,其特征在于:所述正极的转角区域为空白正极集流体。

5. 根据权利要求 4 所述的卷绕式结构的方形锂离子电池,其特征在于:所述转角区域的空白正极集流体上贴有胶带,所述胶带的厚度为正极集流体的 1 ~ 3 倍。

6. 根据权利要求 4 所述的卷绕式结构的方形锂离子电池,其特征在于:所述转角区域的空白正极集流体上涂有保护涂层。

7. 根据权利要求 6 所述的卷绕式结构的方形锂离子电池,其特征在于:所述保护涂层的厚度为正极集流体的 1 ~ 3 倍。

8. 根据权利要求 4 所述的卷绕式结构的方形锂离子电池,其特征在于:所述转角区域的空白正极集流体上涂有导电涂层。

9. 根据权利要求 8 所述的卷绕式结构的方形锂离子电池,其特征在于:所述导电涂层的厚度为正极集流体的 1 ~ 3 倍。

10. 根据权利要求 1 所述的卷绕式结构的方形锂离子电池,其特征在于:所述转角区域在卷绕方向的长度为 1 ~ 2 个电芯厚度。

一种卷绕式结构的方形锂离子电池

技术领域

[0001] 本实用新型属于锂离子电池技术领域,尤其涉及一种卷绕式结构的方形锂离子电池,特别是一种能够降低变形率的卷绕式结构的方形锂离子电池。

背景技术

[0002] 方形电池形状规则,厚度可控,能够适应现代消费电子超轻薄发展的趋势;同时方形电池形相对圆柱形电池比表面积大,有利于大容量电池的散热;方形结构也有利于大规模电池的组装,因此也适于汽车动力电池、储能电池等大规模储能的应用。目前,方形电池电极、隔膜组件的组装方式主要包括叠片和卷绕两种方式。其中,卷绕方式组装方形电池有利于机械自动化生产,提高生产效率和产品的可靠性。

[0003] 然而相对于叠片式结构的电池,卷绕式结构的电池在循环过程中容易发生变形,从而导致电池厚度增加,体积能量密度降低,以及造成电极间的界面变差,电池性能恶化。理想的方形电池应为一平整的方块形状,电池变形是指电池某些部位隆起而背面凹陷,或某些部位凹陷而背面隆起等各种使造成电池不平整的现象。出现这种现象的原因在于卷绕式结构的电池充放电循环过程中因电极膨胀而导致在电池内部不同位置存在不均匀的应力分布,因而容易发生变形;而叠片式结构的电池,各极片独立、平行堆叠,极片均匀膨胀,没有应力分布,因而叠片式电池是整个厚度方向的均匀膨胀,没有变形的问题。

[0004] 电极在循环过程中的膨胀包括由于电极材料充放电过程中的晶格膨胀、电解液对电极的溶胀、因电极加工过程产生的应力在循环过程中逐渐释放导致的电极膨胀,以及电极活性材料在循环过程中因表面膜生长导致的膨胀。在叠片式电池中,极片各个部位均匀膨胀,同时各个集流体不是一个整体,不会互相限制,因此电极膨胀时,电池可整体均匀的膨胀,不易造成电池变形的问题。而卷绕式结构的电池,极片膨胀时受到集流体、隔膜的束缚,从而使内部产生不均匀应力分布,导致电池变形问题。

[0005] 有鉴于此,确有必要提供一种能够解决变形问题的卷绕式结构的方形锂离子电池。

实用新型内容

[0006] 本实用新型的目的在于:针对现有技术的不足,而提供一种能够解决变形问题的卷绕式结构的方形锂离子电池。

[0007] 为了达到上述目的,本实用新型采用如下技术方案:

[0008] 一种卷绕式结构的方形锂离子电池,包括电芯、用于容纳所述电芯的包装袋和灌注于所述包装袋内的电解液,所述电芯包括正极、负极和间隔于所述正极和负极之间的隔膜,所述正极包括正极集流体及涂布在正极集流体上的正极材料层,所述负极包括负极集流体及涂布在负极集流体上的负极材料层,所述正极在转角区域的正极材料层的厚度与正极本体区域的正极材料层的厚度的比值小于等于 90%,所述转角区域在卷绕方向的长度为 0.5~4 个电芯厚度。其中,转角区域是指电极在其转角位置附近的区域。转角区域其在卷

绕方向的长度约为 0.5 ~ 4 倍电芯厚度,以 1 ~ 2 倍的电芯厚度最佳,太短则难以起到抑制电池变形的作用,太长则导致电池能量密度损失。同时,转角区域相对电极转角位置尽量对称分布,其相对转角处转角区域两边长度比在 0.6 ~ 1.5 之间,以使电极分布均匀,达到更佳效果。

[0009] 本体区域是指除转角区域以外的区域。使用此优化结构的电极组装的电池,在充放电、循环过程中,在其卷绕结构的转角区域因电极膨胀产生的应力小,减轻了应力分布不均匀的问题,因而可以减少电池的变形率。在实施中发现,当转角区域的正极材料层厚度相当于正极本体区域电极材料层厚度的 90% 时,电池变形即有改善。

[0010] 作为本实用新型卷绕式结构的方形锂离子电池的一种改进,所述负极在转角区域的负极材料层的厚度与负极本体区域的负极材料层的厚度的比值小于等于 90%。为实现电极(正极或负极)转角区域涂布的电极层厚度低于本体区域电极层厚度,可以采用如下实施方法:

[0011] 第一种是一次性涂布,然后在转角区域吸取、粘取等方法取出一定量的浆料或干燥后磨除、剔除等方法减少活性涂层厚度;

[0012] 第二种是间歇式的调节涂布头的缝隙,在转角区域直接涂布较少的浆料;

[0013] 第三种是两次涂布方法,即先整体涂布一层,然后再涂布本体区域,第二次涂布在转角区域不涂;

[0014] 其中第一种方法和第二种方法在实施上较为困难,第三种方法是目前较为简单、可行的方法。

[0015] 作为本实用新型卷绕式结构的方形锂离子电池的一种改进,所述正极在转角区域的正极材料层的厚度与正极本体区域的正极材料层的厚度的比值小于等于 30%。此时,转角区域活性材料较少,空间多、电极膨胀少;电池膨胀主要体现在本体区域,电池内部几乎不存在应力分布,此时电极膨胀对电池的影响与叠片电池类似,电池整体在厚度方向膨胀,而基本没有变形的现象。

[0016] 作为本实用新型卷绕式结构的方形锂离子电池的一种改进,所述正极的转角区域为空白正极集流体,这是本实用新型的一种特殊情况,也就是说转角区域也可以不涂布电极活性物质,这时电池充放电循环过程的膨胀与叠片电池的膨胀行为相似,对降低电池循环过程的变形率有较好的效果。

[0017] 但是由于裸露的集流体在其边沿容易产生枝状金属碎片,此碎片容易刺穿隔膜导致电池短路。因此,在未涂布的区域需要施加保护层,避免枝晶造成的短路。此保护层可以以下几种方法实现

[0018] 方法一是贴胶带,使用一些化学、电化学稳定的胶带,贴覆在空白集流体区域;

[0019] 方法二是涂覆聚合物层或无机颗粒/粘结剂保护涂层于空白集流体区域;

[0020] 方法三是涂覆导电剂/粘结剂导电涂层于集流体上。

[0021] 前两种方法可覆盖空白集流体前后少量的区域,后一种方法可在涂布活性物质前涂布到集流体上。方法一施加方式比较复杂,但是保护效果好;方法二需要较高精度涂布机器;方式三会导致体积能量密度损失,但是可减少电池内阻,有利于提高功率密度。实际使用可灵活性选择。对于方法一所述胶带,没有特殊的要求,只要有一定强度,能抗金属颗粒刺穿,同时在电池体系中保持化学、电化学稳定性即可。对于方法二所述无机颗粒没有特殊

要求,但要求在电解液中不溶解,在电池体系中保持化学、电化学稳定,如三氧化二铝、二氧化钛、二氧化锆、氧化镁、磷酸铝、沸石等。对于方法二和方法三所述聚合物及粘结剂没有特殊的要求,只要在电池体系中保持粘结性、化学、电化学稳定性即可,如丁二烯-苯乙烯共聚物、聚偏二氟乙烯、偏二氟乙烯-四氟乙烯共聚物、聚丙烯酸钙、聚酯、聚酰亚胺等。胶带、保护涂层、导电涂层的厚度不低于集流体的一倍,以达到基本的保护要求;不大于集流体厚度的三倍,以使空白区域厚度较薄,能够发挥设计的作用。

[0022] 作为本实用新型卷绕式结构的方形锂离子电池的一种改进,所述转角区域在卷绕方向的长度为1~2个电芯厚度。

[0023] 对于卷绕结构的电池,从卷绕结构的内层往外层发展,每增加一层,电极的周长有所增加。因此,作为一种优化设计,转角区域其在卷绕方向的长度随其在电芯中的位置,由内至外递增;每层转角区域长度为其转角两边集流体所夹电池厚度的0.5~4倍,更优化的设计则为转角两边集流体所夹电芯厚度的1~2倍。如此既有利于保持极片本体区域的整齐排列,又有利于以较低的能量密度损失达到降低变形率的目的。

[0024] 在实际实施过程中,可以单独使用优化结构的正极,也可同时使用优化结构的正极和负极;负极、正极可相互独立的采用不同程度的较薄涂布厚度或不涂布电极材料层。但是为了避免活泼的金属锂析出,负极在任何区域的可接受锂的容量一定要高于对应区域正极放出锂的容量,因此不能单独使用此优化结构的负极,或是负极在转角区域的重量与本体区域重量比值不能低于正极在转角区域重量与本体区域重量比值。

[0025] 同样的为了避免金属锂析出,负极正常涂布区域应超出正极正常涂布区域,以避免在电池组装、使用过程中正负极位置的相对移动,导致较薄或无涂布电极材料的负极对应较厚涂布的正极,导致析锂。取决于电池的生产制作工艺及电池本身的大小,负极正常涂布区域应超出正极正常涂布区域的宽度可为0.5mm~10mm。

[0026] 本实用新型适用于电极在加工、充放电、循环过程中电极有厚度膨胀的电池体系。对电解液、隔膜及电池的外壳没有特殊的要求。对正极活性材料也没有特殊的要求,锂过渡金属复合氧化物、锂过渡金属磷酸盐、锂过渡金属硅酸盐、锂过渡金属氟硫酸盐等都可作为此实用新型的电池的正极活性物质。对负极材料无特殊要求,对于使用充放电过程中晶格膨胀较大的材料的电池优势更为明显,如石墨(特别是高石墨化度的人造石墨、天然石墨)、硅及硅/碳复合负极材料、SnCoC等合金负极材料等。

[0027] 相对于现有技术,本实用新型优化了电极结构的卷绕式方形锂离子电池,在其电极的转角区域,涂布的电极材料层厚度低于其本体区域的电极材料层厚度,以此降低电池在充放电及循环过程中因电极膨胀导致的应力,降低电池的变形率,减少电池循环过程的表现厚度,提高电池的能量密度,及改善电池性能。

附图说明

[0028] 下面结合附图和具体实施方式,对本实用新型的锂离子电池进行详细说明,其中:

[0029] 图1为本实用新型具体实施方式1至5的卷绕式方形电池结构示意图;

[0030] 图2为本实用新型具体实施方式6至10的卷绕式方形电池结构示意图;

[0031] 图3为本实用新型具体实施方式11至13的卷绕式方形电池结构示意图。

具体实施方式

[0032] 下面结合具体实施方式和测试结果,对本实用新型作进一步详细的描述。但本实用新型的实施方式不限于此。

[0033] 如图 1 所示,本实用新型一种卷绕式结构的方形锂离子电池,包括电芯、用于容纳所述电芯的包装袋和灌注于所述包装袋内的电解液,所述电芯包括正极 1、负极 2 和间隔于所述正极 1 和负极 2 之间的隔膜 3,所述正极 1 包括正极集流体 11 及涂布在正极集流体 11 上的正极材料层 12,所述负极 2 包括负极集流体 21 及涂布在负极集流体 21 上的负极材料层 22,所述正极转角区域 13 的正极材料层 12 的厚度与正极本体区域的正极材料层 12 的厚度的比值小于等于 90%,所述正极转角区域 13 在卷绕方向的长度为 0.5 ~ 4 个电芯厚度。

[0034] 如图 2 所示,负极转角区域 15 的负极材料层 22 的厚度与负极本体区域的负极材料层 22 的厚度的比值小于等于 90%。

[0035] 如图 3 所示,正极 1 和负极 2 的转角区域为空白正极集流体,即未涂覆活性物质层。此时,为了防止空白集流体刺破隔膜 3,在正极转角区域 13 和负极转角区域 15 的空白正极集流体上设有保护层 14,该保护层 14 可以为胶带、保护涂层或导电涂层,保护层 14 的厚度为相应集流体的 1 ~ 3 倍。

[0036] 当然,本实用新型附图中虽然只表示出在正极 1 和 / 或负极 2 的转角区域的一面设置厚度小于相应电极本体区域的厚度的区域,显然的,还可以在正极 1 和 / 或负极 2 的转角区域的另一面,或者在正极 1 和 / 或负极 2 的转角区域的双面均设置厚度小于相应电极本体区域的厚度的区域。

[0037] 具体实施方式 1

[0038] 正极 1 的制备:将 94 重量份的钴酸锂粉 (LiCoO_2)、3 重量份的乙炔黑、3 重量份的聚偏二氟乙烯 (PVDF)、适量的氮 - 甲基吡咯烷酮,使用高速搅拌机搅拌分散,使其形成均匀的正极浆料。然后使用两次涂布、两次压实的方法:首先使用连续涂布方式,将此浆料涂覆到铝箔集流体上,双面涂布烘干溶剂后将正极密度压到 $3.8\text{g}/\text{cm}^3$,然后涂布第二层,第二层使用间隙涂布方式,正极的间隙宽度为 2 倍电池厚度,每相邻两间隙间涂布宽度为电池卷绕方向宽度减去间隙宽度,正极转角区域 13 和本体区域的涂布重量比见表 1;将极片裁剪到合适大小,得到单元正极 1。

[0039] 负极 2 的制备:将 94 重量份的天然石墨粉、1.5 重量份的乙炔黑、2.5 重量份的丁苯橡胶 (乳液,固含量约 50%,2.5 为干态物质重量比),2 重量份的羧甲基纤维素钠、适量的水,使用高速搅拌机搅拌分散,使其形成均匀的负极浆料,其中丁苯橡胶乳液在浆料分散好后最后一步才加,并慢速搅拌以防止乳液破乳。将此浆料涂覆到铜箔集流体上,烘干溶剂,烘干后单面的单位面积负极涂层重量为 $8.86\text{mg}/\text{cm}^2$,然后以相同重量涂布另一面;将极片压实,压实后涂层的密度约为 $1.6\text{g}/\text{cm}^3$;将极片裁剪到合适大小,得到单元负极 2。

[0040] 电解液:将六氟磷酸锂 (LiPF_6) 溶入到以重量比为碳酸乙烯酯:碳酸二乙酯:碳酸甲乙酯 = 1 : 1 : 1 的混合溶剂中,使锂盐浓度为 1 摩尔每升,加入酸亚乙烯酯作为添加剂,碳酸亚乙烯酯占电解液重量的 3%,得到电解液。

[0041] 隔膜 3 选用聚丙烯多孔膜。

[0042] 锂离子二次电池的制备:将正极 1、隔膜 3、负极 2 卷绕形成电极组件,隔膜 3 处在

正极 1 和负极 2 之间。将所得的电极组放入电池盒袋中。往电池盒中注入电解液,真空封装电池盒。将该电池以恒电流 0.05C 充电至 50% SOC,然后真空排除气体,二次封装即完成电池的制作。

[0043] 具体实施方式 2 ~ 13

[0044] 具体实施方式 2 ~ 5 的负极采用与具体实施方式 1 相同的制作方法。具体实施方式 2 ~ 5 的正极 1、具体实施方式 6 ~ 10 的正极 1 和负极 2 均采用两次涂布、两次压实的实施方法。具体实施方式 2 至 13 的正极 1 和负极 2 的涂布情况见表 1。其中,两次涂布、两次压实的具體操作过程如下:使用连续涂布方式,双面涂布后将正极 1 的密度压到 $3.8\text{g}/\text{cm}^3$,负极 2 的密度压到 $1.5\text{g}/\text{cm}^3$;然后涂布第二层,第二层使用间隙涂布方式,正极 1 的间隙宽度为 2 倍电池厚度,负极 2 的间隙宽度为 1.2 倍电池厚度,每相邻两间隙间涂布宽度为电池卷绕方向宽度减去间隙宽度;在本实用新型的所有具体实施方式中,电池卷绕方向宽度为 200mm,电池厚度为 5mm。双层涂布好后,双层涂布区两层电极涂层总重量正极 1 为 $20.13\text{mg}/\text{cm}^2$,负极 2 为 $8.86\text{mg}/\text{cm}^2$,将电极压实,使双层涂布区的电极层平均密度,正极 1 为 $4.1\text{g}/\text{cm}^3$,负极 2 为 $1.6\text{g}/\text{cm}^3$ 。具体实施方式 11 至 13 的正极 1、负极 2 仅以间歇方式涂布,间隙涂布尺寸参数与上面具体实施方式的间隙涂布参数相同,涂布重量正极 1 为 $20.13\text{mg}/\text{cm}^2$,负极 2 为 $8.86\text{mg}/\text{cm}^2$,将电极压实,使正极 1 的涂层密度为 $4.1\text{g}/\text{cm}^3$,负极 2 的涂层密度为 $1.6\text{g}/\text{cm}^3$ 。在电极的空白集流体区域贴覆 20um 厚度的绿胶。具体实施方式 12 的操作同具体实施方式 11,不同的是空白集流体区域涂覆有保护涂层,该保护涂层包括聚偏二氟乙烯和三氧化二铝,保护涂层的厚度为 $10\mu\text{m}$ 。具体实施方式 13 的操作同具体实施方式 11,不同的是在涂布前在空白集流体区域涂覆导电涂层,导电涂层为丁二烯-苯乙烯共聚物层。

[0045] 以间隙区的中线为转绕的转角位,将正极 1、隔膜 3、负极 2 卷绕形成电极组件,隔膜 3 处在正极 1 和负极 2 之间。将所得的电极组放入电池盒袋中。按照具体实施方式 1 的方法对电池进行封装、首次充电、排气及二次封装,完成电池制作。

[0046] 表 1:各具体实施方式的正、负极转角区域涂层重量,以及电极制作好后转角区域涂层厚度与本体区域涂层厚度的比值

[0047]

组别	转角区域涂层重量 (mg/cm ²)		电极制作好后 转角区域涂层厚度/本体区域涂层厚度	
	负极	正极	负极	正极
具体实施方式 1		16.79	1	0.9
具体实施方式 2		13.06	1	0.7
具体实施方式 3		5.60	1	0.3
具体实施方式 4		1.87	1	0.1
具体实施方式 5		0.94	1	0.05
具体实施方式 6	7.47	16.79	0.9	0.9
具体实施方式 7	5.81	13.06	0.7	0.7
具体实施方式 8	2.49	5.60	0.3	0.3
具体实施方式 9	2.49	1.87	0.3	0.1
具体实施方式 10	0.83	1.87	0.1	0.1
具体实施方式 11	无涂布	无涂布	0	0
具体实施方式 12	无涂布	无涂布	0	0
具体实施方式 13	无涂布	无涂布	0	0

[0048] *注:转角区域与本体区域厚度比值为 1 的电极为无间隙区,使用单层连续涂布、一次冷压制作;比值为 0 的使用单层间歇涂布,一次冷压,冷压后间隙区贴绿胶或涂保护层,或者在涂布前往空白集流体上涂覆导电涂层。

[0049] 电池循环膨胀与变形率测试:

[0050] 以 1C 倍率恒电流将电池充电至 4.2V,再以 4.2V 恒电压充电至电流为 0.05C,然后以 1C 倍率恒电流放电至 3.0V;反复充电、放电 100 次。然后再将电池恒流/恒压充电至 4.2V,使用激光测厚仪扫描测量电池的厚度分布,计算电池的平均厚度,记为 T(100);以两块平行的平板夹紧电池,夹紧力度为 0.5 千克力,以两块平板间距离作为电池 100 次循环后的最大厚度,记为 T(100,max)。以 T(100,max)/T(100)-1 作为电池 100 周循环后的变形率,其结果如表 2 所示。

[0051] 而以常规的一次连续涂布得到的转角区域和本体区域厚度相同的极片制备的电池在相同的测试条件下,100 次循环后的变形率为 2.46%。

[0052] 表 2:具体实施方式 1 至 13 的电池 100 次循环后的变形率

[0053]

组别	转角区域涂层厚度/本体区域涂层厚度		100 次循环电池变形率
	负极	正极	
具体实施方式 1	1	0.9	2.35%
具体实施方式 2	1	0.7	2.23%
具体实施方式 3	1	0.3	1.37%
具体实施方式 4	1	0.1	1.25%
具体实施方式 5	1	0.05	1.03%
具体实施方式 6	0.9	0.9	2.27%
具体实施方式 7	0.7	0.7	2.09%
具体实施方式 8	0.3	0.3	0.86%
具体实施方式 9	0.3	0.1	0.52%
具体实施方式 10	0.1	0.1	0.56%
具体实施方式 11	0	0	0.43%
具体实施方式 12	0	0	0.53%
具体实施方式 13	0	0	0.70%

[0054] 从表 2 可以看出,当正极转角区域 13 采用较低的电极涂层重量,从而降低正极转角区域 13 与正极本体区域的涂层厚度比,或是正极 1 和负极 2 同时降低转角区域与电极涂层区域的涂层厚度比后,电池的变形情况明显减轻。正极转角区域 13 的涂层厚度降至本体区域厚度的 0.9 时,变形率即可从 2.46%降低到 2.35%,正极转角区域 13 和负极转角区域 15 的涂层厚度同时降至相应电极的本体区域厚度的 0.9 时,变形率即可从 2.46%降低到 2.27%;当转角区域涂层厚度降至本体区域厚度的 0.3 或以下时,改善作用则更为明显,如当正极转角区域 13 涂层厚度为本体区域涂层厚度的 0.3,负极转角区域 15 的涂层厚度为本体区域涂层厚度的 0.1 时,电池的变形率只有 0.52%,变形程度只有常规电池的五分之一。

[0055] 电池在充放电过程中,极片会产生膨胀,导致极片膨胀的原因包括电极材料充放电过程中的晶格膨胀、电解液对电极的溶胀、因电极加工过程产生的应力在循环过程中的逐渐释放、电极活性材料在循环过程中表面膜的生长等因素。现有技术的卷绕式方形电池,极片的膨胀被集流体、隔膜所限制,极片的膨胀将导致电池内部产生应力及不均匀的应力分布,从而导致电池结构发生扭曲变形。本实用新型的技术在卷绕结构的转角处涂布层较薄,可以缓解应力的不均匀分布;同时当转角区域较薄或不涂布电极层时,转角区域空间较大,可使电池膨胀类似于叠片电池的膨胀方式,即整体在厚度方向膨胀而不是局部扭曲,因此可减轻电池的变形情况。

[0056] 根据上述说明书的揭示和教导,本实用新型所属领域的技术人员还可以对上述实施方式进行变更和修改。因此,本实用新型并不局限于上面揭示和描述的具体实施方式,对本实用新型的一些修改和变更也应当落入本实用新型的权利要求的保护范围内。此外,尽管本说明书中使用了一些特定的术语,但这些术语只是为了方便说明,并不对本实用新型构成任何限制。

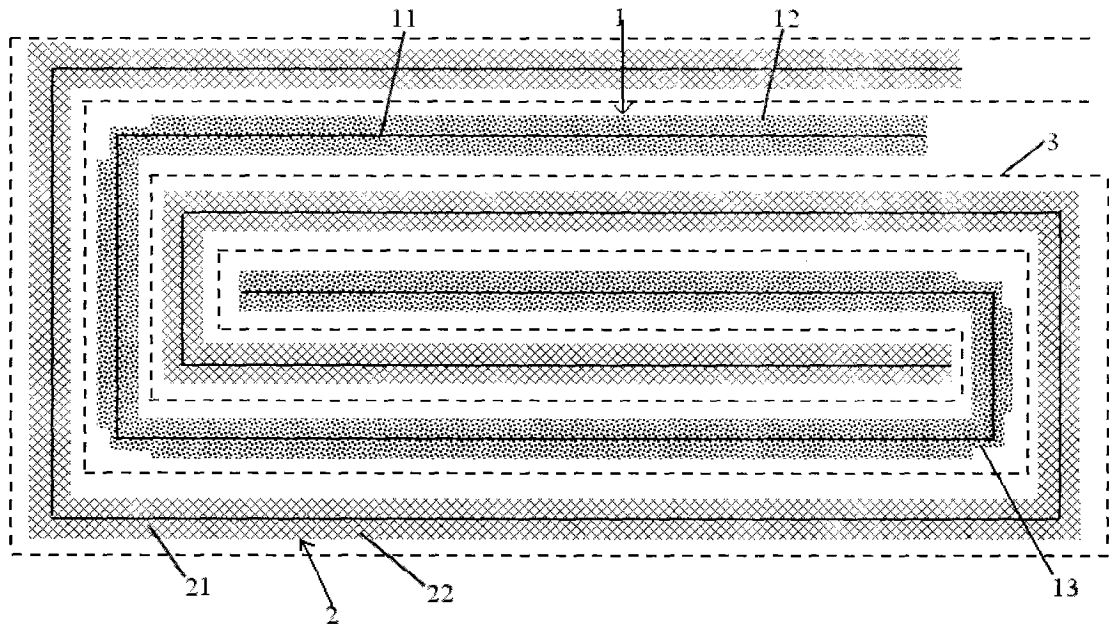


图 1

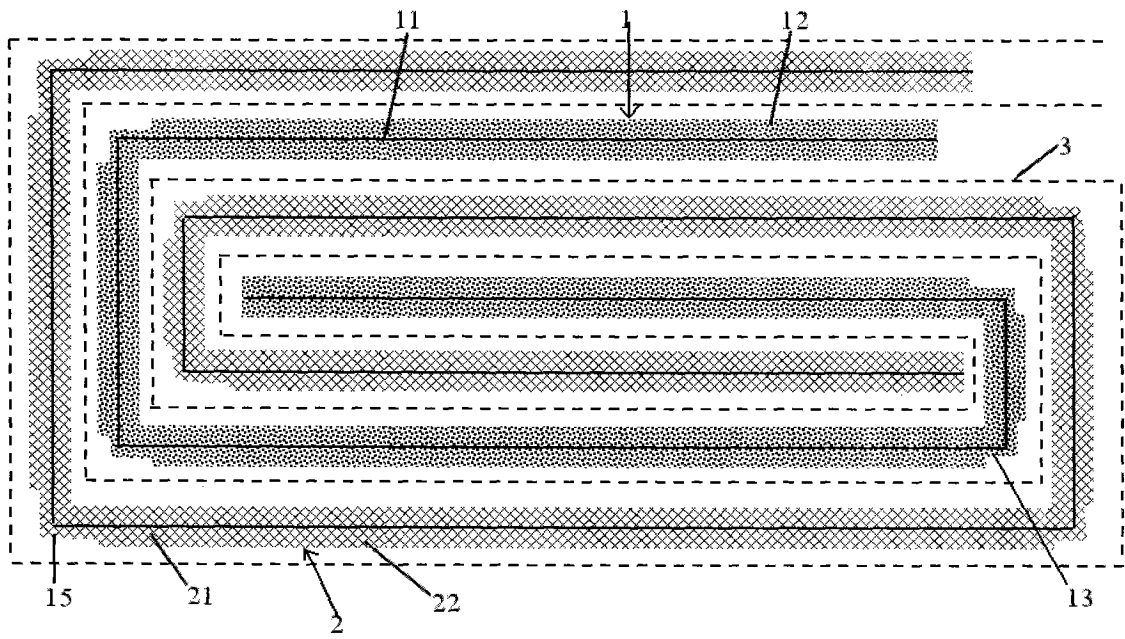


图 2

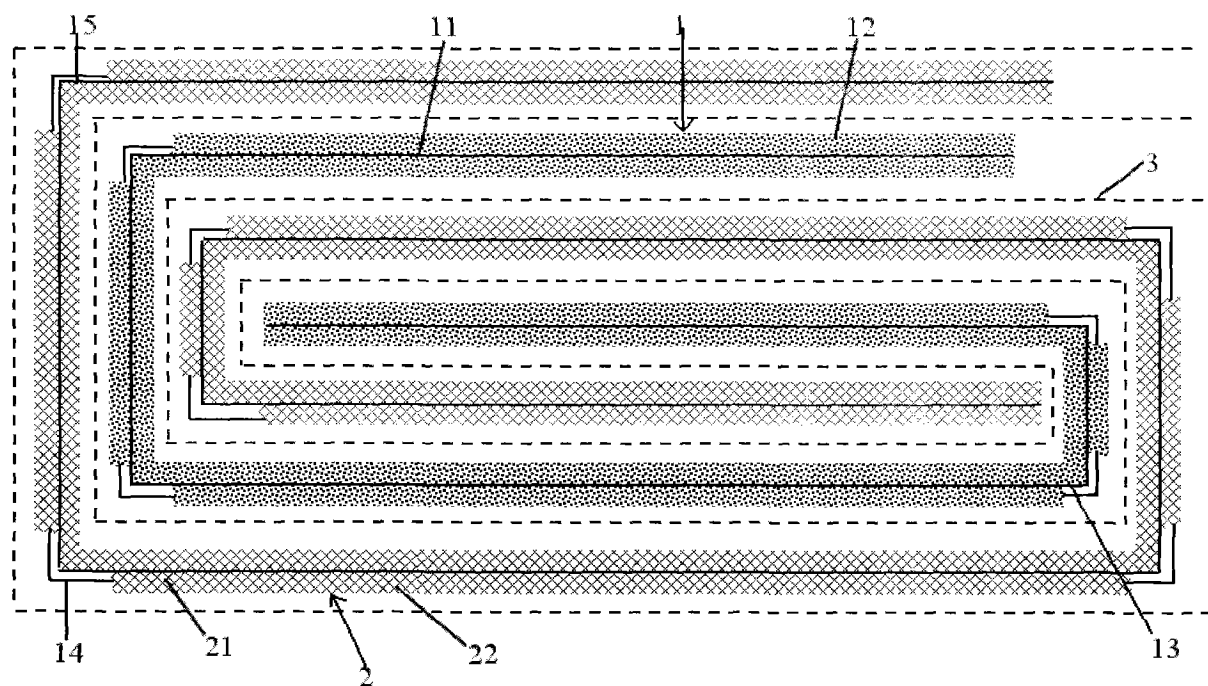


图 3