PTO/AIA/15 (10-17)
Approved for use through 11/30/2020. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995 no persons are required to respond to a collection of information unless it displays a valid OMB control number.

UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.	U 020968-8
First Named Inventor	Xiaojing Liu
Title	ELECTROCHEMICAL APPARATUS AND ELECTRONIC APPARATUS CONTAINING
Priority Mail Express® Label No.	

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

1. [✔] **Fee Transmittal Form** (PTO/SB/17 or equivalent)
2. [ ] **Applicant asserts small entity status.** See 37 CFR 1.27
3. [ ] **Applicant certifies micro entity status.** See 37 CFR 1.29. Applicant must attach form PTO/SB/15A or B or equivalent.
4. [✔] **Specification** [*Total Pages* 30] Both the claims and abstract must start on a new page. *(See MPEP § 608.01(a) for information on the preferred arrangement)*
5. [✔] **Drawing(s)** (35 U.S.C. 113) [*Total Sheets* 5]
6. **Inventor's Oath or Declaration** [*Total Pages* 1] *(including substitute statements under 37 CFR 1.64 and assignments serving as an oath or declaration under 37 CFR 1.63(e))*
   a. [✔] Newly executed (original or copy)
   b. [ ] A copy from a prior application (37 CFR 1.63(d))
7. [✔] **Application Data Sheet** ** See note below.* See 37 CFR 1.76 (PTO/AIA/14 or equivalent)
8. **CD-ROM or CD-R** in duplicate, large table, or Computer Program (*Appendix*)
   [ ] Landscape Table on CD
9. **Nucleotide and/or Amino Acid Sequence Submission** (*if applicable, items a. – c. are required*)
   a. [ ] Computer Readable Form (CRF)
   b. [ ] Specification Sequence Listing on:
      i. [ ] CD-ROM or CD-R (2 copies); or
      ii. [ ] Paper
   c. [ ] Statements verifying identity of above copies

ADDRESS TO: **Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450**

ACCOMPANYING APPLICATION PAPERS

10. [ ] **Assignment Papers** (cover sheet & document(s)) Name of Assignee _____
11. [ ] **37 CFR 3.73(c) Statement** (*when there is an assignee*) [✔] **Power of Attorney**
12. [ ] **English Translation Document** (*if applicable*)
13. [✔] **Information Disclosure Statement** (PTO/SB/08 or PTO-1449)
    [✔] Copies of citations attached
14. [ ] **Preliminary Amendment**
15. [ ] **Return Receipt Postcard** (*MPEP § 503*) (*Should be specifically itemized*)
16. [ ] **Certified Copy of Priority Document(s)** (*if foreign priority is claimed*)
17. [ ] **Nonpublication Request** Under 35 U.S.C. 122(b)(2)(B)(i). Applicant must attach form PTO/SB/35 or equivalent.
18. [ ] **Other:** _____

*Note: (1) Benefit claims under 37 CFR 1.78 and foreign priority claims under 1.55 **must** be included in an Application Data Sheet (ADS).
(2) For applications filed under 35 U.S.C. 111, the application must contain an ADS specifying the applicant if the applicant is an assignee, person to whom the inventor is under an obligation to assign, or person who otherwise shows sufficient proprietary interest in the matter. See 37 CFR 1.46(b).

19. CORRESPONDENCE ADDRESS

[✔] The address associated with Customer Number: 00140 **OR** [ ] Correspondence address below

Name					
Address					
City		State		Zip Code	
Country		Telephone		Email	

Signature	/Shiming Wu/	Date	2022-03-21
Name (Print/Type)	Shiming Wu	Registration No. (Attorney/Agent)	56,885

This collection of information is required by 37 CFR 1.53(b). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Zhuhai CosMX Battery Co. EX1002 (1 of 4)
Zhuhai CosMX Battery Co. v. Ningde Amperex Tech. Ltd.

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

PTO/SB/17 (10-20)
Approved for use through 12/31/2020. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995 no persons are required to respond to a collection of information unless it displays a valid OMB control number

FEE TRANSMITTAL

Complete if known	
Application Number	
Filing Date	
First Named Inventor	Xiaojing Liu
Examiner Name	
Art Unit	
Practitioner Docket No.	U 020968-8

☐ Applicant asserts small entity status. See 37 CFR 1.27.

☐ Applicant certifies micro entity status. See 37 CFR 1.29. Form PTO/SB/15A or B or equivalent must either be enclosed or have been submitted previously.

TOTAL AMOUNT OF PAYMENT ($) 1820

METHOD OF PAYMENT (check all that apply)

☐ Check ☐ Credit Card ☐ Money Order ☐ None ☐ Other (please identify): _____

☒ Deposit Account Deposit Account Number: 12-0425 Deposit Account Name: Ladas & Parry LLC

For the above-identified deposit account, the Director is hereby authorized to (check all that apply):

☒ Charge fee(s) indicated below ☐ Charge fee(s) indicated below, **except for the filing fee**

☒ Charge any additional fee(s) or underpayment of fee(s) under 37 CFR 1.16 and 1.17 ☒ Credit any overpayment of fee(s)

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

FEE CALCULATION

1. BASIC FILING, SEARCH, AND EXAMINATION FEES (U = undiscounted fee; S = small entity fee; M = micro entity fee)

	FILING FEES			SEARCH FEES			EXAMINATION FEES			
Application Type	**U ($)**	**S ($)**	**M ($)**	**U ($)**	**S ($)**	**M ($)**	**U ($)**	**S ($)**	**M ($)**	**Fees Paid ($)**
Utility	320	160*	80	700	350	175	800	400	200	1820
Design	220	110	55	160	80	40	640	320	160	
Plant	220	110	55	440	220	110	660	330	165	
Reissue	320	160	80	700	350	175	2,320	1,160	580	
Provisional	300	150	75	0	0	0	0	0	0	

* The $160 small entity status filing fee for a utility application is further reduced to $80 for a small entity status applicant who files the application via EFS-Web.

2. EXCESS CLAIM FEES

Fee Description	**Undiscounted Fee ($)**	**Small Entity Fee ($)**	**Micro Entity Fee ($)**
Each claim over 20 (including Reissues)	100	50	25
Each independent claim over 3 (including Reissues)	480	240	120
Multiple dependent claims	860	430	215

Total Claims		**Extra Claims**	**Fee ($)**		**Fee Paid ($)**
14	-20 or HP =	_____	x _____	=	_____

HP = highest number of total claims paid for, if greater than 20.

Indep. Claims		**Extra Claims**	**Fee ($)**		**Fee Paid ($)**
2	-3 or HP =	_____	x _____	=	_____

HP = highest number of independent claims paid for, if greater than 3.

Multiple Dependent Claims	
Fee ($)	**Fee Paid ($)**
_____	_____

3. APPLICATION SIZE FEE

If the specification and drawings exceed 100 sheets of paper (excluding electronically filed sequence or computer listings under 37 CFR 1.52(e)), the application size fee due is $420 ($210 for small entity) ($105 for micro entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).

Total Sheets		**Extra Sheets**		**Number of each additional 50 or fraction thereof**	**Fee ($)**		**Fee Paid ($)**
_____	- 100 =	_____	/ 50 =	_____ (round **up** to a whole number)	x _____	=	_____

4. OTHER FEE(S) **Fees Paid ($)**

Non-English specification, $140 fee ($70 for small entity) ($35 for micro entity) _____

Non-electronic filing fee under 37 CFR 1.16(t) for a utility application, $400 fee ($200 small or micro entity) _____

Other (e.g., late filing surcharge): _____ _____

SUBMITTED BY

Signature	/Shiming Wu/	Registration No. (Attorney/Agent) 56,885	Telephone 212-708-1800
Name (Print/Type)	Shiming Wu		Date 2022-03-21

This collection of information is required by 37 CFR 1.136. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

PTO/AIA/14 (02-18)
Approved for use through 11/30/2020. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	U 020968-8
	Application Number	
Title of Invention	ELECTROCHEMICAL APPARATUS AND ELECTRONIC APPARATUS CONTAINING THE ELECTROCHEMICAL APPARATUS	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2:

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 — Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Xiaojing		Liu	

Residence Information (Select One) US Residency ● Non US Residency Active US Military Service

City	Ningde	Country of Residence i	CN

Mailing Address of Inventor:

Address 1	No.1 Xingang Road
Address 2	Zhangwan Town, Jiaocheng District
City	Ningde City, Fujian Province
State/Province	
Postal Code	352100
Country i	CN

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	00140		
Email Address	nymail@ladas.com	Add Email	Remove Email

Application Information:

Title of the Invention	ELECTROCHEMICAL APPARATUS AND ELECTRONIC APPARATUS CONTAINING THE ELECTROCHEMICAL APPARATUS		
Attorney Docket Number	U 020968-8	**Small Entity Status Claimed**	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	5	**Suggested Figure for Publication (if any)**	

PTO/AIA/14 (02-18)
Approved for use through 11/30/2020. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	U 020968-8
	Application Number	
Title of Invention	ELECTROCHEMICAL APPARATUS AND ELECTRONIC APPARATUS CONTAINING THE ELECTROCHEMICAL APPARATUS	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	● Customer Number	US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	00140		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
	Continuation of	PCT/CN2020/087515	2020-04-28

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	U 020968-8
	Application Number	
Title of Invention	ELECTROCHEMICAL APPARATUS AND ELECTRONIC APPARATUS CONTAINING THE ELECTROCHEMICAL APPARATUS	

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button. Add

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	U 020968-8
	Application Number	
Title of Invention	ELECTROCHEMICAL APPARATUS AND ELECTRONIC APPARATUS CONTAINING THE ELECTROCHEMICAL APPARATUS	

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

PTO/AIA/14 (02-18)
Approved for use through 11/30/2020. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	U 020968-8
	Application Number	
Title of Invention	ELECTROCHEMICAL APPARATUS AND ELECTRONIC APPARATUS CONTAINING THE ELECTROCHEMICAL APPARATUS	

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1 — Remove

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

● Assignee	Legal Representative under 35 U.S.C. 117	Joint Inventor
Person to whom the inventor is obligated to assign.	Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

Organization Name	Ningde Amperex Technology Limited		
Mailing Address Information For Applicant:			
Address 1	No. 1 Xingang Road		
Address 2	Zhangwan Town, Jiaocheng Disctrict		
City	Ningde City, Fujian Province	**State/Province**	
Country	CN	Postal Code	352100
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button. Add

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	U 020968-8
	Application Number	
Title of Invention	ELECTROCHEMICAL APPARATUS AND ELECTRONIC APPARATUS CONTAINING THE ELECTROCHEMICAL APPARATUS	

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

Remove

If the Assignee or Non-Applicant Assignee is an Organization check here. ☒

Organization Name	Ningde Amperex Technology Limited

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1	No. 1 Xingang Road		
Address 2	Zhangwan Town, Jiaocheng District		
City	Ningde City, Fujian Province	**State/Province**	
Country i	CN	Postal Code	352100
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button. Add

Signature:

Remove

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Shiming Wu/			Date (YYYY-MM-DD)	2022-03-21
First Name	Shiming	Last Name	Wu	Registration Number	56,885

Additional Signature may be generated within this form by selecting the Add button. Add

PTO/AIA/14 (02-18)
Approved for use through 11/30/2020. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	U 020968-8
	Application Number	
Title of Invention	ELECTROCHEMICAL APPARATUS AND ELECTRONIC APPARATUS CONTAINING THE ELECTROCHEMICAL APPARATUS	

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1 The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3 A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent CooperationTreaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

ELECTROCHEMICAL APPARATUS AND ELECTRONIC APPARATUS CONTAINING THE ELECTROCHEMICAL APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of International Patent Application No. PCT/CN2020/087515, filed on April 28, 2020, the disclosure of which is hereby incorporated by reference in its entirety.

TECHNICAL FIELD

[0002] This application relates to the field of energy storage technologies, and in particular, to a negative electrode structure and an electrochemical apparatus and an electronic apparatus containing the negative electrode structure.

BACKGROUND

[0003] With the rapid development of mobile electronic technologies, people are using mobile electronic apparatuses such as mobile phones, tablet computers, notebook computers, and unmanned aerial vehicles more and more frequently with increasingly higher requirements. Therefore, an electrochemical apparatus (for example, a lithium-ion battery) that provides energy for the electronic apparatuses need to have higher energy density, large rate, higher safety, and less capacity attenuation after repeated charging and discharging processes.

[0004] The energy density and cycle efficiency of the electrochemical apparatuses are closely related to negative electrode materials thereof. At present, since a silicon-based material of at least one of a silicon-based elementary substance, a silicon-based alloy or a compound thereof has a high theoretical gram capacity, silicon-based materials in place of existing graphite materials are being widely studied. However, a silicon-based material itself has the problems of too low electrical conductivity and too high high-temperature expansion rate. Therefore, it is necessary to make further improvement and optimization on the structure of a negative electrode made of a negative electrode material containing the silicon-based material.

SUMMARY

[0005] This application provides an electrochemical apparatus and an electronic apparatus including the electrochemical apparatus in an attempt to solve, at least to some extent, at least one problem existing in the related art.

[0006] According to one aspect of this application, this application provides an electrochemical apparatus, including: a positive electrode, a separator, and a negative electrode. The negative electrode includes: a negative current collector, a negative active material layer, and a negative tab. The negative active material layer contains a silicon-based material, the negative tab is arranged on a side edge of a long axis of the negative current collector and is in contact with the negative active material layer, the negative tab is arranged on the side edge of the long axis of the negative current collector, a distance between a central position of the negative tab and either end of the negative active material layer in a long axis direction is a first length, a length of a long axis of the negative active material layer is a second length, and the negative electrode satisfies the following relationship formula (I):

$$0.5 \geq D \geq 0.6 \times G \qquad \text{formula (I)}$$

where D is a ratio of the first length to the second length, G is a weight percentage of the silicon-based material, and the weight percentage of the silicon-based material is less than or equal to 70%.

[0007] The electrochemical apparatus of this application uses the negative tab satisfying the above configuration, which can effectively reduce the impedance of the negative electrode and control the temperature rise of a battery cell, thereby reducing the cycling expansion rate of the electrochemical apparatus and improving the cycle performance thereof.

[0008] According to another aspect of this application, this application provides an electronic apparatus, and the electronic apparatus includes the foregoing electrochemical apparatus.

[0009] Additional aspects and advantages of the embodiments of the application are partially described and presented in the later description, or explained by implementation of the embodiments of the application.

BRIEF DESCRIPTION OF DRAWINGS

[0010] The following briefly illustrates the accompanying drawings for describing the embodiments of this application or necessary to the prior art so as to describe the embodiments of this application. Apparently, the accompanying drawings in the following description show merely some embodiments of this application. A person skilled in the art may still derive drawings of other embodiments according to the structures shown in these accompanying drawings without creative efforts.

[0011] FIG. 1 is a cross-sectional view of a negative electrode structure according to the prior art.

[0012] FIG. 2 is a top view of a negative electrode structure according to the prior art.

[0013] FIG. 3 is a schematic diagram of a winding cell structure according to the prior art.

[0014] FIG. 4 is a cross-sectional view of a negative electrode structure according to an embodiment of this application.

[0015] FIG. 5 is a top view of a negative electrode structure according to an embodiment of this application.

[0016] FIG. 6 is a schematic diagram of a winding cell structure according to an embodiment of this application.

[0017] FIG. 7 is a schematic diagram of current distribution when a negative tab is arranged at either end of a long axis of the negative electrode.

[0018] FIG. 8 is a schematic diagram of current distribution when a negative tab is arranged at a middle portion of the long axis of the negative electrode.

[0019] FIG. 9 is a three-dimensional curve chart of the arrangement position of negative tab, silicon-based material content in a negative active material layer, and battery cell temperature rise according to the embodiments of this application.

DETAILED DESCRIPTION

[0020] Embodiments of this application will be described in detail below. In the full specification of this application, identical or similar components, as well as components having identical or similar functions, are denoted by like reference numerals. The embodiments described herein with respect to the accompanying drawings are

illustrative and graphical, and are used to provide a basic understanding of this application. The embodiments of this application shall not be construed as a limitation on this application.

[0021] The terms "roughly", "generally", "substantially" and "approximately" used herein are intended to describe and represent small variations. When used in combination with an event or a circumstance, the term may refer to an example in which the exact event or circumstance occurs or an example in which an extremely similar event or circumstance occurs. For example, when used in combination with a value, the term may refer to a variation range of less than or equal to ± 10% of the value, for example, less than or equal to ± 5%, less than or equal to ± 4%, less than or equal to ± 3%, less than or equal to ± 2%, less than or equal to ± 1%, less than or equal to ± 0.5%, less than or equal to ± 0.1%, or less than or equal to ± 0.05%. For example, if the difference between two values is less than or equal to ± 10% of an average value of the values (for example, less than or equal to ± 5%, less than or equal to ± 4%, less than or equal to ± 3%, less than or equal to ± 2%, less than or equal to ± 1%, less than or equal to ± 0.5%, less than or equal to ± 0.1%, or less than or equal to ± 0.05%), the two values may then be considered to be "generally" identical.

[0022] In this specification, unless specified or limited otherwise, the terms of relativity, such as "central", "longitudinal", "lateral", "front", "rear", "right", "left", "inner", "outer", "relatively low", "relatively high", "horizontal", "vertical", "higher than", "lower than", "upper", "lower", "top", "bottom" and derivative terms thereof (for example, "horizontally", "downward", "upward", etc.), shall be construed as referring to the directions described in discussion or shown in the drawings. These terms of relativity are merely used for descriptive convenience, and do not require the construction or operation of this application in a particular direction.

[0023] In addition, quantities, ratios, and other values are sometimes presented in the format of ranges in this specification. It should be understood that such range formats are used for convenience and simplicity and should be flexibly understood as including not only values clearly designated as falling within the range but also all individual values or sub-ranges covered by the range as if each value and sub-range were clearly designated.

[0024] In the description of embodiments and claims, a list of items preceded by the terms such as "at least one of", "at least one type of" or other similar terms may

mean any combination of the listed items. For example, if items A and B are listed, the phrase "at least one of A and B" means only A, only B, or A and B. In another embodiment, if items A, B, and C are listed, the phrase "at least one of A, B, and C" means only A, only B, only C, A and B (excluding C), A and C (excluding B), B and C (excluding A), or all of A, B, and C. The item A may contain one element or a plurality of elements. The item B may contain one element or a plurality of elements. The item C may contain one element or a plurality of elements.

[0025] A silicon-based material itself has a semiconductor property. Since the powder conductivity of the silicon-based material is much smaller than that of the existing graphite material, the impedance of a negative electrode material including the silicon-based material, regardless of electrons or ions, is large. In the charging and discharging cycle process, especially under the high-rate charging and discharging condition, the internal impedance of a battery cell containing the silicon-based material is high, so that energy consumption for heat generation of the battery cell is increased, and the temperature rise of the battery cell is very obvious, which causes the degradation of electrochemical performance such as accelerated attenuation of cyclic capacity and reduction of discharge rate, and may also cause thermal runaway of an electrochemical apparatus to lead to potential safety hazards.

[0026] FIG. 1 and FIG. 2 show a cross-sectional view and a top view of a commercially common negative electrode structure in the prior art. FIG. 3 shows a schematic diagram of a battery cell of a winding structure in the prior art.

[0027] As shown in FIG. 1 and FIG. 2, a negative active material layer 102 in the prior art is arranged on a surface of a negative current collector 101, empty foil regions without the negative active material layer 102 are at two ends of the negative current collector 101 in a length direction, and a negative tab 103 is arranged in an uncoated region at one end of the negative current collector. A winding structure after a negative electrode, a positive electrode and a separator 107 are wound to form a battery cell is shown in FIG. 3. In the prior art, the negative tab 103 is arranged in an empty foil region at one end of the negative current collector 101, and a positive tab 106 is arranged in an empty foil region without a positive active material layer 105 at one end of the positive current collector 104, which can ensure that the negative tab 103 and the positive tab 106 are located in the middle of the battery cell during coiling. This design can effectively improve the machinability when an electrochemical apparatus is

prepared, and the manufacturing cost is low. However, when a negative active material (for example, a silicon-based material) having a high gram capacity is used, if the silicon-based material content of the negative active material is higher, the conductivity of the negative material layer is lower, resulting in an increase in the internal impedance of the negative electrode and a rise in the heat generating power, thereby reducing the cycle performance of the electrochemical apparatus and causing safety hazard of overheating runaway. In addition, the empty foil regions provided on the positive electrode and the negative electrode reduce the energy density of the electrochemical apparatus.

[0028] According to one aspect of this application, this application limits the position of the negative tab and the content of the silicon-based material to reduce the impedance in the negative active material layer, and improves the current density of each part in the negative electrode to reduce the thermal power generated by the internal resistance of the negative electrode during the charging and discharging cycle, thereby improving the cycle performance and safety performance of the electrochemical apparatus.

[0029] FIG. 4 and FIG. 5 show a cross-sectional view and a top view of a negative electrode structure according to some embodiments of this application.

[0030] As shown in FIG. 4 and FIG. 5, this application provides a negative electrode, including: a negative current collector 201, a negative active material layer 202, and a negative tab 203. The negative tab 203 is arranged on a side edge of a long axis of the negative current collector 201 and is in contact with the negative active material layer 202. The negative active material layer 202 contains a silicon-based material, a distance between a central position of the negative tab 203 and either end of the negative active material layer 202 in a long axis direction is a first length 204, and a length of a long axis of the negative active material layer is a second length 205. The negative electrode conforms to the following relationship formula (I):

$$0.5 \geq D \geq 0.6 \times G \qquad \text{formula (I).}$$

[0031] D is a ratio of the first length 204 to the second length 205, G is a weight percentage of the silicon-based material in the negative active material layer 202, and the weight percentage G of the silicon-based material is less than or equal to 70%.

[0032] An electrochemical apparatus having the negative electrode in accordance with the above relationship formula (I) enables the raising temperature caused by the

charging and discharging cycle process during operation to be lower than 15°C. Compared with the prior art, the negative electrode of this application has the advantages that in the charging and discharging cycle process, the conduction distance that a part of current passes through the negative active material layer can be effectively shortened, thereby reducing the internal impedance of the negative electrode itself and the current density of a pole piece region around the negative tab, and reducing the polarization of a battery cell of the negative electrode. In some other embodiments, when the weight percentage G of the silicon-based material is more than 70%, the raising temperature of the electrochemical apparatus caused by the charging and discharging cycle process during operation can still be reduced by putting the central position of the negative tab 203 in the center of the negative active material layer 202 (that is, when the ratio D of the first length 204 to the second length 205 is 0.5).

[0033] In some embodiments, as shown in FIG. 4, the negative electrode accords with the following relationship formula (II):

$$0.9\times(S_1+2S_3)\leq S_1+S_2\leq 1.1\times(S_1+2S_3) \quad \text{formula (II).}$$

[0034] The thickness of the negative current collector 201 is S_1, the thickness of the negative tab 203 is S_2, and the thickness of the negative active material layer 202 is S_3. Through the above configuration, the thickness of a negative pole piece can be more uniform. When the negative pole piece is wound or stacked to form a battery cell, defects such as bulges or depressions caused by uneven thickness of the pole piece can be avoided, and the structural stability of the battery cell in the cycle process can be improved, thereby improving the safety performance and the cycle performance of the electrochemical apparatus.

[0035] In some embodiments, as shown in FIG. 5, the negative active material layer 202 further includes a groove 206, the groove 206 is defined by the negative active material layer 202 and exposes a part of the negative current collector 201, and the negative tab 203 is arranged in the groove. In some other embodiments, an insulating material and/or a bonding material can be arranged in the groove and surround the negative tab 203 to avoid a short circuit caused by the contact between the negative tab and the positive active material layer or the positive tab. It should be understood that the insulating material and the bonding material may be any suitable material common in the art.

[0036] FIG. 7 and FIG. 8 are schematic diagrams of current distribution when the

negative tab is arranged at either end and a middle portion of the long axis of the negative electrode, respectively.

[0037] An ohmic heat Q when current passes through the current collector and a corresponding resistance value R can be calculated for each portion of the negative current collector through the following formulas:

$$Q_i = I_i^2 * R_i * t,$$

$$R_i = \rho * dx/A,$$

where Q_i is a current thermal power of each portion of the negative current collector, R_i is an impedance of each portion of the negative current collector, t is a current circulation time, ρ is a resistivity of the negative current collector, dx is a length of each portion of the negative current collector, and A is a cross-sectional area of the negative current collector. As shown in FIG. 7, when the negative tab is arranged near one end of the current collector, the partial current exported at the portion X_n farthest from the negative tab needs to pass through the portions X_1 to X_n of the negative current collector, and the current exported from the portion X_3 needs to pass through the portions X_1 to X_3 of the negative current collector. When the external discharge current is I and the reaction current of each section is Ia, the current passing through the portion X_1 of the negative current collector is n * Ia, the current passing through the portion X_2 of the negative current collector is (n-1) Ia, the current passing through the portion X_3 of the negative current collector is (n-2) Ia, and the current passing through the portion X_n of the negative current collector is Ia.

[0038] As shown in FIG. 8, when the negative tab is arranged at the middle portion of the negative current collector, the partial current exported at the portion $X_{n/2}$ farthest from the negative tab only needs to pass through the portions X_1 to $X_{n/2}$, and the partial current exported at the other end portion $X_{n/2}'$ also only needs to pass through the portions X_1' to $X_{n/2}'$. Under the same intensity of the discharge current, the negative electrode structure of this application can effectively reduce the intensity of current passing through the negative current collector in the discharge process, thereby reducing the internal impedance of the negative electrode, reducing the overheating temperature rise condition of the negative electrode, and avoiding thermal expansion of the silicon-based material in the negative electrode material.

[0039] In some embodiments, the negative current collector 201 may be a copper foil or a nickel foil. However, other negative current collectors commonly used in the

art may be used without limitations.

[0040] In some embodiments, the thickness of the negative current collector 201 is about 4 μm to 30 μm. In some other embodiments, the thickness of the negative current collector 201 is approximately, for example, about 4.0 μm, about 5.0 μm, about 10.0 μm, about 15.0 μm, about 20.0 μm, about 25.0 μm, or about 30.0 μm, or in a range defined by any two of these values.

[0041] The negative active material layer 202 further includes, in addition to the silicon-based material, a negative electrode material capable of absorbing and releasing lithium (Li) (sometimes referred to as a "negative electrode material capable of absorbing/releasing lithium Li" below). Examples of the material capable of absorbing/releasing lithium (Li) may include a carbon material, a metal compound, an oxide, a sulfide, a nitride of lithium such as LiN3, a lithium metal, a metal alloyed with lithium, and a polymer material. In some embodiments, the silicon-based material contains at least one of an elementary substance of silicon, a compound of silicon, an alloy of silicon, and a silica material. In some embodiments, the silica material is a silicon oxide represented by a general formula SiO_x, where x is about 0.5 to about 1.5, and the silica material includes a crystalline state, an amorphous state, or a combination thereof.

[0042] In some embodiments, the silicon-based material further contains a material layer, the material layer is arranged on at least part of the surface of the silicon-based material, and the material layer contains at least one of a polymer, inorganic particles, amorphous carbon or carbon nano-tubes.

[0043] In some embodiments, the inorganic particles include at least one of lithium cobaltate, lithium iron phosphate, lithium nickel cobalt manganate, lithium nickel cobalt aluminate, an elementary substance of silicon, a compound of silicon, an alloy of silicon and a silica material, and the polymer contains at least one of polyvinylidene fluoride, polyacrylic acid, polyvinyl chloride, carboxymethyl cellulose, polyethylene, polypropylene, polyethylene terephthalate, polyimide and aramid.

[0044] In some embodiments, based on a total weight of the negative active material layer, the weight percentage G of the silicon-based material in the negative active material layer is more than about 0% and less than or equal to about 70%. In some other embodiments, the weight percentage G of the silicon-based material in the negative active material layer is approximately, for example, about 0%, about 10%,

about 20%, about 30%, about 50%, or about 70%, or in a range defined by any two of these values.

[0045] In some embodiments, the ratio of the length of the long axis of the negative active material layer to the length of the long axis of the negative current collector is about 0.8 to about 1.0. In some other embodiments, the ratio of the length of the long axis of the negative active material layer to the length of the long axis of the negative current collector is about 0.9 to about 0.95. By eliminating the areas of free regions of the negative active material layer at the two ends of the negative current collector and the area of an empty foil at the negative tab, the utilization rate of the negative current collector can be effectively increased, and the energy density of the electrochemical apparatus can be further improved.

[0046] According to another aspect of this application, this application provides an electrochemical apparatus including the negative electrode of this application. In some embodiments, the electrochemical apparatus is a lithium-ion battery. The lithium-ion battery includes a positive electrode, a separator, and the negative electrode of the foregoing embodiment. The separator is arranged between the positive electrode and the negative electrode.

[0047] FIG. 6 shows a schematic diagram of a battery cell of a winding structure of an electrochemical apparatus according to some embodiments of this application.

[0048] As shown in FIG. 6, in some embodiments, the electrochemical apparatus is of a winding structure in which the positive electrode, the negative electrode, and the separator are sequentially stacked and wound, the negative electrode includes a negative current collector 201, a negative active material layer 202 and a negative tab 203, and the negative tab 203 is arranged at a position beyond three layers from the center of the winding structure.

[0049] In some embodiments, a positive tab 209 of the positive electrode is arranged at a position one layer inward or outward from the position of the negative tab 203 with respect to the center of the winding structure. The risk of a short circuit between the positive tab 209 and the negative tab 203 can be reduced by arranging the positive tab 209 and the negative tab 203 one layer apart outward.

[0050] In some embodiments, the negative tab of this application is arranged on the negative current collector by welding the negative tab to an arrangement position of the negative current collector. The arrangement position is formed by ultrasonically

cleaning the negative active material layer, which avoids the problem of watermarks when a positive electrode and a negative electrode of a commercial electrochemical apparatus are coated with positive and negative active material layers. In addition, a welding distance between the arrangement position of the negative current collector and the negative tab can be reduced, which helps to further reduce the impedance at the negative tab.

[0051] In some embodiments, as shown in FIG. 6, the negative active material layer 202 and a positive active material layer 208 further include a groove 206, the groove 206 is defined by the negative active material layer 202 or the positive active material layer 208 and exposes a part of the negative current collector 201 or a positive current collector 207, and the groove is arranged around the negative tab 203 or the positive tab 209. In some other embodiments, the groove 206 can be further provided in a region 206' of the positive material layer or the negative material layer corresponding to the negative tab 203 or the positive tab 209. In some other embodiments, an insulating material and/or a bonding material can be arranged in the groove 206 and fill the groove. It should be understood that the insulating material and the bonding material may be any suitable material common in the art. Through the groove, the insulating material and the bonding material, the risk of short circuit of the cell structure can be further reduced.

[0052] In some embodiments, the positive electrode further includes a positive current collector 207 and a positive active material layer 208.

[0053] In some embodiments, the positive current collector 207 may be an aluminum foil or a nickel foil. However, other materials commonly used in the art may be used as the positive current collector without being limited thereto.

[0054] The positive active material layer 208 contains a positive electrode material capable of absorbing and releasing lithium (Li) (sometimes referred to as a "positive electrode material capable of absorbing/releasing lithium Li" below). In some embodiments, the positive electrode material capable of absorbing/releasing lithium (Li) may include one or more of lithium cobaltate, lithium nickel cobalt manganate, lithium nickel cobalt aluminate, lithium manganate, lithium manganese iron phosphate, lithium vanadium phosphate, lithium vanadium phosphate, lithium iron phosphate, lithium titanate, and lithium-rich manganese-based materials.

[0055] In the above-mentioned positive electrode material, the chemical formula of

the lithium cobaltate may be $Li_yCo_aM1_bO_{2-c}$, where M1 represents at least one selected from nickel (Ni), manganese (Mn), magnesium (Mg), aluminum (Al), boron (B), titanium (Ti), vanadium (V), chromium (Cr), iron (Fe), copper (Cu), zinc (Zn), molybdenum (Mo), stannum (Sn), calcium (Ca), strontium (Sr), tungsten (W), yttrium (Y), lanthanum (La), zirconium (Zr) and silicon (Si), and the values of y, a, b and c are respectively in the following ranges: $0.8 \leq y \leq 1.2$, $0.8 \leq a \leq 1$, $0 \leq b \leq 0.2$, and $-0.1 \leq c \leq 0.2$.

[0056] In the above-mentioned positive electrode material, the chemical formula of the lithium nickel cobalt manganate or lithium nickel cobalt aluminate may be $Li_zNi_dM2_eO_{2-f}$, where M2 represents at least one selected from cobalt (Co), manganese (Mn), magnesium (Mg), aluminum (Al). boron (B), titanium (Ti), vanadium (V), chromium (Cr), iron (Fe), copper (Cu), zinc (Zn), molybdenum (Mo), stannum (Sn), calcium (Ca), strontium (Sr), tungsten (W), zirconium (Zr) and silicon (Si), and the values of z, d, e and f are respectively in the following ranges: $0.8 \leq z \leq 1.2$, $0.3 \leq d \leq 0.98$, $0.02 \leq e \leq 0.7$, and $-0.1 \leq f \leq 0.2$.

[0057] In the above-mentioned positive electrode material, the chemical formula of the lithium manganate is $Li_uMn_{2-g}M3_gO_{4-h}$, where M3 represents at least one selected from cobalt (Co), nickel (Ni), magnesium (Mg), aluminum (Al), boron (B), titanium (Ti), vanadium (V), chromium (Cr), iron (Fe), copper (Cu), zinc (Zn), molybdenum (Mo), stannum (Sn), calcium (Ca), strontium (Sr) and tungsten (W), and the values of u, g and h are respectively in the following ranges: $0.8 \leq u \leq 1.2$, $0 \leq g < 1.0$, and $-0.2 \leq h \leq 0.2$.

[0058] In some embodiments, the positive electrode can further include at least one of a binder and a conductive agent. It should be understood that a person skilled in the art would be able to select conventional binders and conductive agents in the art according to actual requirements without being limited thereto.

[0059] In some embodiments, the separator includes, but is not limited to, at least one selected from polyethylene, polypropylene, polyethylene terephthalate, polyimide and aramid. For example, the polyethylene includes at least one component selected from high density polyethylene, low density polyethylene and ultra-high molecular weight polyethylene. In particular, the polyethylene and the polypropylene have a good effect of preventing short circuits, and can improve the stability of the lithium-ion battery by means of a turn-off effect.

[0060] The electrochemical apparatus of this application further includes an electrolyte, the electrolyte may be one or more of a gel electrolyte, a solid electrolyte and an electrolyte solution, and the electrolyte solution includes a lithium salt and a non-aqueous solvent.

[0061] In some embodiments, the lithium salt is selected from one or more of $LiPF_6$, $LiBF_4$, $LiAsF_6$, $LiClO_4$, $LiB(C_6H_5)_4$, $LiCH_3SO_3$, $LiCF_3SO_3$, $LiN(SO_2CF_3)_2$, $LiC(SO_2CF_3)_3$, $LiSiF_6$, LiBOB and lithium difluoroborate. For example, the lithium salt is selected from $LiPF_6$ because it can give a high ionic conductivity and improve the cycle performance.

[0062] The non-aqueous solvent may be a carbonate compound, a carboxylate compound, an ether compound, other organic solvents, or a combination thereof.

[0063] The carbonate compound may be a linear carbonate compound, a cyclic carbonate compound, a fluorocarbonate compound, or a combination thereof.

[0064] Examples of the other organic solvents are dimethylsulfoxide, 1, 2-dioxolane, sulfolane, methylsulfolane, 1, 3-dimethyl-2-imidazolidinone, N-methyl-2-pyrrolidinone, formamide, dimethylformamide, acetonitrile, trimethyl phosphate, triethyl phosphate, trioctyl phosphate, phosphate esters, and combinations thereof.

[0065] In some embodiments, the non-aqueous solvent is selected from a group consisting of ethylene carbonate, propylene carbonate, diethyl carbonate, dimethyl carbonate, methyl ethyl carbonate, propylene carbonate, methyl acetate, ethyl propionate, fluoroethylene carbonate, and a combination thereof.

[0066] It should be understood that methods for preparing the positive electrode, the negative electrode, the separator and the lithium-ion battery in the embodiments of this application may be any suitable conventional methods in the art without departing from the spirit of this application, and are not limited thereto. In one implementation scheme of the method for manufacturing the electrochemical apparatus, the method for preparing the lithium-ion battery includes: the positive electrode, the separator and the negative electrode in the foregoing embodiment are sequentially wound into a battery cell, the battery cell is filled into, for example, an aluminum-plastic film, the electrolyte is injected, and then the processes of vacuum packaging, standing, forming, shaping and the like are performed to obtain the lithium-ion battery.

[0067] The battery cell of the electrochemical apparatus of this application includes not only the winding structure, but also a laminated structure and a folded structure in

some embodiments.

[0068] Although the lithium-ion battery is illustrated above, a person skilled in the art could conceive that the negative electrode of this application may be used in other suitable electrochemical apparatuses after reading this application. Such electrochemical apparatuses include any apparatus in which an electrochemical reaction takes place. Specific embodiments of the apparatus include all kinds of primary batteries, secondary batteries, fuel batteries, solar batteries, or capacitors. Especially, the electrochemical apparatus is a lithium secondary battery, including a lithium metal secondary battery, a lithium-ion secondary battery, a lithium polymer secondary battery, or a lithium-ion polymer secondary battery.

[0069] Some embodiments of this application further provide an electronic apparatus, and the electronic apparatus includes the electrochemical apparatus in the embodiments of this application.

[0070] The electronic apparatus according to the embodiments of this application is not particularly limited, and may be any electronic apparatus known in the prior art. In some embodiments, the electronic apparatus may include, but is not limited to, a notebook computer, a pen-input computer, a mobile computer, an electronic book player, a portable telephone, a portable fax machine, a portable copier, a portable printer, a headset, a video recorder, a liquid crystal television, a portable cleaner, a portable CD player, a mini-disc, a transceiver, an electronic notebook, a calculator, a storage card, a portable recorder, a radio, a standby power source, a motor, an automobile, a motorcycle, a motor bicycle, a bicycle, a lighting appliance, a toy, a game console, a clock, an electric tool, a flash lamp, a camera, a large household battery, and a lithium-ion capacitor.

Examples

[0071] Some examples are listed below, and the electrochemical apparatuses (lithium-ion batteries) therein are respectively subjected to a direct current resistance test, a discharge rate test, a cycle performance test and a cell surface temperature rise test to better describe the technical solution of this application.

[0072] **I. Test methods**

[0073] **1.1 Direct current resistance test:**

[0074] A direct current resistance was calculated by using the following formula,

$R=(U_{0.1C}-U_{1C})/(I_{1C}-I_{0.1C})$, where R was the direct current resistance, I_{1C} was a current of the lithium-ion battery with a discharge rate of 1 C, $I_{0.1C}$ was a current of the lithium-ion battery with a discharge rate of 0.1 C, U_{1C} was a terminal voltage of the lithium-ion battery after discharging for 1 second at the discharge rate of 1 C, and $U_{0.1C}$ was a terminal voltage of the lithium-ion battery after discharging for 10 seconds at the discharge rate of 0.1 C. direct current resistance test process: after the lithium-ion battery of the following examples was fully charged, the lithium-ion battery was discharged for 10 seconds at a constant current of 0.1 C, the current $I_{0.1C}$ and the terminal voltage $U_{0.1C}$ were recorded, then the lithium-ion battery was discharged for 1 second at a constant current of 1 C, and the current I_{1C} and the terminal voltage U_{1C} were recorded. Four lithium-ion batteries in each group were tested, and an average value of the direct current resistances of the lithium-ion batteries was calculated.

[0075] **1.2 Discharge rate test:**

[0076] The lithium-ion battery of the following examples was stood in an incubator of 25°C±2°C for 2 hours, charged to 4.35 V at a constant current of 0.5 C, then charged to 0.05 C at the constant voltage of 4.35 V, stood for 15 minutes, and discharged to 3.0 V at a constant current of 0.2 C. Subsequently, the lithium-ion battery was charged to 4.35 V at the constant current of 0.5 C, then fully charged to 0.05 C at the constant voltage of 4.35 V, and discharged to 3.0 V at the constant current of 1.0 C. The discharge capacities of the lithium-ion battery discharged at the constant currents of 0.2 C and 1.0 C were recorded.

[0077] Four lithium-ion batteries in each group were tested, and an average value of the discharge rates of the lithium-ion batteries was calculated. Discharge rate = discharge capacity of 1.0 C constant current discharge (mAh)/discharge capacity of 0.2 C constant current discharge (mAh).

[0078] **1.3 Cycle performance test:**

[0079] The lithium-ion battery of the following examples was stood in the incubator of 25°C±2°C for 2 hours, charged to 4.35 V at the constant current of 0.5 C, then charged to 0.05 C at the constant voltage of 4.35 V, stood for 15 minutes, and discharged to 3.0 V at the constant current of 0.5 C. This was a charging and discharging cycle process. The discharge capacity of the first cycle of the lithium-ion battery was recorded; the charging and discharging cycle process was repeated multiple times according to the above method, and the discharge capacity after 100 cycles was recorded.

[0080] Four lithium-ion batteries in each group were tested, and an average value of the capacity retention rates of the lithium-ion batteries was calculated. Capacity retention rate of 100 cycles of the lithium-ion battery = discharge capacity at the 100th cycle (mAh)/discharge capacity after the first cycle (mAh) × 100%.

[0081] **1.4 Cell surface temperature rise test:**

[0082] The lithium-ion battery of the following examples was placed in the sealed incubator of 25°C±2°C, and temperatures at four different positions on the cell surface of the lithium-ion battery were monitored. A specific temperature rise test process was: the lithium-ion battery was first discharged to 2.8 V at the constant current of 1.0 C and stood for 30 minutes. Then, the lithium-ion battery was charged to 4.35 V at the constant current of 1.0 C, stood for 5 minutes, and discharged to 2.8 V at the constant current of 1.0 C. This was a charging and discharging cycle process. The charging and discharging cycle process was repeated three times. An average value of cell surface temperature rises of the lithium-ion batteries was calculated.

[0083] **II. Preparation method**

[0084] **2.1 Preparation of a positive electrode**

[0085] Lithium cobaltate, acetylene black and polyvinylidene fluoride in a weight percentage of 94:3:3 were dissolved in an N-methyl pyrrolidone (NMP) solution to form a positive slurry. An aluminum foil was used as a positive current collector, the positive slurry was coated on the positive current collector, and the positive electrode was obtained after drying, cold pressing and cutting.

[0086] **2.2 Preparation of a separator**

[0087] Polyvinylidene fluoride was dissolved in water to form a uniform slurry by mechanical stirring, the slurry was coated on two side surfaces of a porous base material (polyethylene) coated with ceramic coatings on both sides, and the separator was formed after drying.

[0088] **2.3 Preparation of an electrolyte**

[0089] In an environment that the water content was less than 10 ppm, lithium hexafluorophosphate was mixed with non-aqueous organic solvents (ethylene carbonate (EC):diethyl carbonate (DEC):propylene carbonate (PC):propyl propionate (PP):vinylene carbonate (VC) = 20:30:20:28:2, weight percentage) in a weight percentage of 8:92 to form the electrolyte.

[0090] Example 1-1

[0091] Artificial graphite and elementary silicon in a certain weight percentage were uniformly dispersed in deionized water to form a negative slurry. A copper foil was used as a negative current collector having a thickness of 8 μm, 105 mg of the negative slurry was coated on the negative current collector, and a negative tab having a thickness of 80 μm was arranged at one end of the negative current collector in the long axis direction after drying, cold pressing and cutting to obtain a negative electrode. The weight percentage of the elementary silicon in the negative active material layer was 20%. The positive electrode, the separator and the negative electrode were stacked in sequence with the separator located between the positive electrode and the negative electrode to play an isolating role, and then wound into a battery cell with 7 layers (double-sided positive and negative electrodes were counted as one layer). Subsequently, the battery cell was packaged in an aluminum-plastic film packaging bag, and dehydrated at 80°C to obtain a dry cell. Then, the electrolyte was injected into the dry cell, and a lithium-ion battery was obtained by vacuum packaging, standing, forming, shaping and the like.

[0092] Example 1-2

[0093] The preparation method was the same as that in Example 1-1, except that in Example 1-2, the artificial graphite and silicon carbon were mixed and dissolved in deionized water to form a negative slurry, and the weight percentage of the silicon carbon in the negative active material layer was 40%.

[0094] Example 1-3

[0095] The preparation method was the same as that in Example 1-1, except that in Example 1-3, the artificial graphite and silicon carbon were mixed and dissolved in deionized water to form a negative slurry, and the weight percentage of the silicon carbon in the negative active material layer was 50%.

[0096] Example 1-4

[0097] The preparation method was the same as that in Example 1-1, except that in Example 1-4, the artificial graphite and silicon carbon were mixed and dissolved in deionized water to form a negative slurry, and the weight percentage of the silicon carbon in the negative active material layer was 70%.

[0098] Example 1-5

[0099] The preparation method was the same as that in Example 1-1, except that in Example 1-5, the artificial graphite and silicon carbon were mixed and dissolved in

deionized water to form a negative slurry, and the weight percentage of the silicon carbon in the negative active material layer was 90%.

[00100] Examples 2-1 to 2-5

[00101] The preparation method was the same as that in Example 1-1, except that in Examples 2-1 to 2-5, a distance between an arrangement position of the negative tab and the closest end of the negative active material layer in the long axis direction was 0.125 times the length of the long axis of the negative active material layer, and the positive tab was arranged at a position one layer outward from the position of the negative tab with respect to the center of the winding structure. In Examples 2-1 to 2-5, the negative active material included artificial graphite and silicon carbon, and the weight percentages of the silicon carbon in the negative active material layer were 20%, 40%, 50%, 70% and 90%, respectively.

[00102] Examples 3-1 to 3-5

[00103] The preparation method was the same as that in Example 1-1, except that in Examples 3-1 to 3-5, the distance between the arrangement position of the negative tab and the closest end of the negative active material layer in the long axis direction was 0.25 times the length of the long axis of the negative active material layer, and the positive tab was arranged at a position one layer outward from the position of the negative tab with respect to the center of the winding structure. In Examples 3-1 to 3-5, the negative active material included artificial graphite and silicon carbon, and the weight percentages of the silicon carbon in the negative active material layer were 20%, 40%, 50%, 70% and 90%, respectively.

[00104] Examples 4-1 to 4-5

[00105] The preparation method was the same as that in Example 1-1, except that in Examples 4-1 to 4-5, the distance between the arrangement position of the negative tab and the closest end of the negative active material layer in the long axis direction was 0.5 times the length of the long axis of the negative active material layer, and the positive tab is arranged at a position one layer outward from the position of the negative tab with respect to the center of the winding structure. In Examples 4-1 to 4-5, the negative active material included artificial graphite and silicon carbon, and the weight percentages of the silicon carbon in the negative active material layer were 20%, 40%, 50%, 70% and 90%, respectively.

[00106] Examples 5-1 and 5-2

[00107] The preparation method was the same as that in Example 1-1, except that in Examples 5-1 and 5-2, the distances between the arrangement position of the negative tab and the closest end of the negative active material layer in the long axis direction were respectively 0.1 and 0.15 times the length of the long axis of the negative active material layer, the coating thicknesses of the negative active material layer coated on the negative current collector were 35 μm and 45 μm, and the positive tab was arranged at a position one layer outward from the position of the negative tab with respect to the center of the winding structure. In Examples 5-1 and 5-2, the negative active material included artificial graphite and silicon carbon, and the weight percentage of the silicon carbon in the negative active material layer was 20%.

[00108] Examples 5-3 and 5-4

[00109] The preparation method was the same as that in Example 1-1, except that in Examples 5-3 and 5-4, the distance between the arrangement position of the negative tab and the closest end of the negative active material layer in the long axis direction was 0.125 times the length of the long axis of the negative active material layer, and the positive tab is arranged at a position one layer outward from the position of the negative tab with respect to the center of the winding structure. The thicknesses of the negative current collector in Examples 5-3 and 5-4 were respectively 4 μm and 30 μm, and the weight percentage of the silicon carbon in the negative active material layer in Examples 5-3 and 5-4 was 20%.

[00110] The lithium-ion batteries of the above examples were subjected to a direct current resistance test, a discharge rate test, a cycle performance test and a cell surface temperature rise test, and test results were recorded.

[00111] The results of the direct current resistance test, the discharge rate test, the cycle performance test and the cell surface temperature rise test on the lithium-ion batteries of all the examples were shown in Tables 1 to 5 below.

Table 1

Example	Ratio of the distance between the negative tab and the closest end of the negative active material layer to the length of the long axis of the negative active material layer	Weight percentage (%) of silicon-based material	Coating thickness of negative active material (μm)	Thickness of current collector (μm)	Direct current resistance (mΩ)	Discharge rate	Capacity retention rate after 100 cycles	Average temperature rise of cell surface (°C)
Example 1-1	0	20	40	8	27.5	89.1%	86.2%	16.4
Example 1-2	0	40	40	8	37.1	87.6%	83.9%	21.9
Example 1-3	0	50	40	8	43.7	85.3%	79.4%	27.3
Example 1-4	0	70	40	8	58.9	77.8%	65.5%	34.5
Example 1-5	0	90	40	8	70.2	74.3%	60.9%	42.1

Table 2

Example	Ratio of the distance between the negative tab and the closest end of the negative active material layer to the length of the long axis of the negative active material layer	Weight percentage (%) of silicon-based material	Coating thickness of negative active material (μm)	Thickness of current collector (μm)	Direct current resistance (mΩ)	Discharge rate	Capacity retention rate after 100 cycles	Average temperature rise of cell surface (°C)
Example 2-1	0.125	20	40	8	26.4	89.8%	86.8%	14.3
Example 2-2	0.125	40	40	8	35.9	88.7%	84.6%	19.8
Example 2-3	0.125	50	40	8	42.4	86.1%	82.3%	24.5
Example 2-4	0.125	70	40	8	54.8	80.5%	75.2%	31.9
Example 2-5	0.125	90	40	8	66.2	75.4%	69.9%	39.1

Table 3

Example	Ratio of the distance between the negative tab and the closest end of the negative active material layer to the length of the long axis of the negative active material layer	Weight percentage (%) of silicon-based material	Coating thickness of negative active material (μm)	Thickness of current collector (μm)	Direct current resistance (mΩ)	Discharge rate	Capacity retention rate after 100 cycles	Average temperature rise of cell surface (°C)
Example 3-1	0.25	20	40	8	26.4	92.3%	87.4%	10.3
Example 3-2	0.25	40	40	8	34.1	90.6%	85.4%	14.7
Example 3-3	0.25	50	40	8	40.7	89.2%	84.5%	18.2
Example 3-4	0.25	70	40	8	47.8	87.7%	87.3%	24.9
Example 3-5	0.25	90	40	8	54.4	80.8%	82.9%	30.8

Table 4

Example	Ratio of the distance between the negative tab and the closest end of the negative active material layer to the length of the long axis of the negative active material layer	Weight percentage (%) of silicon-based material	Coating thickness of negative active material (μm)	Thickness of current collector (μm)	Direct current resistance (mΩ)	Discharge rate	Capacity retention rate after 100 cycles	Average temperature rise of cell surface (°C)
Example 4-1	0.5	20	40	8	17.3	95.5%	89.9%	8.4
Example 4-2	0.5	40	40	8	25.1	92.1%	89.2%	10.6
Example 4-3	0.5	50	40	8	33.7	91.8%	87.9%	11.9
Example 4-4	0.5	70	40	8	39.9	90.5%	87.0%	14.6
Example 4-5	0.5	90	40	8	47.2	86.3%	86.5%	19.1

Table 5

Example	Ratio of the distance between the negative tab and the closest end of the negative active material layer to the length of the long axis of the negative active material layer	Weight percentage (%) of silicon-based material	Single coating thickness of negative active material (μm)	Thickness of current collector (μm)	Direct current resistance (mΩ)	Discharge rate	Capacity retention rate after 100 cycles	Average temperature rise of cell surface (°C)
Example 5-1	0.1	20	35	8	25.1	90.4%	88.0%	14.6
Example 5-2	0.15	20	45	8	27.1	90.1%	86.3%	14.8
Example 5-3	0.125	20	40	4	30.9	89.1%	85.7%	16.7
Example 5-4	0.125	20	40	30	14.1	93.6%	91.5%	6.3

[00112] FIG. 9 is a three-dimensional curve chart showing the arrangement position of the negative tab, the silicon content in the negative active material layer, and the temperature rise of the battery cell in the examples of Tables 1 to 4 of this application. As shown in FIG. 9, the examples of this application obviously show the influence of the arrangement position of the negative tab and the silicon content on the cycle performance and safety performance of the electrochemical apparatus. According to the results of Table 1, the ratio D of the distance between the center of the negative tab and either end of the negative active material layer in the long axis direction to the length of the long axis of the negative active material layer and the weight percentage G of silicon in the negative active material layer in Examples 1-1, 2-1, 2-2, 3-1, 3-2, 3-3, 4-1, 4-2, 4-3 and 4-4 complied with the following relationship formula:$D \geq 0.6 \times G$. It can be seen from the examples that the electrochemical apparatus according to the examples of this application can effectively reduce the raising temperature of the battery cell during the charging and discharging cycle process to be less than 15°C.

[00113] According to Examples 5-1 to 5-4, when the thickness of the tab was 80 μm, the thickness S_1 of the negative current collector, the thickness S_2 of the negative tab, and the thickness S_3 of the negative active material layer satisfied the following relationship formula: $0.9(S_1+2S_3) \leq S_1+S_2 \leq 1.1\ (S_1+2S_3)$. The temperature rise of the battery cell decreases with the increase of the thickness of the negative current collector. Considering the strength of the current collector and the energy density of the battery cell, the 8 μm current collector is preferred among the examples. By controlling the relationship between the arrangement position of the negative tab and the silicon content, in the case of the negative electrode material with the same silicon content, the electrochemical apparatus provided by the examples of this application can have lower direct current resistance and better discharge rate, and also shows better cycle capacity. In addition, the examples conforming to the relationship between the arrangement position of the negative tab and the silicon content in the examples of this application can effectively control the average temperature rise of the cell surface, thereby ensuring the safety performance of the electrochemical apparatus.

[00114] Through the comparison of the above examples, it can be clearly understood that the cycle performance and safety performance of the electrochemical apparatus of this application can be significantly improved by limiting the relationship between the arrangement position of the negative tab and the weight percentage of silicon in the

negative active material layer.

[00115] References to "some embodiments", "other embodiments", "an embodiment", "another example", "examples", "specific examples", or "some examples" in the specification mean the inclusion of specific features, structures, materials, or characteristics described in the embodiment or embodiment in at least one embodiment or embodiment of the application. Accordingly, descriptions appearing in the specification, such as "in some embodiments", "in the embodiments", "in an embodiment", "in another example", "in an example", "in a particular example", or "for example", are not necessarily references to the same embodiments or examples in the application. In addition, specific features, structures, materials, or characteristics herein may be incorporated in any suitable manner into one or more embodiments or examples.

[00116] Although illustrative embodiments have been demonstrated and described, those skilled in the art should understand that the above embodiments are not to be construed as limiting the application, and that the embodiments may be changed, replaced, and modified without departing from the spirit, principle, and scope of the application.

CLAIMS

What is claimed is

1. An electrochemical apparatus, comprising:

a positive electrode;

a separator; and

a negative electrode;

wherein the negative electrode comprises a negative current collector; a negative active material layer, wherein the negative active material layer contains a silicon-based material; and a negative tab, wherein the negative tab is arranged on a side edge of a long axis of the negative current collector, a distance between a central position of the negative tab and either end of the negative active material layer in a long axis direction is a first length, a length of a long axis of the negative active material layer is a second length, and the negative electrode satisfies the following relationship formula (I):

$$0.5 \geq D \geq 0.6 \times G \qquad \text{formula (I)}$$

wherein D is a ratio of the first length to the second length, G is a weight percentage of the silicon-based material, and the weight percentage of the silicon-based material is less than or equal to 70%.

2. The electrochemical apparatus according to claim 1, wherein a thickness of the negative current collector is 4 μm to 30 μm, and the negative electrode satisfies the following relationship formula (II):

$$0.9\times(S_1+2S_3)\leq S_1+S_2\leq 1.1\times(S_1+2S_3) \qquad \text{formula (II)}$$

wherein the thickness of the negative current collector is S_1, a thickness of the negative tab is S_2, and a thickness of the negative active material layer is S_3.

3. The electrochemical apparatus according to claim 1, wherein the silicon-based material contains at least one of an elementary substance of silicon, a compound of silicon, an alloy of silicon, or a silica material.

4. The electrochemical apparatus according to claim 1, wherein a ratio of the length of the long axis of the negative active material layer to a length of the long axis of the negative current collector is 0.8 to 1.0.

5. The electrochemical apparatus according to claim 1, wherein the electrochemical apparatus is of a winding structure, and the negative tab is arranged at a position beyond three layers from a center of the winding structure.

6. The electrochemical apparatus according to claim 5, wherein a positive tab of the positive electrode is arranged at a position one layer outward from the position of the negative tab with respect to the center of the winding structure.

7. The electrochemical apparatus according to claim 1, wherein the silicon-based material further contains a material layer, the material layer is arranged on at least a part of a surface of the silicon-based material, and the material layer contains at least one of a polymer, inorganic particles, amorphous carbon or carbon nanotubes.

8. The electrochemical apparatus according to claim 7, wherein the inorganic particles comprise at least one of lithium cobaltate, lithium iron phosphate, lithium nickel cobalt manganate, lithium nickel cobalt aluminate, an elementary substance of silicon, a compound of silicon, an alloy of silicon, or a silica material; and the polymer contains at least one of polyvinylidene fluoride, polyacrylic acid, polyvinyl chloride, carboxymethyl cellulose, polyethylene, polypropylene, polyethylene terephthalate, polyimide, or aramid.

9. The electrochemical apparatus according to claim 1, wherein the negative electrode is provided with a groove, and the negative tab is arranged in the groove.

10. An electronic apparatus, comprising an electrochemical apparatus, wherein the electrochemical apparatus comprises:

a positive electrode;

a separator; and

a negative electrode, wherein the negative electrode comprises:

a negative current collector;

a negative active material layer, wherein the negative active material layer contains a silicon-based material; and

a negative tab, wherein the negative tab is arranged on a side edge of a long axis

of the negative current collector, a distance between a central position of the negative tab and either end of the negative active material layer in a long axis direction is a first length, a length of a long axis of the negative active material layer is a second length, and the negative electrode satisfies the following relationship formula (I):

$0.5 \geq D \geq 0.6 \times G$ formula (I)

wherein D is a ratio of the first length to the second length, G is a weight percentage of the silicon-based material, and the weight percentage of the silicon-based material is less than or equal to 70%..

11. The electronic apparatus according to claim 10, wherein a thickness of the negative current collector is 4 μm to 30 μm, and the negative electrode satisfies the following relationship formula (II):

$0.9\times(S_1+2S_3)\leq S_1+S_2\leq 1.1\times(S_1+2S_3)$ formula (II)

wherein the thickness of the negative current collector is S_1, a thickness of the negative tab is S_2, and a thickness of the negative active material layer is S_3.

12. The electronic apparatus according to claim 10, wherein the silicon-based material contains at least one of an elementary substance of silicon, a compound of silicon, an alloy of silicon, or a silica material.

13. The electronic apparatus according to claim 10, wherein a ratio of the length of the long axis of the negative active material layer to a length of the long axis of the negative current collector is 0.8 to 1.0.

14. The electronic apparatus according to claim 10, wherein the electrochemical apparatus is of a winding structure, and the negative tab is arranged at a position beyond three layers from a center of the winding structure.

ABSTRACT

An electrochemical apparatus includes a positive electrode, a separator and a negative electrode. The negative electrode includes a negative current collector, a negative active material layer and a negative tab, and the negative tab is arranged on a side edge of a long axis of the negative current collector and is in contact with the negative active material layer. The negative active material layer includes a silicon-based material, a distance between a central position of the negative tab and either end of the negative active material layer in a long axis direction is a first length, a length of a long axis of the negative active material layer is a second length, and $0.5 \geq D \geq 0.6 \times G$, where D is a ratio of the first length to the second length, G is a weight percentage of the silicon-based material. The weight percentage of the silicon-based material is less than or equal to 70%.

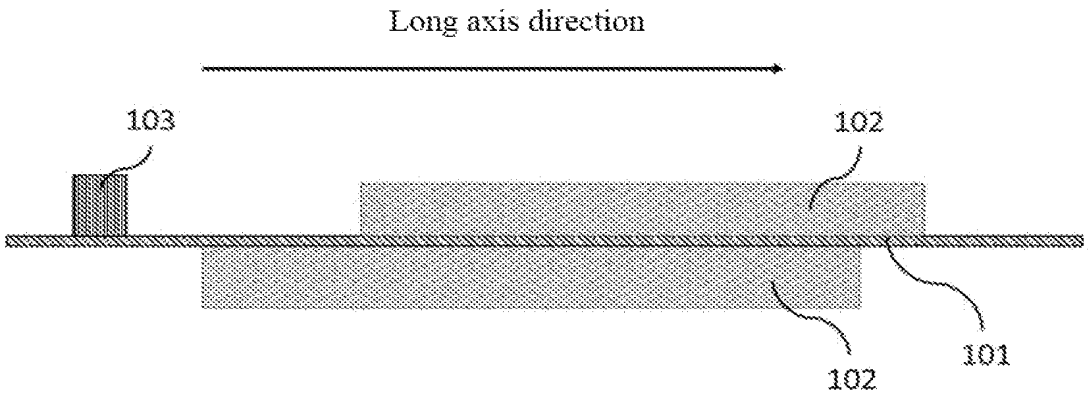

Long axis direction
103
102
102
101

FIG. 1

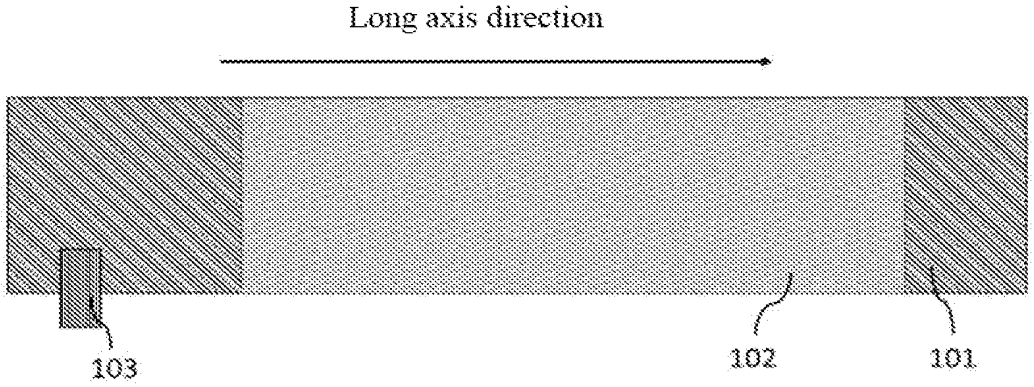

Long axis direction
103
102
101

FIG. 2

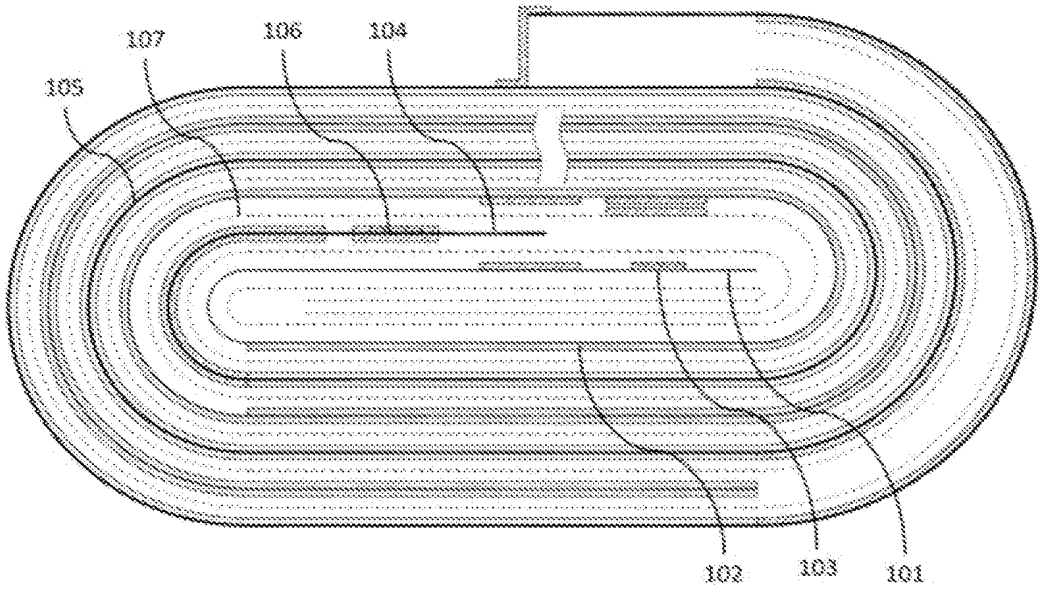

107
106
104
105
102
103
101

FIG. 3

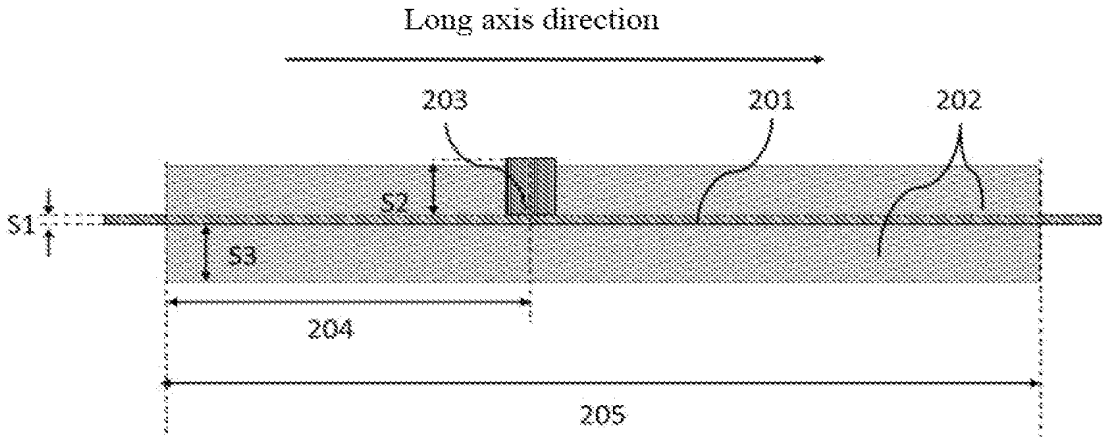

Long axis direction
203
201
202
S1
S2
S3
204
205

FIG. 4

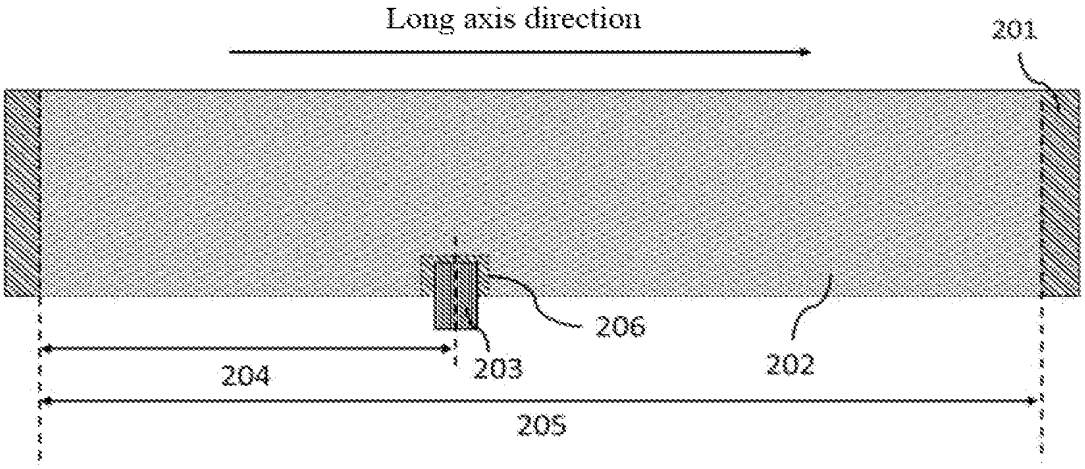

Long axis direction
201
206
204
203
202
205

FIG. 5

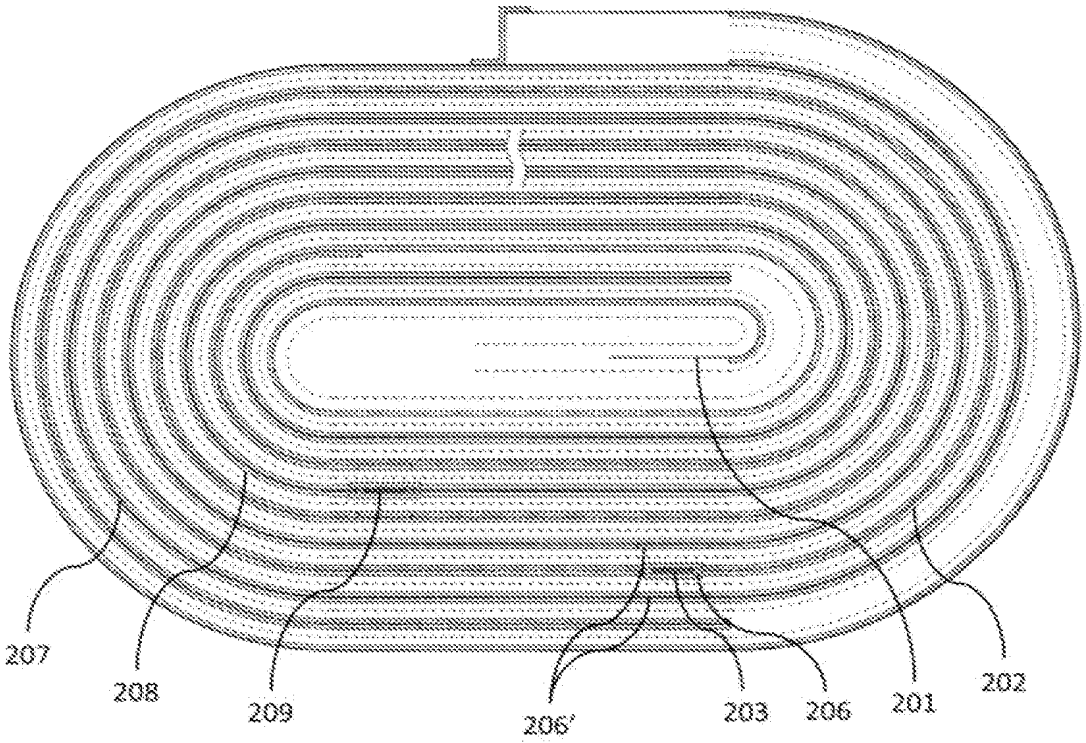

207
208
209
206'
203
206
201
202

FIG. 6

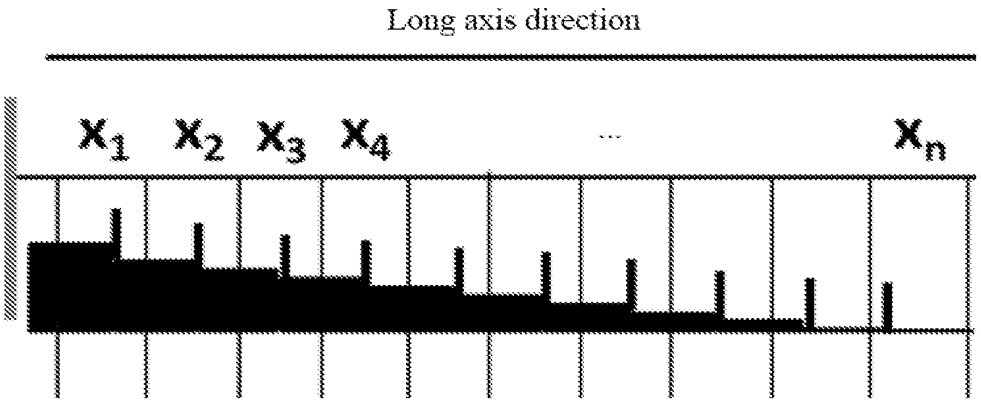

Long axis direction
X1 X2 X3 X4 ... Xn

FIG. 7

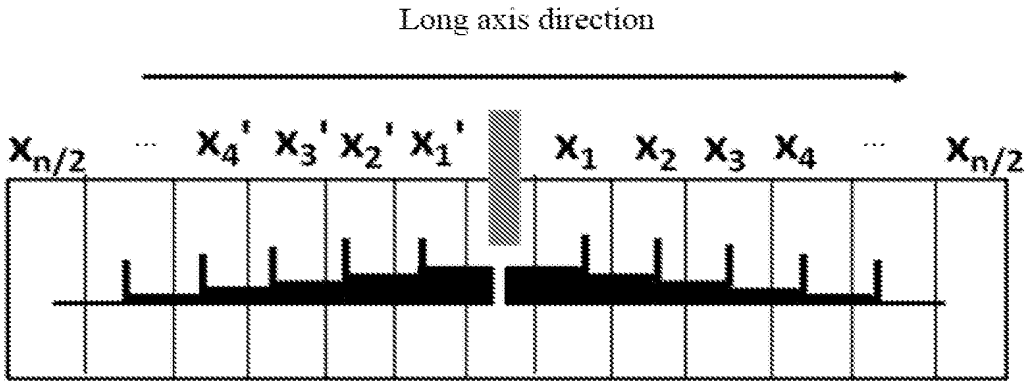

Long axis direction
Xn/2 ... X4' X3' X2' X1' X1 X2 X3 X4 ... Xn/2

FIG. 8

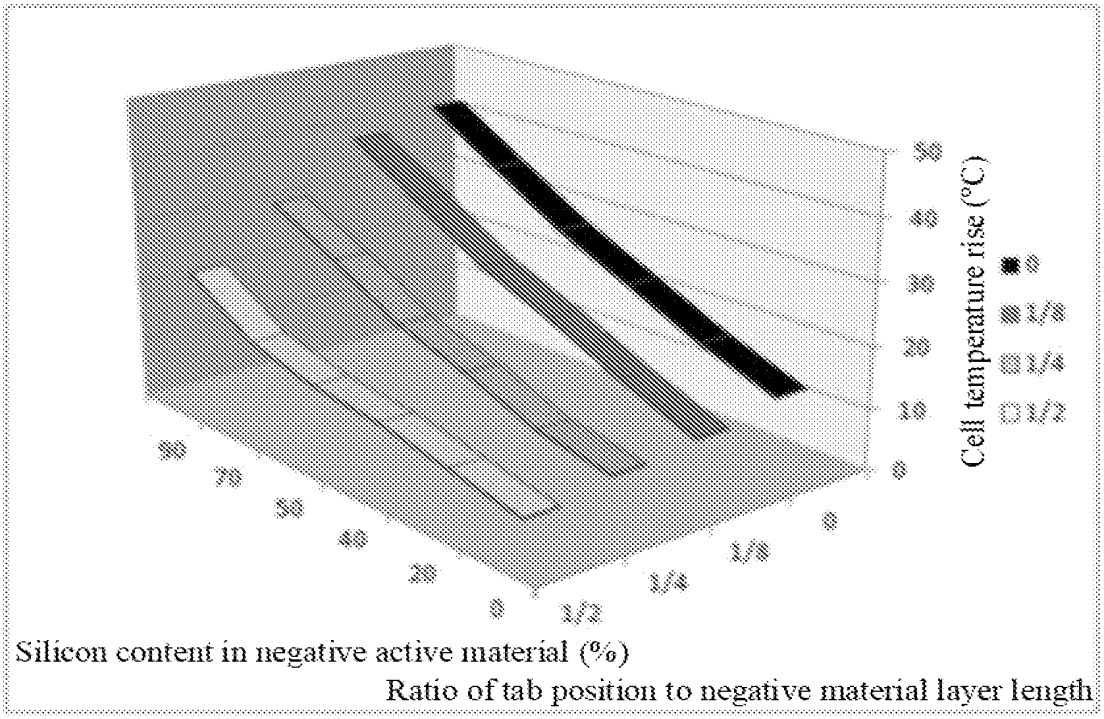

Cell temperature rise (°C)
50
40
30
20
10
0
0
1/8
1/4
1/2
80
70
60
40
20
0
1/2
1/4
1/8
0
Silicon content in negative active material (%)
Ratio of tab position to negative material layer length

FIG. 9

PTO/AIA/01 (06-12)
Approved for use through 01/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	ELECTROCHEMICAL APPARATUS AND ELECTRONIC APPARATUS CONTAINING THE ELECTROCHEMICAL APPARATUS

As the below named inventor, I hereby declare that:

This declaration is directed to:

- ■ The attached application, or
- ■ United States application or PCT international application number _____

filed on _____.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

WARNING:

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

LEGAL NAME OF INVENTOR

Inventor: Xiaojing Liu Date (Optional): _____

Signature: Xiaojing Liu

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82A (07-13)
Approved for use through 03/31/2021. OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5, unless the application number and filing date are identified in the Power of Attorney by Applicant form. If neither form PTO/AIA/82A nor form PTO/AIA82B identifies the application to which the Power of Attorney is directed, the Power of Attorney will not be recognized in the application.

Application Number	to be assigned
Filing Date	
First Named Inventor	Xiaojing Liu
Title	ELECTROCHEMICAL APPARATUS AND ELECTRONIC APPARATUS CONTAINING THE ELECTROCHEMICAL APPARATUS
Art Unit	to be assigned
Examiner Name	to be assigned
Attorney Docket Number	U 020968-8

SIGNATURE of Applicant or Patent Practitioner

Signature	/Shiming Wu/	Date (Optional)	
Name	Shiming Wu	Registration Number	56,885
Title (if Applicant is a juristic entity)			
Applicant Name (if Applicant is a juristic entity)	Ningde Amperex Technology Limited		

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.

☐ *Total of _____ forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82B (07-13)
Approved for use through 11/30/2014. OMB 0651-0051
U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number

POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

Application Number	Filing Date

(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)

☑ I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above: 00140

OR

☐ I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:

☑ The address associated with the above-mentioned Customer Number

OR

☐ The address associated with Customer Number: 00140

OR

Firm or Individual Name	Ladas & Parry LLP				
Address	1040 Avenue of the Americas				
City	New York	State	New York	Zip	10018-3738
Country	USA				
Telephone	(212)708-1800	Email	nymail@ladas.com		

I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

Ningde Amperex Technology Limited

☐ Inventor or Joint Inventor (title not required below)

☐ Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)

☑ Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)

☐ Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

SIGNATURE of Applicant for Patent

The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

Signature	Liangxin Yang	Date (Optional)	
Name	Liangxin Yang		
Title	IP Senior Manager		

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

☑ Total of one forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

(19)中华人民共和国国家知识产权局

(12)实用新型专利

(10)授权公告号 CN 204809314 U
(45)授权公告日 2015.11.25

(21)申请号 201520404064.8
(22)申请日 2015.06.12
(73)专利权人 宁德时代新能源科技有限公司
地址 352100 福建省宁德市蕉城区漳湾镇新港路1号科研楼1F-西
(72)发明人 郭培培 何平 赵义 方宏新 程文强
(74)专利代理机构 北京五洲洋和知识产权代理事务所(普通合伙) 11387
代理人 张向琨
(51)Int.Cl.
H01M 4/13(2010.01)
H01M 4/72(2006.01)
H01M 10/0587(2010.01)
H01M 10/0525(2010.01)

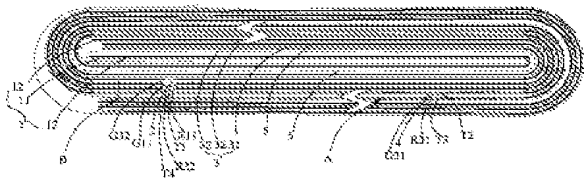
权利要求书2页 说明书9页 附图10页

(54)实用新型名称

二次电池电芯

(57)摘要

本实用新型提供了一种二次电池电芯，其包括阳极极片、阳极极耳、阴极极片、阴极极耳以及隔离膜。阳极极片包括阳极集流体以及阳极膜片。阴极极片包括阴极集流体以及阴极膜片。隔离膜设置于阳极极片和阴极极片之间。阳极极片形成有：阳极极耳收容凹槽，底部为阳极集流体而周侧为阳极膜片，阳极极耳收容于阳极极耳收容凹槽内并电连接于阳极极耳收容凹槽处的阳极集流体。阴极极片形成有：阴极极耳收容凹槽，底部为阴极集流体而周侧为阴极膜片，阴极极耳收容于阴极极耳收容凹槽内并电连接于阴极极耳收容凹槽处的阴极集流体。阴极极片还形成有：阴极极片对位凹槽，底部为阴极集流体而周侧为阴极膜片，位于阴极极片的与阳极极耳收容凹槽对位的区域。



CN 204809314 U

1. 一种二次电池电芯，包括：

阳极极片（1），包括：

阳极集流体（11）；以及

阳极膜片（12），设置在阳极集流体（11）的表面；

阳极极耳（2）；

阴极极片（3），包括：

阴极集流体（31）；以及

阴极膜片（32），设置在阴极集流体（31）的表面；

阴极极耳（4）；以及

隔离膜（5），设置于阳极极片（1）和阴极极片（3）之间；

其中，

阳极极片（1）形成有：

阳极极耳收容凹槽（G11），底部为阳极集流体（11）而周侧为阳极膜片（12），阳极极耳（2）收容于阳极极耳收容凹槽（G11）内并电连接于阳极极耳收容凹槽（G11）处的阳极集流体（11）；

阴极极片（3）形成有：

阴极极耳收容凹槽（G31），底部为阴极集流体（31）而周侧为阴极膜片（32），阴极极耳（4）收容于阴极极耳收容凹槽（G31）内并电连接于阴极极耳收容凹槽（G31）处的阴极集流体（31）；

其特征在于，

阴极极片（3）还形成有：

阴极极片对位凹槽（G32），底部为阴极集流体（31）而周侧为阴极膜片（32），位于阴极极片（3）的与阳极极耳收容凹槽（G11）对位的区域。

2. 根据权利要求 1 所述的二次电池电芯，其特征在于，阴极极片对位凹槽（G32）在长度和宽度上均大于阳极极耳收容凹槽（G11）。

3. 根据权利要求 1 所述的二次电池电芯，其特征在于，所述二次电池电芯还包括：

阴极极片对位凹槽用双面绝缘胶带（T1），覆盖整个阴极极片对位凹槽（G32），且在两面上分别粘接隔离膜（5）和阴极极片对位凹槽（G32）周围的阴极膜片（32）。

4. 根据权利要求 1 所述的二次电池电芯，其特征在于，所述二次电池电芯还包括：

阴极极耳收容凹槽用双面绝缘胶带（T2），覆盖整个阴极极耳收容凹槽（G31），且在两面上分别粘接隔离膜（5）和阴极极耳收容凹槽（G31）周围的阴极膜片（32）。

5. 根据权利要求 1 所述的二次电池电芯，其特征在于，阴极极片（3）还形成有：

阴极配对凹部（R31），底部为阴极集流体（31）而周侧为阴极膜片（32），位于阴极极耳收容凹槽（G31）的正对背侧。

6. 根据权利要求 5 所述的二次电池电芯，其特征在于，所述二次电池电芯还包括：

阴极配对凹部用双面绝缘胶带（T3），覆盖整个阴极配对凹部（R31），且在两面上分别粘接隔离膜（5）和阴极配对凹部（R31）周围的阴极膜片（32）。

7. 根据权利要求 1 所述的二次电池电芯，其特征在于，

阳极极片（1）还形成有：

阳极配对凹部（R11），底部为阳极集流体（11）而周侧为阳极膜片（12），位于阳极极耳收容凹槽（G11）的正对背侧；

阴极极片（3）还形成有：

阴极极片对位凹部（R32），底部为阴极集流体（31）而周侧为阴极膜片（32），位于阴极极片（3）的与阳极配对凹部（R11）对位的区域，且在长度和宽度上均大于阳极配对凹部（R11）。

8. 根据权利要求 7 所述的二次电池电芯，其特征在于，所述二次电池电芯还包括：

阴极极片对位凹部用双面绝缘胶带（T4），覆盖整个阴极极片对位凹部（R32），且在两面上分别粘接隔离膜（5）和阴极极片对位凹部（R32）周围的阴极膜片（32）。

9. 根据权利要求 1 所述的二次电池电芯，其特征在于，

阳极极片（1）为一整体片，二次电池电芯为卷绕式电芯，在阳极极片（1）展开状态下，阳极极片（1）的头部至尾部的距离定义为 D1，阳极极耳收容凹槽（G11）的中心线至阳极极片（1）的头部之间的距离定义为 d1，d1 处于自阳极极片（1）的头部起计算的 1/10D1 ～ 7/10D1 的范围内。

10. 根据权利要求 1 所述的二次电池电芯，其特征在于，

阴极极片（3）为一整体片，二次电池电芯为卷绕式电芯，在阴极极片（3）展开状态下，阴极极片（3）的头部至尾部的距离定义为 D2，阴极极耳收容凹槽（G31）的中心线至阴极极片（3）的头部之间的距离定义为 d2，d2 处于自阴极极片（3）的头部起计算的 1/10D2 ～ 7/10D2 的范围内。

二次电池电芯

技术领域

[0001] 本实用新型涉及电化学储能装置，尤其涉及一种二次电池电芯。

背景技术

[0002] 锂离子电池（为二次电池的一种）在各类电子产品中均有广泛的应用。随着电子产品趋向小型化、智能化，对锂离子电池的能量密度提出了更高的要求。现有技术主要是通过在极片上开设凹槽，将极耳焊接在凹槽内，从而达到提升能量密度的目的。

[0003] 于2014年7月23日授权公告的中国专利文献CN203733894U公开了一种锂离子电池，其中阴极膜片上设置有第一凹槽，阳极膜片上设置有第二凹槽，阴极极耳焊接于第一凹槽内，阳极极耳焊接于第二凹槽内，阴极极耳的上下两个表面上覆盖有第一绝缘胶层，第二凹槽对应的阴极膜片的表面贴有第二绝缘胶层。然而，在充放电循环过程中，由于阴极膜片的表面上的第二绝缘胶层无法阻止被粘盖的阴极膜片中的活性锂游离出来，因此被第二绝缘胶层粘盖的阴极膜片中的活性锂将通过浓差扩散游离至对位的阳极极耳处，但对位的阳极极耳为第二凹槽而无足够空间镶嵌上述游离出的活性锂，因此活性锂将富集在阳极极耳处，使得阳极极耳处出现严重的析锂问题。同时，在该专利文献中，第一绝缘胶层和第二绝缘胶层为绿胶，绿胶为单面绝缘胶层，由于单面绝缘胶层的背面非常光滑，使得单面绝缘胶层的背面和隔离膜接触时不能粘附在一起，造成锂离子电池在粘贴了单面绝缘胶层的区域比较疏松，在锂离子电池的电芯整形工序及充放电过程中，该区域隆起而成为最大变形区，因此该结构的锂离子电池还存在着严重的变形问题。

实用新型内容

[0004] 鉴于现有技术中存在的问题，本实用新型的目的在于提供一种二次电池电芯，当二次电池电芯形成二次电池后，在提高二次电池的能量密度的同时，能减轻二次电池在充放电过程中阴极活性物质富集在阳极极耳处，减轻阳极极耳处出现析出阴极活性物质的问题，提高二次电池的安全性能。

[0005] 为了实现上述目的，本实用新型提供了一种二次电池电芯，其包括阳极极片、阳极极耳、阴极极片、阴极极耳以及隔离膜。阳极极片包括：阳极集流体；以及阳极膜片，设置在阳极集流体的表面。阴极极片包括：阴极集流体；以及阴极膜片，设置在阴极集流体的表面。隔离膜设置于阳极极片和阴极极片之间。阳极极片形成有：阳极极耳收容凹槽，底部为阳极集流体而周侧为阳极膜片，阳极极耳收容于阳极极耳收容凹槽内并电连接于阳极极耳收容凹槽处的阳极集流体。阴极极片形成有：阴极极耳收容凹槽，底部为阴极集流体而周侧为阴极膜片，阴极极耳收容于阴极极耳收容凹槽内并电连接于阴极极耳收容凹槽处的阴极集流体。阴极极片还形成有：阴极极片对位凹槽，底部为阴极集流体而周侧为阴极膜片，位于阴极极片的与阳极极耳收容凹槽对位的区域。

[0006] 本实用新型的有益效果如下：

[0007] 在根据本实用新型所述的二次电池电芯中，阴极极片对位凹槽位于阴极极片的与

阳极极耳收容凹槽对位的区域，阴极极片对位凹槽无阴极活性物质存在，所以当二次电池电芯形成二次电池后，在利用阳极极耳收容凹槽收容阳极极耳、阴极极耳收容凹槽收容阴极极耳来提高二次电池的能量密度的同时，因为阴极极片对位凹槽与阳极极耳对位，从而减少了向阳极极耳游离的阴极活性物质，从而减少了阴极活性物质游离扩散至对位的阳极极耳处，进而能减轻在二次电池充放电过程中阴极活性物质富集在阳极极耳处，最终减轻了阳极极耳处出现析出阴极活性物质的问题，提高二次电池的安全性能。

附图说明

[0008] 图 1 是根据本实用新型的一实施例的二次电池电芯卷绕成型后的结构示意图；

[0009] 图 2 是图 1 的二次电池电芯的阴极极片展开后的两个视图，其中 (a) 为平行于图 1 的纸面方向做出的剖视图，而 (b) 为仰视图；

[0010] 图 3 是图 1 的二次电池电芯的阳极极片展开后的两个视图，其中 (a) 为平行于图 1 的纸面方向做出的剖视图，而 (b) 为俯视图；

[0011] 图 4 是图 1 的两个虚线方框区域的放大示意图，为了清楚起见，以剖视图方式示出，其中 (a) 为由箭头 A 指示的右侧方框区域的放大示意图，而 (b) 为由箭头 B 指示的左侧方框区域的放大示意图；

[0012] 图 5 示出了图 4 的替代实施例的结构示意图；

[0013] 图 6 是根据本实用新型另一实施例的二次电池电芯卷绕成型后的示意图；

[0014] 图 7 是图 6 的两个虚线方框区域的放大示意图，为了清楚起见，以剖视图方式示出，其中 (a) 为由箭头 A 指示的右侧方框区域的放大示意图，而 (b) 为由箭头 B 指示的左侧方框区域的放大示意图；

[0015] 图 8 示出了图 7 的替代实施例的结构示意图；

[0016] 图 9 示出了现有技术的结构示意图；

[0017] 图 10 是图 9 的两个虚线方框区域的放大示意图，为了清楚起见，以剖视图方式示出，其中 (a) 为由箭头 A 指示的右侧方框区域的放大示意图，而 (b) 为由箭头 B 指示的左侧方框区域的放大示意图。

[0018] 其中，附图标记说明如下：

[0019] 1 阳极极片

[0020] 11 阳极集流体

[0021] 12 阳极膜片

[0022] G11 阳极极耳收容凹槽

[0023] R11 阳极配对凹部

[0024] 2 阳极极耳

[0025] 3 阴极极片

[0026] 31 阴极集流体

[0027] 32 阴极膜片

[0028] G31 阴极极耳收容凹槽

[0029] G32 阴极极片对位凹槽

[0030] R31 阴极配对凹部

[0031] R32 阴极极片对位凹部

[0032] 4 阴极极耳

[0033] 5 隔离膜

[0034] T1 阴极极片对位凹槽用双面绝缘胶带

[0035] T2 阴极极耳收容凹槽用双面绝缘胶带

[0036] T3 阴极配对凹部用双面绝缘胶带

[0037] T4 阴极极片对位凹部用双面绝缘胶带

[0038] T1' 阴极极片对位收容区用单面绝缘胶带

[0039] T2' 阴极极耳收容凹槽用单面绝缘胶带

[0040] T3' 阴极配对凹部用单面绝缘胶带

[0041] T4' 阴极极片对位配对区用单面绝缘胶带

具体实施方式

[0042] 下面参照附图来详细说明根据本实用新型的二次电池电芯以及实施例和对比例的测试结果。

[0043] 首先说明根据本实用新型的二次电池电芯。

[0044] 参照图 1 至图 8，本实用新型的二次电池电芯包括阳极极片 1、阳极极耳 2、阴极极片 3、阴极极耳 4 以及隔离膜 5。

[0045] 阳极极片 1 包括：阳极集流体 11；以及阳极膜片 12，设置在阳极集流体 11 的表面。阴极极片 3 包括：阴极集流体 31；以及阴极膜片 32，设置在阴极集流体 31 的表面。隔离膜 5 设置于阳极极片 1 和阴极极片 3 之间。

[0046] 阳极极片 1 形成有：阳极极耳收容凹槽 G11，底部为阳极集流体 11 而周侧为阳极膜片 12，阳极极耳 2 收容于阳极极耳收容凹槽 G11 内并电连接于阳极极耳收容凹槽 G11 处的阳极集流体 11。

[0047] 阴极极片 3 形成有：阴极极耳收容凹槽 G31，底部为阴极集流体 31 而周侧为阴极膜片 32，阴极极耳 4 收容于阴极极耳收容凹槽 G31 内并电连接于阴极极耳收容凹槽 G31 处的阴极集流体 31。

[0048] 阴极极片 3 还形成有：阴极极片对位凹槽 G32，底部为阴极集流体 31 而周侧为阴极膜片 32，位于阴极极片 3 的与阳极极耳收容凹槽 G11 对位的区域。

[0049] 在根据本实用新型所述的二次电池电芯中，阴极极片对位凹槽 G32 位于阴极极片 3 的与阳极极耳收容凹槽 G11 对位的区域，阴极极片对位凹槽 G32 无阴极活性物质存在，所以当二次电池电芯形成二次电池后，在利用阳极极耳收容凹槽 G11 收容阳极极耳 2、阴极极耳收容凹槽 G31 收容阴极极耳 4 来提高二次电池的能量密度的同时，因为阴极极片对位凹槽 G32 与阳极极耳 2 对位，从而减少了向阳极极耳 2 游离的阴极活性物质，减少了阴极活性物质游离扩散至对位的阳极极耳 2 处，进而能减轻在二次电池充放电过程中阴极活性物质富集在阳极极耳 2 处，最终减轻了阳极极耳 2 处出现析出阴极活性物质的问题，提高二次电池的安全性能。

[0050] 在根据本实用新型所述的二次电池电芯中，在实施例中，阴极极片对位凹槽 G32 在长度和宽度上均可大于阳极极耳收容凹槽 G11。在一实施例中，阴极极片对位凹槽 G32 在

长度和宽度上均大于阳极极耳收容凹槽G11 0.5 ～ 3mm，优选在长度和宽度上均大于阳极极耳收容凹槽G11 1 ～ 2mm。在这种情况下，能够完全避免在二次电池充放电过程中阴极活性物质富集在阳极极耳2处，最终完全克服阳极极耳2处出现析出阴极活性物质的问题，进一步提高二次电池的安全性能。

[0051] 在根据本实用新型所述的二次电池电芯中，在一实施例中，参照图1、图2、图4、图5、图6、图7以及图8，所述二次电池电芯还可包括：阴极极片对位凹槽用双面绝缘胶带T1，覆盖整个阴极极片对位凹槽G32，且在两面上分别粘接隔离膜5和阴极极片对位凹槽G32周围的阴极膜片32。

[0052] 在根据本实用新型所述的二次电池电芯中，由于阴极极片对位凹槽用双面绝缘胶带T1覆盖整个阴极极片对位凹槽G32且在两面上分别粘接隔离膜5和阴极极片对位凹槽G32周围的阴极膜片32，所以阴极极片对位凹槽用双面绝缘胶带T1粘接区域比采用单面绝缘胶带时更紧密，从而使得二次电池电芯的整体性加强，从而避免二次电池电芯在整形工序以及二次电池充放电膨胀后该区域隆起成为最大变形区。

[0053] 在根据本实用新型所述的二次电池电芯中，在一实施例中，参照图1、图2、图4、图5、图6、图7以及图8，所述二次电池电芯还可包括：阴极极耳收容凹槽用双面绝缘胶带T2，覆盖整个阴极极耳收容凹槽G31，且在两面上分别粘接隔离膜5和阴极极耳收容凹槽G31周围的阴极膜片32。

[0054] 在根据本实用新型所述的二次电池电芯中，由于阴极极耳收容凹槽用双面绝缘胶带T2覆盖整个阴极极耳收容凹槽G31且在两面上分别粘接隔离膜5和阴极极耳收容凹槽G31周围的阴极膜片32，所以阴极极耳收容凹槽用双面绝缘胶带T2粘接区域比采用单面绝缘胶带时更紧密，从而使得二次电池电芯的整体性加强，从而避免二次电池电芯在整形工序以及二次电池充放电膨胀后该区域隆起成为最大变形区。

[0055] 在根据本实用新型所述的二次电池电芯中，阳极极耳2可采用超声波焊接、激光焊接或热压焊接方式电连接于阳极极耳收容凹槽G11处的阳极集流体11。

[0056] 在根据本实用新型所述的二次电池电芯中，阴极极耳4可采用超声波焊接、激光焊接或热压焊接方式电连接于阴极极耳收容凹槽G31处的阴极集流体31。

[0057] 在根据本实用新型所述的二次电池电芯中，阳极极耳收容凹槽G11可通过激光清洗、机械清洗或发泡胶清洗将阳极膜片12的对应部分去除以露出阳极集流体11而形成；或者阳极极耳收容凹槽G11可通过涂布阳极膜片浆料之前预置热敏型发泡胶纸在阳极集流体11上、之后涂布并干燥阳极膜片浆料以形成阳极膜片12且在干燥阳极膜片浆料时热敏型发泡胶纸从阳极集流体11上剥离形成；或者阳极极耳收容凹槽G11可通过在涂布阳极膜片浆料之前预涂发泡浆料在阳极集流体11上并干燥、之后涂布并干燥阳极膜片浆料以形成阳极膜片12且在干燥阳极膜片浆料时干燥的发泡浆料从阳极集流体11上剥离形成。

[0058] 在根据本实用新型所述的二次电池电芯中，阴极极耳收容凹槽G31可通过激光清洗、机械清洗或发泡胶清洗将阴极膜片32的的对应部分去除以露出阴极集流体31而形成；或者阴极极耳收容凹槽G31可通过涂布阴极膜片浆料之前预置热敏型发泡胶纸在阴极集流体31上、之后涂布并干燥阴极膜片浆料以形成阴极膜片32且在干燥阴极膜片浆料时热敏型发泡胶纸从阴极集流体31上剥离形成；或者阴极极耳收容凹槽G31可通过在涂布阴极膜片浆料之前预涂发泡浆料在阴极集流体31上并干燥、之后涂布并干燥阴极膜片浆料以

形成阴极膜片 32 且在干燥阴极膜片浆料时干燥的发泡浆料从阴极集流体 11 上剥离形成。

[0059] 在根据本实用新型所述的二次电池电芯中，阴极极片对位凹槽 G32 可通过激光清洗、机械清洗或发泡胶清洗而将阴极膜片 32 的对应部分去除以露出阴极集流体 31 而形成；或者阴极极片对位凹槽 G32 可通过涂布阴极膜片浆料之前预置热敏型发泡胶纸在阴极集流体 31 上、之后涂布并干燥阴极膜片浆料以形成阴极膜片 32 且在干燥阴极膜片浆料时热敏型发泡胶纸从阴极集流体 31 上剥离形成；或者阴极极片对位凹槽 G32 可通过在涂布阴极膜片浆料之前预涂发泡浆料在阴极集流体 31 上并干燥、之后涂布并干燥阴极膜片浆料以形成阴极膜片 32 且在干燥阴极膜片浆料时干燥的发泡浆料从阴极集流体 11 上剥离形成。

[0060] 在根据本实用新型所述的二次电池电芯中，阴极极片对位凹槽用双面绝缘胶带 T1 可为双面初始时均已有粘性或是一个单面初始时已有粘性而另一单面是经后续的热压或冷压后有粘性的双面胶带。

[0061] 在根据本实用新型所述的二次电池电芯中，阴极极耳收容凹槽用双面绝缘胶带 T2 可为双面初始时均已有粘性或是一个单面初始时已有粘性而另一单面是经后续的热压或冷压后有粘性的双面胶带。

[0062] 在根据本实用新型所述的二次电池电芯中，在一实施例中，参照图 1、图 4、图 6 以及图 7，阴极极片 3 还可形成有：阴极配对凹部 R31，底部为阴极集流体 31 而周侧为阴极膜片 32，位于阴极极耳收容凹槽 G31 的正对背侧。阴极配对凹部 R31 的设置，便于阴极极耳 4 超声焊接于阴极极耳收容凹槽 G311 中。

[0063] 在根据本实用新型所述的二次电池电芯中，在一实施例中，参照图 1、图 4、图 6 以及图 7，所述二次电池电芯还可包括：阴极配对凹部用双面绝缘胶带 T3，覆盖整个阴极配对凹部 R31，且在两面上分别粘接隔离膜 5 和阴极配对凹部 R31 周围的阴极膜片 32。

[0064] 在根据本实用新型所述的二次电池电芯中，阴极配对凹部 R31 可通过激光清洗、机械清洗或发泡胶清洗将阴极膜片 32 的对应部分去除以露出阴极集流体 31 而形成；或者阴极配对凹部 R31 可通过涂布阴极膜片浆料之前预置热敏型发泡胶纸在阴极集流体 31 上、之后涂布并干燥阴极膜片浆料以形成阴极膜片 32 且在干燥阴极膜片浆料时热敏型发泡胶纸从阴极集流体 31 上剥离形成；或者阴极配对凹部 R31 可通过在涂布阴极膜片浆料之前预涂发泡浆料在阴极集流体 31 上并干燥、之后涂布并干燥阴极膜片浆料以形成阴极膜片 32 且在干燥阴极膜片浆料时干燥的发泡浆料从阴极集流体 11 上剥离形成。

[0065] 在根据本实用新型所述的二次电池电芯中，阴极配对凹部用双面绝缘胶带 T3 可为双面初始时均已有粘性或是一个单面初始时已有粘性而另一单面是经后续的热压或冷压后有粘性的双面胶带。

[0066] 在根据本实用新型所述的二次电池电芯中，在一实施例中，参照图 1、图 3 以及图 4，阳极极片 1 还可形成有：阳极配对凹部 R11，底部为阳极集流体 11 而周侧为阳极膜片 12，位于阳极极耳收容凹槽 G11 的正对背侧。阳极配对凹部 R11 的设置，便于阳极极耳 2 超声焊接于阳极极耳收容凹槽 G11 中。

[0067] 在根据本实用新型所述的二次电池电芯中，在一实施例中，参照图 1、图 2、图 3 以及图 4，阴极极片 3 还可形成有：阴极极片对位凹部 R32，底部为阴极集流体 31 而周侧为阴极膜片 32，位于阴极极片 3 的与阳极配对凹部 R11 对位的区域，且在长度和宽度上均大于阳极配对凹部 R11。优选地，阴极极片对位凹部 R32 在长度和宽度上均大于阳极配对凹部 R11

1 ～ 2mm（即长度和宽度分别大 1 ～ 2mm，至于深度是否相同可以阴极膜片 32 的厚度与阳极膜片 12 的厚度之间的关系来确定）。当然，阴极极片对位凹部 R32 在长度和宽度上均大于阳极配对凹部 R11 的数值可以视实际情况来调整。

[0068] 在根据本实用新型所述的二次电池电芯中，在一实施例中，参照图 1、图 2、图 3 以及图 4，所述二次电池电芯还可包括：阴极极片对位凹部用双面绝缘胶带 T4，覆盖整个阴极极片对位凹部 R32，且在两面上分别粘接隔离膜 5 和阴极极片对位凹部 R32 周围的阴极膜片 32。由于阴极极片对位凹部用双面绝缘胶带 T4 覆盖整个阴极极片对位凹部 R32 且在两面上分别粘接隔离膜 5 和阴极极片对位凹部 R32 周围的阴极膜片 32，所以阴极极片对位凹部用双面绝缘胶带 T4 粘接区域比采用单面绝缘胶带时更紧密，从而使得二次电池电芯的整体性加强，从而避免二次电池电芯在整形工序以及二次电池充放电膨胀后该区域隆起成为最大变形区。

[0069] 在根据本实用新型所述的二次电池电芯中，阳极配对凹部 R11 可通过激光清洗、机械清洗或发泡胶清洗将阳极膜片 12 的对应部分去去除以露出阳极集流体 11 而形成；或者阳极配对凹部 R11 可通过涂布阳极膜片浆料之前预置热敏型发泡胶纸在阳极集流体 11 上、之后涂布并干燥阳极膜片浆料以形成阳极膜片 12 且在干燥阳极膜片浆料时热敏型发泡胶纸从阳极集流体 11 上剥离形成；或者阳极配对凹部 R11 可通过在涂布阳极膜片浆料之前预涂发泡浆料在阳极集流体 11 上并干燥、之后涂布并干燥阳极膜片浆料以形成阳极膜片 12 且在干燥阳极膜片浆料时干燥的发泡浆料从阳极集流体 11 上剥离形成。

[0070] 在根据本实用新型所述的二次电池电芯中，阴极极片对位凹部 R32 可通过激光清洗、机械清洗或发泡胶清洗将阴极膜片 32 的的对应部分去除以露出阴极集流体 31 而形成；或者阴极极片对位凹部 R32 可通过涂布阴极膜片浆料之前预置热敏型发泡胶纸在阴极集流体 31 上、之后涂布并干燥阴极膜片浆料以形成阴极膜片 32 且在干燥阴极膜片浆料时热敏型发泡胶纸从阴极集流体 31 上剥离形成；或者阴极极片对位凹部 R32 可通过在涂布阴极膜片浆料之前预涂发泡浆料在阴极集流体 31 上并干燥、之后涂布并干燥阴极膜片浆料以形成阴极膜片 32 且在干燥阴极膜片浆料时干燥的发泡浆料从阴极集流体 11 上剥离形成。

[0071] 在根据本实用新型所述的二次电池电芯中，阴极极片对位凹部用双面绝缘胶带 T4 可为双面初始时均已有粘性或是一个单面初始时已有粘性而另一单面是经后续的热压或冷压后有粘性的双面胶带。

[0072] 在根据本实用新型所述的二次电池电芯中，在一实施例中，阳极极耳收容凹槽 G11 的宽度为阳极极耳 2 的宽度的 1 ～ 2 倍，阳极极耳收容凹槽 G11 的长度为阳极极耳 2 的收容于阳极极耳收容凹槽 G11 内的部分的长度的 1 ～ 3 倍，阳极极耳收容凹槽 G11 的深度等于阳极膜片 12 的厚度。

[0073] 在根据本实用新型所述的二次电池电芯中，在一实施例中，阴极极耳收容凹槽 G31 的宽度为阴极极耳 4 的宽度的 1 ～ 2 倍，阴极极耳收容凹槽 G31 的长度为阴极极耳 4 的收容于阴极极耳收容凹槽 G31 内的部分的长度的 1 ～ 3 倍，阴极极耳收容凹槽 G31 的深度等于阴极膜片 32 的厚度。

[0074] 在根据本实用新型所述的二次电池电芯中，在一实施例中，参照图 3，阳极极片 1 为一整体片，二次电池电芯为卷绕式电芯，在阳极极片 1 展开状态下，阳极极片 1 的头部至尾部的距离定义为 D1，阳极极耳收容凹槽 G11 的中心线至阳极极片 1 的头部之间的距离定

义为 d1，d1 处于自阳极极片 1 的头部起计算的 1/10D1 ～ 7/10D1 的范围内，从而有利于降低二次电池电芯的直流阻抗 DCR(Direct current resistance)。优选地，d1 处于自阳极极片 1 的头部起计算的 3/10D1 ～ 7/10D1 的范围内。进一步地，d1 越靠近阳极极片 1 的中间位置（即 1/2D1），DCR 越小。

[0075] 在根据本实用新型所述的二次电池电芯中，在一实施例中，参照图 3，阳极集流体 11 位于阳极极片 1 的头部附近处仅一个表面设置阳极膜片 12。

[0076] 在根据本实用新型所述的二次电池电芯中，在一实施例中，参照图 2，阴极极片 3 为一整体片，二次电池电芯为卷绕式电芯，在阴极极片 3 展开状态下，阴极极片 3 的头部至尾部的距离定义为 D2，阴极极耳收容凹槽 G31 的中心线至阴极极片 3 的头部之间的距离定义为 d2，d2 处于自阴极极片 3 的头部起计算的 1/10D2 ～ 7/10D2 的范围内，从而有利于降低二次电池电芯的直流阻抗 DCR。优选地，d2 处于自阴极极片 3 的头部起计算的 3/10D2 ～ 7/10D2 的范围内。进一步地，越靠近阴极极片 3 的中间位置（即 1/2D2），DCR 越小。

[0077] 在根据本实用新型所述的二次电池电芯中，双面胶带包括基材和涂覆在基材的两个表面的胶层。双面初始时均已有粘性的双面胶带的胶层可以为丁苯橡胶层、聚氨酯层、聚丙烯酸酯层或聚偏氟乙烯层。

[0078] 在根据本实用新型所述的二次电池电芯中，在一个单面初始时已有粘性而另一单面是经后续的热压或冷压后有粘性的双面胶带中，一个单面初始时已有粘性的胶层可以为丁苯橡胶层、聚氨酯层、聚丙烯酸酯层或聚偏氟乙烯层；而另一单面是经后续的热压或冷压后有粘性的胶层可以为常温下无初粘性的温敏胶或常温下无初粘性的压敏胶。所述常温下无初粘性的温敏胶是指在常温下，当物体和温敏胶之间发生短暂接触时，不会对物体产生粘结作用的温敏胶。所述常温下无初粘性的压敏胶是指在常温下，当物体和压敏胶之间在指压下发生短暂接触时，不会对物体产生粘结作用的压敏胶。所述常温下无初粘性的温敏胶可选自聚烯烃、聚乙烯醇缩丁醛、聚酰胺类以及聚酯类中的一种或几种。所述常温下无初粘性的压敏胶可选自乙烯－丁烯－聚苯乙烯线性三嵌段共聚物（SEBS）、苯乙烯－丁二烯嵌段共聚物（SEPS）以及环氧化苯乙烯－异戊二烯－苯乙烯嵌段共聚物（ESIS）中的一种或几种。

[0079] 在根据本实用新型的二次电池电芯中，二次电池可为锂离子电池或钠离子电池。当采用锂离子电池时，阴极活性物质含锂。当采用钠离子电池时，阴极活性物质含钠。所述二次电池可为软包装二次电池。

[0080] 最后说明根据本实用新型的以软包装锂离子电池作为举例的实施例和对比例及测试结果。

[0081] 实施例 1

[0082] 以 423482 型号软包装锂离子电池（成品电池厚度为 4.2mm、宽度为 34mm、长度为 82mm）为例，阳极极耳 2 与阴极极耳 4 尺寸一致，即极耳的焊接长度为 15mm，极耳宽度为 4mm、厚度为 0.06mm。

[0083] 采用图 1 ～ 4 所示的结构，经冷压工序后的极片（阳极极片 1 的单层阳极膜片 12 的厚度为 67μm、阴极极片 3 的单层阴极膜片 32 的厚度为 53μm），采用激光在阳极极片 1 的 1/2 处（即 d1 = 1/2D1）清洗出用于焊接阳极极耳 2 的阳极极耳收容凹槽 G11 以及阳极配对凹部 R11，并在阳极极耳 2 对位的阴极极片区清洗出阴极极片对位凹槽 G32 以及阴极极

片对位凹部 R32。采用激光在阴极极片 3 的 1/2 处（即 d2 = 1/2D2）清洗出用于焊接阴极极耳 4 的阴极极耳收容凹槽 G31 以及阴极配对凹部 R31。其中阴极极耳收容凹槽 G31 以及阴极配对凹部 R31 各自宽度均为 6mm、长度均为 20mm，阳极极耳收容凹槽 G11 以及阳极配对凹部 R11 各自宽度均为 6mm、长度均为 20mm，阴极极片对位凹槽 G32 以及阴极极片对位凹部 R32 各自宽度均为 8mm、长度均为 22mm，将阳极极耳 2 焊接于阳极极耳收容凹槽 G11、将阴极极耳 4 焊接于阴极极耳收容凹槽 G31。阴极极片对位凹槽用双面绝缘胶带 T1 覆盖整个阴极极片对位凹槽 G32 且在两面上分别粘接隔离膜 5 和阴极极片对位凹槽 G32 周围的阴极膜片 32，阴极极耳收容凹槽用双面绝缘胶带 T2 覆盖整个阴极极耳收容凹槽 G31 且在两面上分别粘接隔离膜 5 和阴极极耳收容凹槽 G31 周围的阴极膜片 32，阴极配对凹部用双面绝缘胶带 T3 覆盖整个阴极配对凹部 R31 且在两面上分别粘接隔离膜 5 和阴极配对凹部 R31 周围的阴极膜片 32，阴极极片对位凹部用双面绝缘胶带 T4 覆盖整个阴极极片对位凹部 R32 且在两面上分别粘接隔离膜 5 和阴极极片对位凹部 R32 周围的阴极膜片 32，阴极极片对位凹槽用双面绝缘胶带 T1、阴极极耳收容凹槽用双面绝缘胶带 T2、阴极配对凹部用双面绝缘胶带 T3、阴极极片对位凹部用双面绝缘胶带 T4 均为双面初始时均已有粘性的 PET 基材上双面涂覆聚偏氟乙烯层的双面胶带，阳极极片 1、阴极极片 3 和隔离膜 5 卷绕，由此形成二次电池电芯。

[0084] 实施例 2

[0085] 采用图 5 所示的结构，与实施例 1 的不同之处：无阴极配对凹部 R31、阴极配对凹部用双面绝缘胶带 T3、阳极配对凹部 R11、阴极极片对位凹部 R32 以及阴极极片对位凹部用双面绝缘胶带 T4。其余同实施例 1。

[0086] 实施例 3

[0087] 采用图 6 和图 7 所示的结构，与实施例 1 的不同之处：采用激光方式在阳极极片 1 的 3/4 处（即 d1 = 3/4D1，靠近头部附近的阳极膜片 12 单面设置）清洗出用于焊接阳极极耳 2 的阳极极耳收容凹槽 G11，并在阳极极耳 2 对位的阴极极片区清洗出阴极极片对位凹槽 G32，阴极极片对位凹槽用双面绝缘胶带 T1 覆盖整个阴极极片对位凹槽 G32 且在两面上分别粘接隔离膜 5 和阴极极片对位凹槽 G32 周围的阴极膜片 32。其余同实施例 1。

[0088] 实施例 4

[0089] 采用如图 8 所示的结构，与实施例 3 的不同之处：无阴极配对凹部 R31 以及阴极配对凹部用双面绝缘胶带 T3。其余同实施例 3。

[0090] 对比例 1

[0091] 采用如图 8 所示结构，与实施例 4 的不同之处：阳极极耳收容凹槽 G11 的宽度为 6mm、长度均为 20mm，阴极极片对位凹槽 G32 的宽度为 4mm、长度均为 18mm。其余同实施例 4。

[0092] 对比例 2

[0093] 采用图 9 和图 10 所示的结构，与实施例 1 的不同之处：无阴极极片对位凹槽 G32 和阴极极片对位凹部 R32，但采用阴极极片对位收容区用单面绝缘胶带 T1' 粘贴阴极膜片 32 的与阳极极耳收容凹槽 G11 对位的相应区域的表面，采用阴极极片对位配对区用单面绝缘胶带 T4' 粘贴阴极膜片 32 的阳极配对凹部 R11 对位的相应区域的表面，采用阴极极耳收容凹槽用单面绝缘胶带 T2' 粘贴阴极极耳收容凹槽 G31 周围的阴极膜片 32，采用阴极配对

凹部用单面绝缘胶带 T3' 粘贴阴极配对凹部 R31 周围的阴极膜片 32。

[0094] 在实施例 1-4 和对比例 1-2 中分别选取 20 个软包装锂离子电池样品进行 1000 个循环充放电测试，对测试前后的样品的厚度进行测量，并且对测试后的软包装锂离子电池样品进行拆解观察析锂的情况，所得结果示如表 1 所示。

[0095] 表 1 实施例 1-4 与对比例 1-2 的测试结果

[0096]

	平均厚度/mm			发生析锂的样品个数
	1000 循环前	1000 循环后	变形量	
实施例 1	4.067	4.334	0.267	0
实施例 2	4.067	4.334	0.267	0
实施例 3	4.066	4.330	0.264	0
实施例 4	4.066	4.330	0.264	0
对比例 1	4.067	4.358	0.291	9
对比例 2	4.067	4.381	0.314	20

[0097] 从表 1 看出，实施例 1-4 无析锂；而对比例 1 和对比例 2 有析锂，且对比例 2 比对比例 1 析锂严重；实施例 1-4 的变形量远小于对比例 1 和对比例 2。对比例 1 的变形量比对比例 2 的变形量小，但对比例 1 的变形量大于实施例 4 的变形量。

[0098] 由此可见，实施例 1-4 中，阴极极片对位凹槽 G32 在长度和宽度上均大于阳极极耳收容凹槽 G11，能完全避免析锂，且能有效控制软包装锂离子电池的变形。相比对比例 2，在对比例 1 中，阴极极片对位凹槽 G32 在长度和宽度上均小于阳极极耳收容凹槽 G11，能减轻析锂，并减轻变形量。

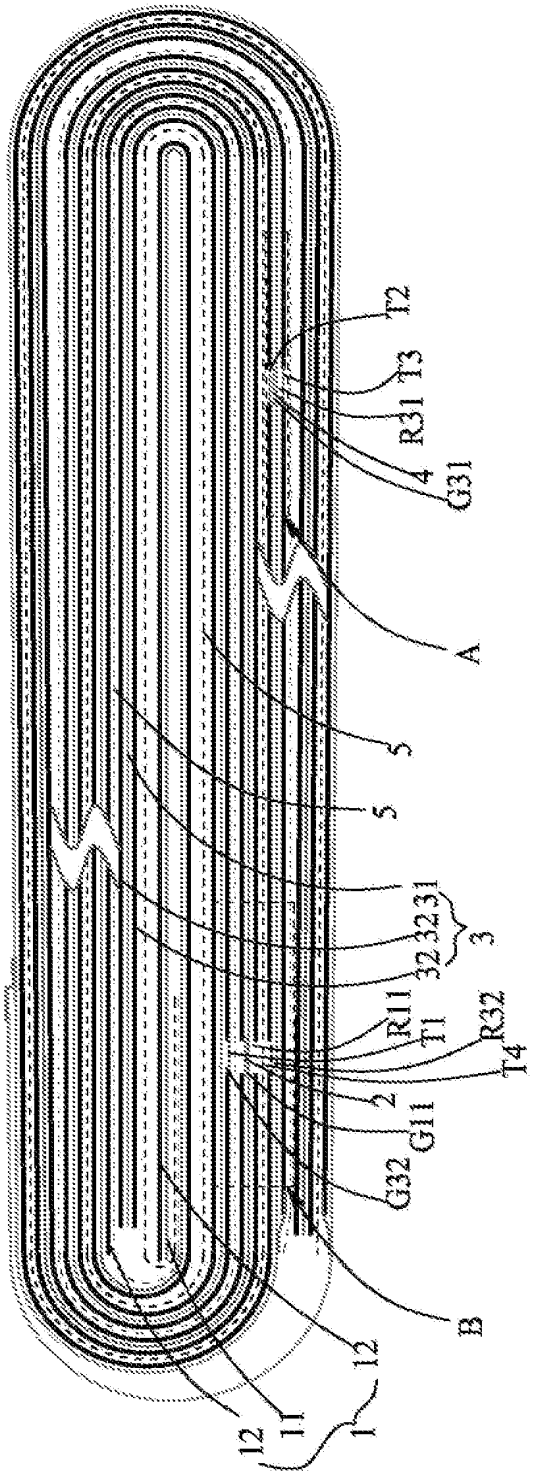


图 1

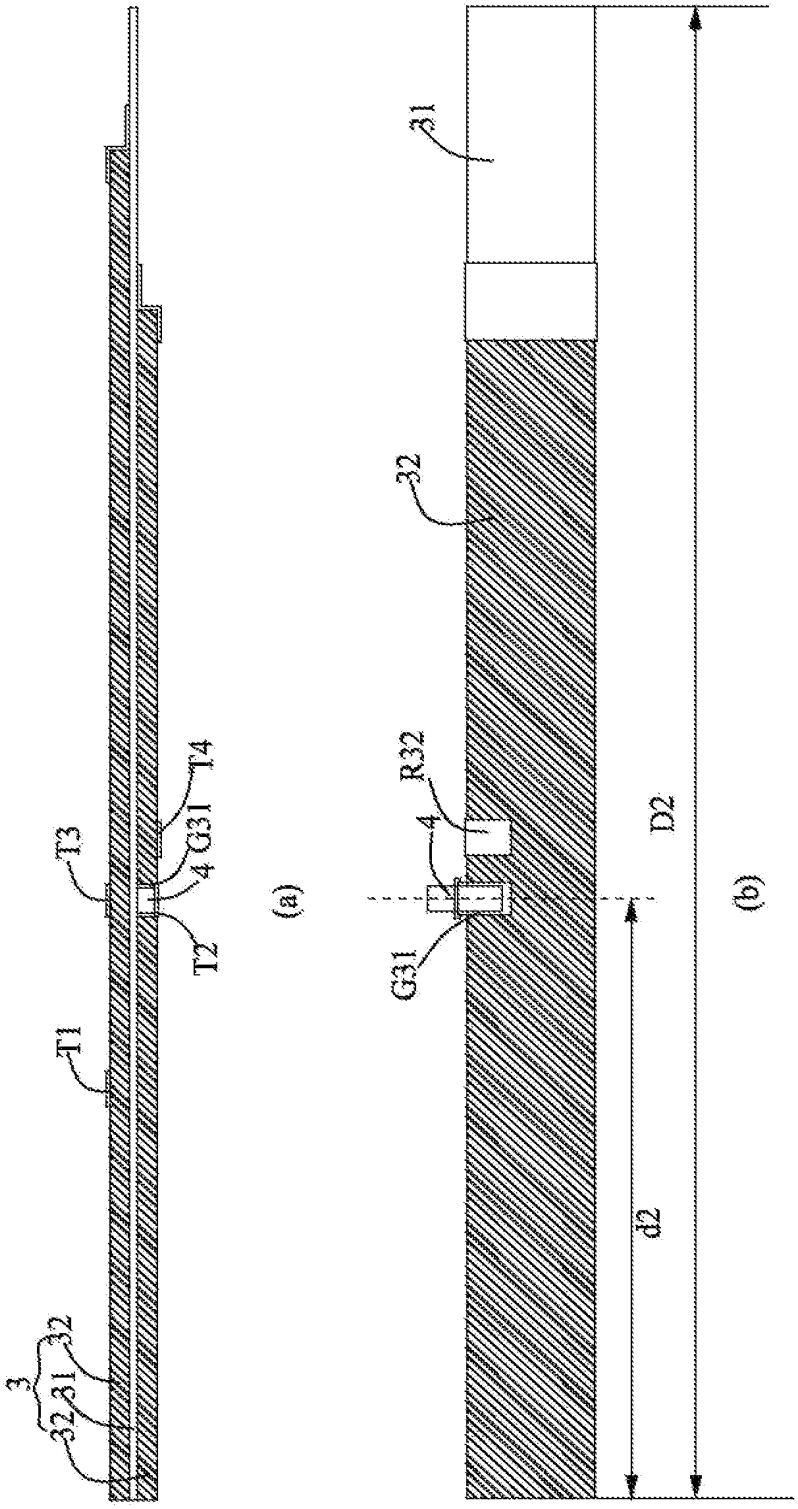


图 2

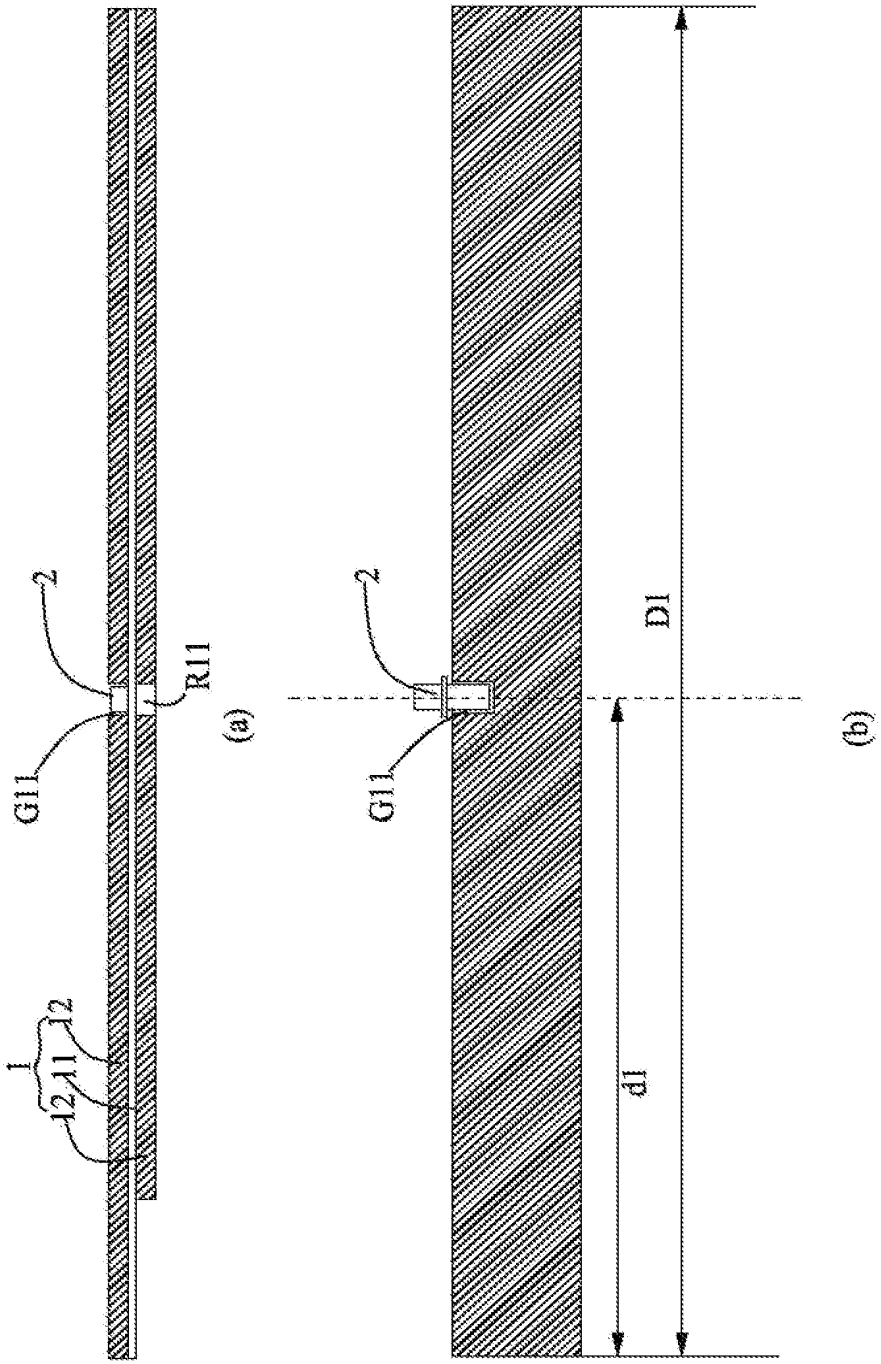


图 3

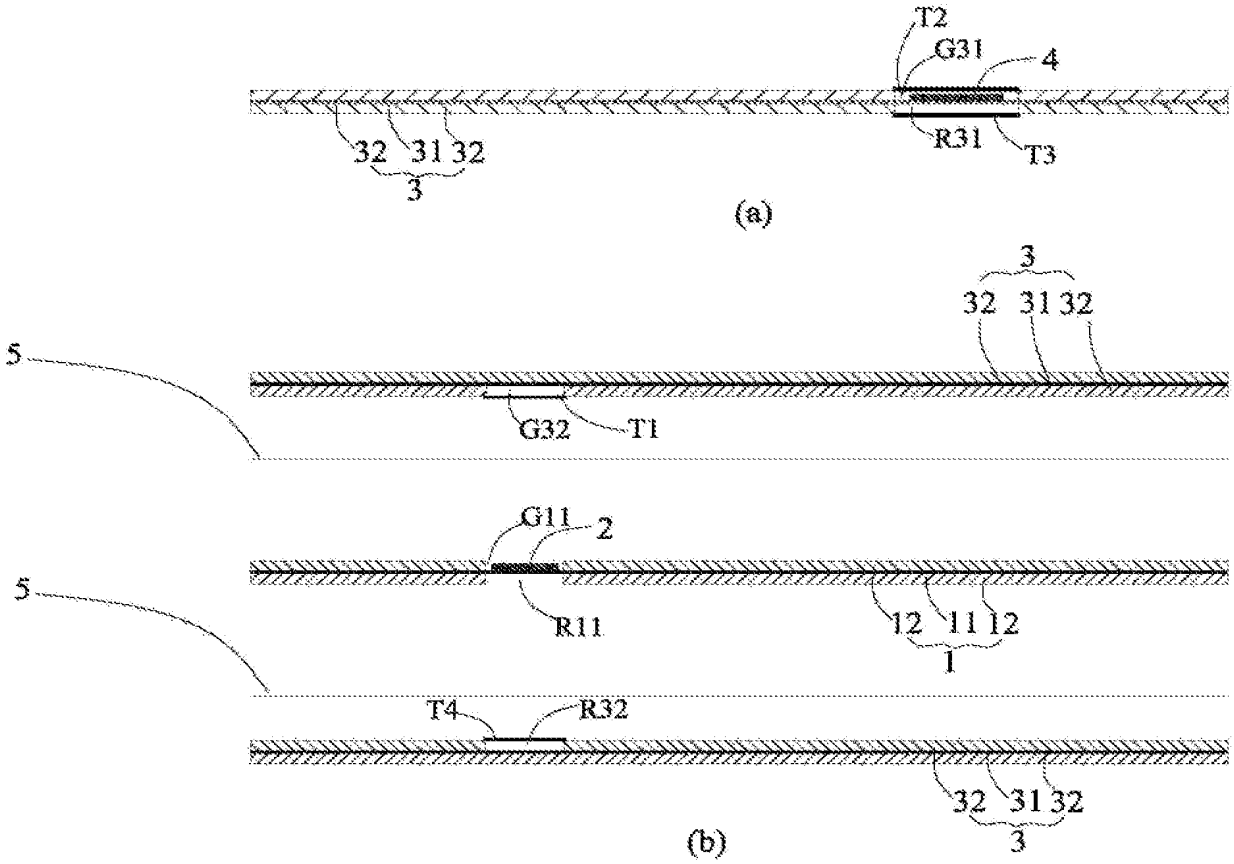

T2
G31
4
32
31
32
3
R31
T3
(a)
3
32
31
32
5
G32
T1
G11
2
5
R11
12
11
12
1
T4
R32
32
31
32
3
(b)

图 4

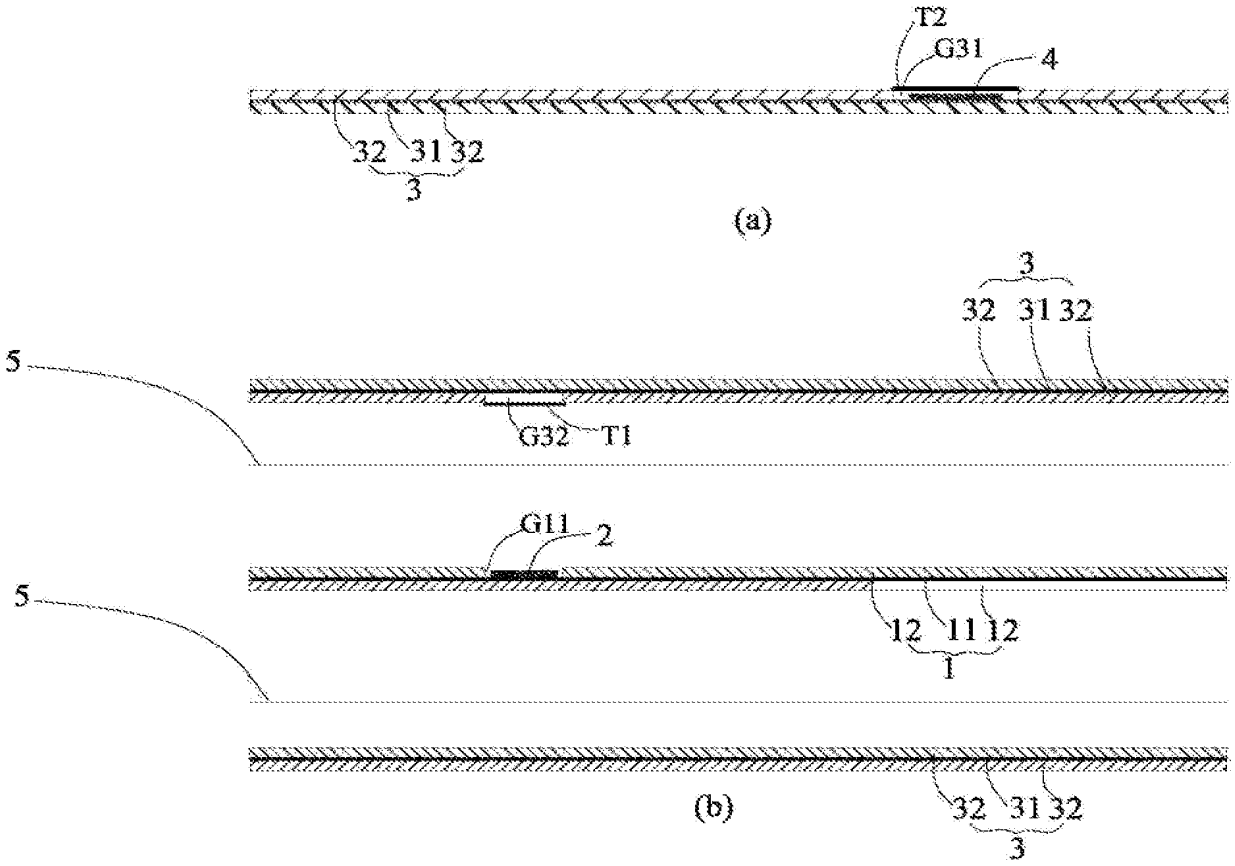


图 5

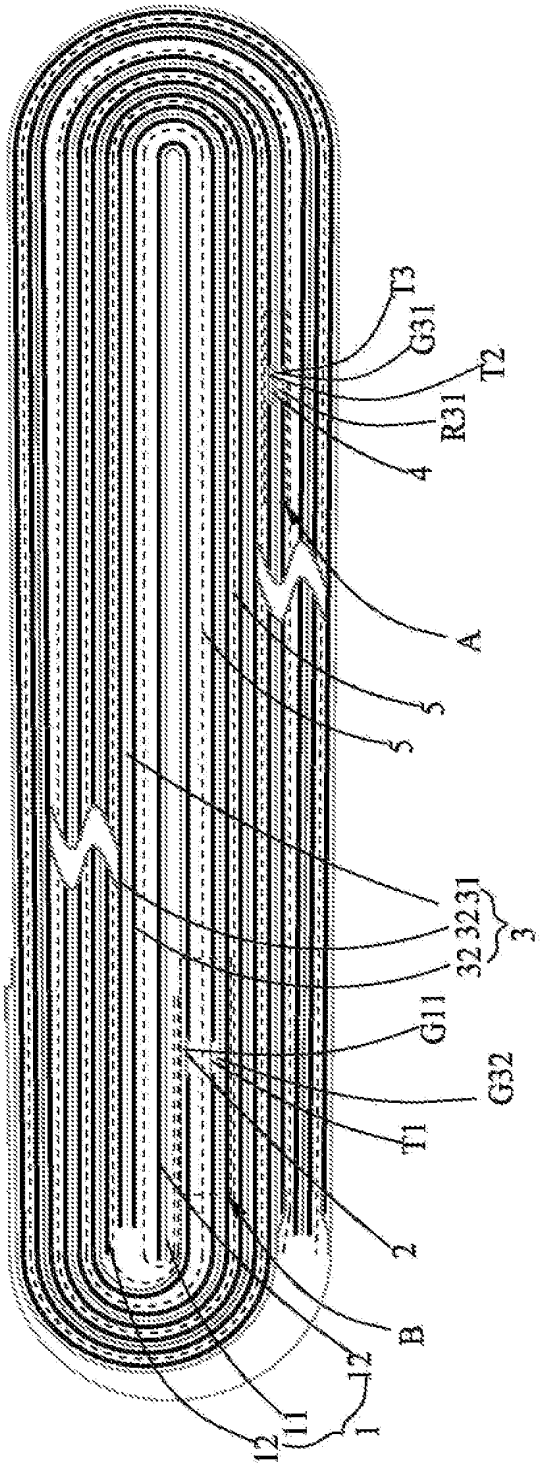


图 6

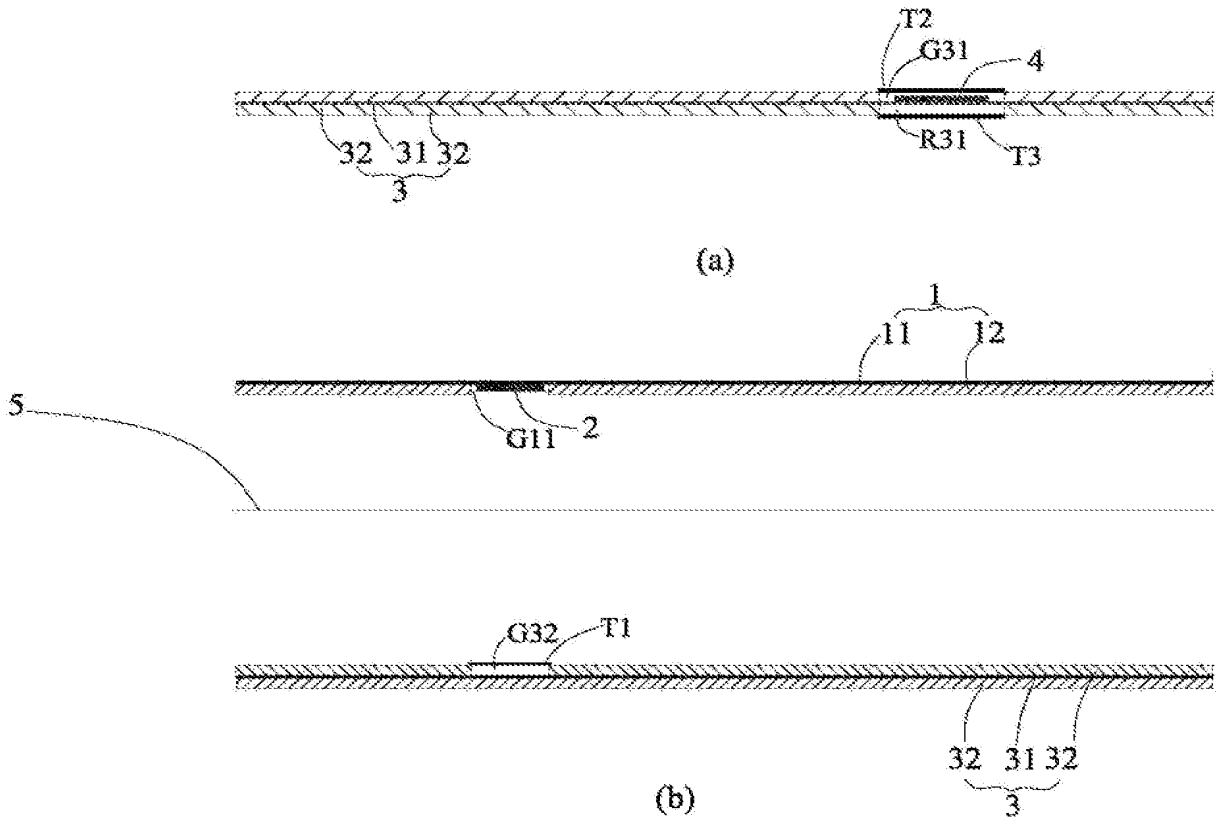


图 7

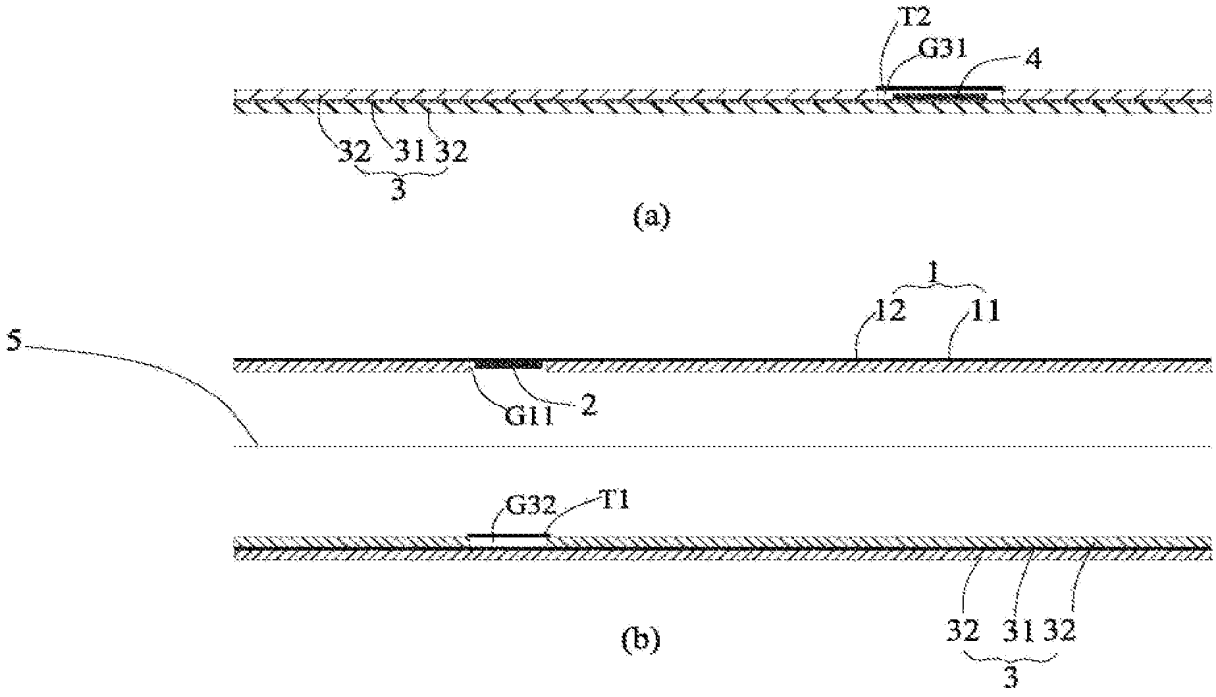


图 8

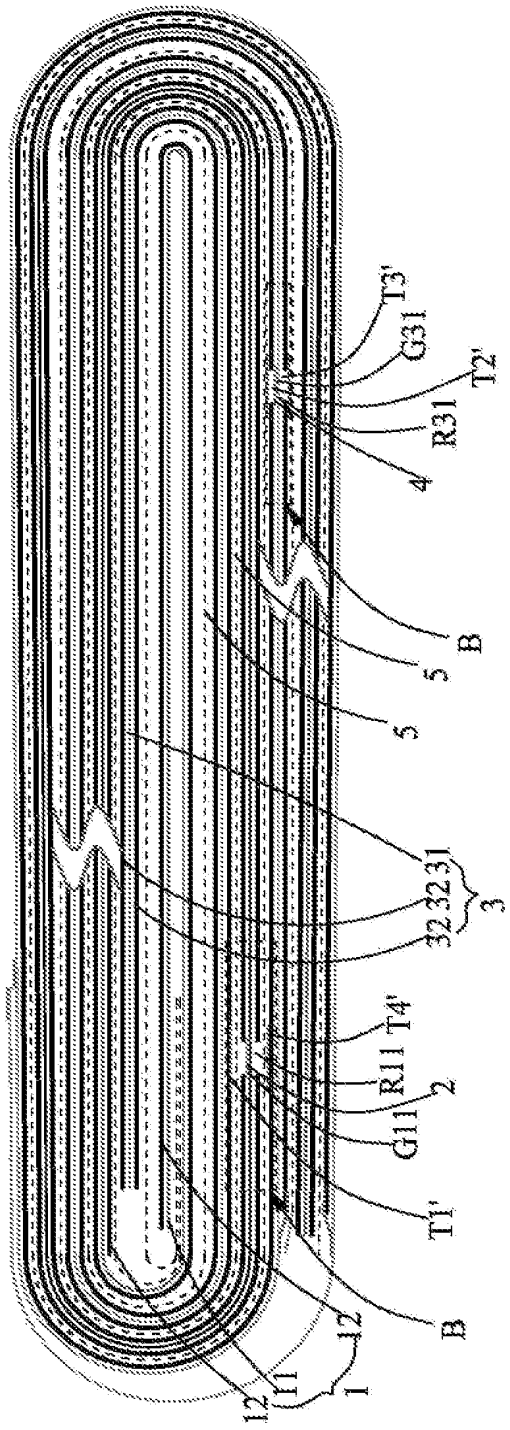


图 9

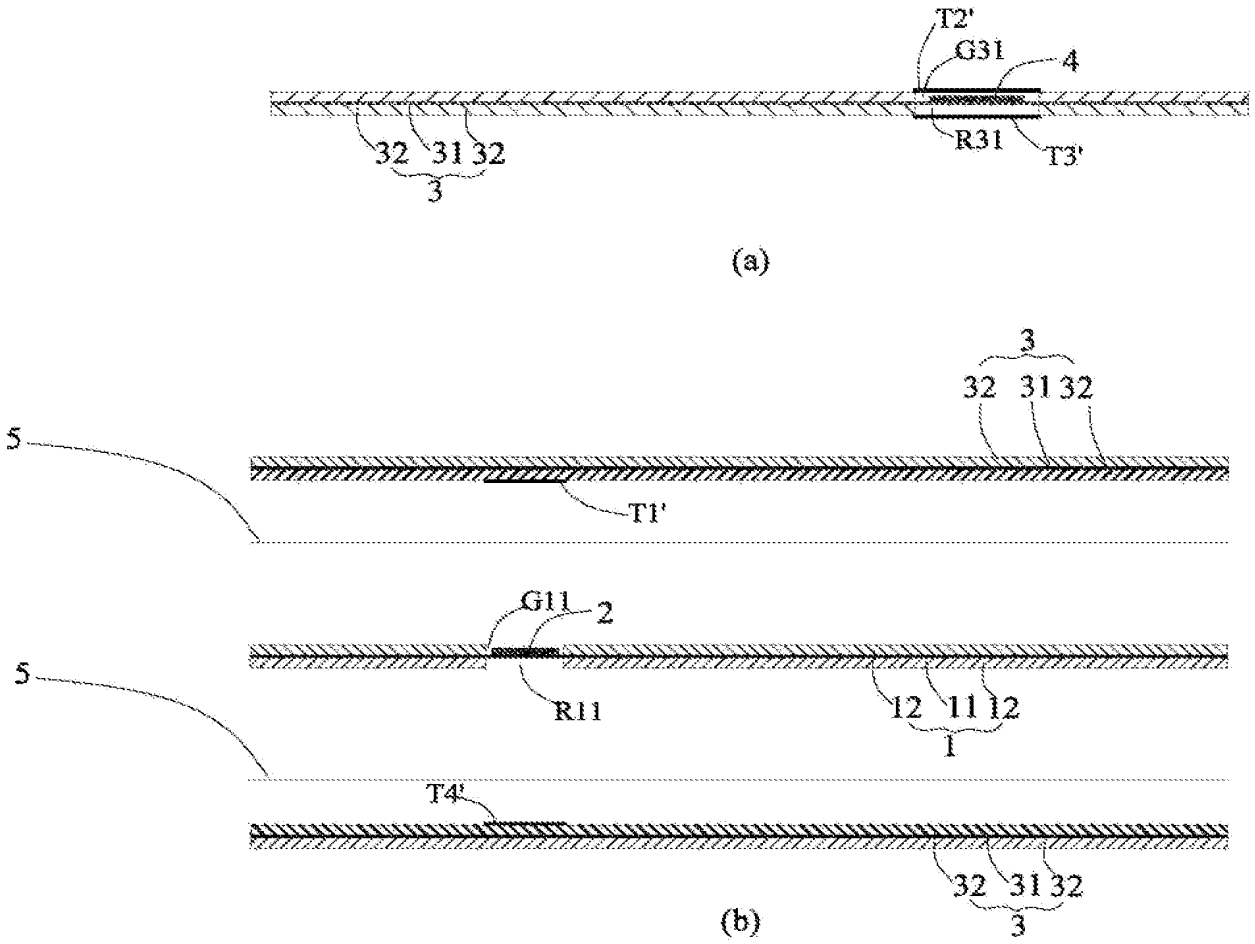

T2'
G31
4
32
31
32
3
R31
T3'
(a)
3
32
31
32
5
T1'
G11
2
5
R11
12
11
12
1
T4'
32
31
32
3
(b)

图 10

(19)中华人民共和国国家知识产权局

(12)实用新型专利

(10)授权公告号 CN 205828514 U
(45)授权公告日 2016.12.21

(21)申请号 201620716715.1

(22)申请日 2016.07.08

(73)专利权人 宁德新能源科技有限公司
地址 352100 福建省宁德市蕉城区漳湾镇新港路1号

(72)发明人 曾巧 王可飞 袁庆丰 蔡家财

(74)专利代理机构 广州三环专利代理有限公司 44202
代理人 王基才

(51)Int.Cl.
H01M 2/26(2006.01)
H01M 2/18(2006.01)
H01M 10/0587(2010.01)

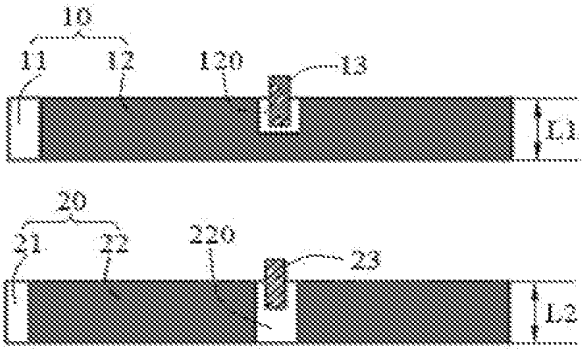
权利要求书1页 说明书4页 附图1页

(54)实用新型名称

二次电芯

(57)摘要

本实用新型提供了一种二次电芯，其包括阳极极片、阴极极片和隔离膜，隔离膜间隔于相邻的阴极极片和阳极极片之间；所述阴极极片和阳极极片均包括集流体、涂覆在集流体至少一个表面上的活性物质层和电连接在集流体上的极耳，活性物质层设有露出空白集流体的极耳凹槽，极耳固定在对应的极耳凹槽中；所述阳极极耳凹槽为未贯穿极片宽度方向的短凹槽，短凹槽三面封闭、一面开口；阴极极耳凹槽为贯穿极片宽度方向的长凹槽，长凹槽两面封闭、两面开口。与现有技术相比，本实用新型二次电芯具有能量密度高、减小析锂、不易膨胀变形、焊接牢固等优点。



CN 205828514 U

1.一种二次电芯，包括阳极极片、阴极极片和隔离膜，隔离膜间隔于相邻的阴极极片和阳极极片之间；

所述阳极极片包括阳极集流体、涂覆在阳极集流体至少一个表面上的阳极活性物质层和电连接在阳极集流体上的阳极极耳，阳极活性物质层中设有露出空白阳极集流体的阳极极耳凹槽，阳极极耳固定在阳极极耳凹槽中；

所述阴极极片包括阴极集流体、涂覆在阴极集流体至少一个表面上的阴极活性物质层和电连接在阴极集流体上的阴极极耳，阴极活性物质层中设有露出空白阴极集流体的阴极极耳凹槽，阴极极耳固定在阴极极耳凹槽中；

其特征在于：所述阳极极耳凹槽为未贯穿极片宽度方向的短凹槽，短凹槽三面封闭、一面开口；阴极极耳凹槽为贯穿极片宽度方向的长凹槽，长凹槽两面封闭、两面开口。

2.根据权利要求1所述的二次电芯，其特征在于：所述阳极极耳凹槽和阴极极耳凹槽在电芯宽度方向上错开一段距离设置，使得阳极极耳和阴极极耳在电芯厚度方向上无重叠。

3.根据权利要求1所述的二次电芯，其特征在于：所述阳极极片、隔离膜和阴极极片层叠后卷绕，二次电芯为卷绕式电芯。

4.根据权利要求3所述的二次电芯，其特征在于：所述阳极极耳凹槽设置于阳极极片的卷绕起始段或卷绕中间段。

5.根据权利要求3所述的二次电芯，其特征在于：所述阴极极耳凹槽设置于阴极极片的卷绕起始段或卷绕中间段。

6.根据权利要求3所述的二次电芯，其特征在于：所述二次电芯包括位于卷绕完成位置的收尾胶，收尾胶在电芯厚度方向上与阴极极耳凹槽的位置对齐。

7.根据权利要求3所述的二次电芯，其特征在于：所述阳极极片的卷绕起始段包括预折段和与预折段连接的平铺层；预折段与平铺层平行，且位于平铺层朝向卷绕中心的一面；阴极极片的卷绕起始段为与平铺层平行的阴极极片卷绕起始层，阴极极片卷绕起始层位于平铺层背向卷绕中心的一面，且在电芯厚度方向上与预折段无重叠。

8.根据权利要求7所述的二次电芯，其特征在于：所述预折段的自由端为阳极极片卷绕起始端A，阴极极片卷绕起始层的自由端为阴极极片卷绕起始端B，AB两端在电芯宽度方向上的距离s为0～4mm。

9.根据权利要求7所述的二次电芯，其特征在于：所述预折段有一面与平铺层相对，预折段的自由端仅在背向平铺层的一面粘贴胶纸，朝向平铺层的一面不粘贴胶纸。

10.根据权利要求7所述的二次电芯，其特征在于：所述隔离膜设有隔离膜卷绕起始层和与隔离膜卷绕起始层相连的隔离膜卷绕次层，隔离膜卷绕起始层和隔离膜卷绕次层均为双层膜结构；预折段紧贴平铺层，预折段和平铺层全部位于隔离膜卷绕起始层与隔离膜卷绕次层之间；阴极极片卷绕起始层则位于隔离膜卷绕次层的两层膜之间。

二次电芯

技术领域

[0001] 本实用新型属于二次电池领域，尤其涉及一种二次电芯。

背景技术

[0002] 随着锂离子二次电池商业化的发展，市场对电芯的能量密度要求越来越高。在常规卷绕式二次电芯中，阴极极片、阳极极片的起始端都设有空白集流体，阴极极耳和阳极极耳分别直接焊接在阴极极片、阳极极片上的空白集流体上。但是，由于极耳厚度的累加，使得焊接极耳区域的厚度为电芯的最大厚度，而未焊接极耳区域的厚度则相对较小，厚度不均匀使得电池的部分空间不能被充分利用，导致在一定型号尺寸内，电池的能量密度难以进一步提高。

[0003] 为了解决上述问题，有些二次电池的电芯采用以下方式固定极耳：在极片的活性物质层中设置露出空白集流体的极耳凹槽，并将极耳固定在极耳凹槽中，从而达到提升能量密度的目的。但是，如果将阴阳极极片的极耳凹槽全部设置为贯穿极片宽度方向的长凹槽，那么长凹槽中无疑会存在无需焊接极耳的空白集流体区域，这部分不涂布活性物质层的区域会导致电芯容量的损失，而且会造成阴极极片上与阳极极耳凹槽对应的区域析锂，为了防止析锂在阴极极片贴胶带则又会进一步降低电芯容量；如果将阴阳极极片的极耳凹槽全部设置为略大于极耳固定端的短凹槽，又无法为循环过程中的极片膨胀提供完整的应力释放窗口。

[0004] 有鉴于此，确有必要提供一种能够解决上述技术问题的二次电芯。

实用新型内容

[0005] 本实用新型的目的在于：提供一种兼顾能量密度、析锂和应力释放的二次电芯。

[0006] 为了实现上述目的，本实用新型提供了一种二次电芯，包括阳极极片、阴极极片和隔离膜，隔离膜间隔于相邻的阴极极片和阳极极片之间；所述阳极极片包括阳极集流体、涂覆在阳极集流体至少一个表面上的阳极活性物质层和电连接在阳极集流体上的阳极极耳，阳极活性物质层中设有露出空白阳极集流体的阳极极耳凹槽，阳极极耳固定在阳极极耳凹槽中；所述阴极极片包括阴极集流体、涂覆在阴极集流体至少一个表面上的阴极活性物质层和电连接在阴极集流体上的阴极极耳，阴极活性物质层中设有露出空白阴极集流体的阴极极耳凹槽，阴极极耳固定在阴极极耳凹槽中；所述阳极极耳凹槽为未贯穿极片宽度方向的短凹槽，短凹槽三面封闭、一面开口；阴极极耳凹槽为贯穿极片宽度方向的长凹槽，长凹槽两面封闭、两面开口。

[0007] 作为本实用新型二次电芯的一种改进，所述阳极极耳凹槽和阴极极耳凹槽在电芯宽度方向上错开一段距离设置，使得阳极极耳和阴极极耳在电芯厚度方向上无重叠。

[0008] 作为本实用新型二次电芯的一种改进，所述阳极极片、隔离膜和阴极极片层叠后卷绕，二次电芯为卷绕式电芯。

[0009] 作为本实用新型二次电芯的一种改进，所述阳极极耳凹槽设置于阳极极片的卷绕

起始段或卷绕中间段。

[0010] 作为本实用新型二次电芯的一种改进，所述阴极极耳凹槽设置于阴极极片的卷绕起始段或卷绕中间段。

[0011] 作为本实用新型二次电芯的一种改进，所述二次电芯包括位于卷绕完成位置的收尾胶，收尾胶在电芯厚度方向上与阴极极耳凹槽的位置对齐。

[0012] 作为本实用新型二次电芯的一种改进，所述阳极极片的卷绕起始段包括预折段和与预折段连接的平铺层；预折段与平铺层平行，且位于平铺层朝向卷绕中心的一面；阴极极片的卷绕起始段为与平铺层平行的阴极极片卷绕起始层，阴极极片卷绕起始层位于平铺层背向卷绕中心的一面，且在电芯厚度方向上与预折段无重叠。

[0013] 作为本实用新型二次电芯的一种改进，所述预折段的自由端为阳极极片卷绕起始端A，阴极极片卷绕起始层的自由端为阴极极片卷绕起始端B，AB两端在电芯宽度方向上的距离s为0～4mm。

[0014] 作为本实用新型二次电芯的一种改进，所述预折段有一面与平铺层相对，预折段的自由端仅在背向平铺层的一面粘贴胶纸，朝向平铺层的一面不粘贴胶纸。

[0015] 作为本实用新型二次电芯的一种改进，所述隔离膜设有隔离膜卷绕起始层和与隔离膜卷绕起始层相连的隔离膜卷绕次层，隔离膜卷绕起始层和隔离膜卷绕次层均为双层膜结构；预折段紧贴平铺层，预折段和平铺层全部位于隔离膜卷绕起始层与隔离膜卷绕次层之间；阴极极片卷绕起始层则位于隔离膜卷绕次层的两层膜之间。

[0016] 与现有技术相比，本实用新型二次电芯具有能量密度高、减小析锂、不易膨胀变形、焊接牢固等优点。

附图说明

[0017] 下面结合附图和具体实施方式，对本实用新型二次电芯及其有益技术效果进行详细说明。

[0018] 图1为本实用新型二次电芯一个实施方式的结构示意图。

[0019] 图2为本实用新型二次电芯阳极极片和阴极极片的极耳连接结构示意图。

具体实施方式

[0020] 为了使本实用新型的目的、技术方案和有益技术效果更加清晰明白，以下结合附图和具体实施方式，对本实用新型进行进一步详细说明。应当理解的是，本说明书中描述的具体实施方式仅仅是为了解释本实用新型，并不是为了限定本实用新型。

[0021] 为了便于说明，本实用新型将阴极极片和阳极极片的较短边定义为极片宽度方向L1、L2，与其垂直的极片延伸方向定义为极片长度方向。很容易理解，由于阴极极片和阳极极片的卷绕都是沿长度方向进行的，因此在最终卷绕成的电芯中，阴阳极极片宽度方向L1、L2对应的是电芯长度方向(图1中垂直于纸面的方向)，也就是说，极片宽度方向L1、L2与电芯宽度方向L并不相同，而是彼此垂直的。

[0022] 请参阅图1和图2，本实用新型二次电芯包括阳极极片10、阴极极片20和隔离膜30。阳极极片10、隔离膜30和阴极极片20层叠后卷绕为卷绕式电芯，隔离膜30间隔于相邻的阳极极片10和阴极极片20之间。

[0023] 阳极极片10包括阳极集流体11、涂覆在阳极集流体11至少一个表面上的阳极活性物质层12和电连接在阳极集流体11上的阳极极耳13。阳极活性物质层12中设有露出空白阳极集流体的阳极极耳凹槽120，阳极极耳13固定在阳极极耳凹槽120中。阳极极耳凹槽120为略大于极耳固定端的短凹槽，其未贯穿阳极极片10的宽度方向L1，因此三面封闭、一面开口。短凹槽的形成方式有多种，其中一种是先在空白阳极集流体的极耳固定位置粘贴易撕膜或热膨胀膜，再进行阳极活性物质层的连续涂布，最后去掉易撕膜或热膨胀膜而形成短凹槽。

[0024] 阴极极片20包括阴极集流体21、涂覆在阴极集流体21至少一个表面上的阴极活性物质层22和电连接在阴极集流体21上的阴极极耳23。阴极活性物质层22中设有露出空白阴极集流体的阴极极耳凹槽220，阴极极耳23固定在阴极极耳凹槽220中。阴极极耳凹槽220为贯穿阴极极片10的宽度方向L2的长凹槽，长凹槽两面封闭、两面开口，其可以采用间歇涂布方式涂布阴极活性物质层而形成。

[0025] 阳极极耳凹槽120/阴极极耳凹槽220可以设置于阳极极片10/阴极极片20在卷绕方向上的任意位置，但是优选为设置在卷绕起始段或卷绕中间段，原因是：设置在阳极极片10/阴极极片20的卷绕起始段时，阳极极耳13/阴极极耳23的位置靠近电芯厚度方向T的中心，与电芯厚度方向T的两个最外层距离相当，电芯更加不易变形；设置在阳极极片10/阴极极片20的卷绕中间段时，内阻最小，电流密度最均匀，使得电芯的放电性能最优。需要说明的是，无论设置在卷绕起始段还是卷绕中间段，阳极极耳凹槽120和阴极极耳凹槽220在电芯宽度方向L上都需要错开一段距离设置，使得阳极极耳13和阴极极耳23在电芯厚度方向T上无重叠，以避免阴阳极短路。

[0026] 与现有技术相比，本实用新型二次电芯至少具有以下优点：

[0027] 1)阳极极耳凹槽120为略大于极耳固定端的短凹槽，其未贯穿阳极极片10的宽度方向L1，因此几乎不存在未涂布阳极活性物质层的空白集流体区域，减小了电芯容量损失；

[0028] 2)与使用长凹槽的阳极极片相比，本实用新型的阳极极耳凹槽120使用短凹槽可以大幅减小阴极极片20上与阳极极耳凹槽120对应区域的析锂；

[0029] 3)由于阴极极耳凹槽220为贯穿阴极极片10的宽度方向L2的长凹槽，因此其能够提供一段完整的应力释放的窗口；同时，阳极极片10上与阴极极耳凹槽220对应的一面处于无脱嵌锂状态，因此也成为阳极极片10的应力释放窗口；两相结合，确保了二次电芯在循环过程中不易膨胀变形；

[0030] 4)由于阴极极片10的活性物质层与阴极集流体的粘接力大于阳极极片20的活性物质层与阳极集流体的粘接力，因此阴极极片10如果采用三面封闭一面开口的短凹槽，去除阴极活性物质层22困难并且存在虚焊的风险；阴极极片10采用两面封闭两面开口的长凹槽可以采用间隙涂布，焊接面积的增大使得内阻减小，同时减轻了虚焊风险；

[0031] 5)阴极极耳凹槽220使用长凹槽虽然会导致一定的阴极活性物质损失，但是长凹槽的存在使得电芯厚度方向T上该区域的厚度最小，可以将电芯卷绕完成时的收尾胶50贴在电芯厚度方向T上与阴极极耳凹槽220对应的位置，从而节省出收尾胶50的厚度，使得活性物质层涂布的厚度增加，补偿了电芯密度的损失。

[0032] 在图1所示实施方式中，阳极极片10的卷绕起始段15包括预折段152和与预折段152连接的平铺层150；预折段152与平铺层150平行，且位于平铺层150朝向卷绕中心的一

面，其紧贴平铺层150或与平铺层150之间仅由隔离膜30间隔。阴极极片20的卷绕起始段为与阳极极片10的平铺层150平行的阴极极片卷绕起始层25，阴极极片卷绕起始层25位于平铺层150背向卷绕中心的一面，且在电芯厚度方向T上与预折段152无重叠。预折段152的自由端为阳极极片卷绕起始端A，阴极极片卷绕起始层25的自由端为阴极极片卷绕起始端B，二者在电芯厚度方向T上仅由阳极极片10的平铺层150和隔离膜30间隔，在电芯宽度方向L（即与电芯厚度方向T垂直的卷绕方向，参见之前的说明，L与L1、L2并不相同）上二者位置接近却无重叠，优选距离s为0～4mm。

[0033] 由于阳极极片10的预折段152与阴极极片卷绕起始层25在电芯厚度方向T上无重叠，因此，预折段152不仅不会增加电芯的厚度，而且可以大致补足阴极极片卷绕起始层25比阳极极片10的平铺层150短而造成的电芯厚度不均，使得电芯更为平整，在充放电时也就不再容易变形。另外，预折段152在电芯厚度方向T上有一面与平铺层150相对，仅有背向平铺层150的一面与阴极极片20相对，因此只需在预折段152的自由端背向平铺层150的一面粘贴胶纸即可，朝向平铺层150的一面则无需粘贴胶纸，这无疑比现有技术减少了胶纸的用量，在节约成本的同时，进一步减小了电芯厚度。

[0034] 在图示实施方式中，阳极极片10的卷绕起始段15为单面涂覆阳极活性物质层12的阳极集流体11，阴极极片卷绕起始层25则为双面涂覆阴极活性物质层22的阴极集流体21。但是，在其他可替换的实施方式中，阳极极片10的卷绕起始段15和阴极极片卷绕起始层25中的一个或两个也可以是双面均不涂覆活性物质层12、22的空白集流体，这些是根据需要设置的，本实用新型的改进点并不对此造成限制和影响。

[0035] 隔离膜30设有隔离膜卷绕起始层31和与隔离膜卷绕起始层31相连的隔离膜卷绕次层32，二者均为双层膜结构。隔离膜卷绕起始层31为起始点相连的两层膜，其在电芯宽度方向T上基本铺满，且两层膜之间因没有设置阳极极片10和阴极极片20而彼此贴紧；在电芯厚度方向T上，隔离膜卷绕起始层31与阳极极耳13、阴极极耳23均重叠。阳极极片10的卷绕起始段15（包括平铺层150和预折段152）全部位于隔离膜卷绕起始层31与隔离膜卷绕次层32之间，阴极极片卷绕起始层25则位于隔离膜卷绕次层32的两层膜之间。

[0036] 易于理解的是，在其他实施方式中，阳极极片10、隔离膜30和阴极极片20的卷绕方式可以有多种变化，这并不会影响本实用新型的实施。

[0037] 根据上述原理，本实用新型还可以对上述实施方式进行适当的变更和修改。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。

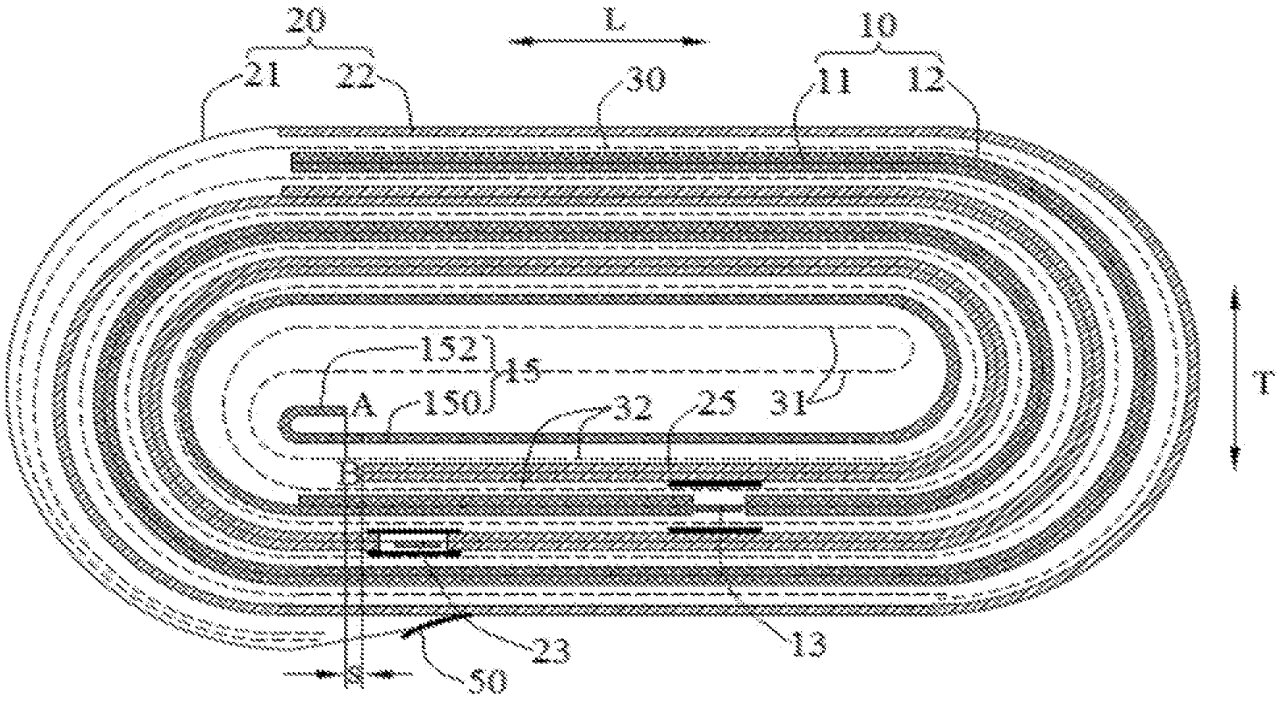

20
L
10
21
22
30
11
12
152
15
A
150
32
25
31
T
23
13
50

图1

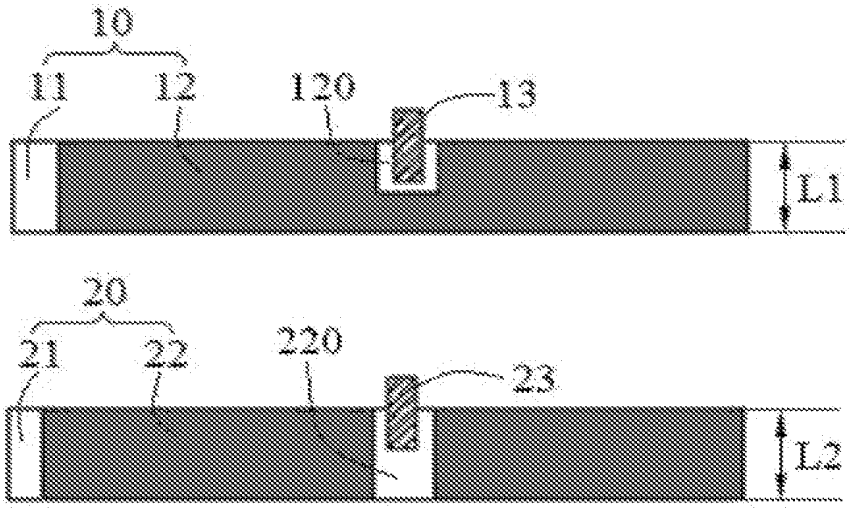

10
11
12
120
13
L1
20
21
22
220
23
L2

图2

(19)中华人民共和国国家知识产权局

(12)实用新型专利

(10)授权公告号 CN 205828573 U
(45)授权公告日 2016.12.21

(21)申请号 201620639646.9

(22)申请日 2016.06.24

(73)专利权人 宁德新能源科技有限公司
地址 352100 福建省宁德市蕉城区漳湾镇新港路1号

(72)发明人 郭培培 肖良针 高伟 王可飞 赵义 何平

(74)专利代理机构 北京五洲洋和知识产权代理事务所(普通合伙) 11387
代理人 张向瑶

(51)Int.Cl.
H01M 10/0587(2010.01)
H01M 10/0525(2010.01)
H01M 4/13(2010.01)
H01M 2/26(2006.01)
H01M 4/70(2006.01)

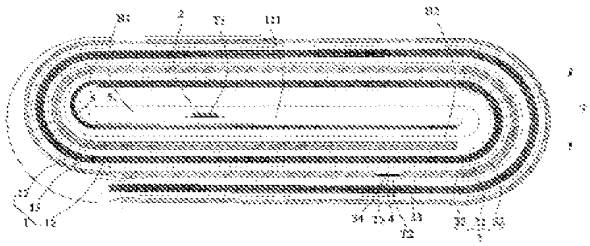
权利要求书2页 说明书7页 附图9页

(54)实用新型名称

卷绕式电芯

(57)摘要

本实用新型提供了一种卷绕式电芯，其包括：第一极片、第一极耳、第二极片、第二极耳以及隔离膜。第一极片包括第一集流体和第一活性物质层。第二极片包括第二集流体和第二活性物质层。第一极片的第一卷绕起始段的第一集流体的正反两个表面上均未涂覆第一活性物质层并定义为第一头部空白集流体，第一头部空白集流体焊接于一个第一极耳。第二极片形成有第二极耳收容凹槽，第二极耳收容凹槽的底部为第二集流体而周侧为第二活性物质层，第二极耳收容于第二极耳收容凹槽内并电连接于第二极耳收容凹槽处的第二集流体。本实用新型的卷绕式电芯提高了卷绕式电芯的容量密度并降低了内阻，且解决了电芯在循环使用过程中容易变形、循环膨胀率较大的问题。



CN 205828573 U

1.一种卷绕式电芯，包括：

第一极片(1)，包括：

第一集流体(11)；以及

第一活性物质层(12)，涂覆在第一集流体(11)的表面上；

第一极耳(2)；

第二极片(3)，包括：

第二集流体(31)；以及

第二活性物质层(32)，涂覆在第二集流体(31)的表面上；

第二极耳(4)；

隔离膜(5)，设置于第一极片(1)和第二极片(3)之间，以将第一极片(1)和第二极片(3)隔离开；

其特征在于，

第一极片(1)具有第一卷绕起始段(B1)，第一卷绕起始段(B1)的第一集流体(11)的正反两个表面上均未涂覆第一活性物质层(12)并定义为第一头部空白集流体(111)，第一极耳(2)固定于第一头部空白集流体(111)；

第二极片(3)的中部形成有第二极耳收容凹槽(33)，第二极耳收容凹槽(33)的底部为第二集流体(31)而周侧为第二活性物质层(32)，第二极耳(4)收容于第二极耳收容凹槽(33)内并电连接于第二极耳收容凹槽(33)处的第二集流体(31)。

2.根据权利要求1所述的卷绕式电芯，其特征在于，

第二极耳收容凹槽(33)的周侧为三边封闭一边开口；或

第二极耳收容凹槽(33)的周侧为两边封闭两边开口。

3.根据权利要求1所述的卷绕式电芯，其特征在于，

第二极片(3)具有第二卷绕起始段(B2)；

第一卷绕起始段(B1)和第二卷绕起始段(B2)在长度方向上分别朝着不同的方向延伸；或

第一卷绕起始段(B1)和第二卷绕起始段(B2)在长度方向上朝着相同的方向延伸。

4.根据权利要求3所述的卷绕式电芯，其特征在于，

第二卷绕起始段(B2)的第二集流体(31)两个表面上均涂覆有第二活性物质层(32)。

5.根据权利要求3所述的卷绕式电芯，其特征在于，

第一极片(1)还具有：第一卷绕收尾段(D1)，第一卷绕收尾段(D1)的第一集流体(11)的正反两个表面均未涂覆第一活性物质层(12)并定义为第一尾部空白集流体(112)。

6.根据权利要求5所述的卷绕式电芯，其特征在于，

第一极耳(2)为两个；

一个第一极耳(2)焊接于第一头部空白集流体(111)，另一个第一极耳(2)焊接于第一尾部空白集流体(112)。

7.根据权利要求1~6中任一项所述的卷绕式电芯，其特征在于，卷绕式电芯还包括：第三极耳(6)，焊接于第一极耳(2)的引出到卷绕式电芯外部的一端，且第三极耳(6)的宽度小于第一极耳(2)的宽度，第三极耳(6)的厚度大于第一极耳(2)的厚度。

8.根据权利要求1~6中任一项所述的卷绕式电芯，其特征在于，

卷绕式电芯还包括：第四极耳(7)，焊接于第二极耳(4)的引出到卷绕式电芯外部的一端，且第四极耳(7)的宽度小于第二极耳宽度，第四极耳(7)的厚度大于第二极耳的厚度。

9.根据权利要求1所述的卷绕式电芯，其特征在于，第二极片(3)还形成有：第二极耳配对凹部(34)，底部为第二集流体(31)而周侧为第二活性物质层(32)，位于第二极耳收容凹槽(33)的正对背侧。

10.根据权利要求1-6中任一项所述的卷绕式电芯，其特征在于，第一极片(1)为正极极片而第二极片(3)为负极极片，第一集流体(11)为正极集流体而第二集流体(31)为负极集流体，第一活性物质层(12)为正极活性物质层而第二活性物质层(32)为负极活性物质层；或者

第一极片(1)为负极极片而第二极片(3)为正极极片，第一集流体(11)为负极集流体而第二集流体(31)为正极集流体，第一活性物质层(12)为负极活性物质层而第二活性物质层(32)为正极活性物质层。

卷绕式电芯

技术领域

[0001] 本发明涉及电池领域，尤其涉及一种卷绕式电芯。

背景技术

[0002] 图14是现有技术中的卷绕式电芯的在一实施例中的卷绕示意图。卷绕式电芯包括第一极片1、第一极耳2、第二极片3、第二极耳4以及隔离膜5。其中，第一极片1的头部(即第一卷绕起始段B1)和第二极片3的头部(即第二卷绕起始段B2)均为空白集流体，第一极耳2和第二极耳4分别焊接于第一极片1和第二极片3的头部的空白集流体上，然后在第一极耳2和第二极耳4上分别粘贴绝缘胶。图15是现有技术中的卷绕式电芯的在另一实施例中的卷绕示意图，其中，第一极片1的中部和第二极片3的中部分别开设有第一极耳收容凹槽13和第二极耳收容凹槽33，并且第一极耳2和第二极耳4分别收容于第一极片1上的第一极耳收容凹槽13内和第二极片3上的第二极耳收容凹槽33内。

[0003] 图14中的卷绕式电芯会造成第一极耳2所在位置和第二极耳4所在位置成为电池的最大厚度区，而第一极耳2和第二极耳4以外的卷绕式电芯的尺寸空间白白浪费，进而导致电芯能量密度较低。此外，由于第一极耳2和第二极耳4分别位于第一极片1的头部和第二极片3的头部，从而导致卷绕式电芯的直流电阻(DCR)较大。图15中的卷绕式电芯在循环过程中容易变形，循环膨胀率较大。

发明内容

[0004] 鉴于背景技术中存在的问题，本发明的目的在于提供一种卷绕式电芯，其提升了电芯的容量密度并减小了内阻，同时解决了电芯在循环使用过程中容易变形、循环膨胀率较大的问题。

[0005] 为了实现上述目的，本发明提供了一种卷绕式电芯，其包括：第一极片、第一极耳、第二极片、第二极耳以及隔离膜。

[0006] 第一极片包括：第一集流体；以及第一活性物质层，涂覆在第一集流体的表面上。第二极片包括：第二集流体；以及第二活性物质层，涂覆在第二集流体的表面上。隔离膜设置于第一极片和第二极片之间，以将第一极片和第二极片隔离开。

[0007] 其中，第一极片具有第一卷绕起始段，第一卷绕起始段的第一集流体的正反两个表面上均未涂覆第一活性物质层并定义为第一头部空白集流体，第一极耳固定于第一头部空白集流体。第二极片的中部形成有第二极耳收容凹槽，第二极耳收容凹槽的底部为第二集流体而周侧为第二活性物质层，第二极耳收容于第二极耳收容凹槽内并电连接于第二极耳收容凹槽处的第二集流体。

[0008] 本发明的有益效果如下：

[0009] 在根据本发明的卷绕式电芯中，第一极耳焊接于第一头部空白集流体，第二极片的中部形成有第二极耳收容凹槽，第二极耳收容于第二极耳收容凹槽内并电连接于第二极耳收容凹槽处的第二集流体。本发明的卷绕式电芯与现有技术中图14所示的卷绕式电芯相

比，由于未将第一极耳和第二极耳同时设置在相应极片的头部，从而明显降低了卷绕式电芯的内阻同时提高了电芯的能量密度。本发明的卷绕式电芯与现有技术中图15所示的卷绕式电芯相比，在卷绕式电芯循环使用过程中更不容易变形，并降低了循环膨胀率。

附图说明

[0010] 图1是根据本发明的卷绕式电芯的在一实施例中的卷绕示意图；

[0011] 图2是图1中的第二极片展开后的示意图；

[0012] 图3是图2的仰视图；

[0013] 图4是图3的变形图；

[0014] 图5是图1中的第一极片展开后的示意图；

[0015] 图6是图5的俯视图；

[0016] 图7是根据本发明的卷绕式电芯的在另一实施例中的卷绕示意图；

[0017] 图8是图7的变形图，其中第一极耳为两个；

[0018] 图9是图7的另一变形图；

[0019] 图10是图1中的第一极耳与第三极耳的焊接立体示意图；

[0020] 图11是图8中的第一极耳与第三极耳的焊接立体示意图；

[0021] 图12是图1中的第二极耳与第四极耳的焊接立体示意图；

[0022] 图13是图12的变形图，其中第二极耳为两个；

[0023] 图14是现有技术中的卷绕式电芯的在一实施例中的卷绕示意图；

[0024] 图15是现有技术中的卷绕式电芯的在另一实施例中的卷绕示意图。

[0025] 其中，附图标记说明如下：

[0026] 1 第一极片

[0027] 11 第一集流体

[0028] 111 第一空白集流体

[0029] 12 第一活性物质层

[0030] 13 第一极耳收容凹槽

[0031] B1 第一卷绕起始段

[0032] D1 第一卷绕收尾段

[0033] 2 第一极耳

[0034] 3 第二极片

[0035] 31 第二集流体

[0036] 32 第二活性物质层

[0037] 33 第二极耳收容凹槽

[0038] 34 第二极耳配对凹部

B2 第二卷绕起始段

D2 第二卷绕收尾段

4 第二极耳

5 隔离膜

T1 第一极耳用双面绝缘胶带

T2 第二极耳收容凹槽用双面绝缘胶带

T3 第二极耳配对凹部用双面绝缘胶带

6 第三极耳

7 第四极耳

T 厚度方向

具体实施方式

[0039] 下面参照附图来详细说明根据本发明的卷绕式电芯。

[0040] 参照图1，图7、图8和图9，根据本发明的卷绕式电芯包括：第一极片1、第一极耳2、第二极片3、第二极耳4以及隔离膜5。

[0041] 第一极片1包括：第一集流体11；以及第一活性物质层12，涂覆在第一集流体11的表面上。第二极片3包括：第二集流体31；以及第二活性物质层32，涂覆在第二集流体31的表面上。隔离膜5设置于第一极片1和第二极片3之间，以将第一极片1和第二极片3隔离开。

[0042] 其中，第一极片1具有第一卷绕起始段B1，第一卷绕起始段B1的第一集流体11的正反两个表面上均未涂覆第一活性物质层12并定义为第一头部空白集流体111，第一极耳2焊接于第一头部空白集流体111。第二极片3的中部(如下面所述的第二极片3的第二卷绕起始段B2与第二卷绕收尾段D2之间的部分)形成有第二极耳收容凹槽33，第二极耳收容凹槽33的底部为第二集流体31而周侧为第二活性物质层32，第二极耳4收容于第二极耳收容凹槽33内并电连接于第二极耳收容凹槽33处的第二集流体31。

[0043] 在根据本发明的卷绕式电芯中，第一极耳2固定于(例如焊接，粘接)第一头部空白集流体111，第二极耳4收容于第二极片3中部的第二极耳收容凹槽33内并电连接于第二极耳收容凹槽33处的第二集流体31。本发明的卷绕式电芯与现有技术中图13所示的卷绕式电芯相比，由于未将第一极耳2和第二极耳4同时设置在相应极片的卷绕起始段，从而明显降低了卷绕式电芯的内阻同时提高了电芯的能量密度。本发明的卷绕式电芯与现有技术中图14所示的卷绕式电芯相比，在卷绕式电芯循环使用过程中更不容易变形，并降低了电芯的循环膨胀率。

[0044] 根据本发明的卷绕式电芯，在一实施例中，参照图3，第二极耳收容凹槽33的周侧可为三边封闭一边开口。

[0045] 在一实施例中，参照图4，第二极耳收容凹槽33的周侧可为两边封闭两边开口。卷绕式电芯在充放电后，第二活性物质层32不仅会沿着第二极片3的厚度方向(即卷绕式电芯的厚度方向T)发生膨胀，从而增加卷绕式电芯的厚度，而且第二活性物质层32还会沿着第二极片3的长度方向发生膨胀，从而对厚度方向T产生挤压进而进一步增加卷绕式电芯的厚度。由于第二极耳收容凹槽33的周侧为两边封闭两边开口，从而使沿着第二极片3的长度方向的膨胀力得到有效释放，从而不会对厚度方向T产生挤压，在一定程度上减小了卷绕式电芯的厚度。

[0046] 在一实施例中，参照图1，图7、图8和图9，第二极片3具有第二卷绕起始段B2。第一卷绕起始段B1和第二卷绕起始段B2在长度方向上可分别朝着不同的方向延伸(如图1、图7、图8和图9所示)。或者，第一卷绕起始段B1和第二卷绕起始段B2在长度方向上如图14和图15所示的那样朝着相同的方向延伸。

[0047] 在一实施例中，第二卷绕起始段B2的第二集流体31的两个表面上均涂覆有第二活性物质层32。第二活性物质层32涂覆在第二卷绕起始段B2的第二集流体31的两面上提高了卷绕式电芯的能量密度。

[0048] 在一实施例中，参照图7、图8和图9，第一极片1还可具有：第一卷绕收尾段D1，第一卷绕收尾段D1的第一集流体11的两面均未涂覆第一活性物质层12并定义为第一尾部空白集流体112。

[0049] 在一实施例中，参照图8和图9，第一极耳2可为两个，两个第一极耳2在卷绕式电芯的厚度方向T上大致对齐。其中一个第一极耳2焊接于第一头部空白集流体111，另一个第一极耳2焊接于第一尾部空白集流体112，从而减小了卷绕式电芯的直流电阻(DCR)和电芯在充放电时的产热量，且电芯的电流密度分布更均匀。

[0050] 在一实施例中，参照图10和图11，卷绕式电芯还可包括：第三极耳6，焊接于第一极耳2的引出到卷绕式电芯外部的一端。

[0051] 在一实施例中，第三极耳6的宽度小于第一极耳2的宽度，并且第三极耳6的厚度大于第一极耳2的厚度，从而在保证第三极耳6的强度和过流截面积的同时减小了第一极耳2焊接后电芯的最大厚度，提高了电芯的能量密度。

[0052] 在一实施例中，参照图1和图8，第二极片3还可具有：第二卷绕收尾段D2，其中第二卷绕收尾段D2的第二集流体31的两面可以均涂覆第二活性物质层32或者只在一面涂覆第二活性物质层32或者均未涂覆第二活性物质层32。

[0053] 在一实施例中，第二极耳4可为两个，相应地，第二极耳收容凹槽33为两个。两个第二极耳4分别收容于对应的第二极耳收容凹槽33中，且在卷绕式电芯的厚度方向T上大致对齐。

[0054] 在这里补充说明的是，当第一极耳2和第二极耳4的数量适当地增加时，卷绕式电芯的充放电倍率也相应地增加。

[0055] 在一实施例中，参照图12和图13，卷绕式电芯还可包括：第四极耳7，焊接于第二极耳4的引出到卷绕式电芯外部的一端。

[0056] 在一实施例中，第四极耳7的宽度小于第二极耳4的宽度，并且第四极耳7的厚度大于第二极耳4的厚度，从而在保证第四极耳7的强度和过流截面积的同时减小了第二极耳4焊接后电芯的最大厚度，提高了电芯的能量密度。

[0057] 在这里补充说明的是，第二极片3的中部形成有第二极耳收容凹槽33指的是第二极耳收容凹槽33设置于第二极片3的处于第二卷绕起始段B2与第二卷绕收尾段D2之间的部分。优选地，第二极耳收容凹槽33设置于第二极片3的处于第二卷绕起始段B2与第二卷绕收尾段T2之间的中间部分，这是本发明优选的第二极耳收容凹槽33的设置位置，从而可以显著地减小卷绕式电芯的内阻。

[0058] 在一实施例中，第一极耳2可采用超声波焊接、激光焊接或热压焊接方式电连接于第一头部空白集流体111。

[0059] 在一实施例中，第二极耳4可采用超声波焊接、激光焊接或热压焊接方式电连接于第二极耳收容凹槽33处的第二集流体31。

[0060] 在一实施例中，参照图1、图2、图7、图8和图9，第二极片3还形成有：第二极耳配对凹部34，底部为第二集流体31而周侧为第二活性物质层32，位于第二极耳收容凹槽33的正对背侧。与第二极耳收容凹槽33类似，第二极耳配对凹部34的周侧可为三边封闭一边开口，也可为两边封闭两边开口。设置第二极耳配对凹部34有利于第二极耳4焊接于第二极耳收容凹槽33内。

[0061] 在一实施例中，第二极耳收容凹槽33可通过激光清洗或机械清洗将第二活性物质层32的对应部分去除以露出第二集流体31而形成。

[0062] 在一实施例中，第二极耳收容凹槽33可通过涂覆阴极膜片浆料之前预置热敏型发泡胶纸在第二集流体31上、之后涂覆并干燥阴极膜片浆料以形成第二活性物质层32且在干燥阴极膜片浆料时热敏型发泡胶纸从第二集流体31上剥离形成。

[0063] 在一实施例中，第二极耳配对凹部34可通过激光清洗或机械清洗将第二活性物质层32的对应部分去除以露出第二集流体31而形成。

[0064] 在一实施例中，第二极耳配对凹部34可通过涂覆阴极膜片浆料之前预置热敏型发泡胶纸在第二集流体31上、之后涂覆并干燥阴极膜片浆料以形成第二活性物质层32且在干燥阴极膜片浆料时热敏型发泡胶纸从第二集流体31上剥离形成。

[0065] 在一实施例中，所述卷绕式电芯还可包括：第一极耳用双面绝缘胶带T1，在两面上分别粘接隔离膜5和第一极耳2。

[0066] 在一实施例中，所述卷绕式电芯还可包括：第二极耳收容凹槽用双面绝缘胶带T2，覆盖整个第二极耳4及第二极耳4周围的部分第二极耳收容凹槽33。

[0067] 在一实施例中，所述卷绕式电芯还可包括：第二极耳配对凹部用双面绝缘胶带T3，覆盖整个第二极耳配对凹部34，且在两面上分别粘接隔离膜5和第二极耳配对凹部34周围的第二活性物质层32。

[0068] 在这里补充说明的是，由于第一极耳用双面绝缘胶带T1、第二极耳收容凹槽用双面绝缘胶带T2和第二极耳配对凹部用双面绝缘胶带T3均采用双面绝缘胶带，其粘接区域比采用单面绝缘胶带时更紧密，从而使得卷绕式电芯的整体性加强，进而避免卷绕式电芯在整形工序以及充放电膨胀后该区域隆起成为最大变形区。在一实施例中，第一极耳用双面绝缘胶带T1为双面初始时均已有粘性或是一个单面初始时已有粘性而另一单面是经后续的热压或冷压后有粘性的双面胶带。

[0069] 在一实施例中，第二极耳收容凹槽用双面绝缘胶带T2为双面初始时均已有粘性或是一个单面初始时已有粘性而另一单面是经后续的热压或冷压后有粘性的双面胶带。

[0070] 在一实施例中，第二极耳配对凹部用双面绝缘胶带T3为双面初始时均已有粘性或是一个单面初始时已有粘性而另一单面是经后续的热压或冷压后有粘性的双面胶带。

[0071] 在这里补充说明的是，第一极耳用双面绝缘胶带T1、第二极耳收容凹槽用双面绝缘胶带T2和第二极耳配对凹部用双面绝缘胶带T3均包括基材和涂覆在基材的两个表面的胶层。双面初始时均已有粘性的双面胶带的胶层可以为丁苯橡胶层、聚氨酯层、聚丙烯酸酯层或聚偏氟乙烯层。在一个单面初始时已有粘性而另一单面是经后续的热压或冷压后有粘性的双面胶带中，一个单面初始时已有粘性的胶层可以为丁苯橡胶层、聚氨酯层、聚丙烯酸酯层或聚偏氟乙烯层；而另一单面是经后续的热压或冷压后有粘性的胶层可以为常温下无初粘性的温敏胶或常温下无初粘性的压敏胶。

[0072] 在一实施例中，第一极耳2的尺寸可与第二极耳4的尺寸一致。进一步地，第一极耳2的宽度可为6mm，厚度可为0.06mm。第二极耳4的宽度为6mm，厚度为0.06mm。

[0073] 在一实施例中，第一极片1的第一活性物质层12的厚度可为131μm，第二极片3的第二活性物质层32的厚度可为112μm。

[0074] 在一实施例中，第一极片1可为正极极片而第二极片3为负极极片，第一集流体11为正极集流体而第二集流体31为负极集流体，第一活性物质层12为正极活性物质层而第二活性物质层32为负极活性物质层。

[0075] 在一实施例中，第一极片1可为负极极片而第二极片3为正极极片，第一集流体11为负极集流体而第二集流体31为负极集流体，第一活性物质层12为负极活性物质层而第二活性物质层32为正极活性物质层。

[0076] 在这里补充说明的是上述所述的第一极片1的第一卷绕起始段B1为紧邻卷绕中心(即紧邻卷针)沿厚度方向T的一侧的一层第一极片1(第一卷绕起始段B1可仅具有平的部

分，如图1、图7、图8所示；或者该层第一极片1可具有平的部分和从该平的部分回折的回折部分，如图9所示）。第一极片1的第一卷绕收尾段D1为第一极片1处于卷绕式电芯的最外侧一层的第一极片1。第二极片2的第二卷绕起始段B2为紧邻卷绕中心沿厚度方向T的另一侧的一层第二极片2（同样地，第二卷绕起始段B2可仅具有平的部分，如图1、图7、图8所示；或者该层第二极片2可具有平的部分和从该平的部分回折的回折部分，如图9所示）。第二极片2的第二卷绕收尾段D2为第二极片2处于卷绕式电芯的最外侧一层的第二极片2。

[0077] 最后补充说明根据本发明的卷绕式电芯用于软包装锂离子电池并作为举例的实施例和对比例及测试结果。其中，在下面所述的实施例及对比例中第一极片1为负极极片而第二极片3为正极极片。

[0078] 实施例1

[0079] 以464090型号软包装锂离子电池（成品电池厚度为4.6mm、宽度为40mm、长度为90mm）为例，第一极耳2与第二极耳4尺寸一致，即极耳的焊接长度为15mm，极耳宽度为6mm、厚度为0.06mm。

[0080] 采用图1所示的结构，经冷压工序后的极片（第一极片1的单侧第一活性物质层12的厚度为131μm、第二极片3的单侧第二活性物质层32的厚度为112μm），采用超声焊接或钎焊或电阻焊将第一极耳2焊接到第一极片1的第一头部空白集流体111上；采用激光或占位法在第二极片3的中部清洗或预留出用于焊接第二极耳4的第二极耳收容凹槽33和第二极耳配对凹部34，随后采用超声焊接或钎焊或电阻焊将第二极耳4焊接到第二极耳收容凹槽33中。第一活性物质层12采用石墨，第二活性物质层32采用钴酸锂。第二极耳收容凹槽33的周侧为三边封闭一边开口。

[0081] 实施例2

[0082] 与实施例1的不同之处：第二极耳收容凹槽33的周侧为两边封闭两边开口。

[0083] 对比例1

[0084] 采用如图13所示结构，与实施例1的不同之处：第二极片3和第一极片1上没有开设任何凹槽，第一极耳2和第二极耳4分别焊接在第一极片1的第一卷绕起始段B1的第一头部空白集流体111和第二极片3的第二卷绕起始段B2的第二头部空白集流体31上。

[0085] 对比例2

[0086] 采用如图14所示结构，与实施例1的不同之处：第一极片1上开设收容第一极耳2的第一极耳收容凹槽13，第二极片3上开设收容第二极耳4的第二极耳收容凹槽33，并完成第一极耳2与第一极耳收容凹槽13的焊接和第二极耳4与第二极耳收容凹槽33的焊接。

[0087] 在实施例1-2和对比例1-2中分别选取20个软包装锂离子电池样品进行1000个循环充放电测试，对测试前后的样品的厚度进行测量，并且对测试后的软包装锂离子电池样品进行拆解观察析锂的情况，所得结果示如表1所示。

[0088] 容量测试：采用标称电流将电芯充电到标称上限电压，然后再以标称电流放电到截至电压所释放出来的电量。

[0089] 厚度测试：用测厚仪测量。

[0090] 变形量=（测试后平均厚度-测试前厚度）/测试前厚度*100%

[0091] 表1 实施例1-2与对比例1-2的测试结果

[0092]

	平均容量/mAh	测试后的平均厚度/mm	直流电阻/mΩ	变形量/%
实施例 1	2835	4.894	50	6.4%
实施例 2	2825	4.805	49	4.5%
对比例 1	2800	4.899	65	6.5%
对比例 2	2845	4.995	47	8.6%

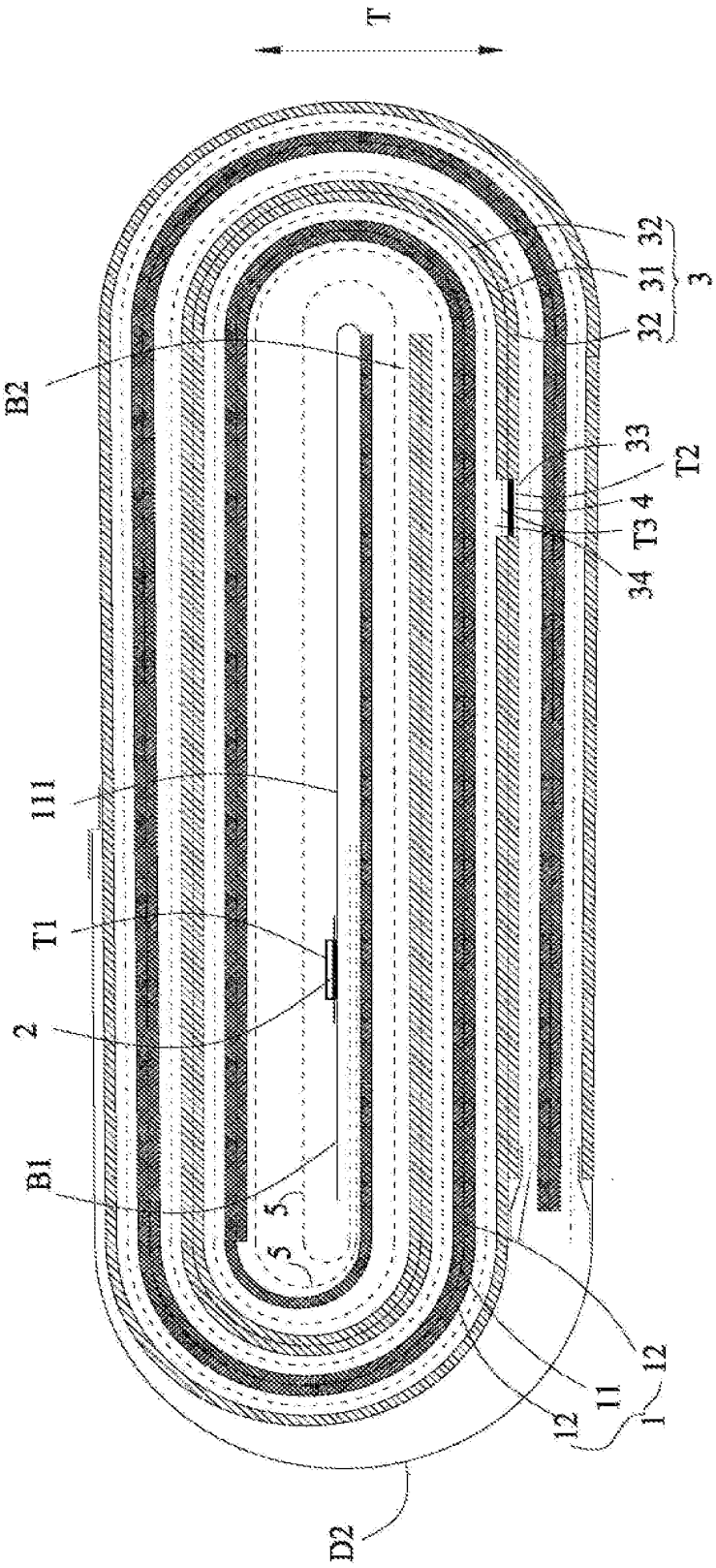

T
B2
111
T1
2
B1
5
3
32
31
32
3
33
T2
4
T3
34
12
11
12
1
D2

图1

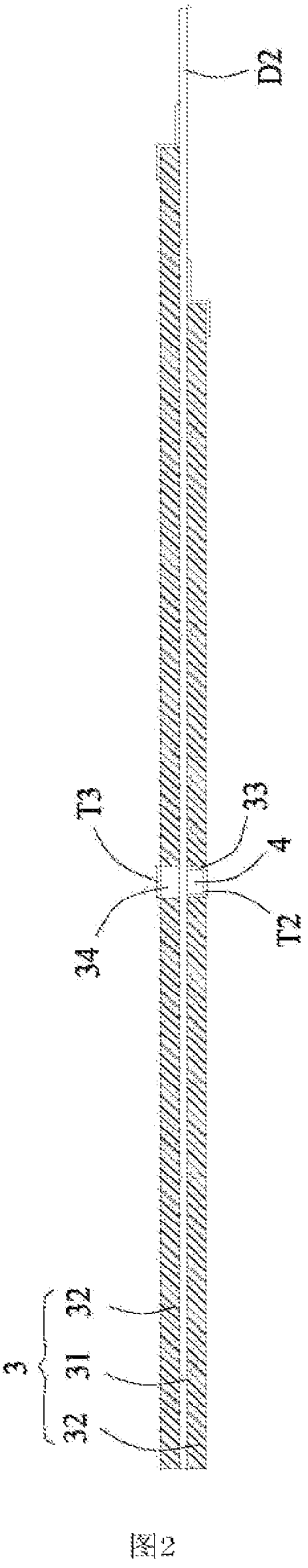

D2
T3
33
4
T2
34
3
32
31
32

图2



图3

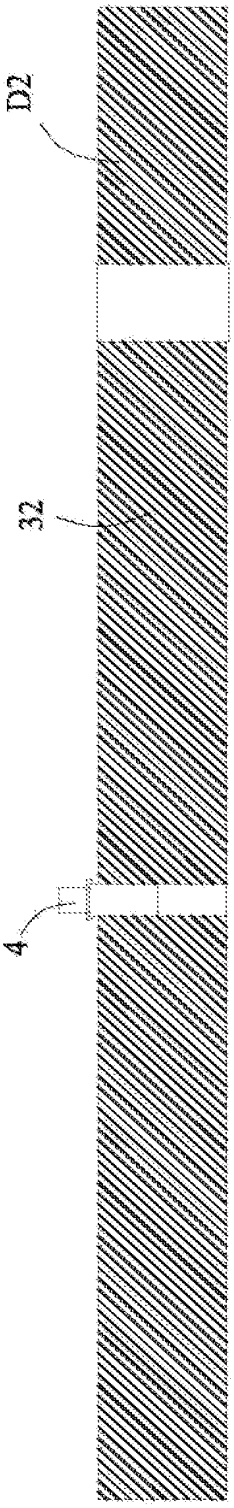


图4

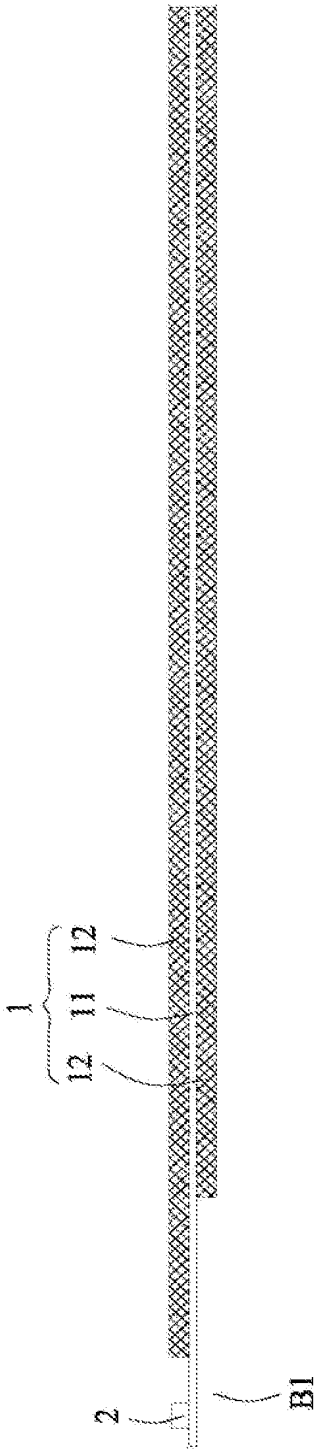


图5

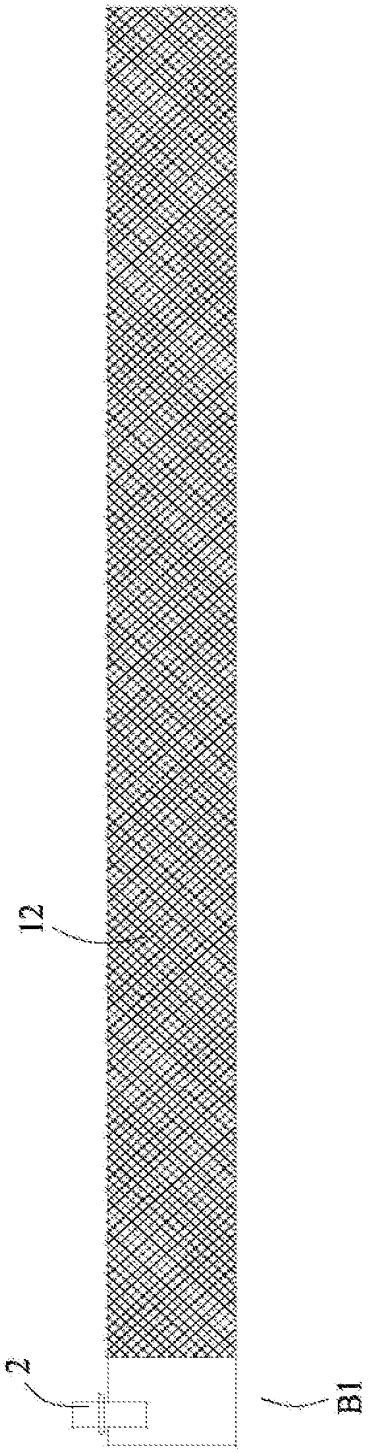


图6

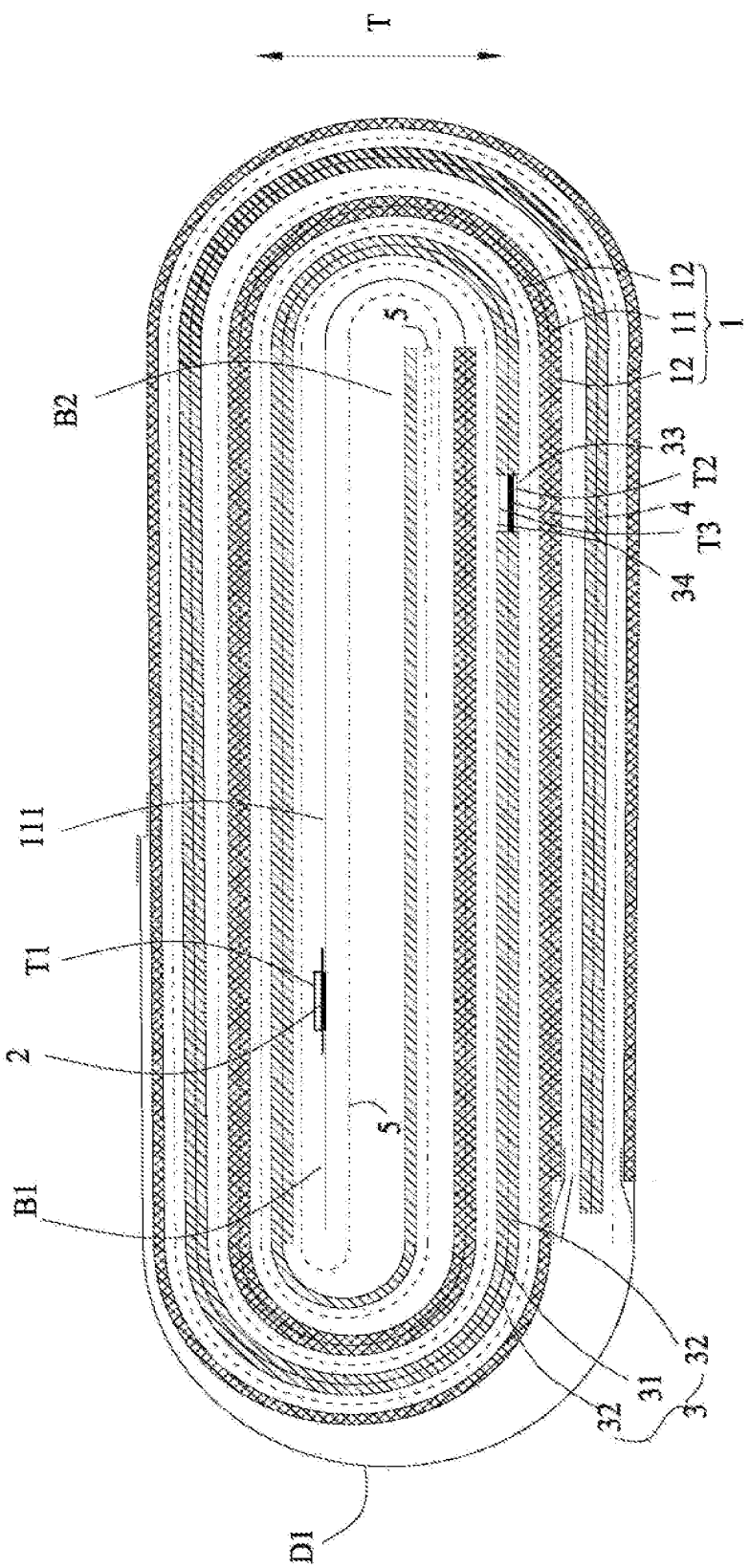


图7

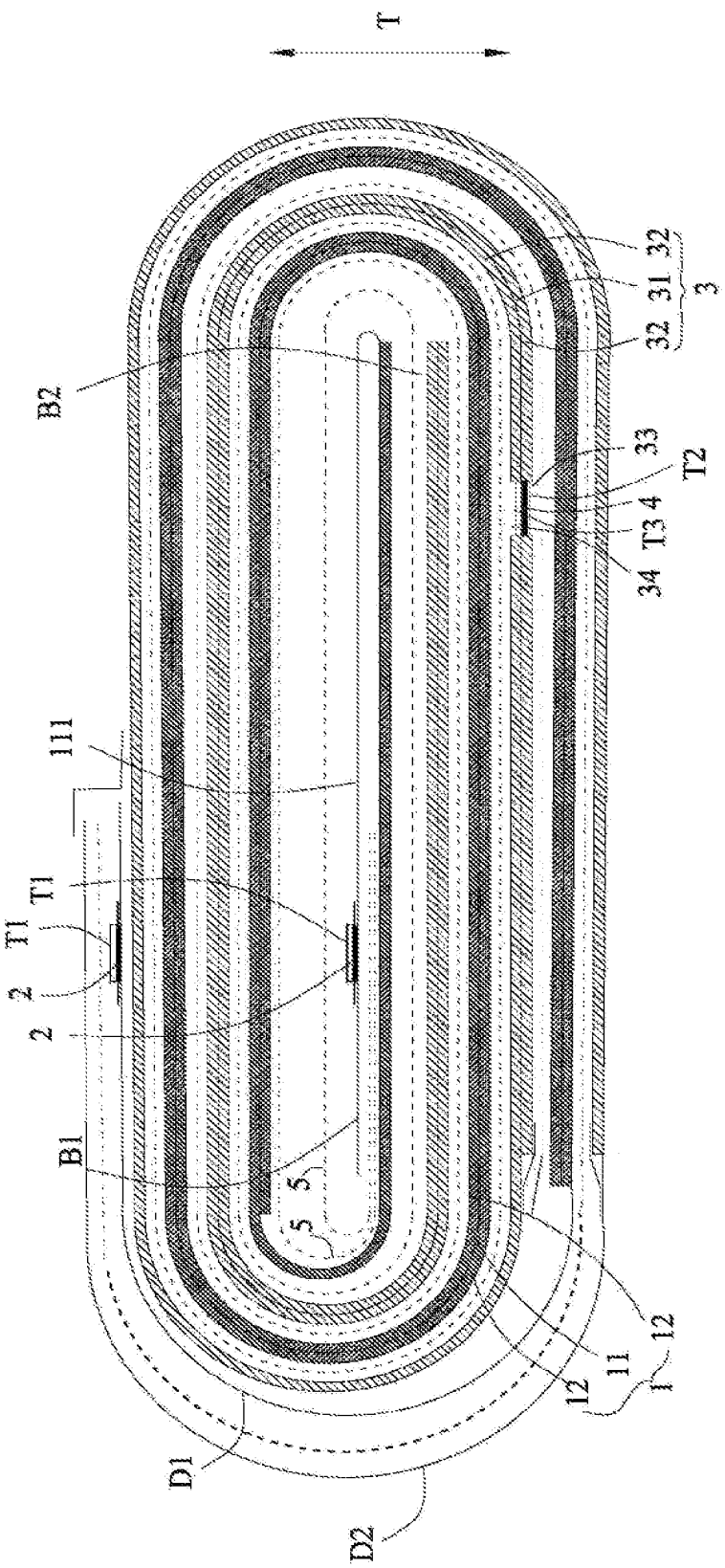


图8

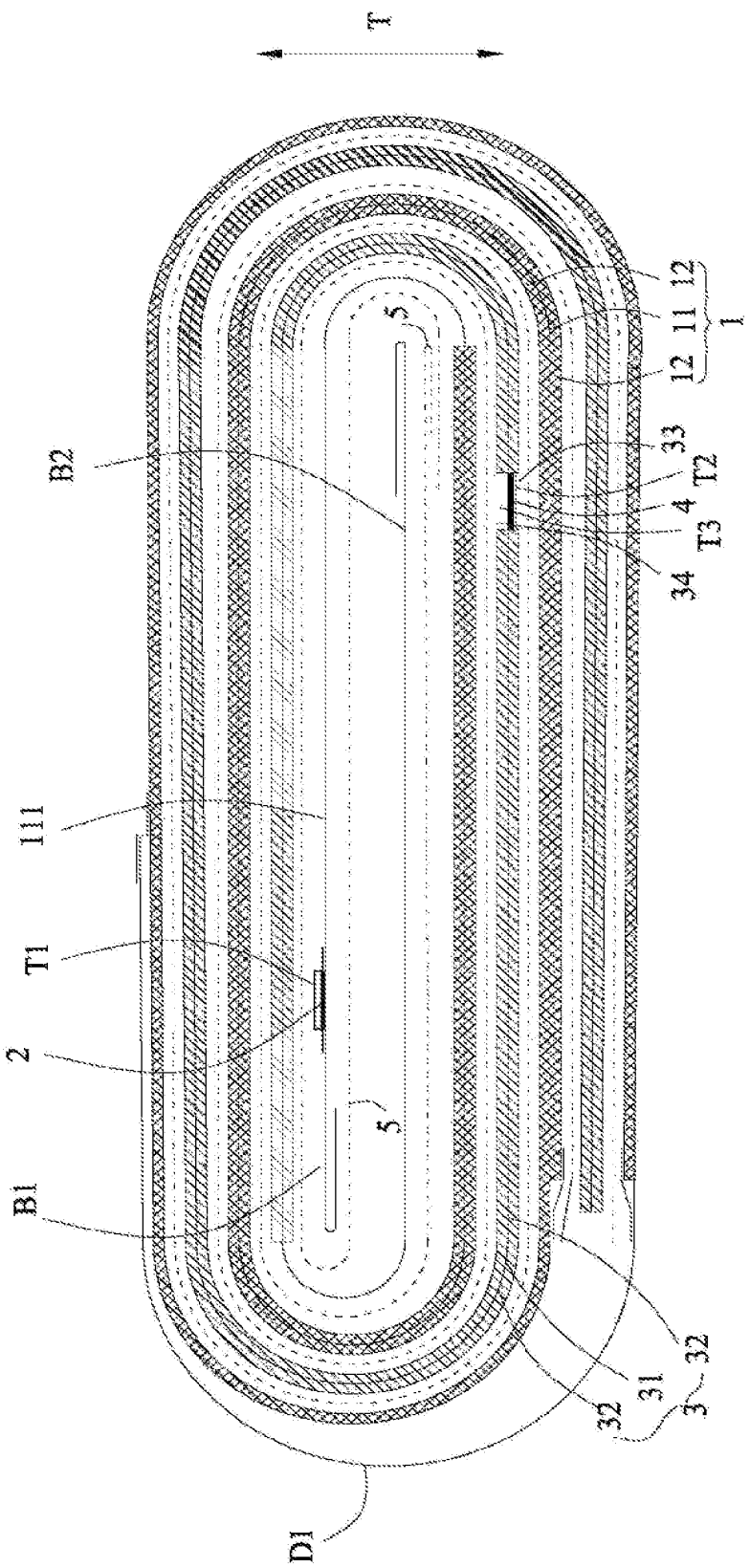


图9

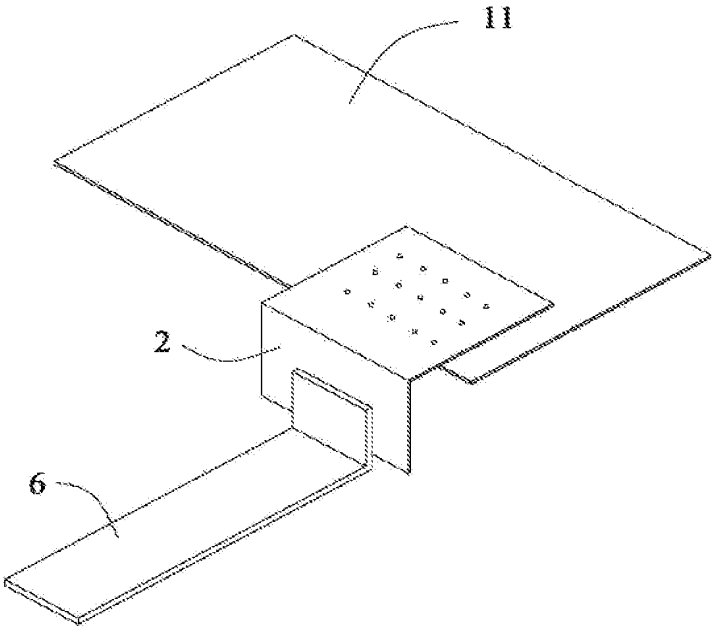


图10

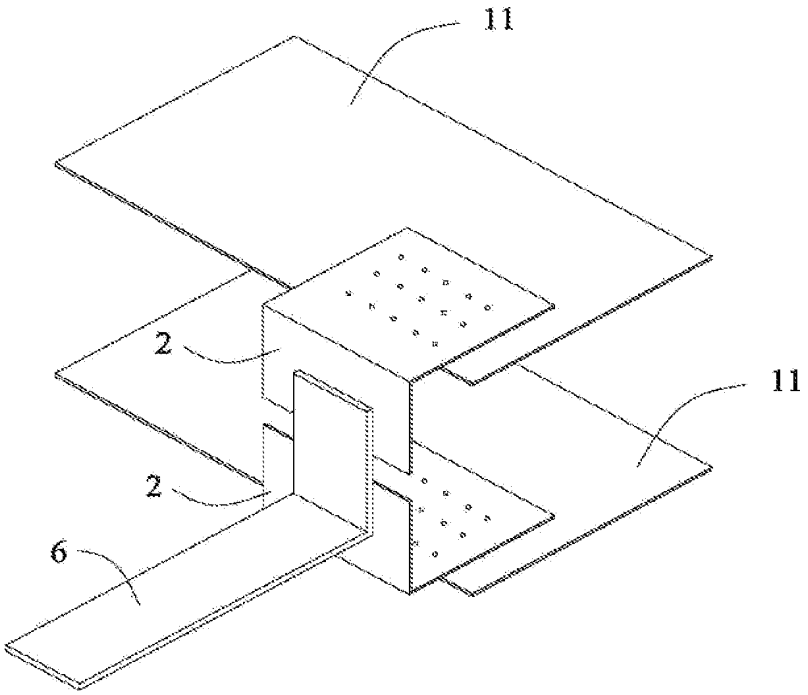


图11

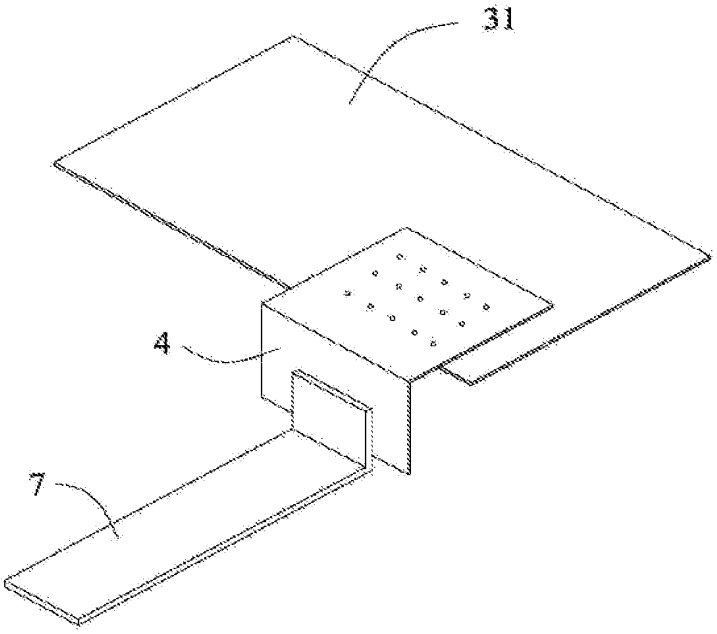


图12

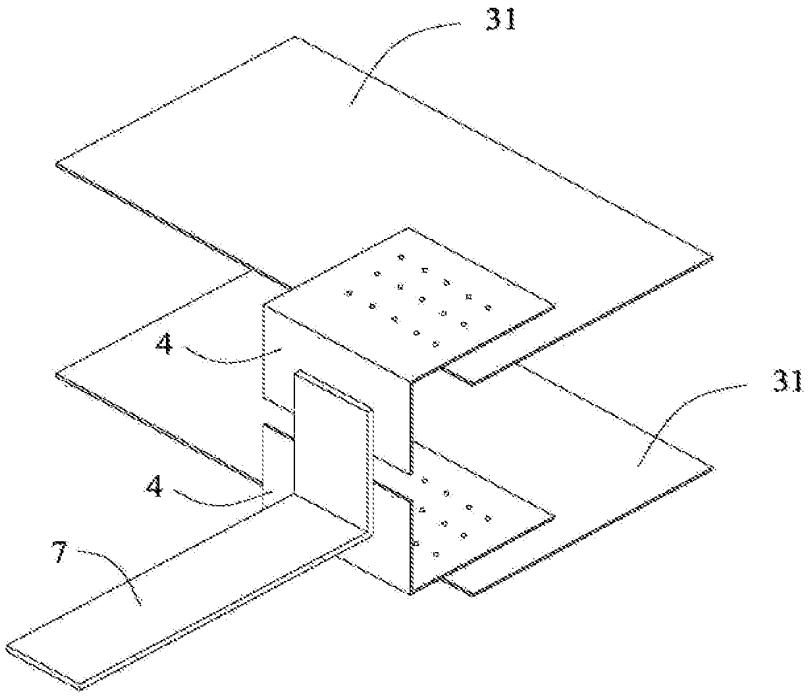


图13

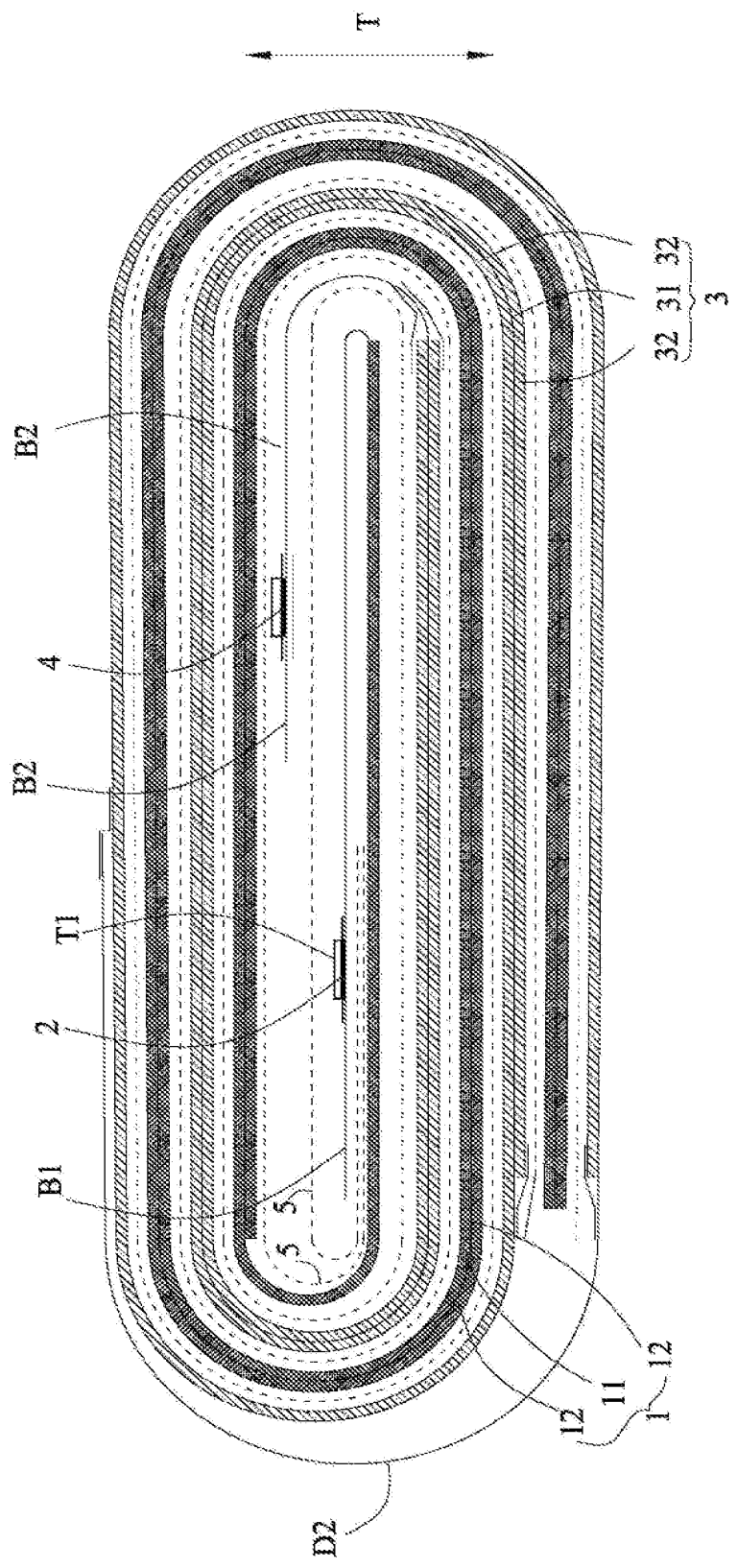


图14

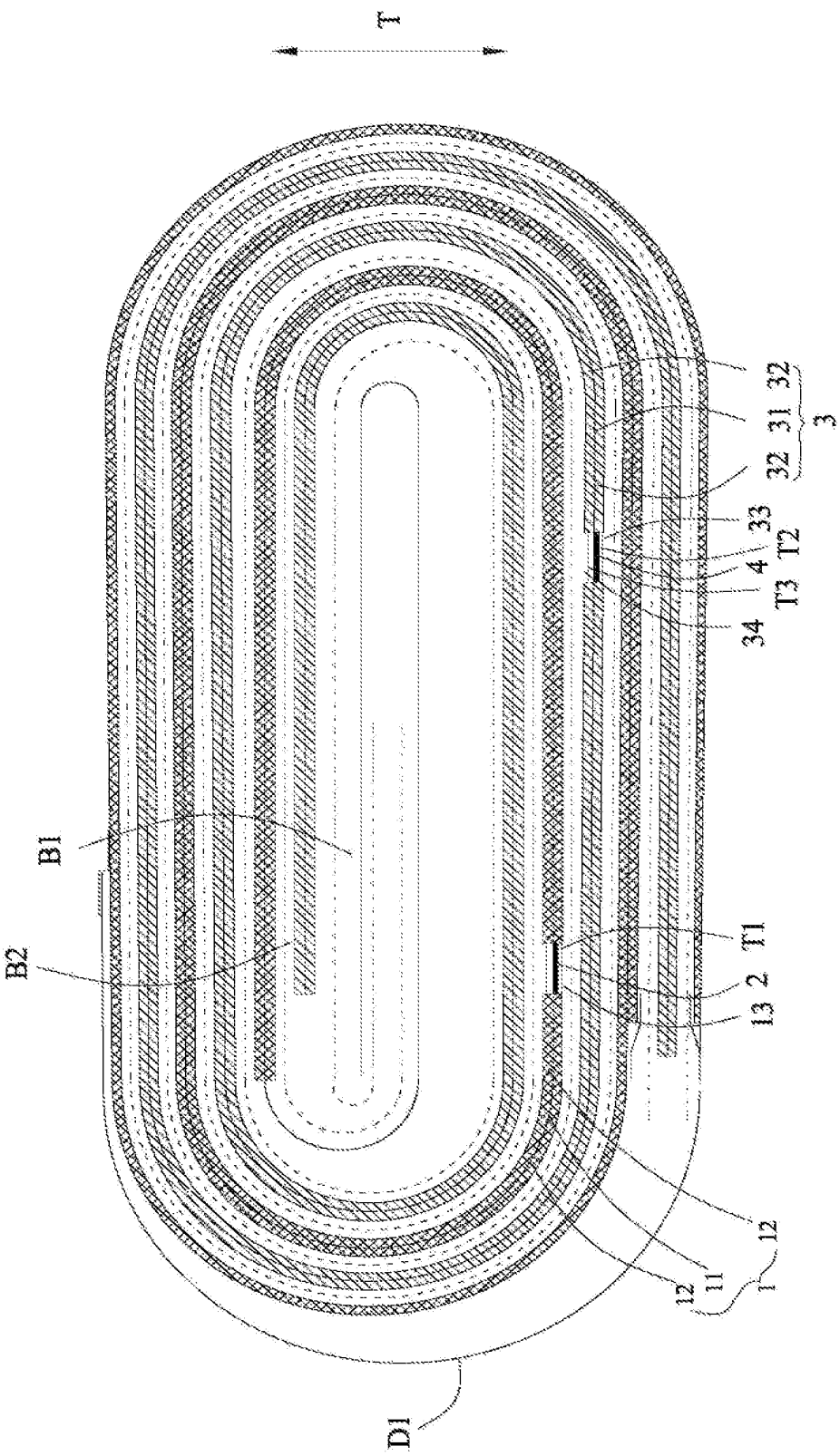


图15

(19)中华人民共和国国家知识产权局

(12)实用新型专利

(10)授权公告号 CN 207459051 U
(45)授权公告日 2018.06.05

(21)申请号 201720829427.1

(22)申请日 2017.07.10

(73)专利权人 东莞市聚和新能源有限公司
地址 523000 广东省东莞市清溪镇罗马村罗马路汉通工业园3A栋1楼

(72)发明人 张习林 李华锋

(51)Int.Cl.
H01M 2/26(2006.01)
H01M 4/13(2010.01)
H01M 10/052(2010.01)

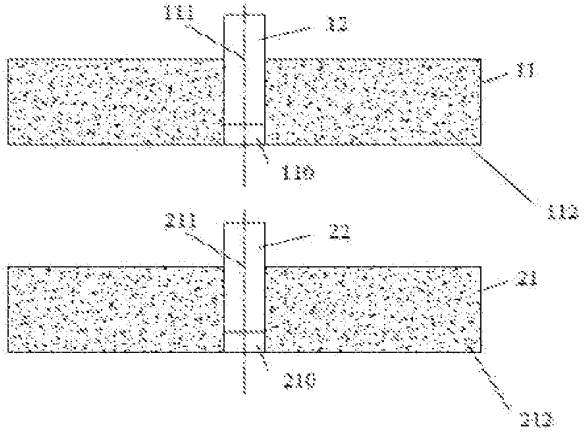
权利要求书1页 说明书4页 附图3页

(54)实用新型名称

一种聚合物电池电极及其电池

(57)摘要

本实用新型涉及电池技术领域，尤其是涉及一种聚合物电池电极及其电池；包括极片、涂布在所述极片上的活性物质和极耳；其特征在于，所述极耳设置在极片上中间位置的极耳留白处，所述极耳的两侧紧邻活性物质，所述极耳的底端与所在极片底端之间留有10-50mm的空白；所述极片上极耳的外表面还设有高温绝缘层；本实用新型不仅提高了生产效率，而且电池内阻、倍率性能均得到大幅度提升。



CN 207459051 U

1.一种聚合物电池电极，包括极片、涂布在所述极片上的活性物质和极耳；其特征在于，所述极耳设置在极片上中间位置的极耳留白处，所述极耳的两侧紧邻活性物质，所述极耳的底端与所在极片底端之间留有10~50mm的空白；所述极片上极耳的外表面还设有高温绝缘层。

2.如权利要求1所述的聚合物电池电极，其特征在于，所述极耳留白设置在所述极片的正中间，所述极耳宽边的中线与所述极片空白宽的中线重叠。

3.如权利要求1所述的聚合物电池电极，其特征在于，所述极耳留白设置在所述极片长边正中偏左的位置，极耳留白靠近正中的一边与极片长边的中线相距5~50mm。

4.如权利要求1所述的聚合物电池电极，其特征在于，所述极耳留白设置在所述极片长边正中偏右的位置，极耳留白靠近正中的一边与极片长边的中线相距5~50mm。

5.如权利要求1~4中任意一项所述的聚合物电池电极，其特征在于，所述极耳宽3~10mm，所述极片长400~1200mm，活性物质在极片上的厚度为0.050~0.070mm。

6.一种聚合物电池，包括正极、负极和正负极之间的隔膜，其特征在于，所述正负极为权利要求1~5中任意一项所述的聚合物电池电极。

7.如权利要求6所述的聚合物电池，其特征在于，所述正负极耳都设置在相应极片上正中偏左的位置。

8.如权利要求6所述的聚合物电池，其特征在于，所述正负极耳都设置在相应极片上正中偏右的位置。

9.如权利要求6所述的聚合物电池，其特征在于，所述正极耳设置在相应极片上正中偏左的位置，所述负极耳设置在相应极片上正中偏右的位置。

10.如权利要求6所述的聚合物电池，其特征在于，所述正极耳设置在相应极片上正中偏右的位置，所述负极耳设置在相应极片上正中偏左的位置。

一种聚合物电池电极及其电池

技术领域

[0001] 本实用新型涉及电池技术领域，尤其是涉及一种高倍率放电聚合物电池电极及其电池。

背景技术

[0002] 高倍率放电聚合物电池是一种可充电电池，主要依靠正负极间锂离子移动进行工作。充电时，锂离子由正极移动到负极；放电时，锂离子由负极移动到正极，正极处于富锂状态。如何进一步提高电池低电阻和高倍率一直是人们追求的目标，人们主要从活性物质和电池结构两个方面进行研究。现有的高倍率放电聚合物电池结构一般分为叠片式和卷绕式，其中，叠片式结构的电极因为多采用极耳叠片方式生产工艺，生产出来的电池内阻相对较低，电池倍率放电性能较好，但是生产效率较低。卷绕式电极生产效率高，但是生产出来的电池内阻较高，倍率放电性能相对较差。

实用新型内容

[0003] 针对上述现有技术的不足，本实用新型的目的于提供了一种聚合物电池电极及其电池；该聚合物电池不仅内阻小，而且倍率放电性能高，同时生产效率高。为了实现上述技术目的，本实用新型的采用如下技术方案：

[0004] 一种聚合物电池电极，包括极片、涂布在所述极片上的活性物质和极耳；所述极耳设置在极片上中间位置的极耳留白处，所述极耳的两侧紧邻活性物质，所述极耳的底端与所在极片底端之间留有10-50mm的空白；所述极片上极耳的外表面还设有高温绝缘层。

[0005] 较佳地，所述极耳留白设置在所述极片的正中间，所述极耳宽边的中线与所述极片空白宽的中线重叠。

[0006] 较佳地，所述极耳留白设置在所述极片长边正中偏左的位置，极耳留白靠近正中的一边与极片长边的中线相距5-50mm。

[0007] 较佳地，所述极耳留白设置在所述极片长边正中偏右的位置，极耳留白靠近正中的一边与极片长边的中线相距5-50mm。

[0008] 较佳地，所述极耳宽3-10mm，所述极片长400-1200mm，活性物质在极片上的厚度为0.050-0.070mm。

[0009] 一种聚合物电池，包括正极、负极和正负极之间的隔膜，所述正负极为所述的聚合物电池电极。

[0010] 较佳地，所述正负极耳都设置在相应极片上正中偏左的位置。

[0011] 较佳地，所述正负极耳都设置在相应极片上正中偏右的位置。

[0012] 较佳地，所述正极耳设置在相应极片上正中偏左的位置，所述负极耳设置在相应极片上正中偏右的位置。

[0013] 较佳地，所述正极耳设置在相应极片上正中偏右的位置，所述负极耳设置在相应极片上正中偏左的位置。

[0014] 本实用新型将极耳设置在极片上中间位置，底端与所在极片底端之间留有10-50mm的空白，让离子向中间位置聚拢，同时极耳的两侧紧邻活性物质，离子也可以直接通过极耳侧边从而节约了部分从电极片导通的路程，大大降低了电阻。其中，试验发现，极耳在所对应极片上偏离正中间的5-50mm的位置，在提高生产效率基础上，电阻、倍率放电性能上表现更好；尤其是正负极耳相对错位的设置。

附图说明

[0015] 图1 为本实用新型实施例1的结构示意图，

[0016] 图2 为本实用新型实施例2的结构示意图，

[0017] 图3 为本实用新型实施例3的结构示意图，

[0018] 图4 为本实用新型实施例4-7的结构示意图，

[0019] 图5 为本实用新型实施例8-11的结构示意图。

具体实施方式

[0020] 下面结合附图对本实用新型的具体实施方式作进一步的详细说明。

[0021] 实施例1

[0022] 见图1，一种聚合物电池，包括正极1、负极2和正负极之间的隔膜。正负极包括极片11、涂布在所述极片上的活性物质(112、212)和极耳12，正负极耳(12、22)都设置在相应极片(11、21)上正中(111、211)的位置，正负极耳的两侧紧邻活性物质(112、212)，正负极耳的底端与其所在相应极片底端之间留有30mm的空白(110、210)；正负极耳的外表面还设有高温绝缘层。

[0023] 其中正负极耳宽3-10mm，所述极片长400-1200mm，活性物质在极片上的厚度为0.050-0.070mm。极耳和极片的参数可以根据所制备电池实际的大小的需要进行调节。

[0024] 实施例2

[0025] 见图2，一种聚合物电池，包括正极1、负极2和正负极之间的隔膜。正负极包括极片、涂布在所述极片上的活性物质(112、212)和极耳，正负极耳(12、22)都设置在相应极片(11、21)上正中(111、211)偏左10mm的位置，正负极耳(12、22)的两侧紧邻活性物质(112、212)，正负极耳(12、22)的底端与其所在相应极片底端之间留有10mm的空白(110、210)； 正负极耳的外表面还设有高温绝缘层。

[0026] 实施例3

[0027] 见图3，一种聚合物电池，包括正极1、负极2和正负极之间的隔膜。正负极包括极片、涂布在所述极片上的活性物质(112、212)和极耳，正负极耳(12、22)都设置在相应极片(11、21)上正中(111、211)正中偏右10mm的位置，正负极耳(12、22)的两侧紧邻活性物质(112、212)，正负极耳(12、22)的底端与其所在相应极片底端之间留有50mm的空白(110、210)； 正负极耳的外表面还设有高温绝缘层。

[0028] 实施例4

[0029] 见图4，一种聚合物电池，包括正极、负极和正负极之间的隔膜。正负极包括极片11、涂布在所述极片上的活性物质112和极耳12，正极耳12设置在相应极片上正中111偏右10mm的位置，正负耳的底端与其所在相应极片底端之间留有25mm的空白120，正极耳12的两

侧紧邻活性物质112。负极耳22设置在相应极片上正中211偏左10mm的位置。负极耳22的两侧紧邻活性物质212，负极耳22的底端与其所在相应极片21底端之间留有25mm的空白210；正负极耳的外表面还设有高温绝缘层。

[0030] 实施例5

[0031] 同实施例4，区在于正极耳12设置在相应极11片上正中111偏左5mm的位置，负极耳22设置在相应极片21上正中211偏右5mm的位置。

[0032] 实施例6

[0033] 同实施例4，区在于正极耳12设置在相应极片11上正中111偏左50mm的位置，负极耳22设置在相应极片21上正中211偏右50mm的位置。

[0034] 实施例7

[0035] 同实施例4，区在于正极耳12设置在相应极片11上正中111偏左5mm的位置，负极耳22设置在相应极片21上正中211偏右20mm的位置。

[0036] 实施例8

[0037] 见图5，一种聚合物电池，包括正极、负极和正负极之间的隔膜。正负极包括极片、涂布在所述极片上的活性物质和极耳，正极耳12设置在相应极11片上正中111偏左30mm的位置，正极耳12的两侧紧邻活性物质112，正极耳12的底端与其所在相应极片11底端之间留有20mm的空白110。负极耳22设置在相应极片21上正中211偏有30mm的位置，负极耳22的两侧紧邻活性物质222，负极耳22的底端与其所在相应极片21底端之间留有20mm的空白210；正负极耳的外表面还设有高温绝缘层。

[0038] 实施例9

[0039] 同实施例8，区在于正极耳12设置在相应极片11上正中111偏左40mm的位置，负极耳22设置在相应极片21上正中211偏右40mm的位置。

[0040] 实施例10

[0041] 同实施例8，区在于正极耳12设置在相应极片11上正中111偏左15mm的位置，负极耳22设置在相应极片21上正中211偏右15mm的位置。

[0042] 实施例11

[0043] 同实施例8，区在于正极耳12设置在相应极片11上正中111偏左25mm的位置，负极耳22设置在相应极片21上正中211偏右25mm的位置

[0044] 对比例1-1

[0045] 同实施例5，正极耳设置在相应极片上正中偏左100mm的位置，负极耳设置在相应极片上正中偏右100mm的位置。

[0046] 对比例1-2

[0047] 同实施例5，正极耳设置在相应极片上正中偏左300mm的位置，负极耳设置在相应极片上正中偏右300mm的位置。

[0048] 对比例1-3

[0049] 同实施例5，正极耳设置在相应极片上正中偏左500mm的位置，负极耳设置在相应极片上正中偏右500mm的位置。

[0050] 对比例2-1

[0051] 同实施例8，正极耳设置在相应极片上正中偏左100mm的位置，负极耳设置在相应

极片上正中偏右100mm的位置。

[0052] 对比例2-2

[0053] 同实施例8，正极耳设置在相应极片上正中偏左300mm的位置，负极耳设置在相应极片上正中偏右300mm的位置。

[0054] 对比例2-3

[0055] 同实施例8，正极耳设置在相应极片上正中偏左500mm的位置，负极耳设置在相应极片上正中偏右500mm的位置。

[0056] 将上述实施例和对比例得到的电池进行检查，结果详见下表：

[0057]

802540-600mAh中间出极极耳倍率测试						
编号	内阻mΩ	1C容量mAh	20C容量mAh	20C:1C容量比率	25C容量mAh	25C:1C容量比率
实施例1	16.5	669	648	96.9%	631	94.0%
实施例2	17.5	665	643	96.7%	627	93.9%
实施例3	17.2	663	643	96.8%	629	92.3%
实施例4	16.1	679	662	97.5%	642	94.5%
实施例5	16.2	673	652	97.7%	637	94.7%
实施例6	16.4	672	650	97.4%	633	94.2%
实施例7	16.3	675	659	97.6%	639	94.6%
实施例8	16.2	679	663	97.5%	640	94.2%
实施例9	16.4	677	659	97.4%	642	94.8%
实施例10	16.1	678	660	97.3%	640	94.4%
实施例11	16.0	674	653	97.7%	636	94.3%
对比例1-1	17.2	669	642	96.0%	622	92.9%
对比例1-2	17.3	665	639	96.1%	615	92.5%
对比例1-3	17.6	661	633	95.9%	608	92.0%
对比例2-1	17.0	664	635	95.7%	620	93.3%
对比例2-2	16.8	665	633	95.9%	616	92.7%
对比例2-3	17.9	660	629	95.3%	610	92.3%

[0058] 由上表可以看出，将极耳设置在极片中间，其内阻较低，比容率较好；其中将正负极耳相对错位设置在极片中间偏中线5~50mm，其内阻更低，比容率更好。

[0059] 上述是本实用新型的较佳实施例，并非用来限制本发明实施范围，故凡以本发明权利要求所述的构造、工艺等效变化或修饰，均应包括在本发明权利要求范围之内。

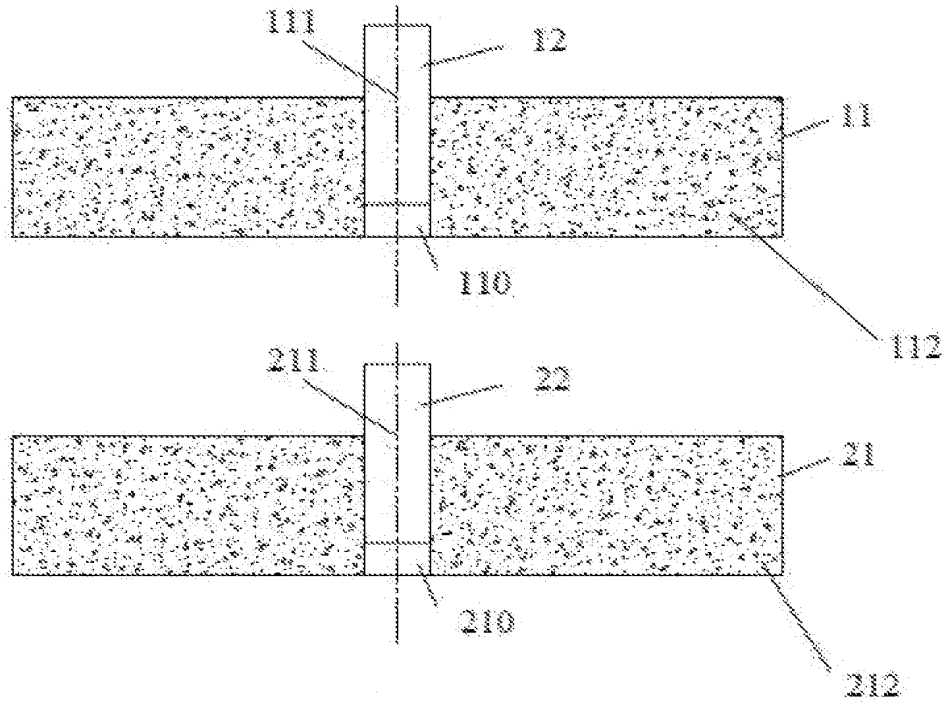

111
12
11
110
112
211
22
21
210
212

图1

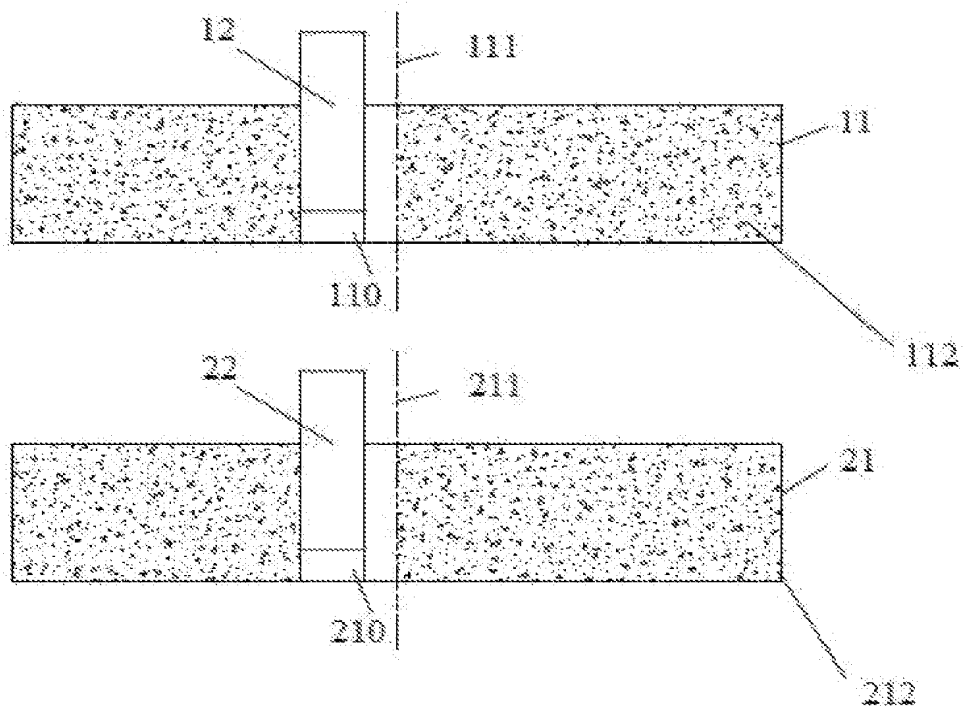

12
111
11
110
112
22
211
21
210
212

图2

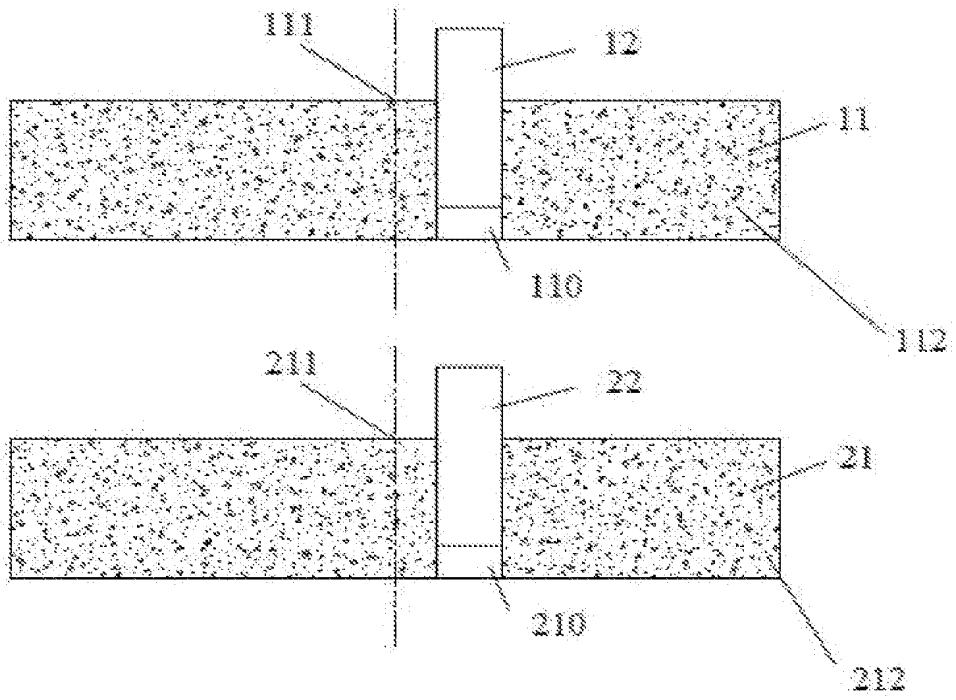

111
12
11
110
112
211
22
21
210
212

图3

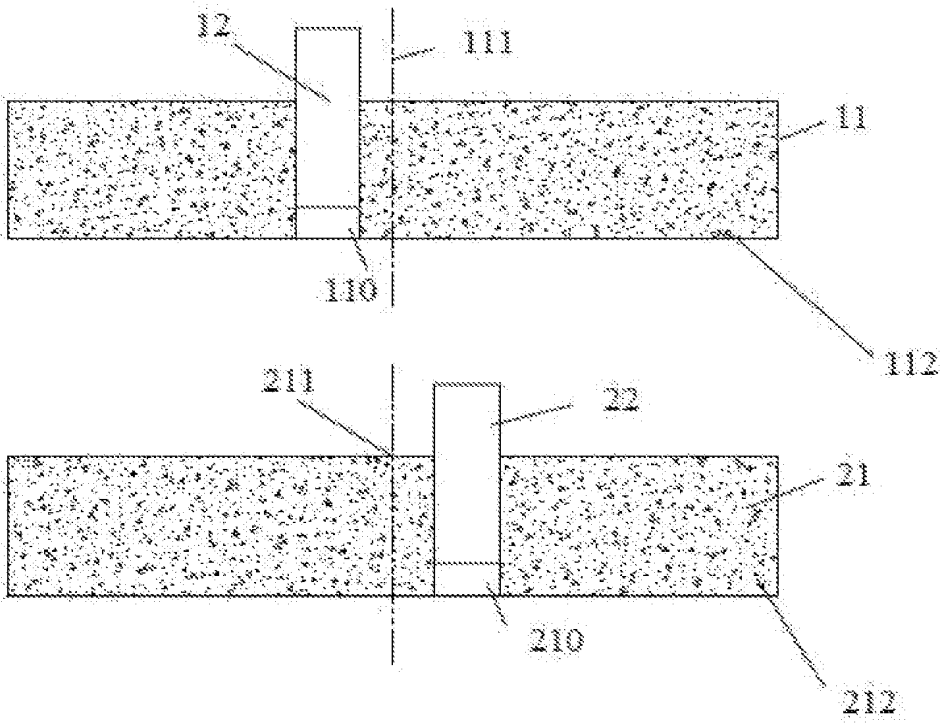

12
111
11
110
112
211
22
21
210
212

图4

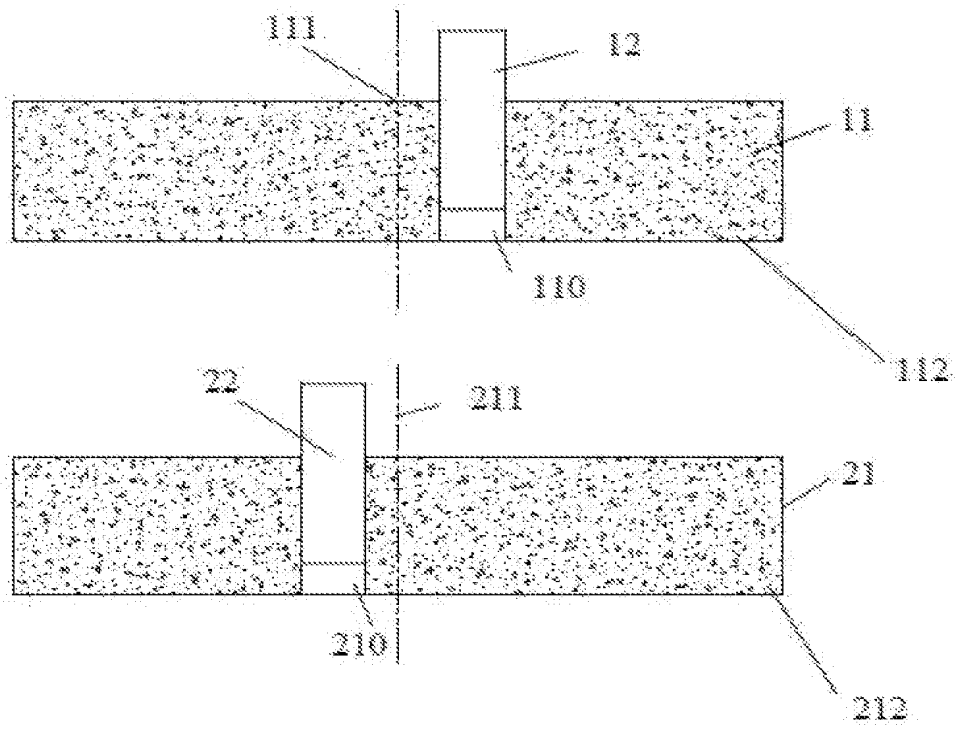


图5

(19)中华人民共和国国家知识产权局

(12)发明专利申请

(10)申请公布号 CN 110753674 A
(43)申请公布日 2020.02.04

(21)申请号 201880039126.6
(22)申请日 2018.06.18
(30)优先权数据
1709685.0 2017.06.16 GB
(85)PCT国际申请进入国家阶段日
2019.12.12
(86)PCT国际申请的申请数据
PCT/GB2018/051689 2018.06.18
(87)PCT国际申请的公布数据
WO2018/229515 EN 2018.12.20
(71)申请人 奈克松有限公司
地址 英国牛津郡
(72)发明人 蒂莫西·博加特 西蒙·福克森
詹姆斯·法雷尔 大卫·本特
丹尼尔·斯卡利特
(74)专利代理机构 中科专利商标代理有限责任公司 11021
代理人 李新红
(51)Int.Cl.
C01B 33/02(2006.01)
C01B 32/00(2006.01)
H01M 4/00(2006.01)
B01J 13/00(2006.01)

权利要求书6页 说明书24页 附图1页

(54)发明名称

用于金属离子电池的电活性材料

(57)摘要

本发明涉及颗粒电活性材料，该颗粒电活性材料由多个复合粒子组成，其中所述复合粒子包含分散在导电碳基体内的多个硅纳米粒子。颗粒材料包含40至65重量%的硅、至少6重量%并且小于20%的氧，并且氧和氮的总量与硅的重量比在0.1至0.45的范围内并且碳与硅的重量比在0.1至1的范围内。所述颗粒电活性材料可用作金属离子电池中的阳极的活性组分。

CN 110753674 A

1.一种用于制备颗粒材料的方法，所述颗粒材料由包含分散在导电热解碳基体内的多个硅纳米粒子的多个复合粒子组成，所述方法包括以下步骤：

(a)在非水溶剂的存在下碾磨硅起始材料以得到含硅纳米粒子在所述溶剂中的分散体，所述含硅纳米粒子的D_{50}粒径在30至500nm的范围内；

(b)使硅纳米粒子在所述溶剂中的所述分散体与热解碳前体接触，所述热解碳前体选自包含至少一个氧或氮原子的一种或多种化合物；

(c)移除所述溶剂以提供涂布有所述热解碳前体的硅纳米粒子；

(d)任选地，在步骤(e)之前，将经涂布的硅纳米粒子加热至200至400℃的温度达5分钟至10小时的时间；以及

(e)在600至1200℃的范围内的热解温度热解所述经涂布的硅纳米粒子以形成包含分散在导电热解碳基体内的多个硅纳米粒子的所述多个复合粒子。

2.根据权利要求1中任一项所述的方法，其中所述热解碳前体选自包含至少一个氧或氮原子的一种或多种芳族或脂族含碳化合物。

3.根据权利要求2所述的方法，其中所述热解碳前体选自包含一个或多个亲电官能团的含碳化合物，优选地其中所述亲电官能团包含羰基部分，更优选地其中所述亲电官能团是酯基团或酰胺基团。

4.根据权利要求3所述的方法，其中所述热解碳前体是包含含碳主链和侧基亲电官能团的聚合物或低聚物。

5.根据权利要求4所述的方法，其中所述热解碳前体是聚乙烯吡咯烷酮(PVP)，或乙烯基吡咯烷酮与一种或多种其他烯键式不饱和单体的共聚物。

6.根据权利要求3至5中任一项所述的方法，其中步骤(d)包括通过所述硅纳米粒子的表面上的亲核官能团与所述热解碳前体的亲电官能团之间的反应使所述硅纳米粒子和所述热解前体交联。

7.根据权利要求6所述的方法，其中步骤(d)包括：在使得反应混合物中的温度升高控制为不大于5℃/min并且在交联反应的持续时间内将所述交联反应的最高温度保持在低于270℃的条件下使所述硅纳米粒子和所述热解碳前体交联。

8.根据权利要求7所述的方法，其中在所述交联反应的持续时间内，所述交联反应的最高温度保持在低于250℃、或低于240℃、或低于230℃、或低于220℃、或低于210℃、或低于200℃。

9.根据权利要求6至8中任一项所述的方法，其中步骤(d)包括混合或搅拌所述经涂布的硅纳米粒子以确保交联步骤期间的均匀反应温度。

10.根据权利要求6至9中任一项所述的方法，其中步骤(d)在氧气的存在下进行，任选地在空气的存在下进行。

11.根据权利要求6至10中任一项所述的方法，其中步骤(d)还包括在交联反应完成后将所述经涂布的硅纳米粒子在100至400℃的范围内的温度下保持一段时间。

12.根据任一项前述权利要求所述的方法，其中所述含硅起始材料选自冶金级硅。

13.根据任一项前述权利要求所述的方法，其中所述硅起始材料具有至少95重量%、至少98重量%或至少99重量%的纯度。

14.根据任一项前述权利要求所述的方法，其中所述硅起始材料包含不大于4重量%的

氧、不大于2重量%的氧、不大于1重量%氧、或不大于0.5重量%氧。

15.根据任一项前述权利要求所述的方法，其中所述含硅起始材料由D_{50}粒度在1至100μm的范围内、或在2至50μm的范围内、或在2至20μm的范围内、或在2至10μm的范围内的硅微粒组成。

16.根据任一项前述权利要求所述的方法，其中所述溶剂选自醇类和酮类，优选地其中所述溶剂是异丙醇。

17.根据任一项前述权利要求所述的方法，其中在碾磨硅期间将硅纳米粒子的所述分散体与所述热解碳前体原位接触，使得步骤(a)和(b)同时进行。

18.根据权利要求1至16中任一项所述的方法，其中步骤(a)和(b)顺序地进行。

19.根据任一项前述权利要求所述的方法，其中在步骤(c)中通过旋转蒸发或通过喷雾干燥移除所述溶剂。

20.根据任一项前述权利要求所述的方法，其中步骤(e)包括将所述经涂布的硅纳米粒子加热至在700至1150℃的范围内、或在800至1100℃的范围内、或在900至1050℃的范围内的热解温度。

21.根据任一项前述权利要求所述的方法，其中步骤(e)在惰性气氛中进行，优选地在氩气或氮气下进行，更优选地在氮气下进行。

22.根据任一项前述权利要求所述的方法，所述方法还包括以下步骤：

(f)减小来自步骤(e)的复合粒子的尺寸。

23.根据任一项前述权利要求所述的方法，所述方法还包括以下步骤：

(g)筛分来自步骤(e)或步骤(f)的复合粒子。

24.根据任一项前述权利要求所述的方法，所述方法还包括以下步骤：

(h)用碳涂层涂布来自步骤(e)、(f)或(g)的复合粒子。

25.根据权利要求24所述的方法，其中通过化学气相沉积(CVD)方法获得所述碳涂层。

26.根据任一项前述权利要求所述的方法，其中所述颗粒材料包含40至65重量%的硅、或43至65重量%的硅、或45至65重量%的硅、或48至62重量%的硅、或50至60重量%的硅、或52至58重量%的硅。

27.根据任一项前述权利要求所述的方法，其中所述颗粒材料中氧和氮的总量与硅的重量比在0.1至0.45、或0.1至0.42、或0.1至0.4、或0.1至0.38、或0.1至0.35的范围内。

28.根据任一项前述权利要求所述的方法，其中所述颗粒材料中氧和氮的总量与硅的重量比是至少0.2、更优选至少0.24、更优选至少0.28、更优选至少0.3、更优选至少0.32、更优选至少0.34。

29.根据任一项前述权利要求所述的方法，其中所述颗粒材料包含总计至少80重量%的硅、碳、氧和氮，总计至少85重量%的硅、碳、氧和氮，总计至少90重量%的硅、碳、氧和氮，或总计至少95重量%的硅、碳、氧和氮，总计总计至少98重量%的硅、碳、氧和氮，或总计至少99重量%的硅、碳、氧和氮。

30.根据任一项前述权利要求所述的方法，其中所述颗粒材料中碳与硅的重量比在0.1至1的范围内。

31.根据权利要求30所述的方法，其中所述颗粒材料中碳与硅的重量比是至少0.15、至少0.2、至少0.25、或至少0.3。

32.根据权利要求30或权利要求31所述的方法，其中所述颗粒材料中碳与硅的重量比不大于0.8、不大于0.7、不大于0.6、不大于0.55、不大于0.5、或不大于0.45。

33.根据任一项前述权利要求所述的方法，其中所述颗粒材料中碳与氧和氮的总量的重量比是至少0.7、或至少0.8、或至少0.85、或至少0.9、或至少0.95。

34.根据任一项前述权利要求所述的方法，包含至少8重量％的氧、或至少10重量％的氧、或至少12重量％的氧、或至少15重量％的氧。

35.根据任一项前述权利要求所述的方法，其中所述颗粒材料包含2至6重量％的氮、更优选2.5至5重量％的氮、更优选3至4.5重量％的氮、并且最优选3.5至4.5重量％的氮。

36.根据任一项前述权利要求所述的方法，其中所述颗粒材料包含至少10重量％的碳、至少15重量％的碳、或至少18重量％的碳。

37.根据任一项前述权利要求所述的方法，其中所述颗粒材料包含不大于35重量％的碳、不大于30重量％的碳、不大于28重量％的碳、或不大于25重量％的碳。

38.一种颗粒材料，所述颗粒材料由多个复合粒子组成，其中所述复合粒子包含分散在导电碳基体内的多个硅纳米粒子，其中：

所述硅纳米粒子包含纳米粒子核心和纳米粒子表面，其中所述纳米粒子表面包含设置在所述纳米粒子核心与所述导电碳基体之间的氧的化合物或氮的化合物或其混合物；

所述颗粒材料包含40至65重量％的硅；

所述颗粒材料包含至少6重量％并且小于20重量％的氧；

所述颗粒材料中氧和氮的总量与硅的重量比在0.1至0.45的范围内；并且

所述颗粒材料中碳与硅的重量比在0.1至1的范围内。

39.一种颗粒材料，所述颗粒材料由多个复合粒子组成，其中所述复合粒子包含分散在导电碳基体内的多个硅纳米粒子，其中：

所述硅纳米粒子包含纳米粒子核心和纳米粒子表面，其中多个桥联氧原子和/或多个桥联氮原子位于在所述纳米粒子表面和所述导电碳基体的至少一部分之间，使得所述导电碳基体化学结合至所述纳米粒子表面；并且

所述颗粒材料包含40至65重量％的硅；

所述颗粒材料包含至少6重量％并且小于20重量％的氧；

所述颗粒材料中氧和氮的总量与所述颗粒材料中的硅的重量比在0.1至0.45的范围内；并且

所述颗粒材料中碳与硅的重量比在0.1至1的范围内。

40.根据权利要求38或39所述的颗粒材料，所述颗粒材料包含43至65重量％的硅、或45至65重量％的硅、或48至62重量％的硅、或50至60重量％的硅、或52至58重量％的硅。

41.根据权利要求38至40中任一项所述的颗粒材料，其中所述颗粒材料中氧和氮的总量与硅的重量比不大于0.42、或不大于0.4、或不大于0.38、或不大于0.35。

42.根据权利要求38至41中任一项所述的颗粒材料，其中所述颗粒材料中氧和氮的总量与硅的重量比是至少0.2、更优选至少0.24、更优选至少0.28、更优选至少0.3、更优选至少0.32、更优选至少0.34。

43.根据权利要求38至42中任一项所述的颗粒材料，所述颗粒材料包含总计至少80重量％的硅、碳、氧和氮，总计至少85重量％的硅、氧、氮和碳，或总计至少90重量％的硅、氧、

氮和碳，或总计至少95重量%的硅、氧、氮和碳，总计至少98重量%的硅、氧、氮和碳，或总计至少99重量%的硅、氧、氮和碳。

44.根据权利要求38至43中任一项所述的颗粒材料，其中碳与硅的重量比是至少0.15、至少0.2、至少0.25、或至少0.3。

45.根据权利要求38至44中任一项所述的颗粒材料，其中碳与硅的重量比不大于0.8、不大于0.7、不大于0.6、不大于0.55、不大于0.5、不大于0.45。

46.根据权利要求38至45中任一项所述的颗粒材料，其中所述颗粒材料中碳与氧和氮的总量的重量比是至少0.7、或至少0.8、或至少0.85、或至少0.9、或至少0.95。

47.根据权利要求38至46中任一项所述的颗粒材料，所述颗粒材料包含至少8重量%的氧、或至少10重量%的氧、或至少12重量%的氧、或至少15重量%的氧。

48.根据权利要求38至47中任一项所述的颗粒材料，所述颗粒材料包含2至6重量%的氮、更优选2.5至5重量%的氮、更优选3至4.5重量%的氮、并且最优选3.5至4.5重量%的氮。

49.根据权利要求38至48中任一项所述的颗粒材料，所述颗粒材料包含至少10重量%的碳、至少15重量%的碳、或至少18重量%的碳。

50.根据权利要求38至49中任一项所述的颗粒材料，所述颗粒材料包含不大于35重量%的碳、不大于30重量%的碳、不大于28重量%的碳、或不大于25重量%的碳。

51.根据权利要求38至50中任一项所述的颗粒材料，其中所述导电碳基体可通过热解碳前体的热解获得，所述热解碳前体选自包含至少一个氧或氮原子的一种或多种芳族或脂族含碳化合物。

52.根据权利要求38至51中任一项所述的颗粒材料，其中所述复合粒子具有在1至25μm的范围内的D_{50}粒径。

53.根据权利要求52所述的颗粒材料，其中所述复合粒子具有至少2μm、至少3μm、至少4μm、或至少5μm的D_{50}粒径。

54.根据权利要求52或权利要求53所述的颗粒材料，其中所述复合粒子具有不大于20μm、不大于18μm、不大于15μm、不大于12μm、或不大于10μm的D_{50}粒径。

55.根据权利要求38至54中任一项所述的颗粒材料，其中所述复合粒子具有至少0.5μm、至少1μm、或至少2μm的D_{10}粒径。

56.根据权利要求38至55中任一项所述的颗粒材料，其中所述复合粒子具有不大于40μm、不大于30μm、不大于25μm、不大于20μm的D_{90}粒径。

57.根据权利要求38至56中任一项所述的颗粒材料，其中所述复合粒子具有5以下、4以下、3以下、2以下、或1.5以下的粒度分布跨度。

58.根据权利要求38至57中任一项所述的颗粒材料，其中所述硅纳米粒子具有在30至500nm的范围内的D_{50}粒径。

59.根据权利要求58所述的颗粒材料，其中所述硅纳米粒子具有至少50nm、或至少60nm、或至少70nm、或至少75nm、或至少80nm的D_{50}粒径。

60.根据权利要求58或权利要求59所述的颗粒材料，其中所述硅纳米粒子具有不大于300nm、或不大于250nm、或不大于200nm、或不大于150nm、或不大于120nm的D_{50}粒径。

61.根据权利要求38至60中任一项所述的颗粒材料，其中所述硅纳米粒子具有至少

10nm、或至少20nm、或至少40nm、或至少60nm的D_{10}粒径。

62.根据权利要求38至61中任一项所述的颗粒材料，其中所述硅纳米粒子具有不大于500nm、不大于400nm、不大于300nm、或不大于200nm的D_{90}粒径。

63.根据权利要求38至62中任一项所述的颗粒材料，其中所述硅纳米粒子具有5以下、4以下、3以下、2以下、或1.5以下的粒度分布跨度。

64.根据权利要求38至63中任一项所述的颗粒材料，所述颗粒材料包含0.1至8重量%的选自铝、铁、铜、镓、镁、钙、钛和锆中的一种或多种元素。

65.根据权利要求38至64中任一项所述的颗粒材料，其中，通过压汞法测定，所述复合粒子具有不大于30%、不大于20%、不大于10%、不大于5%、或不大于2%的粒内孔隙率。

66.根据权利要求38至65中任一项所述的颗粒材料，其中所述复合粒子具有不大于100m^2/g、不大于80m^2/g、不大于60m^2/g、不大于40m^2/g、不大于30m^2/g、不大于25m^2/g、不大于20m^2/g、或不大于15m^2/g的BET表面积。

67.根据权利要求38至66中任一项所述的颗粒材料，其中所述复合粒子具有至少0.1m^2/g、至少1m^2/g、至少2m^2/g、或至少5m^2/g的BET表面积。

68.根据权利要求38至67中任一项所述的颗粒材料，所述颗粒材料在锂化时具有1200至2340mAh/g的比容量。

69.根据权利要求38至68中任一项所述的颗粒材料，其中所述硅纳米粒子的特征在于Si(111)晶格间距为至少10nm、至少12nm、至少14nm、或至少16nm；和/或Si(111)晶格间距不大于100nm、不大于50nm、或不大于35nm，其中所述Si(111)晶格间距通过X射线衍射(XRD)技术测量。

70.一种颗粒材料，所述颗粒材料由多个复合粒子组成，其中所述颗粒材料可根据权利要求1至37中任一项所述的方法获得。

71.一种组合物，所述组合物包含在权利要求38至70的任一项中所限定的颗粒材料以及至少一种其他组分。

72.根据权利要求71所述的组合物，所述组合物是电极组合物，所述电极组合物包含在权利要求38至70的任一项中所限定的颗粒材料以及选自以下各项的至少一种其他组分：(i)粘合剂；(ii)导电添加剂；和(iii)另外的颗粒电活性材料。

73.根据权利要求72所述的电极组合物，其中所述颗粒材料占所述电极组合物的总干重的0.5至80重量%、1至70重量%、1至60重量%、2至50重量%、2至40重量%、2至30重量%、或5至15重量%。

74.根据权利要求72或权利要求73所述的电极组合物，所述电极组合物包含至少一种另外的颗粒电活性材料。

75.根据权利要求74所述的电极组合物，其中所述至少一种另外的颗粒电活性材料选自石墨、硬质炭黑、硅、锗、镓、铝和铅。

76.根据权利要求72至75中任一项所述的电极组合物，所述电极组合物粘合剂，任选地以基于所述电极组合物的总干重为0.5至20重量%、1至15重量%、或2至10重量%的量包含。

77.根据权利要求72至76中任一项所述的电极组合物，所述电极组合物包含一种或多种导电添加剂，任选地以基于所述电极组合物的总干重为0.5至20重量%、1至15重量%、或

2至10重量%的总量包含。

78.一种电极，所述电极包含在权利要求38至70的任一项中所限定的颗粒材料，所述颗粒材料与集流体电接触。

79.根据权利要求78所述的电极，其中所述颗粒材料是在权利要求72至77的任一项中所限定的电极组合物的形式。

80.一种可再充电金属离子电池，所述可再充电金属离子电池包括：(i)阳极，其中所述阳极包括在权利要求78或权利要求79中所述的电极；(ii)阴极，所述阴极包括能够释放和再吸收金属离子的阴极活性材料；和(iii)在所述阳极和所述阴极之间的电解质。

81.在权利要求38至70的任一项中所限定的颗粒材料作为阳极活性材料的用途。

82.根据权利要求81所述的用途，其中所述颗粒材料是在权利要求72至77的任一项中所限定的电极组合物的形式。

用于金属离子电池的电活性材料

[0001] 本发明总体上涉及用于可再充电金属离子电池的电极的电活性材料，并且更具体涉及具有高电化学容量的电活性材料，其适于用作可再充电金属离子电池中的阳极活性材料。本发明的颗粒电活性材料在包含两种以上的不同电活性材料的混合阳极中具有特别的实用性。还提供了用于制备本发明的颗粒电活性材料的方法。

[0002] 可再充电金属离子电池广泛地用于便携式电子设备如移动电话和笔记本电脑，并且正越来越多地应用于电动车辆或混合动力车辆。可再充电金属离子电池通常包括阳极层，阴极层，在阳极层和阴极层之间传输金属离子的电解质，以及设置在阳极和阴极之间的电绝缘多孔隔膜。阴极一般包括设置有含金属离子的金属氧化物系复合材料的层的金属集流体，而阳极一般包括设置有电活性材料的层的金属集流体，所述电活性材料在本文中被定义为在电池的充电和放电期间能够嵌入和释放金属离子的材料。为了避免疑问，在本文中使用的术语“阴极”和“阳极”以这样的含义使用：电池跨过负载放置，以使得阴极是正极并且阳极是负极。当金属离子电池充电时，金属离子从含金属离子的阴极层经由电解质输送至阳极并且嵌入阳极材料中。在本文中使用术语“电池”不仅是指包含单个阳极和单个阴极的装置，而且还指包含多个阳极和/或多个阴极的装置。

[0003] 对提高可再充电金属离子电池的重量和/或体积容量存在关注。当与其他电池技术进行比较时，锂离子电池的使用已经提供了大量改善，但是仍存在进一步发展的余地。截止目前，商业锂离子电池大大地局限于使用石墨作为阳极活性材料。当对石墨阳极进行充电时，锂嵌入到石墨层之间以形成具有经验式Li_xC6(其中x大于0并且小于或等于1)的材料。因此，在锂离子电池中石墨具有372mAh/g的最大理论容量，实际容量稍微更低(约340至360mAh/g)。其他材料，如硅、锡和锗，能够以比石墨显著更高的容量嵌入锂，但是由于难以随着众多次充电/放电循环保持足够的容量而没有得到广泛的商业使用。

[0004] 特别地，由于其对于锂的非常高的容量，硅已被认定为是用于制造具有高重量和体积容量的可再充电金属离子电池的石墨的一种有前景的替代方案(参见，例如Insertion Electrode Materials for Rechargeable LithiumBatteries(用于可再充电锂电池的嵌入电极材料)，Winter,M.等，于Adv.Mater.1998,10,No.10)。在室温，硅在锂离子电池中具有约3,600mAh/g的理论最大比容量(基于$Li_{15}Si_4$)。然而，使用硅作为阳极材料由于在充电和放电时的大的体积变化而复杂化。

[0005] 锂向体相(bulk)硅中的嵌入导致硅材料的体积大幅增加(当硅锂化至其最大容量时高达其初始体积的400％)，并且重复的充电-放电循环在硅材料中造成显著的机械应变，从而导致硅阳极材料的破裂和脱层。脱锂时硅粒子的体积收缩可以导致阳极材料和集流体之间的电接触的损失。此外，在硅表面上形成的固体电解质界面(SEI)层不具有足够的机械容限来适应硅的膨胀和收缩。因此，新暴露的硅表面导致进一步的电解质分解以及SEI层的厚度增加和不可逆的锂损耗。这些失效机制共同导致在连续的充电和放电循环中电化学容量的不可接受的损失。

[0006] 已经提出了多种方法来克服与在对含硅阳极进行充电时观察到的与体积变化相关的问题。解决含硅阳极的不可逆的容量损失的最广泛方法是使用纳米结构的硅粒子作为

电活性材料。据报道，当与微米尺寸粒子相比时，硅纳米粒子和纳米结构硅更能承受充电和放电时的体积变化。然而，纳米尺寸粒子不特别适用于商业规模应用，因为它们难以制备和处理。例如，纳米尺寸粒子倾向于形成团聚体，使得难以获得粒子在阳极材料基体内的有益分散。此外，纳米尺寸粒子的团聚体的形成导致在重复充电-放电循环时的不可接受的容量损失。

[0007] Ohara等(Journal of Power Sources 136(2004)303-306)描述了将硅作为薄膜蒸镀到镍箔集流体上以及使用该结构作为锂离子电池的阳极。尽管该方法提供了良好的容量保持率，但是该薄膜结构没有提供有用量的容量/单位面积，并且当膜厚度增加时，消除了任何的改善。

[0008] WO 2007/083155公开了，通过使用具有高长宽比(即，粒子的最大尺寸与最小尺寸的比率)的硅粒子，可以获得改善的容量保持率。

[0009] US 6,334,939和US 6,514,395公开了包含空隙空间的硅基纳米结构如笼状球形粒子，用于为锂嵌入硅中时发生的膨胀提供缓冲区域。

[0010] WO 2012/175998公开了包含从粒子核心延伸出的多个含硅柱状物的粒子，其可以例如通过化学蚀刻或溅射方法形成。

[0011] 尽管生产其中阳极电活性材料主要或完全为硅的电池仍然是长期目标，但是电池制造商的更直接的目标是确定使用少量硅补充石墨阳极的容量的方式。因此当前焦点在于通过使用"混合"电极获得对现有金属离子电池技术的逐步改善，在所述"混合"电极中常规的石墨基电极通过包含少量的硅而得到改进。

[0012] 混合电极的使用呈现其自身的难题。必须以与在金属离子电池中通常使用的石墨颗粒形式相容的形式提供任何另外的电活性材料。例如，必须可以将另外的电活性材料分散在整个石墨粒子基体中，并且另外的电活性材料的粒子必须具有足够的结构完整性以承受与石墨粒子的混配和随后的电极层的形成，例如，通过诸如压缩、干燥和压延的步骤。

[0013] US 8,526,166公开了锂离子电容器，其包括包含两种类型活性材料粒子的混合阳极活性材料。第一活性材料粒子选自活性碳粒子，如石墨粒子，并且第二活性材料粒子包含氧化硅并且具有10至100nm的粒度。

[0014] WO 2015/157358公开了用于锂离子电池的阳极，其中阳极活性材料包括石墨和纳米尺寸粒子，该纳米尺寸粒子包含例如由二氧化硅的金属热还原获得的晶体硅和SiO_2的混合物。晶体硅和SiO_2的混合物(通常称为SiO_x)可以与其他阳极材料如碳基阳极材料组合使用。

[0015] 尽管迄今为止做出了努力，但是仍然需要改善锂离子电池的电化学存储容量。特别地，仍然需要确定替代的硅基材料，其提供硅的高锂化容量的益处，但是还具有足够的容量保持率和结构稳定性以用于商业上可行的可再充电电池。

[0016] 在第一方面，本发明提供一种用于制备颗粒材料的方法，所述颗粒材料由多个复合粒子组成，所述复合粒子包含分散在导电热解碳基体内的多个硅纳米粒子，所述方法包括以下步骤：

[0017] (a)在非水溶剂的存在下碾磨硅起始材料以得到含硅纳米粒子在所述溶剂中的分散体，所述含硅纳米粒子的D_{50}粒径在30至500nm的范围内；

[0018] (b)使硅纳米粒子在所述溶剂中的分散体与热解碳前体接触，所述热解碳前体选

自包含至少一个氧或氮原子的一种或多种化合物：

[0019] (c)移除溶剂以提供涂布有热解碳前体的硅纳米粒子；

[0020] (d)在步骤(e)之前，将经涂布的硅纳米粒子任选地加热至100至400℃的温度达5分钟至10小时的时间；以及

[0021] (e)在600至1200℃的范围内的热解温度热解经涂布的硅纳米粒子，以形成包含分散在导电热解碳基体内的多个硅纳米粒子的所述多个复合粒子。

[0022] 如在本文中所使用的，术语“复合粒子”应该被理解为主要是指包含分散在导电碳基体内的多个硅纳米粒子的粒子。然而，不排除在构成本发明的颗粒材料的粒子之间硅纳米粒子的分布可能存在一定程度上的统计变化。在这种统计变化的极端情况下，可能存在仅包含单个硅纳米粒子的少量粒子，或者甚至仅包含导电碳基体材料的少量粒子。在本文中提及“颗粒材料由多个复合粒子组成，其中所述复合粒子包含分散在导电热解碳基体内的多个硅纳米粒子”、提及“颗粒材料”以及提及“复合粒子”应该被理解为涵盖个体粒子的组成的这种统计变化。

[0023] 碾磨硅以形成纳米粒子导致了硅的表面积显著增加。新暴露的硅表面具有高反应性，并且通常自发地形成氧化层，其使得电化学性能降低。不受理论束缚，据信在非水溶剂的存在下碾磨含硅起始材料控制硅表面的氧化。然后，硅纳米粒子表面处的硅醇基团能够与来自热解碳前体的含氧或含氮官能团反应，以提供官能化的硅纳米粒子中间体。在热解之后，来自热解碳前体的含氧或含氮官能团与硅表面之间的反应在碳基体与硅纳米粒子表面之间的界面处形成持久的键。该键确保即使在充电和放电期间硅纳米粒子膨胀和收缩时也维持硅纳米粒子和碳基体之间的牢固连接，从而提供本文中关于本发明的第二和第三方面所描述的优点。

[0024] 热解碳前体优选选自包含至少一个氧或氮原子的含有芳族或脂族碳的前体材料。

[0025] 合适的芳族热解碳前体的实例包括以下各项中的一种或多种：吡咯、丙烯腈、2,3-二羟基萘、2,3-二氨基萘、1,5-二羟基萘、1,5-二氨基萘、1,8-二羟基萘、1,8-二氨基萘、2,3-二羟基蒽、2,3-二氨基蒽、4,5-二羟基蒽、4,5-二氨基蒽、9,10-菲醌、2,3-二羟基并四苯、氟化2,3-二羟基并四苯、三氟-甲基-2,3-二羟基并四苯、2,3-二氨基并四苯、氟化2,3-二氨基并四苯、三氟甲基-2,3-二氨基并四苯、2,3-二羟基并五苯、氟化2,3-二羟基并五苯、三氟甲基-2,3-二羟基并五苯、2,3-二氨基并五苯、氟化2,3-二氨基并五苯、三氟甲基-2,3-二氨基并五苯、2,3-二羟基并六苯、氟化2,3-二羟基并六苯、三氟甲基-2,3-二羟基并六苯、2,3-二氨基并六苯、氟化2,3-二氨基并六苯、三氟甲基-2,3-二氨基并六苯、1,2-二羟基苝、氟化1,2-二羟基苝、三氟甲基-1,2-二羟基苝、1,2-二氨基苝、氟化1,2-二氨基苝、三氟甲基-1,2-二氨基苝、儿茶酚、二羟基蒽、氟化二羟基蒽、三氟甲基二羟基蒽、咔咯(corrole)、卟啉、庚-2,4,6-三烯-酮、马来酸、苯甲腈、富马腈(fumaronitrile)、4,5-二羟基双酚、2,3-二羟基双酚、联苯胺(benzidene)、二羟基芪、亚麻油酸(steridonic acid)、二十碳五烯酸、γ-亚麻酸、喹啉、异喹啉、吲哚、噁吟、咪唑、腺嘌呤、鸟嘌呤、四氢喹啉、1,2-二氢喹啉、喹啉-2(1H)-酮、异喹啉-2(1H)-酮、咔唑、吩噁嗪、吩噻嗪、吩噁噻(phenoxathiine)、2,3-二氢氮杂萘、2,5-二氢氮杂萘、氮杂萘、1,2-二氮杂萘、1,3-二氮杂萘、1,4-二氮杂萘、1,6-二氢吡咯并-[2,3-b]-吡咯、二氢吲哚、3H-吲哚、1H-吲哚、2H-吲哚、1H-吲唑、苯并咪唑、4-氮杂吲

喏、5-氮杂吲哚、6-氮杂吲哚、7-氮杂吲哚、间苯二甲酸、对苯二甲酸、酚醛树脂、鞣酸、糠醇和2-萘酚。

[0026] 优选的芳族热解碳前体包括儿茶酚、2,3-二羟基萘、1,5-二羟基萘、2,3-二羟基蒽和1,5-二羟基蒽及其混合物。

[0027] 热解碳前体还包括链烷二醇、聚乙烯醇、樟脑和松脂(gum roisin)(松香)。

[0028] 合适的热解碳前体还包括包含一个或多个亲电官能团(特别是包含羰基部分、优选酯或酰胺基团的官能团)的含碳化合物。优选地,热解碳前体包括聚合物或低聚物,该聚合物或低聚物包含含碳主链和侧基亲电官能团,优选包含羰基部分的侧基官能团,更优选侧基酰胺基团或酯基团,特别是侧基环状酯基团或酰胺基团。最优选地,热解碳前体包括包含含碳主链和侧基环状酰胺基团的聚合物或低聚物。该类别中特别优选的热解碳前体包括聚乙烯吡咯烷酮(PVP)均聚物,以及乙烯基吡咯烷酮与一种或多种其他烯键式不饱和单体的共聚物。优选地,乙烯基吡咯烷酮的共聚物包含至少50mol%的乙烯基吡咯烷酮单体。

[0029] 任选的步骤(d)包括在将经涂布的硅纳米粒子进一步加热至热解温度之前将经涂布的硅纳米粒子加热至在100至400℃、任选地200至400℃的范围内的温度达一段时间(例如,5分钟至10小时)。优选地,选择步骤(d)中的温度使得其在热解碳前体的熔点和沸点之间。

[0030] 在所要求保护的方法的优选实施方案中,热解碳前体选自包含如上所述的一个或多个亲电官能团的化合物,并且步骤(d)包括在硅纳米粒子表面上的亲核官能团与热解碳前体的亲电官能团之间形成交联。

[0031] 已经发现,硅纳米粒子与热解碳前体之间的交联反应导致形成具有较低微孔率的更致密且结合更牢固的导电碳基体。因此,导电碳基体具有更高的导电性,并且复合粒子展现出减少的首次循环损失。然而,发明人已经发现,硅纳米粒子和热解碳前体之间的这种交联反应(在本文中也称为固化反应)是高度放热的,并且发现控制反应温度是有效交联过程的关键因素,因此能够将复合粒子的元素组成控制在以下所述并且与本发明的第二和第三方面有关的优选范围内。

[0032] 具体地,本发明人已经确定,当将涂布有包含一个或多个亲电官能团的热解碳前体(例如PVP)的硅纳米粒子加热至高于100℃时,所得的交联反应是高度放热的,导致快速且不受控的温度升高。发明人已经观察到,加热炉或窑内的粒子的温度可以根据位置和其他特征(如坩埚的尺寸和形状)而显著变化,其结果是交联反应中的温度可能高度不均匀,这对最终复合粒子的性质产生不利影响。

[0033] 不受理论束缚,据信由于放热的交联反应而产生的过量热量导致在交联反应可以完成之前热解碳前体的裂解和亲电官能团的损失。因此,裂解的亲电官能团不再可用于参与与硅纳米粒子表面的交联反应。因此,交联不足导致最终复合粒子的性能变差。

[0034] 因此已经发现,通过避免由来自反应的过量热量引起的不需要的裂解反应,小心地控制步骤(d)中的条件能够使交联反应中获得的交联度最大化,从而在步骤(e)中的热解后得到改善的碳基体。

[0035] 因此,根据所要求保护的方法,如上所述,热解碳前体优选选自包含一个或多个亲电官能团的化合物,并且步骤(d)包括在使得反应混合物中的温度升高控制为不大于5℃/min并且在交联反应的持续时间内将交联反应的最高温度保持在低于270℃的条件下使经

涂布的硅纳米粒子和热解碳前体交联。交联反应的完成可以通过反应放热的热量生成的停止来确定。

[0036] 优选地，步骤(d)还包括混合或搅拌经涂布的硅纳米粒子以确保交联步骤期间的均匀反应温度。例如，步骤(d)可以在旋转窑中进行。

[0037] 任选地，在交联反应的持续时间内，交联反应的最高温度保持在低于250℃、低于240℃、低于230℃、低于220℃、低于210℃或低于200℃。

[0038] 根据本发明的步骤(d)中的受控交联反应导致在步骤(e)的热解之后产生硅纳米粒子核心与导电碳基体之间的独特界面结构。具体地，交联反应导致在硅纳米粒子核心与导电碳基体之间的界面处存在氮和氧化合物。据信这些氧和氮化合物表现为设置在纳米粒子表面和导电碳基体之间的多个桥联氧原子和/或多个桥联氮原子的形式。因此，热解后复合粒子中氧和/或氮的含量指示有效的交联过程，因此与改善的性能有关。

[0039] 更优选地，热解碳前体选自包括聚合物或低聚物，该聚合物或低聚物包含含碳主链结构和侧基亲电官能团，优选包含羰基部分的官能团，更优选酰胺基团或酯基团，特别是环状酯基团或酰胺基团。在交联反应的情况下，特别优选的热解碳前体是聚乙烯吡咯烷酮(PVP)，或如上所述的乙烯基吡咯烷酮的共聚物。

[0040] 优选地，步骤(d)中的交联反应在氧气的存在下进行。例如，步骤(d)中的交联反应可以在空气的存在下进行。虽然发现氧气的存在(例如来自空气)促进交联反应，但是交联反应中的过高温度可能导致硅被不期望地氧化成二氧化硅。因此，除了优化交联反应以外，本发明的方法还减少了不需要的二氧化硅的氧化。

[0041] 最优选地，热解碳前体是PVP，并且步骤(d)包括使经涂布的硅纳米粒子交联，在交联反应的持续时间内反应温度控制在100至300℃、更优选150至280℃、更优选180至280℃的范围内；其中交联反应在空气的存在下进行。

[0042] 任选地，步骤(d)可以包括在完成交联反应之后(如通过反应放热的停止确定的)将经涂布的硅纳米粒子在100至400℃的范围内的温度下保持一段时间(例如，10分钟至2小时)。该固化过程可以促进热解碳前体在硅表面处的各种重排，例如允许热解碳前体迁移到硅表面的空区域和/或允许热解碳前体采用热力学上更稳定的布置。据认为这可以有助于改善硅纳米粒子和导电碳基体之间的结合和/或有助于改善导电碳基体的导电性。

[0043] 来自步骤(c)或(d)的经涂布的硅纳米粒子在步骤(e)中进行热解以形成导电热解碳基体。热解优选在700至1150℃的范围内、或在800至1100℃的范围内、或在900至1050℃的范围内的温度进行。据发现热解碳基体的导电性既取决于所选择的热解碳前体，又取决于热解温度。高于700℃的热解温度通常是优选的，目的在于得到具有高导电性的热解碳基体。热解步骤(e)可以进行5分钟至120分钟、例如10分钟至100分钟、20分钟至80分钟、或40分钟至60分钟的范围内的时间段。

[0044] 热解步骤(e)优选在惰性气氛或还原气氛中进行。例如，热解可以在氩气或氮气(优选氮气)下进行，或者在氩气或氮气与一氧化碳或氢气的混合物下进行。

[0045] 硅起始材料优选具有至少95重量%、至少98重量%或至少99重量%的纯度。

[0046] 硅起始材料可以适宜地选自冶金级硅。冶金级硅是通过电弧炉中在约1900℃的温度下使用炭还原高纯度二氧化硅而获得的。冶金级硅通常包括与少量其他元素合金化的硅，并且可以多种等级获得，纯度范围从95重量%到高于99重量%。冶金级硅中的常见杂质

包括钙、铝、铁、铜、镓和钛及其氧化物。

[0047] 硅起始材料可以包括非晶硅、多晶硅或单晶硅。

[0048] 硅起始材料优选包含不大于4重量%的氧、更优选不大于2重量%的氧、更优选不大于1重量%的氧、更优选不大于0.5重量%的氧。

[0049] 含硅起始材料优选为硅微粒的形式，例如具有在1至100μm的范围内、更优选在2至50μm的范围内、更优选在2至20μm的范围内、更优选在2至10μm的范围内的D_{50}粒度。如果使用更小的含硅起始材料粒子，则在步骤(a)期间暴露的新鲜硅表面的量减少，并且可能存在过量的携带来自起始材料的天然氧化物的硅表面。更大的粒子可能更难以有效地碾磨至纳米粒子尺寸范围。然而，不排除更大的含硅粒子或整料(例如锭或晶片)可以进行初步粉碎步骤(例如研磨或碾磨)，并且任选地筛分以获得在含硅起始材料的优选尺寸范围内的硅微粒。

[0050] 为了避免疑问，如在本文中所使用的术语“粒径”是指等效球直径(esd)，即具有与给定粒子相同的体积的球体的直径，其中粒子体积被理解为包括任何粒内孔的体积。如在本文中所使用的术语“D_{50}”和“D_{50}粒径”是指基于体积的中值粒径，即低于其发现50体积%的粒子群体的直径。如在本文中所使用的术语“D_{10}”和“D_{10}粒径”是指第10百分位的基于体积的中值粒径，即低于其发现10体积%的粒子群体的直径。如在本文中所使用的术语“D_{90}”和“D_{90}粒径”是指第90百分位的基于体积的中值粒径，即低于其发现90体积%的粒子群体的直径。如在本文中所使用的术语“D_{99}”和“D_{99}粒径”是指第99百分位的基于体积的中值粒径，即低于其发现99体积%的粒子群体的直径。

[0051] 粒径和粒度分布可以通过常规的激光衍射技术确定。激光衍射依赖于以下原理：粒子将会以根据粒子尺寸变化的角度散射光，并且一组粒子将会产生由能够与粒度分布相关联的强度和角度限定的散射光的图案。多种激光衍射仪器商业上可用于粒度分布的快速且可靠的测定。除非另外说明，如在本文中说明或报道的粒度分布测量是通过来自Malvern Instruments的常规Malvern Mastersizer 3000粒度分析仪测量的。MalvernMastersizer 3000粒度分析仪通过将氦-氖气体激光束投射穿过含有悬浮在水溶液中的目标粒子的透明池而工作。撞击粒子的光线通过与粒度成反比的角度散射，并且光检测器阵列以多个预定角度测量光的强度，并且使用标准理论原理通过计算机处理以不同角度测量的强度，从而确定粒度分布。如在本文中报道的激光衍射值使用粒子在蒸馏水中的湿分散体得到。取粒子折射率为3.50并且取分散指数为1.330。粒度分布使用Mie散射模型计算。

[0052] 步骤(a)可以使用任何合适的湿磨过程进行，例如球磨、行星式碾磨、喷射式碾磨或其组合。用于步骤(a)的合适溶剂包括烃类(例如，选自甲苯、二甲苯、正己烷、正庚烷、正辛烷、癸烷、十二烷和石油醚)，醚类(例如，选自四氢呋喃、二甘醇二甲醚和三甘醇二甲醚)，酮类(例如，选自丙酮、甲基乙基酮)，醇类(例如，选自异丙醇和正丁醇)，和卤代溶剂(例如，选自1,2-二氯乙烷、1,1,1-三氯乙烷)。其他合适的溶剂包括乙腈、二甲基甲酰胺(DMF)和二甲亚砜(DMSO)。优选的溶剂包括醇类和酮类。特别优选的溶剂是异丙醇。

[0053] 溶剂可以以基于硅起始材料的重量5至50重量%的量、例如基于硅起始材料的重量10至25重量%的量使用。

[0054] 步骤(a)可以在使得硅纳米粒子的新暴露表面处的不需要的副反应最小化的条件下进行。步骤(a)中使用的溶剂可以是脱气和/或无水溶剂。例如，溶剂可以包含小于10ppmw

(按重量计的百万分率)的氧气、小于5ppmw的氧气、或小于1ppmw的氧气。溶剂可以包含小于10ppmw(按重量计的百万分率)的水、小于5ppmw的水、或小于1ppmw的水。更优选地,溶剂可以包含各自均小于10ppmw(按重量计的百万分率)的氧气和水、各自均小于5ppmw的氧气和水、或各自均小于1ppmw的水和氧气。步骤(a)也可以在缺氧和/或无水气氛下进行,例如在惰性气体如氮气或氩气下进行。备选地,步骤(a)可以在其中顶部空间最小化的碾磨容器中进行,以便从碾磨过程中基本上排除大气中的水和/或氧气。优选地,在碾磨之前,用惰性气体如氮气冲洗碾磨容器的顶部空间。

[0055] 任选地,步骤(a)中形成的硅纳米粒子的D_{50}粒径可以是至少50nm、或至少60nm、或至少70nm、或至少75nm、例如至少80nm。任选地,步骤(a)中形成的硅纳米粒子的D_{50}粒径可以不大于300nm、更优选不大于250nm、更优选不大于200nm、更优选不大于150nm、更优选不大于120nm。

[0056] 步骤(a)中形成的硅纳米粒子优选具有在50至250nm的范围内、更优选在60至200nm的范围内、更优选在70至150nm的范围内、更优选在80至120nm的范围内的D_{50}粒径。例如,步骤(a)中形成的硅纳米粒子的D_{50}粒径可以是约100nm。

[0057] 步骤(a)中形成的硅纳米粒子的D_{10}粒径可以是至少10nm、更优选至少20nm、更优选至少40nm、更优选至少60nm。步骤(a)中形成的硅纳米粒子的D_{90}粒径可以不大于500nm、更优选不大于400nm、更优选不大于300nm、更优选不大于200nm。步骤(a)中形成的硅纳米粒子可以具有5以下、更优选4以下、更优选3以下、更优选2以下、更优选1.5以下的粒度分布跨度(如上限定)。

[0058] 步骤(a)和(b)可以同时进行,使得在碾磨硅起始材料期间硅纳米粒子与热解碳前体原位接触。备选地,步骤(a)和(b)可以顺序进行。在步骤(a)和(b)顺序进行的情况下,步骤(b)可以包括将热解碳前体在非水溶剂中的溶液加入到来自步骤(a)的硅纳米粒子的分散体,任选地伴有足以确保热解碳前体在硅纳米粒子分散体中的均匀分布的混合或搅拌。用于溶解热解碳前体的溶剂可以是与在步骤(a)中用于碾磨硅起始材料的溶剂相同的溶剂。

[0059] 适宜地进行步骤(b)以避免硅纳米粒子与氧气和/或水接触。例如,在步骤(b)之前,来自步骤(a)的硅纳米粒子的分散体可以在缺氧和/或无水气氛下储存。硅纳米粒子与热解碳前体的接触也适宜地在缺氧和/或无水惰性气氛下进行。另外,热解碳前体或其在非水溶剂中的溶液优选是脱气的和无水的。例如,热解碳前体或其溶液可以包含小于10ppmw(按重量计的百万分率)的氧气、小于5ppmw的氧气、或小于1ppmw的氧气。热解碳前体或其溶液可以包含小于10ppmw(按重量计的百万分率)的水、小于5ppmw的水、或小于1ppmw的水。更优选地,热解碳前体或其溶液可以包含各自均小于10ppmw(按重量计的百万分率)的氧气和水、各自均小于5ppmw的氧气和水、或各自均小于1ppmw的水和氧气。

[0060] 取决于热解碳前体的结构和热解条件,在热解期间来自热解碳前体的重量损失通常在40至70重量%的范围内。因此,热解碳前体与硅的重量比通常选择为是颗粒材料产品中碳与硅的所需重量比的约1.5至3.5倍高。例如,步骤(b)中热解碳前体与硅的重量比可以在0.15至4、更优选0.2至3、例如0.3至2.5的范围内。

[0061] 可以在步骤(c)中通过任何常规方式移除溶剂。一种溶剂移除技术包括例如使用旋转蒸发设备在减压下蒸发溶剂,任选地同时提供足够的热量以防止溶剂冻结。更优选地,

可以通过喷雾干燥移除溶剂以形成包含分散在热解碳前体内的硅纳米粒子的复合粒子。溶剂移除过程被适宜地控制以避免溶剂蒸气速度过大，因为这可能导致硅纳米粒子夹带在蒸气流中。

[0062] 从步骤(c)获得的材料包括分散在热解碳前体的基体中的硅纳米粒子。在步骤(d)或(e)之前，该材料可以在惰性(例如缺氧和/或无水)气氛下储存。然而，发现热解碳前体的涂层和/或溶剂钝化可以为硅纳米粒子提供足够的保护，以防止硅与氧气或水发生不需要的反应。

[0063] 通过热解步骤(e)获得的导电碳基体通常具有非晶结构，具有类石墨特征，如拉曼光谱中的大G带(~1600cm^{-1})所证明的。然而，如拉曼光谱中明显的D带(~1350cm^{-1})所证明的，碳并不完全为石墨。

[0064] 步骤(e)中经涂布的硅纳米粒子的热解导致形成其中分散有硅纳米粒子的导电碳基体。导电碳基体可以包含尺寸为100μm至几十毫米的大的和/或不规则的粒子。因此，可以对来自步骤(e)的颗粒材料进行尺寸减小步骤(f)以获得粒度减小的颗粒材料。可以使用任何合适的尺寸减小技术，例如球磨、行星式碾磨、喷射式碾磨或其组合。步骤(f)可以在溶剂的存在下进行(湿磨)，或者可以使用干磨技术。如果使用湿磨，则可以通过任何常规方式移除溶剂，例如在减压下蒸发。

[0065] 来自步骤(e)或步骤(f)的颗粒材料可以任选地进行筛分步骤(g)以移除过大的粒子。

[0066] 来自步骤(e)、(f)或(g)的颗粒材料可以通过添加碳涂层来改性。优选地，通过化学气相沉积(CVD)方法获得碳涂层。CVD是本领域公知的方法，并且包括将挥发性含碳气体(例如乙烯)热分解到颗粒材料的表面上。通过CVD形成碳涂层可以与步骤(e)中的热解同时进行，或者紧接在步骤(e)中的热解之后进行。例如，一旦热解反应基本完成，就可以将合适的挥发性含碳气体如乙烯引入热解反应器中。

[0067] 备选地，可以通过将含碳化合物的溶液沉积到颗粒材料的表面上、然后进行热解来形成碳涂层。合适的含碳化合物包括上述热解碳前体。

[0068] 碳涂层的优点在于其通过平滑任何表面缺陷以及通过填充任何残余表面微孔而进一步减小颗粒材料的BET表面积，从而进一步减少首次循环损失。另外，碳涂层改善了复合粒子表面的导电性，减少了电极组合物中对导电添加剂的需求，并且还为形成稳定的SEI层创造了最佳表面，从而循环时的容量保持率得到改善。

[0069] 根据本发明的方法制备的颗粒材料优选包含40至65重量%的硅、更优选43至65重量%的硅、更优选45至65重量%的硅。例如，颗粒材料可以包含48至62重量%的硅、或50至60重量%的硅、或52至58重量%的硅。

[0070] 根据本发明的方法制备的颗粒材料中氧和氮的总量与硅的重量比优选在0.1至0.45的范围内。

[0071] 例如，来自步骤(e)的复合材料中氧和氮的总量与硅的重量比可以不大于0.42、或不大于0.4、或不大于0.38、或不大于0.35。任选地，氧和氮的总量与硅的重量比可以是0.1至0.42、或0.1至0.4、或0.1至0.38、或0.1至0.35。

[0072] 根据本发明的方法制备的颗粒材料中氧和氮的总量与硅的重量比可以是至少0.2、更优选至少0.24、更优选至少0.28、更优选至少0.3、更优选至少0.32、更优选至少

0.34。

[0073] 优选地，根据本发明的方法制备的颗粒材料中氧和氮的总量与硅的重量比可以在0.25至0.42、更优选0.28至0.4、更优选0.3至0.38、并且最优选0.32至0.38的范围内。

[0074] 来自步骤(e)的复合材料中碳与硅的重量比优选在0.1至1的范围内。

[0075] 根据本发明的方法制备的颗粒材料中碳与硅的重量比可以是至少0.15、更优选至少0.2、更优选至少0.25、更优选至少0.3。

[0076] 根据本发明的方法制备的颗粒材料中碳与硅的重量比可以不大于0.8、更优选不大于0.7、更优选不大于0.6、更优选不大于0.55、更优选不大于0.5、更优选不大于0.0.45。

[0077] 例如，根据本发明的方法制备的颗粒材料中碳与硅的重量比可以是0.2至0.6，更优选0.25至0.5，更优选0.3至0.45。

[0078] 根据本发明的方法制备的颗粒材料中碳与氧和氮的总量的重量比(即重量[C]:重量[O+N])可以是至少0.7、更优选至少0.8、更优选至少0.85、或至少0.9、或至少0.95。

[0079] 根据本发明的方法制备的颗粒材料优选包含至少8重量％的氧、或至少10重量％的氧、或至少12重量％的氧、或至少15重量％的氧。

[0080] 根据本发明的方法制备的颗粒材料优选包含8重量％至小于20重量％的氧、更优选10重量％至小于20重量％的氧、更优选12重量％至小于20重量％的氧、更优选15重量％至小于20重量％的氧。

[0081] 根据本发明的方法制备的颗粒材料优选包含2至6重量％的氮、更优选2.5至5重量％的氮、更优选3至4.5重量％的氮、并且最优选3.5至4.5重量％的氮。含氮颗粒材料可以由如在本文中描述的含氮热解碳前体制备。

[0082] 根据本发明的方法制备的颗粒材料优选包含至少10重量％的碳、或至少15重量％的碳、或至少18重量％的碳。根据本发明的方法制备的颗粒材料优选包含不大于35重量％的碳、不大于30重量％的碳、不大于28重量％的碳、或不大于25重量％的碳。例如，根据本发明的方法制备的颗粒材料可以包含15至30重量％的碳、或更优选18至25重量％的碳。

[0083] 在一个优选的实施方案中，根据本发明的方法制备的颗粒材料包含43至65重量％的硅、10重量％至小于20重量％的氧、2至6重量％的氮和15至30重量％的碳；其中颗粒材料中氧和氮的总量与颗粒材料中的硅的重量比在0.25至0.42的范围内；并且其中颗粒材料中碳与硅的重量比在0.2至0.6的范围内。

[0084] 在更优选的实施方案中，根据本发明的方法制备的颗粒材料包含48至62重量％的硅、12重量％至小于20重量％的氧、2.5至5重量％的氮和18至25重量％的碳；其中颗粒材料中氧和氮的总量与颗粒材料中的硅的重量比在0.28至0.4的范围内；并且其中颗粒材料中碳与硅的重量比在0.25至0.5的范围内。

[0085] 在特别优选的实施方案中，根据本发明的方法制备的颗粒材料包含50至60重量％的硅、15重量％至小于20重量％的氧、3至4.5重量％的氮和18至25重量％的碳；其中颗粒材料中氧和氮的总量与颗粒材料中的硅的重量比在0.3至0.38的范围内；并且其中颗粒材料中碳与硅的重量比在0.3至0.45的范围内。

[0086] 根据本发明的方法制备的颗粒材料可以任选地包含除硅、碳或氧以外的少量的一种或多种其他元素。例如，颗粒材料可以包含少量的选自Al、Sb、Cu、Mg、Zn、Mn、Cr、Co、Mo、Ni、Be、Zr、Fe、Na、Sr、P、Sn、Ru、Ag、Au、Ti中的一种或多种其他元素。这样的元素可能作为微

量杂质存在于硅纳米粒子中，例如当硅纳米粒子获自冶金级硅时。例如，颗粒材料可以包含0.1~8重量%的选自铝、铁、铜、镓、镁、钙、钛和锆中的一种或多种元素，其余的材料为硅、碳和氧。备选地，这些元素可以在制造过程中存在。

[0087] 优选地，根据本发明的方法制备的颗粒材料包含总计至少80重量%的硅、碳、氧和氮，总计至少85重量%的硅、氧、氮和碳，总计至少90重量%的硅、氧、氮和碳，或总计至少95重量%的硅、氧和碳，例如总计至少至少98重量%的硅、氧、氮和碳，或总计至少99重量%的硅、氧、氮和碳。

[0088] 在第二方面，本发明提供一种颗粒材料，所述颗粒材料由多个复合粒子组成，其中所述复合粒子包含分散在导电碳基体内的多个硅纳米粒子，其中：

[0089] 硅纳米粒子包含纳米粒子核心和纳米粒子表面，其中纳米粒子表面包含设置在纳米粒子核心与导电碳基体之间的氧的化合物或氮的化合物或其混合物；

[0090] 颗粒材料包含40至65重量%的硅；

[0091] 颗粒材料包含至少6重量%并且小于20重量%的氧；

[0092] 颗粒材料中氧和氮的总量与硅的重量比在0.1至0.45的范围内；

[0093] 并且

[0094] 颗粒材料中碳与硅的重量比在0.1至1的范围内。

[0095] 在第三方面，本发明提供一种颗粒材料，所述颗粒材料由多个复合粒子组成，其中所述复合粒子包含分散在导电碳基体内的多个硅纳米粒子，其中：

[0096] 硅纳米粒子包含纳米粒子核心和纳米粒子表面，其中多个桥联氧原子和/或多个桥联氮原子设置在纳米粒子表面和导电碳基体的至少一部分之间，使得导电碳基体化学结合至纳米粒子表面；并且

[0097] 颗粒材料包含40至65重量%的硅；

[0098] 颗粒材料包含至少6重量%并且小于20重量%的氧；

[0099] 颗粒材料中氧和氮的总量与颗粒材料中的硅的重量比在0.1至0.45的范围内；并且

[0100] 颗粒材料中碳与硅的重量比在0.1至1的范围内。

[0101] 已经发现，本发明的颗粒材料对于在用于金属离子电池的混合电极中使用具有特别有利的性质。使用硅纳米粒子避免了在较大粒子中出现的锂化和脱锂期间的过度机械应变。然而，通过提供复合粒子形式的硅纳米粒子(其中硅纳米粒子分散在导电碳基体内)，可以克服与硅纳米粒子有关的处理问题。

[0102] 此外，本发明的颗粒材料在碳基体和硅纳米粒子的表面之间具有独特的界面。因此，本发明的复合粒子的碳基体不是仅在硅纳米粒子的表面上提供涂层。碳基体和硅纳米粒子的界面处的独特化学性确保了，即使当硅纳米粒子在充电和放电期间膨胀和收缩时，也保持了硅纳米粒子和碳基体之间的牢固连接。因此，有效地维持了硅纳米粒子、碳基体和阳极集流体之间的导电性。由于其独特的结构，本发明的颗粒材料避免了许多容量衰减机制，这些机制是使用硅作为金属离子电池中的阳极活性材料时的特性。特别地，已经发现，当与本领域中公开的用于金属离子电池的其他含硅颗粒形式相比，本发明的颗粒材料与减少的首次循环损失和改善的容量保持率有关。

[0103] 当与仅包含石墨作为活性材料的阳极相比时，本发明的颗粒材料可以用于提供具

有增加的容量的混合阳极。另外，颗粒材料足够稳健以经受制造和并入到阳极层中而没有结构完整性的损失，尤其是当压延阳极层以制造致密均匀层(这在本领域中是常规的)时。

[0104] 本发明的颗粒材料优选包含43至65重量%的硅、更优选45至65重量%的硅。例如，本发明的颗粒材料可以包含48至62重量%的硅、或50至60重量%的硅、或52至58重量%的硅。

[0105] 本发明的颗粒材料中氧和氮的总量与硅的重量比(即重量[O+N]:重量[Si])可以不大于0.42、或不大于0.4、或不大于0.38、或不大于0.35。任选地，氧和氮的总量与硅的重量比可以是0.1至0.42、或0.1至0.4、或0.1至0.38、或0.1至0.35。

[0106] 本发明的颗粒材料中氧和氮的总量与硅的重量比可以是至少0.2、更优选至少0.24、更优选至少0.28、更优选至少0.3、更优选至少0.32、更优选至少0.34。

[0107] 优选地，氧和氮的总量与硅的重量比可以在0.25至0.42、更优选0.28至0.4、更优选0.3至0.38、并且最优选0.32至0.38的范围内。

[0108] 本发明的颗粒材料可以任选地包含除硅、碳、氧和氮以外的少量的一种或多种其他元素。例如，颗粒材料可以包含少量的选自Al、Sb、Cu、Mg、Zn、Mn、Cr、Co、Mo、Ni、Be、Zr、Fe、Na、Sr、P、Sn、Ru、Ag、Au、Ti中的一种或多种其他元素。这样的元素可能作为微量杂质存在于硅纳米粒子中，例如当硅纳米粒子获自冶金级硅时。例如，本发明的颗粒材料可以包含0.1-8重量%的选自铝、铁、铜、镓、镁、钙、钛和锆中的一种或多种元素，其余的材料为硅、碳和氧和/或氮。备选地，这些元素可以在制造过程中存在。

[0109] 优选地，本发明的颗粒材料包含总计至少80重量%的硅、碳、氧和氮，总计至少85重量%的硅、氧、氮和碳，总计至少90重量%的硅、氧、氮和碳，或总计至少95重量%的硅、氧、氮和碳，例如总计至少98重量%的硅、氧、氮和碳，或总计至少99重量%的硅、氧、氮和碳。

[0110] 本发明的颗粒材料中碳与硅的重量比优选为至少0.15、更优选至少0.20、更优选至少0.25、更优选至少0.3。颗粒材料中碳与硅的重量比可以不大于0.8，更优选不大于0.7、更优选不大于0.6、更优选不大于0.55、更优选不大于0.5、更优选不大于0.45。

[0111] 例如，本发明的颗粒材料中碳与硅的重量比可以是0.2至0.6、更优选0.25至0.5、更优选0.3至0.45。

[0112] 本发明的颗粒材料中碳与氧和氮的总量的重量比(即重量[C]:重量[O+N])可以是至少0.7、更优选至少0.8、更优选至少0.85、或至少0.9、或至少0.95。

[0113] 本发明的颗粒材料优选包含至少8重量%的氧、或至少10重量%的氧、或至少12重量%的氧、或至少15重量%的氧。

[0114] 本发明的颗粒材料可以包含小于18重量%的氧。

[0115] 本发明的颗粒材料优选包含8重量%至小于20重量%的氧、更优选10重量%至小于20重量%的氧、更优选12重量%至小于20重量%的氧、更优选15重量%至小于20重量%的氧。

[0116] 在优选的实施方案中，本发明的颗粒材料包含2至6重量%的氮、更优选2.5至5重量%的氮、更优选3至4.5重量%的氮、并且最优选3.5至4.5重量%的氮。

[0117] 本发明的颗粒材料优选包含至少10重量%的碳、至少15重量%的碳、或至少18重量%的碳。本发明的颗粒材料优选包含不大于35重量%的碳、不大于30重量%的碳、不大于

28重量%的碳、或不大于25重量%的碳。例如，本发明的颗粒材料可以包含15至30重量%的碳、或更优选18至25重量%的碳。

[0118] 在一个优选的实施方案中，本发明的颗粒材料包含43至65重量%的硅、10重量%至小于20重量%的氧、2至6重量%的氮和15至30重量%的碳；其中颗粒材料中氧和氮的总量与颗粒材料中的硅的重量比在0.25至0.42的范围内；并且其中颗粒材料中碳与硅的重量比在0.2至0.6的范围内。

[0119] 在一个更优选的实施方案中，本发明的颗粒材料包含48至62重量%的硅、12重量%至小于20重量%的氧、2.5至5重量%的氮和18至25重量%的碳；其中颗粒材料中氧和氮的总量与颗粒材料中的硅的重量比在0.28至0.4的范围内；并且其中颗粒材料中碳与硅的重量比在0.25至0.5的范围内。

[0120] 在一个特别优选的实施方案中，本发明的颗粒材料包含50至60重量%的硅、15重量%至小于20重量%的氧、3至4.5重量%的氮和18至25重量%的碳；其中颗粒材料中氧和氮的总量与颗粒材料中的硅的重量比在0.3至0.38的范围内；并且其中颗粒材料中碳与硅的重量比在0.3至0.45的范围内。

[0121] 复合粒子中的导电碳基体可通过热解碳前体的热解而获得，如参照本发明的第一方面所描述的。通过热解获得的导电碳基体(在本文中称为“热解碳”)可以具有非晶结构，具有类石墨特征，如拉曼光谱中的大G带(~1600cm^{-1})所证明的。

[0122] 复合粒子可以具有在1至25μm的范围内的D_{50}粒径。任选地，D_{50}粒径可以是至少2μm、更优选至少3μm、更优选至少4μm、更优选至少5μm。任选地，D_{50}粒径可以不大于20μm、更优选不大于18μm、更优选不大于15μm、更优选不大于12μm、更优选不大于10μm。例如，复合粒子可以具有在1至20μm、更优选2至18μm、更优选3至15μm、更优选4至12μm、更优选5至10μm的范围内的D_{50}粒径。已经发现，由于它们在浆料中的分散性、它们的结构牢固性、它们在重复充电-放电循环中的容量保持率以及它们用于形成在20至50μm的常规范围内的均匀厚度的致密电极层的适合性，在该尺寸范围内并且具有如本文中列出的孔隙率和孔径分布的粒子理想地适合用于金属离子电池的阳极中。

[0123] 复合粒子的D_{10}粒径优选是至少0.5μm、更优选至少1μm、并且仍更优选至少2μm。通过将D_{10}粒径保持在1μm以上，不期望的亚微米尺寸粒子团聚的可能性降低，得到改善的颗粒材料分散性和改善的容量保持率。

[0124] 复合粒子的D_{90}粒径优选不大于40μm、更优选不大于30μm、更优选不大于25μm、更优选不大于20μm。大粒子的存在导致粒子在电极活性层中的不均匀形成堆积，从而破坏了致密电极层的形成，特别是厚度在20至50μm的范围内的电极层的形成。

[0125] 复合粒子的D_{99}粒径优选不大于50μm、更优选不大于40μm、更优选不大于35μm、并且最优选不大于30μm。

[0126] 复合粒子优选具有窄的尺寸分布跨度。例如，粒度分布跨度(定义为$(D_{90}-D_{10})/D_{50}$)优选为5以下、更优选4以下、更优选3以下、更优选2以下、并且最优选1.5以下。通过保持窄的尺寸分布跨度，将粒子有效堆积成致密电极层是更容易实现的。

[0127] 硅纳米粒子优选具有在30至500nm的范围内的D_{50}粒径。如果硅纳米粒子的D_{50}粒径小于30nm，则粒子的表面积可能变得过大，并且将硅纳米粒子结合至周围的导电碳基体所需要的氧/氮的量可能变得太大，从而减少硅的锂化容量。如果硅纳米粒子的D_{50}粒径大于

500nm，则硅纳米粒子不太能够有效地堆积在复合粒子内，然后需要过量的碳来补偿硅纳米粒子之间的空隙空间。任选地，硅纳米粒子的D_{50}粒径可以是至少50nm、或至少60nm、或至少70nm、或至少75nm、例如至少80nm。任选地，硅纳米粒子的D_{50}粒径可以不大于300nm、更优选不大于250nm、更优选不大于200nm、更优选不大于150nm、更优选不大于120nm。

[0128] 硅纳米粒子优选具有在50至250nm的范围内、更优选在60至200nm的范围内、更优选在70至150nm的范围内、更优选在80至120nm的范围内的D_{50}粒径。例如，硅纳米粒子的D_{50}粒径可以是约100nm。

[0129] 硅纳米粒子的D_{10}粒径可以是至少10nm、更优选至少20nm、更优选至少40nm、更优选至少60nm。硅纳米粒子的D_{90}粒径可以不大于500nm、更优选不大于400nm、更优选不大于300nm、更优选不大于200nm。硅纳米粒子可以具有5以下、更优选4以下、更优选3以下、更优选2以下、更优选1.5以下的粒度分布跨度(如上限定)。选择这些优化的D_{10}、D_{90}和粒度分布跨度值，以使与如上所列出的过小或过大的硅纳米粒子有关的问题最少。

[0130] 构成本发明的颗粒材料的复合粒子优选具有低的孔隙率。例如，如通过压汞法测定的，复合粒子可以具有不大于30%、不大于20%、不大于10%、不大于5%、或不大于2%的粒内孔隙率。由于本发明的颗粒材料依赖于使用纳米尺寸硅粒子来控制锂化和脱锂的机械应力，所以复合粒子内大的孔体积的存在仅减损了利用本发明颗粒材料可获得的体积能量密度。本发明的颗粒材料可以是纳米多孔的，并且可以包括在其整体体积上分布的直径小于2nm的孔。

[0131] 如在本文中所使用的，术语“粒内孔隙率”是指在粒子内的孔的体积与粒子的总体积的比率，并且术语“粒间孔隙率”是指在离散的粒子之间的孔的体积。颗粒材料的总孔隙率可以定义为粒内和粒间孔隙率的总和。

[0132] 压汞法是通过向浸入汞中的材料样品施加不同水平的压力来表征材料的孔隙率和孔径分布的技术。将汞压入样品的孔中所需的压力与孔的尺寸成反比。更具体地，压汞法基于控制向小孔中的液体渗透的毛细管定律。在非润湿液体如汞的情况下，该定律由Washburn方程表示：

[0133] $$D = (1/P)\cdot 4\gamma\cdot\cos\varphi$$

[0134] 其中D是孔径，P是施加的压力，γ是表面张力，并且φ是液体和样品之间的接触角。直接测量渗入样品的孔的汞的体积作为施加的压力的函数。随着分析期间压力增大，针对每个压力点计算孔尺寸并且测量填充这些孔所需的汞的相应体积。在压力范围内进行的这些测量提供了相对于样品材料的孔径分布的孔体积。Washburn方程假定所有孔都是圆柱形的。尽管在实际材料中很少遇到真正的圆柱形孔，但是这种假设为大多数材料提供了孔结构的足够有用的表示。为了避免疑问，在本文中提及孔径应当被理解为是指如通过压汞法确定的等同的圆柱形尺寸。通过如在本文中报道的压汞法得到的值是根据ASTM UOP574-11，在室温对于汞取表面张力γ为480mN/m并且取接触角φ为140°得到的。在室温取汞的密度为13.5462g/cm^3。

[0135] 对于多孔粒子粉末形式的样品来说，样品的总孔体积是粒内和粒间孔的总和。这在压汞法分析中产生了至少双峰孔径分布曲线，其包括与粒内孔径分布相关的在较小孔尺寸的一个或多个峰的组以及与粒间孔径分布相关的在较大孔尺寸的一个或多个峰的组。根

据孔径分布曲线，两组峰之间的最低点表示可以将粒内和粒间孔体积分开的直径。认为在比其大的直径处的孔体积是与粒间孔相关的孔体积。总孔体积减去粒间孔体积得到了粒内孔体积，根据粒内孔体积可以计算粒内孔隙率。

[0136] 多种高精确度的压汞法仪器是可商购获得的，如可从美国Micromeritics Instrument Corporation获得的AutoPore IV系列自动化压汞孔隙率测定仪。对于压汞法的完整综述，可以参考P.A.Webb和C.Orr，在"Analytical Methods in Fine Particle Technology(细粒技术中的分析方法)，1997，Micromeritics Instrument Corporation，ISBN 0-9656783-0中。

[0137] 应该理解的是，压汞法和其他压入技术仅有效确定对于来自待测量多孔粒子的外部的汞(或其他流体)来说可进入的孔的孔体积。如在本文中说明或报道的粒内孔隙率值应当被理解为是指开放孔(即对于来自本发明的粒子的外部的流体来说可进入的孔)的体积。在本文中，当说明或报道粒内孔隙率值时，不应考虑不能通过压汞法确定的完全封闭的孔。

[0138] 本发明的颗粒材料优选具有小于100m^2/g、更优选小于80m^2/g、更优选小于60m^2/g、更优选小于40m^2/g、更优选小于30m^2/g、更优选小于25m^2/g、更优选小于20m^2/g、更优选小于15m^2/g的BET表面积。如在本文中所使用的术语"BET表面积"应当用来指根据ASTM B922/10使用Brunauer-Emmett-Teller理论由固体表面上气体分子的物理吸附的测量计算的每单位质量的表面积。由于本发明的颗粒材料优选包含具有低粒内孔隙率的粒子，所以BET表面积将基本上是复合粒子的粒度和粒度分布的函数。通常，低的BET表面积是优选的，以使在包含本发明的颗粒材料的阳极的首次充电-放电循环期间在复合粒子的表面处的固体电解质界面(SEI)层的形成最小化。然而，由于电活性材料的体相(bulk)对于周围电解质中的金属离子的不易进入性，过低的BET表面积产生不可接受地低的充电率和容量。例如，BET表面积优选为至少0.1m^2/g、更优选至少1m^2/g、更优选至少2m^2/g、更优选至少5m^2/g。例如，BET表面积可以在1m^2/g至25m^2/g的范围内、更优选在2至15m^2/g的范围内。

[0139] 硅纳米粒子的特征可以在于Si(111)晶格间距为至少10nm、至少12nm、至少14nm、或至少16nm，如通过X射线衍射(XRD)技术测量的。

[0140] 任选地，硅纳米粒子的Si(111)晶格间距不大于100nm、不大于50nm、或不大于35nm。

[0141] 本发明的颗粒材料在首次锂化时通常具有1200至2340mAh/g的比充电容量(specific charge capacity)。优选地，本发明的颗粒材料在首次锂化时具有至少1400mAh/g的比充电容量。

[0142] 本发明的颗粒材料优选通过参照本发明的第一方面所限定的方法获得。

[0143] 应理解的是，根据本发明的第一方面的方法制备的颗粒材料可以通过关于根据本发明的第二和第三方面的颗粒材料限定的任何特征进一步限定。任何这样的特征和特征组合应当理解为类似地应用于根据本发明的第一方面制备的颗粒材料。

[0144] 特别地，根据本发明的第一方面的方法制备的颗粒材料中的硅纳米粒子可以包含纳米粒子核心和纳米粒子表面，其中纳米粒子表面包含设置在纳米粒子核心和导电碳基体之间的氧的化合物或氮的化合物或其混合物；颗粒材料包含40至65重量%的硅；颗粒材料包含至少6重量%并且小于20重量%的氧；颗粒材料中氧和氮的总量与硅的重量比在0.1至0.45的范围内；并且颗粒材料中碳与硅的重量比在0.1至1的范围内。

[0145] 根据本发明的第一方面的方法制备的颗粒材料中的硅纳米粒子可以包含纳米粒子核心和纳米粒子表面，其中多个桥联氧原子和/或多个桥联氮原子设置在纳米粒子表面和导电碳基体的至少一部分之间，使得导电碳基体化学结合至纳米粒子表面；并且颗粒材料包含40至65重量％的硅；颗粒材料包含至少6重量％并且小于20重量％的氧；颗粒材料中氧和氮的总量与颗粒材料中的硅的重量比在0.1至0.45的范围内；并且颗粒材料中碳与硅的重量比在0.1至1的范围内。

[0146] 在第四方面，本发明提供一种颗粒材料，所述颗粒材料包含可通过本发明的第一方面的方法获得的多个复合粒子。

[0147] 在本发明的第五方面，提供一种组合物，所述组合物包含根据本发明的第二、第三或第四方面的颗粒材料以及至少一种其他组分。特别地，本发明的第二、第三或第四方面的颗粒材料可以用作电极组合物的组分。

[0148] 因此，提供一种电极组合物，所述电极组合物包含根据本发明的第二、第三或第四方面的颗粒材料以及选自以下各项的至少一种另外的组分：(i)粘合剂；(ii)导电添加剂；和(iii)另外的颗粒电活性材料。用于制备本发明的第五方面的电极组合物的颗粒材料可以具有关于本发明的第二和第三方面描述为优选或任选的特征中的任一种，和/或可以通过包括关于本发明的第一方面描述为优选或任选的特征中的任一种的方法制备。

[0149] 本发明的颗粒材料优选地占电极组合物的总干重的0.5至80重量％、更优选1至70重量％、更优选1至60重量％、更优选2至50重量％、更优选2至40重量％、更优选2至30重量％、更优选5至15重量％。

[0150] 优选地，电极组合物是混合电极组合物，其包含根据本发明的第二、第三或第四方面的颗粒材料以及至少一种另外的颗粒电活性材料。另外的颗粒电活性材料的实例包括石墨、硬质炭黑、硅、锗、镓、铝和铅。至少一种另外的颗粒电活性材料优选选自石墨和硬质炭黑，并且最优选地至少一种另外的颗粒电活性材料是石墨。

[0151] 至少一种另外的颗粒电活性材料优选具有在10至50μm、优选10至40μm、更优选10至30μm并且最优选10至25μm、例如15至25μm的范围内的D_{50}粒径。

[0152] 至少一种另外的颗粒电活性材料的D_{10}粒径优选为至少5μm、更优选至少6μm、更优选至少7μm、更优选至少8μm、更优选至少9μm、并且仍更优选至少10μm。

[0153] 至少一种另外的颗粒电活性材料的D_{90}粒径优选不大于100μm、更优选不大于80μm、更优选不大于60μm、更优选不大于50μm、并且最优选不大于40μm。

[0154] 在优选的实施方案中，至少一种另外的颗粒电活性材料选自含碳粒子、石墨粒子和/或硬质炭黑粒子，其中石墨和硬质炭黑粒子具有在10至50μm的范围内的D_{50}粒径。仍更优选地，至少一种另外的颗粒电活性材料选自石墨粒子，其中该石墨粒子具有在10至50μm的范围内的D_{50}粒径。

[0155] 本发明的颗粒材料优选地占电极组合物中的电活性材料的总干重(即本发明的颗粒材料和至少一种另外的颗粒电活性材料的总干重)的1至50重量％。更优选地，本发明的颗粒材料占电极组合物中的电活性材料的总干重的2至40重量％、更优选4至25重量％、更优选5至20重量％。

[0156] 电极组合物可以任选地包含粘合剂。粘合剂起到将电极组合物粘附至集流体以及保持电极组合物的整体性的作用。可以根据本发明使用的粘合剂的实例包括聚偏二氟乙烯

(PVDF)，聚丙烯酸(PAA)及其碱金属盐，改性聚丙烯酸(mPAA)及其碱金属盐，羧甲基纤维素(CMC)，改性羧甲基纤维素(mCMC)，羧甲基纤维素钠(Na-CMC)，聚乙烯醇(PVA)，藻酸酯及其碱金属盐，苯乙烯-丁二烯橡胶(SBR)和聚酰亚胺。电极组合物可以包含粘合剂的混合物。优选地，粘合剂包括选自聚丙烯酸(PAA)及其碱金属盐、和改性聚丙烯酸(mPAA)及其碱金属盐、SBR以及CMC的聚合物。

[0157] 基于电极组合物的总干重，粘合剂可以适宜地以0.5重量%至20重量%、优选1重量%至15重量%、并且最优选2重量%至10重量%的量存在。

[0158] 粘合剂可以任选地与改变粘合剂的性质的一种或多种添加剂如交联促进剂、偶联剂和/或粘合促进剂组合存在。

[0159] 电极组合物可以任选地包含一种或多种导电添加剂。优选的导电添加剂是非电活性材料，其被包括从而提高电极组合物的电活性组分之间以及电极组合物的电活性组分和集流体之间的导电性。导电添加剂可以适宜地选自炭黑、碳纤维、碳纳米管、石墨烯、乙炔黑、科琴黑、金属纤维、金属粉末和导电金属氧化物。优选的导电添加剂包括炭黑和碳纳米管。

[0160] 基于电极组合物的总干重，一种或多种导电添加剂可以适宜地以0.5重量%至20重量%、优选1重量%至15重量%、并且最优选2重量%至10重量%的总量存在。

[0161] 在第六方面，本发明提供一种电极，所述电极包含参照本发明的第二、第三或第四方面所限定的颗粒材料，所述颗粒材料与集流体电接触。用于制备本发明的第六方面的电极的颗粒材料可以具有关于本发明的第二和第三方面描述为优选或任选的特征中的任一种，和/或可以通过包括关于本发明的第一方面描述为优选或任选的特征中的任一种的方法制备。

[0162] 如在本文中所使用的，术语集流体是指能够将电流输送到电极组合物中的电活性粒子和从电极组合物中的电活性粒子输送电流的任何导电基板。可以用作集流体的材料的实例包括铜、铝、不锈钢、镍、钛和烧结碳。铜是优选的材料。集流体通常是厚度在3至500μm之间的箔或网的形式。本发明的颗粒材料可以施加于集流体的一个或两个表面至优选在10μm至1mm、例如20至500μm、或50至200μm的范围内的厚度。

[0163] 优选地，电极包含参照本发明的第五方面所限定的电极组合物，所述电极组合物与集流体电接触。电极组合物可以具有关于本发明的第五方面描述为优选或任选的特征中的任一种。特别地，优选的是用于形成本发明的第六方面的电极的电极组合物包含如上所述的一种或多种另外的颗粒电活性材料。

[0164] 本发明的第六方面的电极可以适宜地通过以下方式制造：将本发明的颗粒材料(任选地以本发明的电极组合物的形式)与溶剂和任选地一种或多种粘度调节添加剂组合以形成浆料。然后将浆料流延到集流体的表面上并且移除溶剂，从而在集流体的表面上形成电极层。可以适当地进行另外的步骤，诸如热处理以固化任何粘合剂和/或压延电极层。电极层适宜地具有在20μm至2mm、优选20μm至1mm、优选20μm至500μm、优选20μm至200μm、优选20μm至100μm、优选20μm至50μm的范围内的厚度。

[0165] 备选地，例如通过将浆料流延到合适的流延模板上、移除溶剂然后移除流延模板，可以将浆料形成包含本发明的颗粒材料的自立式的膜或垫。所得的膜或垫是内聚的、自立式的块状物形式，然后可以通过已知的方法将其粘结到集流体。

[0166] 本发明的第六方面的电极可以用作金属离子电池的阳极。因此，在第七方面，本发明提供一种可再充电金属离子电池，所述可再充电金属离子电池包括：阳极，所述阳极包括如以上所描述的电极；阴极，所述阴极包括能够释放和再吸收金属离子的阴极活性材料；和在所述阳极和所述阴极之间的电解质。

[0167] 金属离子优选选自锂、钠、钾、钙或镁。更优选地，本发明的可再充电金属离子电池是锂离子电池，并且阴极活性材料能够释放锂离子。

[0168] 阴极活性材料优选为金属氧化物系复合材料。适合的阴极活性材料的实例包括$LiCoO_2$、$LiCo_{0.99}Al_{0.01}O_2$、$LiNiO_2$、$LiMnO_2$、$LiCo_{0.5}Ni_{0.5}O_2$、$LiCo_{0.7}Ni_{0.3}O_2$、$LiCo_{0.8}Ni_{0.2}O_2$、$LiCo_{0.82}Ni_{0.18}O_2$、$LiCo_{0.8}Ni_{0.15}Al_{0.05}O_2$、$LiNi_{0.4}Co_{0.3}Mn_{0.3}O_2$和$LiNi_{0.33}Co_{0.33}Mn_{0.34}O_2$。阴极集流体通常具有3至500μm的厚度。可以用作阴极集流体的材料的实例包括铝、不锈钢、镍、钛和烧结碳。

[0169] 电解质适宜地为含有金属盐例如锂盐的非水电解质，并且可以包括，但不限于，非水电解液、固体电解质和无机固体电解质。可以使用的非水电解液的实例包括非质子有机溶剂，如碳酸亚丙酯、碳酸亚乙酯、碳酸亚丁酯、碳酸二甲酯、碳酸二乙酯、γ-丁内酯、1,2-二甲氧基乙烷、2-甲基四氢呋喃、二甲亚砜、1,3-二氧戊环、甲酰胺、二甲基甲酰胺、乙腈、硝基甲烷、甲酸甲酯、乙酸甲酯、磷酸三酯、三甲氧基甲烷、环丁砜、甲基环丁砜和1,3-二甲基-2-咪唑烷酮。

[0170] 有机固体电解质的实例包括聚乙烯衍生物、聚环氧乙烷衍生物、聚环氧丙烷衍生物、磷酸酯聚合物、聚酯硫化物(polyester sulfide)、聚乙烯醇、聚偏二氟乙烯和含有离子解离基团的聚合物。

[0171] 无机固体电解质的实例包括锂盐的氮化物、卤化物和硫化物，如Li_5NI_2、Li_3N、LiI、$LiSiO_4$、Li_2SiS_3、Li_4SiO_4、LiOH和Li_3PO_4。

[0172] 锂盐可以合适地溶解在所选择的溶剂或溶剂混合物中。适合的锂盐的实例包括LiCl、LiBr、LiI、$LiClO_4$、$LiBF_4$、$LiBC_4O_8$、$LiPF_6$、$LiCF_3SO_3$、$LiAsF_6$、$LiSbF_6$、$LiAlCl_4$、CH_3SO_3Li和CF_3SO_3Li。

[0173] 在电解质是非水有机溶液的情况下，金属离子电池优选设置有插入在阳极和阴极之间的隔膜。隔膜通常由具有高离子渗透性和高机械强度的绝缘材料形成。隔膜通常具有0.01至100μm的孔径和5至300μm的厚度。适合的电极隔膜的实例包括微孔聚乙烯膜。

[0174] 隔膜可以被聚合物电解质材料代替，并且在这种情况下，聚合物电解质材料存在于复合阳极层和复合阴极层二者内。聚合物电解质材料可以是固体聚合物电解质或凝胶型聚合物电解质。

[0175] 在第八方面，本发明提供参照本发明的第二、第三或第四方面所限定的颗粒材料作为阳极活性材料的用途。优选地，颗粒材料为参照本发明的第五方面所限定的电极组合物的形式，并且最优选地电极组合物包含如上所限定的一种或多种另外的颗粒电活性材料。

[0176] 根据ASTM D5373，使用LECO® TruSpec微量元素分析仪对本文中报道的本发明的颗粒材料进行元素分析，以确定颗粒材料中碳、氮和氧的重量%。根据ASTM D5600，使用ICP-AES进行硅的分析。

[0177] 现在将通过实施例和附图1来描述本发明，其为如下所述的样品1至9和比较样品1

的容量保持率(y轴)相对于碳:硅比的图。

实施例

[0178] 实施例1-颗粒硅-碳材料的制备

[0179] 样品1至12的颗粒硅-碳材料和对照样品(CS1)以表1中指定的量使用硅原料和碳源制备。

[0180] 将指定的碳源溶解在玻璃烧杯中的指定溶剂(约40mL)中。添加颗粒硅原料,并且将混合物搅拌以形成浆料。将所得浆料转移到装有1mm氧化锆研磨珠的Retsch球磨机杯中。用另外的溶剂(2x 15mL)冲洗烧杯,并且将洗涤物添加到Retsch球磨机杯中。将盖子放在球磨机杯上,称重。称重第二个球磨机杯,并且调节其重量直到其与第一个球磨机杯的重量相同;在行星式球磨期间,该第二个杯充当第一个杯的配重(counter-balance)。将两个杯固定到Retsch PM200行星式球磨机上,并且将混合物以500rpm碾磨30分钟间隔,静置15分钟,反转磨机的方向并且重复这些步骤,直到每个样品都已达到表1中设定的总活性碾磨时间。

[0181] 表1

[0182]

样品编号	颗粒原料硅			碳源	Si质量/g	C质量/g	溶剂	活性碾磨时间/分钟
	D_{50}	BET/m^2/g	纯度					
1	2.5 μm	6.62	99.9%	2,3-DHN[1]	5	10	IPA[4]	180
2	2.5 μm	6.62	99.9%	DAN[2]	5	5	IPA	180
3	2.5 μm	6.62	99.9%	2,3-DHN	5	10	IPA	180
4	2.5 μm	6.62	99.9%	2,3-DHN	10	10	丙酮	120
5	2.5 μm	6.62	99.9%	2,3-DHN	10	10	IPA	90
6	5.16 μm	1.99	99%	2,3-DHN	5	10	IPA	180
7	5.16 μm	1.99	99%	2,3-DHN	5	5	丙酮	120

[0183]

8	5.16 μm	1.99	99%	2,3-DHN	10	10	IPA	180
9	5.16 μm	1.99	99%	DAB[3]	5	5	IPA	180
10	5.16 μm	1.99	99%	萘	5	5	IPA	180
11	5.16 μm	1.99	99%	DAN	5	5	IPA	180
12	5.16 μm	1.99	99%	2,3-DHN	5	5	IPA	180
13	6 μm	nd[5]	98.4%	2,3-DHN	5	5	IPA	180
14	6 μm	nd	98.4%	2,3-DHN	5	5	丙酮	180
CS1	5.16 μm	1.99	99%	-	5	5	IPA	180

[0184] [1]2,3-二氢萘;[2]2,3-二氨基萘;[3]1,2-二氨基苯;[4]异丙醇;[5]未测定

[0185] 将碾磨杯冷却。将碾磨的材料通过53μm筛网过滤并且用另外的溶剂(约150mL)洗涤,直到滤液变浅。使用Buchi旋转蒸发仪在减压下从滤液中移除溶剂。将所得的残余物在

75℃的烘箱中进一步干燥过夜。

[0186] 将烘干的材料用5x 20mL份的丙酮洗涤以移除任何未结合的碳源。然后，使用表2中指定的热解方案，将丙酮洗涤过的材料在炉中在氧化铝坩埚中进行热解。将材料在氩气流(1L/min)下密封在氧化铝坩埚中，并且对炉输入程序指令从而以5℃/分钟的速率加热到表2中指定的初始温度(T1)。将坩埚在该初始温度下保持表2中指定的第一保持时间(t1)，然后以5℃/min的速率将温度升高到表2中指定的最终温度(T2)，并且将坩埚在该温度下保持表2中指定的第二保持时间(t2)，然后冷却至室温。

[0187] 从坩埚中移出热解的材料，并且使用手持式微粉机进行微粉化达10秒钟的时间段，总微粉化时间多达30秒至1分钟。然后使用Retsch PM200行星式球磨机按照表2中指定的条件对微粉化的材料进行干磨。将材料以表2中指定的量与所需量的碾磨珠一起放入球磨机杯中，以500rpm碾磨2分钟，静置1分钟，改变磨机的方向，并且重复进行直到已经达到表2中指定的总活性碾磨时间。

[0188] 表2

样品编号	热解方案				干磨方案			
	T1 /℃	t1 / h	T2 /℃	T2 /h	10 mm 珠	13 mm 珠	样品质量 / g	活性碾磨时间 /分钟
1	300	1	1000	2	4	4	16	220
2	150	1	1000	2	8	8	15	120
3	300	1	1000	2	4	4	16	220
4	300	1	1000	2	4	4	5	180
5	300	1	1000	2	4	4	9	120
6	300	1	1000	2	4	4	14	75
7	300	1	1000	2	4	4	16	150
8	300	1	1000	2	4	4	12	150
9	150	1	1000	2	4	4	15	220
10	150	1	1000	2	4	4	10	150
11	300	1	1000	2	4	4	14	150
12	300	1	1000	2	4	4	14	150
13	300	1	1000	1	4	4	16	120
14	300	1	1000	1	4	4	11	120
CS1	150	1	1000	2	4	4	14	120

[0189]

[0190] 然后使用Malvern Mastersizer 3000仪器对颗粒材料进行粒度分析，并且使用ICP/MS和LECO这两者技术进行元素分析。还使用Micromeritics Tristar II 3020仪器确

定了所得颗粒材料的BET表面积值，并且样品1至12和比较样品1的结果列于表3中。

[0191] 表3

样品编号	元素组成(LECO)			元素比率		粒度 / μm			BET / m^2/g
	Si%	C%	O%	C/Si	O/Si	D_{10}	D_{50}	D_{90}	
1	49.5	35.8	14.2	0.72	0.29	1	5	20	18
2	49	29.1	9.2	0.59	0.19	1	4	22	48
3	49.5	35.8	14.2	0.72	0.29	1	5	20	18
4	63.4	25.1	11.3	0.40	0.18	1	5	30	28
5	64.1	25.2	10.5	0.39	0.16	1	6	22	15
6	58.4	26.8	14.6	0.46	0.25	1	5	20	15
7	52.3	33.1	14.3	0.63	0.27	1	5	15	20
8	58.4	28	13.5	0.48	0.23	1	6	30	26
9	65.9	18.6	10.2	0.28	0.15	1	6	29	28
10	51.5	32.7	9.7	0.63	0.19	0.89	5.39	22.6	15
11	84	7.5	8.5	0.09	0.10	1	9	100	102
12	83.1	6.7	10.1	0.08	0.12	nd	nd	nd	134
CS1	80.8	8.4	10.8	0.10	0.13	1.25	11.2	56.5	73

[0192]

[0193] 实施例2-电极的制备

[0194] 使用以下方法由实施例1至12的材料和对照样品1(CS1)制备具有表4中指定的组成的阳极。用包含如上所述制备的硅-碳颗粒材料的负极制造测试纽扣电池。将碳Super P(导电碳)和天然石墨(D_{50}=2.85μm)在CMC粘合剂中的分散体在Thinky™混合器中混合。将硅碳颗粒材料添加到混合物中并且在Thinky™混合器中混合30分钟。然后添加SBR粘合剂以得到1:1的CMC:SBR比率，得到具有如表4中列出的颗粒硅-碳:石墨:CMC/SBR:导电碳的重量比的浆料。通过磁力搅拌将浆料进一步混合1小时，然后将其涂布在10μm厚的铜基板(集流体)上，并且在50℃干燥10分钟，然后在120-180℃进一步干燥12小时，从而形成包含铜基板上的活性层的电极。在制造电池之前，将活性层在2T下压延。

[0195] 表4

[0196]

样品编号	阳极组成			
	Si/C 产物重量%	石墨重量%	碳 Super P 重量%	粘合剂重量%
1	10	81	5	4
2	10	81	5	4
3	15	76	5	4
4	10	81	5	4
5	10	81	5	4
6	10	81	5	4
7	10	81	5	4
8	10	81	5	4
9	10	81	5	4
10	10	81	5	4
11	10	81	5	4
12	10	81	5	4
CS1	10	81	5	4

[0197] 实施例3-电池制造和循环

[0198] 半电池制造

[0199] 使用从实施例2的电极切下的0.8cm半径的盘状电极与多孔聚乙烯隔膜、作为对电极的锂箔以及的电解质来制造纽扣半电池，所述电解质包含在含有3重量%碳酸亚乙烯酯的EC/FEC(碳酸亚乙酯/碳酸氟代亚乙酯)的7:3溶液中的1M $LiPF_6$。

[0200] 这些半电池用于测量活性层的初始体积能量密度(VED1)、首次循环损失(FCL)和首次脱锂容量(DC1)。表5中列出了相关值。通过施加C/25的恒定电流(其中"C"代表以mAh计的电极比容量，并且"25"是指25小时)对半电池进行测试，以锂化包含多孔粒子的电极，截止电压为10mV。当达到截止值时，施加10mV的恒定电压，截止电流为C/100。然后将电池在锂化状态下静置1小时。然后将电极以C/25的恒定电流脱锂，截止电压为1V，然后将电池静置1小时。然后施加C/25的恒定电流对锂电池进行第二次锂化，截止电压为10mV，然后施加10mV恒定电压，截止电流为C/100。

[0201] 全电池制造

[0202] 使用从该电极切下的0.8cm半径的盘状负极与多孔聚乙烯隔膜和氧化钴锂正极来制造全纽扣电池。将正极和负极设计为形成平衡对，使得电极的设计容量比为约1:1。然后将包含在含有3重量%碳酸亚乙烯酯的EMC/FEC(碳酸亚乙甲酯/碳酸氟代亚乙酯)的7:3溶液中的1M $LiPF_6$的电解质添加到电池中，然后密封。

[0203] 全电池的循环如下：以C/25的速率施加恒定电流以将阳极锂化，截止电压为4.2V。当达到截止值时，施加4.2V的恒定电压，直到达到C/100的截止电流。然后将电池在锂化状态下静置1小时。然后将阳极以C/25的恒定电流脱锂，截止电压为3.0V。然后将电池静置1小时。在该初始循环后，施加C/2的恒定电流以将阳极锂化，截止电压为4.2V，然后施加4.2V恒定电压，截止电流为C/40。然后将阳极以C/2的恒定电流脱锂，截止值为3.0V。然后将电池静置5分钟。然后将其重复所需的循环数。测定每个样品在100次循环时的充电和放电容量(DC100)和容量保持率(CR100)；表5中也列出了这些值。

[0204] 表5

[0205]

样品编号	电池循环性质				
	VED1 (mAh/g)	FCL (%)	DC1 (mAh/g)	DC100 (mAh/g)	CR100 (%)
1	429	21.2	403	322	0.80
2	468	29.4	386	302	0.78
3	479	27	406	310	0.76
4	441	23.4	432	309	0.72
5	465	24	449	308	0.69
6	303	26	355	284	0.80
7	497	30	312	265	0.85
8	505	24	390	286	0.73

[0206]

9	358	26	402	273	0.68
10	481	32	296	nd	nd
11	416	nd	nd	nd	nd
12	265	nd	nd	nd	nd
CS1	360	25	437	265	0.61

[0207] 图1是容量保持率(y轴)与碳:硅比率的图。观察到，当碳:硅比率大于0.10时观察到良好的容量保持率。在碳:硅比率为0.1以下时，容量保持率是相对差的。理想地，颗粒材料中碳与硅的比率为约0.4至0.65。

[0208] 实施例4-颗粒硅-碳材料的制备

[0209] 将异丙醇(IPA)转移到含有200微米氧化锆研磨珠的Netzsch高能搅拌珠磨机中。然后将珠磨机设定为使IPA再循环，并且将硅缓慢添加到溶剂中，以产生约27％w/w的硅浆料。然后将浆料碾磨至D_{90}＜800nm，同时保持浆料温度低于50℃。粒度测量在Malvern Mastersizer 3000上进行。然后将所得的研磨浆料排入合适的容器中，并且在干燥失重(LOD)水分分析仪上测量固体含量(通常～30％w/w)。该浆料称为“预碾磨”硅浆料。

[0210] 然后使用IPA将"预碾磨"硅浆料调整至20%w/w固体含量，并且装入到含有50微米氧化锆研磨珠的Netzsch珠磨机中。然后将该浆料碾磨至D_{98}＜188nm，同时保持浆料温度低于50℃。粒度测量在Malvern Mastersizer3000上进行。然后将所得的研磨浆料排入合适的容器中，并且在LOD水分分析仪上测量固体含量(通常27~30%w/w)。该浆料称为"纳米碾磨"硅浆料。

[0211] 通过使用顶置式搅拌器将PVP溶解在IPA中，制备IPA中的20%w/w聚乙烯吡咯烷酮(PVP)溶液。然后使用LOD水分分析仪测量其固体含量。然后将该PVP溶液与"纳米碾磨"硅浆料以1份硅与1.1份PVP的固体重量比组合，并且使用顶置式搅拌器混合，直到在高压均质器中完全均质。然后使该均质Si:PVP浆料在约1500巴的压力下通过高压均质器，并且收集于合适的容器中。然后在LOD水分分析仪(Sartorius MA37，于100℃)上测量固体含量，并且在喷雾干燥之前用IPA调节至20%w/w总固体含量。

[0212] 喷雾干燥在具有氮气闭环的ProCept 4M8Trix干燥机上进行。将均质Si/PVP/IPA浆料(410g)以10g/min的速率进料到喷雾干燥器中。从旋风分离器中收集干燥产物(71.2g，87%回收率)，并且发现具有D_{50}＝10.5μm(Malvern Mastersizer/Aero)以及7重量%的挥发物含量。

[0213] 从干燥室壁中回收另外的干燥产物(10.9g)，但是不与来自旋风分离器的材料合并。

[0214] 然后将喷雾干燥的材料(20g批量大小)装入400mL玻璃旋转炉容器中，并且放入Carbolite HTR1100旋转炉中。然后将材料置于0.2ml/min流量的干燥压缩空气下，并且以约0.75rpm旋转。在整个过程中保持该气流和旋转。将炉在受控条件下以不大于5℃/min的升温速率加热至270℃的最高温度，然后在该温度下保持4小时，以使PVP和硅交联。交联后，将材料放置约2小时以冷却，然后从容器中排出。在该阶段，取出~2g样品，并且使用ICP/MS和LECO这两者技术分析材料组成。

[0215] 然后将交联的材料放入氧化铝坩埚中，并且在流动氮气(0.6L/min)下在静态Carbolite管式炉中热解。将炉以5℃/min的速率加热至1170℃，然后在该温度下保持3小时，然后自然冷却(通常10~15小时)。

[0216] 然后，在使用前将热解产物通过38微米筛网筛分。还在元素组成(如上所述)和表面积(BET)、粒度和振实密度方面对材料进行充分表征。使用Micromeritics Tristar II 3020仪器测量BET。下面在表6中提供最终产物的性质。

[0217] 实施例5-不进行温度控制下的颗粒硅-碳材料的制备

[0218] 除了在静态炉中进行交联反应并且不控制交联反应的最高温度以外，以与实施例4中所述的方式进行实施例5。由于放热的交联反应，内部温度从100℃迅速升高到大大超过300℃。下面在表6中提供最终产物的性质。

[0219] 实施例6-经由CVD制备碳涂布的硅-碳复合材料

[0220] 将11.1g的根据实施例5的方法制备的硅-碳复合材料装入到配衡的石英反应容器(400ml/85mm直径)中，并且在Carbolite HTR1100旋转炉中在氩气(200mL/min)下以5℃/min加热至900℃。将振荡设定为约1/min。当炉达到目标温度时，通入乙烯气体(20mL/min)达20分钟。然后停止乙烯流，并且使氩气流动另外5分钟，此后停止加热。在旋转的同时，使产物在氩气下被动冷却，直到内部温度已经降至50℃。将反应容器称量，并且记录0.3g

(2.6%)的近似重量增加。收集产物(10.6g)，并且发现BET已从5.0降至3.4m^2/g。下面在表6中提供最终产物的性质。

[0221] 表6

[0222]

		实施例 4	比较例 5	实施例 6
经由 XPS 的表面表征	碳	89.7%	86%	96.6%
	硅	3.5%	4.63%	1.22%
	硅氧化物	1.6%	3.74%	0.82%
	氧	4.6%	8.0%	1.8%
体相	氧	15.38	16.4	16.4
	碳	19.21	21.24	21.24
	硅	56.22	55.09	55.09
半电池首次循环损失	%	21.9	24.5	23.9
半电池脱锂容量	mAh/g	1647	1719	1691

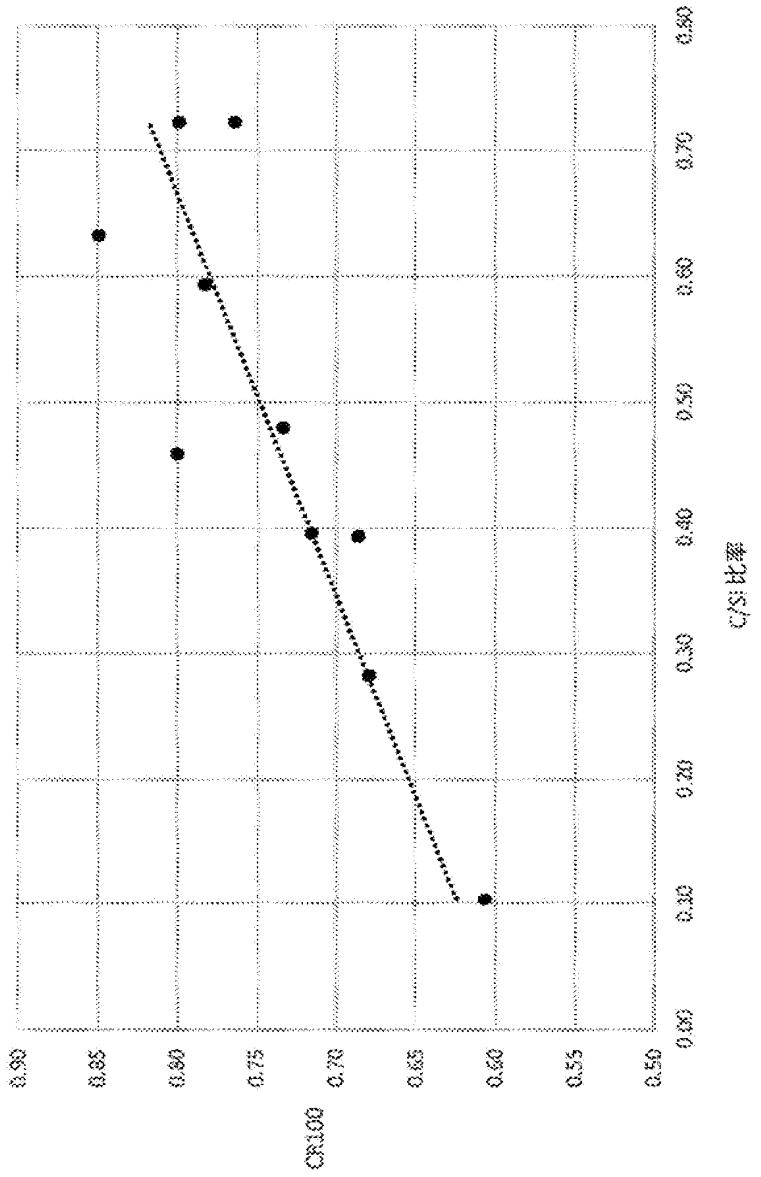

0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
CR100
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
CR24/CR2

图1

(19)中华人民共和国国家知识产权局

(12)实用新型专利

(10)授权公告号 CN 207303263 U
(45)授权公告日 2018.05.01

(21)申请号 201720234356.0

(22)申请日 2017.03.12

(73)专利权人 深圳格林德能源有限公司
地址 518105 广东省深圳市宝安区松岗燕川红湖路168号利源海湾工业园A2栋4楼

(72)发明人 王敏 李国敏 刘小虹

(51)Int.Cl.
H01M 10/0587(2010.01)
H01M 4/13(2010.01)
H01M 2/26(2006.01)

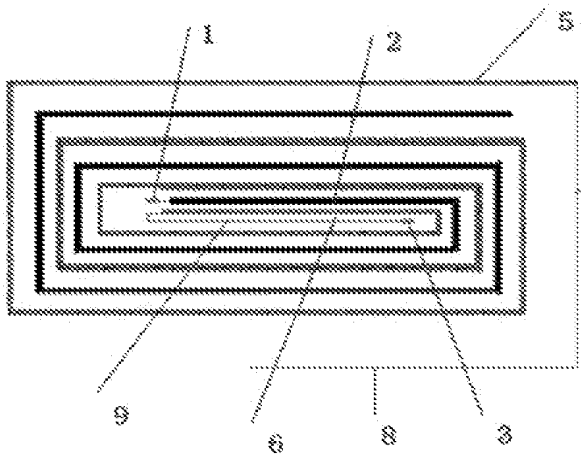
权利要求书1页 说明书2页 附图2页

(54)实用新型名称

一种快充聚合物锂离子电池电芯结构

(57)摘要

本实用新型公开了一种快充聚合物锂离子电池电芯结构，由正极片、正极极耳、负极片、负极极耳、隔离膜和电解液组成，正极片包括铝箔和涂覆于铝箔上的正极活性物质，在所述的正极极片首端表面区域设有极耳。负极片包括铜箔和涂覆于铜箔上的负极活性物质，在所述负极片的前端表面区域设有极耳。此电芯结构正负极耳所对的区域未涂覆活性物质，极耳的厚度就相当于两层活性物质的厚度，使得卷芯极耳位置厚度与其它区域保持一致，提高了空间利用率，同一尺寸的电池容量更高。铜箔的散热性能较好，卷芯最内及最外层为一层空白铜箔区域，极大提高了电池的散热性能，增加了电池快速充放电性能，避免了电池因大电流工作时的热量聚积而发生安全事故。



CN 207303263 U

1.一种快充聚合物锂离子电池电芯结构，由正极片、正极极耳、负极片、负极极耳、隔离膜和电解液组成，其特征在于，所述的正极片包括铝箔和涂覆于铝箔上的正极活性物质，在所述的正极片前端表面区域设有极耳，正极片前端的上下表面均设置有未涂覆正极活性物质层的空白铝箔区；所述的负极片包括铜箔和涂覆于铜箔上的负极活性物质，在所述负极片的前端表面区域设有极耳，负极片前端的上下表面及尾端的上下表面均设置有未涂覆负极活性物质层的空白铜箔区，其中前段的上下表面为第一空白区，尾端的上下表面为第二空白区，负极极耳设置在第一空白区。

2.根据权利要求1所述的一种快充聚合物锂离子电池电芯结构，其特征在于，该电芯结构其正极极耳(1)所对负极区域为未涂有活性物质的上表面头部空白铜箔区(6)、下表面头部空白铜箔区(9)，而负极极耳(3)则包裹于单面涂有负极活性物质的两层负极极片中，其正对区域是未涂有活性物质的上表面头部空白铜箔区(6)，卷芯最内层为未涂覆负极活性物质下表面头部空白铜箔区(9)，最外层则为未涂覆负极活性物质下表面尾部空白铜箔区(5)。

3.根据权利要求1所述的一种快充聚合物锂离子电池电芯结构，其特征在于，所述的正极片前端上下表面区空白铝箔区长度一致，长度为5~20mm。

4.根据权利要求1所述的一种快充聚合物锂离子电池电芯结构，其特征在于，所述的负极片第一空白区上表面长度大于下表面的长度，第二空白区下表面长度长于上表面。

一种快充聚合物锂离子电池电芯结构

技术领域

[0001] 本实用新型属于锂离子电池技术制造领域，具体涉及到一种厚度均匀、散热性好、安全性高的快充聚合物锂离子电池电芯结构。

背景技术

[0002] 锂离子电池具有能量密度大、输出功率高、充放电寿命长、无污染等优点，广泛应用于高能便携式电子设备、交通运输、无人机等领域中，随着锂离子电池应用领域的不断拓展，快速的生活节奏使得人们对电池的充放电时间要求也越来越高。快速、安全、高容量的高性能锂离子电池逐步发展成为某些电子设备的标配。锂离子电池内部正负极活性物质及电解液的化学反应会放出热量，特别是大电流的充放电会产生更多的热量，若产生的热量不能及时散去，将引起电池的升温而进一步促使化学反应的加剧，热量的持续蓄积，电池便存在燃烧、爆炸等风险。

[0003] 目前，随着锂离子电池应用领域的不断拓展，人们对适合快速充放电的高安全性的锂离子电池的需求越来越广泛。传统的锂离子电池结构不适合大电流充放电，大电流充放电时电池内部温度较高，存在较大的安全风险。因此，寻找一种安全性高适合快充的锂离子电池电芯结构十分重要。

发明内容

[0004] 本实用新型目的在于：提供一种散热快、厚度均匀、安全性高的快充聚合物锂离子电池电芯结构。与传统的锂离子电池电芯结构相比，此结构正负极耳所对的区域未涂覆活性物质，极耳的厚度就相当于两层活性物质的厚度，使得卷芯极耳位置厚度与其它区域保持一致，提高了空间利用率，同一尺寸的电池容量更高。铜箔的散热性能较好，卷芯最内及最外层为一层空白铜箔区域，极大的提高了电池的散热性能，增加了电池快速充放电的性能，避免了电池因大电流工作时的热量聚积而发生安全事故。

[0005] 本实用新型采取的技术方案如下：

[0006] 一种快充聚合物锂离子电池电芯结构，由正极片、正极极耳、负极片、负极极耳、隔离膜和电解液组成，所述的正极片包括铝箔和涂覆于铝箔上的正极活性物质，在所述的正极片前端表面区域设有极耳，正极片前端的上下表面均设置有未涂覆正极活性物质层的空白铝箔区；所述的负极片包括铜箔和涂覆于铜箔上的负极活性物质，在所述负极片的前端表面区域设有极耳，负极片前端的上下表面及尾端的上下表面均设置有未涂覆负极活性物质层的空白铜箔区，其中前段的上下表面为第一空白区，尾端的上下表面为第二空白区，负极极耳设置在第一空白区。

[0007] 卷绕完成后，正极极耳1所对负极区域为未涂有活性物质的上表面头部空白铜箔区6、下表面头部空白铜箔区9，而负极极耳3则包裹于单面涂有负极活性物质的两层负极极片中，其正对区域是未涂有活性物质的上表面头部空白铜箔区6，卷芯最内层为未涂覆负极活性物质下表面头部空白铜箔区9，最外层则为未涂覆负极活性物质下表面尾部空白铜箔

区5。

[0008] 所述的正极片前端上下表面区空白铝箔区长度一致，长度为5-20mm。

[0009] 所述的负极片第一空白区上表面长度大于下表面的长度，第二空白区下表面长度长于上表面。

附图说明

[0010] 图1为本实用新型的电芯结构示意图。

[0011] 图2为本实用新型正极片的结构示意图。

[0012] 图3为本实用新型图2的俯视图。

[0013] 图4为本实用新型负极片的结构示意图。

[0014] 图5为本实用新型图4的俯视图。

具体实施方式

[0015] 下面结合附图1、图2、图3、图4及图5对本实用新型做进一步的说明：

[0016] 图1中所述，本实用新型结构的卷芯是由正极片、负极片、隔膜卷绕而成，所述的正极片是由铝箔及涂覆于其上的正极活性物质组成，所述的负极片是由铜箔及涂覆于其上的负极活性物质组成。正极极耳1所对负极区域为未涂有活性物质的上表面头部空白铜箔区6、下表面头部空白铜箔区9，而负极耳3则包裹于单面涂有负极活性物质的2层负极极片中，其正对区域亦是未涂有活性物质的上表面头部空白铜箔区6，卷芯最内层为未涂覆负极活性物质下表面头部空白铜箔区9，最外层则为未涂覆负极活性物质下表面尾部空白铜箔区5。

[0017] 为实现本实用新型的目的，如图4、5所示的负极片，其端部焊有负极极耳，首尾俩端均有未涂覆活性物质的空白铜箔区，首端为第一空白区，其上表面头部空白铜箔区6长于下表面头部空白铜箔区9，尾端为第二空白区，其下表面尾部空白铜箔区5长于上表面尾部空白铜箔区8。

[0018] 如图2、3所示，正极首端设有未涂覆活性物质的空白铝箔区，其中上下表面空白区的长度一致，正极极耳焊于此处，其长度为5-20mm。

[0019] 此电芯结构正负极耳所对的区域未涂覆活性物质，极耳的厚度就相当于两层活性物质的厚度，使得卷芯极耳位置厚度与其它区域保持一致，提高了空间利用率，同一尺寸的电池容量更高。铜箔的散热性能较好，卷芯最内及最外层为一层空白铜箔区，极大的提高了电池的散热性能，增加了电池快速充放电的性能，避免了电池因大电流工作时的热量聚积而发生安全事故。

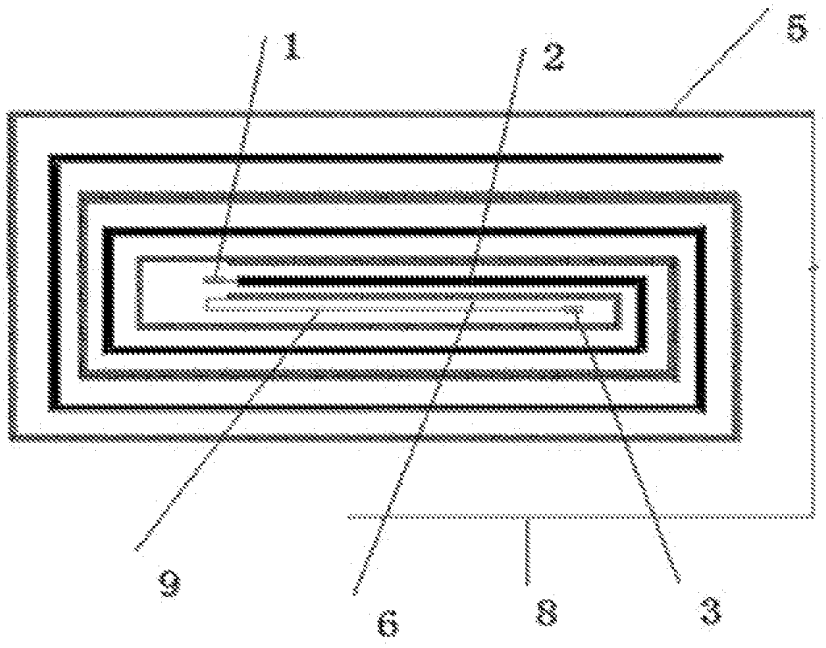


图1



图2

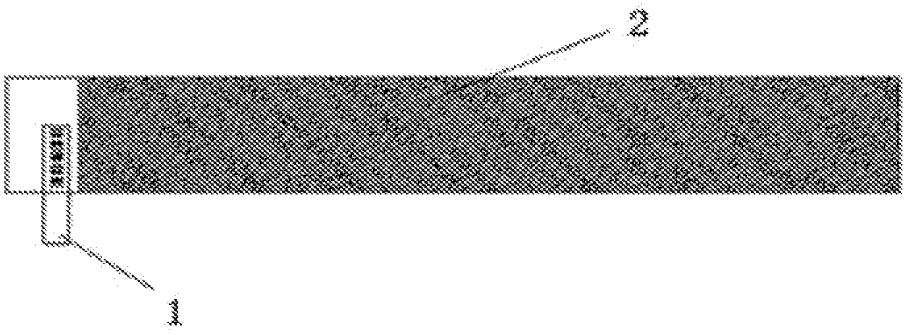


图3

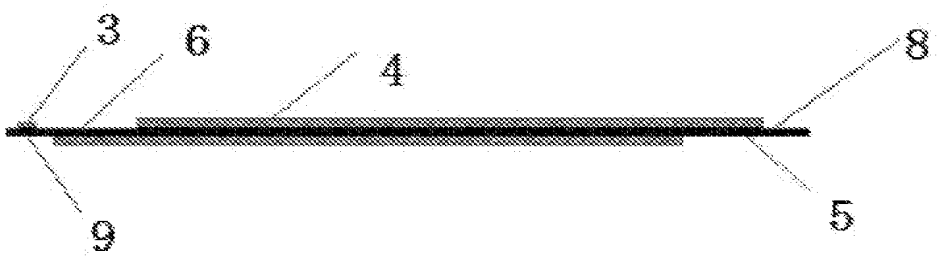


图4

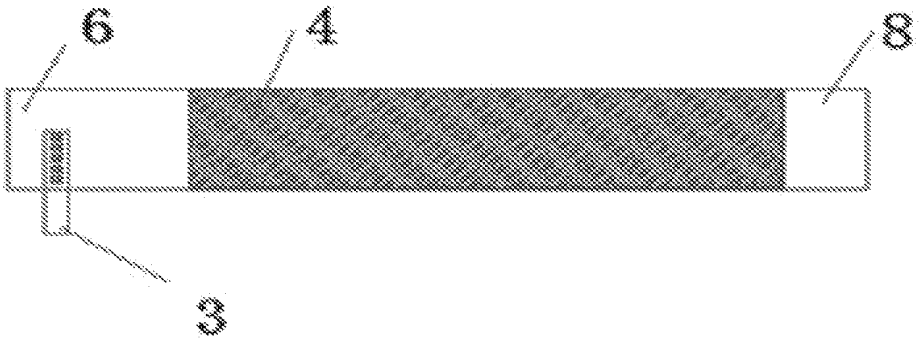


图5

(19)中华人民共和国国家知识产权局

(12)发明专利申请

(10)申请公布号 CN 105336984 A
(43)申请公布日 2016.02.17

(21)申请号 201410374264.3
(22)申请日 2014.07.31
(71)申请人 东莞新能源科技有限公司
地址 523808 广东省东莞市松山湖科技产业园区
申请人 宁德新能源科技有限公司
(72)发明人 叶士特 李松 付成华 褚春波
(74)专利代理机构 北京五洲洋和知识产权代理事务所(普通合伙) 11387
代理人 张向琨
(51)Int.Cl.
H01M 10/0567(2010.01)
H01M 10/0525(2010.01)

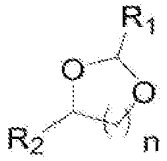
权利要求书2页 说明书10页

(54)发明名称

锂离子电池及其电解液

(57)摘要

本发明提供一种锂离子电池及其电解液。所述锂离子电池的电解液，包括：非水有机溶剂；锂盐，溶解在非水有机溶剂中；以及添加剂，溶解在非水有机溶剂中。所述添加剂包含具有式I结构的1,3-二氧杂环化合物以及氟代碳酸乙烯酯(FEC)；在式I中，R_1、R_2各自独立选自H、甲基或乙基；n选自1～3内的整数；具有式I结构的1,3-二氧杂环化合物在锂离子电池的电解液中的质量百分含量为0.05%～5%；氟代碳酸乙烯酯(FEC)在锂离子电池的电解液中的质量百分含量为1%～8%。所述锂离子电池包括上述锂离子电池的电解液。本发明的锂离子电池具有优异的高温存储性能和低温放电倍率性能。



式I

CN 105336984 A

1. 一种锂离子电池的电解液，包括：

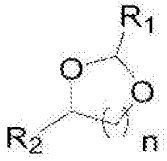
非水有机溶剂；

锂盐，溶解在非水有机溶剂中；以及

添加剂，溶解在非水有机溶剂中；

其特征在于，

所述添加剂包含具有式 I 结构的 1,3- 二氧杂环化合物以及氟代碳酸乙烯酯 (FEC)；



式 I；

在式 I 中，R_1、R_2 各自独立选自 H、甲基或乙基；n 选自 1 ～ 3 内的整数；

具有式 I 结构的 1,3- 二氧杂环化合物在锂离子电池的电解液中的质量百分含量为 0.05% ～ 5%；

氟代碳酸乙烯酯 (FEC) 在锂离子电池的电解液中的质量百分含量为 1% ～ 8%。

2. 根据权利要求 1 所述的锂离子电池的电解液，其特征在于，所述非水有机溶剂包括碳酸酯以及羧酸酯中的一种或几种，碳酸酯包括环状碳酸酯以及链状碳酸酯。

3. 根据权利要求 2 所述的锂离子电池的电解液，其特征在于，

环状碳酸酯选自碳酸丙烯酯 (PC)、碳酸乙烯酯 (EC) 中的一种或几种；

链状碳酸酯选自碳酸二甲酯 (DMC)、碳酸甲乙酯 (EMC)、碳酸甲丙酯 (MPC) 中的一种或几种；

羧酸酯选自 γ - 丁内酯 (GBL)、甲酸甲酯 (FA)、乙酸乙酯 (EA)、丁酸甲酯 (BA) 中的一种或几种。

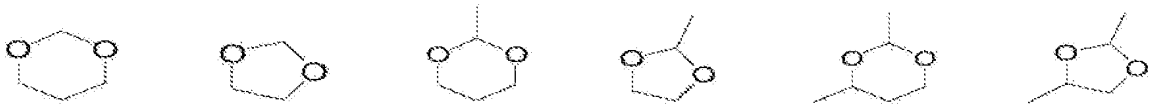
4. 根据权利要求 2 或 3 所述的锂离子电池的电解液，其特征在于，

链状碳酸酯的体积为非水有机溶剂的总体积的 40% ～ 70%；

羧酸酯的体积为非水有机溶剂的总体积的 40% ～ 70%；

余量为环状碳酸酯。

5. 根据权利要求 1 所述的锂离子电池的电解液，其特征在于，所述具有式 I 结构的 1,3- 二氧杂环化合物选自 1,3 二氧六环 (化合物 1)、1,3- 二氧五环 (化合物 2)、2- 甲基 -1,3- 二氧六环 (化合物 3)、2- 甲基 -1,3- 二氧五环 (化合物 4)、2,6- 二甲基 -1,3- 二氧六环 (化合物 5)、2,5- 二甲基 -1,3- 二氧五环 (化合物 6) 中的一种或几种，



化合物 1　化合物 2　化合物 3　化合物 4　化合物 5　化合物 6。

6. 根据权利要求 1 所述的锂离子电池的电解液，其特征在于，

具有式 I 结构的 1,3- 二氧杂环化合物在锂离子电池的电解液中的质量百分含量为 0.5% ～ 2%；

氟代碳酸乙烯酯 (FEC) 在锂离子电池的电解液中的质量百分含量为 2% ～ 4%。

7. 一种锂离子电池，包括：

正极片，包括正极集流体以及设置于正极集流体上的含有正极活性材料的正极膜片；

负极片，包括负极集流体以及设置于负极集流体上的含有负极活性材料的负极膜片；

隔离膜，间隔于正极片和负极片之间；

电解液；以及

电池外包装；

其特征在于，所述电解液为根据权利要求 1-6 中任一项所述的锂离子电池的电解液。

8. 根据权利要求 7 所述的锂离子电池，其特征在于，所述正极活性材料包含能脱出、接受锂离子的材料，所述能脱出、接受锂离子的材料为锂过渡金属复合氧化物，所述锂过渡金属复合氧化物为锂过渡金属氧化物、锂过渡金属氧化物添加其它过渡金属或非过渡金属得到的化合物中的一种或几种，所述锂过渡金属复合氧化物选自锂钴氧化物、锂镍氧化物、锂锰氧化物、锂镍锰氧化物、锂镍钴锰氧化物、锂镍钴铝氧化物中的一种或几种。

9. 根据权利要求 8 所述的锂离子电池，其特征在于，所述锂过渡金属复合氧化物选自 $LiCoO_2$(LCO)、$LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$(NCM333)、$LiNi_{0.5}Mn_{0.3}Co_{0.2}O_2$(NCM523)、$LiCoO_2$(LCO) 添加其它过渡金属得到的化合物、$LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$(NCM333) 添加其它过渡金属得到的化合物、$LiNi_{0.5}Mn_{0.3}Co_{0.2}O_2$(NCM523) 添加其它过渡金属得到的化合物中的一种或几种。

10. 根据权利要求 7 所述的锂离子电池，其特征在于，所述负极活性材料包含能接受、脱出锂离子的材料，所述能接受、脱出锂离子的材料选自软碳、硬碳、人造石墨、天然石墨、硅、硅氧化合物、硅碳复合物、钛酸锂、能与锂形成合金的金属中的一种或几种。

锂离子电池及其电解液

技术领域

[0001] 本发明涉及电池技术领域，尤其涉及一种锂离子电池及其电解液。

背景技术

[0002] 随着便携式电子设备的普及和应用，对锂离子电池的应用环境的要求也越来越高。为了满足电解液在较广温程下的应用需求，目前常用的电解液中的非水有机溶剂主要由链状酯和环状酯组成。

[0003] 1997 年 2 月 25 日公开的美国专利申请公开号为 US6506524 的专利申请中公开了在碱金属离子电池中，为了防止充电时产生树皮状晶体（或树枝状晶体）而引起的短路，在电解液中加入了氟代碳酸亚乙酯 (FEC) 及碳酸亚丙酯。但由于氟代碳酸亚乙酯 (FEC) 容易被还原，特别是在高温环境下，所以其容易在负极上被分解，进而产生 HF 气体或有机气体。

[0004] 为了解决氟代碳酸亚乙酯 (FEC) 的产气问题，2008 年 8 月 27 日公开的中国专利申请公开号为 CN101252205A 的专利申请中公开了在使用氟代碳酸亚乙酯作为添加剂的非水电解质二次电池的极片或隔离膜表面涂覆无机绝缘颗粒层的技术方案，其可以减少氟代碳酸亚乙酯 (FEC) 造成的产气。

[0005] 但上述技术方案的实施会明显增加电池内部极片与隔离膜之间锂离子传输的难度，降低锂离子在电池内部的传输速度。另外还有可能增加工艺难度，对极片柔韧性及加工性能造成不利影响。发明人还发现，依照上述在极片或隔离膜表面涂覆无机绝缘颗粒层的技术方案，要想完全抑制氟代碳酸亚乙酯的分解是难以实现的，其分解后产生的 HF 气体可以透过隔离膜表面的孔隙进入到正极极片的表面，对正极活性材料产生腐蚀作用。特别是在长时间的高温环境下，这种腐蚀作用尤其显著，严重影响了锂离子电池的高温存储性能及长使用寿命。

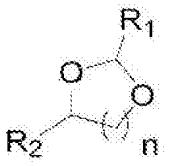
[0006] 此外，氟代碳酸亚乙酯作为常用的 SEI 成膜添加剂，会在负极活性材料表面形成 SEI 膜，同时会增加负极活性材料的阻抗，影响锂离子的传输性能，进而影响锂离子电池的低温放电倍率性能。因此需要寻找一种更为可靠且有效的方法改善锂离子电池性能。

发明内容

[0007] 鉴于背景技术中存在的问题，本发明的目的在于提供一种锂离子电池及其电解液，所述锂离子电池具有优异的高温存储性能和低温放电倍率性能。

[0008] 为了实现上述发明目的，在本发明的第一方面，本发明提供了一种锂离子电池的电解液，其包括：非水有机溶剂；锂盐，溶解在非水有机溶剂中；以及添加剂，溶解在非水有机溶剂中。所述添加剂包含具有式 I 结构的 1,3- 二氧杂环化合物以及氟代碳酸乙烯酯 (FEC)；

[0009]



式 I;

[0010] 在式 I 中，R_1、R_2 各自独立选自 H、甲基或乙基；n 选自 1 ～ 3 内的整数；具有式 I 结构的 1,3- 二氧杂环化合物在锂离子电池的电解液中的质量百分含量为 0.05% ～ 5%；氟代碳酸乙烯酯 (FEC) 在锂离子电池的电解液中的质量百分含量为 1% ～ 8%。

[0011] 在本发明的第二方面，本发明提供了一种锂离子电池，其包括：正极片，包括正极集流体以及设置于正极集流体上的含有正极活性材料的正极膜片；负极片，包括负极集流体以及设置于负极集流体上的含有负极活性材料的负极膜片；隔离膜，间隔于正极片和负极片之间；电解液；以及电池外包装。其中，所述电解液为根据本发明第一方面的锂离子电池的电解液。

[0012] 本发明的有益效果如下：

[0013] 1. 本发明的具有式 I 结构的 1,3- 二氧杂环化合物是一种能在正极表面形成稳定的正极保护膜的电解液添加剂，其特别之处在于其能在氟代碳酸乙烯酯 (FEC) 在负极表面还原形成 HF 气体之前而在正极表面形成稳定的正极 SEI 保护膜，从而避免正极活性材料受到 HF 气体的腐蚀，进而提高锂离子电池的高温存储性能。

[0014] 2. 本发明的具有式 I 结构的 1,3- 二氧杂环化合物还可与氟代碳酸乙烯酯 (FEC) 共同在负极表面形成稳定的负极 SEI 保护膜，且由于负极 SEI 保护膜中含有的具有式 I 结构的 1,3- 二氧杂环化合物具有较高浓度的氧元素，使得负极活性材料表面 SEI 膜处的锂离子的传导性也得到提高，因此锂离子电池的阻抗得到明显的降低，从而锂离子电池的低温放电倍率性能得到改善。

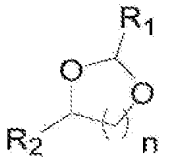
具体实施方式

[0015] 下面详细说明根据本发明的锂离子电池及其电解液以及实施例、比较例及测试结果。

[0016] 首先说明根据本发明第一方面的锂离子电池的电解液。

[0017] 根据本发明第一方面的锂离子电池的电解液，包括：非水有机溶剂；锂盐，溶解在非水有机溶剂中；以及添加剂，溶解在非水有机溶剂中。所述添加剂包含具有式 I 结构的 1,3- 二氧杂环化合物以及氟代碳酸乙烯酯 (FEC)；

[0018]



式 I;

[0019] 在式 I 中，R_1、R_2 各自独立选自 H、甲基或乙基；n 选自 1 ～ 3 内的整数；具有式 I 结构的 1,3- 二氧杂环化合物在锂离子电池的电解液中的质量百分含量为 0.05% ～ 5%；氟代碳酸乙烯酯 (FEC) 在锂离子电池的电解液中的质量百分含量为 1% ～ 8%。

[0020] 在根据本发明第一方面所述的锂离子电池的电解液中，氟代碳酸乙烯酯 (FEC) 具

有较好的成膜性能，有利于锂离子电池的循环容量保持率。但是当锂离子电池在高温存储时，氟代碳酸乙烯酯（FEC）会分解产生 HF，这是导致锂离子电池性能下降甚至产气的主要原因。而具有式 I 结构的 1,3- 二氧杂环化合物是一种能在正极表面形成稳定的正极保护膜的电解液添加剂，其特别之处在于其能在氟代碳酸乙烯酯（FEC）在负极表面还原形成 HF 气体之前而在正极表面形成稳定的正极 SEI 保护膜，从而避免正极活性材料受到 HF 气体的腐蚀，进而提高锂离子电池的高温存储性能。此外，具有式 I 结构的 1,3- 二氧杂环化合物还可与氟代碳酸乙烯酯（FEC）共同在负极表面形成稳定的负极 SEI 保护膜，且由于负极 SEI 保护膜中含有的具有式 I 结构的 1,3- 二氧杂环化合物具有较高浓度的氧元素，使得负极活性材料表面 SEI 膜处的锂离子的传导性也得到提高，因此锂离子电池的阻抗得到明显的降低，从而锂离子电池的低温放电倍率性能得到改善。

[0021] 具有式 I 结构的 1,3- 二氧杂环化合物在锂离子电池的电解液中的质量百分含量低于 0.05%，则其无法充分发挥作用；具有式 I 结构的 1,3- 二氧杂环化合物在锂离子电池的电解液中的质量百分含量高于 5%，虽然可以明显抑制 HF 气体对正极活性材料的腐蚀作用，但是由于生成的正极 SEI 保护膜过厚过密，阻碍了锂离子的正常脱嵌过程，因此会对锂离子电池的容量发挥产生不利的影响，而且还会严重影响锂离子电池的低温放电倍率性能。氟代碳酸乙烯酯（FEC）在锂离子电池的电解液中的质量百分含量低于 1%，则氟代碳酸乙烯酯（FEC）无法形成稳定的 SEI 膜；氟代碳酸乙烯酯（FEC）在锂离子电池的电解液中的质量百分含量高于 8%，则会导致锂离子电池的产气问题恶化。

[0022] 在根据本发明第一方面所述的锂离子电池的电解液中，所述锂盐可选自 $LiN(C_aF_{2a+1}SO_2)(C_bF_{2b+1}SO_2)$、$LiPF_6$、$LiBF_4$、LiBOB、$LiAsF_6$、$Li(CF_3SO_2)_2N$、$LiCF_3SO_3$ 以及 $LiClO_4$ 中的至少一种，其中，a、b 为自然数。

[0023] 在根据本发明第一方面所述的锂离子电池的电解液中，所述锂盐的浓度可为 0.5M ～ 2.0M。

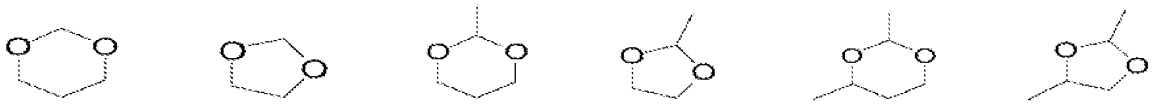
[0024] 在根据本发明第一方面所述的锂离子电池的电解液中，所述非水有机溶剂可包括碳酸酯以及羧酸酯中的一种或几种，碳酸酯可包括环状碳酸酯以及链状碳酸酯。

[0025] 在根据本发明第一方面所述的锂离子电池的电解液中，环状碳酸酯可选自碳酸丙烯酯（PC）、碳酸乙烯酯（EC）中的一种或几种；链状碳酸酯可选自碳酸二甲酯（DMC）、碳酸甲乙酯（EMC）、碳酸甲丙酯（MPC）中的一种或几种；羧酸酯可选自 γ- 丁内酯（GBL）、甲酸甲酯（FA）、乙酸乙酯（EA）、丁酸甲酯（BA）中的一种或几种。

[0026] 在根据本发明第一方面所述的锂离子电池的电解液中，链状碳酸酯的体积可为非水有机溶剂的总体积的 40%～ 70%；羧酸酯的体积可为非水有机溶剂的总体积的 40%～ 70%；余量可为环状碳酸酯。如果链状碳酸酯的体积大于非水有机溶剂的总体积的 70%，则虽然对电解液的电导率有帮助，但是会提高高温产气的风险；如果链状碳酸酯的体积小于非水有机溶剂的总体积的 40%，则对低温电导率有负面的影响，进而影响锂离子电池的低温放电倍率性能。

[0027] 在根据本发明第一方面所述的锂离子电池的电解液中，所述具有式 I 结构的 1,3- 二氧杂环化合物可选自 1,3 二氧六环（化合物 1）、1,3- 二氧五环（化合物 2）、2- 甲基 -1,3- 二氧六环（化合物 3）、2- 甲基 -1,3- 二氧五环（化合物 4）、2,6- 二甲基 -1,3- 二氧六环（化合物 5）、2,5- 二甲基 -1,3- 二氧五环（化合物 6）中的一种或几种，

[0028]



化合物 1 化合物 2 化合物 3 化合物 4 化合物 5 化合物 6。

[0029] 在根据本发明第一方面所述的锂离子电池的电解液中，具有式 I 结构的 1,3- 二氧杂环化合物在锂离子电池的电解液中的质量百分含量可为 0.5%～ 2%。

[0030] 在根据本发明第一方面所述的锂离子电池的电解液中，氟代碳酸乙烯酯 (FEC) 在锂离子电池的电解液中的质量百分含量可为 2%～ 4%。

[0031] 其次说明根据本发明第二方面的锂离子电池。

[0032] 根据本发明第二方面的锂离子电池，包括：正极片，包括正极集流体以及设置于正极集流体上的含有正极活性材料的正极膜片；负极片，包括负极集流体以及设置于负极集流体上的含有负极活性材料的负极膜片；隔离膜，间隔于正极片和负极片之间；电解液；以及电池外包装。其中，所述电解液为根据本发明第一方面的锂离子电池的电解液。

[0033] 在根据本发明第二方面所述的锂离子电池中，所述正极活性材料可包含能脱出、接受锂离子的材料。

[0034] 在根据本发明第二方面所述的锂离子电池中，正极活性材料中能脱出、接受锂离子的材料可为锂过渡金属复合氧化物，所述锂过渡金属复合氧化物可为锂过渡金属氧化物、锂过渡金属氧化物添加其它过渡金属或非过渡金属得到的化合物中的一种或几种，所述锂过渡金属复合氧化物可选自锂钴氧化物、锂镍氧化物、锂锰氧化物、锂镍锰氧化物、锂镍钴锰氧化物、锂镍钴铝氧化物中的一种或几种。

[0035] 在根据本发明第二方面所述的锂离子电池中，所述锂过渡金属复合氧化物可选自 $LiCoO_2$(LCO)、$LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$(NCM333)、$LiNi_{0.5}Mn_{0.3}Co_{0.2}O_2$(NCM523)、$LiCoO_2$(LCO) 添加其它过渡金属得到的化合物、$LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$(NCM333) 添加其它过渡金属得到的化合物、$LiNi_{0.5}Mn_{0.3}Co_{0.2}O_2$(NCM523) 添加其它过渡金属得到的化合物中的一种或几种。

[0036] 在根据本发明第二方面所述的锂离子电池中，所述负极活性材料可包含能接受、脱出锂离子的材料。

[0037] 在根据本发明第二方面所述的锂离子电池中，负极活性材料中能接受、脱出锂离子的材料可选自软碳、硬碳、人造石墨、天然石墨、硅、硅氧化合物、硅碳复合物、钛酸锂、能与锂形成合金的金属中的一种或几种。

[0038] 实施例 1

[0039] 1. 锂离子电池的正极片的制备

[0040] 将正极活性材料 $LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$(NCM333)、导电剂乙炔黑、粘结剂聚偏二氟乙烯 (PVDF) 按重量比 96:2:2 在 N- 甲基吡咯烷酮溶剂体系中充分搅拌混合均匀后，涂覆于集流体 Al 箔上烘干、冷压、焊接极耳，得到锂离子电池的正极片。

[0041] 2. 锂离子电池的负极片的制备

[0042] 将负极活性材料石墨、导电剂乙炔黑、粘结剂丁苯橡胶 (SBR)、增稠剂羧甲基纤维素钠 (CMC) 按重量比 95:2:2:1 在去离子水溶剂体系中充分搅拌混合均匀后，涂覆于集流体 Cu 箔上烘干、冷压、焊接极耳，得到锂离子电池的负极片。

[0043] 3. 锂离子电池的隔离膜的制备

[0044] 以 PE 多孔聚合薄膜作为锂离子电池的隔离膜。

[0045] 4. 锂离子电池的电解液的制备

[0046] 锂离子电池的电解液以 1mol/L 的 $LiPF_6$ 为锂盐，以碳酸乙烯酯（EC）、碳酸丙烯酯（PC）和碳酸甲乙酯（EMC）的混合物（体积比 30:5:65）为非水有机溶剂，以在锂离子电池的电解液中的质量百分含量为 1%的氟代碳酸乙烯酯（FEC）和在锂离子电池的电解液中的质量百分含量为 1%的 1,3- 二氧六环（化合物 1）为添加剂。

[0047] 5. 锂离子电池的制备

[0048] 将正极片、隔离膜、负极片按顺序叠好，使隔离膜处于正极片和负极片的中间起到隔离作用，之后卷绕得到裸电芯，将裸电芯置于外包装中，注入电解液并封装、化成，得到锂离子电池。

[0049] 实施例 2

[0050] 依照实施例 1 的方法制备锂离子电池，除以下不同之处：

[0051] 4. 锂离子电池的电解液的制备

[0052] 氟代碳酸乙烯酯（FEC）在锂离子电池的电解液中的质量百分含量为 2%。

[0053] 实施例 3

[0054] 依照实施例 1 的方法制备锂离子电池，除以下不同之处：

[0055] 4. 锂离子电池的电解液的制备

[0056] 氟代碳酸乙烯酯（FEC）在锂离子电池的电解液中的质量百分含量为 3%。

[0057] 实施例 4

[0058] 依照实施例 1 的方法制备锂离子电池，除以下不同之处：

[0059] 4. 锂离子电池的电解液的制备

[0060] 氟代碳酸乙烯酯（FEC）在锂离子电池的电解液中的质量百分含量为 4%。

[0061] 实施例 5

[0062] 依照实施例 1 的方法制备锂离子电池，除以下不同之处：

[0063] 4. 锂离子电池的电解液的制备

[0064] 氟代碳酸乙烯酯（FEC）在锂离子电池的电解液中的质量百分含量为 8%。

[0065] 实施例 6

[0066] 依照实施例 3 的方法制备锂离子电池，除以下不同之处：

[0067] 4. 锂离子电池的电解液的制备

[0068] 1,3- 二氧六环（化合物 1）在锂离子电池的电解液中的质量百分含量为 0.05%。

[0069] 实施例 7

[0070] 依照实施例 3 的方法制备锂离子电池，除以下不同之处：

[0071] 4. 锂离子电池的电解液的制备

[0072] 1,3- 二氧六环（化合物 1）在锂离子电池的电解液中的质量百分含量为 0.5%。

[0073] 实施例 8

[0074] 依照实施例 3 的方法制备锂离子电池，除以下不同之处：

[0075] 4. 锂离子电池的电解液的制备

[0076] 1,3- 二氧六环（化合物 1）在锂离子电池的电解液中的质量百分含量为 2%。

[0077] 实施例 9

[0078] 依照实施例 3 的方法制备锂离子电池，除以下不同之处：

[0079] 4. 锂离子电池的电解液的制备

[0080] 1,3- 二氧六环（化合物 1）在锂离子电池的电解液中的质量百分含量为 5%。

[0081] 实施例 10

[0082] 依照实施例 1 的方法制备锂离子电池，除以下不同之处：

[0083] 4. 锂离子电池的电解液的制备

[0084] 添加剂为在锂离子电池的电解液中的质量百分含量为 3% 的氟代碳酸乙烯酯 (FEC) 和在锂离子电池的电解液中的质量百分含量为 1% 的 1,3- 二氧五环（化合物 2）。

[0085] 实施例 11

[0086] 依照实施例 1 的方法制备锂离子电池，除以下不同之处：

[0087] 4. 锂离子电池的电解液的制备

[0088] 添加剂为在锂离子电池的电解液中的质量百分含量为 3% 的氟代碳酸乙烯酯 (FEC) 和在锂离子电池的电解液中的质量百分含量为 1% 的 2- 甲基 -1,3- 二氧六环（化合物 3）。

[0089] 实施例 12

[0090] 依照实施例 1 的方法制备锂离子电池，除以下不同之处：

[0091] 4. 锂离子电池的电解液的制备

[0092] 添加剂为在锂离子电池的电解液中的质量百分含量为 3% 的氟代碳酸乙烯酯 (FEC) 和在锂离子电池的电解液中的质量百分含量为 1% 的 2- 甲基 -1,3- 二氧五环（化合物 4）。

[0093] 实施例 13

[0094] 依照实施例 1 的方法制备锂离子电池，除以下不同之处：

[0095] 4. 锂离子电池的电解液的制备

[0096] 添加剂为在锂离子电池的电解液中的质量百分含量为 3% 的氟代碳酸乙烯酯 (FEC) 和在锂离子电池的电解液中的质量百分含量为 1% 的 2,6- 二甲基 -1,3- 二氧六环（化合物 5）。

[0097] 实施例 14

[0098] 依照实施例 1 的方法制备锂离子电池，除以下不同之处：

[0099] 4. 锂离子电池的电解液的制备

[0100] 添加剂为在锂离子电池的电解液中的质量百分含量为 3% 的氟代碳酸乙烯酯 (FEC) 和在锂离子电池的电解液中的质量百分含量为 1% 的 2,5- 二甲基 -1,3- 二氧五环（化合物 6）。

[0101] 实施例 15

[0102] 依照实施例 3 的方法制备锂离子电池，除以下不同之处：

[0103] 1. 锂离子电池的正极片的制备

[0104] 正极活性材料为 $LiNi_{0.5}Mn_{0.3}Co_{0.2}O_2$ (NCM523)。

[0105] 实施例 16

[0106] 依照实施例 3 的方法制备锂离子电池，除以下不同之处：

[0107] 1. 锂离子电池的正极片的制备

[0108] 正极活性材料为 $LiCoO_2$(LCO)。

[0109] 对比例 1

[0110] 依照实施例 1 的方法制备锂离子电池，除以下不同之处：

[0111] 4. 锂离子电池的电解液的制备

[0112] 不加入添加剂。

[0113] 对比例 2

[0114] 依照实施例 1 的方法制备锂离子电池，除以下不同之处：

[0115] 4. 锂离子电池的电解液的制备

[0116] 添加剂为在锂离子电池的电解液中的质量百分含量为 5％的氟代碳酸乙烯酯(FEC)。

[0117] 对比例 3

[0118] 依照实施例 1 的方法制备锂离子电池，除以下不同之处：

[0119] 4. 锂离子电池的电解液的制备

[0120] 添加剂为在锂离子电池的电解液中的质量百分含量为3％的1,3-二氧六环（化合物 1)。

[0121] 对比例 4

[0122] 依照实施例 15 的方法制备锂离子电池，除以下不同之处：

[0123] 4. 锂离子电池的电解液的制备

[0124] 不加入添加剂。

[0125] 对比例 5

[0126] 依照实施例 3 的方法制备锂离子电池，除以下不同之处：

[0127] 4. 锂离子电池的电解液的制备

[0128] 1,3-二氧六环（化合物 1）在锂离子电池的电解液中的质量百分含量为 6％。

[0129] 对比例 6

[0130] 依照实施例 1 的方法制备锂离子电池，除以下不同之处：

[0131] 4. 锂离子电池的电解液的制备

[0132] 氟代碳酸乙烯酯 (FEC) 在锂离子电池的电解液中的质量百分含量为 10％。

[0133] 最后给出实施例 1-16 和对比例 1-6 的锂离子电池及其电解液的性能测试过程以及测试结果。

[0134] (1) 锂离子电池的高温存储性能测试

[0135] 在 25℃下，各取 5 支锂离子电池，以 0.5C 倍率恒定电流充电至电压高于 4.35V，进一步以 4.35V 恒定电压充电至电流低于 0.05C，使其处于 4.35V 满充状态，测试存储前满充锂离子电池的厚度并记为 D0，之后将满充锂离子电池置于 60℃烘箱中，21 天后取出，立即测试存储后的锂离子电池的厚度并记为 D1。

[0136] 锂离子电池高温存储后的厚度膨胀率 $\varepsilon = (D1-D0)/D0\times 100\%$。

[0137] 以 5 支锂离子电池高温存储后的厚度膨胀率的平均值，作为该锂离子电池高温存储后的厚度膨胀率。

[0138] (2) 锂离子电池的低温放电倍率性能测试

[0139] 在25℃下，各取5支锂离子电池，以0.5C倍率恒定电流充电至电压高于4.35V，进一步以4.35V恒定电压充电至电流低于0.05C，之后分别在25℃和-10℃下静置60min，再以0.2C倍率恒定电流放电至电压为3.0V。记录锂离子电池在不同温度下的放电容量D(25℃)和D(-10℃)。

[0140] 锂离子电池的低温放电倍率(%)=D(-10℃)/D(25℃)×100%。

[0141] 以5支锂离子电池低温放电倍率的平均值，作为该锂离子电池的低温放电倍率。

[0142] 表1给出实施例1~16和对比例1~6的相关参数以及性能测试结果。

[0143] 接下来对锂离子电池的性能测试结果进行分析。

[0144] 从实施例1~14和对比例1~3的对比中可以看出，本发明的包含具有式I结构的1,3-二氧杂环化合物以及氟代碳酸乙烯酯(FEC)的锂离子电池比不加入任何添加剂的锂离子电池(对比例1)、仅加入氟代碳酸乙烯酯(FEC)的锂离子电池(对比例2)、仅加入具有式I结构的1,3-二氧杂环化合物的锂离子电池(对比例3)具有较低的高温厚度膨胀率和较高的低温放电倍率。这是由于单独的具有式I结构的1,3-二氧杂环化合物或单独的氟代碳酸乙烯酯(FEC)均会恶化锂离子电池的高温存储性能和低温放电倍率性能，但是当氟代碳酸乙烯酯(FEC)和具有式I结构的1,3-二氧杂环化合物共同使用时，具有式I结构的1,3-二氧杂环化合物能在氟代碳酸乙烯酯(FEC)在负极表面还原形成HF气体之前而在正极表面形成稳定的正极SEI保护膜，从而避免正极活性材料受到HF气体的腐蚀，进而提高锂离子电池的高温存储性能。具有式I结构的1,3-二氧杂环化合物还可与氟代碳酸乙烯酯(FEC)共同在负极表面形成稳定的负极SEI保护膜，且由于负极SEI保护膜中含有的具有式I结构的1,3-二氧杂环化合物具有较高浓度的氧元素，使得负极活性材料表面SEI膜处的锂离子的传导性也得到提高，因此锂离子电池的阻抗得到明显的降低，从而锂离子电池的低温放电倍率性能得到改善。从实施例15和对比例4的对比中也可以看到类似的结果。

[0145] 从实施例1~5和对比例6的对比中可以看出，随着FEC的质量百分含量增加，锂离子电池高温存储后的厚度膨胀率先降低后增加，锂离子电池的低温放电倍率先增加后降低。当FEC在锂离子电池的电解液中的质量百分含量高于8%(对比例6)，会导致锂离子电池的产气问题恶化。

[0146] 从实施例3和实施例6-9和对比例5的对比中可以看出，随着具有式I结构的1,3-二氧杂环化合物的质量百分含量增加，锂离子电池高温存储后的厚度膨胀率先降低后增加，锂离子电池的低温放电倍率先增加后降低。且当具有式I结构的1,3-二氧杂环化合物的质量百分含量过低时(实施例6)，对锂离子电池的性能改善并不明显；当具有式I结构的1,3-二氧杂环化合物的质量百分含量过高时(对比例5)，虽然可以明显抑制HF气体对正极活性材料的腐蚀作用，由于生成的正极SEI保护膜过厚过密，阻碍了锂离子的正常脱嵌过程，因此会对锂离子电池的容量发挥产生不利的影响，而且还会严重影响锂离子电池的低温放电倍率性能。

[0147] 从实施例3、实施例11和实施例13的对比中可以看出，随着取代基的数目的增加，锂离子电池的高温存储性能和低温放电倍率性能均变差，这是由于取代基的结构增大了成膜过程中组分的空间位阻，进而对锂离子的传导带来了负面影响。从实施例10、实施例12和实施例14的对比中也可以看到类似的结果。

[0148] 从实施例 3、实施例 15 和实施例 16 的对比中可以看出，使用 NCM333 和 NCM523 作为正极活性材料的锂离子电池比使用 LCO 作为正极活性材料的锂离子电池具有更好的高温存储性能和低温放电倍率性能。这可能是由于具有式 I 结构的 1,3- 二氧杂环化合物和 FEC 更适用于三元正极活性材料，从而能在正极形成更好的 SEI 保护膜；此外，三元正极活性材料的 pH 值更高，能够更好地催化具有式 I 结构的 1,3- 二氧杂环化合物参与正极 SEI 保护膜的形成，从而使得正极 SEI 保护膜中的氧溶度更高，进而提高锂离子的传输率，改善锂离子电池的高温存储性能和低温放电倍率性能。

[0149] 表 1 实施例 1-16 和对比例 1-6 的参数及性能测试结果

[0150]

	正极活性材料	非水有机溶剂	FEC	1,3-二氧杂环化合物		高温厚度膨胀率	低温放电倍率
		锂盐	含量/%	名称	含量/%		
实施例1	NCM333	EC:PC:EMC=30:5:65 1M LiPF6	1%	1%	化合物1	50%	87%
实施例2	NCM333	EC:PC:EMC=30:5:65 1M LiPF6	2%	1%	化合物1	35%	89%
实施例3	NCM333	EC:PC:EMC=30:5:65 1M LiPF6	3%	1%	化合物1	12%	94%
实施例4	NCM333	EC:PC:EMC=30:5:65 1M LiPF6	4%	1%	化合物1	20%	90%
实施例5	NCM333	EC:PC:EMC=30:5:65 1M LiPF6	8%	1%	化合物1	55%	85%
实施例6	NCM333	EC:PC:EMC=30:5:65 1M LiPF6	3%	0.05%	化合物1	52%	87%
实施例7	NCM333	EC:PC:EMC=30:5:65 1M LiPF6	3%	0.5%	化合物1	39%	88%
实施例8	NCM333	EC:PC:EMC=30:5:65 1M LiPF6	3%	2%	化合物1	16%	93%
实施例9	NCM333	EC:PC:EMC=30:5:65 1M LiPF6	3%	5%	化合物1	42%	88%
实施例10	NCM333	EC:PC:EMC=30:5:65 1M LiPF6	3%	1%	化合物2	14%	95%
实施例11	NCM333	EC:PC:EMC=30:5:65 1M LiPF6	3%	1%	化合物3	16%	92%
实施例12	NCM333	EC:PC:EMC=30:5:65 1M LiPF6	3%	1%	化合物4	19%	90%
实施例13	NCM333	EC:PC:EMC=30:5:65 1M LiPF6	3%	1%	化合物5	20%	89%
实施例14	NCM333	EC:PC:EMC=30:5:65 1M LiPF6	3%	1%	化合物6	22%	88%
实施例15	NCM523	EC:PC:EMC=30:5:65 1M LiPF6	3%	1%	化合物1	18%	92%
实施例16	LCO	EC:PC:EMC=30:5:65 1M LiPF6	3%	1%	化合物1	47%	85%
对比例1	NCM333	EC:PC:EMC=30:5:65 1M LiPF6	/	/	/	56%	82%
对比例2	NCM333	EC:PC:EMC=30:5:65 1M LiPF6	5%	/	/	55%	66%
对比例3	NCM333	EC:PC:EMC=30:5:65 1M LiPF6	/	2%	化合物1	60%	82%
对比例4	NCM523	EC:PC:EMC=30:5:65 1M LiPF6	/	/	/	59%	84%
对比例5	NCM333	EC:PC:EMC=30:5:65 1M LiPF6	3%	6%	化合物1	55%	76%
对比例6	NCM333	EC:PC:EMC=30:5:65 1M LiPF6	10%	1%	化合物1	65%	82%

(19)中华人民共和国国家知识产权局

(12)实用新型专利

(10)授权公告号 CN 207602716 U
(45)授权公告日 2018.07.10

(21)申请号 201721269256.8

(22)申请日 2017.09.29

(73)专利权人 上海比亚迪有限公司
地址 201611 上海市松江区车墩镇香泾路999号

(72)发明人 姜新军 沈志诚 张宝生 郭长营

(51)Int.Cl.
H01M 10/0587(2010.01)

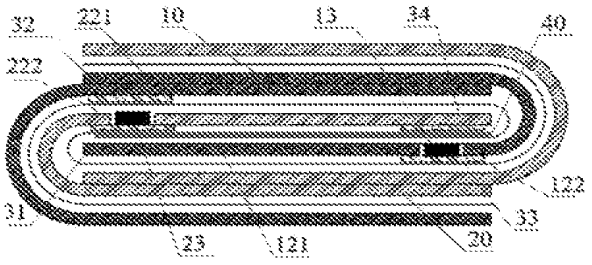
权利要求书1页 说明书5页 附图3页

(54)实用新型名称

一种卷绕式电池及电池组

(57)摘要

本实用新型提供了一种卷绕式电池，正极集流体的第一半圈一面敷料，一面留白，敷料的一面设置正极极耳凹槽，正极极耳设置在正极极耳凹槽内；负极集流体的第一半圈一面敷料，一面留白，敷料的一面设置有负极极耳凹槽，负极极耳设置在负极极耳凹槽内；在此基础上，对第一绝缘胶和第二绝缘的位置进行了配合限定。本实用新型还提供一种由本实用新型提供的卷绕式电池组成的电池组。本实用新型提供的卷绕式电池，解决了现有的卷绕式电池中，负极片双面敷料，开槽工艺复杂、生产效率低，同时会造成大量的敷料面积损失，影响电池容量的技术问题。



CN 207602716 U

1.一种卷绕式电池，包括正极片、负极片以及设置在所述正极片与所述负极片之间的隔膜，所述正极片包括正极集流体和设置在所述正极集流体表面的正极活性物质层，所述负极片包括负极集流体和设置在所述负极集流体表面的负极活性物质层，所述正极集流体的第一半圈与所述负极集流体的第一半圈相对设置且位于卷绕式电池的最内圈，其特征在于，所述正极集流体的第一半圈临近所述负极集流体的第一半圈的一面留白，所述正极集流体的第一半圈远离所述负极集流体的第一半圈的一面设置有第一正极活性物质层；所述负极集流体的第一半圈临近所述正极集流体的第一半圈的一面留白，所述负极集流体的第一半圈远离所述正极集流体的第一半圈的一面设置有第一负极活性物质层；所述第一正极活性物质层上设置有正极极耳凹槽，所述正极极耳凹槽内设置有正极极耳；所述第一负极活性物质层上设置有负极极耳凹槽，所述负极极耳凹槽内设置有负极极耳；所述负极集流体的第一半圈临近所述正极集流体的第一半圈的一面上设置有第一绝缘胶，所述第一绝缘胶与所述负极极耳凹槽的位置对应；所述正极片与所述第一负极活性物质层相对的一面上设置有第二绝缘胶，所述第二绝缘胶与所述负极极耳凹槽的位置对应。

2.根据权利要求1所述的卷绕式电池，其特征在于，所述第一正极活性物质层上对应所述正极极耳凹槽的位置设置有第三绝缘胶，所述负极集流体的第一半圈留白的一面上设置有第四绝缘胶，所述第四绝缘胶与所述正极极耳凹槽的位置对应。

3.根据权利要求1所述的卷绕式电池，其特征在于，所述第一正极活性物质层上对应所述正极极耳凹槽的位置设置有第五绝缘胶，所述正极集流体的第一半圈留白的一面上设置有第六绝缘胶，所述第六绝缘胶与所述正极极耳凹槽的位置对应。

4.根据权利要求1所述的卷绕式电池，其特征在于，所述负极集流体的第一半圈与所述正极集流体的第一半圈的卷绕方向相反。

5.一种电池组，包括若干相互串联或并联的单体电池，其特征在于，所述单体电池中为权利要求1-4任意一项所述的卷绕式电池。

一种卷绕式电池及电池组

技术领域

[0001] 本实用新型涉及动力电池领域，尤其涉及一种卷绕式电池。

背景技术

[0002] 随着新能源产业的不断发展，尤其是电动汽车的不断发展；对于作为电动汽车核心部件的动力电池，其要求也越来越高，尤其是对安全性及比容量的综合要求。而对于动力电池而言，容量、安全性以及成本的要求，成为了行业内研发动力电池的主流方向。

[0003] 在卷绕式电池内部，极耳的引出、设置方式，会影响到卷绕式电池内部集流体双面的敷料量，进而影响卷绕式电池的整体容量；同时，因为极耳的引出位置需要贴胶、绝缘，不良的设计，其加工过程中，可能会导致大量敷料的损失或者导致被绝缘胶覆盖的正极材料或负极材料不能发挥其作用，造成敷料的浪费、成本的提高。

[0004] 现有技术中，提供了一种卷绕式电池，其在正极极耳的上下表面贴有绝缘胶，正极极耳所在的正极片一面对应正极活性物质层，一面对应正极集流体；也就是说，正极片来回卷绕一圈，作为卷绕式电池的最内圈。负极极耳所在的负极集流体两面都涂覆有负极活性物质层，并且在负极极耳上下表面对应的正极活性物质层上贴胶，对负极极耳进行绝缘保护。

[0005] 但是，上述方案中，负极极耳所在的负极集流体两面都涂覆有负极活性物质层，需要在负极片的正反两面都进行开槽处理，将负极极耳设置在槽内；两面开槽不能完全重合好，会增加敷料面积的损失，影响容量，同时双面开槽会降低生产效率。另外，正极片对应于负极极耳的位置处，设置有正极活性物质层，如此，会造成被覆盖的正极活性材料不能发挥容量，损失成本较高。

发明内容

[0006] 本实用新型的目的在于提供一种卷绕式电池，旨在解决现有技术中的卷绕式电池中，负极片双面敷料，开槽工艺复杂、生产效率低，同时会造成大量的敷料面积损失，影响电池容量的技术问题。

[0007] 为解决上述技术问题，本实用新型的技术方案是：

[0008] 本发明提供了一种卷绕式电池，包括正极片、负极片以及设置在所述正极片与所述负极片之间的隔膜，所述正极片包括正极集流体和设置在所述正极集流体表面的正极活性物质层，所述负极片包括负极集流体和设置在所述负极集流体表面的负极活性物质层，所述正极集流体的第一半圈与所述负极集流体的第一半圈相对设置且位于卷绕式电池的最内圈，其中，所述正极集流体的第一半圈临近所述负极集流体的第一半圈的一面留白，所述正极集流体的第一半圈远离所述负极集流体的第一半圈的一面设置有第一正极活性物质层；所述负极集流体的第一半圈临近所述正极集流体的第一半圈的一面留白，所述负极集流体的第一半圈远离所述正极集流体的第一半圈的一面设置有第一负极活性物质层；所述第一正极活性物质层上设置有正极极耳凹槽，所述正极极耳凹槽内设置有正极极耳；所

述第一负极活性物质层上设置有负极极耳凹槽，所述负极极耳凹槽内设置有负极极耳；所述负极集流体的第一半圈临近所述正极集流体的第一半圈的一面上设置有第一绝缘胶，所述第一绝缘胶与所述负极极耳凹槽的位置对应；所述正极片与所述第一负极活性物质层相对的一面上设置有第二绝缘胶，所述第二绝缘胶与所述负极极耳凹槽的位置对应。

[0009] 一些实施例中，所述第一正极活性物质层上对应所述正极极耳凹槽的位置设置有第三绝缘胶，所述负极集流体的第一半圈留白的一面上设置有第四绝缘胶，所述第四绝缘胶与所述正极极耳凹槽的位置对应。

[0010] 一些实施例中，所述第一正极活性物质层上对应所述正极极耳凹槽的位置设置有第五绝缘胶，所述正极集流体的第一半圈留白的一面上设置有第六绝缘胶，所述第六绝缘胶与所述正极极耳凹槽的位置对应。

[0011] 一些实施例中，所述负极集流体的第一半圈与所述正极集流体的第一半圈的卷绕方向相反。

[0012] 本实用新型还提供了一种电池组，包括若干相互串联或并联的单体电池，其中，所述单体电池为本实用新型提供的卷绕式电池。

[0013] 本实用新型的有益效果：本实用新型中，负极片一面敷料，一面不敷料，只需在负极片的一面开槽，不需要正反面都开槽并且对位，降低了开槽难度，提高了生产效率；同时，负极片只有一面设置负极活性物质层，降低了对负极活性物质的损耗，提高了损失，保证了电池容量。

附图说明

[0014] 图1为本实用新型一个实施例中，卷绕式电池的卷绕结构示意图。

[0015] 图2为本实用新型一个实施例中，正极片的正面正视图。

[0016] 图3为本实用新型一个实施例中，正极片的侧面视图。

[0017] 图4为本实用新型一个实施例中，正极片的反面正视图。

[0018] 图5是本实用新型一个实施例中，负极片的正面正视图。

[0019] 图6是本实用新型一个实施例中，负极片的侧面视图。

[0020] 图7是本实用新型一个实施例中，负极片反面正视图。

[0021] 图8是本实用新型另一个实施例中，卷绕式电池的卷绕结构示意图。

[0022] 图9是本实用新型另一个实施例中，卷绕式电池的卷绕结构示意图。

[0023] 附图标记包括：

[0024] 正极片 10；正极集流体 11；正极活性物质层 12；第一正极活性物质层 121；正极极耳凹槽 122；正极极耳 13；负极片 20；负极集流体 21；负极活性物质层 22；第一负极活性物质层 221；负极极耳凹槽 222；负极极耳 23；第一绝缘胶 31；第二绝缘胶 32；第三绝缘胶 33；第四绝缘胶 34；第五绝缘胶 35；第六绝缘胶 36；隔膜 40。

具体实施方式

[0025] 下面详细描述本实用新型的实施例，所述实施例的示例在附图中示出，其中自始至终相同或类似的标号表示相同或类似的元件或具有相同或类似功能的元件。下面通过参

考附图1~9描述的实施例是示例性的，旨在用于解释本实用新型，而不能理解为对本实用新型的限制。

[0026] 在本实用新型的描述中，需要理解的是，术语“长度”、“宽度”、“上”、“下”、“前”、“后”、“左”、“右”、“竖直”、“水平”、“顶”、“底”“内”、“外”等指示的方位或位置关系为基于附图所示的方位或位置关系，仅是为了便于描述本实用新型和简化描述，而不是指示或暗示所指的装置或元件必须具有特定的方位、以特定的方位构造和操作，因此不能理解为对本实用新型的限制。

[0027] 此外，术语“第一”、“第二”仅用于描述目的，而不能理解为指示或暗示相对重要性或者隐含指明所指示的技术特征的数量。由此，限定有“第一”、“第二”的特征可以明示或者隐含地包括一个或者更多个该特征。在本实用新型的描述中，“多个”的含义是两个或两个以上，除非另有明确具体的限定。

[0028] 在本实用新型中，除非另有明确的规定和限定，术语“安装”、“相连”、“连接”、“固定”等术语应做广义理解，例如，可以是固定连接，也可以是可拆卸连接，或成一体；可以是机械连接，也可以是电连接；可以是直接相连，也可以通过中间媒介间接相连，可以是两个元件内部的连通或两个元件的相互作用关系。对于本领域的普通技术人员而言，可以根据具体情况理解上述术语在本实用新型中的具体含义。

[0029] 为了解决现有技术中负极片20双面敷料，开槽工艺复杂、生产效率低，同时会造成大量的敷料面积损失，影响电池容量的技术问题。

[0030] 本实用新型的一个实施例中，如图1-7所示，一种卷绕式电池，包括正极片10、负极片20以及设置在所述正极片10与所述负极片20之间的隔膜40，如图1所示，正极片10和负极片20之间的为隔膜40所述正极片10包括正极集流体11和设置在所述正极集流体11表面的正极活性物质层12，所述负极片20包括负极集流体21和设置在所述负极集流体21表面的负极活性物质层22，所述正极集流体11的第一半圈与所述负极集流体21的第一半圈相对设置且位于卷绕式电池的最内圈，其中，所述正极集流体11的第一半圈临近所述负极集流体21的第一半圈的一面留白，所述正极集流体11的第一半圈远离所述负极集流体21的第一半圈的一面设置有第一正极活性物质层121；所述负极集流体21的第一半圈临近所述正极集流体11的第一半圈的一面留白，所述负极集流体21的第一半圈远离所述正极集流体11的第一半圈的一面设置有第一负极活性物质层221；所述第一正极活性物质层121上设置有正极极耳凹槽122，所述正极极耳凹槽122内设置有正极极耳13；所述第一负极活性物质层221上设置有负极极耳凹槽222，所述负极极耳凹槽222内设置有负极极耳23；所述负极集流体21的第一半圈临近所述正极集流体11的第一半圈的一面上设置有第一绝缘胶31，所述第一绝缘胶31与所述负极极耳凹槽222的位置对应；所述正极片10与所述第一负极活性物质层221相对的一面上设置有第二绝缘胶32，所述第二绝缘胶32与所述负极极耳凹槽222的位置对应。

[0031] 本实用新型中，负极片20一面敷料，一面不敷料，只需在负极片20的一面开槽，不需要正反面都开槽并且对位，降低了开槽难度，提高了生产效率；同时，负极片20只有一面设置负极活性物质层22，降低了对负极活性物质的损耗，提高了损失，保证了电池容量。

[0032] 在本实用新型中，第一正极活性物质层121指的是涂覆在正极集流体11第一半圈上的活性物质层；第一负极活性物质层221指的是涂覆在负极集流体21的第一半圈上的活性物质层。

[0033] 如图1所示，本实用新型提供的卷绕式电芯，由正极片10、隔膜40和负极片20卷绕而成。为了保证电池的容量，正极片10除最内半圈(即正极集流体11的第一半圈)有一面留白(未敷料)外，其余部分都在正极集流体11的双面涂覆有正极活性材料；同样的，负极片20除最内半圈(即负极集流体21的第一半圈)有一面留白(未敷料)外，其余部分也都在负极集流体21的双面涂覆有负极活性材料。

[0034] 上述正极集流体11的第一半圈，指的是由电池电芯内部正极集流体11的起始端向外卷绕，位于最里面的正极集流体11的一个半圈；同样的，负极集流体21的第一半圈，指的是由电池电芯内部负极集流体21的起始端开始向外卷绕，位于最里面的负极集流体21的一个半圈。

[0035] 在该正极集流体11的第一半圈和负极集流体21的第一半圈内，均是一面涂料、一面未涂料。通过单面涂料，一方面保证卷绕式电池的容量；另一方面，方便正极极耳凹槽122和负极极耳凹槽222的加工和开槽，只需要在正极集流体11或负极集流体21的一面具有活性物质的一面进行开槽即可，无需双面开槽，不需要两面开槽的对应工序，方便加工。

[0036] 另外，在该实施例中，上述“临近”负极集流体21的第一半圈相对所述正极集流体11的第一半圈的一面或者正极集流体11的第一半圈相对负极集流体21的第一半圈的一面。

[0037] 在本实用新型中，正极极耳凹槽122或负极极耳凹槽222可以通过激光清洗、机械清洗或者发泡胶清洗方式，将正极极耳凹槽122或者负极极耳凹槽222处的活性物质去除，形成凹槽。

[0038] 而第一绝缘胶31、第二绝缘胶32、第三绝缘胶33、第四绝缘胶34、第五绝缘胶35和第六绝缘胶36，只是为了区分该绝缘胶在同一个实施例中的不同位置或者在不同实施例中；而绝缘胶本身的材料，可以选取热熔胶层或绿胶层的任意一种或各自选择不同的绝缘胶材料，比如：绿胶层、黑胶层、黄胶层或白胶层。

[0039] 其中，正极片10、负极片20、正极活性物质层12、负极活性物质层22等的材料选择，是本领域常用的选择，在此不做特殊限定，也不在赘述。

[0040] 如图1所示，本实用新型的一个实施例中，所述第一正极活性物质层121上对应所述正极极耳凹槽122的位置设置有第三绝缘胶33，所述负极集流体21的第一半圈留白的一面上设置有第四绝缘胶34，所述第四绝缘胶34与所述正极极耳凹槽122的位置对应。

[0041] 而如图8所示，本实用新型的另一个实施例中，所述第一正极活性物质层121上对应所述正极极耳凹槽122的位置设置有第五绝缘胶35，所述正极集流体11的第一半圈留白的一面上设置有第六绝缘胶36，所述第六绝缘胶36与所述正极极耳凹槽122的位置对应。

[0042] 在本申请中，所谓的“位置对应”指的是绝缘胶可以覆盖正极极耳13或者负极极耳23的位置。

[0043] 如图9所示，本实用新型的一个实施例中，正极集流体11的第一半圈比负极集流体21短，正极集流体11未延伸到与负极极耳凹槽222对应的位置；也就是说，负极极耳凹槽222隔着隔膜40直接与负极集流体21的第二半圈对应，负极极耳凹槽222与负极集流体21的第二半圈之间没有正极集流体11。

[0044] 而在本实用新型的一个具体实施例中，如图1或图8所示，负极集流体21的第一半圈与正极集流体11的第一半圈的卷绕方向相反。也就是说，正极集流体11的第一半圈和负极集流体21的第一半圈相互叠置，同时又分别向相反的方向延伸并卷绕。此处的相反，仅仅

是指在第一半圈处处于相反的延伸方向，当卷绕到第二圈或第三圈后，正极集流体11和负极集流体21的卷绕方向会变的一致。

[0045] 本实用新型还提供了一种电池组，包括若干相互串联或并联的单体电池，其中，上述单体电池为本实用新型提供的卷绕式电池。

[0046] 综上所述可知本实用新型乃具有以上所述的优良特性，得以令其在使用上，增进以往技术中所未有的效能而具有实用性，成为一极具实用价值的产品。

[0047] 以上所述仅为本实用新型的较佳实施例而已，并不用以限制本实用新型，凡在本实用新型的思想和原则之内所作的任何修改、等同替换或改进等，均应包含在本实用新型的保护范围之内。

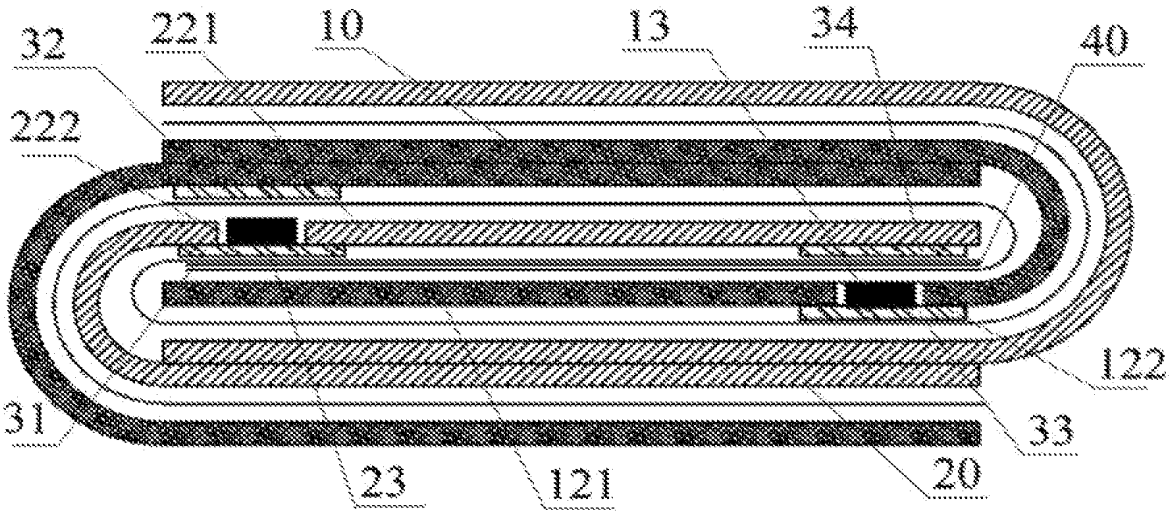

32
221
10
13
34
40
222
122
31
33
23
121
20

图1

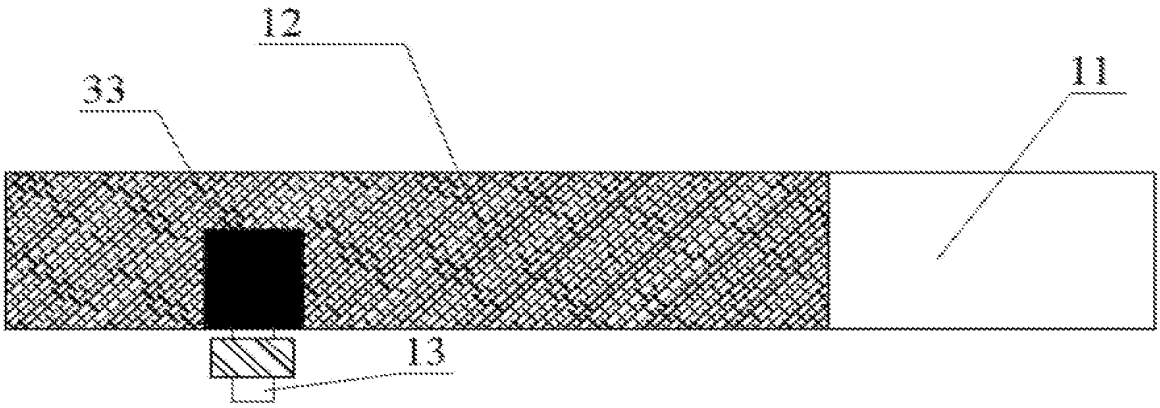

12
11
33
13

图2

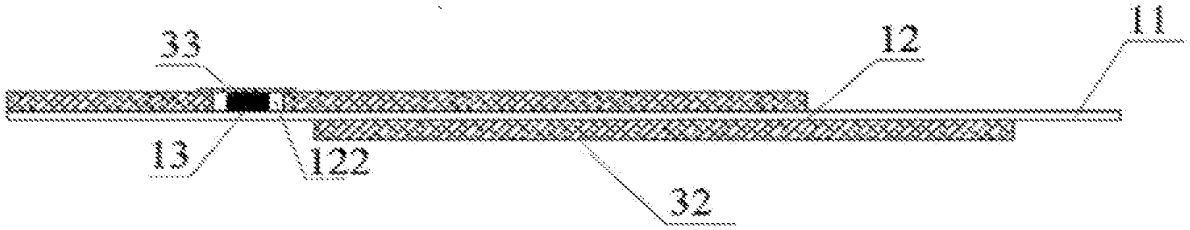

33
12
11
13
122
32

图3

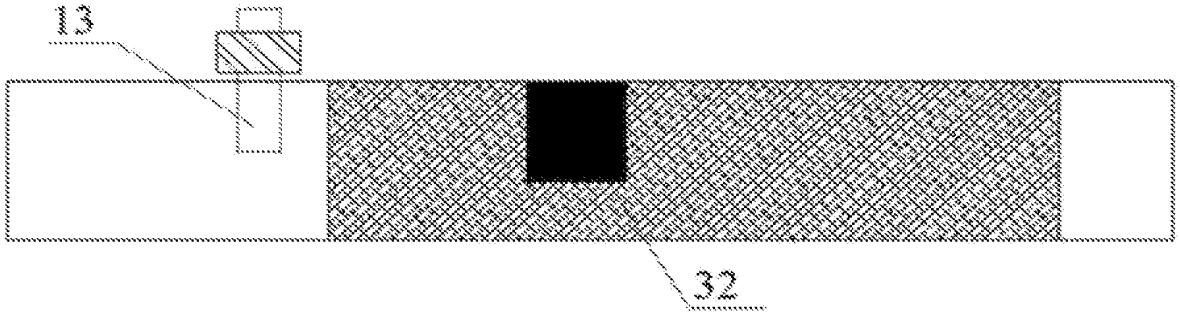


图4

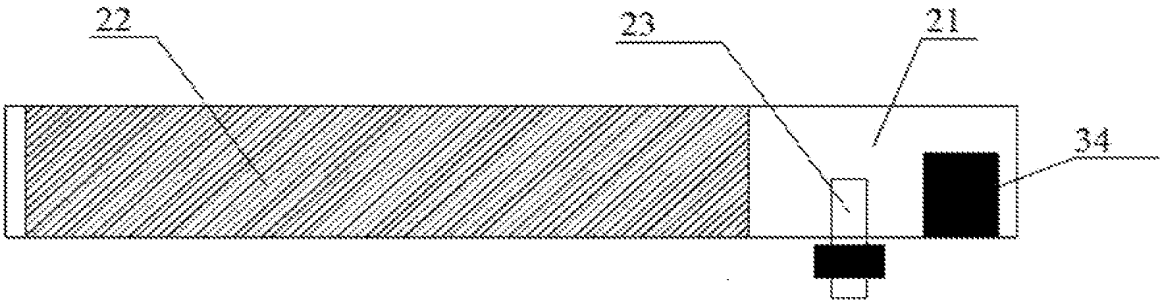


图5

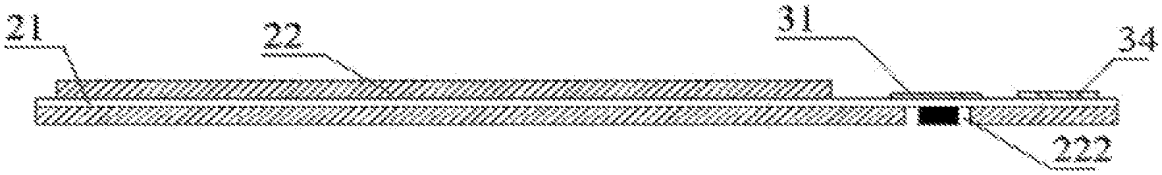


图6

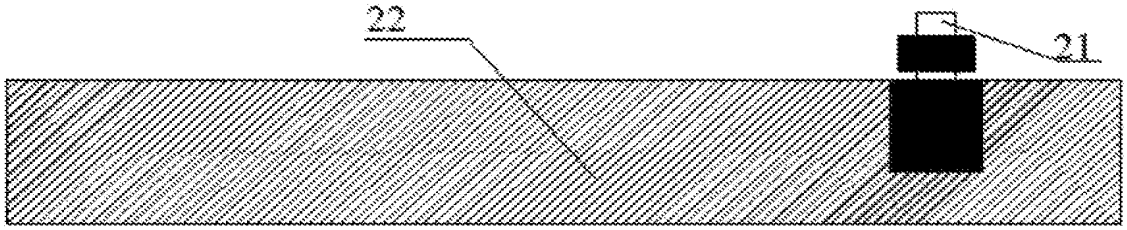


图7

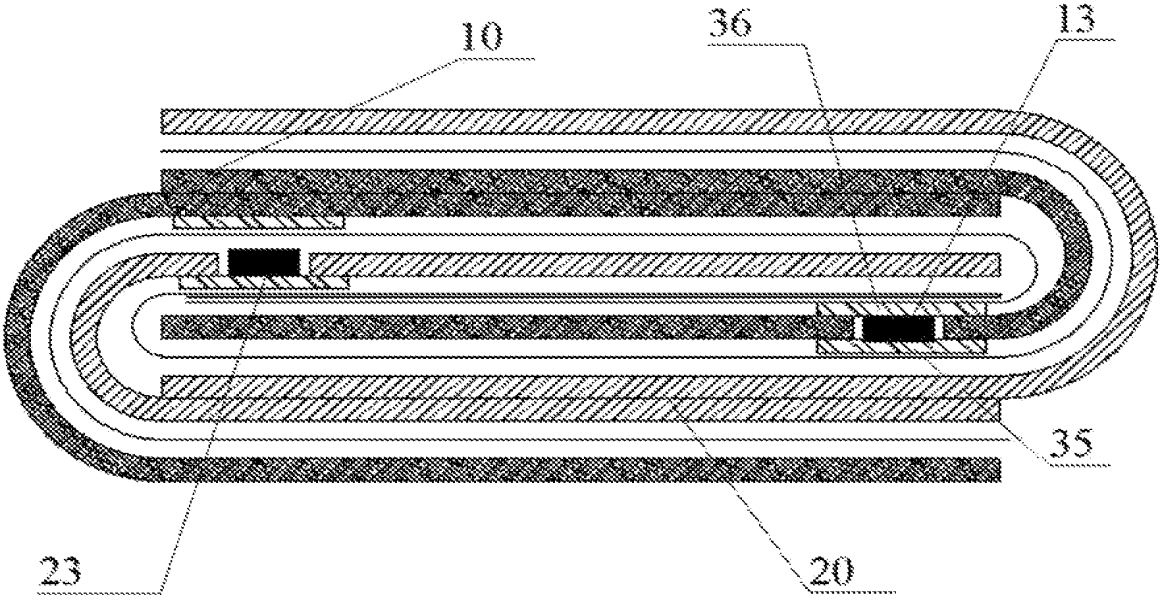


图8

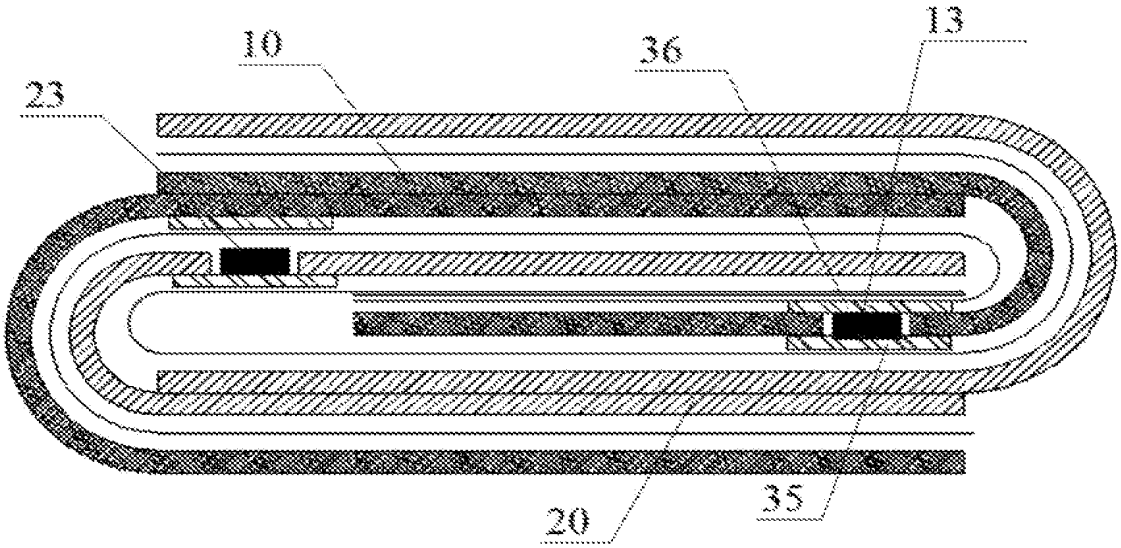


图9

(19)中华人民共和国国家知识产权局

(12)发明专利申请

(10)申请公布号 CN 110459730 A
(43)申请公布日 2019.11.15

(21)申请号 201910688515.8

(22)申请日 2019.07.29

(71)申请人 漳州华锐锂能新能源科技有限公司
地址 363300 福建省漳州市云霄县云陵工业开发区

(72)发明人 杨宪宝

(74)专利代理机构 泉州市潭思专利代理事务所（普通合伙）35221
代理人 廖仲禧

(51)Int.Cl.
H01M 4/04(2006.01)
H01M 4/139(2010.01)
H01M 10/0585(2010.01)
H01M 4/13(2010.01)
H01M 4/62(2006.01)
H01M 4/74(2006.01)
H01M 10/04(2006.01)
H01M 10/0525(2010.01)
H01M 10/615(2014.01)

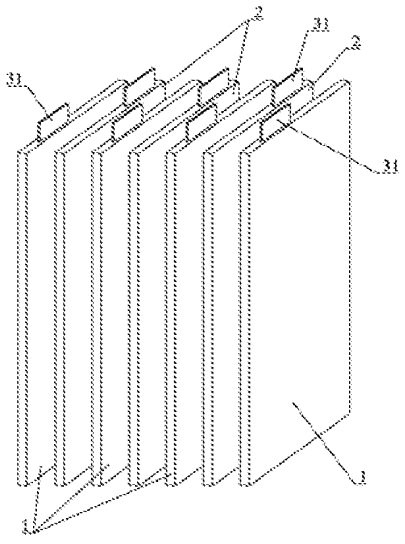
权利要求书1页 说明书4页 附图3页

(54)发明名称

一种锂离子电池及其制作方法

(57)摘要

本发明公开一种锂离子电池的制作方法，包括以下步骤：①分别制作正极片和负极片；②化成：将正极片和负极片交替叠加后固定，加热烘烤后，在无水环境中，浸入到电解液中，以0.01C~0.2C的电流化成，得到电池半成品；③模压成型和封装：将化成后的电池半成品加热到60~100℃，放入预制模具中，施加0.2~15MPa的压力，使之成型；再放入外壳中，经封装后得到锂离子电池。本发明提供一种锂离子电池及其制作方法，不经过涂布、分切、制片等工序，可以一次将极片成型，制作方法简单高效。



CN 110459730 A

1.一种锂离子电池的制作方法，其特征在于，包括以下步骤：

①分别制作正极片和负极片：

将粘结剂和导电剂粉料以及正极活性物质或负极活性物质粉料混合搅拌均匀后，加热到80~200℃，放入内置金属网的预制模具中，对模具中的粉料施加3~20MPa的压力，使之成型，分别得到正极成型体和负极成型体；所述金属网的一端形成有伸出于所述正极成型体或负极成型体侧边之外的导电极耳；

将正极成型体和负极成型体浸入陶瓷溶液中，烘干后所述正极成型体和负极成型体表面包覆一层陶瓷层；

再将正极成型体和负极成型体浸入高分子聚合物溶液中，烘干后在正极成型体和负极成型体表面形成高分子聚合物层，得到正极片和负极片；

②化成：将正极片和负极片交替叠加后固定，加热烘烤后，在无水环境中，浸入到电解液中，以0.01C~0.2C的电流化成，得到电池半成品；

③模压成型和封装：将化成后的电池半成品加热到60~100℃，放入预制模具中，施加0.2~15MPa的压力，使之成型；再放入外壳中，经封装后得到锂离子电池。

2.如权利要求1所述的一种锂离子电池的制作方法，其特征在于，所述陶瓷层的厚度为5~60μm。

3.如权利要求1所述的一种锂离子电池的制作方法，其特征在于，所述高分子聚合物层的厚度为3~30μm。

4.如权利要求1所述的一种锂离子电池的制作方法，其特征在于，所述正极活性物质包括钴酸锂、锰酸锂、镍钴锰酸锂、磷酸铁锂、钛酸锂或镍钴铝酸锂中的一种或者几种。

5.如权利要求1所述的一种锂离子电池的制作方法，其特征在于，所述的负极活性物质包括石墨、中间相碳微球、硬碳、软碳、钛酸锂或硅碳中的一种或者几种。

6.如权利要求1所述的一种锂离子电池的制作方法，其特征在于，所述粘结剂包括PVDF、PTFE、丙烯酸酯或丁苯橡胶。

7.如权利要求1所述的一种锂离子电池的制作方法，其特征在于，所述导电剂包括炭黑，CNT，石墨，石墨烯或金属丝。

8.如权利要求1所述的一种锂离子电池的制作方法，其特征在于，所述金属网的目数80~1200目；所述金属网包括铝网、镍网、铜网或不锈钢网。

9.一种锂离子电池，其特征在于，包括正极片、负极片和电解液，所述正极片包括正极成型体，还包括包覆在正极成型体外表面的陶瓷层，所述陶瓷层外表面还包覆有一层高分子聚合物层；所述正极成型体包括正极材料层和设置在正极材料层内的金属网；

所述负极片包括负极成型体，还包括包覆在负极成型体外表面的陶瓷层，所述陶瓷层外表面还包覆有一层高分子聚合物层；所述负极成型体包括负极材料层和设置在负极材料层内的金属网；

所述正极成型体和负极成型体内的所述金属网的一端分别形成有伸出于所述正极材料层或负极材料层的侧边之外的导电极耳；所述正极片和负极片交替叠加设置，所述电解液渗透在极片中和填充在极片之间。

一种锂离子电池及其制作方法

技术领域

[0001] 本发明涉及锂离子电池领域，具体涉及的是一种锂离子电池及其制作方法。

背景技术

[0002] 传统的锂离子电池采用溶剂溶解混合后涂布的方式，以将正/负极材料涂覆在金属箔材上形成正/负极材料层（正/负极材料一般包括正/负极活性物质、粘结剂和导电剂），再经过分切、制片等工序制得极片，生产工序繁琐，生产周期长久，而且容易产生毛刺，造成安全隐患。

[0003] 有鉴于此，本申请人针对现有技术中的上述缺陷深入研究，遂有本案产生。

发明内容

[0004] 本发明的主要目的在于提供一种锂离子电池及其制作方法，不经过涂布、分切、制片等工序，可以一次将极片成型，制作方法简单高效。

[0005] 为了达成上述目的，本发明的解决方案是：

[0006] 一种锂离子电池的制作方法，其中，包括以下步骤：

[0007] ①分别制作正极片和负极片：

[0008] 将粘结剂和导电剂粉料以及正极活性物质或负极活性物质粉料混合搅拌均匀后，加热到80~200℃，放入内置金属网的预制模具中，对模具中的粉料施加3~20MPa的压力，使之成型，分别得到正极成型体和负极成型体；所述金属网的一端形成有伸出于所述正极成型体或负极成型体侧边之外的导电极耳；

[0009] 将正极成型体和负极成型体浸入陶瓷溶液中，烘干后所述正极成型体和负极成型体表面包覆一层陶瓷层；

[0010] 再将正极成型体和负极成型体浸入高分子聚合物溶液中，烘干后在正极成型体和负极成型体表面形成高分子聚合物层，得到正极片和负极片；

[0011] ②化成：将正极片和负极片交替叠加后固定，加热烘烤后，在无水环境中，浸入到电解液中，以0.01C~0.2C的电流化成，得到电池半成品；

[0012] ③模压成型和封装：将化成后的电池半成品加热到60~100℃，放入预制模具中，施加0.2~15MPa的压力，使之成型；再放入外壳中，经封装后得到锂离子电池。

[0013] 进一步，所述陶瓷层的厚度为5~60μm。

[0014] 进一步，所述高分子聚合物层的厚度为3~30μm。

[0015] 进一步，所述正极活性物质包括钴酸锂、锰酸锂、镍钴锰酸锂、磷酸铁锂、钛酸锂或镍钴铝酸锂中的一种或者几种。

[0016] 进一步，所述的负极活性物质包括石墨、中间相碳微球、硬碳、软碳、钛酸锂或硅碳中的一种或者几种。

[0017] 进一步，所述粘结剂包括PVDF、PTFE、丙烯酸酯或丁苯橡胶。

[0018] 进一步，所述导电剂包括炭黑，CNT，石墨，石墨烯或金属丝。

[0019] 进一步，所述金属网的目数80~1200目；所述金属网包括铝网、镍网、铜网或不锈钢网。

[0020] 一种锂离子电池，其中，包括正极片、负极片和电解液，所述正极片包括正极成型体，还包括包覆在正极成型体外表面的陶瓷层，所述陶瓷层外表面还包覆有一层高分子聚合物层；所述正极成型体包括正极材料层和设置在正极材料层内的金属网；

[0021] 所述负极片包括由负极活性物质、粘结剂和导电剂粉料组成的负极成型体，还包括包覆在负极成型体外表面的陶瓷层，所述陶瓷层外表面还包覆有一层高分子聚合物层；所述负极成型体包括负极材料层和设置在负极材料层内的金属网；

[0022] 所述正极成型体和负极成型体内的所述金属网的一端形成有伸出于所述正极成型体或负极成型体的侧边之外的导电极耳；所述正极片和负极片交替叠加设置，所述电解液渗透在极片中和填充在极片之间。

[0023] 进一步，所述陶瓷层的厚度为5~60μm。

[0024] 进一步，所述高分子聚合物层的厚度为3~30μm。

[0025] 进一步，所述金属网的目数80~1200目。

[0026] 进一步，所述金属网包括铝网、镍网、铜网或不锈钢网。

[0027] 采用上述结构后，本发明涉及的一种锂离子电池的制作方法，其至少具有以下有益效果：

[0028] 一、将混合的粉料放置在预制模具前加热到80~200℃使得粉料中的粘结剂软化，从而将活性物质和导电剂粘结在一起，再经过内置金属网的模具施压形成片状的正极成型体或负极成型体。

[0029] 二、步骤③中加热加压过程中，正极片和负极片上的高分子聚合物层将正极片和负极片粘结在一起；所述正极片和负极片上设置有陶瓷层，起到隔离电子的作用，防止正极片和负极片之间发生短路，而锂离子可以穿过陶瓷层在正极片和负极片之间迁移。

[0030] 三、所述金属网位于所述正极成型体和负极成型体内，通过与金属网相连接的导电极耳与外界导线相连接。

[0031] 四、步骤③中，将化成后的电池半成品加热到60~100℃能够降低电解液的粘度，起到加速电解液的渗透速率的作用，以便于电解液渗透至正极片和负极片中；步骤③中施加0.2~15MPa的压力能够将化成产生的气体排出极片表面，防止在极片表面形成死锂影响电池效果。

附图说明

[0032] 图1为锂离子电池的立体结构示意图。

[0033] 图2为正极片的剖面结构示意图。

[0034] 图3为负极片的剖面结构示意图。

[0035] 图4为正极片的结构示意图。

[0036] 图5为负极片的结构示意图。

[0037] 图中：

[0038] 正极片1；正极成型体11；正极材料层111；负极片2；负极成型体21；负极材料层211；金属网3；导电极耳31；陶瓷层4；高分子聚合物层5。

具体实施方式

[0039] 为了进一步解释本发明的技术方案，下面通过具体实施例来对本发明进行详细阐述。

[0040] 如图1至图5所示，其为本发明涉及的一种锂离子电池的制作方法，包括以下步骤：

[0041] ①分别制作正极片1和负极片2：将粘结剂和导电剂粉料以及正极活性物质或负极活性物质粉料混合搅拌均匀后，加热到80~200℃，放入内置金属网3的预制模具中，对模具中的粉料施加3~20MPa的压力，使之成型，分别得到正极成型体11和负极成型体21；所述正极成型体11和负极成型体21内的所述金属网3的一端形成有伸出于所述正极成型体11或负极成型体21侧边之外的导电极耳31；将正极成型体11和负极成型体21浸入陶瓷溶液中，烘干后所述正极成型体11和负极成型体21表面包覆一层陶瓷层4，所述陶瓷层4的厚度为5~60μm；再将正极成型体11和负极成型体21浸入高分子聚合物溶液中，烘干后在正极成型体11和负极成型体21表面形成高分子聚合物层5，得到正极片1和负极片2。优选地，所述高分子聚合物层5的厚度为3~30μm。

[0042] ②化成：将正极片1和负极片2交替叠加后固定，加热烘烤后，在无水环境中，浸入到电解液中，以0.01C~0.2C的电流化成，得到电池半成品。

[0043] ③模压成型和封装：将化成后的电池半成品加热到60~100℃，放入预制模具中，施加0.2~15MPa的压力，使之成型；再放入外壳中，经封装后得到锂离子电池。

[0044] 这样，本发明涉及的一种锂离子电池的制作方法，将混合的粉料放置在预制模具前加热到80~200℃使得粉料中的粘结剂软化，从而将活性物质和导电剂粘结在一起，再经过模具施压形成片状的正极成型体11或负极成型体21。

[0045] 步骤③中加热加压的过程中，正极片1和负极片2上的高分子聚合物层5将正极片1和负极片2粘结在一起；所述正极片1和负极片2上设置有陶瓷层4，起到隔离电子的作用，防止正极片1和负极片2之间发生短路，而锂离子可以穿过陶瓷层4在正极片1和负极片2之间迁移。

[0046] 当锂离子电池充电和放电时，所述金属网3位于所述正极成型体11和负极成型体21内，通过与金属网3相连接的导电极耳31与外界导线相连接。

[0047] 步骤③中，将化成后的电池半成品加热到60~100℃能够降低电解液的粘度，起到加速电解液的渗透速率的作用，以便于电解液渗透至正极片1和负极片2中；步骤③中施加0.2~15MPa的压力能够将化成产生的气体排出极片表面，防止在极片表面形成死锂影响电池效果。

[0048] 优选地，所述正极活性物质包括钴酸锂、锰酸锂、镍钴锰酸锂、磷酸铁锂、钛酸锂或镍钴铝酸锂中的一种或者几种。

[0049] 优选地，所述的负极活性物质包括石墨、中间相碳微球、硬碳、软碳、钛酸锂或硅碳中的一种或者几种。

[0050] 优选地，所述粘结剂包括PVDF、PTFE、丙烯酸酯或丁苯橡胶。通过粘结剂的粘结作用将正极活性物质或负极活性物质与导电剂粘结在一起。

[0051] 优选地，所述导电剂包括炭黑，CNT，石墨，石墨烯或金属丝。

[0052] 优选地，所述金属网3的目数80~1200目；所述金属网3包括铝网、镍网、铜网或不锈钢网。

[0053] 一种锂离子电池，包括正极片1、负极片2和电解液，所述正极片1包括正极成型体11，还包括包覆在正极成型体11外表面的厚度为5~60μm的陶瓷层4，所述陶瓷层4外表面还包覆有一层厚度为3~30μm的高分子聚合物层5；所述正极成型体11包括正极材料层111和设置在正极材料层111内的金属网3；

[0054] 所述负极片2包括负极成型体21，还包括包覆在负极成型体21外表面的厚度为5~60μm的陶瓷层4，所述陶瓷层4外表面还包覆有一层厚度为3~30μm的高分子聚合物层5；所述负极成型体21包括负极材料层211和设置在负极材料层211内的金属网3；

[0055] 所述正极成型体11和负极成型体21内的述金属网3的一端形成有伸出于所述正极成型体11或负极成型体21的侧边之外的导电极耳31；所述正极片1和负极片2交替叠加设置，所述电解液渗透在极片中和填充在极片之间。

[0056] 优选地，所述金属网3的目数80~1200目。更进一步的，所述金属网3包括铝网、镍网、铜网或不锈钢网。

[0057] 这样，所述金属网3位于所述正极成型体11和负极成型体21内，通过与金属网3相连接的导电极耳31与外界导线相连接；正极片1和负极片2上的高分子聚合物层5将正极片1和负极片2粘结在一起，所述正极片1和负极片2上设置有陶瓷层4，起到隔离电子的作用，防止正极片1和负极片2之间发生短路，而锂离子可以穿过陶瓷层4在正极片1和负极片2之间迁移。本发明的锂离子电池具有结构简单，制造方便的特点。

[0058] 上述实施例和图式并非限定本发明的产品形态和式样，任何所属技术领域的普通技术人员对其所做的适当变化或修饰，皆应视为不脱离本发明的专利范畴。

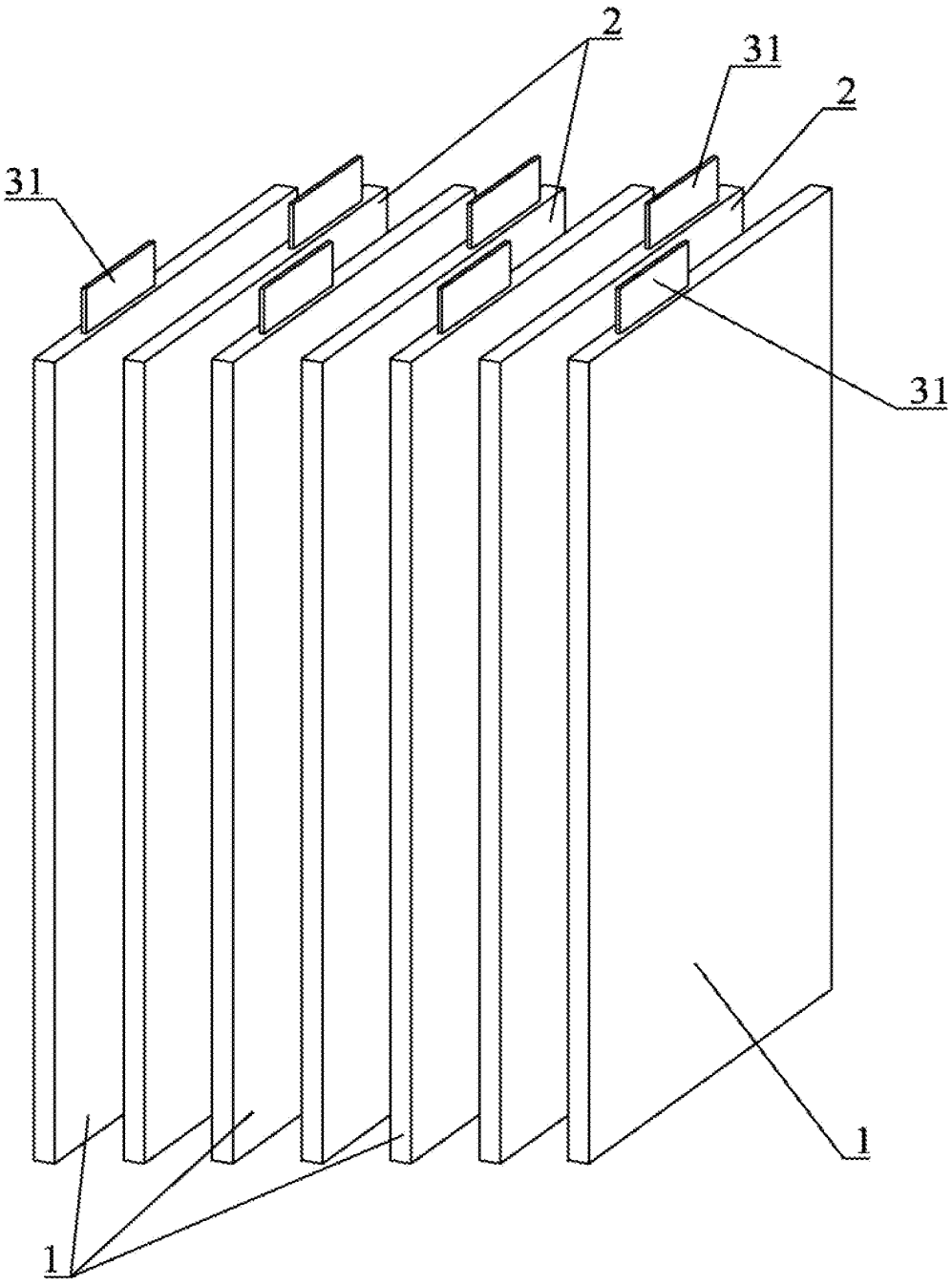


图1

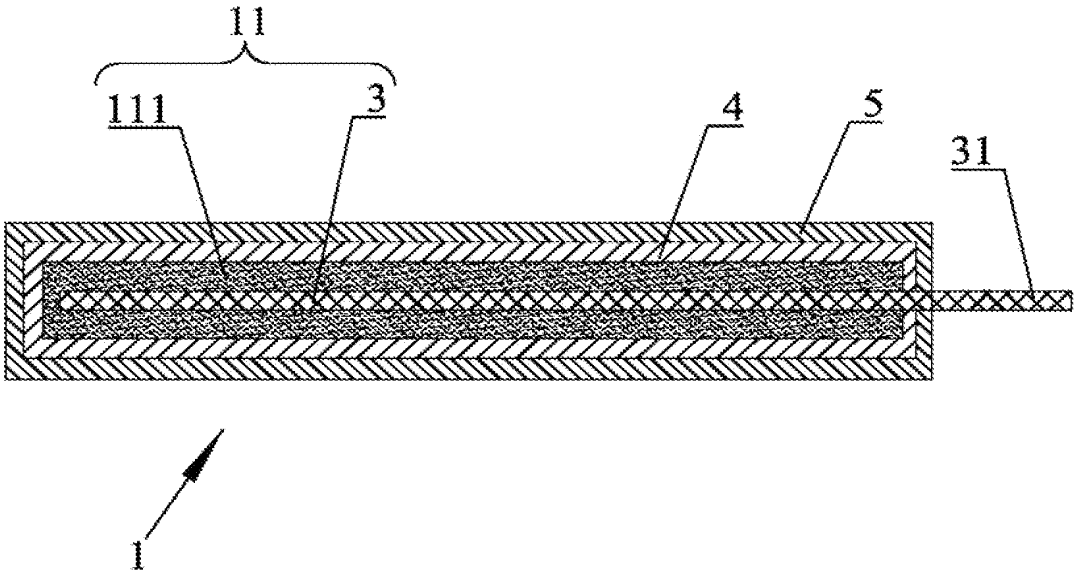


图2

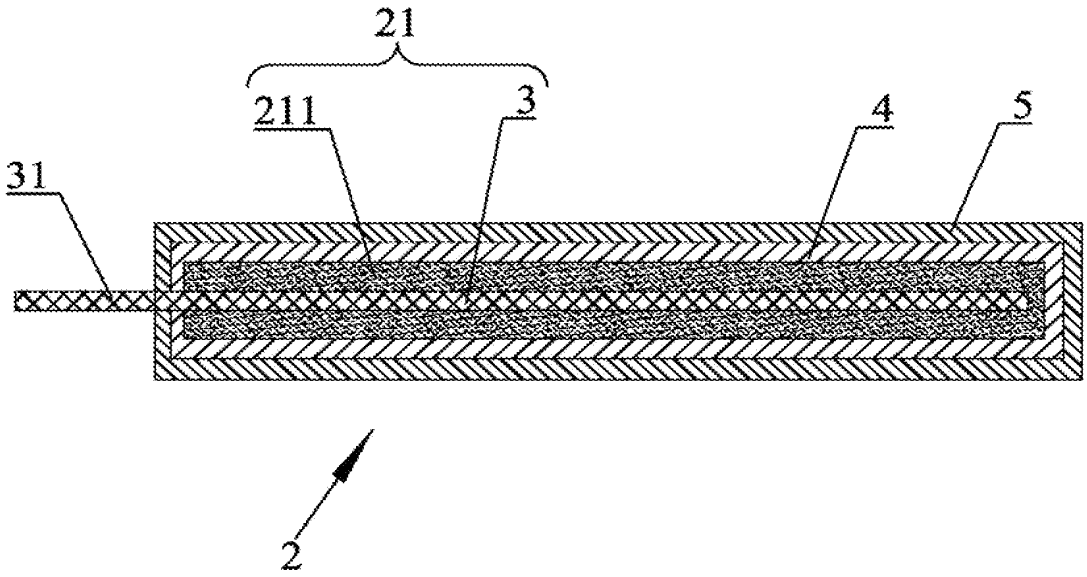


图3

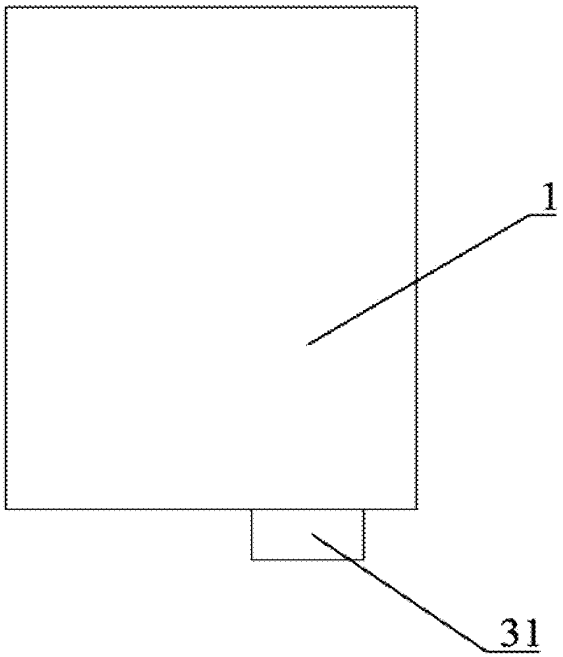


图4

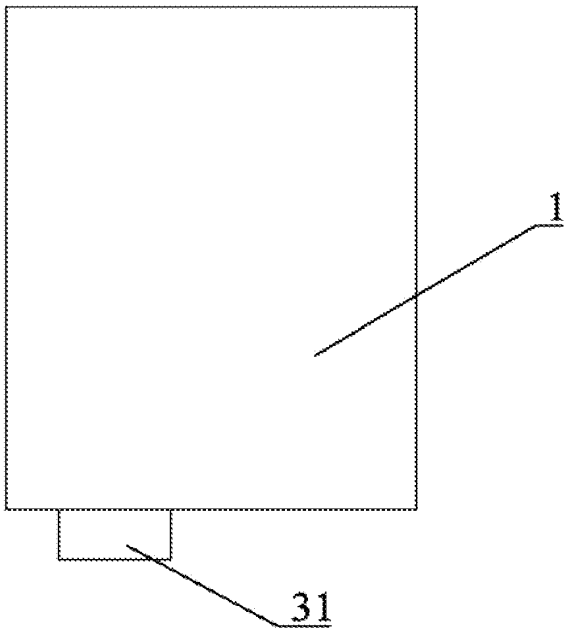


图5

(19)中华人民共和国国家知识产权局

(12)发明专利申请

(10)申请公布号 CN 107834014 A
(43)申请公布日 2018.03.23

(21)申请号 201710841354.2

(22)申请日 2017.09.18

(71)申请人 东莞市迈科新能源有限公司
地址 523000 广东省东莞市大朗镇犀牛陂村美景大道西1888号迈科工业园1号厂房
申请人 东莞市迈科科技有限公司
东莞市迈科锂离子电池工业节能技术研究院

(72)发明人 余伟源 刘勇 于丰 王娜 宋晓娜 朱坤庆

(74)专利代理机构 天津市北洋有限责任专利代理事务所 12201
代理人 潘俊达

(51)Int.Cl.
H01M 2/26(2006.01)
H01M 2/34(2006.01)
H01M 10/04(2006.01)
H01M 10/0525(2010.01)
H01M 10/0587(2010.01)

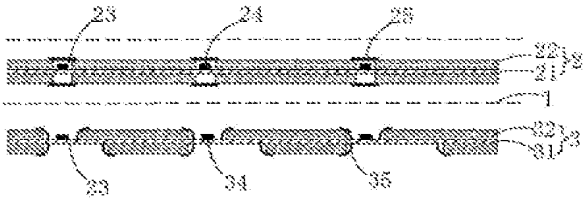
权利要求书1页 说明书4页 附图1页

(54)发明名称

一种高功率圆柱型锂离子电芯

(57)摘要

本发明属于锂离子电池技术领域，尤其涉及一种高功率圆柱型锂离子电芯，其在负极集流体的两侧分别预留有多个未涂覆负极活性材料层的负极间隙位，负极间隙位焊接有负极极耳，负极间隙位还贴覆有负极绝缘胶并覆盖负极极耳，负极绝缘胶的两端在负极片的宽度方向上分别外露负极片边缘1~10mm；正极集流体的两侧分别预留有多个未涂覆正极活性材料层、且与负极间隙位一一对应的正极间隙位，正极间隙位焊接有正极极耳，正极间隙位与正极活性材料层间贴覆有正极绝缘胶，正极绝缘胶的两端在正极片的宽度方向上分别外露正极片边缘1~10mm。本发明既能够保证电池的功率要求，避免电池极耳位置发生析锂，又能准确判断正极片和负极片间隙位对位情况。



CN 107834014 A

1.一种高功率圆柱型锂离子电芯，其由正极片、隔离膜和负极片依次层叠后沿同一方向卷绕而成，其特征在于：所述负极片包括负极集流体和涂覆在负极集流体两侧的负极活性材料层，所述负极集流体的两侧分别预留有多个未涂覆负极活性材料层的负极间隙位，所述负极间隙位焊接有负极极耳，所述负极间隙位还贴覆有负极绝缘胶并覆盖所述负极极耳，所述负极绝缘胶的两端在负极片的宽度方向上分别外露负极片边缘1～10mm；

所述正极片包括正极集流体和涂覆在正极集流体两侧的正极活性材料层，所述正极集流体的两侧分别预留有多个未涂覆正极活性材料层、且与负极间隙位一一对应的正极间隙位，所述正极间隙位焊接有正极极耳，所述正极间隙位与所述正极活性材料层之间还贴覆有正极绝缘胶，所述正极绝缘胶的两端在正极片的宽度方向上分别外露正极片边缘1～10mm。

2.根据权利要求1所述的高功率圆柱型锂离子电芯，其特征在于：所述负极绝缘胶的两端在负极片的宽度方向上分别外露负极片边缘1～5mm；所述正极绝缘胶的两端在正极片的宽度方向上分别外露正极片边缘1～5mm。

3.根据权利要求1所述的高功率圆柱型锂离子电芯，其特征在于：所述负极绝缘胶的两侧在负极片的长度方向上分别覆盖0.5～5mm的负极活性材料层。

4.根据权利要求1所述的高功率圆柱型锂离子电芯，其特征在于：所述正极绝缘胶的两侧在正极片的长度方向上分别覆盖0.5～5mm的正极活性材料层。

5.根据权利要求1所述的高功率圆柱型锂离子电芯，其特征在于：沿所述电芯卷绕的方向上，所述负极片两侧的负极间隙位的宽度都保持相等。

6.根据权利要求5所述的高功率圆柱型锂离子电芯，其特征在于：沿所述电芯卷绕的方向上，所述正极片其中一侧的正极间隙位的宽度保持相等，所述正极片另一侧的正极间隙位的宽度依次增加。

7.根据权利要求1所述的高功率圆柱型锂离子电芯，其特征在于：多个所述正极极耳焊接在正极片的同一侧，多个所述负极极耳焊接在负极片的同一侧。

8.根据权利要求1所述的高功率圆柱型锂离子电芯，其特征在于：所述负极片每一侧的负极间隙位的数量设置为三个，三个所述负极间隙位分别设置在负极片的头部、中部和尾部。

9.根据权利要求8所述的高功率圆柱型锂离子电芯，其特征在于：所述正极片每一侧的正极间隙位的数量设置为三个，三个所述正极间隙位分别设置在正极片的头部、中部和尾部。

一种高功率圆柱型锂离子电芯

技术领域

[0001] 本发明属于锂离子电池技术领域，尤其涉及一种高功率圆柱型锂离子电芯。

背景技术

[0002] 锂离子电池由于具有能量密度高，自放电低，无记忆效应等突出优点已经成为移动能源的主要解决方案，并广泛应用在便携式电子产品，电动汽车以及储能电站等多个领域。

[0003] 其中，圆柱型电池一般由钢壳、顶盖、正极片、负极片、隔膜、电解液等组成。目前，商业化圆柱型电池一般为正极耳从顶盖引出，负极耳通过底部焊接与钢壳连接，这种设计存在的瓶颈是只能通过一个极耳引出正负极，如果按原结构采用正负极多极耳引出，必然导致负极耳的对应位置出现正极活性物质，从而导致电池充电析锂，引发安全事故。在商业化的应用中，如果通过改变引出结构或更改其他设备来实现多极耳对位引出，显然从成本和技术要求来说，都是一项很大的投入。此外，相对于18650、26650等商业化圆柱型电池，32650圆柱型电池直径更大，其极片的长度也更长，如果按行业通用的采用单极耳引出，电池的内阻必然很大，在动力电池上应用难以满足高功率和低自耗电的要求。

发明内容

[0004] 本发明的目的在于：针对现有技术的不足，而提供一种既能够保证电池的功率要求，避免电池极耳位置发生析锂，又能判断正极片和负极片间隙位对位情况的高功率圆柱型锂离子电芯。

[0005] 为了实现上述目的，本发明采用以下技术方案：

[0006] 一种高功率圆柱型锂离子电芯，其由正极片、隔离膜和负极片依次层叠后沿同一方向卷绕而成，所述负极片包括负极集流体和涂覆在负极集流体两侧的负极活性材料层，所述负极集流体的两侧分别预留有多个未涂覆负极活性材料层的负极间隙位，所述负极间隙位焊接有负极极耳，所述负极间隙位还贴覆有负极绝缘胶并覆盖所述负极极耳，所述负极绝缘胶的两端在负极片的宽度方向上分别外露负极片边缘1～10mm；

[0007] 所述正极片包括正极集流体和涂覆在正极集流体两侧的正极活性材料层，所述正极集流体的两侧分别预留有多个未涂覆正极活性材料层、且与负极间隙位一一对应的正极间隙位，所述正极间隙位焊接有正极极耳，所述正极间隙位与所述正极活性材料层之间还贴覆有正极绝缘胶，所述正极绝缘胶的两端在正极片的宽度方向上分别外露正极片边缘1～10mm。

[0008] 作为本发明所述的高功率圆柱型锂离子电芯的优选方案，所述负极绝缘胶的两端在负极片的宽度方向上分别外露负极片边缘1～5mm；所述正极绝缘胶的两端在正极片的宽度方向上分别外露正极片边缘1～5mm。

[0009] 作为本发明所述的高功率圆柱型锂离子电芯的优选方案，所述负极绝缘胶的两侧在负极片的长度方向上分别覆盖0.5～5mm的负极活性材料层。

[0010] 作为本发明所述的高功率圆柱型锂离子电芯的优选方案，所述正极绝缘胶的两侧在正极片的长度方向上分别覆盖0.5～5mm的正极活性材料层。

[0011] 作为本发明所述的高功率圆柱型锂离子电芯的优选方案，沿所述电芯卷绕的方向上，所述负极片两侧的负极间隙位的宽度都保持相等。

[0012] 作为本发明所述的高功率圆柱型锂离子电芯的优选方案，沿所述电芯卷绕的方向上，所述正极片其中一侧的正极间隙位的宽度保持相等，所述正极片另一侧的正极间隙位的宽度依次增加。

[0013] 作为本发明所述的高功率圆柱型锂离子电芯的优选方案，多个所述正极极耳焊接在正极片的同一侧，多个所述负极极耳焊接在负极片的同一侧。

[0014] 作为本发明所述的高功率圆柱型锂离子电芯的优选方案，所述负极片每一侧的负极间隙位的数量设置为三个，三个所述负极间隙位分别设置在负极片的头部、中部和尾部。

[0015] 作为本发明所述的高功率圆柱型锂离子电芯的优选方案，所述正极片每一侧的正极间隙位的数量设置为三个，三个所述正极间隙位分别设置在正极片的头部、中部和尾部。

[0016] 相比于现有技术，本发明的有益效果在于：1)本发明的电芯采用多极耳结构设计，可以有效的降低电池的阻抗，提升电池的动力学性能，满足高功率和低自耗电的要求；2)电芯卷绕完成后，正极片一侧的正极间隙位与负极片相对侧的负极间隙位对位，正极片另一侧的正极间隙位通过卷绕后与负极片另一侧的负极间隙位对位，从而使得负极片的间隙位不存在正极活性物质，因此杜绝了极耳位置发生析锂的风险；3)在正负极间隙位贴覆绝缘胶，且使绝缘胶外露极片两侧边缘1～10mm；这样的设计，一方面，可以杜绝正极片敷料边缘摩擦隔离膜导致与负极片发生接触的风险，提高电池的安全性；另一方面，多极耳卷芯结构必然存在极耳对位处于卷芯内侧，在不拆解卷芯的情况下，一般无法准确判断是否在工艺范围内对位，而通过在正负极间隙位贴覆绝缘胶，并且使绝缘胶外露极片两侧边缘1～10mm，这样只需观察外露绝缘胶的位置即可判断极耳对位是否满足工艺范围；此外，当极片敷料层边缘厚度不一致时，极片容易在此处被拉断，从而导致电芯良品率降低，而本发明在正负极间隙位与敷料层边缘贴覆绝缘胶后，可缓解敷料层与极片间隙位之间受力的突变，从而降低了敷料层边缘断带的风险，可以极大地提高良品生产率。

附图说明

[0017] 图1为本发明的锂离子电芯卷绕前的结构示意图。

[0018] 图中：1-隔离膜；2-负极片；21-负极集流体；22-负极活性材料层；23-负极间隙位；24-负极极耳；25-负极绝缘胶；3-正极片；31-正极集流体；32-正极活性材料层；33-正极间隙位；34-正极极耳；35-正极绝缘胶。

具体实施方式

[0019] 为使本发明的技术方案和优点更加清楚，下面将结合具体实施例和说明书附图，对本发明的技术方案进行清楚、完整地描述，显然，所描述的实施例是本发明一部分实施例，而不是全部的实施例。基于本发明中的实施例，本领域普通技术人员在没有作出创造性劳动前提下所获得的所有其他实施例，都属于本发明保护的范围。

[0020] 实施例1

[0021] 本实施例一种高功率圆柱型锂离子电芯，其由正极片3、隔离膜1和负极片2依次层叠后沿同一方向卷绕而成，负极片2包括负极集流体21和涂覆在负极集流体21两侧的负极活性材料层22，负极集流体21的两侧分别预留有三个未涂覆负极活性材料层22的负极间隙位23，三个负极间隙位23分别设置在负极片2的头部、中部和尾部，且三个负极间隙位23的宽度保持相等；三个负极间隙位23分别焊接有负极极耳24，三个负极极耳24焊接在负极片2的同一侧，负极间隙位23还贴覆有负极绝缘胶25并覆盖负极极耳24，负极绝缘胶25的两端在负极片2的宽度方向上分别外露负极片2边缘1mm；负极绝缘胶25的两侧在负极片2的长度方向上分别覆盖0.5mm的负极活性材料层22。

[0022] 正极片3包括正极集流体31和涂覆在正极集流体31两侧的正极活性材料层32，正极集流体31的两侧分别预留有三个未涂覆正极活性材料层32、且与负极间隙位23一一对应的正极间隙位33，三个正极间隙位33分别设置在正极片3的头部、中部和尾部，其中，正极片3其中一侧的正极间隙位33的宽度保持相等，正极片3另一侧的正极间隙位33的宽度依次增加，以保证正极片3一侧的正极间隙位33与负极片2相对侧的负极间隙位23对位，正极片3另一侧的正极间隙位33通过卷绕后与负极片2另一侧的负极间隙位23对位；三个正极间隙位33分别焊接有正极极耳34，三个正极极耳34焊接在正极片3的同一侧，正极间隙位33与正极活性材料层32之间还贴覆有正极绝缘胶35，正极绝缘胶35的两端在正极片3的宽度方向上分别外露正极片3边缘1mm；正极绝缘胶35的两侧在正极片3的长度方向上分别覆盖0.5mm的正极活性材料层32。

[0023] 实施例2

[0024] 本实施例一种高功率圆柱型锂离子电芯，其由正极片3、隔离膜1和负极片2依次层叠后沿同一方向卷绕而成，负极片2包括负极集流体21和涂覆在负极集流体21两侧的负极活性材料层22，负极集流体21的两侧分别预留有四个未涂覆负极活性材料层22的负极间隙位23，四个负极间隙位23分别设置在负极片2的头部、中部和尾部，且四个负极间隙位23的宽度保持相等；四个负极间隙位23分别焊接有负极极耳24，四个负极极耳24焊接在负极片2的同一侧，负极间隙位23还贴覆有负极绝缘胶25并覆盖负极极耳24，负极绝缘胶25的两端在负极片2的宽度方向上分别外露负极片2边缘5mm；负极绝缘胶25的两侧在负极片2的长度方向上分别覆盖5mm的负极活性材料层22。

[0025] 正极片3包括正极集流体31和涂覆在正极集流体31两侧的正极活性材料层32，正极集流体31的两侧分别预留有四个未涂覆正极活性材料层32、且与负极间隙位23一一对应的正极间隙位33，四个正极间隙位33分别设置在正极片3的头部、中部和尾部，其中，正极片3其中一侧的正极间隙位33的宽度保持相等，正极片3另一侧的正极间隙位33的宽度依次增加，以保证正极片3一侧的正极间隙位33与负极片2相对侧的负极间隙位23对位，正极片3另一侧的正极间隙位33通过卷绕后与负极片2另一侧的负极间隙位23对位；四个正极间隙位33分别焊接有正极极耳34，四个正极极耳34焊接在正极片3的同一侧，正极间隙位33与正极活性材料层32之间还贴覆有正极绝缘胶35，正极绝缘胶35的两端在正极片3的宽度方向上分别外露正极片3边缘5mm；正极绝缘胶35的两侧在正极片3的长度方向上分别覆盖5mm的正极活性材料层32。

[0026] 对比例1

[0027] 与实施例1不同的是，本对比例的电芯采用双极耳引出结构，其余同实施例1，这里

不再赘述。

[0028] 对比例2

[0029] 与实施例2不同的是，本对比例的电芯采用双极耳引出结构，其余同实施例2，这里不再赘述。

[0030] 分别对实施例1～2和对比例1～2的锂离子电芯进行电化学性能测试，测试结果见表1。

[0031] 表1实施例1～2和对比例1～2的锂离子电芯电化学性能测试结果

[0032]

项目		对比例 1	实施例 1	对比例 2	实施例 2
阻抗（mΩ）		7.78	6.12	7.80	6.10
阻抗降低比例（%）		21.30%		21.70%	
中值电压（V）	1C/1C	3.146	3.160	3.150	3.170
	1C/2C	3.059	3.079	3.062	3.084
	1C/3C	2.983	3.010	2.988	3.025
	1C/5C	2.852	2.892	2.864	2.912
	1C/6C	2.784	2.833	2.790	2.866
电压提升（%）	1C/1C	0.45%		0.63%	
	1C/2C	0.68%		0.72%	
	1C/3C	0.91%		1.24%	
	1C/5C	1.40%		1.68%	
	1C/6C	1.76%		2.72%	

[0033] 由表1的测试结果可知，相比于现有的双极耳电芯结构，本发明的锂离子电芯具有更低的阻抗和更高电压提升性能，能够有效满足动力电池高功率和低自耗电的要求。

[0034] 根据上述说明书的揭示和教导，本发明所属领域的技术人员还能够对上述实施方式进行变更和修改。因此，本发明并不局限于上述的具体实施方式，凡是本领域技术人员在本发明的基础上所作出的任何显而易见的改进、替换或变型均属于本发明的保护范围。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，并不对本发明构成任何限制。

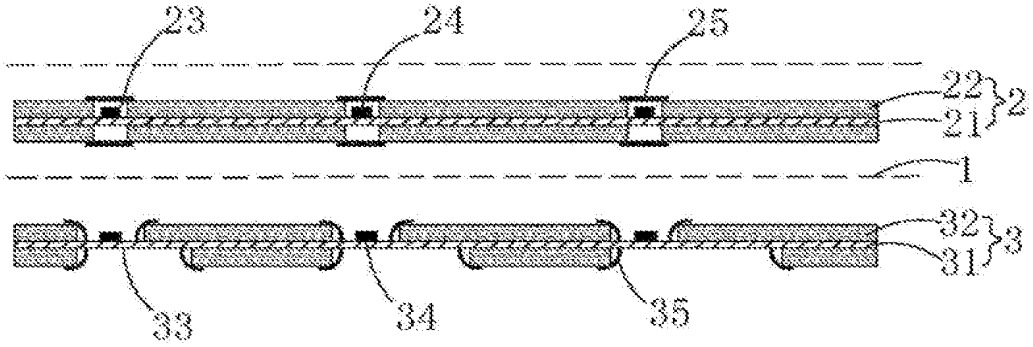


图1

[19] 中华人民共和国国家知识产权局

[51] Int. Cl.
H01M 10/40 (2006.01)
H01M 4/02 (2006.01)
H01M 4/64 (2006.01)

[12] 发明专利申请公布说明书

[21] 申请号 200510015388.3

[43] 公开日 2007 年 4 月 18 日

[11] 公开号 CN 1949580A

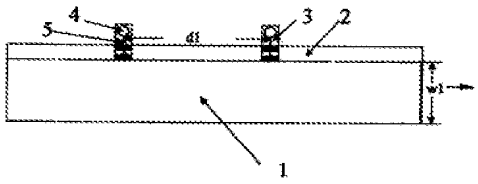
[22] 申请日 2005.10.14
[21] 申请号 200510015388.3
[71] 申请人 中国电子科技集团公司第十八研究所
地址 300381 天津市南开区李七庄凌庄子道 18 号
[72] 发明人 刘兴江 张 遥 朱广焱 杨 凯 喻津汉 吴滨成
[74] 专利代理机构 天津市鼎和专利商标代理有限公司
代理人 李 凤
权利要求书 1 页 说明书 9 页 附图 2 页

[54] 发明名称

一种高功率锂离子电池

[57] 摘要

本发明属于一种高功率锂离子电池，包括正极、负极、隔膜和非水电解液，正、负极的含活性材料的涂覆层为连续涂覆层，正、负极沿卷绕方向一侧留有集流体空白，空白处设正、负极耳，其特点是：正极耳截面积 S_1、正极耳间隔 d_1 及正极含活性材料涂覆层宽度 w_1 满足：$1\times10^{-5}\leqslant S_1/(d_1\times w_1)\leqslant4\times10^{-5}$；负极耳截面积 S_2、负极耳间隔 d_2 及负极的含活性材料涂覆层宽度 w_2 满足：$1\times10^{-5}\leqslant S_2/(d_2\times w_2)\leqslant3\times10^{-5}$。保证了电池大功率放电时的电池温度得到有效控制，降低电极内阻，提高电池安全性和循环寿命。可广泛用于混合动力车，电动工具以及各种助推器等的电源，在实现锂离子电池高功率化方面具有广泛的应用前景。



1. 一种高功率锂离子电池，包括正极、负极、隔膜和非水电解液，正极由正极集流体和均匀涂在其两面的含正极活性材料涂覆层构成；负极由负极集流体和均匀涂在其两面的含负极活性材料涂覆层构成；正极和负极的含活性材料的涂覆层为连续涂覆层，并在正、负极的沿卷绕方向的一侧留有集流体空白，在空白处设置电流导出正、负极耳，其特征在于：所述正极极耳的截面积 S_1、正极极耳间隔 d_1 以及含正极活性材料涂覆层宽度 w_1 满足下式：$1x10^{-5} \leqslant S_1/(d_1xw_1) \leqslant 4x10^{-5}$；所述负极极耳的截面积 S_2、负极极耳间隔 d_2 以及含负极活性材料涂覆层宽度 w_2 满足下式：$1x10^{-5} \leqslant S_2/(d_2xw_2) \leqslant 3x10^{-5}$。

2. 根据权利要求 1 所述的高功率锂离子电池，其特征在于：所述含正极活性材料涂覆层的双面涂布重量为 10mg-30mg/cm^2，所述含负极活性材料涂覆层的双面涂布重量为 4.8mg-14.5mg/cm^2。

3. 根据权利要求 1 所述的高功率锂离子电池，其特征在于：所述正极极耳和正极集流体为一体式结构、所述负极极耳和负极集流体为一体式结构，极耳与集流体过渡区域呈宽于极耳的弧形或三角形结构。

4. 根据权利要求 1 所述的高功率锂离子电池，其特征在于：所述正极极耳为超声焊焊接在正极集流体上的铝带，铝带的厚度不大于正极厚度的 1.5 倍；所述负极极耳为超声焊焊接在负极集流体上的镍带或铜带，其厚度不大于负极厚度的 1.5 倍。

5. 根据权利要求 1 所述的高功率锂离子电池，其特征在于：所述正极极耳的个数或总面积大于所述负极极耳的个数或总面积。

6. 根据权利要求 1-4 所述的高功率锂离子电池，其特征在于：所述极耳的宽度为 5mm-20mm，所述极耳至少与集流体重叠部分留有帘状切口，并逐一与集流体焊接。

7. 根据权利要求 6 所述的高功率锂离子电池，其特征在于：所述极耳的宽度为 6-12mm。

一种高功率锂离子电池

技术领域

本发明属于锂离子电池技术领域，特别是涉及一种高功率锂离子电池。

背景技术

与传统的铅酸、镍镉、镍氢等二次电池相比，由于锂离子电池具有比能量高，自放电少等优点，已被广泛应用于手机、笔记本计算机、摄像机等电子器具。

目前公知的小功率锂离子电池主要由具有断续涂覆层的负极板、具有断续涂覆层的正极板、电解液以及介于正负极板间防止其短路的隔膜组成。其中负极板是由负极集流体和嵌入/放出锂离子的碳质材料等构成；正极板是由正极集流体和嵌入/放出锂离子的氧化钴锂等复合氧化物构成；电解液是溶有$LiPF_6$等的非质子有机溶剂的溶液。前述正极板与负极板被制成薄板或箔状，然后把正、负极板及介于其间的隔膜按顺序层叠或者螺旋状缠卷而形成电芯。再把这一电芯装入不锈钢、镀镍的铁、或者更轻的铝金属外壳、或者叠层铝塑软包装薄膜电池容器内，再注入电解液，密封而制成电池。

近年来，随着混合动力车，各种助推器的高性能化，对电池的高倍率充放电性能要求越来越高，有时甚至要求电池在 10C 以上倍率放电。但一般商品化的锂离子电池在 2C 倍率放电时，只能放出其标称容量的 80%左右，而根本不能在 10C 倍率放电，其主要原因是内阻过大，特别是在大电流放电时，极耳等发热严重，电池整体温度过度升高，造成安全性和循环寿命方面重大隐患。专利号 02295729.4 方形锂离子二次电池披露了电池正极板、负极板均由连续承载活性物质涂覆层主体部分和与正、负极板自成一体的非涂覆层部分构成，该结构电池与小型功率锂离子电池相比，降低了内阻并提高了倍率放电性能，但只适用于方形电池，并且不能保证电池大功率放电时电池温度得到有效控制。

发明内容

本发明为解决现有技术中存在的问题，提供了一种可制成圆柱型、长园

形、方形、钮扣形和铝叠膜软包装等形状，并能保证电池大功率放电时电池温度得到有效控制的高功率锂离子电池。

本发明为解决公知技术中存在的技术问题采用的技术方案是：高功率锂离子电池，包括正极、负极、隔膜和非水电解液，正极由正极集流体和均匀涂在其两面的含正极活性材料涂覆层构成；负极由负极集流体和均匀涂在其两面的含负极活性材料涂覆层构成；正极和负极的含活性材料的涂覆层为连续涂覆层，并在正、负极的沿卷绕方向的一侧留有集流体空白，在空白处设置电流导出正、负极耳，其特征在于：所述正极极耳的截面积 S_1、正极极耳间隔 d_1 以及正极含活性材料涂覆层宽度 w_1 满足下式：$1x10^{-5} \leqslant S_1/(d_1xw_1) \leqslant 4x10^{-5}$；所述负极极耳的截面积 S_2、负极极耳间隔 d_2 以及负极含活性材料涂覆层宽度 w_2 满足下式：$1x10^{-5} \leqslant S_2/(d_2xw_2) \leqslant 3x10^{-5}$。

本发明还可以采取如下技术措施来实现：所述含正极活性材料涂覆层的双面涂布重量为 10mg-30mg/cm^2，所述含负极活性材料涂覆层的双面涂布重量为 4.8mg-14.5mg/cm^2；所述正极极耳和正极集流体为一体式结构、所述负极极耳和负极集流体为一体式结构，极耳与集流体过渡区域呈宽于极耳的弧形或三角形结构；所述正极极耳为超声焊焊接在正极集流体上的铝带，铝带的厚度不大于正极厚度的 1.5 倍；所述负极极耳为超声焊焊接在负极集流体上的镍带或铜带，其厚度不大于负极厚度的 1.5 倍；所述正极极耳的个数或总面积大于所述负极极耳的个数或总面积；所述极耳的宽度为 5mm-20mm，所述极耳至少与集流体重叠部分留有帘状切口，并逐一与集流体焊接；所述极耳的宽度为 6-12mm。

本发明具有的优点和积极效果是：保证电池大功率放电时的电池温度得到有效控制，降低电极的内阻，提高电池安全性和循环寿命，制作方法经济、简便，保证电池的活性材料利用率高、大倍率放电性能良好。在规模生产上易于实现，在实现锂离子电池高功率化方面具有广泛的应用前景。

附图说明

图 1 为本发明高功率锂离子电池正极板活性材料涂覆结构示意图；

图 2 为本发明高功率锂离子电池负极板活性材料涂覆结构示意图；

图 3 为本发明的高功率锂离子电池在不同倍率放电时电池表面温度变化曲线图。

图中的标号分别为：1、正极板活性材料涂覆层；2、正极集流体；3、正极极耳；4、正极极耳铆接孔；5、正极极耳剪切口；6、负极板活性材料涂覆层；7、负极集流体；8、负极极耳；9、负极极耳铆接孔；10、负极极耳剪切口。

具体实施方式

为能进一步了解本发明的发明内容、特点及功效，兹列举以下实施例，并配合附图详细说明如下：

参照附图 1-3，箭头为电极的卷绕方向。本发明的正极活性材料涂覆层 1 采用氧化钴锂活性材料；负极活性材料涂覆层 6 包含碳纤维和至少从球形石墨或鳞片状石墨中选出的一种活性材料，其中碳纤维的含量大于 1wt%，小于 5wt%；所述正极活性材料涂覆层 1 和负极活性材料涂覆层 6 的双面涂布重量分别为 10mg-30mg/cm^2，4.8mg-14.5mg/cm^2。

对于卷绕式电芯，由于内圈曲率的影响，正极极耳 3 和负极极耳 8 不能太宽，根据电池容量及极耳设置密度的不同，正极极耳 3 和负极极耳 8 的宽度为 5mm-20mm，最佳宽度为 6-12mm；同时为防止使用宽的外焊极耳在弯曲卷绕时造成对电极的损伤甚至短路，将正极极耳 3 和负极极耳 8 分别与正极集流体 2 和负极集流体 7 重叠部分留有帘状正极极耳剪切口 5 和负极极耳剪切口 10，并逐一与相应的集流体焊接。正极极耳 3 和负极极耳 8 端部分别设有正极极耳铆接孔 4 和负极极耳铆接孔 9。当正极极耳 3 和正极集流体 2、负极极耳 8 和负极集流体 7 为一体式结构时，其过渡区域为宽于极耳的类弧形或三角形结构。

正极极耳 3 为铝带，通过超声焊焊接在正极集流体 2 上，其截面积 S_1 和相邻正极极耳 3 间隔 d_1 以及正极活性材料涂覆层 1 宽度 w_1 满足下式：$1x10^{-5} \leqslant S_1/(d_1xw_1) \leqslant 4x10^{-5}$，并且正极极耳 3 的厚度不大于正极厚度的 1.5 倍。因为如果 $S_1/(d_1xw_1) < 1x10^{-5}$ 则导致内阻较大，大电流放电时会温升过高，影响安全性和循环寿命。$S_1/(d_1xw_1) > 4x10^{-5}$ 时，则极耳过大影响电池的制备。如果正极极耳 3 的厚度大于正极厚度的 1.5，焊接和其他操作则难以进行。当然，电极的空白预留足够的宽度，也可从预留空白处裁出极耳，其宽度与间隔同样要求满足上式要求，不过，因为铝箔较薄，因此在上述范围内优选比值下限即采用较宽的极耳。

负极极耳 8 为镍质或铜质薄带，通过超声焊焊接在负极集流体 7 上，镍带或铜带的截面积 S_2 和相邻负极极耳 4 间隔 d_2 以及负极活性材料涂覆层 6 宽度 w_2 满足下式：$1x10^{-5} \leqslant S_2/(d_2xw_2) \leqslant 3x10^{-5}$，并且极耳的厚度不大于负极厚度的 1.5 倍。与正极相类似，因为如果 $S_2/(d_2xw_2) < 1x10^{-5}$ 则导致内阻较大，大电流放电时会温升过高，影响安全性和循环寿命。$S_2/(d_2xw_2) > 4x10^{-5}$ 时，则负极极耳 8 过大影响电池的制备。另外负极极耳 8 的厚度不大于负极厚度的 1.5 倍为好，如果大于 1.5 倍则过厚，焊接和其他操作难以进行。当然，电极的空白预留足够的宽度，也可从预留空白处裁出负极极耳 8，其宽度与间隔同样要求满足上式要求，不过，因为铜箔更薄，因此在上述范围内优选比值下限即采用较宽的极耳。

由于铝极易形成氧化膜，影响其导电性能，因此正极极耳 3 的个数或总面积大于负极极耳 8 的个数或总面积。

同时此处虽然采用了氧化钴锂做为正极活性材料，但本发明并不仅限于氧化钴锂，可用于本发明的正极活性材料的组成式为 Li_xMO_2、$Li_yM_2O_4$（式中 M 为一种以上的过渡金属，$0 \leqslant x \leqslant 1$，$0 \leqslant y \leqslant 2$）的复合氧化物，及具有隧道或层状结构的硫族元素化合物或氧化物。其具体实例可列举为 $LiNiO_2$、$LiCo_xNi_{1-x}O_2$、$LiNi_xCo_yNi_{1-x-y}O_2$、$LiMn_2O_4$、$Li_2Mn_2O_4$、$LiNi_{0.5}Mn_{1.5}O_4$，、$LiFePO_4$、MnO_2、FeO_2、V_2O_5、V_6O_{13}、TiO_2、TiS_2 等。当然也包括铝、Mg 等元素参杂的上述化合物的衍生物。另外，有机化合物也可用作本发明的正极活性材料比如聚吡咯、聚苯胺等导电高分子。而且不管是无机化合物还是有机化合物，上述各种化合物也可混合使用。

作为本发明的锂离子电池，正极优选包含长不大于 20 微米的纳米碳纤维，且其添加量相对于正极涂层总重不超过 10wt%。这是因为通过加入一定量，一定长度的纳米碳纤维，可充分保证电极内活性材料间及与集流体间的导电性。同时，又能使得电极的综合性能得以保证。纤维的长度超过 20 微米，则有可能使部分纤维穿过隔膜到达对电极，造成正负极板间的微短路。另外，如果添加量超过 10wt%，则必须同时加入大量的粘结剂才能保持电极材料层的附着力。而过量的粘结剂则是造成电极内阻升高的原因。因此，纳米碳纤维的添加量以不超过 10wt%为好。

本发明使用了气相生长纳米碳纤维(VGCF)、乙炔黑(AB)，此外也可使用碳黑、以及稳定的金属纳米纤维如 Ni 等。优选纤维状导电材料。因为纤维状导电材料宜于维持导电途径。

作为可用于本发明的负极材料虽然列举了球形石墨及鳞片形石墨、可用于本发明的负极活性材料不仅限于此、其它可列举如下，与 Li 可形成合金的金属元素如铝，Si，Pb，Sn，Zn 等，过渡金属氧化物如 NiO、CoO、Co_2O_3、CuO 等、还有 $LiFe_2O_3$ 、Nb_2O_3、WO_2、 MoO_2,、SiO 等的金属氧化物、易石墨化碳材料及硬碳等的碳质材料以及上述材料的混合物。考虑到电池的充放电寿命及安全性，优选碳质材料。

作为本发明的电解液，可包括下列有机溶剂的一种或者多种的混合物。碳酸乙酯(EC)、碳酸丙烯酯(PC)、二甲基碳酸酯(DMC)、乙基甲基碳酸酯(EMC)、二乙基碳酸酯(DEC)、γ-丁内酯(GBL)、环丁砜、二甲亚砜、乙月青(AN)、二甲基甲酰胺、二乙基甲酰胺、1，2-二甲氧基乙烷、1，2-二乙氧基乙烷、四氢呋喃(THF)、2-甲基四氢呋喃、二氧戊环、甲基乙酸酯等极性溶剂。为得到良好的电池放电性能及寿命，最好使在上述溶剂中含有碳酸乙烯酯(EC)。

溶解在电解液溶剂中的电解质盐可包括以下单一电解质盐及其混合物。例如 $LiPF_6$、 $LiClO_4$、 $LiBF_4$、 $LiAsF_6$、$LiCF_3CO_2$、$LiCF_3(CF)_3$、$LiCF_3(C_2F_5)_3$、$LiCF_3SO_3$、$LiN(SO_2CF_3)_2$、$LiN(SO_2CF_2CF_3)_2$、 $LiN(COCF_3)_2$、 $LiN(COCF_2CF_3)_2$ 及 $LiPF_3(CF_2CF_3)_3$。最好在电解质盐中部分含有 $LiPF_6$ 或 $LiBF_4$，而会在负极上形成良好的皮膜而得到良好的放电特性及寿命。

同时为抑制不可逆容量及负极材料表面 SEI 皮膜的过渡成长、优选添加添加剂碳酸亚乙烯酯(VC)及其衍生物，如 4，5-二甲基碳酸亚乙烯酯、4，5-二乙基碳酸亚乙烯酯、4，5-二丙基碳酸亚乙烯酯、4-乙基-5-甲基碳酸亚乙烯酯、4-乙基-5-丙基碳酸亚乙烯酯。另外环形硫酸酯也有利于形成良好的 SEI、如乙二醇硫酸酯、1，2-丙二醇硫酸酯、1，2-丁二醇硫酸酯、1，3-丁二醇硫酸酯、2，3-丁二醇、苯乙二醇硫酸酯等。

本发明的隔膜可采用编织物、非编织物、微孔合成树脂膜等。上述隔膜层材料中，特别优选微孔合成树脂膜，尤其是优选聚乙烯及聚丙烯微孔膜或它们的复合微孔膜等的聚稀烃微多孔膜。这些聚烯烃类微多孔膜被采用的理由

是其优于较好的厚度，膜强度，膜电阻特性。

如果采用胶体电解质，则其又可兼做隔离层。在这种情况下，可使用有孔的聚合物固体电解质，再使其含有电解液。

本发明的电池可制成圆柱型、长园形、方形、钮扣形和铝叠膜软包装等。容量可为数十 mAh 到数十 Ah 甚至 100Ah 以上。但当制作大容量锂离子电池时，以圆柱型、长园形、方形为好。

实施例 1

正极的制备:

称取正极活性材料的 93wt%的 $LiCoO_2$、聚偏二氟乙烯(PVdF)粘接剂的 N-甲基-2-吡咯烷酮(NMP)溶液并使 PVdF 的含量为 4.5wt%，作为导电材料的 2.5wt%(VGCF)，将三者混合形成正极混合物，向混合物中加入 NMP 用搅拌机制备出糊状物，然后将此糊状物均匀地连续涂到厚度为 20μm铝箔的两面，涂膜宽度为 220mm，在铝箔的一侧正反两面留有 20mm 的空白，再经干燥、辊压后，分切掉 20mm 空白的相反一侧（不留空白）而制得涂层宽 200mm、20mm 宽空白的正极板。涂敷重量为 22mg/cm^2。

负极的制备:

在重量为 60%的中间相碳微球 MCMB, 30%的鳞片状石墨，重量为 2%的 VGCF 及重量为 8%的 PVdF(以 NMP 的溶液方式加入)制成糊状物，然后将此糊状物均匀地连续涂到厚度为 10μm铜箔的两面、涂布方式与正极相同，再经干燥，辊压而制得负极板。涂布重量为 10mg/cm^2。

正极极耳的焊接:

如图 1 所示：首先选用厚为 100 微米，宽为 10mm 的铝带作为正极极耳 3，在将与正极集流体 2 焊接一侧开 30mm 口，使铝带一侧均分为两部分，另一侧设有正极极耳铆接孔 4，用于铆接固定在正极极柱上。然后用超声焊机把均分的两部分铝带四点焊接固定在正极集流体 2 上，以同样的方法，在间隔 200mm 处再焊下一个正极极耳 3，以此类推。由此得到的极耳参数 $S_1/(d_1xw_1)$ 为 $2.5x10^{-5}$。

负极极耳的焊接:

如图 2 所示：选用厚为 100 微米，宽为 10mm 的镍带作为负极极耳 8，在

将与负极集流体 7 焊接一侧开 30mm 口，使负极极耳 8 一侧均分为 2 部分，另一侧设有负极极耳铆接孔 9，用于铆接固定在负极极柱上。然后用超声焊机把均分的两部分镍带四点焊接固定在负极集流体 7 上，以同样的方法，在间隔 200mm 处再焊下一个负极极耳 8，以此类推。由此得到的极耳参数 $S_2/(d_2xw_2)$ 为 $2.5x10^{-5}$。

用厚度约为 25 微米的微孔聚乙烯膜作隔膜体。

使用的非水电解质为溶有 1 mol/l $LiPF_6$，体积比 1:1:1 的 EC+DEC+DMC 混合溶剂溶液，在此基础上添加相对电解液总量 1.0 wt%的碳酸亚乙烯酯。

35Ah 电池的装配:

把上述正极、隔膜、负极按顺序使活性材料涂层以隔膜相间正相面对，正负、极耳在相反一侧。叠放正极、隔膜、负极缠绕而成电芯、插入圆筒、铆好极耳、焊好电极盖、经 60℃ 真空干燥后再注液封口。如此装配成 35Ah 电池作为电池 A1,并按如下方法进行电化学测试和温度测量。

充放电及壳体温度测试:

首先进行容量测试: 充电为 CC-CV 模式;放电为 CC 模式。即用 0.2C 倍率恒电流充电到 4.2V,然后 4.2V 恒电压 2 小时;放电同样用 0.2C 倍率恒电流放电到 2.75V 止。用以上方法得到的放电容量作为初始容量。然后进行倍率放电实验，即与容量测试同样,均以 CC-CV 充电到 4.2V,再分别以相当于 5C,10C 恒电流放电到 2.5V,以此得到的容量作为各个倍率放电的容量。并且,在大倍率放电时用热敏电阻检测壳体外壁中央部位的温度变化。每次均待电压(OCV)恢复后再对残余容量进行低倍率(0.2C)放电到 2.75V 后再充电。把按以上方法进行充放电及温度检测结果整理在表 1 中。图 3 为电池的各倍率放电和电池表面温度变化图。

实施例 2

除了 d1,d2 改为 300mm 以外,其它一切都与实施例 1 相同而制作了本发明的电池 A2,其测量结果同样列举于表 1 中。

实施例 3

除了 d2 改为 500mm 以外,其它一切都与实施例 1 相同而制作了本发明的电池 A3,其测量结果同样列举于表 1 中。

实施例 4

除了 d1 改为 500mm 以外，其它一切都与实施例 1 相同而制作了本发明的电池 A4，其测量结果同样列举于表 1 中。

实施例 5

除了正、负极极耳改为 50 微米厚(S1，S2=0.5mm²)，其它一切都与实施例 1 相同而制作了本发明的电池 A5，其测量结果同样列举于表 1 中。

对比例 1

除了 d2 改为 600mm 以外，其它一切都与实施例 1 相同而制作了本发明的电池 B1，其测量结果同样列举于表 1 中。

对比例 2

除了 d1，d2 改为 600mm 以外，其它一切都与实施例 1 相同而制作了本发明的电池 B2，其测量结果同样列举于表 1 中。

表 1

电池	d1 (mm)	w1 (mm)	S1 (mm²)	S1/(d1xw1) (x10⁻³)	d2 (mm)	w2 (mm)	S2 (mm²)	S2/(d2xw2) (x10⁻³)	容量 (Ah)	电压平台 (V)	温度 (℃)
实施例 A1	200	200	1	2.5	200	200	1	2.5	34.2	3.34	68
实施例 A2	300	200	1	1.67	300	200	1	1.67	33.5	3.32	71
实施例 A3	200	200	1	2.5	500	200	1	1.0	32	3.25	73
实施例 A4	500	200	1	1.0	200	200	1	2.5	30	3.20	74.3
实施例 A5	200	200	0.5	1.25	200	200	0.5	1.25	28	3.10	76
对比例 B1	200	200	1	2.5	600	200	1	0.83	25	2.95	81
对比例 B2 (7C)	600	200	1	0.83	600	200	1	0.83	16	2.71	82

从表 1 的结果可清楚地知道:采用连续涂膜、侧面出极耳结构的实施例电池 A1—A4 放电容量大、电压平台非常高（>3.2 V）、高温升小。但当极耳间距过大时，内阻增大、大倍率放电容量小、电压平台低、温升高，表面温度甚至高于 80℃，同时、虽然在表中没有显示，但很清楚 A1 容量降低到初始容量的 80%是在 50 循环后，而 B1 只循环了 3 次、B2 为 10 次(7C)、B3 为 15 次(7C)。所以正极和负极电极的含活性材料的涂层为连续涂层，并在电极的沿卷绕方向的一侧留有集流体空白，在空白处留有电流导出极耳，且正极的极耳为铝带,铝带极耳的截面积 S_1 和极耳间隔 d_1 以及正极涂层宽度 w_1 满足下式: $1x10^{-5} \leqslant S_1/(d_1xw_1) \leqslant 4x10^{-5}$,并且极耳的厚度不大于正极厚度的 1.5 倍；负极的极耳为镍质或铜质薄带,通过超声焊焊接在负极集流体上，镍或铜带极耳的截面积 S_2 和极耳间隔 d_2 以及负极涂层宽度 w_2 满足下式: $1x10^{-5} \leqslant S_2/(d_2xw_2) \leqslant 3x10^{-5}$,并且极耳的厚度不大于负极厚度的 1.5 倍，对电池的高倍率放电容量、抑制温升和提高循环寿命是有效的。

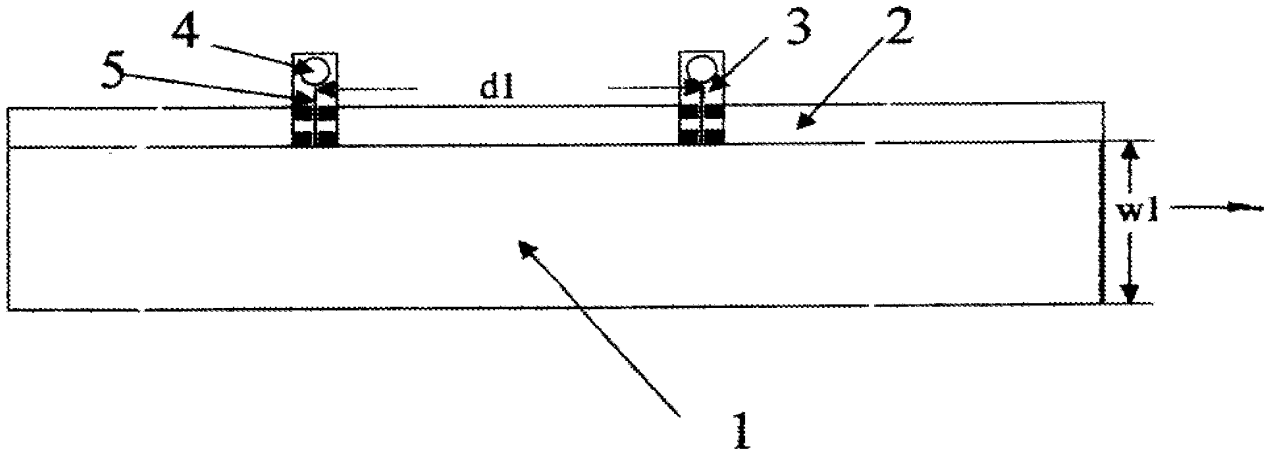


图 1

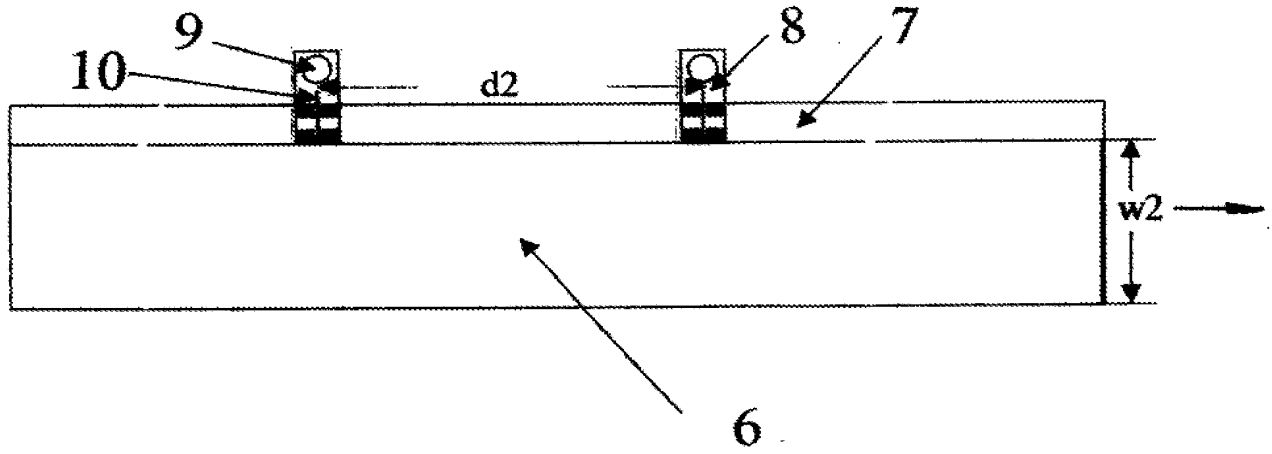


图 2

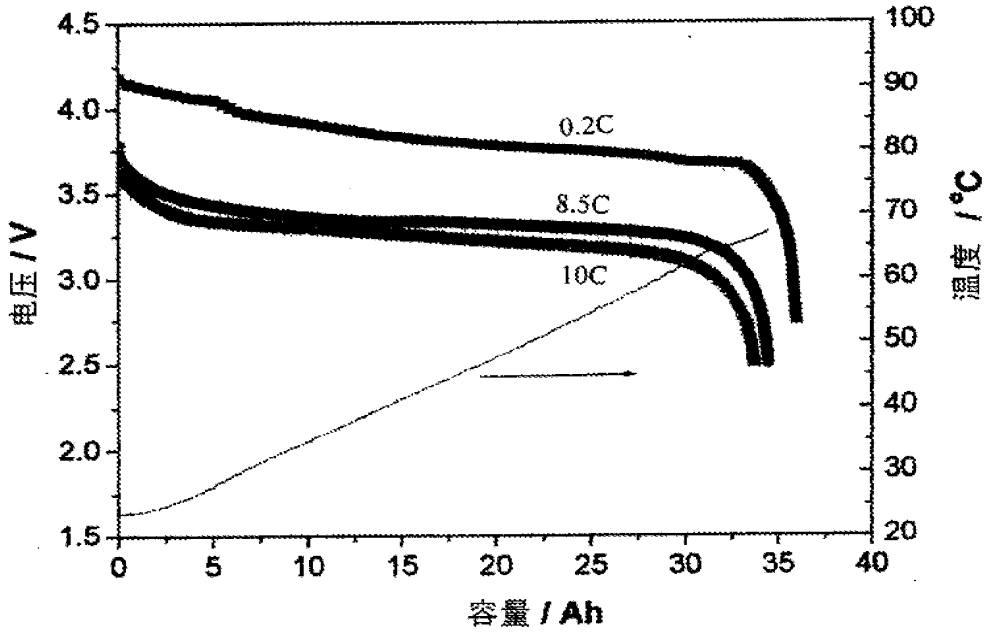

4.5
4.0
3.5
3.0
2.5
2.0
1.5
电压 / V
0
5
10
15
20
25
30
35
40
容量 / Ah
100
90
80
70
60
50
40
30
20
温度 / °C
0.2C
8.5C
10C

图 3

Secondary cell electricity core

Abstract

The utility model provides a secondary cell electricity core, it includes positive pole pole piece, positive pole utmost point ear, negative pole pole piece, negative pole utmost point ear and barrier film. The positive pole pole piece includes the positive pole mass flow body and positive pole diaphragm. The negative pole pole piece includes the negative pole mass flow body and negative pole diaphragm. The barrier film sets up between positive pole pole piece and negative pole pole piece. The positive pole pole piece is formed with: the recess is accommodated to positive pole utmost point ear, inclines to the positive pole diaphragm for positive pole mass flow body week in the bottom, and positive pole utmost point ear is accommodated in the recess is accommodated to positive pole utmost point ear and the electric positive pole mass flow body of accommodating the groove in positive pole utmost point ear of connecting. The negative pole pole piece is formed with: the recess is accommodated to negative pole utmost point ear, inclines to the negative pole diaphragm for negative pole mass flow body week in the bottom, and negative pole utmost point ear is accommodated in the recess is accommodated to negative pole utmost point ear and the electric negative pole mass flow body of accommodating the groove in negative pole utmost point ear of connecting. The negative pole pole piece still is formed with: negative pole pole piece counterpoint recess, bottom are for negative pole mass flow body week side is the negative pole diaphragm, and what lie in the negative pole pole piece accommodates the region that the recess was counterpointed with positive pole utmost point ear.

Classifications

- *Y02E60/10* Energy storage using batteries

View 1 more classifications

CN204809314U

China

Download PDF Find Prior Art Similar

Other languages: Chinese

Inventor: [redacted], 何平, 赵义, 方亚强, 谢文强

Current Assignee : Contemporary Amperex Technology Co Ltd

Worldwide applications

2015 CN

Application CN201520404064.8U events

2015-06-12 Application filed by Ningde Contemporary Amperex Technology Co Ltd

2015-06-12 Priority to CN201520404064.8U

2015-11-25 Application granted

2015-11-25 Publication of CN204809314U

Info: Cited by (5), Legal events, Similar documents, Priority and Related Applications

External links: Espacenet, Global Dossier, Discuss

Claims (10)

Hide Dependent

1. a secondary cell battery core, comprising:

Anode pole piece (1), comprising:

Anode collector (11); And

Anode diaphragm (12), is arranged on the surface of anode collector (11);

Anode lug (2);

Cathode sheet (3), comprising:

Cathode current collector (31); And

Negative electrode diaphragm (32), is arranged on the surface of cathode current collector (31);

Cathode tab (4); And

Barrier film (5), is arranged between anode pole piece (1) and cathode sheet (3);

Wherein,

Anode pole piece (1) is formed:

Anode lug accommodating grooves (G11), bottom is anode collector (11) and all sides are anode diaphragm (12), and it is interior and be electrically connected on the anode collector (11) at anode lug accommodating grooves (G11) place that anode lug (2) is contained in anode lug accommodating grooves (G11);

Cathode sheet (3) is formed:

Cathode tab accommodating grooves (G31), bottom is cathode current collector (31) and all sides are negative electrode diaphragm (32), and it is interior and be electrically connected on the cathode current collector (31) at cathode tab accommodating grooves (G31) place that cathode tab (4) is contained in cathode tab accommodating grooves (G31);

It is characterized in that,

Cathode sheet (3) is also formed:

Cathode sheet contraposition groove (G32), bottom is cathode current collector (31) and all sides are negative electrode diaphragm (32), that be positioned at cathode sheet (3) with region that is anode lug accommodating grooves (G11) contraposition.

2. secondary cell battery core according to claim 1, is characterized in that, cathode sheet contraposition groove (G32) is all greater than anode lug accommodating grooves (G11) in length and width.

3. secondary cell battery core according to claim 1, is characterized in that, described secondary cell battery core also comprises:

Cathode sheet contraposition groove is with double-sided insulation adhesive tape (T1), cover whole cathode sheet contraposition groove (G32), and distinguish the negative electrode diaphragm (32) around bonding barrier film (5) and cathode sheet contraposition groove (G32) on two sides.

4. secondary cell battery core according to claim 1, is characterized in that, described secondary cell battery core also comprises:

Cathode tab accommodating grooves is with double-sided insulation adhesive tape (T2), cover whole cathode tab accommodating grooves (G31), and distinguish the negative electrode diaphragm (32) around bonding barrier film (5) and cathode tab accommodating grooves (G31) on two sides.

5. secondary cell battery core according to claim 1, is characterized in that, cathode sheet (3) is also formed:

Negative electrode pairing recess (R31), bottom is cathode current collector (31) and all sides are negative electrode diaphragm (32), be positioned at cathode tab accommodating grooves (G31) just to dorsal part.

6. secondary cell battery core according to claim 5, is characterized in that, described secondary cell battery core also comprises:

Negative electrode pairing recess is with double-sided insulation adhesive tape (T3), cover whole negative electrode pairing recess (R31), and on two sides, distinguish the negative electrode diaphragm (32) around bonding barrier film (5) and negative electrode pairing recess (R31).

7. secondary cell battery core according to claim 1, is characterized in that,

Anode pole piece (1) is also formed:

Anode pairing recess (R11), bottom is anode collector (11) and all sides are anode diaphragm (12), be positioned at anode lug accommodating grooves (G11) just to dorsal part;

Cathode sheet (3) is also formed:

Cathode sheet contraposition recess (R32), bottom is cathode current collector (31) and all sides are negative electrode diaphragm (32), what be positioned at cathode sheet (3) matches the region of recess (R11) contraposition with anode, and in length and width, be all greater than anode pairing recess (R11).

8. secondary cell battery core according to claim 7, is characterized in that, described secondary cell battery core also comprises:

Cathode sheet contraposition recess is with double-sided insulation adhesive tape (T4), cover whole cathode sheet contraposition recess (R32), and distinguish the negative electrode diaphragm (32) around bonding barrier film (5) and cathode sheet contraposition recess (R32) on two sides.

9. secondary cell battery core according to claim 1, is characterized in that,

Anode pole piece (1) is an integrated piece, secondary cell battery core is takeup type battery core, under anode pole piece (1) deployed condition, the head of anode pole piece (1) is D1 to the distance definition of afterbody, the center line of anode lug accommodating grooves (G11) to anode pole piece (1) head between distance definition be in the scope of the 1/10D1 ~ 7/10D1 of calculating d1, d1 are in from anode pole piece (1) head.

10. secondary cell battery core according to claim 1, is characterized in that,

Cathode sheet (3) is an integrated piece, secondary cell battery core is takeup type battery core, under cathode sheet (3) deployed condition, the head of cathode sheet (3) is D2 to the distance definition of afterbody, the center line of cathode tab accommodating grooves (G31) to cathode sheet (3) head between distance definition be in the scope of the 1/10D2 ~ 7/10D2 of calculating d2, d2 are in from cathode sheet (3) head.

Description

Secondary cell battery core

Technical field

The utility model relates to electrochemical energy storage device, particularly relates to a kind of secondary cell battery core.

Background technology

Lithium ion battery (one for secondary cell) is all widely used in each electronic product.Along with electronic product trend is miniaturized, intelligent, the energy density of lithium ion battery is had higher requirement.Prior art, mainly by offering groove on pole piece, by tab welding in groove, thus reaches the object promoting energy density.

In July, 2014, the Chinese patent literature CN203733894U of Granted publication on the 23rd discloses a kind of lithium ion battery, wherein negative electrode diaphragm is provided with the first groove, anode diaphragm is provided with the second groove, cathode tab is welded in the first groove, anode tab welding is in the second groove, two surfaces up and down of cathode tab are coated with the first insulation glue-line, and the second insulation glue-line is posted on the surface of the negative electrode diaphragm that the second groove is corresponding.But, in charge and discharge cycles process, because the second insulation glue-line on the surface of negative electrode diaphragm cannot stop by the active lithium in the negative electrode diaphragm of sticky lid free out, therefore will be dissociated to the anode lug place of contraposition by concentration difference diffusion by the active lithium that the second insulation glue-line glues in the negative electrode diaphragm of lid, but the anode lug of contraposition is the second groove and without the above-mentioned active lithium that dissociates of enough spatial tessellations, therefore active lithium will be enriched in anode lug place, make anode lug place occur serious analysing lithium problem.Simultaneously, in this patent documentation, first insulation glue-line and the second insulation glue-line are green glue, green glue is single-sided insulation glue-line, due to the back side unusual light of single-sided insulation glue-line, can not adhere to each other when the back side of single-sided insulation glue-line is contacted with barrier film, the regional compare that lithium ion battery is pasting single-sided insulation glue-line is caused to loosen, in the battery core trimming and charge and discharge process of lithium

ion battery, this region is swelled and becomes maximum distortion district, and therefore the lithium ion battery of this structure also also exists serious problem on deformation.

Utility model content

In view of problems of the prior art, the purpose of this utility model is to provide a kind of secondary cell battery core, after secondary cell battery core forms secondary cell, while the energy density improving secondary cell, secondary cell cathode active material in charge and discharge process can be alleviated and be enriched in anode lug place, alleviate the problem that cathode active material appears separating out in anode lug place, improve the security performance of secondary cell.

To achieve these goals, the utility model provides a kind of secondary cell battery core, and it comprises anode pole piece, anode lug, cathode sheet, cathode tab and barrier film.Anode pole piece comprises: anode collector; And anode diaphragm, be arranged on the surface of anode collector.Cathode sheet comprises: cathode current collector; And negative electrode diaphragm, be arranged on the surface of cathode current collector.Barrier film is arranged between anode pole piece and cathode sheet.Anode pole piece is formed: anode lug accommodating grooves, and bottom is anode collector and all sides are anode diaphragm, and anode lug to be contained in anode lug accommodating grooves and to be electrically connected on the anode collector at anode lug accommodating grooves place.Cathode sheet is formed: cathode tab accommodating grooves, and bottom is cathode current collector and all sides are negative electrode diaphragm, and cathode tab to be contained in cathode tab accommodating grooves and to be electrically connected on the cathode current collector at cathode tab accommodating grooves place.Cathode sheet is also formed: cathode sheet contraposition groove, and bottom is for cathode current collector and all sides are negative electrode diaphragm, that be positioned at cathode sheet with region that the is contraposition of anode lug accommodating grooves.

The beneficial effects of the utility model are as follows:

According in secondary cell battery core described in the utility model, cathode sheet contraposition groove be positioned at cathode sheet with the region of anode lug accommodating grooves contraposition, cathode sheet contraposition groove exists without cathode active material, so after secondary cell battery core forms secondary cell, anode lug is accommodated utilizing anode lug accommodating grooves, while cathode tab accommodating grooves collecting cathode tab improves the energy density of secondary cell, because cathode sheet contraposition groove and the contraposition of anode lug, thus decrease the free cathode active material of anode lug, thus decrease cathode active material and dissociate and diffuse to the anode lug place of contraposition, and then cathode active material in charging/discharging of secondary cell process can be alleviated be enriched in anode lug place, finally alleviate the problem that cathode active material appears separating out in anode lug place, improve the security performance of secondary cell.

Accompanying drawing explanation

Fig. 1 be according to the secondary cell battery core coiling and molding of an embodiment of the present utility model after structural representation;

Fig. 2 is two views after the cathode sheet of the secondary cell battery core of Fig. 1 launches, wherein (a) cutaway view of making for the paper direction being parallel to Fig. 1, and (b) is upward view;

Fig. 3 is two views after the anode pole piece of the secondary cell battery core of Fig. 1 launches, wherein (a) cutaway view of making for the paper direction being parallel to Fig. 1, and (b) is vertical view;

Fig. 4 is the enlarged diagram in two dashed rectangle regions of Fig. 1, for the sake of clarity, illustrate with cross-sectional view, wherein (a) is the enlarged diagram of the right side boxed area indicated by arrow A, and (b) is the enlarged diagram of the left side boxed area indicated by arrow B;

Fig. 5 shows the structural representation of the alternate embodiment of Fig. 4;

Fig. 6 be according to the secondary cell battery core coiling and molding of another embodiment of the utility model after schematic diagram;

Fig. 7 is the enlarged diagram in two dashed rectangle regions of Fig. 6, for the sake of clarity, illustrate with cross-sectional view, wherein (a) is the enlarged diagram of the right side boxed area indicated by arrow A, and (b) is the enlarged diagram of the left side boxed area indicated by arrow B;

Fig. 8 shows the structural representation of the alternate embodiment of Fig. 7;

Fig. 9 shows the structural representation of prior art;

Figure 10 is the enlarged diagram in two dashed rectangle regions of Fig. 9, for the sake of clarity, illustrate with cross-sectional view, wherein (a) is the enlarged diagram of the right side boxed area indicated by arrow A, and (b) is the enlarged diagram of the left side boxed area indicated by arrow B.

Wherein, description of reference numerals is as follows:

1 anode pole piece

11 anode collector

12 anode diaphragms

G11 anode lug accommodating grooves

R11 anode pairing recess

2 anode lugs

3 cathode sheets

31 cathode current collectors

32 negative electrode diaphragms

G31 cathode tab accommodating grooves

G32 cathode sheet contraposition groove

R31 negative electrode pairing recess

R12 cathode sheet contraposition recess

G22 cathode sheet contraposition recess

4 cathode tab

5 barrier films

T1 cathode sheet contraposition groove double-sided insulation adhesive tape

T2 cathode tab accommodating grooves double-sided insulation adhesive tape

T3 negative electrode pairing recess double-sided insulation adhesive tape

T4 cathode sheet contraposition recess double-sided insulation adhesive tape

T1' cathode sheet contraposition accommodating area single-sided insulation adhesive tape

T2' cathode tab accommodating grooves single-sided insulation adhesive tape

T3' negative electrode pairing recess single-sided insulation adhesive tape

T4' cathode sheet contraposition notchchave single-sided insulation adhesive tape

Embodiment

Describe the test result according to secondary cell battery core of the present utility model and embodiment and comparative example with reference to the accompanying drawings in detail.

First illustrate according to secondary cell battery core of the present utility model.

Referring to figs. 1 through Fig. 8, secondary cell battery core of the present utility model comprises anode pole piece 1, anode lug 2, cathode sheet 3, cathode tab 4 and barrier film 5.

Anode pole piece 1 comprises: anode collector 11; And anode diaphragm 12, be arranged on the surface of anode collector 11.Cathode sheet 3 comprises: cathode current collector 31; And negative electrode diaphragm 32, be arranged on the surface of cathode current collector 31.Barrier film 5 is arranged between anode pole piece 1 and cathode sheet 3.

Anode pole piece 1 is formed: anode lug accommodating grooves G11, and bottom is anode collector 11 and all sides are anode diaphragm 12, and anode lug 2 to be contained in anode lug accommodating grooves G11 and to be electrically connected on the anode collector 11 at anode lug accommodating grooves G11 place.

Cathode sheet 3 is formed: cathode tab accommodating grooves G31, and bottom is cathode current collector 31 and all sides are negative electrode diaphragm 32, and cathode tab 4 to be contained in cathode tab accommodating grooves G31 and to be electrically connected on the cathode current collector 31 at cathode tab accommodating grooves G31 place.

Cathode sheet 3 is also formed: cathode sheet contraposition groove G32, and bottom is for cathode current collector 31 and all sides are negative electrode diaphragm 32, that be positioned at cathode sheet 3 with region that is anode lug accommodating grooves G11 contraposition.

According in secondary cell battery core described in the utility model, cathode sheet contraposition groove G32 be positioned at cathode sheet 3 with the region of anode lug accommodating grooves G11 contraposition, cathode sheet contraposition groove G32 exists without cathode active material, so after secondary cell battery core forms secondary cell, anode lug 2 is accommodated utilizing anode lug accommodating grooves G11, while cathode tab accommodating grooves G31 collecting cathode tab 4 improves the energy density of secondary cell, because cathode sheet contraposition groove G32 and anode lug 2 contraposition, thus decrease the free cathode active material of anode lug 2, decrease cathode active material to dissociate and diffuse to anode lug 2 place of contraposition, and then cathode active material in charging/discharging of secondary cell process can be alleviated be enriched in anode lug 2 place, finally alleviate the problem that cathode active material appears separating out in anode lug 2 place, improve the security performance of secondary cell.

According in secondary cell battery core described in the utility model, in an embodiment, cathode sheet contraposition groove G32 all can be greater than anode lug accommodating grooves G11 in length and width in one embodiment, cathode sheet contraposition groove G32 is all greater than anode lug accommodating grooves G11 0.5 ~ 3mm in length and width, in length and width, be preferably all greater than anode lug accommodating grooves G11 1 ~ 2mm.In this case, cathode active material in charging/discharging of secondary cell process can be avoided completely to be enriched in anode lug 2 place, finally overcome the problem that cathode active material appears separating out in anode lug 2 place completely, improve the security performance of secondary cell further.

According in secondary cell battery core described in the utility model, in one embodiment, with reference to Fig. 1, Fig. 2, Fig. 4, Fig. 5, Fig. 6, Fig. 7 and Fig. 8, described secondary cell battery core also can comprise: cathode sheet contraposition groove double-sided insulation adhesive tape T1, cover whole cathode sheet contraposition groove G32, and distinguish the negative electrode diaphragm 32 around bonding barrier film 5 and cathode sheet contraposition groove G32 on two sides.

According in secondary cell battery core described in the utility model, cover whole cathode sheet contraposition groove G32 due to cathode sheet contraposition groove double-sided insulation adhesive tape T1 and on two sides, distinguish the negative electrode diaphragm 32 around bonding barrier film 5 and cathode sheet contraposition groove G32, so cathode sheet contraposition groove double-sided insulation adhesive tape T1 bonding region is than tightr during employing single-sided insulation adhesive tape, thus the globality of secondary cell battery core is strengthened, thus avoid secondary cell battery core this region protuberance after trimming and charging/discharging of secondary cell expand to become maximum distortion district.

According in secondary cell battery core described in the utility model, in one embodiment, with reference to Fig. 1, Fig. 2, Fig. 4, Fig. 5, Fig. 6, Fig. 7 and Fig. 8, described secondary cell battery core also can comprise: cathode tab accommodating grooves double-sided insulation adhesive tape T2, cover whole cathode tab accommodating grooves G31, and distinguish the negative electrode diaphragm 32 around bonding barrier film 5 and cathode tab accommodating grooves G31 on two sides.

According in secondary cell battery core described in the utility model, cover whole cathode tab accommodating grooves G31 due to cathode tab accommodating grooves double-sided insulation adhesive tape T2 and on two sides, distinguish the negative electrode diaphragm 32 around bonding barrier film 5 and cathode tab accommodating grooves G31, so cathode tab accommodating grooves double-sided insulation adhesive tape T2 bonding region is than tightr during employing single-sided insulation adhesive tape, thus the globality of secondary cell battery core is strengthened, thus avoid secondary cell battery core this region protuberance after trimming and charging/discharging of secondary cell expand to become maximum distortion district.

According in secondary cell battery core described in the utility model, anode lug 2 can adopt ultrasonic bonding, laser welding or thermal compression welding mode to be electrically connected on the anode collector 11 at anode lug accommodating grooves G11 place.

According in secondary cell battery core described in the utility model, cathode tab 4 can adopt ultrasonic bonding, laser welding or thermal compression welding mode to be electrically connected on the cathode current collector 31 at cathode tab accommodating grooves G31 place.

According in secondary cell battery core described in the utility model, the corresponding part of anode diaphragm 12 to be removed by the cleaning of laser cleaning, mechanical cleaning or foamed glue and is formed to expose anode collector 11 by anode lug accommodating grooves G11; Or anode lug accommodating grooves G11 by thermosensitive type foaming gummed paper preset before coating anode diaphragm slurry in anode collector 11, coating afterwards dry anode diaphragm slurry to be to form anode diaphragm 12 and thermosensitive type foaming gummed paper peels off formation from anode collector 11 when dry anode diaphragm slurry; Or anode lug accommodating grooves G11 by precoating foamed slurry before being coated with anode diaphragm slurry in anode collector 11 and dry, coating afterwards dry anode diaphragm slurry with forms anode diaphragm 12 and at dry anode diaphragm slurry time drying foamed slurry peel off formation from anode collector 11.

According in secondary cell battery core described in the utility model, cathode tab accommodating grooves G31 by the cleaning of laser cleaning, mechanical cleaning or foamed glue by negative electrode diaphragm 32 corresponding part remove and formed to expose cathode current collector 31; Or cathode tab accommodating grooves G31 by preset thermosensitive type foaming gummed paper before coated cathode diaphragm slurry on cathode current collector 31, coating afterwards dried cathode diaphragm slurry to be to form negative electrode diaphragm 32 and thermosensitive type foaming gummed paper peels off formation from cathode current collector 31 when dried cathode diaphragm slurry; Or cathode tab accommodating grooves G31 by precoating foamed slurry before coated cathode diaphragm slurry on cathode current collector 31 and dry, coating afterwards dried cathode diaphragm slurry to form negative electrode diaphragm 32 and the foamed slurry of drying peels off formation from cathode current collector 11 when dried cathode diaphragm slurry.

According in secondary cell battery core described in the utility model, the corresponding part of negative electrode diaphragm 32 is removed by the cleaning of laser cleaning, mechanical cleaning or foamed glue and is formed to expose cathode current collector 31 by cathode sheet contraposition groove G32; Or cathode sheet contraposition groove G32 by preset thermosensitive type foaming gummed paper before coated cathode diaphragm slurry on cathode current collector 31, coating afterwards dried cathode diaphragm slurry to be to form negative electrode diaphragm 32 and thermosensitive type foaming gummed paper peels off formation from cathode current collector 31 when dried cathode diaphragm slurry; Or cathode sheet contraposition groove G32 by precoating foamed slurry before coated cathode diaphragm slurry on cathode current collector 31 and dry, coating afterwards dried cathode diaphragm slurry to form negative electrode diaphragm 32 and the foamed slurry of drying peels off formation from cathode current collector 11 when dried cathode diaphragm slurry.

According in secondary cell battery core described in the utility model, cathode sheet contraposition groove double-sided insulation adhesive tape T1 can be two-sided initial time all toughness or an one side initial time toughness and another one side are through follow-up hot pressing or sticking two-sided tape after cold pressing.

According in secondary cell battery core described in the utility model, cathode tab accommodating grooves double-sided insulation adhesive tape T2 can be two-sided initial time all toughness or an one side initial time toughness and another one side are through follow-up hot pressing or sticking two-sided tape after cold pressing.

According in secondary cell battery core described in the utility model, in one embodiment, with reference to Fig. 1, Fig. 4, Fig. 6 and Fig. 7, cathode sheet 3 also can be formed: negative electrode pairing recess R31, bottom is cathode current collector 31 and all sides are negative electrode diaphragm 32, be positioned at cathode tab accommodating grooves G31 just to dorsal part.The setting of negative electrode pairing recess R31, is convenient to cathode tab 4 ultra-sonic welded in cathode tab accommodating grooves G311.

According in secondary cell battery core described in the utility model, in one embodiment, with reference to Fig. 1, Fig. 4, Fig. 6 and Fig. 7, described secondary cell battery core also can comprise: negative electrode pairing recess double-sided insulation adhesive tape T3, cover whole negative electrode pairing recess R31, and on two sides, distinguish the negative electrode diaphragm 32 around bonding barrier film 5 and negative electrode pairing recess R31.

According in secondary cell battery core described in the utility model, the corresponding part of negative electrode diaphragm 32 to be removed by the cleaning of laser cleaning, mechanical cleaning or foamed glue and is formed to expose cathode current collector 31 by negative electrode pairing recess R31; Or negative electrode pairing recess R31 by thermosensitive type foaming gummed paper preset before coated cathode diaphragm slurry on cathode current collector 31, coating afterwards dried cathode diaphragm slurry to be to form negative electrode diaphragm 32 and thermosensitive type foaming gummed paper peels off formation from cathode current collector 31 when dried cathode diaphragm slurry; Or negative electrode pairing recess R31 by precoating foamed slurry before coated cathode diaphragm slurry on cathode current collector 31 and dry, coating afterwards dried cathode diaphragm slurry to form negative electrode diaphragm 32 and the foamed slurry of drying peels off formation from cathode current collector 11 when dried cathode diaphragm slurry.

According in secondary cell battery core described in the utility model, negative electrode pairing recess double-sided insulation adhesive tape T3 can be two-sided initial time all toughness or an one side initial time toughness and another one side are through follow-up hot pressing or sticking two-sided tape after cold pressing.

According in secondary cell battery core described in the utility model, in one embodiment, with reference to Fig. 1, Fig. 3 and Fig. 4, anode pole piece 1 also can be formed: anode pairing recess R11, bottom is anode collector 11 and all sides are anode diaphragm 12, be positioned at anode lug accommodating grooves G11 just to dorsal part.The setting of anode pairing recess R11, is convenient to anode lug 2 ultra-sonic welded in anode lug accommodating grooves G11.

According in secondary cell battery core described in the utility model, in one embodiment, with reference to Fig. 1, Fig. 2, Fig. 3 and Fig. 4, cathode sheet 3 also can be formed: cathode sheet contraposition recess R32, bottom is cathode current collector 31 and all sides are negative electrode diaphragm 32, what be positioned at cathode sheet 3 matches the region of recess R11 contraposition with anode, and in length and width, be all greater than anode pairing recess R11.Preferably, cathode sheet contraposition recess R32 be all greater than in length and width anode pairing recess R11 1 ~ 2mm (namely length and width distinguish large 1 ~ 2mm, as the degree of depth whether identical can the relation between the thickness of negative electrode diaphragm 32 and the thickness of anode diaphragm 12 determine).Certainly, the numerical value that cathode sheet contraposition recess R32 is all greater than anode pairing recess R11 in length and width can adjust depending on actual conditions.

According in secondary cell battery core described in the utility model, in one embodiment, with reference to Fig. 1, Fig. 2, Fig. 3 and Fig. 4, described secondary cell battery core also can comprise: cathode sheet contraposition recess double-sided insulation adhesive tape T4, cover whole cathode sheet contraposition recess R32, and distinguish the negative electrode diaphragm 32 around bonding barrier film 5 and cathode sheet contraposition recess R32 on two sides.Cover whole cathode sheet contraposition recess R32 due to cathode sheet contraposition recess double-sided insulation adhesive tape T4 and on two sides, distinguish the negative electrode diaphragm 32 around bonding barrier film 5 and cathode sheet contraposition recess R32, so cathode sheet contraposition recess double-sided insulation adhesive tape T4 bonding region is than tightr during employing single-sided insulation adhesive tape, thus the globality of secondary cell battery core is strengthened, thus secondary cell battery core this region protuberance after trimming and charging/discharging of secondary cell expand is avoided to become maximum distortion district.

According in secondary cell battery core described in the utility model, the corresponding part of anode diaphragm 12 to be removed by the cleaning of laser cleaning, mechanical cleaning or foamed glue and is formed to expose anode collector 11 by anode pairing recess R11; Or anode pairing recess R11 by thermosensitive type foaming gummed paper preset before coating anode diaphragm slurry in anode collector 11, coating afterwards dry anode diaphragm slurry to be to form anode

diaphragm 12 and thermosensitive type foaming gummed paper peels off formation from anode collector 11 when dry anode diaphragm slurry; Or anode pairing recess R11 by precoating foamed slurry before being coated with anode diaphragm slurry in anode collector 11 and dry, coating afterwards dry anode diaphragm slurry with forms anode diaphragm 12 and at dry anode diaphragm slurry time drying foamed slurry peel off formation from anode collector 11.

According in secondary cell battery core described in the utility model, cathode sheet contraposition recess R32 by the cleaning of laser cleaning, mechanical cleaning or foamed glue by negative electrode diaphragm 32 corresponding part remove and formed to expose cathode current collector 31; Or cathode sheet contraposition recess R32 by preset thermosensitive type foaming gummed paper before coated cathode diaphragm slurry on cathode current collector 31, coating afterwards dried cathode diaphragm slurry to be to form negative electrode diaphragm 32 and thermosensitive type foaming gummed paper peels off formation from cathode current collector 31 when dried cathode diaphragm slurry; Or cathode sheet contraposition recess R32 by precoating foamed slurry before coated cathode diaphragm slurry on cathode current collector 31 and dry, coating afterwards dried cathode diaphragm slurry to form negative electrode diaphragm 32 and the foamed slurry of drying peels off formation from cathode current collector 11 when dried cathode diaphragm slurry.

According in secondary cell battery core described in the utility model, cathode sheet contraposition recess double-sided insulation adhesive tape T4 can be two-sided initial time all toughness or an one side initial time toughness and another one side are through follow-up hot pressing or sticking two-sided tape after colding pressing.

According in secondary cell battery core described in the utility model, in one embodiment, the width of anode lug accommodating grooves G11 is 1 ~ 2 times of the width of anode lug 2, the length of anode lug accommodating grooves G11 is 1 ~ 3 times that is contained in the length of the part in anode lug accommodating grooves G11 of anode lug 2, and the degree of depth of anode lug accommodating grooves G11 equals the thickness of anode diaphragm 12.

According in secondary cell battery core described in the utility model, in one embodiment, the width of cathode tab accommodating grooves G31 is 1 ~ 2 times of the width of cathode tab 4, the length of cathode tab accommodating grooves G31 is 1 ~ 3 times that is contained in the length of the part in cathode tab accommodating grooves G31 of cathode tab 4, and the degree of depth of cathode tab accommodating grooves G31 equals the thickness of negative electrode diaphragm 32.

According in secondary cell battery core described in the utility model, in one embodiment, with reference to Fig. 3, anode pole piece 1 is an integrated piece, secondary cell battery core is takeup type battery core, under anode pole piece 1 deployed condition, the head of anode pole piece 1 is 01 to the distance definition of afterbody, the center line of anode lug accommodating grooves G11 to anode pole piece 1 head between distance definition be d1, d1 is in the scope of the 1/10D1 ~ 7/10D1 of calculating from the head of anode pole piece 1, thus be conducive to the DC impedance DCR (Directcurrentresistance) reducing secondary cell battery core Preferably, d1 is in the scope of the 3/10D1 ~ 7/10D1 of calculating from the head of anode pole piece 1.Further, d1 is the closer to the centre position (i.e. 1/2D1) of anode pole piece 1, and DCR is less.

According in secondary cell battery core described in the utility model, in one embodiment, with reference to Fig. 3, the head vicinity that anode collector 11 is positioned at anode pole piece 1 only arranges anode diaphragm 12 in a surface.

According in secondary cell battery core described in the utility model, in one embodiment, with reference to Fig. 2, cathode sheet 3 is an integrated piece, secondary cell battery core is takeup type battery core, under cathode sheet 3 deployed condition, the head of cathode sheet 3 is 02 to the distance definition of afterbody, the center line of cathode tab accommodating grooves G31 to cathode sheet 3 head between distance definition be d2, d2 is in the scope of the 1/10D2 ~ 7/10D2 of calculating from the head of cathode sheet 3, thus is conducive to the DC impedance DCR reducing secondary cell battery core Preferably, d2 is in the scope of the 3/10D2 ~ 7/10D2 of calculating from the head of cathode sheet 3 Further, the closer to the centre position (i.e. 1/2D2) of cathode sheet 3, DCR is less.

According in secondary cell battery core described in the utility model, two-sided tape comprises base material and is coated in the superficial glue-line of two of base material.Two-sided initial time all sticking two-sided tape glue-line can be butadiene-styrene rubber layer, layer of polyurethane, polyacrylic acid ester layer or polyvinylidene fluoride layer.

According in secondary cell battery core described in the utility model, when an one side is initial, toughness and another one side are that when an one side is initial, sticking glue-line can be butadiene-styrene rubber layer, layer of polyurethane, polyacrylic acid ester layer or polyvinylidene fluoride layer through follow-up hot pressing or after colding pressing in sticking two-sided tape; And another one side be through follow-up hot pressing or after colding pressing sticking glue-line can under normal temperature without the pressure sensitive adhesive without tack under the temperature sensitive glue of tack or normal temperature.Temperature sensitive glue without tack under described normal temperature refers at normal temperatures, when there is of short duration contact between object and temperature sensitive glue, can not produce the temperature sensitive glue of cementation to object.Refer at normal temperatures without the pressure sensitive adhesive of tack under described normal temperature, when there is of short duration contact under finger pressure between object and pressure sensitive adhesive, the pressure sensitive adhesive of cementation can not be produced to object.Without the temperature sensitive glue of tack one or more in polyolefin, polyvinyl butyral resin, polyamide-based and polyesters optional under described normal temperature.One or more in Ethylene/Butylene-polystyrene linear three block copolymer (SEBS), styrene-butadiene block copolymer (SEPS) and epoxidized styrene-isoprene-phenylethene block copolymer (ESBS) can be selected from without the pressure sensitive adhesive of tack under described normal temperature.

According in secondary cell battery core of the present utility model, secondary cell can be lithium ion battery or sodium-ion battery.When adopting lithium ion battery, cathode active material is containing lithium.When adopting sodium-ion battery, cathode active material is containing sodium.Described secondary cell can be secondary battery of soft package.

Finally illustrate according to of the present utility model with flexible packing lithium ion battery embodiment as an example and comparative example and test result.

Embodiment 1

For 423482 model flexible packing lithium ion batteries (resultant battery thickness be 4.2mm, width be that 34mm, length are for 82mm), anode lug 2 and cathode tab 4 consistent size, namely the weld length of lug is 15mm, and lug width is 4mm, thickness is 0.06mm.

Adopt the structure shown in Fig. 1 ~ 4, pole piece after cold pressing process (thickness of the single layer anode diaphragm 12 of anode pole piece 1 be 67 μm, the thickness of the monolayer cathodes diaphragm 32 of cathode sheet 3 be 53 μm), adopt laser to clean out anode lug accommodating grooves G11 for welding anode lug 2 and anode at 1/2 place (i.e. d1=1/2D1) of anode pole piece 1 and match recess R11, and clean out cathode sheet contraposition groove G32 and cathode sheet contraposition recess R32 in the cathode sheet district of anode lug 2 contraposition.Adopt laser to clean out at 1/2 place (i.e. d2=1/2D2) of cathode sheet 3 and match recess R31 for the cathode tab accommodating grooves G31 of welded cathode lug 4 and negative electrode.Wherein width is 6mm to cathode tab accommodating grooves G31 and negative electrode pairing recess R31 separately, length is 20mm, width is 6mm to anode lug accommodating grooves G11 and anode pairing recess R11 separately, length is 20mm, width is 6mm to cathode sheet contraposition groove G32 and cathode sheet contraposition recess R32 separately, length is 22mm, anode lug 2 is welded in anode lug accommodating grooves G11, cathode tab 4 is welded in cathode tab accommodating grooves G31.Cathode sheet contraposition groove covers whole cathode sheet contraposition groove G32 with two-sided edge adhesive tape T1 and on two sides, distinguishes the negative electrode diaphragm 32 around bonding barrier film 5 and cathode sheet contraposition groove G32, cathode tab accommodating grooves double-sided insulation adhesive tape T2 covers whole cathode tab accommodating grooves G31 and on two sides, distinguishes the negative electrode diaphragm 32 around bonding barrier film 5 and cathode tab accommodating grooves G31, negative electrode pairing recess double-sided insulation adhesive tape T3 covers whole negative electrode pairing recess R31 and on two

sides, distinguishes the negative electrode diaphragm 32 around bonding barrier film 5 and negative electrode pairing recess R31, cathode sheet contraposition recess double-sided insulation adhesive tape T4 covers whole cathode sheet contraposition recess R32 and on two sides, distinguishes the negative electrode diaphragm 32 around bonding barrier film 5 and cathode sheet contraposition recess R32, cathode sheet contraposition groove double-sided insulation adhesive tape T1, cathode tab accommodating grooves double-sided insulation adhesive tape T2, negative electrode pairing recess double-sided insulation adhesive tape T3, cathode sheet contraposition recess double-sided insulation adhesive tape T4 be two-sided initial time all sticking PET base material on the two-sided tape of dual coating polyvinylidene fluoride layer, anode pole piece 1, cathode sheet 3 and barrier film 5 reel, form secondary cell battery core thus.

Embodiment 2

Adopt the structure shown in Fig. 5, and the difference of embodiment 1: match recess R31, negative electrode without negative electrode and match recess double-sided insulation adhesive tape T3, anode and match recess R11, cathode sheet contraposition recess R32 and cathode sheet contraposition recess double-sided insulation adhesive tape T4.All the other are with embodiment 1.

Embodiment 3

Adopt the structure shown in Fig. 6 and Fig. 7, with the difference of embodiment 1: adopt laser mode at 3/4 place (the i.e. d1=3/4D1 of anode pole piece 1, anode diaphragm 12 one side near the head is arranged) clean out anode lug accommodating grooves G11 for welding anode lug 2, and clearing out cathode sheet contraposition groove G12 in the cathode sheet district of anode lug 2 contraposition, cathode sheet contraposition groove covers whole cathode sheet contraposition groove G12 with two-sided edge adhesive tape T1 and on two sides, distinguishes the negative electrode diaphragm 32 around bonding barrier film 5 and cathode sheet contraposition groove G12 All the other are with embodiment 1.

Embodiment 4

Adopt structure as shown in Figure 8, and the difference of embodiment 3: match recess R31 and negative electrode without negative electrode and match recess double-sided insulation adhesive tape T3 All the other are with embodiment 3.

Comparative example 1

Adopt structure as shown in Figure 8, and the difference of embodiment 4: the width of anode lug accommodating grooves G11 is 6mm, length is 21mm, and the width of cathode sheet contraposition groove G12 is 4mm, length is 18mm All the other are with embodiment 4.

Comparative example 2

Adopt the structure shown in Fig. 9 and Figure 10, with the difference of embodiment 1: without cathode sheet contraposition groove G32 and cathode sheet contraposition recess R32, but it is that adopt cathode sheet contraposition accommodating area single-sided insulation adhesive tape T1' to paste negative electrode diaphragm 32 with surface that the is respective regions of anode lug accommodating grooves G11 contraposition, cathode sheet contraposition collochore single-sided insulation adhesive tape T4' is adopted to paste the surface of the respective regions of the anode pairing recess R11 contraposition of negative electrode diaphragm 32, adopt the negative electrode diaphragm 32 around cathode tab accommodating grooves single-sided insulation adhesive tape T2' stickup cathode tab accommodating grooves G31, adopt the negative electrode diaphragm 32 around negative electrode pairing recess single-sided insulation adhesive tape T3' stickup negative electrode pairing recess R31.

In embodiment 1-4 and comparative example 1-2, choose 20 flexible packing lithium ion battery samples respectively carry out 1000 cycle charge discharge electrical testings, the thickness of the sample before and after test is measured, and the flexible packing lithium ion battery sample after test is disassembled to the situation of observing and analysing lithium, acquired results shows as shown in table 1.

The test result of table 1 embodiment 1-4 and comparative example 1-2

As seen from Table 1, embodiment 1-4 is without analysing lithium; And comparative example 1 and comparative example 2 analyse lithium, and comparative example 2 to analyse lithium than comparative example 1 serious; The deflection of embodiment 1-4 is much smaller than comparative example 1 and comparative example 2.The deflection of comparative example 1 is less than the deflection of comparative example 2, but the deflection of comparative example 1 is greater than the deflection of embodiment 4.

As can be seen here, in embodiment 1-4, cathode sheet contraposition groove G32 is all greater than anode lug accommodating grooves G11 in length and width, can avoid analysing lithium completely, and effectively can control the distortion of flexible packing lithium ion battery.Compare ratio 2, in comparative example 1, cathode sheet contraposition groove G32 is all less than anode lug accommodating grooves G11 in length and width, can alleviate and analyse lithium, and alleviate deflection.

Cited By (5)

Publication number	Priority date	Publication date	Assignee	Title
WO2018197382A1 *	2017-04-12	2018-10-25	宁德时代新能源科技股份有限公司	Secondary battery cell
WO2018000188A1 *	2016-06-28	2018-01-04	宁德新能源科技有限公司	Secondary battery core
CN109659584A *	2018-06-24	2019-04-19	宁德新能源科技有限公司	Takeup type battery core
CN111525194A *	2020-04-28	2020-08-11	宁德新能源科技有限公司	Electrochemical device and electronic device including the same
CN111554982A *	2020-05-11	2020-08-18	珠海冠宇电池股份有限公司	Winding battery cell, preparation method thereof, battery and electronic product
Family To Family Citations				

* Cited by examiner, † Cited by third party, ‡ Family to family citation

Similar Documents

Publication	Publication Date	Title

CN205480931U	2016-11-25	Secondary cell electricity core
CN205828957U	2016-12-21	Takeup type battery core
CN105374959B	2021-09-07	Thin power storage device and method for manufacturing same
CN104157914A	2014-11-19	High-power flexible packaged lithium ion battery and processing process thereof
CN109565084A	2019-04-02	Takeup type battery core
KR102256599B1	2021-05-26	Pressing jig and method of fabricating secondary battery using the same
CN102623667A	2012-08-01	Soft package thin and ultrathin cell structure and manufacturing method thereof
CN102136603B	2014-10-08	Polymer lithium-ion battery and manufacture method thereof
JP6418183B2	2018-10-24	Method for producing electrode roll body
CN109417152A	2019-03-01	Secondary cell battery core
CN205828957U	2016-12-21	Secondary cell battery core
CN107834127B	2020-07-07	Secondary battery core
CN111525180B	2022-02-25	Secondary battery core
CN111180679A	2020-04-14	Three-electrode battery cell, three-electrode soft package battery and preparation method thereof
CN111193056A	2020-05-22	Disc type battery and preparation method thereof
CN105355921B	2018-04-03	A kind of electrochemical cell and preparation method thereof
CN201673068U	2010-12-15	Miniature polymer lithium ion battery with dissymmetrical assembly structure
CN202695604U	2013-01-23	Roll core structural battery cell and lithium ion battery of roll core structural battery cell
TW201503458A	2015-01-16	Manufacturing method of curved battery and structure thereof
CN202695643U	2013-01-23	Lithium-ion battery rolling core structure battery cell and lithium-ion battery thereof
CN108400274A	2018-08-14	A kind of battery with diaphragm bag making
CN211045578U	2020-07-17	Lithium ion battery tubular tab and battery containing same
CN210245650U	2020-04-03	Novel ultra-thin battery
US2810110A	1957-04-08	Primary cell and battery
CN207818811U	2018-09-04	Lithium ion battery without foil

Priority And Related Applications

Priority Applications (1)

Application	Priority date	Filing date	Title
CN201520404064.8U	2015-06-12	2015-06-12	Secondary cell electricity core

Applications Claiming Priority (1)

Application	Filing date	Title
CN201520404064.8U	2015-06-12	Secondary cell electricity core

Legal Events

Date	Code	Title	Description
2015-11-25	GR01	Patent grant	
2015-11-25	C14	Grant of patent or utility model	
2016-04-20	CP03	Change of name, title or address	**Address after**: 352100 Jiaocheng District of Ningde City, Fujian Province Zhang Wan Zhen Xingang Road No. 1 **Patentee after**: Contemporary Amperex Technology Co.,Ltd.

		Address before: 352100 Jiaocheng District of Ningde City, Fujian Province Zhang Wan Zhen Xingang Road No. 1 West Building 1F- research **Patentee before:** Contemporary Amperex Technology Co.,Ltd.	
2016-04-20	C56	Change in the name or address of the patentee	

Concepts

machine-extracted

Download Filter table

Name	Image	Sections	Count	Query match
electricity		title,abstract	2	0.000
insulation		claims,description	53	0.000
adhesive tape		claims,description	45	0.000

Show all concepts from the description section

Secondary battery core

Abstract

This utility model provides a kind of secondary battery core, and it includes anode pole piece, cathode sheet and isolating membrane, and isolating membrane is interval between adjacent cathode sheet and anode pole piece; Described cathode sheet and anode pole piece all include collector, the active material layer being coated at least one surface of collector and electrical connection lug on a current collector, active material layer is provided with the lug groove exposing blank collector, and lug is fixed in the lug groove of correspondence; Described anode lug groove is the short groove not running through pole piece width, and short groove three side sealing closes, an opening; Cathode tab groove is the long recess running through pole piece width, long recess two face closure, two sides opening.Compared with prior art, this utility model secondary battery core has energy density height, reduction analysis lithium, is difficult to the advantage such as dilatancy, firm welding.

Classifications

Y02E60/10 Energy storage using batteries

View 1 more classifications

CN205828514U

China

Download PDF Find Prior Art Similar

Other languages: Chinese

Inventor: 曾杰, 王可飞, 金庆幸, 曾毅军

Current Assignee : Ningde Amperex Technology Ltd

Worldwide applications

2016 CN

Application CN201620716715.1U events

2016-07-08 Application filed by Ningde Amperex Technology Ltd

2016-07-08 Priority to CN201620716715.1U

2016-12-21 Application granted

2016-12-21 Publication of CN205828514U

Info: Cited by (1), Legal events, Similar documents, Priority and Related Applications

External links: Espacenet, Global Dossier, Discuss

Claims (10)

Hide Dependent

1. a secondary battery core, including anode pole piece, cathode sheet and isolating membrane, isolating membrane be interval in adjacent cathode sheet and Between anode pole piece:

Described anode pole piece includes anode collector, the anode active material layer being coated at least one surface of anode collector With the anode lug being connected electrically in anode collector, anode active material layer is provided with the anode exposing blank anode collector Lug groove, anode lug is fixed in anode lug groove;

Described cathode sheet includes cathode current collector, the cathode active material layer being coated at least one surface of cathode current collector With the cathode tab being connected electrically on cathode current collector, cathode active material layer is provided with the negative electrode exposing blank cathode current collector Lug groove, cathode tab is fixed in cathode tab groove;

it is characterized in that: described anode lug groove is the short groove not running through pole piece width, short groove three side sealing closes, one Face opening; Cathode tab groove is the long recess running through pole piece width, long recess two face closure, two sides opening.

Secondary battery core the most according to claim 1, it is characterised in that: described anode lug groove and cathode tab groove exist The segment distance that staggers on battery core width is arranged so that anode lug and cathode tab are non-overlapping on battery core thickness direction.

Secondary battery core the most according to claim 1, it is characterised in that: described anode pole piece, isolating membrane and cathode sheet layer Poststack winds, and secondary battery core is takeup type battery core.

Secondary battery core the most according to claim 3, it is characterised in that: described anode lug groove is arranged at anode pole piece Winding the initial segment or winding interlude.

Secondary battery core the most according to claim 3, it is characterised in that: described cathode tab groove is arranged at cathode sheet Winding the initial segment or winding interlude.

Secondary battery core the most according to claim 3, it is characterised in that: described secondary battery core includes that being positioned at winding completes position Ending glue, ending glue on battery core thickness direction with the aligned in position of cathode tab groove.

Secondary battery core the most according to claim 3, it is characterised in that: the winding the initial segment of described anode pole piece includes pre-folding Section and the tiling layer being connected with pre-trisection; Pre-trisection is parallel with tiling layer, and is positioned at the tiling layer one side towards winding center; Cloudy The winding the initial segment of pole pole piece is the cathode sheet winding initial layers parallel with tiling layer, and cathode sheet winding initial layers is positioned at flat The one side of laying winding center dorsad, and non-overlapping with pre-trisection on battery core thickness direction.

Secondary battery core the most according to claim 7, it is characterised in that: the free end of described pre-trisection is anode pole piece winding initiating terminal A, the free end of cathode sheet winding initial layers is that cathode sheet winds initiating terminal B, and AB two ends are at battery core width On distance s be 0 ~ 4mm.

Secondary battery core the most according to claim 7, it is characterised in that: described pre-trisection has one side relative, in advance with tiling layer The free end of trisection only pastes gummed paper in the one side of the layer that tiles dorsad, does not paste gummed paper towards the one side of tiling layer.

Secondary battery core the most according to claim 7, it is characterised in that: described isolating membrane is provided with isolating membrane winding initial layers And the isolating membrane winding sublevel that initial layers is connected is wound with isolating membrane, isolating membrane winding initial layers and isolating membrane wind sublevel and are Double membrane structure; Pre-trisection is close to the layer that tiles, and pre-trisection peace laying is entirely located in isolating membrane winding initial layers and isolation film roll Between sublevel; Cathode sheet winding initial layers is then between the two membranes of isolating membrane winding sublevel.

Description

Secondary battery core

Technical field

This utility model belongs to secondary cell field, particularly relates to a kind of secondary battery core.

Background technology

Along with the business-like development of lithium rechargeable battery, the energy density of battery core is required more and more higher by market.Often in rule coiled secondary battery core, cathode sheet, the initiating terminal of anode pole piece are designed with blank collector, cathode tab and anode pole Ear is directly welded on the blank collector on cathode sheet, anode pole piece respectively.But, due to adding up of lug thickness, make Obtaining the maximum gauge that thickness is battery core in soldering polar ear region, the thickness in unwelded lug region is the most relatively small, and thickness is not The segment space uniformly making battery can not be fully utilized, and causes in certain gauge size, and the energy density of battery is difficult to improve further.

In order to solve the problems referred to above, the battery core of some secondary cell fixes lug in the following ways: in the activity of pole piece Material layer arranges the lug groove exposing blank collector, and lug is fixed in lug groove, thus reach to promote energy The purpose of metric density.But, if the length that the lug groove of anode and cathode pole piece is all set to run through pole piece width is recessed Groove, then can there is the blank collector region without soldering polar ear in long recess undoubtedly, this part is not coated with active material layer Region can cause the loss of battery core capacity, and region analysis lithium corresponding with anode lug groove on cathode sheet can be caused, in order to prevent analysis lithium from taping at cathode sheet, battery core capacity can be reduced again further; If the lug by anode and cathode pole piece is recessed Groove is all set to for the short groove of end slightly larger than lug, cannot expand for the pole piece in cyclic process again and provide complete answering Power release window.

In view of this, a kind of secondary battery core that can solve the problem that above-mentioned technical problem of necessary offer.

Utility model content

The purpose of this utility model is: provides a kind of and takes into account energy density, analysis lithium and the secondary battery core of Stress Release.

To achieve these goals, this utility model provides a kind of secondary battery core, including anode pole piece, cathode sheet and isolating membrane, isolating membrane is interval between adjacent cathode sheet and anode pole piece; Described anode pole piece includes anode collector, painting Overlay on the anode active material layer at least one surface of anode collector and the anode lug being connected electrically in anode collector, Being provided with the anode lug groove exposing blank anode collector in anode active material layer, it is recessed that anode lug is fixed on anode lug in groove; Described cathode sheet includes cathode current collector, the cathode active material being coated at least one surface of cathode current collector Layer and the cathode tab being connected electrically on cathode current collector, be provided with the moon exposing blank cathode current collector in cathode active material layer Pole lug groove, cathode tab is fixed in cathode tab groove; Described anode lug groove is not for run through pole piece width Short groove, short groove three side sealing closes, an opening; Cathode tab groove is the long recess running through pole piece width, long recessed Groove two face closure, two sides opening

As a kind of improvement of this utility model secondary battery core, described anode lug groove and cathode tab groove are in battery core The segment distance that staggers on width is arranged so that anode lug and cathode tab are non-overlapping on battery core thickness direction.

As a kind of improvement of this utility model secondary battery core, after described anode pole piece, isolating membrane and cathode sheet stacking Winding, secondary battery core is takeup type battery core.

As a kind of improvement of this utility model secondary battery core, described anode lug groove is arranged at the winding of anode pole piece The initial segment or winding interlude.

As a kind of improvement of this utility model secondary battery core, described cathode tab groove is arranged at the winding of cathode sheet The initial segment or winding interlude.

As a kind of improvement of this utility model secondary battery core, described secondary battery core includes being positioned at the receipts having wound position Tail glue, ending glue on battery core thickness direction with the aligned in position of cathode tab groove.

As a kind of improvement of this utility model secondary battery core, the winding the initial segment of described anode pole piece include pre-trisection and The tiling layer being connected with pre-trisection; Pre-trisection is parallel with tiling layer, and is positioned at the tiling layer one side towards winding center; Negative electrode pole The winding the initial segment of sheet is the cathode sheet winding initial layers parallel with tiling layer, and cathode sheet winding initial layers is positioned at tiling layer The one side of winding center dorsad, and non-overlapping with pre-trisection on battery core thickness direction.

As a kind of improvement of this utility model secondary battery core, the free end of described pre-trisection is that anode pole piece winding is initial End A, the free end of cathode sheet winding initial layers is that cathode sheet winds initiating terminal B, and AB two ends are on battery core width Distance s is 0 ~ 4mm

As a kind of improvement of this utility model secondary battery core, described pre-trisection has one side relative with tiling layer, pre-trisection Free end only the layer that tiles dorsad one side paste gummed paper, towards tiling layer one side do not paste gummed paper

As a kind of improvement of this utility model secondary battery core, described isolating membrane be provided with isolating membrane winding initial layers and with every The isolating membrane winding sublevel being connected around initial layers from film roll, isolating membrane winding initial layers and isolating membrane winding sublevel are duplexture structure; Pre-trisection is close to the layer that tiles, and pre-trisection peace laying is entirely located in isolating membrane winding initial layers and winds sublevel with isolating membrane Between; Cathode sheet winding initial layers is then between the two membranes of isolating membrane winding sublevel.

Compared with prior art, this utility model secondary battery core has energy density height, reduction analysis lithium, is difficult to expand change The advantage such as shape, firm welding.

Accompanying drawing explanation

Below in conjunction with the accompanying drawings and detailed description of the invention, this utility model secondary battery core and Advantageous Effects thereof are carried out in detail Describe in detail bright.

Fig. 1 is the structural representation of this utility model one embodiment of secondary battery core.

Fig. 2 is this utility model secondary battery core anode pole piece and the electrode tab connection structure schematic diagram of cathode sheet.

Detailed description of the invention

In order to make the purpose of this utility model, technical scheme and Advantageous Effects become apparent from understanding, below in conjunction with attached Figure and detailed description of the invention, be further elaborated to this utility model.It should be appreciated that described in this specification Detailed description of the invention is only used to explain this utility model, is not intended to limit this utility model.

For convenience of description, the shorter edge of cathode sheet and anode pole piece is defined as pole piece width by this utility model L1, L2, perpendicular pole piece bearing of trend is defined as pole piece length direction It will be understood that due to cathode sheet and anode The winding of pole piece is carried out the most along its length, therefore in the battery core being finally wound into, anode and cathode pole piece width L1, What L2 was corresponding is battery core length direction (being perpendicular to the direction of paper in Fig. 1), say, that pole piece width L1, L2 and electricity Core width L also differs, but perpendicular to one another.

Referring to Fig. 1 and Fig. 2, this utility model secondary battery core includes anode pole piece 10, cathode sheet 20 and isolating membrane 30. Being wound as takeup type battery core after anode pole piece 10, isolating membrane 30 and cathode sheet 20 stacking, isolating membrane 30 is interval in adjacent sun Between pole pole piece 10 and cathode sheet 20.

The anode activity that anode pole piece 10 includes anode collector 11, is coated at least one surface of anode collector 11 Material layer 12 and the anode lug 13 being connected electrically in anode collector 11.Anode active material layer 12 is provided with and exposes blank sun The anode lug groove 120 of pole collector, anode lug 13 is fixed in anode lug groove 120 Anode lug groove 120 is Fix the short groove of end slightly larger than lug, it does not runs through the width L1 of anode pole piece 10, and therefore three side sealing closes, one side is opened Mouthful.The generation type of short groove has multiple, and one of which is that the first lug fixed position stickup in blank anode collector is easily torn Film or thermal expansion film, then carry out the continuous coating of anode active material layer, finally remove easily tore film or thermal expansion film and formed short Groove.

Cathode sheet 20 includes cathode current collector 21, the cathode activity being coated at least one surface of cathode current collector 21 Material layer 22 and the cathode tab 23 being connected electrically on cathode current collector 21.Cathode active material layer 22 is provided with and exposes blank the moon The cathode tab groove 220 of pole collector, cathode tab 23 is fixed in cathode tab groove 220.Cathode tab groove 220 is Running through the long recess of the width L2 of cathode sheet 10, long recess two face closure, two sides opening, it can use interval coating Mode coated cathode active material layer and formed.

Anode lug groove 120/ cathode tab groove 220 can be arranged at anode pole piece 10/ cathode sheet 20 at winding Optional position on direction, but it is preferably arranged on winding the initial segment or winding interlude, and reason is: be arranged on anode pole piece During the winding the initial segment of 10/ cathode sheet 20, being located proximate in battery core thickness direction T of anode lug 13/ cathode tab 23 The heart, suitable with two outermost layer distances of battery core thickness direction T, battery core is more unlikely to deform; It is arranged on anode pole piece 10/ negative electrode During the winding interlude of pole piece 20, internal resistance is minimum, and electric current density is the most uniform so that the discharge performance of battery core is optimum.Need explanation , no matter it is arranged on winding the initial segment or winds interlude, anode lug groove 120 and cathode tab groove 220 are at electricity A segment distance setting of staggering it is required for so that anode lug 13 and cathode tab 23 are at battery core thickness direction T on core width L Upper non-overlapping, to avoid anode and cathode short circuit.

Compared with prior art, this utility model secondary battery core at least has the advantage that

1) anode lug groove 120 is slightly over lug and fixes the short groove of end, and it does not runs through the width of anode pole piece 10 Direction L1, therefore there's almost no the blank collector region of uncoated anode active material layer, reduces battery core capacitance loss;

2) compared with the anode pole piece using long recess, anode lug groove 120 of the present utility model uses the short groove can Significantly to reduce on cathode sheet 20 the analysis lithium with anode lug groove 120 corresponding region;

3) due to the long recess that cathode tab groove 220 is the width L2 running through cathode sheet 10, therefore it can The window of one section of complete Stress Release is provided; Meanwhile, on anode pole piece 10, the one side corresponding with cathode tab groove 220 is in State without removal lithium embedded, the most also becomes the Stress Release window of anode pole piece 10; Two combine, it is ensured that secondary battery core is in circulation During be difficult to dilatancy;

4) it is more than the activity of anode pole piece 20 due to the active material layer of cathode sheet 10 and the bonding force of cathode current collector Material layer and the bonding force of anode collector, if therefore cathode sheet 10 uses three side sealing to close the short groove of an opening, go Except cathode active material layer 22 is difficult and there is the risk of rosin joint; Cathode sheet 10 uses the length of two face closure two sides openings recessed Groove can use gap to be coated with, and the increase of bonding area makes internal resistance reduce, and alleviates rosin joint risk simultaneously;

5) although cathode tab groove 220 uses long recess that certain cathode active material can be caused to lose, but long recessed The existence of groove makes the thickness minimum in this region on battery core thickness direction T, and the ending glue 50 when can be completed by electric core winding pastes Position corresponding with cathode tab groove 220 on battery core thickness direction T, thus save the thickness of ending glue 50 so that live Property material layer coating thickness increase, compensate for the loss of battery core density.

In the embodiment shown in fig. 1, the winding the initial segment 15 of anode pole piece 10 include pre-trisection 152 and with pre-trisection The 152 tiling layers 150 connected; Pre-trisection 152 is parallel with tiling layer 150, and is positioned at tiling layer 150 towards winding center Face, its be close to tile layer 150 or and tiling layer 150 between be only spaced by isolating membrane 30.The winding the initial segment of cathode sheet 20 is The cathode sheet winding initial layers 25 parallel with the tiling layer 150 of anode pole piece 10, cathode sheet winding initial layers 25 is positioned at flat The one side of laying 150 winding center dorsad, and non-overlapping with pre-trisection 152 on battery core thickness direction T.Pre-trisection 152 from Being that anode pole piece winds initiating terminal A by end, the free end of cathode sheet winding initial layers 25 is that cathode sheet winds initiating terminal B, The two only tiling layer 150 and isolating membrane 30 by anode pole

piece 10 on battery core thickness direction T is spaced, at battery core width L (L with L1, L2 also differ for i.e. vertical with battery core thickness direction T coiling direction, the explanation before seeing) the two position upper connects Near the most non-overlapping, preferred distance s is 0 ~ 4mm.

Pre-trisection 152 and cathode sheet winding initial layers 25 nothing weight on battery core thickness direction T due to anode pole piece 10 Folded, therefore, pre-trisection 152 not only will not increase the thickness of battery core, and can substantially supply cathode sheet winding initial layers 25 And the battery core uneven thickness that cause shorter than the tiling layer 150 of anode pole piece 10 so that battery core is the most smooth, when discharge and recharge the most just No longer it is easily deformed.It addition, pre-trisection 152 has one side relative with tiling layer 150 on battery core thickness direction T, only have and put down dorsad The one side of laying 150 is relative with cathode sheet 20, the one side of the layer 150 that therefore only need to tile dorsad at the free end of pre-trisection 152 Stickup gummed paper, towards tiling layer 150 one side then without pasting gummed paper, this decreases the use of gummed paper undoubtedly than prior art Amount, while cost-effective, further reduces battery core thickness.

In the shown embodiment, the winding the initial segment 15 of anode pole piece 10 is one side coated anode active material layer 12 Anode collector 11, cathode sheet winding initial layers 25 is then the cathode current collector 21 of dual coating cathode active material layer 22. But, in other interchangeable embodiments, the winding the initial segment 15 of anode pole piece 10 and cathode sheet winding initial layers 25 in one or two can also be the two-sided blank collector being all not coated by active material layer 12,22, these are as required Arranging, this is not caused restriction and impact by improvement of the present utility model.

Isolating membrane 30 is provided with isolating membrane winding initial layers 31 and the isolating membrane winding being connected with isolating membrane winding initial layers 31 Sublevel 32, both at double membrane structure.The two membranes that isolating membrane winding initial layers 31 is connected for starting point, it is at battery core width Substantially it is paved with on the T of direction, and is adjacent to each other because being not provided with anode pole piece 10 and cathode sheet 20 between two membranes; In battery core On thickness direction T, isolating membrane winding initial layers 31 and anode lug 13, cathode tab 23 are equal the most overlapping.The winding of anode pole piece 10 The initial segment 15 (including tile layer 150 and pre-trisection 152) is entirely located in isolating membrane winding initial layers 31 and winds sublevel with isolating membrane Between 32, cathode sheet winding initial layers 25 is then between the two membranes of isolating membrane winding sublevel 32.

It can be readily appreciated that in other embodiments, anode pole piece 10, isolating membrane 30 and the winding side of cathode sheet 20 Formula can have multiple change, and this can't affect enforcement of the present utility model.

According to above-mentioned principle, this utility model can also carry out suitable change and amendment to above-mentioned embodiment.Therefore, This utility model is not limited to detailed description of the invention disclosed and described above, to modifications and changes more of the present utility model Should also be as falling in scope of the claims of the present utility model.Although additionally, it is specific to employ some in this specification Term, but these terms are merely for convenience of description, this utility model do not constituted any restriction.

Cited By (1)

Publication number	Priority date	Publication date	Assignee	Title
WO2018099168A1 *	2016-12-02	2018-06-07	[redacted]	Cathode plate, anode plate, and battery cell
Family To Family Citations				

* Cited by examiner, † Cited by third party, ‡ Family to family citation

Similar Documents

Publication	Publication Date	Title
WO2018121483A1	2018-07-05	Wound-type battery cell
CN207320217U	2018-05-04	Secondary cell
CN208099852U	2017-04-12	Coiling formula secondary electricity core
CN205376658U	2016-07-06	Secondary battery
CN104600256A	2015-05-06	Preparation method of lithium ion battery multi-pole-ear pole piece, preparation method of pole group and battery
CN205564899U	2016-09-07	Coiling type battery cell
CN110729447A	2020-01-24	Battery cell pole piece and battery cell
CN205828514U	2016-12-21	Secondary battery core
CN110808377A	2020-02-18	Battery cell, battery and electronic equipment
CN205828556U	2016-12-21	Secondary cell takeup type battery core
WO2018038489A1	2018-03-01	Spiral-wound battery
CN205846127U	2016-12-28	A kind of secondary cell battery core
CN111403788B	2021-12-10	Electrode assembly and battery
CN205828576U	2016-12-21	Takeup type battery core
CN206003909U	2017-03-08	A kind of takeup type battery core

CN102760905A	2012-10-31	High-capacity lithium battery
CN201369367Y	2009-12-23	Power lithium battery bare cell with double-tab structure
CN107302110A	2017-10-27	Takeup type battery core
CN205846128U	2016-12-28	A kind of secondary cell battery core
CN206379431U	2017-08-04	Takeup type pole group
WO2018121183A1	2018-07-05	Coiled cell
CN210897528U	2020-06-30	Lithium ion battery cell
CN211045637U	2020-07-17	Polymer battery cell
CN210926138U	2020-07-03	Battery cell pole piece
CN215680715U	2022-01-28	Lithium battery positive and negative plate structure and lithium battery

Priority And Related Applications

Priority Applications (1)

Application	Priority date	Filing date	Title
CN201620716715.1U	2016-07-08	2016-07-08	Secondary battery core

Applications Claiming Priority (1)

Application	Filing date	Title
CN201620716715.1U	2016-07-08	Secondary battery core

Legal Events

Date	Code	Title	Description
2016-12-21	C14	Grant of patent or utility model	
2016-12-21	GR01	Patent grant	

Concepts

machine-extracted

Download Filter table

Name	Image	Sections	Count	Query match
membrane		claims,abstract,description	46	0.000
sealing		claims,abstract,description	5	0.000
winding		claims,description	64	0.000
cathode active material		claims,description	9	0.000
anode active material		claims,description	8	0.000
glue		claims,description	6	0.000
initiatory		claims,description	6	0.000
isolation		claims	1	0.000
lithium		abstract,description	8	0.000
Li				
lithium		abstract,description	8	0.000
active material		abstract,description	5	0.000

⊗ welding	abstract,description	2	0.000

Show all concepts from the description section

Takeup type battery core

Abstract

This utility model provides a kind of takeup type battery core, comprising: the first pole piece, the first lug, the second pole piece, the second lug and isolating membrane.First pole piece includes the first collector and the first active material layer.Second pole piece includes the second collector and the second active material layer The first volume of the first pole piece the most uncoated first active material layer be defined as the first head blank collector on positive and negative two surfaces of the first collector of the initial segment, the first head blank collector is welded in first lug.Second pole piece is formed with the second lug accommodating grooves, the bottom of the second lug accommodating grooves is the second collector and week side is the second active material layer, in the second lug is contained in the second lug accommodating grooves and be electrically connected to the second collector at the second lug accommodating grooves.Takeup type battery core of the present utility model improves the capacity density of takeup type battery core and reduces internal resistance, and solves battery core and be easily deformed, circulate the problem that expansion rate is bigger during recycling.

CN205828573U

China

Download PDF Find Prior Art Similar

Other languages: Chinese

Inventor: [illegible], 肖德时, 夏伟, 王阿飞, 殷义, 徐平

Current Assignee : Ningde Amperex Technology Ltd

Worldwide applications

2016 CN

Application CN201620639646.9U events

2016-06-24 Application filed by Ningde Amperex Technology Ltd

2016-06-24 Priority to CN201620639646.9U

2016-12-21 Application granted

2016-12-21 Publication of CN205828573U

Info: Cited by (9), Legal events, Similar documents, Priority and Related Applications

External links: Espacenet, Global Dossier, Discuss

Classifications

Y02E60/10 Energy storage using batteries

View 1 more classifications

Claims (10)

Hide Dependent

1. a takeup type battery core, including:

First pole piece (1), including:

First collector (11); And

First active material layer (12), is coated on the surface of the first collector (11);

First lug (2);

Second pole piece (3), including:

Second collector (31); And

Second active material layer (32), is coated on the surface of the second collector (31);

Second lug (4);

Isolating membrane (5), is arranged between the first pole piece (1) and the second pole piece (3), with by the first pole piece (1) and the second pole piece (3) Keep apart;

It is characterized in that,

First pole piece (1) has the first volume around the initial segment (81), the first volume around the initial segment (81) the first collector (11) just The most uncoated first active material layer (12) be defined as the first head blank collector (111), the first pole on anti-two surfaces Ear (2) is fixed on the first head blank collector (111);

The middle part of the second pole piece (3) is formed with the second lug accommodating grooves (33), and the bottom of the second lug accommodating grooves (33) is Second collector (31) and week side be the second active material layer (32), the second lug (4) is contained in the second lug accommodating grooves (33) in and be electrically connected to second collector (31) at the second lug accommodating grooves (33) place.

Takeup type battery core the most according to claim 1, it is characterised in that

All sides of the second lug accommodating grooves (33) are that three bandings close openings at one side; Or

All sides of the second lug accommodating grooves (33) are closing both sides, both sides openings.

Takeup type battery core the most according to claim 1, it is characterised in that

Second pole piece (3) has volume Two around the initial segment (B2);

The first volume extends towards different directions around the initial segment (B2) the most respectively around the initial segment (B1) and volume Two; Or

The first volume extends towards identical direction around the initial segment (B2) with volume Two in the longitudinal direction around the initial segment (B1).

Takeup type battery core the most according to claim 3, it is characterised in that

Volume Two is coated with the second active material layer (32) on (31) two surfaces of the second collector of the initial segment (B2).

Takeup type battery core the most according to claim 3, it is characterised in that

First pole piece (1) also has: the first volume is around ending section (D1), and the first volume is around first collector (11) of ending section (D1) Positive and negative the most uncoated first active material layer in two surfaces (12) are also defined as the first afterbody blank collector (112).

Takeup type battery core the most according to claim 5, it is characterised in that

First lug (2) is two:

One the first lug (2) is welded in the first head blank collector (111), and another first lug (2) is welded in first Afterbody blank collector (112).

7. according to the takeup type battery core according to any one of claim 1-6, it is characterised in that takeup type battery core also includes: the Three lugs (6), are welded in the one end outside takeup type battery core that is drawn out to of the first lug (2), and the width of the 3rd lug (6) are little in the width of the first lug (2), the thickness of the 3rd lug (6) is more than the thickness of the first lug (2).

8. according to the takeup type battery core according to any one of claim 1-6, it is characterised in that

Takeup type battery core also includes: the 4th lug (7), and be welded in the second lug (4) is drawn out to outside takeup type battery core End, and the width of the 4th lug (7) is less than the second lug width, the thickness of the 4th lug (7) is more than the thickness of the second lug.

Takeup type battery core the most according to claim 1, it is characterised in that the second pole piece (3) is also formed with: the second lug is joined To recess (34), bottom is the second collector (31) and week side is the second active material layer (32), is positioned at the second lug and houses recessed Groove (33) just to dorsal part.

10. according to the takeup type battery core according to any one of claim 1-6, it is characterised in that the first pole piece (1) is positive pole pole Sheet and the second pole piece (3) is cathode pole piece, the first collector (11) is plus plate current-collecting body and the second collector (31) is negative pole collection Fluid, the first active material layer (12) is positive electrode active material layer and the second active material layer (32) is negative electrode active material layer; Or

First pole piece (1) is cathode pole piece and the second pole piece (3) is anode pole piece, the first collector (11) be negative current collector and Second collector (31) is plus plate current-collecting body, and the first active material layer (12) is negative electrode active material layer and the second active material layer (32) it is positive electrode active material layer.

Description

Takeup type battery core

Technical field

The present invention relates to field of batteries, particularly relate to a kind of takeup type battery core.

Background technology

Figure 14 is the winding schematic diagram in one embodiment of takeup type battery core of the prior art.Takeup type battery core includes First pole piece the 1, first lug the 2, second pole piece the 3, second lug 4 and isolating membrane 5.Wherein, the head (i.e. of the first pole piece 1 One winding the initial segment B1) and the head (i.e. volume Two is around the initial segment B2) of the second pole piece 3 be blank collector, the first lug 2 It is respectively welded on the blank collector of the first pole piece 1 and the head of the second pole piece 3 with the second lug 4, then at the first lug 2 insulating cement is pasted respectively with on the second lug 4.Figure 15 is the volume in another embodiment of takeup type battery core of the prior art Around schematic diagram, wherein, the middle part of the first pole piece 1 and the middle part of the second pole piece 3 offer the first lug accommodating grooves 13 He respectively Second lug accommodating grooves 33, and the first lug receipts that the first lug 2 and the second lug 4 are contained on the first pole piece 1 respectively in the second lug accommodating grooves 33 in holding groove 13 and on the second pole piece 3.

Takeup type battery core in Figure 14 can cause the first lug 2 position and the second lug 4 position to become battery Maximum gauge district, and the dimensional space of the takeup type battery core beyond the first lug 2 and the second lug 4 wastes, and then leads Send a telegraph core energy density relatively low.Additionally, due to the first lug 2 and the second lug 4 lay respectively at the head and second of the first pole piece 1 The head of pole piece 3, thus cause the D.C. resistance (DCR) of takeup type battery core bigger.Takeup type battery core in Figure 15 is being circulated throughout Being easily deformed in journey, circulation expansion rate is bigger.

Summary of the invention

In view of problem present in background technology, it is an object of the invention to provide a kind of takeup type battery core, it improves The capacity density of battery core also reduces internal resistance, solves battery core simultaneously and is easily deformed during recycling, circulates expansion rate Bigger problem.

To achieve these goals, the invention provides a kind of takeup type battery core, comprising: the first pole piece, the first lug, Second pole piece, the second lug and isolating membrane.

First pole piece includes: the first collector; And first active material layer, it is coated on the surface of the first collector. Second pole piece includes: the second collector; And second active material layer, it is coated on the surface of the second collector.Isolating membrane sets It is placed between the first pole piece and the second pole piece, so that the first pole piece and the second pole piece are kept apart.

Wherein, the first pole piece has the first volume around the initial segment, and the first volume is around positive and negative two of the first collector of the initial segment The most uncoated first active material layer be defined as the first head blank collector on surface, the first lug is fixed on the first head Blank collector.The middle part of the second pole piece is formed with the second lug accommodating grooves, and the bottom of the second lug accommodating grooves is second

Collector and week side is the second active material layer, the second lug is contained in the second lug accommodating grooves and is electrically connected to the second pole The second collector at ear accommodating grooves.

Beneficial effects of the present invention is as follows:

In the takeup type battery core according to the present invention, the first tab welding is in the first head blank collector, the second pole piece Middle part be formed with the second lug accommodating grooves, the second lug is contained in the second lug accommodating grooves and is electrically connected to the second pole The second collector at ear accommodating grooves The takeup type battery core of the present invention and the takeup type battery core phase shown in Figure 14 in prior art Ratio, owing to the first lug and the second lug not being simultaneously located at the head of corresponding pole piece, thus significantly reduces takeup type electricity The internal resistance of core improves the energy density of battery core simultaneously.The takeup type battery core of the present invention and the winding shown in Figure 15 in prior art Formula battery core is compared, more difficult deformation during takeup type battery core recycles, and reduces circulation expansion rate.

Accompanying drawing explanation

Fig. 1 is the winding schematic diagram in one embodiment of the takeup type battery core according to the present invention;

Fig. 2 is the schematic diagram after the second pole piece in Fig. 1 launches;

Fig. 3 is the upward view of Fig. 2;

Fig. 4 is the deformation pattern of Fig. 3;

Fig. 5 is the schematic diagram after the first pole piece in Fig. 1 launches;

Fig. 6 is the top view of Fig. 5;

Fig. 7 is the winding schematic diagram in another embodiment of the takeup type battery core according to the present invention;

Fig. 8 is the deformation pattern of Fig. 7, and wherein the first lug is two;

Fig. 9 is another deformation pattern of Fig. 7;

Figure 10 is the first lug in Fig. 1 and the welding schematic perspective view of the 3rd lug;

Figure 11 is the first lug in Fig. 8 and the welding schematic perspective view of the 3rd lug;

Figure 12 is the second lug in Fig. 1 and the welding schematic perspective view of the 4th lug;

Figure 13 is the deformation pattern of Figure 12, and wherein the second lug is two;

Figure 14 is the winding schematic diagram in one embodiment of takeup type battery core of the prior art;

Figure 15 is the winding schematic diagram in another embodiment of takeup type battery core of the prior art.

Wherein, description of reference numerals is as follows:

1 first pole piece B2 volume Two is around the initial segment

11 first collector D2 volume Twos are around ending section

111 first blank collector 4 second lugs

12 first active material layer 5 isolating membrane

13 first lug accommodating grooves T1 the first lug double-sided insulation adhesive tapes

The B1 first volume around the initial segment T2 the second lug accommodating grooves with two-sided absolutely

The D1 first volume is around ending section edge adhesive tape

2 first lug T3 the second lugs pairing recesses with two-sided absolutely

3 second pole piece edge adhesive tapes

31 second collector 6 the 3rd lugs

32 second active material layer 7 the 4th lugs

33 second lug accommodating grooves T thickness directions

34 second lug pairing recesses

Detailed description of the invention

Describe the takeup type battery core according to the present invention with reference to the accompanying drawings in detail.

With reference to Fig. 1, Fig. 7, Fig. 8 and Fig. 9, include according to the takeup type battery core of the present invention, first pole piece the 1, first lug 2, Second pole piece the 3, second lug 4 and isolating membrane 5.

First pole piece 1 includes: the first collector 11; And first active material layer 12, it is coated in the first collector 11 On surface Second pole piece 3 includes: the second collector 31; And second active material layer 32, it is coated in the table of the second collector 31 On face.isolating membrane 5 is arranged between the first pole piece 1 and the second pole piece 3, the first pole piece 1 and the second pole piece 3 to be kept apart.

Wherein, the first pole piece 1 has the first volume around the initial segment B1, the first volume around the initial segment B1 the first collector 11 just The most uncoated first active material layer 12 be defined as the first head blank collector 111 on anti-two surfaces, the first lug 2 welds it is connected to the first head blank

collector 111 (volume Two of the second pole piece 3 as described below is around initial at the middle part of the second pole piece 3 (section B2) and volume Two part between ending section (B2) it is formed with the second lug accommodating grooves 33, the second lug accommodating grooves 33 Bottom be the second collector 31 and week side is the second active material layer 32, the second lug 4 is contained in the second lug accommodating grooves in 33 and be electrically connected to the second collector 31 at the second lug accommodating grooves 33.

In the takeup type battery core according to the present invention, it is blank that the first lug 2 is fixed on (such as welding, bonding) first head Collector 111, the second lug 4 is contained in the second lug accommodating grooves 33 in the middle part of the second pole piece 3 and is electrically connected to the second pole The second collector 31 at ear accommodating grooves 33 The takeup type battery core of the present invention and the takeup type electricity shown in Figure 13 in prior art Core is compared, and owing to the first lug 2 and the second lug 4 not being simultaneously located at the winding the initial segment of corresponding pole piece, thus substantially drops The internal resistance of low takeup type battery core improves the energy density of battery core simultaneously.The takeup type battery core of the present invention and prior art are schemed Takeup type battery core shown in 14 is compared, more difficult deformation during takeup type battery core recycles, and reduces battery core Cirnulation expansion rate.

Takeup type battery core according to the present invention, in one embodiment, with reference to Fig. 3, all sides of the second lug accommodating grooves 33 Can be that three bandings close openings at one side.

In one embodiment, with reference to Fig. 4, all sides of the second lug accommodating grooves 33 can be closing both sides, both sides openings.Volume Wound battery core is after discharge and recharge, and the second active material layer 32 not only can be along thickness direction (the i.e. takeup type battery core of the second pole piece 3 Thickness direction T) expand, thus increase the thickness of takeup type battery core, and the second active material layer 32 also can be along The length direction of two pole pieces 3 expands, thus thickness direction T produces extruding and then increases the thickness of takeup type battery core further Degree.Owing to all sides of the second lug accommodating grooves 33 are closing both sides, both sides openings, so that along the length side of the second pole piece 3 To expansive force effectively discharged, from without to thickness direction T produce extruding, reduce to a certain extent takeup type electricity The thickness of core.

In one embodiment, with reference to Fig. 1, Fig. 7, Fig. 8 and Fig. 9, the second pole piece 3 has volume Two around the initial segment B2.First Winding the initial segment B1 and volume Two around the initial segment B2 can extend towards different direction respectively in the longitudinal direction (as Fig. 1, Fig. 7, Shown in Fig. 8 and Fig. 9) Or, the first volume around the initial segment B1 and volume Two around the initial segment B2 in the longitudinal direction such as Figure 14 and Figure 15 Extend towards identical direction as Suo Shi.

In one embodiment, volume Two is coated with the second work on two surfaces of the second collector 31 of the initial segment B2 Properly material layer 32.Second active material layer 32 is coated in volume Two and improves on the two sides of the second collector 31 of the initial segment B2 The energy density of takeup type battery core.

In one embodiment, with reference to Fig. 7, Fig. 8 and Fig. 9, the first pole piece 1 also can have the first volume around ending section D1, first Wind the most uncoated first active material layer 12 in two sides of the first collector 11 of ending section D1 and be defined as the first afterbody blank Collector 112.

In one embodiment, with reference to Fig. 8 and Fig. 9, the first lug 2 can be two, and two the first lugs 2 are in takeup type battery core Thickness direction T on substantially aligned.One of them first lug 2 is welded in the first head blank collector 111, and another is first years old Lug 2 is welded in the first afterbody blank collector 112, thus reduces the D.C. resistance (DCR) of takeup type battery core and battery core exists Quantity of heat production during discharge and recharge, and the electric current distribution of battery core is evenly.

In one embodiment, with reference to Figure 10 and Figure 11, takeup type battery core may also include that the 3rd lug 6, is welded in the first pole Ear 2 be drawn out to the one end outside takeup type battery core.

In one embodiment, the width of the 3rd lug 6 is less than the width of the first lug 2, and the thickness of the 3rd lug 6 is big in the thickness of the first lug 2, thus reduce the first lug 2 while the intensity and overflow section ensureing the 3rd lug 6 is long-pending The maximum gauge of battery core after welding, improves the energy density of battery core.

In one embodiment, with reference to Fig. 1 and Fig. 8, the second pole piece 3 also can have: volume Two around ending section D2, wherein second The two sides of the second collector 31 of winding ending section D2 can be coated with the second active material layer 32 or only in one side coating the Two active material layers 32 or the most uncoated second active material layer 32.

In one embodiment, the second lug 4 can be two, and correspondingly, the second lug accommodating grooves 33 is two.Two Two lugs 4 are contained in the second lug accommodating grooves 33 of correspondence respectively, and the most right on the thickness direction T of takeup type battery core Together.

Here remark additionally, when the first lug 2 and the second lug 4 reasonable quantity increase time, takeup type electricity The charge-discharge magnification of core the most correspondingly increases.

In one embodiment, with reference to Figure 12 and Figure 13, takeup type battery core may also include that the 4th lug 7, is welded in the second pole Ear 4 be drawn out to the one end outside takeup type battery core.

In one embodiment, the width of the 4th lug 7 is less than the width of the second lug 4, and the thickness of the 4th lug 7 is big in the thickness of the second lug 4, thus reduce the second lug 4 while the intensity and overflow section ensureing the 4th lug 7 is long-pending The maximum gauge of battery core after welding, improves the energy density of battery core.

Here remarking additionally, the middle part of the second pole piece 3 is formed with the second lug accommodating grooves 33 and refers to second What lug accommodating grooves 33 was arranged at the second pole piece 3 is in volume Two around portion between ending section D2 of the initial segment B2 and volume Two Point.Preferably, what the second lug accommodating grooves 33 was arranged at the second pole piece 3 is in volume Two around the initial segment B2 and volume Two around receipts Mid portion between rear T2, this be currently preferred second lug accommodating grooves 33 position is set, such that it is able to achvious Write ground and reduce the internal resistance of takeup type battery core.

In one embodiment, the first lug 2 can use ultrasonic bonding, laser welding or thermal compression welding mode to be electrically connected to First head blank collector 111.

In one embodiment, the second lug 4 can use ultrasonic bonding, laser welding or thermal compression welding mode to be electrically connected to The second collector 31 at second lug accommodating grooves 33.

In one embodiment, with reference to Fig. 1, Fig. 2, Fig. 7, Fig. 8 and Fig. 9, the second pole piece 3 is also formed with: the second lug pairing Recess 34, bottom is the second collector 31 and week side is the second active material layer 32, is just being positioned at the second lug accommodating grooves 33 To dorsal part.Similar with the second lug accommodating grooves 33, all sides of the second lug pairing recess 34 can be that three bandings close openings at one side, it is alternatively closing both sides, both sides opening Second lug pairing recess 34 beneficially second lug 4 is set and is welded in the second lug receipts Hold in groove 33.

In one embodiment, the second lug accommodating grooves 33 can pass through laser cleaning or mechanical cleaning by the second active substance The corresponding part of layer 32 goes to be formed divided by exposing the second collector 31

In one embodiment, the second lug accommodating grooves 33 can be sent out by preset thermosensitive type before coated cathode diaphragm slurry Bubble gummed paper on the second collector 31, coating afterwards dried cathode diaphragm slurry to be to form the second active material layer 32 and dry During dry negative electrode diaphragm slurry, thermosensitive type foaming gummed paper peels off formation from the second collector 31.

In one embodiment, the second lug pairing recess 34 can pass through laser cleaning or mechanical cleaning by the second active substance The corresponding part of layer 32 goes to be formed divided by exposing the second collector 31.

In one embodiment, the second lug pairing recess 34 can be sent out by preset thermosensitive type before coated cathode diaphragm slurry Bubble gummed paper on the second collector 31, coating afterwards dried cathode diaphragm slurry to be to form the second active material layer 32 and dry During dry negative electrode diaphragm slurry, thermosensitive type foaming gummed paper peels off formation from the second collector 31.

In one embodiment, described takeup type battery core may also include that the first lug double-sided insulation adhesive tape T1, on two sides Bonding isolating membrane 5 and the first lug 2 respectively.

In one embodiment, described takeup type battery core may also include that the second lug accommodating grooves double-sided insulation adhesive tape T2, Cover part the second lug accommodating grooves 33 around whole second lug 4 and the second lug 4.

In one embodiment, described takeup type battery core may also include that the second lug pairing recess double-sided insulation adhesive tape T3, Cover whole second lug pairing recess 34, and distinguish on two sides around bonding isolating membrane 5 and the second lug pairing recess 34 The second active material layer 32.

Here remark additionally, owing to the first lug double-sided insulation adhesive tape T1, the second lug accommodating grooves are with double Face insulating tape T2 and the second lug pairing recess double-sided insulation adhesive tape T3 all uses double-sided insulation adhesive tape, its bonding region ratio During employing single-sided insulation adhesive tape more closely, so that the globality of takeup type battery core is strengthened, and then takeup type battery core is avoided to exist After trimming and discharge and recharge expand, this region protuberance becomes maximum distortion district.In one embodiment, the first lug is with two-sided insulating tape T1 be two-sided initial time time toughness or an one side are initial the most toughness and another one side is through follow-up Hot pressing or sticking two-sided tape after colding pressing.

In one embodiment, the second lug accommodating grooves double-sided insulation adhesive tape T2 be two-sided initial time the most toughness or Be an one side initial time toughness and another one side be through follow-up hot pressing or sticking two-sided tape after colding pressing.

In one embodiment, second lug pairing recess double-sided insulation adhesive tape T3 be two-sided initial time the most toughness or Be an one side initial time toughness and another one side be through follow-up hot pressing or sticking two-sided tape after colding pressing.

Here remark additionally, the first lug double-sided insulation adhesive tape T1, the second lug accommodating grooves with two-sided absolutely Edge adhesive tape T2 and the second lug pairing recess double-sided insulation adhesive tape T3 all includes base material and two surfaces being coated in base material Glue-line.Two-sided initial time the most sticking two-sided tape glue-line can be butadiene-styrene rubber layer, layer of polyurethane, polyacrylate Layer or polyvinylidene fluoride layer.When an one side is initial, toughness and another one side are through follow-up hot pressing or to have after colding pressing viscous in the two-sided tape of property, when an one side is initial, the most sticking glue-line can be butadiene-styrene rubber layer, layer of polyurethane, polyacrylic acid Ester layer or polyvinylidene fluoride layer; And another one side be through follow-up hot pressing or after colding pressing sticking glue-line can be nothing under room temperature Without the pressure sensitive adhesive of tack under the temperature sensitive glue of tack or room temperature.

In one embodiment, the size of the first lug 2 can be with the consistent size of the second lug 4.Further, the first lug The width of 2 can be 6mm, and thickness can be 0.06mm.The width of the second lug 4 is 6mm, and thickness is 0.06mm.

In one embodiment, the thickness of the first active material layer 12 of the first pole piece 1 can be 131 μm, the of the second pole piece 3 The thickness of two active material layers 32 can be 112 μm.

In one embodiment, the first pole piece 1 can be anode pole piece and the second pole piece 3 is cathode pole piece, the first collector 11 For plus plate current-collecting body, the second collector 31 is negative current collector, and the first active material layer 12 is for positive electrode active material layer second Active material layer 32 is negative electrode active material layer.

In one embodiment, the first pole piece 1 can be cathode pole piece and the second pole piece 3 is anode pole piece, the first collector 11 For negative current collector, the second collector 31 is negative current collector, and the first active material layer 12 is for negative electrode active material layer second Active material layer 32 is positive electrode active material layer.

Here remark additionally be the first pole piece 1 described above the first volume around the initial segment B1 for next-door neighbour winding center (first volume can only have flat portion around the initial segment B1 to one layer of first pole piece 1 of the side of (i.e. next-door neighbour's volume pin) through-thickness T Point, as shown in Fig. 1, Fig. 7, Fig. 8; Or this layer the first pole piece 1 can have flat part and the inflection from this flat part inflection Part, as shown in Figure 9) The first volume of the first pole piece 1 is the outermost that the first pole piece 1 is in takeup type battery core around ending section D1 First pole piece 1 of one layer.The volume Two of the second pole piece 2 is around the opposite side that the initial segment B2 is next-door neighbour winding center through-thickness T One layer of second pole piece 2 (similarly, volume Two can only have flat part around the initial segment B2, as shown in Fig. 1, Fig. 7, Fig. 8; Or This layer of person the second pole piece 2 can have flat part and the reverse from this flat part inflection, as shown in Figure 9).Second pole piece The volume Two of 2 is the second pole piece 2 that the second pole piece 2 is in the outermost one layer of takeup type battery core around ending section D2.

The takeup type battery core finally remarked additionally according to the present invention is for flexible packing lithium ion battery reality as an example Execute example and comparative example and test result.Wherein, in the most described embodiment and comparative example, the first pole piece 1 is for cathode pole piece Second pole piece 3 is anode pole piece.

Embodiment 1

With 654190 model flexible packing lithium ion batteries (resultant battery thickness as 4.6mm, width as 40mm, a length of As a example by 90mm), the first lug 2 and

Pole piece model number, positive ion battery (positive battery materials are lithium, nickel cobalt manganese ternary material, graphite as negative), the first lug 2 and the second lug 4 consistent size, the i.e. weld length of lug are 15mm, lug width be 6mm, Thickness is 0.05mm.

Use the structure shown in Fig. 1, pole piece (one side first active material layer 12 of the first pole piece 1 after cold pressing process The thickness of one side the second active material layer 32 that thickness is 131 μm, the second pole piece 3 be 112 μm), use ultra-sonic welded or pricker First lug 2 is welded on the first head blank collector 111 of the first pole piece 1 by welderin or electric resistance welding; Use laser or occupy-place Method is cleaned at the middle part of the second pole piece 3 or reserves the second lug accommodating grooves 33 and the second pole for welding the second lug 4 Ear pairing recess 34, uses ultra-sonic welded or soldering or electric resistance welding that the second lug 4 is welded to the second lug accommodating grooves subsequently in 33.First active material layer 12 uses graphite, and the second active material layer 32 uses cobalt acid lithium.Second lug accommodating grooves 33 All sides are that three bandings close openings at one side.

Embodiment 2

Difference with embodiment 1: all sides of the second lug accommodating grooves 33 are closing both sides, both sides openings.

Comparative example 1

Use structure as shown in figure 13, with the difference of embodiment 1: do not offer on the second pole piece 3 and the first pole piece 1 Any groove, the first lug 2 and the second lug 4 are respectively welded at the first volume first head around the initial segment B1 of the first pole piece 1 The volume Two of blank collector 111 and the second pole piece 3 is on the second head blank collector 31 of the initial segment B2.

Comparative example 2

Use structure as shown in figure 14, with the difference of embodiment 1: offer on the first pole piece 1 and house the first lug 2 First lug accommodating grooves 13, the second pole piece 3 is offered the second lug accommodating grooves 33 housing the second lug 4, and completes the Welding of one lug 2 and the first lug accommodating grooves 13 and welding of the second lug 4 and the second lug accommodating grooves 33.

In embodiment 1-2 and comparative example 1-2, choose 20 flexible packing lithium ion battery samples respectively carry out 1000 and follow ling charge-discharge test, measures the thickness of the sample before and after test, and to the flexible packing lithium ion battery sample after test Product carry out disassembling the situation observing analysis lithium, and acquired results shows as shown in table 1.

Volume test: use nominal current that battery core is charged to nominal upper limit voltage, discharge into nominal current the most again By the electricity that voltage is discharged.

Thickness measuring: measure with calibrator.

Thickness * 100% before deflection=(thickness before average thickness test after test)/test

Table 1 embodiment 1-2 and the test result of comparative example 1-2

Cited By (9)

Publication number	Priority date	Publication date	Assignee	Title
WO2017219345A1 *	2016-06-24	2017-12-28	宁[redacted]公司	Spiral-wound battery cell
CN108206302A *	2017-12-25	2018-06-26	[redacted]公司	A kind of lithium ion battery winds structure
CN110190242A *	2019-03-26	2019-08-30	宁[redacted]公司	Pole piece, battery core and battery
WO2019200538A1 *	2018-04-17	2019-10-24	宁[redacted]公司	Battery cell and battery
CN110380108A *	2018-04-12	2019-10-25	宁[redacted]公司	Battery core and electrochemical appliance with it
KR20200045545A *	2017-11-07	2020-05-04	닝더 엠프렉스 테크놀로지 리미티드	Winding cell
CN111313102A *	2020-03-03	2020-06-19	宁[redacted]公司	Battery cell, electrochemical device comprising same and electronic device
WO2020192651A1 *	2019-03-26	2020-10-01	宁[redacted]公司	Pole piece, battery cell and battery
WO2021134509A1 *	2019-12-31	2021-07-08	宁[redacted]公司	Battery and electronic device
Family To Family Citations				

* Cited by examiner, † Cited by third party, ‡ Family to family citation

Similar Documents

Publication	Publication Date	Title
CN205828957U	2016-12-21	Takeup type battery core
CN109565084A	2019-04-02	Takeup type battery core
KR20140113186A	2014-09-24	Electrode Assembly and Secondary battery with the Same and Method of thereof
EP2509935A2	2012-09-26	Bipolar electrode pair/separation membrane assembly, bipolar battery including same, and production method thereof

CN105794022A	2016-07-20	Secondary battery, and method for producing same
KR20120086974A	2012-08-19	Galvanic cell comprising sheathing
CN104718655A	2015-06-17	Method for manufacturing electrode assembly
US11133560B2	2021-09-28	Insulating tape and li-ion battery adopting the same
CN109786841B	2020-12-15	Preparation method of lithium ion electrochemical energy storage device
CN106159206A	2016-11-23	Method for preparing lithium ion battery pole pieces
CN205542997U	2016-08-31	Polyvinylidene fluoride coating non -woven fabrics diaphragm paper polymer lithium ion secondary cell
CN108470874A	2018-08-31	Improve method, the preparation process of lithium ion battery and the lithium ion battery of battery core extrusion performance
CN109560327B	2021-05-18	Silica gel pad and application thereof in preparation of lithium ion battery
CN108159931SB	2018-12-04	Flexible battery and preparation method thereof
CN205828567U	2016-12-21	Secondary cell battery core
CN109417152A	2019-03-01	Secondary cell battery core
CN111430671A	2020-07-17	Bipolar pole piece and preparation method thereof, lithium ion battery and preparation method thereof
FR3019804B1	2019-05-31	Method for evaluating insulating performance of separator for electrochemical device
CN207530064U	2018-06-22	A kind of lithium battery electric core with double faced adhesive tape
CN110654347A	2020-02-28	Electrochemical device and separator thereof
CN111009679A	2020-04-14	Three-electrode battery cell, three-electrode soft package battery and preparation method thereof
CN205814851U	2017-05-03	High voltage fills lithium ion battery soon
CN102013528A	2011-04-13	Improved lithium ion battery manufacture process
CN107684127B	2020-07-07	Secondary battery core
CN108376822A	2018-08-03	Pole drying device and include battery unit according to the electrode of pole drying device manufacturing

Priority And Related Applications

Priority Applications (1)

Application	Priority date	Filing date	Title
CN201620639646.9U	2016-06-24	2016-06-24	Takeup type battery core

Applications Claiming Priority (1)

Application	Filing date	Title
CN201620639646.9U	2016-06-24	Takeup type battery core

Legal Events

Date	Code	Title	Description
2016-12-21	GR01	Patent grant	
2016-12-21	C14	Grant of patent or utility model	

Concepts

machine-extracted

Download Filter table

Name	Image	Sections	Count	Query match
active material		claims,abstract,description	46	0.000
membrane		claims,abstract,description	10	0.000

negative electrode material	claims,description	4	0.000
positive electrode material	claims,description	4	0.000
fluid	claims	1	0.000
recycling	abstract,description	2	0.000

Show all concepts from the description section

A kind of polymer battery electrode and its battery

Abstract

The utility model is related to battery technology field, more particularly, to a kind of polymer battery electrode and its battery, including pole piece, the active material and lug that are coated on the pole piece; It is characterized in that, the lug is arranged on the lug blank space in centre position on pole piece, the blank of 10-50mm is left close to active material in the both sides of the lug between the bottom of the lug and place pole piece bottom;The outer surface of lug is additionally provided with high-temperature insulating layer on the pole piece; The utility model not only increases production efficiency, and the internal resistance of cell, high rate performance are improved significantly.

Classifications

- Y02E60/10 Energy storage using batteries

CN207459051U

China

Download PDF Find Prior Art Similar

Other languages: Chinese

Inventor: [redacted]

Current Assignee : Dongguan Poly New Energy Co Ltd

Worldwide applications

2017 CN

Application CN201720829427.1U events

2017-07-10 Application filed by Dongguan Poly New Energy Co Ltd

2017-07-10 Priority to CN201720829427.1U

2018-06-05 Application granted

2018-06-05 Publication of CN207459051U

Info: Cited by (2), Legal events, Similar documents, Priority and Related Applications

External links: Espacenet, Global Dossier, Discuss

Claims (10)

Hide Dependent

1. a kind of polymer battery electrode, including pole piece, the active material and lug that are coated on the pole piece; Its feature exists The lug blank space in centre position on pole piece is arranged in, the lug, and the both sides of the lug are close to active material, the pole The blank of 10-50mm is left between the bottom of ear and place pole piece bottom;The outer surface of lug is additionally provided with high temperature on the pole piece insulating layer.

2. polymer battery electrode as described in claim 1, which is characterized in that the lug, which is left white, is arranged on the pole piece Middle, the center line of the lug broadside and the wide middle line overlap of the pole piece blank.

3. polymer battery electrode as described in claim 1, which is characterized in that the lug is left white that be arranged on the pole piece long Side hits exactly position to the left, and lug is left white the center line by admedial one side and pole piece long side at a distance of 5-50mm.

4. polymer battery electrode as described in claim 1, which is characterized in that the lug is left white that be arranged on the pole piece long Side hits exactly position to the right, and lug is left white the center line by admedial one side and pole piece long side at a distance of 5-50mm.

5. the polymer battery electrode as described in any one in claim 1-4, which is characterized in that the wide 8- of lug 10mm, the long 400-1200mm of pole piece, thickness of the active material on pole piece are 0.050-0.070mm.

6. a kind of polymer battery, including the membrane between anode, cathode and positive and negative anodes, which is characterized in that it is described it is positive and negative extremely Polymer battery electrode in claim 1-5 described in any one.

7. polymer battery as claimed in claim 6, which is characterized in that the positive and negative lug is all disposed on corresponding pole piece just in position to the left.

8. polymer battery as claimed in claim 6, which is characterized in that the positive and negative lug is all disposed on corresponding pole piece just in position to the right.

9. polymer battery as claimed in claim 6, which is characterized in that the anode ear is arranged on corresponding pole piece and hits exactly partially Left position, the negative electrode lug, which is arranged on corresponding pole piece, hits exactly position to the right.

10. polymer battery as claimed in claim 6, which is characterized in that the anode ear is arranged on corresponding pole piece and hits exactly Position to the right, the negative electrode lug, which is arranged on corresponding pole piece, hits exactly position to the left.

Description

A kind of polymer battery electrode and its battery

Technical field

The utility model is related to battery technology field, more particularly, to a kind of high-multiplying power discharge polymer battery electrode and its Battery.

Background technology

High-multiplying power discharge polymer battery is a kind of rechargeable battery, relies primarily on positive and negative interpolar lithium ion movement and carries out work Make During charging, lithium ion is moved to cathode by anode; During electric discharge, lithium ion is moved to anode by cathode, and anode is in rich lithium shape State How to further improve battery low resistance and high magnification be always target that people pursue, people mainly from active material and Two aspects of battery structure are studied.Existing high-multiplying power discharge electrostrictive polymer pool structure is generally divided into stacked and winding Formula, wherein, the electrode of laminated structure is because mostly using lug lamination process production technology, the internal resistance of cell produced is opposite Relatively low, battery multiplying power discharging property is preferable, but production efficiency is relatively low.Horizontal electrode production efficiency is high, but produces The internal resistance of cell it is higher, multiplying power discharging property is relatively poor.

Utility model content

In view of the above shortcomings of the prior art, the purpose of this utility model in provide a kind of polymer battery electrode and its Battery; Not only internal resistance is small for the polymer battery, but also multiplying power discharging property is high, while production efficiency is high in order to realize above-mentioned skill Art purpose, the utility model adopt the following technical scheme that:

A kind of polymer battery electrode, including pole piece, the active material and lug that are coated on the pole piece; The lug Be arranged on the lug blank space in centre position on pole piece, the both sides of the lug close to active material, the bottom of the lug with The blank of 10-50mm is left between the pole piece bottom of place;The outer surface of lug is additionally provided with high-temperature insulating layer on the pole piece.

It is preferred that the lug is left white the middle for being arranged on the pole piece, center line and the pole of the lug broadside The wide middle line overlap of piece blank.

It is preferred that the lug, which is left white, is arranged on pole piece long side center position to the left, lug is left white close to center One side and pole piece long side center line at a distance of 5-50mm.

It is preferred that the lug, which is left white, is arranged on pole piece long side center position to the right, lug is left white close to center One side and pole piece long side center line at a distance of 5-50mm.

It is preferred that the wide 3-10mm of lug, the long 400-1200mm of pole piece, thickness of the active material on pole piece are 0.050-0.070mm.

A kind of polymer battery, including the membrane between anode, cathode and positive and negative anodes, the positive and negative extremely described polymerization Object battery electrode.

It is preferred that the positive and negative lug is all disposed on corresponding pole piece and hits exactly position to the left.

It is preferred that the positive and negative lug is all disposed on corresponding pole piece and hits exactly position to the right.

It is preferred that the anode ear, which is arranged on corresponding pole piece, hits exactly position to the left, the negative electrode lug is arranged on accordingly Position to the right is hit exactly on pole piece.

It is preferred that the anode ear, which is arranged on corresponding pole piece, hits exactly position to the right, the negative electrode lug is arranged on accordingly Position to the left is hit exactly on pole piece.

Lug is arranged on centre position on pole piece by the utility model, and 10- is left between bottom and place pole piece bottom The blank of 50mm, allows ion to gather to centre position, while the both sides of lug, close to active material, ion can also directly pass through Lug side greatly reduces resistance so as to save the distance that part is turned on from electrode slice Wherein, experiment is found, lug exists Deviate the position of the 5-50mm of middle on corresponding pole piece, on the basis of production efficiency is improved, on resistance, multiplying power discharging property It performs better than; The setting of especially positive and negative lug relative dislocation.

Description of the drawings

Fig. 1 is the structure diagram of the utility model embodiment 1,

Fig. 2 is the structure diagram of the utility model embodiment 2,

Fig. 3 is the structure diagram of the utility model embodiment 3,

Fig. 4 is the structure diagram of the utility model embodiment 4-7,

Fig. 5 is the structure diagram of the utility model embodiment 8-11.

Specific embodiment

Specific embodiment of the present utility model is described in further detail below in conjunction with the accompanying drawings.

Embodiment 1

See Fig. 1, a kind of polymer battery, including the membrane between anode 1, cathode 2 and positive and negative anodes.Positive and negative anodes include pole piece 11st, the active material being coated on the pole piece (112、212) With lug 12, positive and negative lug (12、22) It is all disposed within corresponding pole Piece (11、21) Upper center (111、211) Position, the both sides of positive and negative lug are close to active material (112、212) , positive and negative lug The blank of 30mm is left between pole piece bottom corresponding to where it of bottom (110、210) ;The outer surface of positive and negative lug is additionally provided with height Warm insulating layer.

The wherein positive and negative wide 3-10mm of lug, the long 400-1200mm of pole piece, thickness of the active material on pole piece are 0.050-0.070mm.The parameter of lug and pole piece can be adjusted according to the needs of the size of prepared battery reality.

Embodiment 2

See Fig. 2, a kind of polymer battery, including the membrane between anode 1, cathode 2 and positive and negative anodes.Positive and negative anodes include pole Piece, the active material being coated on the pole piece (112、212) And lug, positive and negative lug (12、22) It is all disposed within corresponding pole piece (11、21) Upper center (111、211) The position of 10mm to the left, positive and negative lug (12、22) Both sides close to active material (112、212) , positive and negative lug (12、22) Bottom and corresponding pole piece bottom where it between leave the blank of 10mm (110、210) ,Just The outer surface of negative electrode lug is additionally provided with high-temperature insulating layer.

Embodiment 3

See Fig. 3, a kind of polymer battery, including the membrane between anode 1, cathode 2 and positive and negative anodes.Positive and negative anodes include pole Piece, the active material being coated on the pole piece (112、212) And lug, positive and negative lug (12、22) It is all disposed within corresponding pole piece (11、21) Upper center (111、211) Hit exactly the position of 10mm to the right, positive and negative lug (12、22) Both sides close to active material (112、212) , positive and negative lug (12、22) Bottom and corresponding pole piece bottom where it between leave the blank of 50mm (110、210) ,The outer surface of positive and negative lug is additionally provided with high-temperature insulating layer.

Embodiment 4

See Fig. 4, a kind of polymer battery, including the membrane between anode, cathode and positive and negative anodes.Positive and negative anodes include pole piece 11st, the active material 112 and lug 12 being coated on the pole piece, it is to the right that anode ear 12 is arranged on center 111 on corresponding pole piece The position of 10mm, leaves the blank 120 of 25mm between the bottom of positive and negative ear and corresponding pole piece bottom where it, and the two of anode ear 12 Side is close to active material 112.Negative electrode lug 22 is arranged on the position that 211 10mm to the left are hit exactly on corresponding pole piece The two of negative electrode lug 22.The blank 210 of 25mm is left between 21 bottom of pole piece corresponding to where it of the bottom of negative electrode lug 22 close to active material 212 in side, The outer surface of positive and negative lug is additionally provided with high-temperature insulating layer.

Embodiment 5

With embodiment 4, area is that anode ear 12 is arranged on the position that corresponding 11 on piece of pole hits exactly 111 5mm to the left, negative electrode lug 22 are arranged on the position that 211 5mm to the right are hit exactly on corresponding pole piece 21.

Embodiment 6

With embodiment 4, area is that anode ear 12 is arranged on the position that 111 50mm to the left are hit exactly on corresponding pole piece 11, cathode Ear 22 is arranged on the position that 211 50mm to the right are hit exactly on corresponding pole piece 21.

Embodiment 7

With embodiment 4, area is that anode ear 12 is arranged on the position that 111 8mm to the left are hit exactly on corresponding pole piece 11, negative electrode lug 22 are arranged on the position that 211 20mm to the right are hit exactly on corresponding pole piece 21.

Embodiment 8

See Fig. 5, a kind of polymer battery, including the membrane between anode, cathode and positive and negative anodes.Positive and negative anodes include pole piece, The active material and lug being coated on the pole piece, anode ear 12 are arranged on corresponding 11 on piece of pole and hit exactly 111 30mm/s to the left Position, close to active material 112, the bottom of anode ear 12 is stayed between 11 bottom of pole piece corresponding to where it for the both sides of anode ear 12 There is the blank 110 of 25mm.Negative electrode lug 22, which is arranged on corresponding pole piece 21, hits exactly the 211 inclined positions for having 35mm, and the two of negative electrode lug 22 The blank 210 of 20mm is left between 21 bottom of pole piece corresponding to where it of the bottom of negative electrode lug 22 close to active material 222 in side; The outer surface of positive and negative lug is additionally provided with high-temperature insulating layer.

Embodiment 9

With embodiment 8, area is that anode ear 12 is arranged on the position that 111 40mm to the left are hit exactly on corresponding pole piece 11, cathode Ear 22 is arranged on the position that 211 40mm to the right are hit exactly on corresponding pole piece 21.

Embodiment 10

With embodiment 8, area is that anode ear 12 is arranged on the position that 111 15mm to the left are hit exactly on corresponding pole piece 11, cathode Ear 22 is arranged on the position that 211 15mm to the right are hit exactly on corresponding pole piece 21.

Embodiment 11

With embodiment 8, area is that anode ear 12 is arranged on the position that 111 25mm to the left are hit exactly on corresponding pole piece 11, cathode Ear 22 is arranged on the position that 211 25mm to the right are hit exactly on corresponding pole piece 21

Comparative example 1-1

With embodiment 5, anode ear is arranged on the position that 100mm to the left is hit exactly on corresponding pole piece, and negative electrode lug is arranged on accordingly The position of 100mm to the right is hit exactly on pole piece.

Comparative example 1-2

With embodiment 5, anode ear is arranged on the position that 300mm to the left is hit exactly on corresponding pole piece, and negative electrode lug is arranged on accordingly The position of 300mm to the right is hit exactly on pole piece.

Comparative example 1-3

With embodiment 5, anode ear is arranged on the position that 500mm to the left is hit exactly on corresponding pole piece, and negative electrode lug is arranged on accordingly The position of 500mm to the right is hit exactly on pole piece.

Comparative example 2-1

With embodiment 8, anode ear is arranged on the position that 100mm to the left is hit exactly on corresponding pole piece, and negative electrode lug is arranged on accordingly The position of 100mm to the right is hit exactly on pole piece.

Comparative example 2-2

With embodiment 8, anode ear is arranged on the position that 300mm to the left is hit exactly on corresponding pole piece, and negative electrode lug is arranged on accordingly The position of 300mm to the right is hit exactly on pole piece.

Comparative example 2-3

With embodiment 8, anode ear is arranged on the position that 500mm to the left is hit exactly on corresponding pole piece, and negative electrode lug is arranged on accordingly The position of 500mm to the right is hit exactly on pole piece.

The battery that above-described embodiment and comparative example obtain is checked, the results detailed in following table:

As can be seen from the above table, lug is arranged among pole piece, internal resistance is relatively low, preferable than capacity rate: It wherein will be positive and negative Lug relative dislocation is arranged among pole piece center line 5-50mm partially, and internal resistance is lower, more preferable than capacity rate.

Above-mentioned is the preferred embodiment of the utility model, is not used for limiting the scope of the present invention, therefore all with the present invention Construction, technique equivalent change or modification described in claim, should all be included within scope of the invention as claimed.

Cited By (2)

Publication number	Priority date	Publication date	Assignee	Title
CN111525194A *	2020-04-28	2020-08-11	[redacted]	Electrochemical device and electronic device including the same
CN112117424A *	2019-06-21	2020-12-22	[redacted]	Single battery, power battery pack and vehicle

Family To Family Citations

* Cited by examiner, † Cited by third party, ‡ Family to family citation

Similar Documents

Publication	Publication Date	Title
WO2017105572A3	2017-10-19	Process for producing lithium batteries having an ultra-high energy density
JP2011520214A5	2012-05-17	
CN207459051U	2018-06-05	A kind of polymer battery electrode and its battery
JP2015534243A5	2016-09-15	
JP2010524177A5	2011-05-12	
CN202495523U	2012-10-17	Lithium ion battery and electrode plate thereof
WO2009054632A3	2009-06-18	Stacking type electrochemical cell having quasi-bipolar structure
CN204793030U	2015-11-18	Mix anodal pole piece and lithium ion power batteries
CN109244339A	2019-01-18	A kind of ternary lithium ion battery of high safety high-energy density
CN204905369U	2015-12-23	Lamination electricity core
CN205461398U	2016-09-14	A kind of stacked high-multiplying-power battery pole piece current collector and battery thereof
CN203774413U	2014-08-13	Polymer lithium ion battery cell structure
CN108963321A	2018-12-07	Lithium secondary battery
CN204144367U	2015-02-04	Environmental protection breathable safe battery inner septum
CN105406082A	2016-03-16	Composite pole piece of high-magnification lithium ion battery positive pole and preparation method of composite pole piece
CN207265163U	2018-04-20	A kind of graphene lithium battery structure
CN204991484U	2016-01-20	Honeycomb electrode capacitance ware
CN204144369U	2015-02-04	Point-like ceramic cell inner septum
CN207009589U	2018-02-13	A kind of polymer lithium cell electric core
CN208907878U	2018-01-19	A kind of high-capacity battery
CN205564877U	2016-09-07	Anodal pole piece and winding - type batteries
CN104659218	2018-06-26	Coiled lead-acid accumulator
CN202352752U	2012-07-25	High-capacity high-stability lithium battery

CN207009589U	2018-02-13	A kind of round flow-through polymer lithium cell electric core
CN202067860U	2011-12-07	Cathode current collector of cylindrical zinc-air battery

Priority And Related Applications

Priority Applications (1)

Application	Priority date	Filing date	Title
CN201720829427.1U	2017-07-10	2017-07-10	A kind of polymer battery electrode and its battery

Applications Claiming Priority (1)

Application	Filing date	Title
CN201720829427.1U	2017-07-10	A kind of polymer battery electrode and its battery

Legal Events

Date	Code	Title	Description
2018-06-05	GR01	Patent grant	
2018-06-05	GR01	Patent grant	

Concepts

machine-extracted

Download Filter table

Name	Image	Sections	Count	Query match
polymer		title,claims,abstract,description	26	0.000
active material		claims,abstract,description	23	0.000
corresponding		claims,description	43	0.000
membrane		claims,description	7	0.000
manufacturing process		abstract,description	6	0.000
engineering process		abstract,description	4	0.000

Show all concepts from the description section

Electroactive material for metal ion batteries

Abstract

The present invention relates to a particulate electroactive material consisting of a plurality of composite particles, wherein the composite particles comprise a plurality of silicon nanoparticles dispersed within a conductive carbon matrix. The particulate material comprises 40 to 65 wt% silicon, at least 6 wt% and less than 20% oxygen, and the weight ratio of the total amount of oxygen and nitrogen to silicon is in the range of 0.1 to 0.45 and the weight ratio of carbon to silicon is in the range of 0.1 to 1. The particulate electroactive material may be used as an active component of an anode in a metal-ion battery.

Classifications

- H01M4/362 Composites

View 40 more classifications

CN110753674A

China

Download PDF Find Prior Art Similar

Other languages: Chinese

Inventor: [redacted]

Current Assignee : Nexeon Ltd

Worldwide applications

2017 GB 2018 US KR WO CN JP EP

Application CN201880039126.6A events

2017-06-16 Priority to GB1709685.0A

2017-06-16 Priority to GB1709685.0

2018-06-18 Application filed by Nexeon Ltd

2018-06-18 Priority to PCT/GB2018/051689

2020-02-04 Publication of CN110753674A

Info: Patent citations (9), Cited by (7), Legal events, Similar documents, Priority and Related Applications

External links: Espacenet, Global Dossier, Discuss

Claims (82)

Hide Dependent

1. A method for preparing a particulate material composed of a plurality of composite particles comprising a plurality of silicon nanoparticles dispersed within a conductive pyrolytic carbon matrix, the method comprising the steps of:

(a) milling a silicon starting material in the presence of a non-aqueous solvent to obtain a dispersion of silicon-containing nanoparticles in said solvent, D of said silicon-containing nanoparticles$_{50}$ particle size in the range of 30 to 500 nm;

(b) contacting the dispersion of silicon nanoparticles in the solvent with a pyrolytic carbon precursor selected from one or more compounds comprising at least one oxygen or nitrogen atom;

(c) removing the solvent to provide silicon nanoparticles coated with the pyrolytic carbon precursor;

(d) optionally, prior to step (e), heating the coated silicon nanoparticles to a temperature of 200 to 400 °C for a time of 5 minutes to 10 hours; and

(e) pyrolyzing the coated silicon nanoparticles at a pyrolysis temperature in a range of 600 to 1200 °C to form the plurality of composite particles comprising a plurality of silicon nanoparticles dispersed within a conductive pyrolytic carbon matrix.

2. The method of any one of claims 1, wherein the pyrolytic carbon precursor is selected from one or more aromatic or aliphatic carbon-containing compounds comprising at least one oxygen or nitrogen atom.

3. The method of claim 2, wherein the pyrolytic carbon precursor is selected from carbon-containing compounds comprising one or more electrophilic functional groups, preferably wherein the electrophilic functional groups comprise a carbonyl moiety, more preferably wherein the electrophilic functional groups are ester groups or amide groups.

4. The method of claim 3, wherein the pyrolytic carbon precursor is a polymer or oligomer comprising a carbon-containing backbone and pendant electrophilic functional groups.

5. The method of claim 4, wherein the pyrolytic carbon precursor is polyvinylpyrrolidone (PVP), or a copolymer of vinylpyrrolidone and one or more other ethylenically unsaturated monomers.

6. The method of any one of claims 3 to 5, wherein step (d) comprises cross-linking the silicon nanoparticles and the pyrolytic precursor by reaction between nucleophilic functional groups on the surface of the silicon nanoparticles and electrophilic functional groups of the pyrolytic carbon precursor.

7. The method of claim 6, wherein step (d) comprises: crosslinking the silicon nanoparticles and the pyrolytic carbon precursor under conditions such that the temperature rise in the reaction mixture is controlled to be no greater than 5 °C/min and the maximum temperature of the crosslinking reaction is maintained below 270

°C for the duration of the crosslinking reaction.

8. The method of claim 7, wherein the maximum temperature of the crosslinking reaction is maintained at less than 250 °C, or less than 240 °C, or less than 230 °C, or less than 220 °C, or less than 210 °C, or less than 200 °C for the duration of the crosslinking reaction.

9. The method of any one of claims 6 to 8, wherein step (d) comprises mixing or agitating the coated silicon nanoparticles to ensure a uniform reaction temperature during the crosslinking step.

10. The process according to any one of claims 6 to 9, wherein step (d) is carried out in the presence of oxygen, optionally in the presence of air.

11. The method of any one of claims 6 to 10, wherein step (d) further comprises holding the coated silicon nanoparticles at a temperature in the range of 100 to 400 °C for a period of time after the crosslinking reaction is complete.

12. A method according to any preceding claim, wherein the silicon-containing starting material is selected from metallurgical grade silicon.

13. The method of any preceding claim, wherein the silicon starting material has a purity of at least 95 wt.%, at least 98 wt.%, or at least 99 wt.%.

14. The method of any preceding claim, wherein the silicon starting material comprises no greater than 4 wt.% oxygen, no greater than 2 wt.% oxygen, no greater than 1 wt.% oxygen, or no greater than 0.5 wt.% oxygen.

15. The method of any preceding claim, wherein the silicon-containing starting material consists of D_{50}silicon microparticles having a particle size in the range of 1 to 100 μm, or in the range of 2 to 50 μm, or in the range of 2 to 20 μm, or in the range of 2 to 10 μm.

16. The method of any preceding claim, wherein the solvent is selected from alcohols and ketones, preferably wherein the solvent is isopropanol.

17. A method according to any preceding claim, wherein the dispersion of silicon nanoparticles is contacted with the pyrolytic carbon precursor in situ during milling of silicon such that steps (a) and (b) are performed simultaneously.

18. The method of any one of claims 1 to 16, wherein steps (a) and (b) are performed sequentially.

19. The process of any preceding claim, wherein the solvent is removed in step (c) by rotary evaporation or by spray drying.

20. A method according to any preceding claim wherein step (e) comprises heating the coated silicon nanoparticles to a pyrolysis temperature in the range 700 to 1150 °C, or in the range 800 to 1100 °C, or in the range 900 to 1050 °C.

21. The process according to any preceding claim, wherein step (e) is carried out in an inert atmosphere, preferably under argon or nitrogen, more preferably under nitrogen.

22. The method of any preceding claim, further comprising the steps of:

(f) reducing the size of the composite particles from step (e).

23. The method of any preceding claim, further comprising the steps of:

(g) sieving the composite particles from step (e) or step (f).

24. The method of any preceding claim, further comprising the steps of:

(h) coating the composite particles from step (e), (f) or (g) with a carbon coating.

25. The method of claim 24, wherein the carbon coating is obtained by a Chemical Vapor Deposition (CVD) method.

26. A method according to any preceding claim, wherein the particulate material comprises 40 to 65 wt% silicon, or 43 to 65 wt% silicon, or 45 to 65 wt% silicon, or 48 to 62 wt% silicon, or 50 to 60 wt% silicon, or 52 to 58 wt% silicon.

27. A method according to any preceding claim, wherein the weight ratio of the total amount of oxygen and nitrogen to silicon in the particulate material is in the range 0.1 to 0.45, or 0.1 to 0.42, or 0.1 to 0.4, or 0.1 to 0.38, or 0.1 to 0.35.

28. A method according to any preceding claim, wherein the weight ratio of the total amount of oxygen and nitrogen to silicon in the particulate material is at least 0.2, more preferably at least 0.24, more preferably at least 0.28, more preferably at least 0.3, more preferably at least 0.32, more preferably at least 0.34.

29. The method of any preceding claim, wherein the particulate material comprises at least 80% by weight total of silicon, carbon, oxygen, and nitrogen, at least 85% by weight total of silicon, carbon, oxygen, and nitrogen, at least 90% by weight total of silicon, carbon, oxygen, and nitrogen, or at least 95% by weight total of silicon, carbon, oxygen, and nitrogen, at least 98% by weight total of silicon, carbon, oxygen, and nitrogen, or at least 99% by weight total of silicon, carbon, oxygen, and nitrogen.

30. A method according to any preceding claim, wherein the weight ratio of carbon to silicon in the particulate material is in the range 0.1 to 1.

31. The method of claim 30, wherein the weight ratio of carbon to silicon in the particulate material is at least 0.15, at least 0.2, at least 0.25, or at least 0.3.

32. The method of claim 30 or claim 31, wherein the weight ratio of carbon to silicon in the particulate material is no greater than 0.8, no greater than 0.7, no greater than 0.6, no greater than 0.55, no greater than 0.5, or no greater than 0.45.

33. A method according to any preceding claim, wherein the weight ratio of carbon to the total amount of oxygen and nitrogen in the particulate material is at least 0.7, or at least 0.8, or at least 0.85, or at least 0.9, or at least 0.95.

34. The method of any preceding claim, comprising at least 8 wt% oxygen, or at least 10 wt% oxygen, or at least 12 wt% oxygen, or at least 15 wt% oxygen.

35. A method according to any preceding claim, wherein the particulate material comprises from 2 to 6 wt% nitrogen, more preferably from 2.5 to 5 wt% nitrogen, more preferably from 3 to 4.5 wt% nitrogen, and most preferably from 3.5 to 4.5 wt% nitrogen.

36. The method of any preceding claim, wherein the particulate material comprises at least 10 wt% carbon, at least 15 wt% carbon, or at least 18 wt% carbon.

37. The method of any preceding claim, wherein the particulate material comprises no greater than 35 wt% carbon, no greater than 30 wt% carbon, no greater than 28 wt% carbon, or no greater than 25 wt% carbon.

38. A particulate material consisting of a plurality of composite particles, wherein the composite particles comprise a plurality of silicon nanoparticles dispersed within a conductive carbon matrix, wherein:

the silicon nanoparticles comprise a nanoparticle core and a nanoparticle surface, wherein the nanoparticle surface comprises a compound of oxygen or a compound of nitrogen or a mixture thereof disposed between the nanoparticle core and the conductive carbon matrix;

the particulate material comprises 40 to 65 wt% silicon;

the particulate material comprises at least 6 wt% and less than 20 wt% oxygen;

the weight ratio of the total amount of oxygen and nitrogen to silicon in the particulate material is in the range of 0.1 to 0.45; and is

The weight ratio of carbon to silicon in the particulate material is in the range of 0.1 to 1.

39. A particulate material consisting of a plurality of composite particles, wherein the composite particles comprise a plurality of silicon nanoparticles dispersed within a conductive carbon matrix, wherein:

the silicon nanoparticle comprises a nanoparticle core and a nanoparticle surface, wherein a plurality of bridging oxygen atoms and/or a plurality of bridging nitrogen atoms are located between the nanoparticle surface and at least a portion of the conductive carbon matrix such that the conductive carbon matrix is chemically bound to the nanoparticle surface; and is

The particulate material comprises 40 to 65 wt% silicon;

the particulate material comprises at least 6 wt% and less than 20 wt% oxygen;

a weight ratio of a total amount of oxygen and nitrogen in the particulate material to silicon in the particulate material is in a range of 0.1 to 0.45; and is

The weight ratio of carbon to silicon in the particulate material is in the range of 0.1 to 1.

40. The particulate material of claim 38 or 39, comprising 43 to 65 wt.% silicon, or 45 to 65 wt.% silicon, or 48 to 62 wt.% silicon, or 50 to 60 wt.% silicon, or 52 to 58 wt.% silicon.

41. The particulate material of any one of claims 38 to 40, wherein a weight ratio of a total amount of oxygen and nitrogen to silicon in the particulate material is not greater than 0.42, or not greater than 0.4, or not greater than 0.38, or not greater than 0.35.

42. The particulate material of any one of claims 38 to 41, wherein the weight ratio of the total amount of oxygen and nitrogen to silicon in the particulate material is at least 0.2, more preferably at least 0.24, more preferably at least 0.28, more preferably at least 0.3, more preferably at least 0.32, more preferably at least 0.34.

43. The particulate material of any one of claims 38 to 42, comprising at least 80 wt.% silicon, carbon, oxygen and nitrogen in total, at least 85 wt.% silicon, oxygen, nitrogen and carbon in total, or at least 90 wt.% silicon, oxygen, nitrogen and carbon in total, or at least 95 wt.% silicon, oxygen, nitrogen and carbon in total, at least 98 wt.% silicon, oxygen, nitrogen and carbon in total, or at least 99 wt.% silicon, oxygen, nitrogen and carbon in total.

44. The particulate material of any one of claims 38 to 43, wherein the weight ratio of carbon to silicon is at least 0.15, at least 0.2, at least 0.25, or at least 0.3.

45. The particulate material of any one of claims 38 to 44, wherein the weight ratio of carbon to silicon is not greater than 0.8, not greater than 0.7, not greater than 0.6, not greater than 0.55, not greater than 0.5, not greater than 0.45.

46. The particulate material of any one of claims 38 to 45, wherein a weight ratio of carbon to a total amount of oxygen and nitrogen in the particulate material is at least 0.7, or at least 0.8, or at least 0.85, or at least 0.9, or at least 0.95.

47. The particulate material of any one of claims 38 to 46, comprising at least 8 wt.% oxygen, or at least 10 wt.% oxygen, or at least 12 wt.% oxygen, or at least 15 wt.% oxygen.

48. The particulate material of any one of claims 38 to 47, comprising 2 to 6 wt% nitrogen, more preferably 2.5 to 5 wt% nitrogen, more preferably 3 to 4.5 wt% nitrogen, and most preferably 3.5 to 4.5 wt% nitrogen.

49. The particulate material of any one of claims 38 to 48, comprising at least 10 wt.% carbon, at least 15 wt.% carbon, or at least 18 wt.% carbon.

50. The particulate material of any one of claims 38 to 49, comprising not greater than 35 wt.% carbon, not greater than 30 wt.% carbon, not greater than 28 wt.% carbon, or not greater than 25 wt.% carbon.

51. The particulate material of any one of claims 38 to 50, wherein the electrically conductive carbon matrix is obtainable by pyrolysis of a pyrolysed carbon precursor selected from one or more aromatic or aliphatic carbon-containing compounds comprising at least one oxygen or nitrogen atom.

52. The particulate material of any one of claims 38 to 51, wherein the composite particles have a D in a range of 1 to 25 μm_{50}And (4) the particle size.

53. The particulate material of claim 52, wherein the composite particles have a D of at least 2 µm, at least 3 µm, at least 4 µm, or at least 5 μm_{50}And (4) the particle size.

54. The particulate material of claim 52 or claim 53, wherein the composite particles have a D of not greater than 20 µm, not greater than 18 µm, not greater than 15 µm, not greater than 12 µm, or not greater than 10 μm_{50}And (4) the particle size.

55. The particulate material of any one of claims 38 to 54, wherein the composite particles have a D of at least 0.5 µm, at least 1 µm, or at least 2 μm_{10}And (4) the particle size.

56. The particulate material of any one of claims 38 to 55, wherein the composite particles have a D of not greater than 40 µm, not greater than 30 µm, not greater than 25 µm, not greater than 20 μm_{90}And (4) the particle size.

57. The particulate material of any one of claims 38 to 56, wherein the composite particles have a particle size distribution span of 5 or less, 4 or less, 3 or less, 2 or less, or 1.5 or less.

58. The particulate material of any one of claims 38 to 57, wherein the silicon nanoparticles have a D in the range of 30 to 500nm$_{50}$And (4) the particle size.

59. The particulate material of claim 58, wherein the silicon nanoparticles have a D of at least 50nm, or at least 60nm, or at least 70nm, or at least 75nm, or at least 80nm$_{50}$And (4) the particle size.

60. The particulate material of claim 58 or claim 59, wherein the silicon nanoparticles have a D of no greater than 300nm, or no greater than 250nm, or no greater than 200nm, or no greater than 150nm, or no greater than 120nm$_{50}$And (4) the particle size.

61. The particulate material of any one of claims 38 to 60, wherein the silicon nanoparticles have a D of at least 10nm, or at least 20nm, or at least 40nm, or at least 60nm$_{;0}$And (4) the particle size.

62. The particulate material of any one of claims 38 to 61, wherein the silicon nanoparticles have a Dp of not greater than 500nm, not greater than 400nm, not greater than 300nm, or not greater than 200nm$_{50}$And (4) the particle size.

63. The particulate material of any one of claims 38 to 62, wherein the silicon nanoparticles have a particle size distribution span of 5 or less, 4 or less, 3 or less, 2 or less, or 1.5 or less.

64. The particulate material of any one of claims 38 to 63, comprising 0.1 to 8 wt% of one or more elements selected from the group consisting of aluminium, iron, copper, gallium, magnesium, calcium, titanium and zirconium.

65. The particulate material of any one of claims 38 to 64, wherein the composite particles have an intra-granular porosity of not greater than 30%, not greater than 20%, not greater than 10%, not greater than 5%, or not greater than 2%, as determined by mercury intrusion.

66. The particulate material of any one of claims 38 to 65, wherein the composite particles have no greater than 100m^2(g) not more than 80m^2(ii) g is not more than 60m^2(iv) g, not more than 40m^2(g) not more than 30m^2(ii) g is not more than 25m^2(ii) g is not more than 20m^2/g, or not more than 15m^{2}BET surface area in g.

67. The particulate material of any one of claims 38 to 66, wherein the composite particles have at least 0.1m^{2}A ratio of/g, at least 1m^{2}A/g of at least 2m^{2}Per g, or at least 5m^{2}BET surface area in g.

68. The particulate material of any one of claims 38 to 67, having a specific capacity of 1200 to 2340mAh/g upon lithiation.

69. The particulate material of any one of claims 38 to 68, wherein the silicon nanoparticles are characterized by Si (111) lattice spacings of at least 10nm, at least 12nm, at least 14nm, or at least 16 nm, and/or a Si (111) lattice spacing of no greater than 100nm, no greater than 60nm, or no greater than 35nm, wherein the Si (111) lattice spacing is measured by X-ray diffraction (XRD) techniques.

70. A particulate material consisting of a plurality of composite particles, wherein the particulate material is obtainable according to the method of any one of claims 1 to 37.

71. A composition comprising a particulate material as defined in any one of claims 38 to 70 and at least one further component.

72. A composition according to claim 71, which is an electrode composition comprising a particulate material as defined in any one of claims 38 to 70 and at least one further component selected from: (i) a binder; (ii) a conductive additive; and (iii) a further particulate electroactive material.

73. The electrode composition of claim 72, wherein the particulate material comprises 0.5 to 80, 1 to 70, 1 to 60, 2 to 50, 2 to 40, 2 to 30, or 5 to 15 weight percent of the total dry weight of the electrode composition.

74. An electrode composition according to claim 72 or claim 73 comprising at least one further particulate electroactive material.

75. The electrode composition of claim 74, wherein said at least one additional particulate electroactive material is selected from the group consisting of graphite, hard carbon black, silicon, germanium, gallium, aluminium, and lead.

76. The electrode composition of any one of claims 72 to 75, said electrode composition binder, optionally, being included in an amount of 0.5 to 20 wt.%, 1 to 15 wt.%, or 2 to 10 wt.%, based on the total dry weight of the electrode composition.

77. The electrode composition of any one of claims 72 to 76, comprising one or more conductive additives, optionally in a total amount of 0.5 to 20 wt.%, 1 to 15 wt.%, or 2 to 10 wt.%, based on the total dry weight of the electrode composition.

78. An electrode comprising a particulate material as defined in any one of claims 38 to 70 in electrical contact with a current collector.

79. The electrode according to claim 78 wherein the particulate material is in the form of an electrode composition as defined in any one of claims 72 to 77.

80. A rechargeable metal-ion battery, comprising: (i) an anode, wherein the anode comprises an electrode as set forth in claim 78 or claim 79; (ii) a cathode comprising a cathode active material capable of releasing and reabsorbing metal ions; and (iii) an electrolyte between the anode and the cathode.

81. Use of a particulate material as defined in any one of claims 38 to 70 as an anode active material.

82. The use according to claim 81, wherein the particulate material is in the form of an electrode composition as defined in any one of claims 72 to 77.

Description

Electroactive material for metal ion batteries

The present invention relates generally to electroactive materials for electrodes of rechargeable metal ion batteries, and more particularly to electroactive materials having high electrochemical capacity suitable for use as anode active materials in rechargeable metal ion batteries. The particulate electroactive material of the present invention has particular utility in hybrid anodes comprising two or more different electroactive materials. Methods for preparing the particulate electroactive materials of the invention are also provided.

Rechargeable metal-ion batteries are widely used in portable electronic devices such as mobile phones and notebook computers, and are increasingly being applied to electric vehicles or hybrid vehicles. Rechargeable metal-ion batteries generally include an anode layer, a cathode layer, an electrolyte that transports metal ions between the anode layer and the cathode layer, and an electrically insulating porous separator disposed between the anode and cathode. The cathode generally includes a metal current collector provided with a layer of a metal oxide-based composite material containing metal ions, while the anode generally includes a metal current collector provided with a layer of an electroactive material, which is defined herein as a material capable of intercalating and deintercalating metal ions during charging and discharging of the battery. For the avoidance of doubt, the terms "cathode" and "anode" as used herein are used in the sense that the cell is placed across a load such that the cathode is positive and the anode is negative. When the metal-ion battery is charged, metal ions are transported from the metal-ion-containing cathode layer to the anode via the electrolyte and are embedded in the anode material. The term "battery" is used herein to refer not only to devices comprising a single anode and a single cathode, but also to devices comprising multiple anodes and/or multiple cathodes.

There is interest in increasing the weight and/or volume capacity of rechargeable metal-ion batteries. The use of lithium ion batteries has provided for when compared to other battery technologiesThere is still room for further development although a number of improvements are available. Up to now, commercial lithium ion batteries are largely limited to the use of graphite as an anode active material. When a graphite anode is charged, lithium is intercalated between graphite layers to form Li_xC_6 having an empirical formula x (where x is greater than 0 and less than or equal to 1). Thus, graphite has a maximum theoretical capacity of 372mAh/g in lithium ion batteries, with a slightly lower actual capacity (about 340 to 360 mAh/g). Other materials, such as silicon, tin and germanium, are capable of intercalating lithium with significantly higher capacity than graphite, but have not gained widespread commercial use due to the difficulty in maintaining adequate capacity over numerous charge/discharge cycles.

In particular, silicon has been identified as a promising alternative to graphite for the manufacture of Rechargeable metal ion batteries with high weight and volume capacity due to its very high capacity for lithium (see, e.g., Insert electrode Materials for Rechargeable lithium batteries), Winter, m. et al in adv. material.1998, 10, No. 10). At room temperature, silicon has a theoretical maximum specific capacity of about 3,600mAh/g (based on Li) in lithium ion batteries$_{15}Si_4$). However, the use of silicon as an anode material is complicated by large volume changes upon charging and discharging.

The intercalation of lithium into bulk silicon results in a large increase in the volume of the silicon material (up to 400% of its initial volume when the silicon is lithiated to its maximum capacity) and repeated charge-discharge cycles cause significant mechanical strain in the silicon material, leading to cracking and delamination of the silicon anode material. The volume shrinkage of the silicon particles during delithiation can lead to a loss of electrical contact between the anode material and the current collector. In addition, the Solid Electrolyte Interface (SEI) layer formed on the silicon surface does not have sufficient mechanical tolerance to accommodate expansion and contraction of silicon. Thus, the newly exposed silicon surface leads to further electrolyte decomposition and increased thickness of the SEI layer and irreversible lithium depletion. These failure mechanisms collectively result in an unacceptable loss of electrochemical capacity over successive charge and discharge cycles.

Various approaches have been proposed to overcome the problems associated with the volume change observed when charging silicon-containing anodes. The most widespread approach to address the irreversible capacity loss of silicon-containing anodes is to use nanostructured silicon particles as electroactive materials. It is reported that silicon nanoparticles and nanostructured silicon are more tolerant to volume changes upon charging and discharging when compared to micron-sized particles. However, nano-sized particles are not particularly suitable for commercial scale applications because they are difficult to prepare and handle. For example, nano-sized particles tend to form agglomerates, making it difficult to obtain a beneficial dispersion of the particles within the anode material matrix. Furthermore, the formation of agglomerates of nano-sized particles results in an unacceptable loss of capacity upon repeated charge-discharge cycles.

Ohara et al (Journal of Power Sources 136(2004)303-306) describe the evaporation of silicon as a thin film onto a nickel foil current collector and the use of this structure as the anode of a lithium ion battery. While this method provides good capacity retention, the thin film structure does not provide useful amounts of capacity per unit area and eliminates any improvement as the film thickness increases.

WO 2007/083155 discloses that by using silicon particles with a high aspect ratio (i.e. the ratio of the largest dimension to the smallest dimension of the particles), an improved capacity retention can be obtained.

US 6,334,939 and US 6,514,395 disclose silicon-based nanostructures such as caged spherical particles containing void spaces to provide a buffer region for expansion that occurs when lithium is intercalated into silicon.

WO 2012/175992 discloses particles comprising a plurality of silicon-containing pillars extending from a core of the particle, which may be formed, for example, by chemical etching or sputtering methods.

While it remains a long-term goal to produce cells in which the anode electroactive material is primarily or entirely silicon, a more direct goal of cell manufacturers is to determine the way to supplement the capacity of graphite anodes with small amounts of silicon. The current focus is therefore on the gradual improvement of existing metal-ion battery technology by using "hybrid" electrodes, in which conventional graphite-based electrodes are improved by the inclusion of small amounts of silicon.

The use of hybrid electrodes presents its own challenges. Any additional electroactive material must be provided in a form that is compatible with the graphite particulate forms typically used in metal-ion batteries. For example, it must be possible to disperse the additional electroactive material throughout the graphite particle matrix, and the particles of the additional electroactive material must have sufficient structural integrity to withstand compounding with the graphite particles and subsequent formation of the electrode layer, e.g., by steps such as compression, drying, and calendaring.

US 8,526,166 discloses a lithium ion capacitor comprising a mixed anode active material comprising two types of active material particles. The first active material particles are selected from activated carbon particles, such as graphite particles, and the second active material particles comprise silica and have a particle size of 10 to 100 nm.

WO 2015/157358 discloses an anode for a lithium ion battery, wherein the anode active material comprises graphite and nano-sized particles comprising crystalline silicon and SiO, e.g. obtained by metallothermic reduction of silicon dioxide$_2$A mixture of (s). Crystalline silicon and SiO_2Mixture of (1) (commonly known as $SiO)_x$) May be used in combination with other anode materials such as carbon-based anode materials.

Despite efforts to date, there remains a need to improve the electrochemical storage capacity of lithium ion batteries. In particular, there remains a need to identify alternative silicon-based materials that provide the benefits of high lithiation capacity of silicon, but also have sufficient capacity retention and structural stability for use in commercially viable rechargeable batteries.

In a first aspect, the present invention provides a process for preparing a particulate material consisting of a plurality of composite particles comprising a plurality of silicon nanoparticles dispersed within a conductive pyrolytic carbon matrix, the process comprising the steps of:

(a) milling a silicon starting material in the presence of a non-aqueous solvent to obtain a dispersion of silicon-containing nanoparticles in said solvent, (i) of said silicon-containing nanoparticles$_{50}$Having a particle size of 30 to 500nmWithin the range:

(b) contacting a dispersion of silicon nanoparticles in the solvent with a pyrolytic carbon precursor selected from one or more compounds comprising at least one oxygen or nitrogen atom;

(c) removing the solvent to provide silicon nanoparticles coated with a pyrolytic carbon precursor;

(d) optionally heating the coated silicon nanoparticles to a temperature of 100 to 400 °C for a time of 5 minutes to 10 hours prior to step (e); and

(e) pyrolyzing the coated silicon nanoparticles at a pyrolysis temperature in a range of 600 to 1200 °C to form the plurality of composite particles comprising a plurality of silicon nanoparticles dispersed within a conductive pyrolytic carbon matrix.

As used herein, the term "composite particle" should be understood to refer primarily to a particle comprising a plurality of silicon nanoparticles dispersed within a conductive carbon matrix. However, it is not excluded that there may be some degree of statistical variation in the distribution of the silicon nanoparticles between the particles constituting the particulate material of the present invention. In the extreme case of such statistical variations, there may be a small number of particles containing only a single silicon nanoparticle, or even only a conductive carbon matrix material. Reference herein to "a particulate material consisting of a plurality of composite particles, wherein the composite particles comprise a plurality of silicon nanoparticles dispersed within a conductive pyrolytic carbon matrix," reference to "a particulate material" and reference to "a composite particle" should be understood to encompass such statistical variation in the composition of individual particles.

Milling silicon to form nanoparticles results in a significant increase in the surface area of the silicon. The newly exposed silicon surface has high reactivity and often spontaneously forms an oxide layer, which degrades electrochemical performance. Without being bound by theory, it is believed that milling the silicon-containing starting material in the presence of a non-aqueous solvent controls the oxidation of the silicon surface. The silanol groups at the surface of the silicon nanoparticles can then be reacted with oxygen-containing or nitrogen-containing functional groups from the pyrolytic carbon precursor to provide functionalized silicon nanoparticle intermediates. After pyrolysis, the reaction between the oxygen or nitrogen-containing functional groups from the pyrolytic carbon precursor and the silicon surface forms a permanent bond at the interface between the carbon matrix and the surface of the silicon nanoparticles. This bond ensures that a strong connection between the silicon nanoparticles and the carbon matrix is maintained even as the silicon nanoparticles expand and contract during charging and discharging, providing the advantages described herein with respect to the second and third aspects of the invention.

The pyrolytic carbon precursor is preferably selected from aromatic or aliphatic carbon containing precursor materials comprising at least one oxygen or nitrogen atom.

Examples of suitable aromatic pyrolytic carbon precursors include one or more of the following: pyrole, acrylonitrile, 2, 3-dihydroxynaphthalene, 2, 3-diaminonaphthalene, 1, 8-dihydroxynaphthalene, 1, 8-diaminonaphthalene, 1, 5-dihydroxynaphthalene, 1, 5-diaminonaphthalene, 1, 8-dihydroxyanthracene, 2, 3-dihydroxyanthracene, 2, 3-diaminoanthracene, 4, 5-dihydroxyanthracene, 4, 5-diaminoanthracene, 9, 10-phenanthrenequinone, 2, 3-dihydroxytetracene, fluorinated 2, 3-dihydroxytetracene, trifluoro-methyl-2, 3-dihydroxytetracene, 2, 3-diaminotetracene, fluorinated 2, 3-diaminotetracene, trifluoromethyl-2, 3-diaminotetracene, 2, 3-dihydroxypentacene, fluorinated 2, 3-dihydroxypentacene, trifluoromethyl-2, 3-dihydroxypentacene, 2, 3-diaminopentabenzene, fluorinated 2, 3-diaminopentabenzene, trifluoromethyl-2, 3-diaminopentabenzene, 2, 3-dihydroxyhexacene, fluorinated 2, 3-dihydroxyhexacene, trifluoromethyl-2, 3-dihydroxyhexacene, 2, 3-diaminohexacene, fluorinated 2, 3-diaminohexacene, trifluoromethyl-2, 3-diaminohexacene, 1, 2-dihydroxypyrene, fluorinated 1, 2-dihydroxypyrene, trifluoromethyl-1, 2-dihydroxypyrene, 1, 2-diaminopyrene, fluorinated 1, 2-diaminopyrene, trifluoromethyl-1, 2-diaminopyrene, catechol, dihydroxypyreneFluorinated dihydroxyTrifluoromethyl dihydroxyCorrole (corrole), porphyrin, hepta-2, 4,6-triene-one, maleic acid, benzonitrile, fumaronitrile (fumaronitrile), 4, 5-dihydroxybisphenol, 2, 3-dihydroxybisphenol, benzidine (benzidene), dihydroxystilbene, linoleic acid (eteronic acid), eicosapentaenoic acid, gamma-linolenic acid, quinoline, isoquinoline, indole, purine, imidazole, aderine, guanine, tetrahydroquinoline, 1, 2-dihydroquinoline, quinolin-2 (1H) -one, isoquinolin-2 (1H) -one, carbazole, phenoxazine, phenothiazine, phenoxathiin (phenoxathiine), 2, 3-dihydmazaarsathiane2, 5-dihydroazepinesAza derivatives1, 2-diazepines1, 3-diazepines1, 4-diazepines1, 6-dihydropyrrolo- [2, 3-b]-pyrrole, indoline, 3H-indole, 1H-indole, 2H-indole, 1H-indazole, benzimidazole, 4-azaindole, 5-azaindole, 6-azaindole, 7-azaindole, isophthalic acid, terephthalic acid, phenolic resin, tannic acid, furfuryl alcohol and 2-naphthol.

Preferred aromatic pyrolytic carbon precursors include catechol, 2, 3-dihydroxynaphthalene, 1, 5-dihydroxynaphthalene, 2, 3-dihydroxyanthracene, and 1, 5-dihydroxyanthracene, and mixtures thereof.

Pyrolytic carbon precursors also include alkanediols, polyvinyl alcohol, camphor, and rosin (gum rosin).

Suitable pyrolytic carbon precursors also include carbon-containing compounds that contain one or more electrophilic functional groups, particularly functional groups that contain a carbonyl moiety, preferably an ester or amide group. Preferably, the pyrolytic carbon precursor comprises a polymer or oligomer comprising a carbon-containing backbone and pendant electrophilic functional groups, preferably pendant functional groups comprising carbonyl moieties, more preferably pendant amide groups or ester groups, especially pendant cyclic ester groups or amide groups. Most preferably, the pyrolytic carbon precursor comprises a polymer or oligomer comprising a carbon-containing backbone and pendant cyclic amide groups. Particularly preferred pyrolytic carbon precursors in this class include polyvinylpyrrolidone (PVP) homopolymer, and copolymers of vinylpyrrolidone with one or more other ethylenically unsaturated monomers. Preferably, the copolymer of vinylpyrrolidone comprises at least 50 mol% of vinylpyrrolidone monomer.

Optional step (d) includes heating the coated silicon nanoparticles to a temperature in the range of 100 to 400 °C, optionally 200 to 400 °C, for a period of time (e.g., 5 minutes to 10 hours) before further heating the coated silicon nanoparticles to a pyrolysis temperature. Preferably, the temperature in step (d) is selected such that it is between the melting point and the boiling point of the pyrolytic carbon precursor.

In a preferred embodiment of the claimed method, the pyrolytic carbon precursor is selected from compounds comprising one or more electrophilic functional groups as described above, and step (d) comprises forming cross-links between nucleophilic functional groups on the surface of the silicon nanoparticles and electrophilic functional groups of the pyrolytic carbon precursor.

It has been found that the cross-linking reaction between the silicon nanoparticles and the pyrolytic carbon precursor results in the formation of a denser and more strongly bonded conductive carbon matrix with lower microporosity. Thus, the conductive carbon matrix has higher conductivity, and the composite particle exhibits reduced first cycle loss. However, the inventors have found that this cross-linking reaction (also referred to herein as the curing reaction) between the silicon nanoparticles and the pyrolytic carbon precursor is highly exothermic, and that controlling the reaction temperature is a key factor in the effective cross-linking process, and thus the elemental composition of the composite particles can be controlled within the preferred ranges described below and associated with the second and third aspects of the invention.

In particular, the present inventors have determined that when silicon nanoparticles coated with a pyrolytic carbon precursor comprising one or more electrophilic functional groups (e.g., PVP) are heated to above 160 °C, the resulting crosslinking reaction is highly exothermic, resulting in a rapid and uncontrolled temperature rise. The inventors have observed that the temperature of the particles within the furnace or kiln can vary significantly depending on location and other characteristics (such as the size and shape of the crucible), with the result that the temperature in the crosslinking reaction can be highly non-uniform, which adversely affects the properties of the final composite particles.

Without being bound by theory, it is believed that the excess heat generated due to the exothermic crosslinking reaction results in the cracking of the pyrolytic carbon precursor and the loss of electrophilic functional groups before the crosslinking reaction can be completed. Thus, the cleaved electrophilic functional groups are no

longer available to participate in the crosslinking reaction with the surface of the silicon nanoparticles. Thus, insufficient crosslinking results in poor properties of the final composite particle.

It has therefore been found that careful control of the conditions in step (d) enables the degree of cross-linking obtained in the cross-linking reaction to be maximised by avoiding unwanted cleavage reactions caused by excess heat from the reaction, thereby resulting in an improved carbon substrate after pyrolysis in step (e).

Thus, according to the claimed process, as described above, the pyrolytic carbon precursor is preferably selected from compounds comprising one or more electrophilic functional groups, and step (d) comprises crosslinking the coated silicon nanoparticles and pyrolytic carbon precursor under conditions such that the temperature rise in the reaction mixture is controlled to be no more than 5 °C/min and the maximum temperature of the crosslinking reaction is maintained below 270 °C for the duration of the crosslinking reaction. Completion of the crosslinking reaction can be determined by cessation of heat generation by the reaction exotherm.

Preferably, step (d) further comprises mixing or stirring the coated silicon nanoparticles to ensure a uniform reaction temperature during the crosslinking step. For example, step (d) may be carried out in a rotary kiln.

Optionally, the maximum temperature of the crosslinking reaction is maintained below 250 °C, below 240 °C, below 230 °C, below 220 °C, below 210 °C or below 200 °C for the duration of the crosslinking reaction.

The controlled crosslinking reaction in step (d) according to the present invention results in a unique interface structure between the silicon nanoparticle core and the conductive carbon matrix after the pyrolysis of step (e). Specifically, the crosslinking reaction results in the presence of nitrogen and oxygen compounds at the interface between the silicon nanoparticle core and the conductive carbon matrix. It is believed that these oxygen and nitrogen compounds take the form of multiple bridging oxygen atoms and/or multiple bridging nitrogen atoms disposed between the nanoparticle surface and the conductive carbon matrix. Thus, the content of oxygen and/or nitrogen in the composite particles after pyrolysis is indicative for an efficient crosslinking process and is therefore associated with improved performance.

More preferably, the pyrolytic carbon precursor is selected from the group consisting of polymers or oligomers comprising a carbon containing backbone structure and pendant electrophilic functional groups, preferably functional groups comprising a carbonyl moiety, more preferably amide groups or ester groups, especially cyclic ester groups or amide groups. In the case of a crosslinking reaction, a particularly preferred pyrolytic carbon precursor is polyvinylpyrrolidone (PVP), or a copolymer of vinylpyrrolidone as described above.

Preferably, the crosslinking reaction in step (d) is carried out in the presence of oxygen. For example, the crosslinking reaction in step (d) may be carried out in the presence of air. While the presence of oxygen (e.g., from air) was found to promote the crosslinking reaction, excessive temperatures in the crosslinking reaction may result in undesirable oxidation of the silicon to silica. Thus, in addition to optimizing the crosslinking reaction, the process of the present invention also reduces the unwanted oxidation of silica.

Most preferably, the pyrolytic carbon precursor is PVP and step (d) comprises cross-linking the coated silicon nanoparticles, the reaction temperature being controlled in the range of 100 to 300 °C, more preferably 150 to 280 °C, more preferably 180 to 280 °C for the duration of the cross-linking reaction; wherein the crosslinking reaction is carried out in the presence of air.

Optionally, step (d) may include holding the coated silicon nanoparticles at a temperature in the range of 100 to 400 °C for a period of time (e.g., 10 minutes to 2 hours) after the crosslinking reaction is completed (as determined by the cessation of the reaction exotherm). The curing process may promote various rearrangements of the pyrolytic carbon precursor at the silicon surface, for example, allowing the pyrolytic carbon precursor to migrate to vacant regions of the silicon surface and/or allowing the pyrolytic carbon precursor to adopt a more thermodynamically stable arrangement. It is believed that this may help to improve the bonding between the silicon nanoparticles and the conductive carbon matrix and/or help to improve the conductivity of the conductive carbon matrix.

The coated silicon nanoparticles from step (c) or (d) are pyrolyzed in step (e) to form a conductive pyrolytic carbon matrix. The pyrolysis is preferably carried out at a temperature in the range of 700 to 1150 °C, or in the range of 800 to 1100 °C, or in the range of 900 to 1050 °C. It was found that the conductivity of the pyrolytic carbon matrix depends both on the selected pyrolytic carbon precursor and on the pyrolysis temperature. Pyrolysis temperatures above 700 °C are generally preferred in order to obtain a pyrolytic carbon matrix with high conductivity. The pyrolysis step (e) may be carried out for a time period in the range of 5 minutes to 120 minutes, for example 10 minutes to 100 minutes, 20 minutes to 80 minutes, or 40 minutes to 60 minutes.

The pyrolysis step (e) is preferably carried out in an inert atmosphere or in a reducing atmosphere. For example, pyrolysis may be carried out under argon or nitrogen (preferably nitrogen), or under a mixture of argon or nitrogen with carbon monoxide or hydrogen.

The silicon starting material preferably has a purity of at least 95 wt.%, at least 98 wt.%, or at least 99 wt.%.

The silicon starting material may suitably be selected from metallurgical grade silicon. Metallurgical grade silicon is obtained by reducing high purity silina using carbon in an electric arc furnace at a temperature of about 1900 °C. Metallurgical grade silicon typically comprises silicon alloyed with small amounts of other elements and is available in a variety of grades, with purities ranging from 95% by weight to over 99% by weight. Common impurities in metallurgical grade silicon include calcium, aluminum, iron, copper, gallium, and titanium and their oxides.

The silicon starting material may comprise amorphous silicon, polycrystalline silicon or monocrystalline silicon.

The silicon starting material preferably comprises not more than 4 wt.% oxygen, more preferably not more than 2 wt.% oxygen, more preferably not more than 1 wt.% oxygen, more preferably not more than 0.5 wt.% oxygen.

The silicon-containing starting material is preferably in the form of silicon particles, for example having a D in the range of 1 to 1000 μm, more preferably in the range of 2 to 50 μm, more preferably in the range of 2 to 20 μm, more preferably in the range of 2 to 10 μm.$_{50}$Particle size. If smaller silicon-containing starting material particles are used, the amount of fresh silicon surface exposed during step (a) is reduced and there may be an excess of silicon surface carrying native oxide from the starting material. Larger particles may be more difficult to mill efficiently in the nanoparticle size range. However, it is not excluded that larger silicon-containing particles or monoliths (e.g. ingots or wafers) may be subjected to a preliminary comminution step (e.g. grinding or milling) and optionally sieved to obtain silicon microparticles within the preferred size range of the silicon-containing starting material.

For the avoidance of doubt, the term "particle size" as used herein refers to the equivalent spherical diameter (esd), i.e. the diameter of a sphere having the same volume as a given particle, wherein the particle volume is understood to include the volume of any intragranular pores. The term "D" as used herein$_{50}$"and" D_{50}Particle size "refers to the volume-based median particle size, i.e., the diameter of the population of particles below which 50 volume% is found. The term "D" as used herein$_{10}$"and" D_{10}Particle size "refers to the 10 th percentile volume-based median particle size, i.e., the diameter of the population of particles below which 10 volume% is found. The term "D" as used herein$_{90}$"and" D_{90}Particle size "refers to the volume-based median particle size at the 90 th percentile, i.e., the diameter of the population of particles below which 90 volume% is found. The term "D" as used herein$_{99}$"and" D_{99}Particle size "refers to the 99 th percentile volume-based median particle size, i.e., the diameter of the population of particles below which 99 volume% is found.

The particle size and particle size distribution can be determined by conventional laser diffraction techniques. Laser diffraction relies on the following principle: the particles will scatter light at angles that vary according to particle size, and a group of particles will produce a pattern of scattered light defined by the intensity and angle that can be correlated with the particle size distribution. A variety of laser diffraction instruments are commercially available for rapid and reliable determination of particle size distribution. Unless otherwise indicated, particle size distribution measurements as illustrated or reported herein are measured by a conventional Malvern Mastersizer3000 particle size analyzer from Malvern Instruments. The malvern mastersizer3000 particle size analyzer works by projecting a helium-neon gas laser beam through a transparent cell containing target particles suspended in an aqueous solution. Light rays striking the particles are scattered through angles inversely proportional to particle size, and the photodetector array measures the intensity of the light at a plurality of predetermined angles, and the intensities measured at different angles are processed by a computer using standard theoretical principles to determine the particle size distribution. The laser diffraction values as reported herein were obtained using a wet dispersion of the particles in distilled water. The particle refractive index was taken to be 3.50 and the dispersion index was taken to be 1.330. The particle size distribution was calculated using the Mie scattering model.

Step (a) may be carried out using any suitable wet milling process, such as ball milling, planetary milling, jet milling or a combination thereof. Suitable solvents for step (a) include hydrocarbons (e.g. selected from toluene, xylene, n-hexane, n-heptane, n-octane, decane, dodecane and petroleum ether), ethers (e.g. selected from tetrahydrofuran, diglyme and triglyme), ketones (e.g. selected from acetone, methyl ethyl ketone), alcohols (e.g. selected from isopropanol and n-butanol), and halogenated solvents (e.g. selected from 1, 2-dichloroethane, 1, 1, 1-trichloroethane). Other suitable solvents include acetonitrile, Dimethylformamide (DMF) and Dimethylsulfoxide (DMSO). Preferred solvents include alcohols and ketones. A particularly preferred solvent is isopropanol.

The solvent may be used in an amount of 5 to 50 wt% based on the weight of the silicon starting material, for example 10 to 25 wt% based on the weight of the silicon starting material.

Step (a) may be performed under conditions that minimize unwanted side reactions at the newly exposed surfaces of the silicon nanoparticles. The solvent used in step (a) may be a degassed and/or anhydrous solvent. For example, the solvent may comprise less than 10ppmw (parts per million by weight) oxygen, less than 5ppmw oxygen, or less than 1ppmw oxygen. The solvent may comprise less than 10ppmw (parts per million by weight) water, less than 5ppmw water, or less than 1ppmw water. More preferably, the solvent may comprise less than 10ppmw (parts per million by weight) each of oxygen and water, less than 5ppmw each of oxygen and water, or less than 1ppmw each of water and oxygen. Step (a) may also be carried out under an oxygen-deficient and/or anhydrous atmosphere, for example under an inert gas such as nitrogen or oxygen. Alternatively, step (a) may be carried out in a milling vessel in which the headspace is minimised, so as to substantially exclude atmospheric water and/or oxygen from the milling process. Preferably, the headspace of the milling vessel is flushed with an inert gas, such as nitrogen, prior to milling.

Optionally, D of the silicon nanoparticles formed in step (a)$_{50}$The particle size may be at least 50nm, or at least 60nm, or at least 70nm, or at least 75nm, for example at least 80 nm. Optionally, D of the silicon nanoparticles formed in step (a)$_{50}$The particle size may be no greater than 300nm, more preferably no greater than 250nm, more preferably no greater than 200nm, more preferably no greater than 150nm, more preferably no greater than 120 nm.

The silicon nanoparticles formed in step (a) preferably have a D in the range of from 50 to 250nm, more preferably in the range of from 60 to 200nm, more preferably in the range of from 70 to 150nm, more preferably in the range of from 80 to 120nm$_{50}$And (A) the particle size. For example, D of the silicon nanoparticles formed in step (a)$_{50}$The particle size may be about 100 nm.

D of the silicon nanoparticles formed in step (a)$_{10}$The particle size may be at least 10nm, more preferably at least 20nm, more preferably at least 40nm, more preferably at least 50 nm. D of the silicon nanoparticles formed in step (a)$_{90}$The particle size may be no greater than 500nm, more preferably no greater than 400nm, more preferably no greater than 300nm, more preferably no greater than 200 nm. The silicon nanoparticles formed in step (a) may have a particle size distribution span (as defined above) of 5 or less, more preferably 4 or less, more preferably 3 or less, more preferably 2 or less, more preferably 1.5 or less.

Steps (a) and (b) may be performed simultaneously such that the silicon nanoparticles are contacted with the pyrolytic carbon precursor in situ during milling of the silicon starting material. Alternatively, steps (a) and (b) may be performed sequentially. Where steps (a) and (b) are performed sequentially, step (b) may comprise adding a solution of the pyrolytic carbon precursor in a non-aqueous solvent to the dispersion of silicon nanoparticles from step (a), optionally with mixing or agitation sufficient to ensure uniform distribution of the pyrolytic carbon precursor in the silicon nanoparticle dispersion. The solvent used to dissolve the pyrolytic carbon precursor may be the same solvent as the solvent used to mill the silicon starting material in step (a).

Step (b) is suitably carried out to avoid contact of the silicon nanoparticles with oxygen and/or water. For example, prior to step (b), the dispersion of silicon nanoparticles from step (a) may be stored under an oxygen-depleted and/or anhydrous atmosphere. The contacting of the silicon nanoparticles with the pyrolytic carbon precursor is also suitably carried out under an inert atmosphere devoid of oxygen and/or water. In addition, the pyrolytic carbon precursor or a solution thereof in a non-aqueous solvent is preferably degassed and anhydrous. For example, the pyrolytic carbon precursor or solution thereof can comprise less than 10ppmw (parts per million by weight) oxygen, less than 5ppmw oxygen, or less than 1ppmw oxygen. The pyrolytic carbon precursor or solution thereof can comprise less than 10ppmw (parts per million by weight) water, less than 5ppmw water, or less than 1ppmw water. More preferably, the pyrolytic carbon precursor or solution thereof can comprise less than 10ppmw (parts per million by weight) each of oxygen and water, less than 5ppmw each of oxygen and water, or less than 1ppmw each of water and oxygen.

Depending on the structure of the pyrolytic carbon precursor and the pyrolysis conditions, the weight loss from the pyrolytic carbon precursor during pyrolysis is typically in the range of 40 to 70 weight percent. Thus, the weight ratio of pyrolytic carbon precursor to silicon is typically selected to be about 1.5 to 3.5 times greater than the desired weight ratio of carbon to silicon in the particulate material product. For example, the weight ratio of the pyrolytic carbon precursor to silicon in step (b) may be in the range of 0.15 to 4, more preferably 0.2 to 3, e.g. 0.3 to 2.5.

The solvent may be removed in step (c) by any conventional means. One solvent removal technique includes evaporating the solvent under reduced pressure, for example using a rotary evaporation apparatus, optionally while providing sufficient heat to prevent the solvent from freezing. More preferably, the solvent may be removed by spray drying to form composite particles comprising silicon nanoparticles dispersed within a pyrolytic carbon precursor. The solvent removal process is suitably controlled to avoid excessive solvent vapor velocity, as this may result in entrainment of silicon nanoparticles in the vapor stream.

The material resulting from step (c) comprises silicon nanoparticles dispersed in a matrix of a pyrolytic carbon precursor. Prior to step (d) or (e), the material may be stored under an inert (e.g. oxygen deficient and/or anhydrous) atmosphere. However, it has been found that the coating of the pyrolytic carbon precursor and/ or solvent passivation can provide sufficient protection to the silicon nanoparticles to prevent unwanted reactions of silicon with oxygen or water.

The conductive carbon matrix obtained by pyrolysis step (e) typically has an amorphous structure with graphite-like features, such as a large G-band (~1600 cm) in the raman spectrum[-1]) As demonstrated. However, the D-band (. about.1350 cm) as evident in Raman spectra[-1]) It was demonstrated that the carbon was not entirely graphite.

The pyrolysis of the coated silicon nanoparticles in step (e) results in the formation of a conductive carbon matrix in which the silicon nanoparticles are dispersed. The conductive carbon matrix may contain large and/or irregular particles having a size of 100 μm to several tens of millimeters. Thus, the particulate material from step (e) may be subjected to a size reduction step (f) to obtain a reduced particle size particulate material. Any suitable size reduction technique may be used, such as ball

milling, planetary milling, jet milling, or a combination thereof. Step (f) may be carried out in the presence of a solvent (wet milling), or a dry milling technique may be used. If wet milling is used, the solvent may be removed by any conventional means, for example evaporation under reduced pressure.

The particulate material from step (e) or step (f) may optionally be subjected to a sieving step (g) to remove oversize particles.

The particulate material from step (e), (f) or (g) may be modified by the addition of a carbon coating. Preferably, the carbon coating is obtained by a Chemical Vapor Deposition (CVD) method. CVD is a well known method in the art and involves the thermal decomposition of a volatile carbon-containing gas (e.g., ethylene) onto the surface of a particulate material. The formation of the carbon coating by CVD may be performed simultaneously with the pyrolysis in step (e) or immediately after the pyrolysis in step (e). For example, once the pyrolysis reaction is substantially complete, a suitable volatile carbon-containing gas, such as ethylene, may be introduced into the pyrolysis reactor.

Alternatively, the carbon coating may be formed by depositing a solution of carbon-containing compounds onto the surface of the particulate material, followed by pyrolysis. Suitable carbon-containing compounds include the aforementioned pyrolytic carbon precursors.

The carbon coating is advantageous in that it further reduces the BET surface area of the particulate material by smoothing out any surface defects and by filling in any residual surface micropores, thereby further reducing first cycle losses. In addition, the carbon coating improves the conductivity of the composite particle surface, reduces the need for conductive additives in the electrode composition, and also creates an optimal surface for the formation of a stable SEI layer, resulting in improved capacity retention upon cycling.

The particulate material prepared according to the process of the present invention preferably comprises from 40 to 65% by weight silicon, more preferably from 43 to 65% by weight silicon, more preferably from 45 to 65% by weight silicon. For example, the particulate material may comprise 48 to 62 wt% silicon, or 50 to 60 wt% silicon, or 52 to 58 wt% silicon.

The weight ratio of the total amount of oxygen and nitrogen to silicon in the particulate material produced according to the process of the present invention is preferably in the range 0.1 to 0.45.

For example, the weight ratio of the total amount of oxygen and nitrogen to silicon in the composite from step (e) may be no greater than 0.42, or no greater than 0.4, or no greater than 0.38, or no greater than 0.35. Optionally, the weight ratio of the total amount of oxygen and nitrogen to silicon may be 0.1 to 0.42, or 0.1 to 0.4, or 0.1 to 0.38, or 0.1 to 0.35.

The weight ratio of the total amount of oxygen and nitrogen to silicon in the particulate material produced according to the process of the present invention may be at least 0.2, more preferably at least 0.24, more preferably at least 0.28, more preferably at least 0.3, more preferably at least 0.32, more preferably at least 0.34.

Preferably, the weight ratio of the total amount of oxygen and nitrogen to silicon in the particulate material produced according to the method of the present invention may be in the range of from 0.25 to 0.42, more preferably from 0.28 to 0.4, more preferably from 0.3 to 0.38, and most preferably from 0.32 to 0.38.

The weight ratio of carbon to silicon in the composite from step (e) is preferably in the range of 0.1 to 1.

The weight ratio of carbon to silicon in the particulate material produced according to the process of the present invention may be at least 0.15, more preferably at least 0.2, more preferably at least 0.25, more preferably at least 0.3.

The weight ratio of carbon to silicon in the particulate material produced according to the process of the present invention may be no greater than 0.8, more preferably no greater than 0.7, more preferably no greater than 0.6, more preferably no greater than 0.55, more preferably no greater than 0.5, more preferably no greater than 0.0.45.

For example, the weight ratio of carbon to silicon in the particulate material produced according to the process of the present invention may be from 0.2 to 0.6, more preferably from 0.25 to 0.5, more preferably from 0.3 to 0.45.

The weight ratio of carbon to the total amount of oxygen and nitrogen (i.e. weight [C]: weight [O + N]) in the particulate material produced according to the process of the present invention may be at least 0.7, more preferably at least 0.8, more preferably at least 0.85, or at least 0.9, or at least 0.95.

The particulate material produced according to the process of the present invention preferably comprises at least 8 wt% oxygen, or at least 10 wt% oxygen, or at least 12 wt% oxygen, or at least 15 wt% oxygen.

The particulate material produced according to the process of the present invention preferably comprises from 8 wt% to less than 20 wt% oxygen, more preferably from 10 wt% to less than 20 wt% oxygen, more preferably from 12 wt% to less than 20 wt% oxygen, more preferably from 15 wt% to less than 20 wt% oxygen.

The particulate material produced according to the process of the present invention preferably comprises from 2 to 6 wt% nitrogen, more preferably from 2.5 to 5 wt% nitrogen, more preferably from 3 to 4.5 wt% nitrogen, and most preferably from 3.5 to 4.5 wt% nitrogen. The nitrogen-containing particulate material may be prepared from a nitrogen-containing pyrolytic carbon precursor as described herein.

The particulate material produced according to the process of the present invention preferably comprises at least 10 wt% carbon, or at least 15 wt% carbon, or at least 18 wt% carbon. The particulate material produced according to the process of the present invention preferably comprises no more than 35 wt% carbon, no more than 30 wt% carbon, no more than 28 wt% carbon, or no more than 25 wt% carbon. For example, the particulate material produced according to the process of the present invention may comprise from 15 to 30 wt% carbon, or more preferably from 18 to 25 wt% carbon.

In a preferred embodiment, the particulate material produced according to the process of the present invention comprises 43 to 65 wt% silicon, 10 to less than 20 wt% oxygen, 2 to 6 wt% nitrogen and 15 to 30 wt% carbon, wherein the weight ratio of the total amount of oxygen and nitrogen in the particulate material to the silicon in the particulate material is in the range of 0.25 to 0.42; and wherein the weight ratio of carbon to silicon in the particulate material is in the range of 0.2 to 0.6.

In a more preferred embodiment, the particulate material produced according to the method of the present invention comprises 48 to 62 wt% silicon, 12 to less than 20 wt% oxygen, 2.5 to 5 wt% nitrogen and 18 to 25 wt% carbon, wherein the weight ratio of the total amount of oxygen and nitrogen in the particulate material to the silicon in the particulate material is in the range of 0.28 to 0.4; and wherein the weight ratio of carbon to silicon in the particulate material is in the range of 0.25 to 0.5.

In a particularly preferred embodiment, the particulate material produced according to the process of the present invention comprises from 50 to 60% by weight silicon, from 15% to less than 20% by weight oxygen, from 3 to 4.5% by weight nitrogen and from 18 to 25% by weight carbon; wherein the weight ratio of the total amount of oxygen and nitrogen in the particulate material to the silicon in the particulate material is in the range of 0.3 to 0.38; and wherein the weight ratio of carbon to silicon in the particulate material is in the range of 0.3 to 0.45.

The particulate material prepared according to the process of the present invention may optionally comprise minor amounts of one or more other elements in addition to silicon, carbon or oxygen. For example, the particulate material may contain small amounts of one or more other elements selected from Al, Sb, Cu, Mg, Zn, Mn, Cr, Co,

silicon, carbon or oxygen. For example, the particulate material may contain small amounts of one or more elements selected from Al, Sb, Cu, Mg, Zn, Mn, Cr, Co, Mo, Ni, Be, Zr, Fe, Na, Sr, P, Sn, Ru, Ag, Au, Ti. Such elements may be present in the silicon nanoparticles as trace impurities, for example when the silicon nanoparticles are obtained from metallurgical grade silicon. For example, the particulate material may contain 0.1-8 wt% of one or more elements selected from aluminium, iron, copper, gallium, magnesium, calcium, titanium and zirconium, the remainder being silicon, carbon and oxygen. Alternatively, these elements may be present during the manufacturing process.

Preferably, the particulate material produced according to the method of the present invention comprises at least 80 wt% silicon, carbon, oxygen and nitrogen in total, at least 85 wt% silicon, oxygen, nitrogen and carbon in total, at least 90 wt% silicon, oxygen, nitrogen and carbon in total, or at least 95 wt% silicon, oxygen and carbon in total, for example at least 98 wt% silicon, oxygen, nitrogen and carbon in total, or at least 99 wt% silicon, oxygen, nitrogen and carbon in total.

In a second aspect, the present invention provides a particulate material consisting of a plurality of composite particles, wherein the composite particles comprise a plurality of silicon nanoparticles dispersed within a conductive carbon matrix, wherein:

the silicon nanoparticles comprise a nanoparticle core and a nanoparticle surface, wherein the nanoparticle surface comprises a compound of oxygen or a compound of nitrogen or a mixture thereof disposed between the nanoparticle core and the conductive carbon matrix;

the particulate material comprises 40 to 65 wt% silicon;

the particulate material comprises at least 6 wt% and less than 20 wt% oxygen;

the weight ratio of the total amount of oxygen and nitrogen to silicon in the particulate material is in the range of 0.1 to 0.45;

and is

The weight ratio of carbon to silicon in the particulate material is in the range of 0.1 to 1.

In a third aspect, the present invention provides a particulate material consisting of a plurality of composite particles, wherein the composite particles comprise a plurality of silicon nanoparticles dispersed within a conductive carbon matrix, wherein:

the silicon nanoparticles comprise a nanoparticle core and a nanoparticle surface, wherein a plurality of bridging oxygen atoms and/or a plurality of bridging nitrogen atoms are disposed between the nanoparticle surface and at least a portion of the conductive carbon matrix such that the conductive carbon matrix is chemically bound to the nanoparticle surface; and is

The particulate material comprises 40 to 65 wt% silicon;

the particulate material comprises at least 6 wt% and less than 20 wt% oxygen;

the weight ratio of the total amount of oxygen and nitrogen in the particulate material to the silicon in the particulate material is in the range of 0.1 to 0.45; and is

The weight ratio of carbon to silicon in the particulate material is in the range of 0.1 to 1.

It has been found that the particulate material of the present invention has particularly advantageous properties for use in a hybrid electrode for a metal-ion battery. The use of silicon nanoparticles avoids excessive mechanical strain during lithiation and delithiation that occurs in larger particles. However, by providing silicon nanoparticles in the form of composite particles, wherein the silicon nanoparticles are dispersed within a conductive carbon matrix, processing problems associated with the silicon nanoparticles can be overcome.

Furthermore, the particulate material of the present invention has a unique interface between the carbon matrix and the surface of the silicon nanoparticles. Thus, the carbon matrix of the composite particles of the present invention does not provide a coating only on the surface of the silicon nanoparticles. The unique chemistry at the interface of the carbon matrix and the silicon nanoparticles ensures that a strong connection between the silicon nanoparticles and the carbon matrix is maintained even when the silicon nanoparticles expand and contract during charge and discharge. Therefore, the electrical conductivity among the silicon nanoparticles, the carbon matrix, and the anode current collector is effectively maintained. Due to its unique structure, the particulate material of the present invention avoids many capacity fade mechanisms that are characteristic of the use of silicon as an anode active material in metal ion batteries. In particular, it has been found that the particulate material of the present invention is associated with reduced first cycle loss and improved capacity retention when compared to other silicon-containing particulate forms disclosed in the art for use in metal-ion batteries.

The particulate material of the present invention may be used to provide a hybrid anode having increased capacity when compared to an anode comprising graphite alone as the active material. In addition, the particulate material is robust enough to withstand fabrication and incorporation into the anode layer without loss of structural integrity, particularly when the anode layer is calendered to produce a dense, uniform layer (as is conventional in the art).

The particulate material of the present invention preferably comprises from 43 to 65% by weight silicon, more preferably from 45 to 65% by weight silicon. For example, the particulate material of the present invention may comprise 48 to 62 wt% silicon, or 50 to 60 wt% silicon, or 52 to 58 wt% silicon.

The weight ratio of the total amount of oxygen and nitrogen to silicon (i.e., weight { O + N } weight { Si }) in the particulate material of the present invention may be no greater than 0.42, or no greater than 0.4, or no greater than 0.38, or no greater than 0.35. Optionally, the weight ratio of the total amount of oxygen and nitrogen to silicon may be 0.1 to 0.42, or 0.1 to 0.4, or 0.1 to 0.38, or 0.1 to 0.35.

The weight ratio of the total amount of oxygen and nitrogen to silicon in the particulate material of the invention may be at least 0.2, more preferably at least 0.24, more preferably at least 0.28, more preferably at least 0.3, more preferably at least 0.32, more preferably at least 0.34.

Preferably, the weight ratio of the total amount of oxygen and nitrogen to silicon may be in the range of 0.25 to 0.42, more preferably 0.28 to 0.4, more preferably 0.3 to 0.38, and most preferably 0.32 to 0.38.

The particulate material of the present invention may optionally comprise minor amounts of one or more other elements in addition to silicon, carbon, oxygen and nitrogen. For example, the particulate material may contain small amounts of one or more other elements selected from Al, Sb, Cu, Mg, Zn, Mn, Cr, Co, Mo, Ni, Be, Zr, Fe, Na, Sr, P, Sn, Ru, Ag, Au, Ti. Such elements may be present in the silicon nanoparticles as trace impurities, for example when the silicon nanoparticles are obtained from metallurgical grade silicon. For example, the particulate material of the present invention may comprise 0.1 to 8 wt% of one or more elements selected from aluminium, iron, copper, gallium, magnesium, calcium, titanium and zirconium, the remainder being silicon, carbon and oxygen and/or nitrogen. Alternatively, these elements may be present during the manufacturing process.

Preferably, the particulate material of the present invention comprises at least 80 wt% silicon, carbon, oxygen and nitrogen in total, at least 85 wt% silicon, oxygen, nitrogen and carbon in total, at least 90 wt% silicon, oxygen, nitrogen and carbon in total, or at least 95 wt% silicon, oxygen, nitrogen and carbon in total, for example at least 98 wt% silicon, oxygen, nitrogen and carbon in total, or at least 99 wt% silicon, oxygen, nitrogen and carbon in total.