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Application Number: 17707129 Document Date: 03/29/2022

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Form Revision Date: March 1, 2019

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UTILITY PATENT APPLICATION TRANSMITTAL

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

Attorney Docket No.	14850059US
First Named Inventor	Ting YI
Title	NEGATIVE ELECTRODE AND ELECTROCHEMICAL APPARATUS CONTAINING SA
Express Mail 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* 2]
6. **Inventor's Oath or Declaration** [*Total Pages* 6] *(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: 62008 **OR** ☐ Correspondence address below

Name					
Address					
City		State		Zip Code	
Country		Telephone		Email	

Signature	/Timothy J. Maier/	Date	March 29, 2022
Name (Print/Type)	Timothy J. Maier	Registration No. (Attorney/Agent)	51,986

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.

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.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	14850059US
	Application Number	
Title of Invention	NEGATIVE ELECTRODE AND ELECTROCHEMICAL APPARATUS CONTAINING SAME, AND ELECTRONIC 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
	Ting		YI	

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

City	Ningde, Fujian	Country of Residence [i]	CN

Mailing Address of Inventor:

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

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Hang		CUI	

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

City	Ningde, Fujian	Country of Residence [i]	CN

Mailing Address of Inventor:

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

Inventor 3 Remove

Legal Name

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	Application Number	
Title of Invention	NEGATIVE ELECTRODE AND ELECTROCHEMICAL APPARATUS CONTAINING SAME, AND ELECTRONIC APPARATUS	

Prefix	Given Name	Middle Name	Family Name	Suffix
	Yuansen		XIE	

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

City	Ningde, Fujian	Country of Residence [i]	CN

Mailing Address of Inventor:

Address 1	No. 1 Xingang Road, Zhangwan Town		
Address 2	Jiaocheng District		
City	Ningde, Fujian	**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	62008		
Email Address	patent@maierandmaier.com	Add Email	Remove Email

Application Information:

Title of the Invention	NEGATIVE ELECTRODE AND ELECTROCHEMICAL APPARATUS CONTAINING SAME, AND ELECTRONIC APPARATUS		
Attorney Docket Number	14850059US	**Small Entity Status Claimed**	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	2	**Suggested Figure for Publication (if any)**	

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).

[i]

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

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	14850059US
	Application Number	
Title of Invention	NEGATIVE ELECTRODE AND ELECTROCHEMICAL APPARATUS CONTAINING SAME, AND ELECTRONIC APPARATUS	

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	62008		

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/CN2019/130465	2019-12-31

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

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).

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	Application Number	
Title of Invention	NEGATIVE ELECTRODE AND ELECTROCHEMICAL APPARATUS CONTAINING SAME, AND ELECTRONIC APPARATUS	

Remove

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)
201911267132.X	CN	2019-12-11	BA7B

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.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	14850059US
	Application Number	
Title of Invention	NEGATIVE ELECTRODE AND ELECTROCHEMICAL APPARATUS CONTAINING SAME, AND ELECTRONIC 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.

Zhuhai CosMX Battery Co. - EX1002
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	14850059US
	Application Number	
Title of Invention	NEGATIVE ELECTRODE AND ELECTROCHEMICAL APPARATUS CONTAINING SAME, AND ELECTRONIC 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, Zhangwan Town		
Address 2	Jiaocheng District		
City	Ningde, Fujian	**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.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	14850059US
	Application Number	
Title of Invention	NEGATIVE ELECTRODE AND ELECTROCHEMICAL APPARATUS CONTAINING SAME, AND ELECTRONIC 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, Zhangwan Town		
Address 2	Jiaocheng District		
City	Ningde, Fujian	**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	/Timothy J. Maier/			Date (YYYY-MM-DD)	2022-03-29
First Name	Timothy	Last Name	Maier	Registration Number	51986

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

Zhuhai CosMX Battery Co. - EX1002
Zhuhai CosMX Battery Co. v. Ningde Amperex Tech. Ltd.
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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	14850059US
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Zhuhai CosMX Battery Co. - EX1002
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Privacy Act Statement

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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.

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NEGATIVE ELECTRODE AND ELECTROCHEMICAL APPARATUS CONTAINING SAME, AND ELECTRONIC APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a bypass continuation application of PCT application PCT/CN2019/130465, filed on December 31st, 2019, which claims the benefit of priority from Chinese patent application 201911267132.X filed on December 11st, 2019, the disclosure of which is hereby incorporated by reference in its entirety.

TECHNICAL FIELD

[0001] This application relates to the technical field of energy storage, and in particular, to a negative electrode and an electrochemical apparatus containing the same, and an electronic apparatus.

BACKGROUND

[0002] With the rapid development of mobile electronic technologies, the frequency and experience requirements of people for using mobile electronic apparatuses such as mobile phones, tablet computers, notebook computers and unmanned aerial vehicles are increasingly high. Therefore, an electrochemical apparatus (for example, a lithium-ion battery) that provides energy for the electronic apparatuses needs to have higher energy density, larger rate, higher safety, and less capacity attenuation after repeated charge and discharge processes.

[0003] In a cycling process of the lithium-ion battery, the precipitation of lithium metal caused by the polarization of a negative electrode is one of the main reasons that

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impair the cycle performance of the lithium-ion battery. In view of this, the polarization of the negative electrode during the cycling of the battery needs to be reduced, and one of the feasible solutions is to further study and optimize a negative electrode structure.

SUMMARY

[0004] This application provides a negative electrode and an electrochemical apparatus including the same, and an electronic apparatus, in an attempt to solve at least one problem existing in the related art to at least some extent.

[0005] According to one aspect of this application, this application provides a negative electrode. The negative electrode includes: a negative current collector, a first negative active material layer and a second negative active material layer. The first negative active material layer is arranged on one side of a first portion of the negative current collector, and the second negative active material layers are arranged on two sides of a second portion, different from the first portion, of the negative current collector; a ratio K of a weight per unit area of the first negative active material layer to a weight per unit area of the second negative active material layer on the negative current collector is about 0.47 to 0.52, and a ratio R of a compacted density of the first negative active material layer to a compacted density of the second negative active material layer is about 0.9 to 1.1.

[0006] According to another aspect of this application, this application provides an electrochemical apparatus, including a positive electrode, a separator and the above-mentioned negative electrode.

[0007] According to yet another aspect of this application, this application provides an electronic apparatus. The electronic apparatus includes the foregoing electrochemical apparatus.

[0008] 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.

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BRIEF DESCRIPTION OF DRAWINGS

[0009] The accompanying drawings necessary to describe the embodiments of this application or the prior art will be briefly described below in order to describe the embodiments of this application conveniently. It is apparent that the drawings in the following description are only partial embodiments of this application. Those skilled in the art can still obtain, without creative work, drawings of other embodiments according to structures illustrated in these drawings.

[0010] FIG. 1 is a schematic structural diagram of a negative electrode of an embodiment of this application.

[0011] FIG. 2 is a schematic diagram of a negative active material formed by mixing a silicon-based material with graphite before and after cold pressing.

[0012] FIG. 3 is a curve of cycle capacities of Example 4 and Comparative Example 2 of this application.

DETAILED DESCRIPTION

[0013] Embodiments of this application will be described in detail below. Throughout the description 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 drawings are illustrative and diagrammatic, and are intended to provide a basic understanding of this application. The embodiments of this application shall not be construed as a limitation on this application.

[0014] As used herein, the terms "approximately", "substantially", "practically" and "about" are used to describe and illustrate small changes. 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,

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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 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 "substantially" the same.

[0015] In this specification, unless specified or limited otherwise, relative words such as: "central", "longitudinal", "lateral", "forward", "rearward", "right", "left", "inner", "outer", "lower", "higher", "horizontal", "vertical", "greater", "less", "above", "below", "top", "bottom" and derivatives thereof (for example, "horizontally", "downwardly", "upwardly") should be construed as referring to the orientation depicted in the discussion or depicted in the drawings. These relative words are used for descriptive convenience only and do not require the construction or operation of this application in a particular orientation.

[0016] In addition, quantities, ratios, and other values are sometimes presented in the format of ranges herein. 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.

[0017] In the specific implementation modes 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 "one of A and B" means only A; or only B; or A and B. In another example, 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.

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[0018] In the prior art, in order to pursue the optimal energy density and the stability and simplicity of a preparation process, a design that active materials are arranged on two sides of a middle portion of an electrode piece and an active material is arranged on one side of an end portion of the pole piece is adopted for a winding type electrode component. Referring to FIG. 1, lithium metal of a lithium-ion battery in the prior art often precipitate in a region 102A of which one side is provided with a negative active material and in a region 103A (accounting for 10% of an area of an entire negative active material layer-coated region), adjacent to the region 102A, of a region of which both sides are provided with the negative active materials due to limitations in a preparation process (the term "lithium plating" refers to precipitation of lithium metal below).

[0019] In addition, using a negative active material with a higher gram capacity is also a way to improve the energy density. Silicon has a high theoretical gram capacity (4200 mAh/g) and has a broad prospect for application in lithium-ion batteries. However, in a charge and discharge cycle process, due to poor electrical conductivity of the silicon-based material, lithium ions are easily accumulated on the surface of a negative electrode during intercalation and deintercalation to cause the lithium plating. In addition, due to the fact that the silicon-based material is high in a thermal expansion rate, when such the negative electrode design that the active materials are arranged on the two sides of the middle portion and the active material is arranged on the single side of the end portion of the negative electrode is adopted, a junction of the region of which the single side is provided with the active material and the region of which the two sides are provided with the active materials is easily deformed by heating, and then the lithium plating is intensified. The lithium plating represents the loss of lithium ions in the lithium-ion battery, causing the battery capacity loss and accelerating the cycling attenuation, so that the cycle performance of the lithium-ion battery is reduced. In addition, the lithium plating may cause excessive deintercalation of the lithium ions from a positive electrode to replenish the lost lithium ions, thereby destroying the structure of the positive electrode.

[0020] According to this application, by means of regulating and controlling the

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setting weights of the active material layers on the single side and the two sides and the compacted density ratio of the active material layers on the single side and the two sides in a cold pressing process, the polarization and the lithium plating are alleviated from the structure aspect of a negative electrode, and the cycle performance and the safety of the lithium-ion battery are improved.

[0021] FIG. 1 is a schematic structural diagram of a negative electrode of an embodiment of this application.

[0022] According to one aspect of this application, this application provides a negative electrode 10, including: a negative current collector 101, a first negative active material layer 102 and a second negative active material layer 103. The first negative active material layer 102 is arranged on one side of a first portion of the negative current collector 10; and the second negative active material layers 103 are arranged on two sides of a second portion, different from the first portion, of the negative current collector 10. A ratio K of a weight per unit area of the first negative active material layer 102 to a weight per unit area of the second negative active material layer 103 on the negative current collector 10 is about 0.47 to 0.52, and a ratio R of a compacted density of the first negative active material layer 102 to a compacted density of the second negative active material layer 103 is about 0.9 to 1.1.

[0023] In other embodiments, the ratio of the weight per unit area of the first negative active material layer 102 to the weight per unit area of the second negative active material layer 103 on the negative current collector 10 is about 0.5, and the ratio of the compacted density of the first negative active material layer to the compacted density of the second negative active material layer is about 0.97 to 1.0.

[0024] In a cyclic process, when the weights per unit area of the negative active material layers on the negative current collector are not consistent, a current density distributed on the active material layers with different weights per unit area is not uniform; and the non-uniform current density of the negative electrode may cause different retention conditions of lithium ions. When the current density is large, the lithium ions are more easily retained on the surface under the condition that the transmission of the lithium ions is limited, and lithium plating is caused. When the

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weight per unit area of the first negative active material layer 102 and the weight per unit area of the second negative active material layer 103 on the negative current collector 10 are more consistent, the current density distribution of the negative electrode can be maintained, thereby reducing the lithium plating.

[0025] As used herein, the term "compaction density" is obtained by dividing the weight of active materials per unit area on the current collector by a total thickness of the cold-pressed active material layers in a direction perpendicular to the surface of the current collector.

[0026] FIG. 2 is a schematic diagram of a negative active material formed by mixing a silicon-based material with graphite before and after cold pressing.

[0027] As shown in FIG. 2, an intensity C110 of a diffraction peak of a 110 crystal plane of the negative active material formed by mixing a silicon-based material with graphite before cold pressing is higher as measured by an X-ray diffraction method, which represents that a crystal structure of the negative active material before cold pressing is arranged in the 110 crystal plane. After cold pressing, an intensity C004 of a diffraction peak of a 004 crystal plane of the negative active material as measured by the X-ray diffraction method increases along with the increase of the compaction density, which represents that the arrangement of the crystal structure of the negative active material gradually tends to the 004 crystal plane along with the increase of the compaction density. When the crystal structure of the negative active material is arranged in the 004 crystal plane, the resistance against intercalation and deintercalation of the lithium ions is relatively high. Therefore, the higher the compacted density of the negative active material layer, the easier the lithium plating.

[0028] When the compaction densities of the first negative active material layer 102 and the second negative active material layer 103 are more consistent, the lithium plating in the region 102A of which the single side is provided with the negative active material and in the region 103A, adjacent to the region 102A, of the region of which the two sides are provided with the negative active materials are more uniform. Therefore, it is not easy to cause a large amount of lithium plating at any single position of the region 102A of which the single side is provided with the negative active material

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or the region 103A, adjacent to the region 102A, of the region of which the two sides are provided with the negative active materials, thereby reducing the lithium plating and improving the cycle performance of the electrochemical apparatus.

[0029] In some embodiments, the first negative active material layer and the second negative active material layer each independently have a compacted density of about 1.3 g/cm^3 to about 2.0 g/cm^3.

[0030] In some embodiments, the first negative active material layer and the second negative active material layer each independently include a silicon-based material and graphite. The silicon-based material is selected from a group composed of silicon oxide, silicon carbon, and a combination thereof. In some embodiments, the silicon oxide is represented by the general formula SiO_x, where $0.5 \leq x \leq 1.6$.

[0031] In some embodiments, a weight of the silicon-based material in the first negative active material layer and the second negative active material layer is greater than or equal to about 5% and less than about 100%, based on a total weight of the silicon-based material and the graphite. In other embodiments, the weight of the silicon-based material in the first negative active material layer and the second negative active material layer is from about 10% to about 40%. In other embodiments, the weight of the silicon-based material in the first negative active material layer and the second negative active material layer is about 15%.

[0032] The negative active material of the first negative active material layer and the second negative active material layer includes the silicon-based material and the graphite. The Dv99 of the silicon-based material is relatively small, generally less than about 20 μm, but the Dv99 of the graphite is relatively large, generally up to more than about 30 μm. A compaction thickness of an electrode piece is at least greater than a particle size of one particle, otherwise the particle would be crushed, resulting in accelerated cycling attenuation.

[0033] In some embodiments, the first negative active material layer and the second negative active material layer each independently have a single-layer thickness from about 40 μm to about 60 μm. In some embodiments, a total thickness of the second negative active material layer is from about 80 μm to about 120 μm.

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[0034] In some embodiments, the first negative active material layer and the second negative active material layer each have a particle size Dv50 from about 8.0 μm to about 20 μm. In other embodiments, the first negative active material layer and the second negative active material layer each have a particle size Dv50 that is approximately, for example, about 8.0 μm, about 9.0 μm, about 10.0 μm, about 12.0 μm, about 14.0 μm, about 16.0 μm, about 18.0 μm, or about 20.0 μm, or in a range defined by any two of these values.

[0035] In some embodiments, a form of the silicon-based material includes a crystalline state, an amorphous state, or a combination thereof.

[0036] In some embodiments, the silica-based material has a particle size Dv50 of about 4.0 μm to about 10 μm. In other embodiments, the silicon-based material has a particle size Dv50 that is approximately, for example, about 4.0 μm, about 5.0 μm, about 6.0 μm, about 7.0 μm, about 8.0 μm, about 9.0 μm, or about 10.0 μm, or in a range defined by any two of these values.

[0037] In some other embodiments, the silicon-based material further includes a carbon coating layer.

[0038] In some embodiments, for the silicon-based material, a ratio of a peak height at a wavenumber of 500 cm^{-1} ± 10 cm^{-1} to a peak height at a wavenumber of 1350 cm^{-1} ± 10 cm^{-1} in a Raman spectrum (Jobin Yvon LabRAM HR spectrometer, wavelength: 532 nm, test range: 50 cm^{-1} to 2000 cm^{-1}) is greater than 0. A Raman characteristic peak of the silicon is represented at a wavenumber of about 500 cm^{-1}, and a characteristic peak of the carbon coated the surface of the silicon is represented at a wavenumber of about 1350 cm^{-1}.

[0039] In some embodiments, the first negative active material layer and the second negative active material layer each independently include a binder and a conductive agent. The binder includes a material selected from a group composed of polyacrylate, polyimide, polyamide, polyamideimide, polyvinylidene fluoride, styrene-butadiene rubber, sodium alginate, polyvinyl alcohol, polytetrafluoroethylene, polyacrylonitrile, sodium carboxymethyl cellulose, potassium carboxymethyl cellulose, and a combination thereof, and the conductive agent includes a material selected from a group

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composed of conductive carbon black, acetylene black, Ketjen black, graphene, and a combination thereof.

[0040] It should be understood that those skilled in the art can select to add any conventional binder or conductive agent in the art according to actual needs without limitation.

[0041] In some embodiments, based on a total weight of the first negative active material layer, the total weight of the silicon-based material and the graphite in the first negative active material layer is about 94% to about 96%, a weight of the binder is about 2.8% to about 4.0%, and a weight of the conductive agent is about 0.4% to about 1.6%.

[0042] In some embodiments, based on a total weight of the second negative active material layer, the total weight of the silicon-based material and the graphite in the second negative active material layer is about 94% to about 96%, a weight of the binder is about 2.8% to about 4.0%, and a weight of the conductive agent is about 0.4% to about 1.6%.

[0043] In some embodiments, a preparation method for a negative electrode of this application includes the following steps that:

[0044] A certain amount of a silicon-based material and graphite are taken, and are mixed with a binder and a conductive agent according to a fixed weight ratio, and the mixture is mixed into deionized water for uniform stirring. After stirring, mixed slurry is obtained by screening. The mixed slurry has a viscosity from about 2500 mPa.S to about 4000 mPa.S and a solid content from about 35% to about 50%.

[0045] The mixed slurry is separately coated on a copper foil current collector. A weight per unit area of the mixed slurry coated on one side of a portion is about 65 g/m^2 to about 130 g/m^2, and a weight per unit area of the mixed slurry coated on two sides of a portion is about 130 g/m^2 to about 260 g/m^2; and the mixed slurry is dried. After drying, cold pressing treatment is performed to obtain a first negative active material layer and a second negative active material layer. A compacted density of the second negative active material layer is about 1.3 g/cm^3 to about 2.0 g/cm^3, and a ratio R of a compacted density of the first negative active material layer to the compacted density

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of the second negative active material layer is about 0.9 to about 1.1. Then, the negative electrode is obtained by means of a cutting procedure.

[0046] It should be understood that each step in the preparation method for the negative electrode in the embodiment of this application may be selected or substituted for other conventional processing methods in the art according to specific requirements without departing from the spirit of this application, and is not limited thereto.

[0047] According to another aspect of this application, some embodiments of this application further provide 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: the negative electrode in the foregoing embodiment, a separator and a positive electrode, and the separator is arranged between the positive electrode and the negative electrode.

[0048] In some embodiments, a positive current collector may be an aluminum foil or a nickel foil, and the negative current collector may be a copper foil or a nickel foil. However, other positive current collectors and negative current collectors commonly used in the art may be used without limitation.

[0049] In some embodiments, the positive electrode includes a positive material capable of absorbing and releasing lithium (Li) (sometimes referred to as "a positive material capable of absorbing/releasing lithium Li" below). The example of the positive material capable of absorbing and releasing lithium (Li) may include one or more of lithium cobalt oxide, lithium nickel cobalt manganese, lithium nickel cobalt aluminate, lithium manganese oxide, lithium manganese iron phosphate, lithium vanadium phosphate, lithium vanadyl phosphate, lithium iron phosphate, lithium titanate and lithium-rich manganese-base materials.

[0050] In the above-mentioned positive materials, the chemical formula of the lithium cobalt oxide may be $Li_yCo_aM1_bO_{2-c}$, where M1 represents at least one of nickel (Ni), manganese (Mn), magnesium (Mg), aluminum (Al), boron (B), titanium (Ti), vanadium (V), chromium (Cr), iron (Fe), copper (Cu), zinc (Zn), molybdenum (Mo), tin (Sn), calcium (Ca), strontium (Sr), tungsten (W), yttrium (Y), lanthanum (La), zirconium (Zr) and silicon (Si), and values of y, a, b and c are respectively within the

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following ranges: $0.8 \leq y \leq 1.2$, $0.8 \leq a \leq 1$, $0 \leq b \leq 0.2$, and $-0.1 \leq c \leq 0.2$;

[0051] In the above-mentioned positive electrode materials, 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 of cobalt (Co), manganese (Mn), magnesium (Mg), aluminum (Al), boron (B), titanium (Ti), vanadium (V), chromium (Cr), iron (Fe), copper (Cu), zinc (Zn), molybdenum (Mo), tin (Sn), calcium (Ca), strontium (Sr), tungsten (W), zirconium (Zr), and silicon (Si), and values of z, d, e, and f are respectively within 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 $-0.1 \leq f \leq 0.2$;

[0052] In the above-mentioned positive electrode materials, the chemical formula of the lithium manganese oxide is $Li_uMn_{2-g}M3_gO_{4-h}$, where M3 represents at least one of cobalt (Co), nickel (Ni), magnesium (Mg), aluminum (Al), boron (B), titanium (Ti), vanadium (V), chromium (Cr), iron (Fe), copper (Cu), zinc (Zn), molybdenum (Mo), tin (Sn), calcium (Ca), strontium (Sr), and tungsten (W), and values of z, g, and h are respectively within the following ranges: $0.8 \leq u \leq 1.2$, $0 \leq g < 1.0$ and $-0.2 \leq h \leq 0.2$.

[0053] In some embodiments, the positive electrode may further include at least one of a binder and a conductive agent. It should be understood that those skilled in the art can select conventional binders and conductive agents in the art according to practical requirements without limitation.

[0054] In some embodiments, the separator includes, but is not limited to, at least one of polyethylene, polypropylene, polyethylene glycol terephthalate, polyimide, and aramid. For example, the polyethylene includes at least one component of high density polyethylene, low density polyethylene and ultra-high molecular weight polyethylene. Particularly, polyethylene and polypropylene have a good effect of preventing short circuits, and can improve the stability of a battery by a turn-off effect.

[0055] The lithium-ion battery of this application further includes an electrolyte. The electrolyte may be one or more of a gel electrolyte, a solid electrolyte, and an electrolyte, and the electrolyte includes lithium salt and a non-aqueous solvent.

[0056] In some embodiments, the lithium salt is one or more of $LiPF_6$, $LiBF_4$, $LiAsF_6$, $LiClO_4$, $LiB(C_6H_5)_4$, $LiCH_3SO_3$, $LiCF_3SO_3$, $LiN(SO_2CF_3)_2$, $LiC(SO_2CF_3)_3$,

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$LiSiF_6$, LiBOB, and lithium difluoroborate. For example, $LiPF_6$ is used as the lithium salt because it provides high ionic conductivity and improves the cycle characteristics.

[0057] The non-aqueous solvent may be a carbonate compound, a carboxylate compound, an ether compound, other organic solvents, or a combination thereof.

[0058] The above carbonate compound may be a linear carbonate compound, a cyclic carbonate compound, a fluorocarbonate compound, or a combination thereof.

[0059] The examples of 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 ester, and a combination thereof.

[0060] In some embodiments, the non-aqueous solvent is selected from a group composed of ethylene carbonate, propylene carbonate, diethyl carbonate, dimethyl carbonate, ethyl methyl carbonate, propylene carbonate, methyl acetate, ethyl propionate, fluoroethylene carbonate, and a combination thereof.

[0061] It should be understood that the preparation methods for the negative electrode, the positive electrode, the separator and the lithium-ion battery in the embodiments of this application can select any conventional methods in the art according to specific requirements without departing from the spirit of this application. In one implementation solution of a preparation method for an electrochemical apparatus, a preparation method for the lithium-ion battery includes that: the negative electrode, the separator and the positive electrode in the above embodiments are sequentially wound, folded or stacked to form an electrode component; the electrode component is loaded into, for example, an aluminum-plastic film, and the electrolyte is injected, followed by vacuum packaging, standing, chemical conversion, shaping and other processes to obtain the lithium-ion battery.

[0062] Although illustrated above as a lithium-ion battery, those skilled in the art, after reading this application, will appreciate that the negative electrodes of this application may be used in other suitable electrochemical apparatuses. The electrochemical apparatus includes any apparatus in which an electrochemical reaction occurs. Specific examples of the apparatus include all kinds of primary batteries,

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secondary batteries, fuel batteries, solar batteries, or capacitors. Particularly, 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.

[0063] Some embodiments of this application further provide an electronic apparatus. The electronic apparatus includes the electrochemical apparatus of the embodiment of this application.

[0064] The electronic apparatus of the embodiment of this application is not particularly limited and may be any electronic apparatus known in the art. In some embodiments, the electronic apparatus may include, but is not limited to, a notebook computer, a pen-input type 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 compact disc (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 light, a camera, a large household storage battery, a lithium-ion capacitor, and the like.

SPECIFIC EXAMPLES

[0065] Some specific examples and comparative examples are set forth below, and unit weight and compacted density tests are performed on the negative electrodes, and cycle performance tests and lithium plating tests are performed on the electrochemical apparatuses (lithium-ion batteries) to better explain the technical solutions of this application.

[0066] **I. Test method**

[0067] **Laser particle size analysis:**

[0068] A laser particle size test is to test a particle size distribution according to the principle that particles in different sizes can make laser produce scattering with different

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intensities. Main indexes for characterizing particle size characteristics of particles are Dn10, Dv10, Dv50, Dv90, Dv99 and the like. Dv50 is referred to as the particle size and represents a particle size when a volume of a sample reaches 50% of a total volume from a small particle size in a volume-based particle size distribution. The examples and the comparative examples of this application used a Mastersizer 3000 laser particle size distribution tester to analyze particle sizes of particles of samples: the sample of the negative active material was dispersed in a 100 mL dispersing agent (deionized water) to make a shading degree reach 8% to 12%. The sample was then subjected to ultrasonic treatment for 5 minutes at an ultrasonic intensity of 40 KHz and 180 W. After the ultrasonic treatment, laser particle size distribution analysis was performed on the sample to obtain particle size distribution data.

[0069] **Unit weight and compacted density test:**

[0070] Small round active material samples with an area of 1540.25 mm^2 were respectively obtained from a first negative active material layer and a second negative active material layer on a negative electrode to be tested along the surface of a negative current collector. After the negative current collector was removed, a weight of the negative active material thereof was recorded. Active material samples at 12 different positions were taken into each group, and weights per unit area of the first negative active material layer and the second negative active material layer were calculated.

[0071] A total thickness of the first negative active material layer and the second negative active material layer on the negative electrode in a direction perpendicular to the surface of the current collector was measured (a thickness of the current collector is excluded). Active material samples at 12 different positions were taken into each group, and compaction densities of the first negative active material layer and the second negative active material layer were calculated. $\text{Compaction density} = \text{Weight of negative active material} \Big/ \frac{\text{Total thickness of negative active material in a direction perpendicular to surface of current collector}}{}$.

[0072] **Cycle performance test**

[0073] The lithium-ion batteries of the following examples and comparative examples were left standing in an incubator at 25°C ± 2°C for 2 hours, charged at a

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constant current of 0.5 C to 4.45 V, then charged at a constant voltage of 4.45 V to 0.02 C and left standing for 15 minutes, and the batteries were discharged to 3.0 V at a constant current of 0.5 C. This was one charge and discharge cycle process, and discharge capacities of the first cycle of the lithium-ion batteries were recorded. Then, the charge and discharge cycle process was performed repeatedly according to the foregoing method, and the discharge capacities of each charge and discharge cycle process were recorded, and then were compared with the discharge capacities of the first cycle to obtain a cyclic capacity curve.

[0074] Four lithium-ion batteries in each group were taken, and an average value of capacity retention rates of the lithium-ion batteries were calculated. A cycling capacity retention rate of the lithium-ion battery = (Discharge capacity of the 400th cycle (mAh)/Discharge capacity of the first cycle (mAh))×100%.

[0075] **Lithium plating test:**

[0076] The lithium-ion batteries of the following examples and comparative examples were left standing in an incubator at 25°C ± 2°C for 2 hours and discharged to 3.00 V at a constant current of 0.5 C. After standing for 5 minutes, the lithium-ion batteries were charged to 4.45 V at a constant current of 0.7 C and then charged to 0.02 C at a constant voltage of 4.45 V. This was a lithium plating test cycle. After the above lithium plating test cycle was repeated for 10 times, the lithium-ion batteries were discharged to 3.00 V at a constant current of 0.5 C; and then the lithium-ion batteries were disassembled, and a ratio S of a lithium plating area (in gray) to an area of the negative active material layers was calculated. The degree of lithium plating was determined according to the ratio S of the lithium plating area (in gray) of the fully charged negative electrode to the area of the negative active material layers: the ratio less than 3% indicated slight lithium plating; the ratio from 3% to 5% indicated lithium plating; and the ratio greater than 5% indicated severe lithium plating.

[0077] **II. Preparation method**

[0078] **Preparation of positive electrode**

[0079] Lithium cobalt oxide ($LiCoO_2$), conductive carbon black and polyvinylidene fluoride (PVDF) were dissolved in an N-methylpyrrolidone (NMP) solution in a weight

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ratio of 96.7:1.7:1.6 to form positive slurry. An aluminum foil was used as a positive current collector, and the positive slurry was coated on the positive current collector; and a positive electrode was obtained via drying, cold pressing and cutting procedures.

[0080] **Preparation of electrolyte**

[0081] Under an environment that a moisture content is less than 10 ppm, the lithium hexafluorophosphate, the fluoroethylene carbonate (FEC) and a non-aqueous organic solvent (a weight ratio of ethylene carbonate (EC):dimethyl carbonate (DMC):diethyl carbonate (DEC) was 1:1:1) were prepared into an electrolyte in which a weight concentration of the fluoroethylene carbonate was 10 wt% and a concentration of the lithium hexafluorophosphate was 1 mol/L.

[0082] **Preparation of lithium-ion battery**

[0083] A polyethylene (PE) porous polymer film was used as a separator. The positive electrode, the separator, and the negative electrodes of the following examples and comparative examples were sequentially stacked, so that the separator was located between the positive electrode and the negative electrode for separation, and then were wound into an electrode component. Subsequently, the electrode component was packed into an aluminum-plastic film packing bag, and was subjected to moisture removal at 80°C to obtain a dry electrode component. Subsequently, the electrolyte was injected into the dry electrode component, and the procedures of vacuum packaging, standing, chemical conversion, shaping and the like were performed, Therefore completing the preparation of the lithium-ion batteries of the following examples and comparative examples.

[0084] Example 1

[0085] 400 g of SiO_x ($0.5 \leq x \leq 1.6$), 2400 g of artificial graphite and 35 g of conductive carbon black were added into a stirrer and stirred for 120 minutes at a revolution speed of 20 r/min. Subsequently, 95 g of polyacrylic acid was added into the stirred mixture, stirred for 60 minutes at a revolution speed of 20 r/min and a rotation speed of 1200 r/min, and further stirred for 120 minutes in deionized water to obtain mixed slurry. The mixed slurry was filtered by using a 170-mesh double-layer screen to obtain negative slurry.

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[0086] A copper foil was used as a negative current collector. The negative slurry was coated on the negative current collector. The weight per unit area of the negative slurry coated on one side of a portion was 76.6 g/m^2, and the weight per unit area of the negative slurry coated on two sides of a portion was 153.2 g/m^2. A coating weight ratio K of the two was 0.5, and the two were dried. After drying, cold pressing treatment was performed to obtain a first negative active material layer and a second negative active material layer. A compacted density of the second negative active material layer was 1.78 g/cm^3, and a ratio R of a compacted density of the first negative active material layer to the compacted density of the second negative active material layer was 0.9. Then, a negative electrode was obtained by means of a cutting procedure.

[0087] Example 2

[0088] The preparation method was the same as the preparation method of Example 1, except that the ratio R of the compacted density of the first negative active material layer to the compacted density of the second negative active material layer in Example 2 was 0.95.

[0089] Example 3

[0090] The preparation method was the same as the preparation method of Example 1, except that the ratio R of the compacted density of the first negative active material layer to the compacted density of the second negative active material layer in Example 3 was 0.97.

[0091] Example 4

[0092] The preparation method was the same as the preparation method of Example 1, except that the ratio R of the compacted density of the first negative active material layer to the compacted density of the second negative active material layer in Example 4 was 1.0.

[0093] Example 5

[0094] The preparation method was the same as the preparation method of Example 1, except that the ratio R of the compacted density of the first negative active material layer to the compacted density of the second negative active material layer in Example 5 was 1.1.

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[0095] Example 6

[0096] The preparation method was the same as the preparation method of Example 1, except that the weight per unit area of the negative slurry coated on the single side of the portion in Example 6 was 76.6 g/m^2, and the coating weight ratio K per unit area of the two was 0.47.

[0097] Example 7

[0098] The preparation method was the same as the preparation method of Example 1, except that the weight per unit area of the negative slurry coated on the single side of the portion in Example 7 was 76.6 g/m^2, and the coating weight ratio K per unit area of the two was 0.52.

[0099] Example 8

[00100] The preparation method was the same as the preparation method of Example 1, except that the silicon-based material used in Example 8 was 400 g of silicon carbon (SiC).

[00101] Comparative Example 1

[00102] The preparation method was the same as the preparation method of Example 1, except that the ratio R of the compacted density of the first negative active material layer to the compacted density of the second negative active material layer in Comparative Example 1 was 0.85.

[00103] Comparative Example 2

[00104] The preparation method was the same as the preparation method of Example 1, except that the ratio R of the compacted density of the first negative active material layer to the compacted density of the second negative active material layer in Comparative Example 2 was 1.5.

[00105] Comparative Example 3

[00106] The preparation method was the same as the preparation method of Example 1, except that the weight per unit area of the negative slurry coated on the single side of the portion in Comparative Example 3 was 76.6 g/m^2, and the coating weight ratio K per unit area of the two was 0.4.

[00107] Comparative Example 4

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[00108] The preparation method was the same as the preparation method of Example 1, except that the weight per unit area of the negative slurry coated on the single side of the portion in Comparative Example 4 was 76.6 g/m^2, and the coating weight ratio K per unit area of the two was 0.55.

[00109] Comparative Example 5

[00110] The preparation method was the same as the preparation method of Example 1, except that the silicon-based material used in Comparative Example 5 was 400 g of silicon carbon (SiC).

[00111] Comparative Example 6

[00112] The preparation method was the same as the preparation method of Example 1, except that the silicon-based material used in Comparative Example 6 was 400 g of silicon carbon (SiC), and the ratio R of the compacted density of the first negative active material layer to the compacted density of the second negative active material layer was 1.2.

[00113] Unit weight and compacted density tests were performed on the negative electrodes of the above examples and comparative examples. Subsequently, a cycle performance test and a storage expansion rate test were performed on the lithium-ion batteries, and their test results were recorded.

[00114] The statistical values of the negative electrodes of Examples 1-8 and Comparative Examples 1-6 and the results that pass through the unit weight and compacted density tests, the cycle performance test and the lithium plating test were shown in Table 1 below.

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Table 1

Example/Comparative Example	Silicon-based material	K value of fresh negative electrode	R value of fresh negative electrode	Capacity retention rate in cycling (-)	K value after 400 cycles	R value after 400 cycles	S value of the region (102A) of the first negative active material layer after 400 cycles	S value of the region (103A), adjacent to the first negative active material layer, of the second negative active material layer after 400 cycles	S value after lithium plating test cycles
Example 1	Silicon oxide	0.5	0.9	90.3%	0.5	0.88	0	2.8%	2.6%
Example 2	Silicon oxide	0.5	0.95	91.1%	0.5	0.94	0	1.6%	2.0%
Example 3	Silicon oxide	0.5	0.97	91.7%	0.5	0.96	0	0	0
Example 4	Silicon oxide	0.5	1.0	92.1%	0.5	1.0	0	0	0
Example 5	Silicon oxide	0.5	1.1	91.9%	0.5	1.12	2.4%	0	2.5%
Example 6	Silicon oxide	0.47	1.0	89.7%	0.47	0.95	2.7%	0	2.8%
Example 7	Silicon oxide	0.52	1.0	90.6%	0.52	1.08	0	1.8%	2.0%

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Example/Comparative Example	Silicon-based material	K value of fresh negative electrode	R value of fresh negative electrode	Capacity retention rate in cycling (-)	K value after 400 cycles	R value after 400 cycles	S value of the region (102A) of the first negative active material layer after 400 cycles	S value of the region (103A), adjacent to the first negative active material layer, of the second negative active material layer after 400 cycles	S value after lithium plating test cycles
Example 8	Silicon carbon	0.5	1.0	89%	0.5	1.0	0	0	0
Comparative Example 1	Silicon oxide	0.5	0.85	83.4%	0.5	0.78	2.0%	3.3%	20%
Comparative Example 2	Silicon oxide	0.5	1.5	80.3%	0.5	1.6	6%	4.5%	22%
Comparative Example 3	Silicon oxide	0.4	1.0	77.5%	0.4	0.83	8%	2.5%	30%
Comparative Example 4	Silicon oxide	0.55	1.0	82.5%	0.55	1.1	2.6%	8.9%	26%

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Example/Comparative Example	Silicon-based material	K value of fresh negative electrode	R value of fresh negative electrode	Capacity retention rate in cycling (-)	K value after 400 cycles	R value after 400 cycles	S value of the region (102A) of the first negative active material layer after 400 cycles	S value of the region (103A), adjacent to the first negative active material layer, of the second negative active material layer after 400 cycles	S value after lithium plating test cycles
Comparative Example 5	Silicon carbon	0.5	0.85	73.1%	0.5	0.72	2.7%	4.3%	28%
Comparative Example 6	Silicon carbon	0.5	1.2	79%	0.5	1.4	3.4%	3.1%	24%

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[00115] As shown in table 1, compared with the corresponding comparative examples, the examples of this application can effectively reduce lithium plating on the negative electrode and improve the cycling capacity retention rate of the lithium-ion battery.

[00116] As can be seen by comparing Examples 1-5 and 8 with Comparative Examples 1, 2, 5 and 6, when the ratio R of the compacted density of the first negative active material layer to the compacted density of the second negative active material layer is closer to 1, the lithium plating of the negative electrode can be reduced more. When the ratio K of the weight per unit area of the first negative active material layer to the weight per unit area of the second negative active material layer is 0.5, since the coating weight of the electrode piece is uniform, the current density between the first negative active material layer and the second negative active material layer is the same; and at this time, R value<1 indicates that the compacted density of the first negative active material layer region is smaller, and lithium ions are more easily intercalated and deintercalated in the first negative active material layer region, so that no lithium plating occurs in the first negative active material layer region. R>1 indicates that the compacted density of the first negative active material layer region is larger, so that lithium ions have higher deintercalation resistance, and lithium plating is easier to occur in the first negative active material layer region.

[00117] FIG. 3 is a curve of cycling capacities of Example 4 and Comparative Example 2 of this application.

[00118] As shown in FIG. 3, the ratio R of the compacted density of the first negative active material layer of the fresh negative electrode in Example 4 to the compacted density of second negative active material layer was 1. After 400 cycles, expansive deformation was not easy to occur due to the consistent compaction density, and the R value did not change much. Therefore, the lithium-ion battery of Example 4 can maintain an extremely high capacity retention rate throughout the cycle. In contrast, the ratio R of the compaction densities of the negative electrode of Comparative Example 2 was 1.5; after 400 cycles, the originally inconsistent compaction densities caused different contents of the silicon-based materials of the first negative active material and

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the second negative active material on the negative electrode, Therefore resulting in inconsistent expansion rates and intensified changes of the compaction densities. Therefore, the capacity retention rate of the lithium-ion battery of Comparative Example 2 would be sharply decreased.

[00119] As can be seen by comparing Examples 4, 6, and 7 with Comparative Examples 3 and 4, when the ratio K of the weight per unit area of the first negative active material layer to the weight per unit area of the second negative active material layer is closer to 0.5, the lithium plating of the negative electrode can be reduced more. $K<0.5$ indicates that the first negative active material layer region contains fewer negative active materials, resulting in a large current density of the first negative active material layer region in the cycle process, so that lithium plating is easy to occur. $K>0.5$ indicates that the first negative active material layer region contains more negative active materials, resulting in a small current density of the first negative active material layer region in the cycle process, so that lithium plating is hard to occur.

[00120] By means of comparison of the above-mentioned examples and comparative examples, it can be clearly understood that by controlling the ratio K of the weights per unit area and the ratio R of the compaction densities of the first negative active material layer to the second negative active material layer, the negative electrode of this application can effectively reduce the degree of lithium plating, thereby improving the cycle performance of the lithium-ion battery.

[00121] References to "some embodiments", "partial embodiments", "an embodiment", "another example", "for example", "specific examples", or "partial examples" in the whole specification mean the inclusion of specific features, structures, materials, or characteristics described in the embodiment or example in at least one embodiment or example of this application. Accordingly, descriptions appearing in the whole 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 this application. In addition, specific features, structures, materials, or characteristics herein may be incorporated in any suitable manner into one or more embodiments or examples.

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[00122] 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 this application, and that the embodiments may be changed, replaced, and modified without departing from the spirit, principle, and scope of this application.

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CLAIMS

What is claimed is:

1. A negative electrode, comprising:

a negative current collector;

a first negative active material layer, wherein the first negative active material layer is arranged on one side of a first portion of the negative current collector; and

a second negative active material layer, wherein the second negative active material layer is arranged on two sides of a second portion, different from the first portion, of the negative current collector;

wherein a ratio of a weight per unit area of the first negative active material layer to a weight per unit area of the second negative active material layer on the negative current collector is 0.47 to 0.52, and a ratio of a compacted density of the first negative active material layer to a compacted density of the second negative active material layer is 0.9 to 1.1.

2. The negative electrode according to claim 1, wherein the first negative active material layer and the second negative active material layer each independently comprise a silicon-based material and graphite, wherein the silicon-based material is selected from the group consisting of silicon oxide, silicon carbon, and a combination thereof.

3. The negative electrode according to claim 2, wherein a weight of the silicon-based material in the first negative active material layer and the second negative active material layer is greater than or equal to 5% and less than 100%, based on a total weight of the silicon-based material and the graphite.

4. The negative electrode according to claim 2, wherein a form of the silicon-based material comprises a crystalline state, an amorphous state, or a combination thereof, wherein the first negative active material layer has a particle size Dv50 of 8.0 μm to 20 μm, and the second negative active material layer has a particle size Dv50 of 8.0 μm to 20 μm.

5. The negative electrode according to claim 2, wherein for the silicon-based material, a ratio of a peak height at a wavenumber of 500 cm^{-1} ± -10 cm^{-1} to a peak

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height at a wavenumber of 1350 cm^{-1} ± 10 cm^{-1} in a Raman spectrum is greater than 0.

6. The negative electrode according to claim 2, wherein the silicon-based material further comprises a carbon coating layer.

7. The negative electrode according to claim 2, wherein the first negative active material layer and the second negative active material layer each independently comprise a binder and a conductive agent; wherein the binder comprises a material selected from the group consisting of polyacrylate, polyimide, polyamide, polyamideimide, polyvinylidene fluoride, styrene-butadiene rubber, sodium alginate, polyvinyl alcohol, polytetrafluoroethylene, polyacrylonitrile, sodium carboxymethyl cellulose, potassium carboxymethyl cellulose, and a combination thereof; and the conductive agent comprises a material selected from the group consisting of conductive carbon black, acetylene black, Ketjen black, graphene, and a combination thereof.

8. The negative electrode according to claim 7, wherein based on a total weight of the first negative active material layer, the total weight of the silicon-based material and the graphite in the first negative active material layer is 94% to 96%, a weight of the binder is 2.8% to 4.0%, and a weight of the conductive agent is 0.4% to 1.6%; and

based on a total weight of the second negative active material layer, the total weight of the silicon-based material and the graphite in the second negative active material layer is 94% to 96%, the weight of the binder is 2.8% to 4.0%, and the weight of the conductive agent is 0.4% to 1.6%.

9. The negative electrode according to claim 1, wherein a thickness of the first negative active material layer is 40 μm to 60 μm, and a single-layer thickness of the second negative active material layer is 40 μm to 60 μm.

10. An electrochemical apparatus, comprising:

a positive electrode;

a separator; and

a negative electrode;

wherein the negative electrode comprises a negative current collector; a first negative active material layer, wherein the first negative active material layer is arranged on one side of a first portion of the negative current collector; and a second

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negative active material layer, wherein the second negative active material layers are arranged on two sides of a second portion, different from the first portion, of the negative current collector,

wherein a ratio of a weight per unit area of the first negative active material layer to a weight per unit area of the second negative active material layer on the negative current collector is 0.47 to 0.52, and a ratio of a compacted density of the first negative active material layer to a compacted density of the second negative active material layer is 0.9 to 1.1.

11. An electronic apparatus, comprising the electrochemical apparatus according to claim 10.

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ABSTRACT

A negative electrode includes a negative current collector, a first negative active material layer and a second negative active material layer. The first negative active material layer is arranged on one side of a first portion of the negative current collector, and the second negative active material layers are arranged on two sides of a second portion, different from the first portion, of the negative current collector. A ratio of a weight per unit area of the first negative active material layer to a weight per unit area of the second negative active material layer on the negative current collector is 0.47 to 0.52, and a ratio of a compacted density of the first negative active material layer to a compacted density of the second negative active material layer is 0.9 to 1.1.

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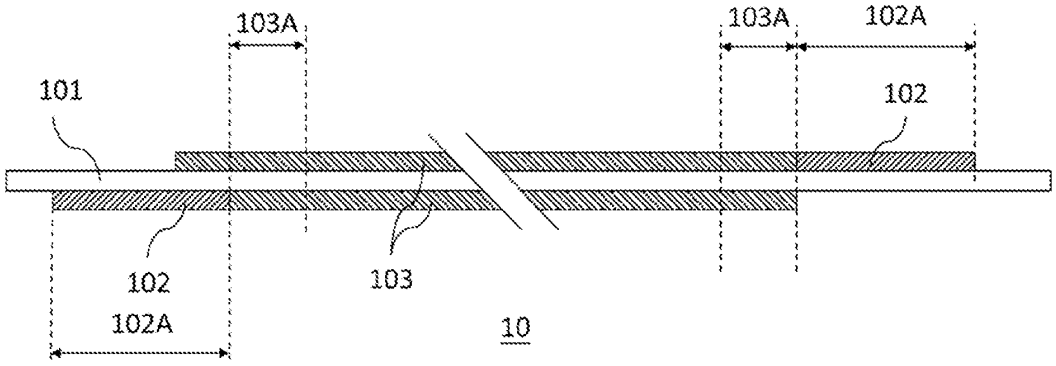

103A
103A
102A
101
102
102
103
102A
10

FIG. 1

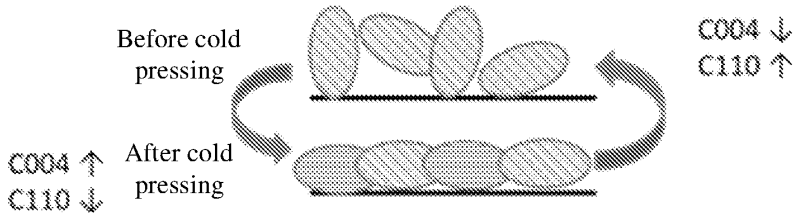

Before cold pressing
C004 ↓
C110 ↑
C004 ↑
C110 ↓
After cold pressing

FIG. 2

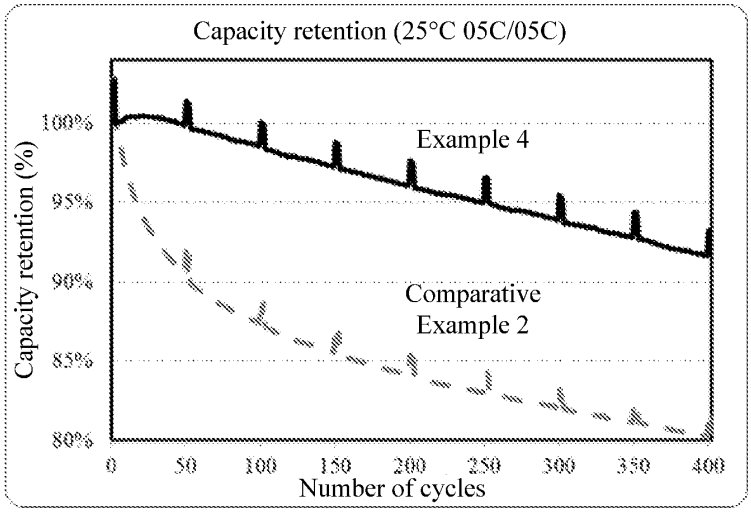

Capacity retention (25°C 05C/05C)
Capacity retention (%)
100%
95%
90%
85%
80%
Example 4
Comparative
Example 2
0
50
100
150
200
250
300
350
400
Number of cycles

FIG. 3

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

Title of Invention	NEGATIVE ELECTRODE AND ELECTROCHEMICAL APPARATUS CONTAINING SAME, AND ELECTRONIC APPARATUS

As the below named inventor, I hereby declare that:

This declaration is directed to: [X] 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.

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LEGAL NAME OF INVENTOR

Inventor: Ting Yi Date (Optional): _____

Signature: Ting Yi

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.**

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Privacy Act Statement

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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/01 (06-12)
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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	NEGATIVE ELECTRODE AND ELECTROCHEMICAL APPARATUS CONTAINING SAME, AND ELECTRONIC APPARATUS

As the below named inventor, I hereby declare that:

This declaration is directed to:

- [X] 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: Hang Cui Date (Optional) :_____

Signature: Hang Cui

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.

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This declaration is directed to:

- [X] 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.

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LEGAL NAME OF INVENTOR

Inventor: Yuansen Xie Date (Optional): _____

Signature: Yuansen Xie

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

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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	
Filing Date	March 29, 2022
First Named Inventor	Ting YI
Title	NEGATIVE ELECTRODE AND ELECTROCHEMICAL APPARATUS CONTAINING SAME, AND ELECTRONIC APPARATUS
Art Unit	TBD
Examiner Name	TBD
Attorney Docket Number	14850059US

SIGNATURE of Applicant or Patent Practitioner

Signature	/Timothy J. Maier/	Date (Optional)	March 29, 2022
Name	Timothy J. Maier	Registration Number	51,986
Title (if Applicant is a juristic entity)			
Applicant Name (if Applicant is a juristic entity)			

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 1 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.**

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

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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: 62008

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:

OR

Firm or Individual Name					
Address					
City		State		Zip	
Country					
Telephone		Email			

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 forms are submitted.

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PTO/SB/08a (02-18)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	
Filing Date	2022-03-29
First Named Inventor	Ting YI
Art Unit	TBD
Examiner Name	TBD
Attorney Docket Number	14850059US

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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	1	20130171502	A1	2013-07-04	CHEN GUORONG ET AL	Cited in NPL cite No. 1
	2	20190305317	A1	2019-10-03	NEC CORPORATION	Cited in NPL cite No. 1
	3	20070048615	A1	2007-03-01	PANASONIC CORPORATION	Cited in NPL cite No. 2

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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	109841794	CN	A	2019-06-04	NINGDE AMPEREX TECHNOLOGY LTD	Cited in NPL cite No. 1; English Abstract Attached	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2022-03-29
	First Named Inventor	Ting YI
	Art Unit	TBD
	Examiner Name	TBD
	Attorney Docket Number	14850059US

	2	102683751	CN	A	2012-09-19	ZHEJIANG ZHENLONG BATTERY CO LTD	Cited in NPL cite No. 1; English Abstract Attached	
	3	102856538	CN	A	2013-01-02	FDK TWICELL CO LTD	Cited in NPL cite No. 1 & 2; English Abstract Attached	
	4	110010902	CN	A	2019-07-12	NINGDE AMPEREX TECHNOLOGY LTD	Cited in NPL cite No. 1; English Abstract Attached	
	5	108023117	CN	A	2018-05-11	BEIJING NAT BATTERY TECH CO LTD	English Abstract Attached	
	6	109378480	CN	A	2019-02-22	ZHUHAI COSLIGHT BATTERY CO LTD	English Abstract Attached	
	7	101934269	CN	A	2011-01-05	NINGBO VEKEN BATTERY CO LTD	Cited in NPL Cite No. 3; English Abstract Attached	
	8	103825044	CN	A	2014-05-28	SONY CORPORATION	Cited in NPL Cite No. 2; English Abstract Attached	
	9	205376669	CN	U	2016-07-06	NINGDE NEW ENERGY TECHNOLOGY CO LTD	Cited in NPL Cite No. 2; English Abstract Attached	
	10	101944607	CN	A	2011-01-12	HUNAN CORUN NEW ENERGY CO LTD	Cited in NPL Cite No. 2; English Abstract Attached	
	11	108701807	CN	A	2018-10-23	NANOSCALE COMPONENTS INC	Cited in NPL Cite No. 2; English Abstract Attached	
	12	3387687	EP	A1	2018-10-17	NANOSCALE COMPONENTS INC	Cited in NPL Cite No. 2 & Corresponding to WO2017100415; English Abstract Attached	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2022-03-29
	First Named Inventor	Ting YI
	Art Unit	TBD
	Examiner Name	TBD
	Attorney Docket Number	14850059US

	13	2017100415	WO	A1	2017-06-15	NANOSCALE COMPONENTS INC	Corresponding to EP3387687	

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	International Search Report mailed September 16, 2020, corresponding to International Application No. PCT/CN2019/130465; 6 pages (with English translation).	☒
	2	First Office Action issued September 23, 2020, corresponding to Chinese Application No. 201911267132.X; 6 pages (with English Translation).	☒
	3	Notification to Grant Patent Right for Invention issued April 1, 2021, corresponding to Chines Application No. 201911267132.X; 6 pages (with English Translation).	☒

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EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2022-03-29
	First Named Inventor	Ting YI
	Art Unit	TBD
	Examiner Name	TBD
	Attorney Docket Number	14850059US

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Timothy J. Maier/	Date (YYYY-MM-DD)	2022-03-29
Name/Print	Timothy J. Maier	Registration Number	51,986

This collection of information is required by 37 CFR 1.97 and 1.98. 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 1 hour 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.**

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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.

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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 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.

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Espacenet

Bibliographic data: CN109841794 (A) — 2019-06-04

Electrode plate and electrochemical device comprising same

Inventor(s): WANG HUIXIN; HUANG SILIN; CHENG SHENG; YU HONGMING ± (王慧鑫, ; 黄思林, ; 程晟, ; 余红明)

Applicant(s): NINGDE AMPEREX TECHNOLOGY LTD ± (宁德新能源科技有限公司, ; 东莞新能安科技有限公司)

Classification: - international: ***H01M10/0525; H01M10/42; H01M4/13; H01M4/131; H01M4/133; H01M4/134; H01M4/136; H01M4/137***
- cooperative: **H01M10/0525 (US); H01M4/131 (EP); H01M4/133 (EP, US); H01M4/134 (EP); H01M4/386 (EP, US); H01M4/525 (EP); H01M4/587 (EP); H01M4/625 (EP);** H01M2004/021 (EP); H01M2004/027 (EP); H01M2004/028 (EP, US); Y02E60/10 (EP)

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Abstract of CN109841794 (A)

The application relates to an electrode plate and an electrochemical device comprising the same. The electrode plate has a first region and a second region. The electrode plate comprises a substrate and an electrode active substance applied to at least one surface of the substrate. The charge-discharge thickness difference of the electrode plate in the first region is Delta D1, the charge-discharge thickness difference of the electrode plate in the second region is Delta D2, and Delta D1 is smaller than Delta D2. When the electrode plate of the application is applied to the electrochemical device, the formation of lithium dendrite can be reduced, and the safety of the electrochemical device can be improved.

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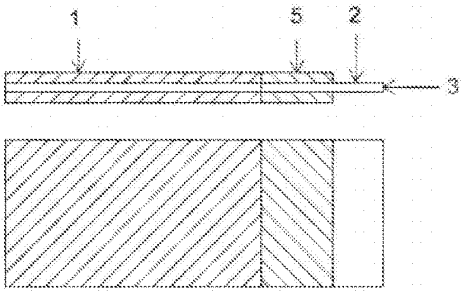
权利要求书1页 说明书19页 附图1页

(54)发明名称

电极极片和包含所述电极极片的电化学装置

(57)摘要

本申请涉及电极极片和包含所述电极极片的电化学装置。所述电极极片包括第一区和第二区，其中所述电极极片包括基材以及在所述基材的至少一个表面上涂敷的电极活性物质，且其中所述第一区的电极极片的充放电厚度差为$\triangle D_1$，所述第二区的电极极片的充放电厚度差为$\triangle D_2$，其中$\triangle D_1$小于$\triangle D_2$。当将本申请所述的电极极片应用于电化学装置时，能够有效地降低锂枝晶的形成，改善电化学装置的安全性。



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1.一种电极极片，其包括第一区和第二区，

其中所述电极极片包括基材以及在所述基材的至少一个表面上涂敷的电极活性物质，且

其中所述第一区的电极极片的充放电厚度差为$\triangle D_1$，所述第二区的电极极片的充放电厚度差为$\triangle D_2$，其中$\triangle D_1$小于$\triangle D_2$。

2.根据权利要求1所述的电极极片，其中所述第一区的电极极片的厚度为L_1，所述第二区的电极极片的厚度为L_2，其中L_2大体上等于L_1。

3.根据权利要求1所述的电极极片，其中所述第一区包括主体区，所述第二区包括边缘区。

4.根据权利要求1所述的电极极片，其中所述第一区和所述第二区分别包括具有大体上相同的充电膨胀率的电极活性物质或者具有不同的充电膨胀率的电极活性物质。

5.根据权利要求1所述的电极极片，其中所述第一区的电极活性物质包括三元材料，所述第二区的电极活性物质包括钴酸锂。

6.根据权利要求1所述的电极极片，其中所述第一区的电极活性物质和所述第二区的电极活性物质均包括碳材料，且其中所述第一区的碳材料的OI值小于所述第二区的碳材料的OI值。

7.根据权利要求1所述的电极极片，其中所述第一区的电极活性物质和所述第二区的电极活性物质均包括碳材料，其中所述第一区的碳材料的石墨化度小于所述第二区的碳材料的石墨化度。

8.根据权利要求1所述的电极极片，其中所述第一区的电极活性物质包括石墨，所述第二区的电极活性物质包括硅。

9.根据权利要求1所述的电极极片，其中所述第一区的电极活性物质包括硬碳，所述第二区的电极活性物质包括石墨和/或硅。

10.一种电芯，其包括权利要求1-9中任一者所述的电极极片。

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电极极片和包含所述电极极片的电化学装置

技术领域

[0001] 本申请涉及储能技术领域，尤其涉及电极极片和包含所述电极极片的电化学装置。

背景技术

[0002] 随着消费电子类的产品如笔记本电脑、手机、掌上游戏机、平板电脑、移动电源和无人机等的普及，人们对其中的电化学装置(例如，电池)的要求越来越严格。例如，人们不仅要求电池轻便，而且还要求电池拥有高容量和长的工作寿命。在众多的电池中，锂离子电池凭借其具有能量密度高、安全性高、自放电低、无记忆效应、工作寿命长等突出优点已经在市场上占据主流地位。

[0003] 然而，到目前为止，电化学装置的安全性仍无法得到有效的保障。例如，当锂离子电池经过长期的充放电循环后，锂离子电池的电极极片，尤其是阳极极片的表面上会析出锂而形成锂枝晶。锂枝晶的形成很大程度上会戳破阳极极片和阴极极片之间的隔离膜，导致阴极极片和阳极极片直接接触而发生电化学短路，从而大大降低电芯的安全性。因此，提高电化学装置的安全性是本领域重要的研究课题。

发明内容

[0004] 本申请提供一种电极极片以及包含所述电极极片的电芯和电化学装置以试图在至少某种程度上解决至少一个存在于相关领域中的问题。

[0005] 在一个实施例中，本申请提供了一种电极极片，其包括第一区和第二区，其中所述电极极片包括基材以及在所述基材的至少一个表面上涂敷的电极活性物质，且其中所述第一区的电极极片的充放电厚度差为$\triangle D_1$，所述第二区的电极极片的充放电厚度差为$\triangle D_2$，其中$\triangle D_1$小于$\triangle D_2$。

[0006] 在一些实施例中，所述第一区的电极极片的厚度为L_1，所述第二区的电极极片的厚度为L_2，其中L_2大体上等于L_1。

[0007] 在一些实施例中，在制备电极极片的过程中使第一区的极片厚度L_1大体上等于第二区的极片厚度L_2。

[0008] 在一些实施例中，在电芯化成过程中或化成后使第一区的极片厚度L_1大体上等于第二区的极片厚度L_2。

[0009] 在一些实施例中，所述第一区包括主体区而所述第二区包括边缘区。

[0010] 在一些实施例中，所述第一区和所述第二区分别包括具有大体上相同的充电膨胀率的电极活性物质。

[0011] 在一些实施例中，所述第一区和所述第二区分别包括具有不同的充电膨胀率的电极活性物质。

[0012] 在一些实施例中，所述第一区和所述第二区分别包括相同的电极活性物质。

[0013] 在一些实施例中，所述第一区和所述第二区分别包括不同的电极活性物质。

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[0014] 在一些实施例中，所述第一区的电极活性物质包括三元材料，而所述第二区的电极活性物质包括钴酸锂。

[0015] 在一些实施例中，所述第一区的电极活性物质和所述第二区的电极活性物质均包括碳材料，且其中所述第一区的碳材料的OI值小于所述第二区的碳材料的OI值。

[0016] 在一些实施例中，所述第一区的电极活性物质和所述第二区的电极活性物质均包括碳材料，其中所述第一区的碳材料的石墨化度小于所述第二区的碳材料的石墨化度。

[0017] 在一些实施例中，所述第一区的电极活性物质包括石墨，而所述第二区的电极活性物质包括硅。

[0018] 在一些实施例中，所述第一区的电极活性物质包括硬碳，而所述第二区的电极活性物质包括石墨和/或硅。

[0019] 在一些实施例中，所述电极极片可以用作电化学装置中的阳极极片和/或阴极极片。

[0020] 在一个实施例中，本申请还提供了一种电芯，其包括上述实施例中所述的电极极片。

[0021] 在一个实施例中，本申请还提供了一种电化学装置，其包括本申请所述的电芯。

[0022] 在一些实施例中，所述电化学装置为锂离子电池。

[0023] 本申请通过在所述电芯的极片不同区进行差异设置，改善了所述电芯的极片不同区域锂沉积不均匀的问题，降低了锂枝晶形成的概率、及发生电化学短路的可能性，从而大大提高电芯的安全性。本申请实施例的额外层面及优点将部分地在后续说明中描述、显示、或是经由本申请实施例的实施而阐释。

附图说明

[0024] 在下文中将简要地说明为了描述本申请实施例或现有技术所必要的附图以便于描述本申请的实施例。显而易见地，下文描述中的附图仅只是本申请中的部分实施例。对本领域技术人员而言，在不需要创造性劳动的前提下，依然可以根据这些附图中所例示的结构来获得其他实施例的附图。

[0025] 图1示出了现有技术中的常见的电极极片的结构；

[0026] 图2示出了本申请的一些实施例中的经分区的电极极片的结构示意图。

[0027] 附图标记1指示主体区；

[0028] 附图标记2指示空箔区；

[0029] 附图标记3指示基材；

[0030] 附图标记4指示边缘薄区；

[0031] 附图标记5指示边缘区。

具体实施方式

[0032] 本申请的实施例将会被详细的描示在下文中。在本申请说明书全文中，将相同或相似的组件以及具有相同或相似的功能的组件通过类似附图标记来表示。在此所描述的有关附图的实施例为说明性质的、图解性质的且用于提供对本申请的基本理解。本申请的实施例不应该被解释为对本申请的限制。

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[0033] 如本文中所使用，术语“大致”、“大体”、“大体上”、“实质”及“约”用以描述及说明小的变化。当与事件或情形结合使用时，所述术语可指代其中事件或情形精确发生的例子以及其中事件或情形极近似地发生的例子。举例来说，当结合数值使用时，术语可指代小于或等于所述数值的±10%的变化范围，例如小于或等于±5%、小于或等于±4%、小于或等于±3%、小于或等于±2%、小于或等于±1%、小于或等于±0.5%、小于或等于±0.1%、或小于或等于±0.05%。举例来说，如果两个数值之间的差值小于或等于所述值的平均值的±10%(例如小于或等于±5%、小于或等于±4%、小于或等于±3%、小于或等于±2%、小于或等于±1%、小于或等于±0.5%、小于或等于±0.1%、或小于或等于±0.05%)，那么可认为所述两个数值“大体上”相同。

[0034] 另外，有时在本文中以范围格式呈现量、比率和其它数值。应理解，此类范围格式是用于便利及简洁起见，且应灵活地理解，不仅包含明确地指定为范围限制的数值，而且包含涵盖于所述范围内的所有个别数值或子范围，如同明确地指定每一数值及子范围一般。

[0035] 术语“主体区”为涂敷主要的电极活性物质的区域或者涂敷电极活性物质的主要区域。例如，在本申请的一些实施例中，在电极极片的不同区域中分别涂敷不同的电极活性物质A和B，其中电极活性物质A为主要的电极活性物质，那么涂敷活性物质A的区域为主体区。再例如，在本申请的一些实施例中，在电极极片的不同区域C和D中涂敷相同的电极活性物质，其中区域C的面积大，那么区域C为主体区。

[0036] 术语“边缘区”为距离主体区边缘几毫米到几十毫米(例如约3mm至40mm)的区域。在本申请的一些实施例中，边缘区可以，但不限制为，距离主体区边缘约30mm的区域、距离主体区边缘约20mm的区域、距离主体区边缘约10mm的区域、或者距离主体区边缘约5mm的区域。

[0037] 一、电极极片

[0038] 以锂离子电池为例，目前应用于锂离子电池的电极极片有多种结构类别，例如多极耳卷绕结构(MTW)、全极耳卷绕结构(FTW)、和叠片结构(Stack)等。通常，锂离子电池的电极极片包括基材(也称，集流体)和位于基材的至少一个表面上的电极活性物质，其中大多数的基材为金属材料以起到传递电子的作用，而电极活性物质则能够将化学能转化成电能。

[0039] 图1示出了现有技术中的常见的电极极片的结构。如图1所示，在制备电极极片的过程中，现有技术通常会将极片分为活性物质区和空箔区(也称，极耳区)，其中空箔区为距离基材边缘几毫米至几十毫米的区域而不涂敷任何电极活性物质以用于附接极耳。

[0040] 针对电极极片中的活性物质区，现有技术通常是不分区的。当将电极活性物质涂敷至活性物质区时，由于大多数的浆料呈现液体状态而具有流动性，这就造成浆料难以避免地流向空箔区。由于浆料中的固体颗粒(例如，电极活性物质)的流动速率小于液体分子(例如，溶剂)的流动速率，这就导致相较于活性物质区，空箔区的电极活性物质较少且因此极片厚度较薄而形成边缘薄区。

[0041] 电化学装置通常包括电芯，而电芯通常包括阳极极片、阴极极片和隔离膜，其中隔离膜设置在阳极极片和阴极极片之间以防止短路。在将电芯应用于电化学装置之前，通常需要对电芯进行化成。在化成阶段，会对电芯同时进行充放电循环和压制工艺以激活阳极极片和阴极极片，并将阳极极片、隔膜和阴极极片紧密压实在一起而增强电芯的稳定性并

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减小电芯的体积，从而改善电芯的循环稳定性并提高电芯的体积比容量。

[0042] 在化成阶段，伴随着充放电的进行，电极极片上的活性物质会发生体积膨胀。例如，就锂离子电池而言，充电的过程即为锂离子嵌入阳极活性物质的过程，而放电过程即为锂离子嵌入阴极活性物质的过程。如上所述，现有技术中的电极极片同时存在厚区（例如，主体区）和薄区（例如，边缘区）。当在压制的过程中施加相同的压力至电芯的表面时，相较于厚区的极片，薄区的极片受压较轻，这就有可能导致薄区的阳极极片、隔膜和阴极极片之间的粘结力较弱，难以实现上述三者之间紧密的贴合，从而导致随着充放电次数的增加而出现局部界面分离的现象。

[0043] 当阳极极片、隔膜和阴极极片之间出现局部界面分离时，会导致电流密度在电极表面上的不均匀的分布且使得电极极片的一部分电极活性物质难以发挥电化学活性。例如，当过量的锂离子存在阳极极片的薄区时，由于阳极极片薄区的阳极活性物质无法完全“吸收”这些锂离子，这些锂离子中的一部分会在阳极极片的表面上沉积形成锂枝晶。锂枝晶的形成很大程度上会戳破隔离膜，导致阴极极片和阳极极片直接接触而发生电化学短路，从而大大降低电芯的安全性。

[0044] 至少为了克服上述缺陷，本申请将电极极片分成多个区域并进行差异涂布，在薄区涂覆充放电后厚度变化较大的物质，实现薄区的充放电厚度差大于厚区充放电厚度差，通过补偿电极极片涂布后有明显变薄效应的区域的厚度，使得电极极片的多个区域的厚度大体上相同。

[0045] 图2示出了本申请的其中一些实施例中的经分区的电极极片的结构示意图。如图2所示，在本申请的一些实施例中，所述电极极片包括基材和在所述基材的至少一个表面上涂敷的电极活性物质，其中所述电极极片包括第一区（例如，主体区）和第二区（例如，边缘区），且其中所述第一区的电极极片的厚度为L_1，所述第二区的电极极片的厚度为L_2，其中L_2大体上等于L_1。在本申请的一些实施例中，“大体上等于”所限定的范围为：较大值与较小值的差值与较大值的比值大于等于0且小于等于2%。例如此处“L_2大体上等于L_1”的范围为：$0 \leq (L_1-L_2)/L_1 \leq 2\%$。

[0046] 由于不同区域的电极极片厚度是大体相同的，那么当电极极片在化成设备的平板夹具间各处受力相同时，电极极片的各个区域和主体区一样具备大致相同的界面粘结力。在主体区不会产生界面分离的条件下，其他区也不会因受力不均匀而产生的局部界面分离的现象。因此，这就大大降低了锂离子在阳极极片的表面形成锂枝晶的概率，提高了电芯的安全性。

[0047] 本申请并不限制第一区和第二区的电极极片的厚度的值。在本申请的一些实施例中，第一区的极片厚度L_1和第二区的极片厚度L_2可以在，但不限制于，约10μm-约500μm的范围内。例如，L_1或L_2可以，但不限制为，约20μm、约30μm、约40μm、约50μm、约60μm、约70μm、约80μm、约90μm、约100μm、约110μm、约120μm、约130μm、约140μm、约150μm、约160μm、约170μm、约180μm、约190μm、约200μm、约220μm、约240μm、约260μm、约280μm、约300μm、约320μm、约340μm、约360μm、约380μm、约400μm、约420μm、约440μm、约460μm、约480μm、约500μm。

[0048] 在本申请的一些实施例中，在制备电极极片的过程中使第一区的极片厚度L_1大体上等于第二区的极片厚度L_2。

[0049] 在本申请的一些实施例中，在电芯化成过程中使第一区的极片厚度L_1大体上等于

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第二区的极片厚度L_2。

[0050] 在本申请的一些实施例中，不需要在制备电极极片的阶段使得第一区的极片厚度L_1大体上等于第二区的极片厚度L_2，只需要在电芯的化成阶段或化成后实现L_1大体上等于L_2即可。也即，即便在电极极片的制备过程中出现极片薄区的情形，在电芯的化成阶段中补偿薄区的厚度以弥补其与厚区之间的厚度差异，也能实现上述两个不同区域的厚度大体上相等。

[0051] 在本申请的一些实施例中，所述第一区包括主体区而所述第二区包括边缘区。

[0052] 此外，上述提及的“空箔区”为在制备电极极片的过程中为附接极耳而留出的空白区域，而制备完成的电极极片中并不一定包含空箔区。

[0053] 在本申请的一些实施例中，所述第一区和所述第二区分别包括具有大体上相同的充电膨胀率的电极活性物质。“充电膨胀率”指的是相较于未经过充电的电极活性物质，经充电后的电极活性物质的体积膨胀率。“具有大体上相同的充电膨胀率”意味着在充电过程中，第一区和第二区的电极活性物质经历大体上同等程度的膨胀。由于不同的电极活性物质可能具有大体上相同的充电膨胀率，因此在本申请的一些实施例中，所述第一区和所述第二区可以采用不同的电极活性物质。当然，在本申请的一些实施例中，所述第一区和所述第二区可以采用相同的电极活性物质。在上述实施例中，如果想要获得具有大体上相同厚度的电极极片，需要在制备电极极片的过程中，在第一区和第二区的基材上分别涂敷厚度相同的电极活性物质。

[0054] 在本申请的一些实施例中，所述第一区和所述第二区分别包括具有大体上不同的充电膨胀率的电极活性物质。也即，在充电过程中，第一区和第二区的电极活性物质经历不同程度的膨胀。例如，针对在制备电极极片的过程中出现边缘薄区的情形，可以在边缘薄区涂敷充电膨胀率更大的电极活性物质以补偿在制备阶段主体区和边缘区充放电厚度差。

[0055] 本申请所述的电极极片可以用作电化学装置中的阴极极片，也可以用作电化学装置中的阳极极片。以下将具体描述可以用作锂离子电池的阴极极片和阳极极片的电极活性物质。

[0056] (一)阴极极片

[0057] 在本申请的一些实施例中，锂离子电池的阴极极片包括阴极基材(也称，阴极集流体)和位于阴极基材的至少一个表面上的阴极活性物质。在一些实施例中，所述阴极基材可为，但不限于，铝箔或镍箔。

[0058] 锂离子电池的阴极活性物质包括能够吸收和释放锂(Li)的阴极材料(下文中，有时称为“能够吸收/释放锂Li的阴极材料”)。能够吸收/释放锂(Li)的阴极材料的实例可以包括但不限于：钴酸锂、三元材料、锰酸锂、磷酸锰铁锂、磷酸钒锂、磷酸钒氧锂、磷酸铁锂、钛酸锂和含锂锰基材料。

[0059] 在上述阴极材料中，钴酸锂的化学式可以，但不限制为，$Li_xCo_aM1_bO_{2-c}H_d$，其中M1选自由镍(Ni)、锰(Mn)、镁(Mg)、铝(Al)、硼(B)、钛(Ti)、钒(V)、铬(Cr)、铁(Fe)、铜(Cu)、锌(Zn)、钼(Mo)、锡(Sn)、钙(Ca)、锶(Sr)、钨(W)、钇(Y)、镧(La)、锆(Zr)、硅(Si)及其组合组成的群组，其中H选自由氟(F)、硫(S)、硼(B)、氮(N)或磷(P)及其组合组成的群组，其中x、a、b、c和d值分别在以下范围内：$0.8\leq x\leq 1.2$、$0.8\leq a\leq 1$、$0\leq b\leq 0.2$、$-0.1\leq c\leq 0.2$、$0\leq d\leq 0.2$。

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[0060] 在上述阴极材料中，三元材料指的是含有锂元素、除了锂元素以外的三种不同的金属元素和氧元素组成的能够可逆地嵌入和脱出锂离子的材料。在一些实施例中，三元材料的化学式可以为$Li_yM2_eM3_fM4_gO_{2-h}$，其中，M2-M4选自由镍(Ni)、钴(Co)、锰(Mn)、镁(Mg)、铝(Al)、硼(B)、钛(Ti)、钒(V)、铬(Cr)、铁(Fe)、铜(Cu)、锌(Zn)、钼(Mo)、锡(Sn)、钙(Ca)、锶(Sr)、钨(W)、锆(Zr)、硅(Si)及其组合组成的群组，y、e、f、g和h值分别在以下范围内：$0.8\leq y\leq 1.2$、$0.3\leq e\leq 0.98$、$0.02\leq f\leq 0.7$、$0.02\leq g\leq 0.7$、$-0.1\leq h\leq 0.2$。在本申请的一些实施例中，所述三元材料包括镍钴锰酸锂和/或镍钴铝酸锂。

[0061] 在上述阴极材料中，锰酸锂的化学式为$Li_zMn_{2-p}M5_pO_{4-r}$，其中M5表示选自由钴(Co)、镍(Ni)、镁(Mg)、铝(Al)、硼(B)、钛(Ti)、钒(V)、铬(Cr)、铁(Fe)、铜(Cu)、锌(Zn)、钼(Mo)、锡(Sn)、钙(Ca)、锶(Sr)、钨(W)及其组合组成的群组，z、p和r值分别在以下范围内：$0.8\leq z\leq 1.2$、$0\leq p<1.0$和$-0.2\leq r\leq 0.2$。

[0062] 在本申请的一些实施例中，所述阴极第一区的电极活性物质包括，但不限制于，三元材料，而所述阴极第二区的电极活性物质包括，但不限制于，钴酸锂，其中三元材料的充电膨胀率小于钴酸锂的充电膨胀率。在上述实施例中，即便在电极极片的制备过程中第二区的极片厚度薄于第一区的极片厚度，只要在电芯的化成阶段后钴酸锂会发生较大的膨胀以补偿第一区和第二区极片充放电厚度差，仍然能够实现上述两个区域的厚度大体上相等。

[0063] (二)阳极极片

[0064] 在本申请的一些实施例中，锂离子电池的阳极极片包括阳极基材(也称，阳极集流体)和位于阳极基材的至少一个表面上的阳极活性物质。在一些实施例中，所述阳极基材可为，但不限于，铜箔或镍箔。

[0065] 锂离子电池的阳极活性物质包括能够吸收和释放锂(Li)的阳极材料(下文中，有时称为“能够吸收/释放锂(Li)的阳极材料”)。能够吸收/释放锂(Li)的阳极材料可以包括但不限于：碳材料、金属化合物、氧化物、硫化物、锂的氮化物(例如LiN_3)、锂金属、与锂一起形成合金的金属和聚合物材料。

[0066] 碳材料可以包括但不限于：低石墨化的碳、易石墨化的碳、人造石墨、天然石墨、中间相碳微球、软碳、硬碳、热解碳、焦炭、玻璃碳、有机聚合物化合物烧结体、碳纤维和活性碳。其中，焦炭可以包括沥青焦炭、针状焦炭和石油焦炭。有机聚合物化合物烧结体指的是通过在适当的温度下煅烧聚合物材料(例如，苯酚塑料或者呋喃树脂)以使之碳化获得的材料，这些材料可以分为低石墨化碳或者易石墨化的碳。聚合物材料可以包括但不限于聚乙炔和聚吡咯。

[0067] 在能够吸收/释放锂(Li)的这些阳极材料中，更进一步地，选择充电和放电电压接近于锂金属的充电和放电电压的材料。这是因为阳极材料的充电和放电电压越低，锂离子电池越容易具有更高的能量密度。其中，阳极材料可以选择碳材料，因为在充电和放电时它们的晶体结构只有小的变化，因此，可以获得良好的循环特性以及大的充电和放电容量。尤其可以选择石墨，因为它可以给出大的电化学当量和高的能量密度。

[0068] 此外，能够吸收/释放锂(Li)的阳极材料可以包括单质锂金属、能够和锂(Li)一起形成合金的金属元素和半金属元素，包括这样的元素的合金和化合物等等。特别地，将它们和碳材料一起使用，因为在这种情况中，可以获得良好的循环特性以及高能量密度。除了包

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括两种或者多种金属元素的合金之外，这里使用的合金还包括包含一种或者多种金属元素和一种或者多种半金属元素的合金。所述合金可以处于以下状态固溶体、共晶晶体(共晶混合物)、金属间化合物及其混合物。

[0069] 金属元素和半金属元素的例子可以包括锡(Sn)、铅(Pb)、铝(Al)、铟(In)、硅(Si)、锌(Zn)、锑(Sb)、铋(Bi)、镉(Cd)、镁(Mg)、硼(B)、镓(Ga)、锗(Ge)、砷(As)、银(Ag)、锆(Zr)、钇(Y)和铪(Hf)。上述合金和化合物的例子可以包括具有化学式：$Ma_sMb_tLi_u$的材料和具有化学式：$Ma_pMc_qMd_r$的材料。在这些化学式中，Ma表示能够与锂一起形成合金的金属元素和半金属元素中的至少一种元素；Mb表示除锂和Ma之外的金属元素和半金属元素中的至少一种元素；Mc表示非金属元素中的至少一种元素；Md表示除Ma之外的金属元素和半金属元素中的至少一种元素；并且s、t、u、p、q和r满足$s>0$、$t\geq0$、$u\geq0$、$p>0$、$q>0$和$r\geq0$。

[0070] 此外，可以在阳极中使用不包括锂(Li)的无机化合物，例如MnO_2、V_2O_5、V_6O_{13}、NiS和MoS。

[0071] 在本申请的一些实施例中，所述阳极第一区的电极活性物质和所述阳极第二区的电极活性物质均包括碳材料，且其中所述阳极第一区的碳材料的OI值小于所述阳极第二区的碳材料的OI值。OI值为碳材料中的石墨层状结构的取向指数，其中OI值越大表示碳材料中的石墨层状结构越平行于基材。在本申请中，OI值是通过X射线衍射仪(XRD)测得的，其中$OI=C(004)/C(110)$，其中C(004)表示碳材料的(004)晶面的衍射峰的强度，而C(110)表示碳材料的(110)晶面的衍射峰的强度。在本申请的一些实施例中，所述碳材料包括石墨材料。

[0072] 在上述实施例中，碳材料的OI值越大，表明锂离子越容易嵌入至碳材料中，那么碳材料的体积膨胀率越大。在上述实施例中，即便在电极极片的制备过程中第二区的极片厚度薄于第一区的极片厚度，只要在电芯的化成阶段中或化成后OI值较大的碳材料会发生较大的膨胀以补偿第一区和第二区极片充放电厚度差，仍然能够实现上述两个区域的厚度大体上相等。

[0073] 在本申请的一些实施例中，所述阳极第一区的电极活性物质和所述阳极第二区的电极活性物质均包括碳材料，其中所述阳极第一区的碳材料的石墨化度小于所述阳极第二区的碳材料的石墨化度。石墨化度是衡量碳材料中的碳原子的排布有序性的指标，其中碳原子的排布越有序，其石墨化度越高。在本申请中，石墨化度G是通过XRD测得的，其中$G=(0.172-d_{004})/(0.172-0.16769)\times100\%$，$d_{004}=0.07709/\sin\theta$，其中θ为碳材料的(004)晶面的衍射角。在本申请的一些实施例中，所述碳材料包括石墨材料。

[0074] 在上述实施例中，碳材料的石墨化度越大，表明锂离子越容易嵌入至碳材料中，那么碳材料的体积膨胀率越大。在上述实施例中，即便在电极极片的制备过程中第二区的极片厚度薄于第一区的极片厚度，只要在电芯的化成阶段中或化成后石墨化度较大的碳材料会发生较大的膨胀以补偿第一区和第二区极片充放电厚度差，仍然能够实现上述两个区域的厚度大体上相等。

[0075] 在本申请的一些实施例中，所述阳极第一区的电极活性物质包括石墨，而所述阳极第二区的电极活性物质包括硅。在进行充放电的过程中(也即，在锂离子嵌入或脱出阳极材料的过程中)，硅的体积膨胀率大于石墨的体积膨胀率。

[0076] 在本申请的一些实施例中，所述第一区的电极活性物质包括硬碳，而所述第二区

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的电极活性物质包括石墨和/或硅，其中在充放电过程中石墨或硅的体积膨胀率均大于硬碳。

[0077] (三)包含第三区的电极极片

[0078] 在本申请的一些实施例中，所述电极极片还包括第三区，其中第三区经布置以与第二区相邻但远离第一区。其中第三区的设置原理与第二区的设置原理类似，均是为了补偿薄区的厚度差以获得厚度大体上相同的电极极片。其中所述第三区的电极极片的厚度为L_3，且其中L_3大体上等于L_1。本申请并不限制第二区的电极极片的厚度的值。在本申请的一些实施例中，第三区的电极极片的厚度L_3可以处于与L_1或L_2的厚度范围相同的范围。

[0079] 在本申请的一些实施例中，在制备电极极片的过程中使第三区的电极极片的厚度L_3大体上等于第一区的电极极片的厚度L_1。

[0080] 在本申请的一些实施例中，在电芯化成过程中使第三区的电极极片的厚度L_3大体上等于第一区的电极极片的厚度L_1。

[0081] 在本申请的一些实施例中，不需要在制备电极极片的阶段使第三区的电极极片的厚度L_3大体上等于第一区的电极极片的厚度L_1，只需要在电芯的化成阶段实现L_1大体上等于L_3即可。也即，即便在电极极片的制备过程中出现极片薄化的现象，只要第三区的电极活性物质能够在电芯的化成阶段发生较大的膨胀来补偿不同区域充放电厚度差，仍然能够实现上述不同区域的极片厚度大体上相等。

[0082] 在本申请的一些实施例中，所述第一区包括主体区，所述第二区包括边缘1区，而所述第三区包括边缘2区，其中所述边缘2区远离主体区。

[0083] 在本申请的一些实施例中，所述第一区、所述第二区和所述第三区可以分别包括具有大体上相同的充电膨胀率的电极活性物质。

[0084] 在本申请的一些实施例中，所述第一区、所述第二区和所述第三区分别包括具有部分相同或者完全不同的充电膨胀率的电极活性物质。

[0085] 在本申请的一些实施例中，所述第一区、所述第二区和所述第三区可以分别采用完全相同、部分相同或者完全不同的电极活性物质。

[0086] (四)包含绝缘区的电极极片

[0087] 在本申请的一些实施例中，所述电极极片还包括绝缘区，所述绝缘区安置于基材的边缘处而起到绝缘的作用以防止阴阳两极之间的短路。在一些实施例中，所述绝缘区包括陶瓷，其中所述陶瓷的单位面积容量为0。

[0088] 二、电芯和电化学装置

[0089] 本申请的实施例还提供了利用本申请电极极片的电芯和电化学装置。在一些实施例中，电芯包括阴极极片和阳极极片。在一些实施例中，电化学装置包括电芯和外壳。在本申请的一些实施例中，该电化学装置为锂离子电池。

[0090] 在本申请的一些实施例中，本申请所述的电芯包含本申请实施例所述的阴极极片和本申请实施例所述的阳极极片中的至少一者。具体的阴极极片和阳极极片的结构和组成请参见上文，在此不再赘述。

[0091] 锂离子电池的电芯还包括电解液，电解液的状态可以是凝胶态、固态和液态中的一种或多种。液态电解液包括锂盐和非水溶剂。

[0092] 锂盐选自$LiPF_6$、$LiBF_4$、$LiAsF_6$、$LiClO_4$、$LiB(C_6H_5)_4$、$LiCH_3SO_3$、$LiCF_3SO_3$、LiN

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$(SO_2CF_3)_2$、$LiC(SO_2CF_3)_3$、LiBOB和$LiPO_2F_2$中的一种或多种。例如，锂盐选用LiPF6，因为它可以给出高的离子导电率并改善循环特性。

[0093] 非水溶剂可为碳酸酯化合物、羧酸酯化合物、醚化合物、腈化合物、其它有机溶剂或它们的组合。

[0094] 碳酸酯化合物的实例为碳酸二乙酯(DEC)、碳酸二甲酯(DMC)、碳酸二丙酯(DPC)、碳酸甲丙酯(MPC)、碳酸乙丙酯(EPC)、碳酸甲乙酯(MEC)、碳酸亚乙酯(EC)、碳酸亚丙酯(PC)、碳酸亚丁酯(BC)、碳酸乙烯基亚乙酯(VEC)、碳酸氟代亚乙酯(FEC)、碳酸1,2-二氟亚乙酯、碳酸1,1-二氟亚乙酯、碳酸1,1,2-三氟亚乙酯、碳酸1,1,2,2-四氟亚乙酯、碳酸1-氟-2-甲基亚乙酯、碳酸1-氟-1-甲基亚乙酯、碳酸1,2-二氟-1-甲基亚乙酯、碳酸1,1,2-三氟-2-甲基亚乙酯、碳酸三氟甲基亚乙酯及其组合。

[0095] 在一些实施例中，基于电解液总重量，碳酸酯化合物的含量为约1重量％以上。在一些实施例中，碳酸酯化合物的含量为约3重量％以上。在一些实施例中，碳酸酯化合物的含量为约5重量％以上。在一些实施例中，碳酸酯化合物的含量为约10重量％以上。在一些实施例中，碳酸酯化合物的含量为约50重量％以上。在一些实施例中，碳酸酯化合物的含量为约58重量％以上。在一些实施例中，碳酸酯化合物的含量为约60重量％以下。在一些实施例中，碳酸酯化合物的含量为约50重量％以下。在一些实施例中，环状碳酸酯化合物的含量为约40重量％以下。在一些实施例中，碳酸酯化合物的含量为约1重量％-约60重量％。在一些实施例中，碳酸酯化合物的含量为约3重量％-约50重量％。

[0096] 羧酸酯化合物的实例为乙酸甲酯、乙酸乙酯、乙酸正丙酯、乙酸叔丁酯、丙酸甲酯、丙酸乙酯、丙酸丙酯、γ-丁内酯、癸内酯、戊内酯、甲瓦龙酸内酯、己内酯及其组合。

[0097] 在一些实施例中，基于电解液总重量，羧酸酯化合物的含量为约1重量％以上。在一些实施例中，羧酸酯化合物的含量为约3重量％以上。在一些实施例中，羧酸酯化合物的含量为约5重量％以上。在一些实施例中，羧酸酯化合物的含量为约10重量％以上。在一些实施例中，羧酸酯化合物的含量为约60重量％以下。在一些实施例中，羧酸酯化合物的含量为约50重量％以下。在一些实施例中，羧酸酯化合物的含量为约40重量％以下。在一些实施例中，羧酸酯化合物的含量为约1重量％-约60重量％。在一些实施例中，羧酸酯酯化合物的含量为约3重量％-约50重量％。

[0098] 醚化合物的实例为四氢呋喃、2-甲基四氢呋喃、1,3-二氧戊环、2-甲基1,3-二氧戊环、4-甲基1,3-二氧戊环、1,3-二氧六环、1,4-二氧六环、二甲氧基丙烷、二甲氧基甲烷、1,1-二甲氧基乙烷、1,2-二甲氧基乙烷、二乙氧基甲烷、1,1-二乙氧基乙烷、1,2-二乙氧基乙烷、乙氧基甲氧基甲烷、1,1-乙氧基甲氧基乙烷、1,2-乙氧基甲氧基乙烷、$HCF_2CF_2CH_2OCF_2CF_2H$、$(CF_3)_2CFCF(CF_2CF_3)(OCH_3)$、$CF_3CHFCF_2CH(CH_3)OCF_2CHFCF_3$、$HCF_2CF_2CH_2OCF_2CF_2CF_2CF_2H$、$HCF_2CF_2OCH_2CF_3$、$HCF_2CF_2OCH_2CH_2OCF_2CF_2H$、$HCF_2CF_2OCH_2CH_2CH_2OCF_2CF_2H$及其组合。

[0099] 在一些实施例中，基于电解液总重量，醚化合物的含量为约0.01重量％以上。在一些实施例中，醚化合物的含量为约0.05重量％以上。在一些实施例中，醚化合物的含量为约1重量％以上。在一些实施例中，醚化合物的含量为约2重量％以上。在一些实施例中，醚化合物的含量为约10重量％以下。在一些实施例中，醚化合物的含量为约6重量％以下。在一些实施例中，醚化合物的含量为约5重量％以下。在一些实施例中，醚化合物的含量为约

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0.01重量%-约10重量%。在一些实施例中，醚化合物的含量为约1重量%-约6重量%。

[0100] 腈化合物的实例如丁二腈、戊二腈、己二腈、1,5-二氰基戊烷、1,6-二氰基己烷、1,7-二氰基庚烷、1,8-二氰基辛烷、1,9-二氰基壬烷、1,10-二氰基癸烷、1,12-二氰基十二烷、四甲基丁二腈、2-甲基戊二腈、2,4-二甲基戊二腈、2,2,4,4-四甲基戊二腈、1,4-二氰基戊烷、1,4-二氰基戊烷、2,5-二甲基-2,5-己烷二碳腈、2,6-二氰基庚烷、2,7-二氰基辛烷、2,8-二氰基壬烷、1,6-二氰基癸烷、1,2-二氰基苯、1,3-二氰基苯、1,4-二氰基苯、3,5-二氧杂-庚二腈、1,4-二(氰基乙氧基)丁烷、乙二醇二(2-氰基乙基)醚、二乙二醇二(2-氰基乙基)醚、三乙二醇二(2-氰基乙基)醚、四乙二醇二(2-氰基乙基)醚、3,6,9,12,15,18-六氧杂二十烷酸二腈、1,3-二(2-氰基乙氧基)丙烷、1,4-二(2-氰基乙氧基)丁烷、1,5-二(2-氰基乙氧基)戊烷、乙二醇二(4-氰基丁基)醚、1,3,5-戊三甲腈、1,2,3-丙三甲腈、1,3,6-己烷三腈、1,2,6-己烷三腈、1,2,3-三(2-氰基乙氧基)丙烷或1,2,4-三(2-氰基乙氧基)丁烷及其组合。

[0101] 在一些实施例中，基于电解液总重量，腈合物的含量为约0.01重量%以上。在一些实施例中，腈化合物的含量为约0.05重量%以上。在一些实施例中，腈化合物的含量为约1重量%以上。在一些实施例中，腈化合物的含量为约2重量%以上。在一些实施例中，二腈化合物的含量为约10重量%以下。在一些实施例中，腈化合物的含量为约6重量%以下。在一些实施例中，二腈化合物的含量为约5重量%以下。在一些实施例中，腈化合物的含量为约0.01重量%-约10重量%。在一些实施例中，腈化合物的含量为约1重量%-约6重量%。

[0102] 其它有机溶剂的实例为二甲亚砜、1,3-丙磺酸内酯、环丁砜、甲基环丁砜、1,3-二甲基-2-咪唑烷酮、N-甲基-2-吡咯烷酮、甲酰胺、二甲基甲酰胺、磷酸三甲酯、磷酸三乙酯、磷酸三辛酯、和磷酸三丙酯及其组合。

[0103] 在一些实施例中，锂离子电池的电芯还在阴极极片与阳极极片之间设有隔离膜以防止短路。本申请的电化学装置中使用的隔离膜的材料和形状没有特别限制，其可为任何现有技术中公开的技术。在一些实施例中，隔离膜包括由对本申请的电解液稳定的材料形成的聚合物或无机物等。

[0104] 例如隔离膜可包括基材层和表面处理层。基材层为具有多孔结构的无纺布、膜或复合膜，基材层的材料选自聚乙烯、聚丙烯、聚对苯二甲酸乙二醇酯和聚酰亚胺中的至少一种。具体的，可选用聚丙烯多孔膜、聚乙烯多孔膜、聚丙烯无纺布、聚乙烯无纺布或聚丙烯-聚乙烯-聚丙烯多孔复合膜。

[0105] 基材层的至少一个表面上设置有表面处理层，表面处理层可以是聚合物层或无机物层，也可以是混合聚合物与无机物所形成的层。

[0106] 无机物层包括无机颗粒和粘结剂，无机颗粒选自氧化铝、氧化硅、氧化镁、氧化钛、二氧化铪、氧化锡、二氧化铈、氧化镍、氧化锌、氧化钙、氧化锆、氧化钇、碳化硅、勃姆石、氢氧化铝、氢氧化镁、氢氧化钙和硫酸钡中的一种或几种的组合。粘结剂选自聚偏氟乙烯、偏氟乙烯-六氟丙烯的共聚物、聚酰胺、聚丙烯腈、聚丙烯酸酯、聚丙烯酸、聚丙烯酸盐、聚乙烯吡咯烷酮、聚乙烯醚、聚甲基丙烯酸甲酯、聚四氟乙烯和聚六氟丙烯中的一种或几种的组合。聚合物层中包含聚合物，聚合物的材料包括聚酰胺、聚丙烯腈、丙烯酸酯聚合物、聚丙烯酸、聚丙烯酸盐、聚乙烯吡咯烷酮、聚乙烯醚、聚偏氟乙烯或聚(偏氟乙烯-六氟丙烯)中的至少一种。

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[0107] 隔离膜需要有机械稳健性以承受电极材料的拉伸和刺穿，且隔离膜孔径通常小于1微米。包括微孔聚合物膜，无纺布垫和无机膜的各种隔离膜已经用于锂离子电池中，其中基于微孔聚烯烃材料的聚合物膜是最常与电解液组合使用的隔离膜。微孔聚合物膜能够制成非常薄(通常约5μm-25μm)和高多孔性(通常约20%-50%)以降低电阻且提高离子传导性。同时，该聚合物膜仍然有机械稳健性。本领域技术人员当能理解，广泛使用于锂离子电池的各种隔离膜都适用于本申请。

[0108] 虽然上面以锂离子电池进行了举例说明，但是本领域技术人员在阅读本申请之后，能够想到本申请的阴极材料可以用于其他合适的电化学装置。这样的电化学装置包括发生电化学反应的任何装置，它的具体实例包括所有种类的一次电池、二次电池、燃料电池、太阳能电池或电容。特别地，所述电化学装置是锂二次电池，包括锂金属二次电池、锂离子二次电池、锂聚合物二次电池或锂离子聚合物二次电池。

[0109] 三、应用

[0110] 由本申请所述的电极极片制造的电化学装置适用于各种领域的电子设备。

[0111] 本申请的电化学装置的用途没有特别限定，其可用于现有技术中已知的任何用途。在一个实施例中，本申请的电化学装置可用于，但不限于，笔记本电脑、笔输入型计算机、移动电脑、电子书播放器、便携式电话、便携式传真机、便携式复印机、便携式打印机、头戴式立体声耳机、录像机、液晶电视、手提式清洁器、便携CD机、迷你光盘、收发机、电子记事本、计算器、存储卡、便携式录音机、收音机、备用电源、电机、汽车、摩托车、助力自行车、自行车、照明器具、玩具、游戏机、钟表、电动工具、闪光灯、照相机、家庭用大型蓄电池和锂离子电容器等。

[0112] 下面以锂离子电池为例并且结合具体的制备本申请阴极材料的实施例及对电化学装置的测式方式以用于说明本申请锂离子电池的制备及效能，本领域的技术人员将理解，本申请中描述的制备方法仅是实例，其他任何合适的制备方法均在本申请的范围内。

[0113] 四、实施例

[0114] 锂离子电池的制备

[0115] 采用以下制备方法将阴极活性物质制备成锂离子电池。具体的，将阴极活性物质、导电剂、粘结剂按一定的重量比在N-甲基吡咯烷酮中充分搅拌混合均匀制成阴极浆料，然后将所得阴极浆料均匀涂布在阴极集电体铝箔的正反两个表面上，之后在85℃下烘干，得到阴极活性材料层，之后经过冷压、分条、裁片、焊接阴极极耳，得到阴极极片。

[0116] 将阳极活性物质、粘结剂、分散剂按照一定的重量比在去离子水中充分搅拌混合均匀制成阳极浆料，之后将阳极浆料均匀涂覆在阳极集电体铜箔的正反两面上，然后在85℃下烘干，形成阳极活性材料层，然后进行冷压、分条、裁片、焊接阳极极耳，得到阳极极片。

[0117] 将锂盐$LiPF_6$与非水有机溶剂(碳酸乙烯酯(EC)：碳酸二乙酯(DEC)：碳酸亚丙酯(PC)：丙酸丙酯(PP)：碳酸亚乙烯酯(VC)＝20:30:20:28:2，质量比)按质量比8:92配制而成的溶液作为锂离子电池的电解液。

[0118] 隔离膜采用陶瓷涂覆的聚乙烯(PE)材料隔离膜。

[0119] 将阴极极片、隔离膜、阳极极片按顺序叠好，使隔离膜处于正阳极中间起到隔离的作用。将电极组件置于包装壳中，注入电解液并封装，进行化成之后制成最终的锂离子电池。

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[0120] 电极极片的厚度及充放电厚度差测试

[0121] 厚度测试：使用0.1μm高精度数显千分尺(Mitutoyo牌)进行极片厚度测量。将装配好的电芯进行拆解，取出电极极片并用碳酸二乙酯(DEC)溶剂洗去表面残留物；用无尘纸擦拭千分尺测试头去除异物保证测试精度；将极片放入千分尺测试头中，旋动千分尺手柄紧密接触极片，读出厚度数值。选取极片上的十个不同的点，测得十个厚度数据取平均值。

[0122] 充放电厚度差测试：对电极极片充或放电至合适电压(大于活性材料充或放电下限截止电压)使电极极片中的锂部分或全部脱出，按上述厚度测试方法测的极片厚度；之后再对此极片充或放电至合适电压(小于活性材料充或放电上限截止电压)使电极极片嵌锂，按上述厚度测试方法测的极片厚度，计算得出着两次测试厚度差。

[0123] 以下将详细描述本申请所提供的电极极片的具体实施方式。

[0124] (一)实施例1和对比例1

[0125] 实施例1涉及对阴极极片进行分区涂布，而不对阳极极片进行分区涂布。以下将具体描述实施例1和对比例1中的阴极极片的制备方法：

[0126] 实施例1的电极极片的制备方法：

[0127] (1)制备浆料

[0128] 阴极$LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$浆料：将阴极活性成分$LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$、导电碳黑和粘结剂聚偏二氟乙烯PVDF按97%:1.5%:1.5%重量比例混合，并用适量的N-甲基吡咯烷酮稀释，然后在真空搅拌机中搅拌形成均匀的阴极浆料。

[0129] 阴极$LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$+$LiCoO_2$浆料：将阴极活性成分(50wt%的$LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$和50wt%的$LiCoO_2$)、导电碳黑和粘结剂聚偏二氟乙烯PVDF按97%:1.5%:1.5%重量比例混合，并用适量N-甲基吡咯烷酮稀释，然后在真空搅拌机中搅拌形成均匀的阴极浆料。

[0130] 阳极浆料：将阳性活性成分石墨、粘结剂丁苯橡胶SBR和分散剂羧甲基纤维素CMC按97%:1%:2%重量比例混合，并用适量蒸馏水稀释，然后在真空搅拌机中搅拌形成均匀的阳极浆料。

[0131] (2)阴极分区涂布

[0132] 阴极分区涂布：按如下操作进行分区涂布，

[0133] A、通过主体涂布头将步骤(1)中制备的$LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$浆料单面涂布至铝箔的主体区(下称，第1区)，且通过边缘涂布头将步骤(1)中制备的$LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$+$LiCoO_2$浆料单面涂布至距离主体区边缘10mm的区域(下称，第2区)。将涂布好的单面极片放置85℃的高温烘箱中烘干；

[0134] B、对上述单面涂布的极片进行第二面涂布，涂布方法、区域和材料与步骤A所述相同。将涂布好的双面极片放置85℃的高温烘箱中烘干，获得实施例1所述的阴极极片。

[0135] (3)阳极涂布

[0136] C、将步骤(1)中制备的阳极浆料在铜箔基材上进行单面涂布，将涂布好的单面极片放置85℃的高温烘箱中烘干；

[0137] D、对上述单面涂布的极片进行第二面涂布，涂布方法、区域和材料与步骤C所述相同。将涂布好的双面极片放置85℃的高温烘箱中烘干，获得实施例1所述的阳极极片。

[0138] 对比例1的电极极片的制备方法：

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[0139] 对比例1和实施例1的差异仅在于：不对阴极极片进行分区涂敷，按照常规工艺在铝箔主体区涂敷阴极$LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$浆料。

[0140] 表1

[0141]

	阴极极片第1区	阴极极片第2区	制备的阴极极片1区的厚度(μm)	制备的阴极极片2区的厚度(μm)	化成后阴极极片1区的厚度(μm)	化成后阴极极片2区的厚度(μm)	循环前阳极极片1区的厚度(μm)	循环前阳极极片2区的厚度(μm)	循环500次后阳极极片1区的厚度(μm)	循环500次后阳极极片2区的厚度(μm)
实施例1	$LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$	50wt%$LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$+50wt%$LiCoO_2$	121.1	116.8	125.9	124.8	98.5	96.7	118.2	116.0
对比例1	$LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$	$LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$	120.8	114.3	125.6	118.9	98.6	96.6	118.3	132.9

[0142] *请注意表1中厚度的前4列数据为阴极极片的厚度，而后4列数据为满充状态阳极极片的厚度。由于在锂离了电池中，相较于阴极极片，阳极极片的析锂现象比较严重，因此本申请主要采用阳极极片的厚度参数来衡量锂离子电池的析锂程度，从而反映锂离子电池的安全性能。

[0143] 参见表1所示的前4列厚度数据可知，对比例1和实施例1中经制备的阴极极片的2区厚度均薄于1区的厚度，但是由于钴酸锂的充电膨胀率大于三元材料的充电膨胀率，因此在化成阶段中实施例1中的2区的阴极材料的较大膨胀补偿了1区极片和2区极片充放电厚度差，从而获得了1区厚度和2区厚度大体上相等的阴极极片。而参见表1所示的后4列厚度数据可知，经过500次充放电循环后，实施例1中的阳极极片的2区厚度远远低于对比例1中的阳极极片的2区厚度，这说明了实施例1中的阳极极片的析锂程度远远小于对比例1中的阳极极片的析锂程度。

[0144] (二)实施例2A-5和对比例2-5

[0145] 实施例2A-5和对比例2A-5仅涉及对阳极极片进行分区涂布，而不对阴极极片进行分区涂布。以下将具体描述实施例2A-5和对比例2A-5中的阳极极片的制备方法：

[0146] 实施例2A的电极极片的制备方法：

[0147] (1)制备浆料

[0148] 阳极A型石墨(OI值为12，石墨化度为92％)的石墨浆料：将阳性活性成分A型石墨、粘结剂丁苯橡胶SBR和分散剂羧甲基纤维素CMC按97％:1％:2％重量比例混合，并用适量蒸馏水稀释，然后在真空搅拌机中搅拌形成均匀的阳极浆料。

[0149] 阳极B型石墨(OI值为19，石墨化度为92％)的石墨浆料：将阳性活性成分B型石墨(OI值为19)、粘结剂丁苯橡胶SBR和分散剂羧甲基纤维素CMC按97％:1％:2％重量比例混合，并用适量蒸馏水稀释，然后在真空搅拌机中搅拌形成均匀的阳极浆料。

[0150] 阴极浆料：将阴极活性成分$LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$、导电碳黑和粘结剂聚偏二氟乙烯PVDF按97％:1.5％:1.5％重量比例混合，并用适量的N-甲基吡咯烷酮稀释，然后在真空搅拌机中搅拌形成均匀的阴极浆料。

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[0151] (2)阳极分区涂布

[0152] 阳极分区涂布:按如下操作进行分区涂布,

[0153] A、通过主体涂布头将步骤(1)中制备的A型石墨浆料单面涂布至铜箔的主体区(下称,第1区),而通过边缘涂布头将步骤(1)中制备的B型石墨浆料单面涂布至距离主体区边缘10mm的区域(下称,第2区)。将涂布好的单面极片放置85℃的高温烘箱中烘干;

[0154] B、对上述单面涂布的极片进行第二面涂布,涂布方法、区域和材料与步骤A所述相同。将涂布好的双面极片放置85℃的高温烘箱中烘干,获得实施例2所述的阳极极片。

[0155] (3)阴极涂布

[0156] C、将步骤(1)中制备的阴极浆料在铝箔基材上进行单面涂布,将涂布好的单面极片放置85℃的高温烘箱中烘干;

[0157] D、对上述单面涂布的极片进行第二面涂布,涂布方法、区域和材料与步骤C所述相同。将涂布好的双面极片放置85℃的高温烘箱中烘干,获得实施例1所述的阴极极片。

[0158] 实施例2B-5的电极极片的制备方法:

[0159] 实施例2B-5和实施例2A的差异仅在于:改变阳极1区的浆料、阳极2区的浆料和阴极浆料的配方,具体配方见表2。

[0160] 对比例2B-5的电极极片的制备方法:

[0161] 对比例2B-5分别对应实施例2B-5。对比例2B-5与各自实施例的差异仅在于:不对阳极极片进行分区涂敷,按照常规工艺在铜箔主体区涂敷阳极1区浆料。

[0162] 表2

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[0163]

实施例	阳极1区浆料	阳极2区浆料	阴极浆料
实施例2B	阳极活性成分C型石墨（OI值为12，石墨化度为97%）、粘结剂丁苯橡胶SBR和分散剂羧甲基纤维素CMC按97.2%:1%:1.8%重量比例混合	阳极活性成分D型石墨（OI值为19，石墨化度为97%）、粘结剂丁苯橡胶SBR和分散剂羧甲基纤维素CMC按97.2%:1%:1.8%重量比例混合	阴极活性成分$LiCoO_2$、导电碳黑和粘结剂聚偏二氟乙烯PVDF按97.5%:1%:1.5%重量比例混合
实施例3A	阳极活性成分E型石墨（石墨化度G=93%，OI值为10）、粘结剂丁苯橡胶SBR和分散剂羧甲基纤维素CMC按97.2%:1%:1.8%重量比例混合	阳极活性成分F型石墨（石墨化度G=96%，OI值为10）、粘结剂丁苯橡胶SBR和分散剂羧甲基纤维素CMC按97.2%:1%:1.8%重量比例混合	阴极活性成分$LiCoO_2$、导电碳黑和粘结剂聚偏二氟乙烯PVDF按97.5%:1%:1.5%重量比例混合
实施例3B	阳极活性成分E型石墨（石墨化度G=93%，OI值为20）、粘结剂丁苯橡胶SBR和分散剂羧甲基纤维素CMC按97.2%:1%:1.8%重量比例混合	阳极活性成分F型石墨（石墨化度G=96%，OI值为20）、粘结剂丁苯橡胶SBR和分散剂羧甲基纤维素CMC按97.2%:1%:1.8%重量比例混合	阴极活性成分$LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$、导电碳黑和粘结剂聚偏二氟乙烯PVDF按97.7%:1%:1.3%重量比例混合
实施例4	阳极活性成分A型石墨、粘结剂丁苯橡胶SBR和分散剂羧甲基纤维素CMC按97.5%:1.5%:1%重量比例混合	阳极活性成分60%A型石墨+40%硅、导电碳黑，粘结剂丙烯酸树脂PAA和分散剂羧甲基纤维素CMC按95%:1%:3%:1%重量比例混合	阴极活性成分$LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$、导电碳黑和粘结剂聚偏二氟乙烯PVDF按97.7%:1%:1.3%重量比例混合
实施例5	阳极活性成分硬碳、导电碳黑、粘结剂丙烯酸树脂PAA和分散剂羧甲基纤维素CMC按95%:1%:3%:1%重量比例混合	阳极活性成分硅、导电碳黑、粘结剂丙烯酸树脂PAA和分散剂羧甲基纤维素CMC按95%:1.5%:2.5%:1%重量比例混合	阴极活性成分$LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$、导电碳黑和粘结剂聚偏二氟乙烯PVDF按96.5 %:1.5%:2 %重量比例混合

[0164] 参见表3所示的前4列厚度数据可知，对比例2A-2B和实施例2A-2B中经制备的阳极极片的2区厚度均薄于阳极极片的1区的厚度。但是由于OI值较大的石墨的充电膨胀率大于OI值较小的石墨的充电膨胀率，因此在化成阶段中实施例2A-2B中的2区石墨的膨胀补偿了1区极片和2区极片充放电厚度差，从而获得了1区厚度和2区厚度大体上相等的阳极极片。而参见表3所示的后4列厚度数据可知，经过500次充放电循环后，实施例2A-2B中的阳极极

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片的2区厚度远远低于对比例2A-2B中的阳极极片的2区厚度，这说明了实施例2A-2B中的阳极极片的析锂程度远远小于对比例2A-2B中的阳极极片的析锂程度。

[0165] 表3

[0166]

	阳极极片第1区	阳极极片第2区	制备的阳极极片1区的厚度(mm)	制备的阳极极片2区的厚度(mm)	化成后阳极极片1区的厚度(mm)	化成后阳极极片2区的厚度(mm)	循环前阳极极片1区的厚度(μm)	循环前阳极极片2区的厚度(μm)	循环500次后阳极极片1区的厚度(μm)	循环500次后阳极极片2区的厚度(μm)
实施例2A	OI值为12的石墨(石墨化度为92%)	OI值为19的石墨(石墨化度为92%)	74.7	72.3	91.2	90.8	95.3	95.4	115.2	114.9
实施例2B	OI值为12的石墨(石墨化度为97%)	OI值为19的石墨(石墨化度为97%)	74.3	72.1	94.9	94.5	99.1	99.8	119.8	118.3
对比例2A	OI值为12的石墨(石墨化度为92%)	OI值为12的石墨(石墨化度为92%)	75.1	73.6	91.6	89.8	95.7	93.9	116.1	142.3
对比例2B	OI值为12的石墨(石墨化度为97%)	OI值为12的石墨(石墨化度为97%)	74.8	71.9	95.0	92.4	99.8	97.4	119.8	143.6
实施例3A	石墨化度为93%的石墨（OI值=10）	石墨化度为96%的石墨（OI值=10）	77.9	75.8	95.0	94.5	99.3	99.2	121.1	121.9
实施例3B	石墨化度为93%的石墨	石墨化度为96%的石墨	77.4	75.5	97.3	96.9	101.1	100.6	125.5	124.8

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[0167]

	（OI值=20）	（OI值=20）								
对比例3A	石墨化度为93%的石墨（OI值=10）	石墨化度为93%的石墨（OI值=10）	78.3	76.8	95.5	93.7	99.8	97.9	120.3	139.5
对比例3B	石墨化度为93%的石墨（OI值=20）	石墨化度为93%的石墨（OI值=20）	77.2	75.1	98.6	96.9	104.4	101.5	129.5	153.7
实施例4	石墨	石墨+硅	82.4	81.9	100.5	100.8	105.0	105.5	126.2	127.1
对比例4	石墨	石墨	82.6	81.3	100.8	99.2	105.3	103.7	125.9	151.9
实施例5	硬碳	硅	64.4	63.0	78.6	78.0	82.1	81.7	98.5	99.1
对比例5	硬碳	硬碳	65.0	63.6	79.3	77.6	82.9	81.1	99.0	123.8

[0168] *请注意表3中的厚度数据均为满充状态阳极极片的数据。

[0169] 参见表3所示的前4列厚度数据可知，对比例3A-3B和实施例3A-3B中经制备的阳极极片的2区厚度均薄于阳极极片的1区的厚度。但是由于石墨化度较高的石墨的充电膨胀率大于石墨化度较低的石墨的充电膨胀率，因此在化成阶段中实施例3A-3B中的2区石墨的膨胀补偿了1区极片和2区极片充放电厚度差，从而获得了1区厚度和2区厚度大体上相等的阳极极片。而参见表3所示的后4列厚度数据可知，经过500次充放电循环后，实施例3A-3B中的阳极极片的2区厚度低于对比例3A-3B中的阳极极片的2区厚度，这说明了实施例3A-3B中的阳极极片的析锂程度小于对比例3A-3B中的阳极极片的析锂程度。

[0170] 同理，由于硅的充电膨胀率大于石墨和硬碳的充电膨胀率，因此，在化成阶段中实施例4和5中的2区阳极活性物质的膨胀补偿了1区极片和2区极片充放电厚度差，从而获得了1区厚度和2区厚度大体上相等的阳极极片。表3所示的后4列厚度数据可知，经过500次充放电循环后，实施例4和5中的阳极极片的析锂程度小于对比例4和5中的阳极极片的析锂程度。

[0171] 基于上述实施例和对比例的数据可知，通过补偿现有技术中的电极极片的薄区的厚度以使得电极极片中的不同区的厚度大体上相同，能够减轻或避免电极极片的局部分离，从而有效地抑制锂枝晶的形成，大大提高锂离子电池的安全性能。

[0172] (三)实施例6-8

[0173] 相较于上述实施例1-5，实施例6-8的电极极片进一步增加了第3区。其中第3区与第2区相邻但远离第1区。第3区为距离第2区的边缘10mm的区域。

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[0174] 实施例6-8的电极极片的制备方法：

[0175] 实施例6与实施例1的差异仅在于：进一步将$LiCoO_2$浆料涂敷电极极片的第3区。其中，$LiCoO_2$浆料的制备过程同$LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$浆料的制备过程。

[0176] 实施例7与实施例2的差异仅在于：进一步将OI值为25的E型石墨浆料涂敷电极极片的第3区。其中，E型石墨浆料的制备过程同A型石墨浆料的制备过程。

[0177] 实施例8与实施例4的差异仅在于：进一步将硅浆料涂敷电极极片的第3区。其中，硅浆料的制备过程同石墨+硅浆料的制备过程。

[0178] 表4

[0179]

	阴/阳极极片第1区	阴/阳极极片第2区	阴/阳极极片第3区	制备的阴/阳极极片1区的厚度(mm)	制备的阴/阳极极片2区的厚度(mm)	制备的阴/阳极极片3区的厚度(mm)
实施例6	$LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$	50wt%$LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$+50wt%$LiCoO_2$	$LiCoO_2$	121.3	116.2	113.9
实施例7	OI值为12的石墨	OI值为19的石墨	OI值为25的石墨	75.1	72.8	70.3
实施例8	石墨	60%石墨+40%硅	硅	82.1	79.4	76.8

[0180]

	化成后阴/阳极极片1区的厚度(mm)	化成后阴/阳极极片2区的厚度(mm)	化成后阴/阳极极片3区的厚度(mm)	循环前阳极极片1区的厚度(μm)	循环前阳极极片2区的厚度(μm)	循环前阳极极片3区的厚度(μm)	循环500次后阳极极片1区的厚度(μm)	循环500次后阳极极片2区的厚度(μm)	循环500次后阳极极片3区的厚度(μm)
实施例6	126.1	124.9	125.1	98.7	96.4	96.2	118.8	116.7	115.5
实施例7	90.9	91.1	90.5	95.7	95.6	94.8	115.5	114.3	113.9
实施	100.5	100.8	111.0	105.0	105.5	104.9	126.2	127.1	126.8

[0181]

例8									

[0182] 参见表4的数据可知，无论在电极的制备阶段电极极片的1-3区的厚度如何，只要在电芯的化成阶段中电极极片的1-3区的厚度大体上相等的条件下，经过500次充放电循环后，实施例6-8中的电极极片的厚度变化均不大，均能够有效地抑制锂枝晶的形成，从而提高电芯的安全性能。

[0183] 整个说明书中对“一些实施例”、“部分实施例”、“一个实施例”、“另一举例”、“举例”、“具体举例”或“部分举例”的引用，其所代表的意思是在本申请中的至少一个实施例或举例包含了该实施例或举例中所描述的特定特征、结构、材料或特性。因此，在整个说明书中的各处所出现的描述，例如：“在一些实施例中”、“在实施例中”、“在一个实施例中”、“在

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另一个举例中”，“在一个举例中”、“在特定举例中”或“举例“，其不必然是引用本申请中的相同的实施例或示例。此外，本文中的特定特征、结构、材料或特性可以以任何合适的方式在一个或多个实施例或举例中结合。

[0184] 尽管已经演示和描述了说明性实施例，本领域技术人员应该理解上述实施例不能被解释为对本申请的限制，并且可以在不脱离本申请的精神、原理及范围的情况下对实施例进行改变，替代和修改。

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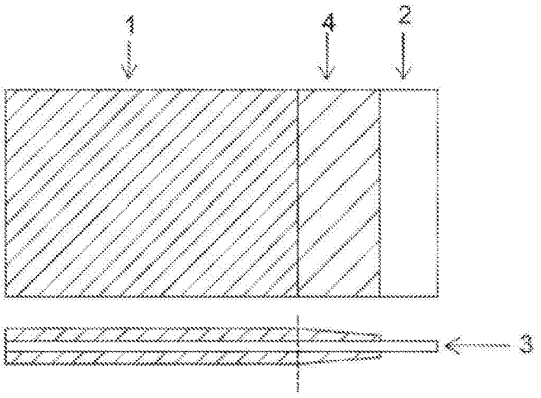


图1

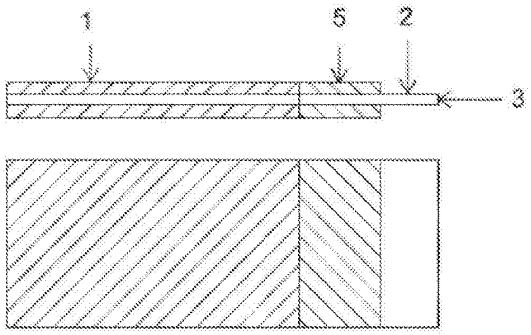


图2

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Espacenet

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High-capacity high-magnification square lithium ion power battery and manufacturing method thereof

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Abstract of CN102683751 (A)

The invention discloses a high-capacity high-magnification square lithium ion power battery and a manufacturing method thereof. The high-capacity high-magnification square lithium ion power battery comprises a battery cell, wherein the battery cell comprises a negative piece, a positive piece and a diaphragm, wherein a plurality of blank copper foils are arranged on one side of the negative piece; a plurality of blank aluminum foils are arranged on one side of the positive piece; the diaphragm is arranged between the negative piece and the positive piece; all blank copper foils on the negative piece extend out of one side of the diaphragm; all blank aluminum foils on the positive piece extend out of the other side of the diaphragm; the battery cell is formed by laminating and winding the negative piece, the diaphragm and the positive piece; all blank copper foils are overlapped in order; and all blank aluminum foils are overlapped in order. The invention has the advantages that a novel coating method and a novel pole piece slitting mode are employed, lamination and winding are combined, connection strips are eliminated, production efficiency is improved, production cost is reduced, the internal resistance of the battery is reduced, a discharge platform of the battery is lifted, and the safety of the battery is improved.

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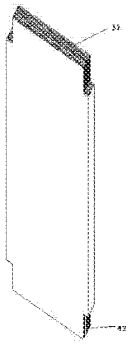
权利要求书 2 页 说明书 5 页 附图 4 页

(54)发明名称

一种大容量高倍率方形锂离子动力电池及其制造方法

(57)摘要

本发明公开了一种大容量高倍率方形锂离子动力电池及其制造方法，其包括电芯，所述电芯包括一侧设有若干空白铜箔的负极片、一侧设有若干空白铝箔的正极片、隔膜，负极片与正极片之间设置隔膜，并使负极片上的所有空白铜箔在隔膜的一侧伸出，正极片上的所有空白铝箔在隔膜的另一侧伸出，负极片、隔膜和正极片叠放卷绕后形成电芯，所有空白铜箔整齐重叠，所有空白铝箔整齐重叠。本发明采用新的涂布方法和新的极片分切方式，既实现了叠片与卷绕的组合，又减少了连接条的使用，提高了生产效率，降低了生产成本，减小了电池内阻，提升了电池的放电平台，提高了电池的安全性。



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1. 一种大容量高倍率方形锂离子动力电池的制造方法，其特征在于：依次包括以下步骤：

a) 采用活性物质、导电剂和粘结剂按一定比例充分混合后制成正极浆料，采用涂布机将正极浆料涂覆到正极集流体上，在正极集流体的正面宽度方向的中间位置留出正极空白(12)，正极空白(12)的一侧涂覆有第一正极浆料层(11)，正极空白(12)的另一侧涂覆有第二正极浆料层(13)，第一正极浆料层(11)、第二正极浆料层(13)和正极空白(12)的长度均相等，第一正极浆料层(11)和第二正极浆料层(13)的宽度相等，在正极集流体的背面宽度方向的中间位置留出正极空白(12)，正极空白(12)的一侧涂覆有第一正极浆料层(11)，正极空白(12)的另一侧涂覆有第二正极浆料层(13)，第一正极浆料层(11)、第二正极浆料层(13)和正极空白(12)的长度均相等，第一正极浆料层(11)和第二正极浆料层(13)的宽度相等；第一正极浆料层(11)与第二正极浆料层(13)的浆料成分相同；

b) 采用活性物质、导电剂和粘结剂按一定比例充分混合后制成负极浆料，采用涂布机将负极浆料涂覆到负极集流体上，在负极集流体的正面宽度方向的中间位置留出负极空白(22)，负极空白(22)的一侧涂覆有第一负极浆料层(21)，负极空白(22)的另一侧涂覆有第二负极浆料层(23)，第一负极浆料层(21)、第二负极浆料层(23)和负极空白(22)的长度均相等，第一负极浆料层(21)和第二负极浆料层(23)的宽度相等，在负极集流体的背面宽度方向的中间位置留出负极空白(22)，负极空白(22)的一侧涂覆有第一负极浆料层(21)，负极空白(22)的另一侧涂覆有第二负极浆料层(23)，第一负极浆料层(21)、第二负极浆料层(23)和负极空白(22)的长度均相等，第一负极浆料层(21)和第二负极浆料层(23)的宽度相等；第一负极浆料层(21)与第二负极浆料层(23)的浆料成分相同；

c) 将涂覆后的正极集流体进行对称分切，分切后得到两条形状和尺寸一致的正极片，对称分切是对正极空白(12)处进行分切，保留若干空白铝箔(32)，切除掉正极左端切除空箔(31)、若干正极中间切除空箔(33)和正极右端切除空箔(34)，设正极左端切除空箔(31)的长度为 W_{31}，保留若干空白铝箔(32)的长度为 W_{32}，正极中间切除空箔(33)的长度为 W_{33}，正极右端切除空箔(34)的长度为 W_{34}，则 $W_{33}=2W_{31}=2W_{34}$，$W_{32}+W_{31}+1/2W_{33}=$ 卷芯宽度；

d) 将涂覆后的负极集流体进行对称分切，分切后得到两条形状和尺寸一致的负极片，对称分切是对负极空白(22)处进行分切，保留若干空白铜箔(42)，切除掉负极左端切除空箔(41)、若干负极中间切除空箔(43)和负极右端切除空箔(44)，设负极左端切除空箔(41)的长度为 W_{41}，保留若干空白铜箔(42)的长度为 W_{42}，负极中间切除空箔(43)的长度为 W_{43}，负极右端切除空箔(44)的长度为 W_{44}，则 $W_{33}=2W_{41}=2W_{44}$，$W_{42}+W_{41}+1/2W_{43}=$ 卷芯宽度；

e) 采用卷绕的方式，将负极片放在隔膜上，用隔膜将负极片包裹住，负极片上的空白铜箔(42)在隔膜的一侧伸出，卷半圈后，将正极片插入卷针和隔膜之间，正极片上的空白铝箔(32)在隔膜的另一侧伸出，然后将负极片、隔膜和正极片卷绕成电芯，隔膜围绕在电芯外圈，用终止胶带固定，卷绕后，在电芯一侧的空白铜箔(42)整齐叠放，在电芯另一侧的空白铝箔(32)整齐叠放；

f) 将负极耳与卷绕好的电芯一侧的空白铜箔(42)进行焊接，焊接完成后用聚酰亚胺胶带包裹固定；将正极耳与卷绕好的电芯另一侧的空白铝箔(32)进行焊接，焊接完成后用聚酰亚胺胶带包裹固定；

g) 将焊接有正极耳和负极耳的电芯依次进行封装、真空干燥、注液、封口、化成、整形、

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分容和老化，得到大容量高倍率方形锂离子动力电池。

2. 如权利要求 1 所述的一种大容量高倍率方形锂离子动力电池的制造方法，其特征在于：所述 a) 步骤中正极浆料中活性物质、导电剂与粘结剂的质量比例为：88 ～ 93%，3 ～ 6%，3 ～ 6%；b) 步骤中负极浆料中活性物质、导电剂与粘结剂的质量比例为：90 ～ 95%，2 ～ 5%，2 ～ 5%。

3. 如权利要求 2 所述的一种大容量高倍率方形锂离子动力电池的制造方法，其特征在于：所述 a) 步骤中活性物质采用锰酸锂、钴酸锂、镍钴锰酸锂、磷酸铁锂中的一种或多种，导电剂采用超导炭黑或者导电石墨，粘结剂采用聚偏氟乙烯；b) 步骤中活性物质采用天然石墨或者人造石墨，导电剂采用超导炭黑或者导电石墨，粘结剂采用水性粘合剂。

4. 如权利要求 1 所述的一种大容量高倍率方形锂离子动力电池的制造方法，其特征在于：所述 c) 步骤中正极中间切除空箔（33）的长度 W_{33} 为 1 ～ 2.5cm，d) 步骤中负极中间切除空箔（43）的长度 W_{43} 为 1 ～ 2.5cm。

5. 如权利要求 1 ～ 4 中任一项所述的一种大容量高倍率方形锂离子动力电池的制造方法，其特征在于：所述 e) 步骤中隔膜的宽度比负极片的宽度大 2 ～ 3mm，负极片的宽度比正极片的宽度大 1 ～ 2mm。

6. 大容量高倍率方形锂离子动力电池，其特征在于：包括电芯，所述电芯包括一侧设有若干空白铜箔（42）的负极片、一侧设有若干空白铝箔（32）的正极片、隔膜，负极片与正极片之间设置隔膜，并使负极片上的所有空白铜箔（42）在隔膜的一侧伸出，正极片上的所有空白铝箔（32）在隔膜的另一侧伸出，负极片、隔膜和正极片叠放卷绕后形成电芯，所有空白铜箔（42）整齐重叠，所有空白铝箔（32）整齐重叠。

7. 如权利要求 6 所述的大容量高倍率方形锂离子动力电池，其特征在于：所述隔膜的宽度比负极片的宽度大 2 ～ 3mm，负极片的宽度比正极片的宽度大 1 ～ 2mm。

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一种大容量高倍率方形锂离子动力电池及其制造方法

【技术领域】

[0001] 本发明涉及大容量高倍率方形锂离子动力电池及其制造方法，属于电池领域，特别是涉及一种具有大容量、高倍率放电性能的可充放电的二次锂离子电池的结构及制造方法。

【背景技术】

[0002] 锂离子电池是性能卓越的新一代环保、可再生的化学能源，目前正以其它电池所不能比拟的优势迅速占领了移动电话、笔记本电脑、小型摄像机、数码照相机、电动工具、电动汽车等应用领域。容量高、体积小、安全性能好的动力电池越来越受到消费者的亲睐。

[0003] 目前传统的方形锂离子电池成型主要分为卷绕式和叠片式，这两种装备方式各有优缺点：卷绕式电芯结构简单、比能量大，但是内阻较大，不利于大电流放电；叠片式电芯极片短、电池内阻较小，有利于大电流充放电，但是实际生产中极片多，切边多，生产效率低，并且不利于控制极片边缘毛刺。采用多极耳制作方式可以综合两者的优点，实现快速充电和大电流放电。目前，多极耳电池的制作方法是通过在正负极极片上焊接多个连接条来实现的，专利 CN101714624A 中公布了一种多极耳锂离子电池的制造方法，分别在正、负极片上点焊多个极耳，并且极耳的间距遵循螺旋线极坐标方程，该发明的特点是卷绕后，同一极性的极耳在卷芯的顶端整齐的排列，这种方式虽然可以一定程度的提高电池的大电流工作能力，但是极耳焊接位点不易控制，操作繁杂，生产效率低；同时多个极耳的使用提高了生产成本，并且，一张极片上焊接多个极耳，增加了电池的内阻，限制了电池倍率放电性能的进一步提升。

【发明内容】

[0004] 本发明的目的就是解决现有技术中的问题，提出一种大容量高倍率方形锂离子动力电池及其制造方法，既能够电芯结构简单、比能量大，又能够内阻较小，有利于大电流充放电，同时，还能降低成本，提高生产效率。

[0005] 为实现上述目的，本发明提出了一种大容量高倍率方形锂离子动力电池及其制造方法，依次包括以下步骤：

[0006] a) 采用活性物质、导电剂和粘结剂按一定比例充分混合后制成正极浆料，采用涂布机将正极浆料涂覆到正极集流体上，在正极集流体的正面宽度方向的中间位置留出正极空白，正极空白的一侧涂覆有第一正极浆料层，正极空白的另一侧涂覆有第二正极浆料层，第一正极浆料层、第二正极浆料层和正极空白的长度均相等，第一正极浆料层和第二正极浆料层的宽度相等，在正极集流体的背面宽度方向的中间位置留出正极空白，正极空白的一侧涂覆有第一正极浆料层，正极空白的另一侧涂覆有第二正极浆料层，第一正极浆料层、第二正极浆料层和正极空白的长度均相等，第一正极浆料层和第二正极浆料层的宽度相等；第一正极浆料层（11）与第二正极浆料层（13）的浆料成分相同；

[0007] b) 采用活性物质、导电剂和粘结剂按一定比例充分混合后制成负极浆料，采用涂

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布机将负极浆料涂覆到负极集流体上，在负极集流体的正面宽度方向的中间位置留出负极空白，负极空白的一侧涂覆有第一负极浆料层，负极空白的另一侧涂覆有第二负极浆料层，第一负极浆料层、第二负极浆料层和负极空白的长度均相等，第一负极浆料层和第二负极浆料层的宽度相等，在负极集流体的背面宽度方向的中间位置留出负极空白，负极空白的一侧涂覆有第一负极浆料层，负极空白的另一侧涂覆有第二负极浆料层，第一负极浆料层、第二负极浆料层和负极空白的长度均相等，第一负极浆料层和第二负极浆料层的宽度相等；第一负极浆料层（21）与第二负极浆料层（23）的浆料成分相同；

[0008] c）将涂覆后的正极集流体进行对称分切，分切后得到两条形状和尺寸一致的正极片，对称分切是对正极空白处进行分切，保留若干空白铝箔，切除掉正极左端切除空箔、若干正极中间切除空箔和正极右端切除空箔，设正极左端切除空箔的长度为 W_{31}，保留若干空白铝箔的长度为 W_{32}，正极中间切除空箔的长度为 W_{33}，正极右端切除空箔的长度为 W_{34}，则 $W_{33}=2W_{31}=2W_{34}$，且 $W_{32}+W_{31}+1/2W_{33}$= 卷芯宽度；

[0009] d）将涂覆后的负极集流体进行对称分切，分切后得到两条形状和尺寸一致的负极片，对称分切是对负极空白处进行分切，保留若干空白铜箔，切除掉负极左端切除空箔、若干负极中间切除空箔和负极右端切除空箔，设负极左端切除空箔的长度为 W_{41}，保留若干空白铜箔的长度为 W_{42}，负极中间切除空箔的长度为 W_{43}，负极右端切除空箔的长度为 W_{44}，则 $W_{43}=2W_{41}=2W_{44}$，且 $W_{42}+W_{41}+1/2W_{43}$= 卷芯宽度；

[0010] e）采用卷绕的方式，将负极片放在隔膜上，用隔膜将负极片包裹住，负极片上的空白铜箔在隔膜的一侧伸出，卷半圈后，将正极片插入卷针和隔膜之间，正极片上的空白铝箔在隔膜的另一侧伸出，然后将负极片、隔膜和正极片卷绕成电芯，隔膜围绕在电芯外圈，用终止胶带固定，卷绕后，在电芯一侧的空白铜箔整齐叠放，在电芯另一侧的空白铝箔整齐叠放；

[0011] f）将负极耳与卷绕好的电芯一侧的空白铜箔进行焊接，焊接完成后用聚酰亚胺胶带包裹固定；将正极耳与卷绕好的电芯另一侧的空白铝箔进行焊接，焊接完成后用聚酰亚胺胶带包裹固定；

[0012] g）将焊接有正极耳和负极耳的电芯依次进行封装、真空干燥、注液、封口、化成、整形、分容和老化，得到大容量高倍率方形锂离子动力电池。

[0013] 作为优选，所述 a）步骤中正极浆料中活性物质、导电剂与粘结剂的质量比例为：88 ～ 93%，3 ～ 6%，3 ～ 6%；b）步骤中负极浆料中活性物质、导电剂与粘结剂的质量比例为：90 ～ 95%，2 ～ 5%，2 ～ 5%。

[0014] 作为优选，所述 a）步骤中活性物质采用锰酸锂、钴酸锂、镍钴锰酸锂、磷酸铁锂中的一种或多种，导电剂采用超导炭黑或者导电石墨，粘结剂采用聚偏氟乙烯；b）步骤中活性物质采用天然石墨或者人造石墨，导电剂采用超导炭黑或者导电石墨，粘结剂采用水性粘合剂。

[0015] 作为优选，所述 c）步骤中正极中间切除空箔的宽度 W_{33} 为 1 ～ 2.5cm，d）步骤中负极中间切除空箔的宽度 W_{43} 为 1 ～ 2.5cm。

[0016] 作为优选，所述 e）步骤中隔膜的宽度比负极片的宽度大 2 ～ 3mm，负极片的宽度比正极片的宽度大 1 ～ 2mm。

[0017] 为实现上述目的，本发明还提出了一种大容量高倍率方形锂离子动力电池，包括

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电芯，所述电芯包括一侧设有若干空白铜箔）的负极片、一侧设有若干空白铝箔的正极片、隔膜，负极片与正极片之间设置隔膜，并使负极片上的所有空白铜箔在隔膜的一侧伸出，正极片上的所有空白铝箔在隔膜的另一侧伸出，负极片、隔膜和正极片叠放卷绕后形成电芯，所有空白铜箔整齐重叠，所有空白铝箔整齐重叠。

[0018] 作为优选，所述隔膜的宽度比负极片的宽度大 2 ～ 3mm，负极片的宽度比正极片的宽度大 1 ～ 2mm。

[0019] 本发明的有益效果：本发明采用新的涂布方法和新的极片分切方式，制造出“凹凸相连”的电极片，极片卷绕后，两端引出的空白箔材部分替代连接条与极耳相连，既实现了叠片与卷绕的组合，又减少了连接条的使用，一方面提高了生产效率，降低了生产成本；另一方面避免了极片上焊接多个连接条造成的内阻增大的情况。此种“凹凸相连”形状的电极片的发明，从根本上实现了卷绕与叠片方式的完美组合，多层次全方位减小电池内阻，提升了电池的放电平台；同时减少了放电时的热量生成，提高了电池的安全性。本发明彻底解决了目前存在的卷绕方式不适合大容量动力电池以及叠片式电池的安全性能较差和不易操作的问题，对大容量高倍率方形锂离子动力电池的发展应用具有重要的意义。

[0020] 本发明的特征及优点将通过实施例结合附图进行详细说明。

【附图说明】

[0021] 图 1 是本发明中所涉及的涂布后的正极集流体的结构示意图；

[0022] 图 2 是本发明中所涉及的涂布后的负极集流体的结构示意图；

[0023] 图 3 是本发明中所涉及的涂布后的正极集流体分切过程的示意图；

[0024] 图 4 是本发明中所涉及的涂布后的负极集流体分切过程的示意图；

[0025] 图 5 是本发明中所涉及的涂布后的正极集流体分切后得到的单个正极片的结构示意图；

[0026] 图 6 是本发明中所涉及的涂布后的负极集流体分切得到的单个负极片的结构示意图；

[0027] 图 7 是本发明一种大容量高倍率方形锂离子动力电池中电芯的结构示意图；

[0028] 图 8 是本发明一种大容量高倍率方形锂离子动力电池中正极耳的结构示意图；

[0029] 图 9 是本发明中一种大容量高倍率方形锂离子动力电池中负极耳的结构示意图。

【具体实施方式】

[0030] 大容量高倍率方形锂离子动力电池的制造方法，依次包括以下步骤：

[0031] a) 参阅图 1，采用活性物质、导电剂和粘结剂按一定比例充分混合后制成正极浆料，采用涂布机将正极浆料涂覆到正极集流体上，在正极集流体的正面宽度方向的中间位置留出正极空白 12，正极空白 12 的一侧涂覆有第一正极浆料层 11，正极空白 12 的另一侧涂覆有第二正极浆料层 13，第一正极浆料层 11、第二正极浆料层 13 和正极空白 12 的长度均相等，第一正极浆料层 11 和第二正极浆料层 13 的宽度相等，在正极集流体的背面宽度方向的中间位置留出正极空白 12，正极空白 12 的一侧涂覆有第一正极浆料层 11，正极空白 12 的另一侧涂覆有第二正极浆料层 13，第一正极浆料层 11、第二正极浆料层 13 和正极空白 12 的长度均相等，第一正极浆料层 11 和第二正极浆料层 13 的宽度相等；第一正极浆料层 11

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与第二正极浆料层 13 浆料成分完全相同。正极浆料中活性物质、导电剂与粘结剂的质量比例为 :88 ～ 93%,3 ～ 6%,3 ～ 6% ;正极的活性物质采用锰酸锂、钴酸锂、镍钴锰酸锂、磷酸铁锂中的一种或多种,导电剂采用超导炭黑或者导电石墨,粘结剂采用聚偏氟乙烯。

[0032] b) 参阅图 2,采用活性物质、导电剂和粘结剂按一定比例充分混合后制成负极浆料,采用涂布机将负极浆料涂覆到负极集流体上,在负极集流体的正面宽度方向的中间位置留出负极空白 22,负极空白 22 的一侧涂覆有第一负极浆料层 21,负极空白 22 的另一侧涂覆有第二负极浆料层 23,第一负极浆料层 21、第二负极浆料层 23 和负极空白 22 的长度均相等,第一负极浆料层 21 和第二负极浆料层 23 的宽度相等,在负极集流体的背面宽度方向的中间位置留出负极空白 22,负极空白 22 的一侧涂覆有第一负极浆料层 21,负极空白 22 的另一侧涂覆有第二负极浆料层 23,第一负极浆料层 21、第二负极浆料层 23 和负极空白 22 的长度均相等,第一负极浆料层 21 和第二负极浆料层 23 的宽度相等 ;第一正极浆料层 11 与第二正极浆料层 13 浆料成分完全相同。负极浆料中活性物质、导电剂与粘结剂的质量比例为 :90 ～ 95%,2 ～ 5%,2 ～ 5%。负极的活性物质采用天然石墨或者人造石墨,导电剂采用超导炭黑或者导电石墨,粘结剂采用水性粘合剂。

[0033] c) 参阅图 3、5,将涂覆后的正极集流体进行对称分切,分切后得到两条形状和尺寸一致的正极片,对称分切是对正极空白 12 处进行分切,保留若干空白铝箔 32,切除掉正极左端切除空箔 31、若干正极中间切除空箔 33 和正极右端切除空箔 34,设正极左端切除空箔 31 的长度为 W_{31},保留若干空白铝箔 32 的长度为 W_{32},正极中间切除空箔 33 的长度为 W_{33},正极右端切除空箔 34 的长度为 W_{34},则 $W_{33}=2W_{31}=2W_{34}$,且 $W_{32}+W_{31}+1/2W_{33}=$ 卷芯宽度 ;卷芯宽度是指 e) 步骤中负极片、隔膜和正极片卷绕成电芯后整个的宽度。正极中间切除空箔 33 的长度 W_{33} 为 1 ～ 2.5cm。空白铝箔 32 的宽度与涂布时正极空白 12 (或称 :正极留白)的宽度相同。

[0034] d) 参阅图 4、6,将涂覆后的负极集流体进行对称分切,分切后得到两条形状和尺寸一致的负极片,对称分切是对负极空白 22 处进行分切,保留若干空白铜箔 42,切除掉负极左端切除空箔 41、若干负极中间切除空箔 43 和负极右端切除空箔 44,设负极左端切除空箔 41 的长度为 W_{41},保留若干空白铜箔 42 的长度为 W_{42},负极中间切除空箔 43 的长度为 W_{43},负极右端切除空箔 44 的长度为 W_{44},则 $W_{43}=2W_{41}=2W_{44}$,且 $W_{42}+W_{41}+1/2W_{43}=$ 卷芯宽度 ;卷芯宽度是指 e) 步骤中负极片、隔膜和正极片卷绕成电芯后整个的宽度。负极中间切除空箔 43 的长度 W_{43} 为 1 ～ 2.5cm。空白铜箔 42 的宽度与涂布时负极空白 22 (或称 :负极留白)的宽度相同。

[0035] e) 参阅图 7,采用卷绕的方式,将负极片放在隔膜上,用隔膜将负极片包裹住,负极片上的空白铜箔 42 在隔膜的一侧伸出,卷半圈后,将正极片插入卷针和隔膜之间,正极片上的空白铝箔 32 在隔膜的另一侧伸出,然后将负极片、隔膜和正极片卷绕成电芯,隔膜围绕在电芯外圈,用终止胶带固定,卷绕后,在电芯一侧的空白铜箔 42 整齐叠放,在电芯另一侧的空白铝箔 32 整齐叠放 ;隔膜的宽度比负极片的宽度大 2 ～ 3mm,负极片的宽度比正极片的宽度大 1 ～ 2mm。

[0036] f) 参阅图 8、9,将负极耳与卷绕好的电芯一侧的空白铜箔 42 进行焊接,焊接完成后用聚酰业胺胶带包裹固定 ;将正极耳与卷绕好的电芯另一侧的空白铝箔 32 进行焊接,焊接完成后用聚酰亚胺胶带包裹固定。

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[0037] g) 将焊接有正极耳和负极耳的电芯依次进行封装、真空干燥、注液、封口、化成、整形、分容和老化，得到大容量高倍率方形锂离子动力电池。

[0038] 参阅图 7，大容量高倍率方形锂离子动力电池，包括电芯，所述电芯包括一侧设有若干空白铜箔 42 的负极片、一侧设有若干空白铝箔 32 的正极片、隔膜，负极片与正极片之间设置隔膜，并使负极片上的所有空白铜箔 42 在隔膜的一侧伸出，正极片上的所有空白铝箔 32 在隔膜的另一侧伸出，负极片、隔膜和正极片叠放卷绕后形成电芯，所有空白铜箔 42 整齐重叠，所有空白铝箔 32 整齐重叠，空白铜箔 42 上焊接有负极耳，空白铜箔 42 与负极耳的焊接处包裹有胶带，空白铝箔 32 上焊接有正极耳，空白铝箔 32 与正极耳的焊接处包裹有胶带；所述隔膜的宽度比负极片的宽度大 2 ～ 3mm，负极片的宽度比正极片的宽度大 1 ～ 2mm。

[0039] 上述实施例是对本发明的说明，不是对本发明的限定，任何对本发明简单变换后的方案均属于本发明的保护范围。

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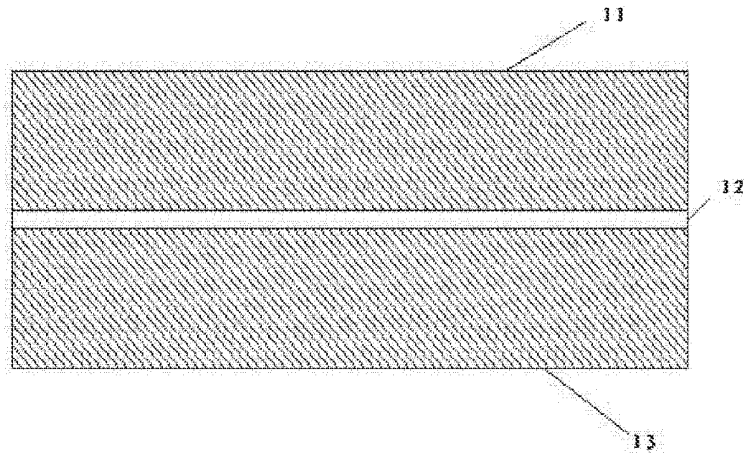


图 1

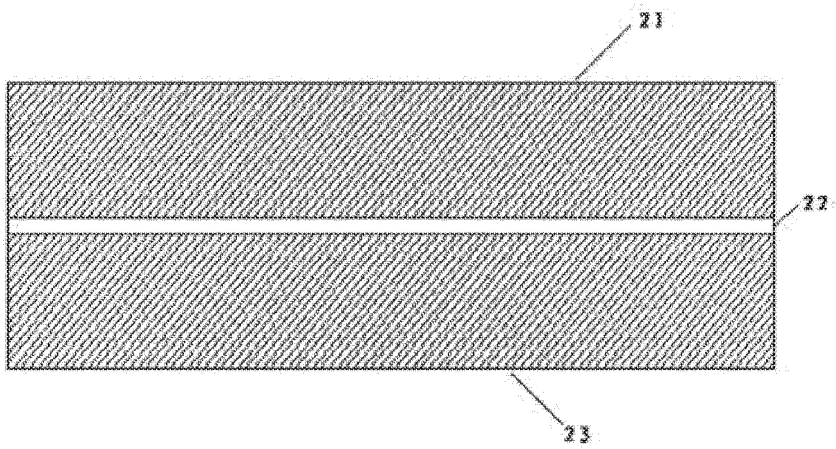


图 2

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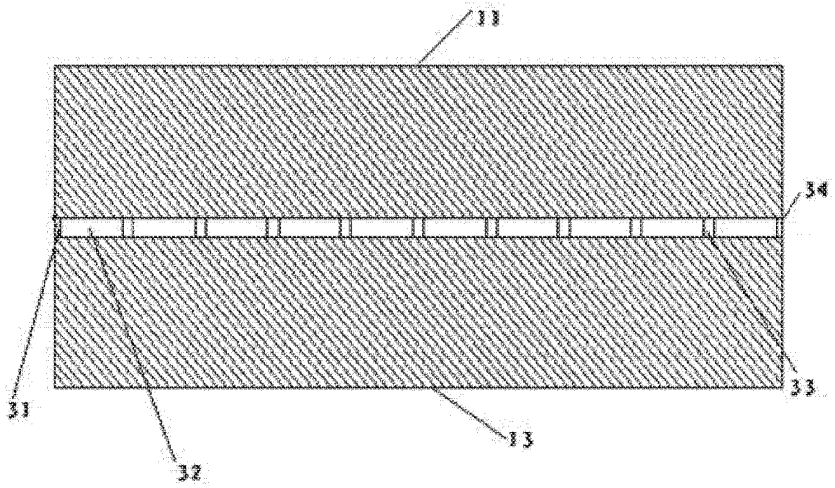


图 3

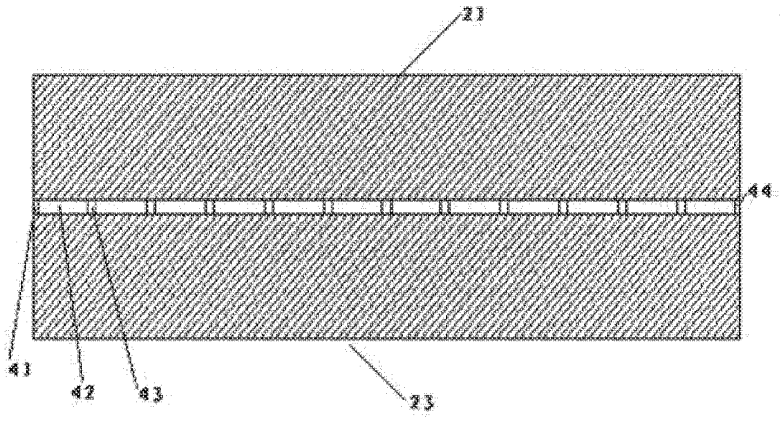


图 4

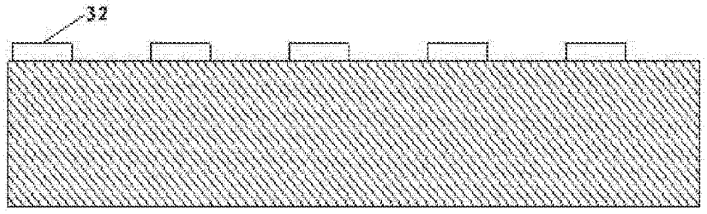


图 5

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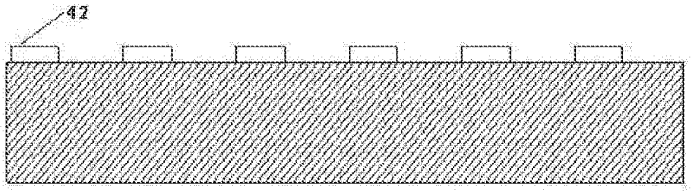


图 6

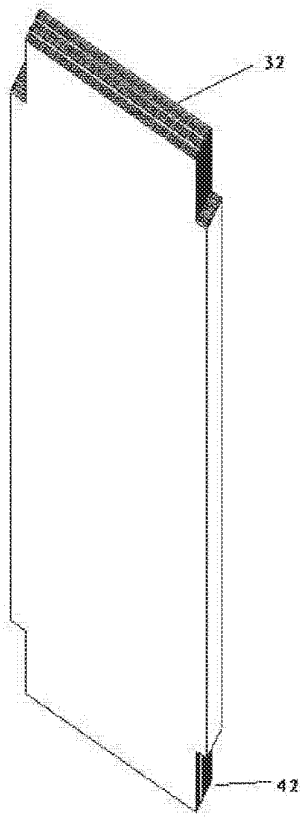


图 7

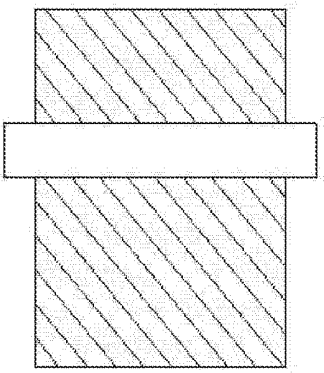


图 8

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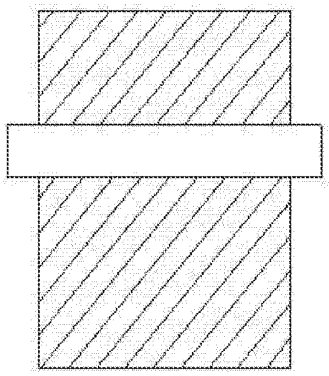


图 9

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Espacenet

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Negative-electrode plate and cylindrical cell including same

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Applicant(s): FDK TWICELL CO LTD ± (FDK TWICELL CO., LTD, ; FDK株式会社)

Classification: **- international:** ***H01M10/28; H01M10/30; H01M4/32***
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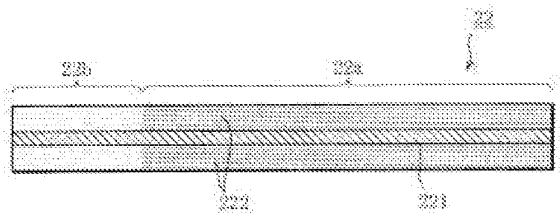
Application number: CN201210220054 20120629 Global Dossier

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Abstract of CN102856538 (A)

FIG. 4



A negative-electrode plate 22 for use in a cylindrical cell, intended to be laid over a positive-electrode plate 21 with a separator 23 interposed between and rolled to form a cylindrical electrode body 20, with the positive-electrode plate 21 inside, the electrode body being arranged in a bottomed cylindrical outer can 10 to form the cylindrical cell, comprises a first negative-electrode part 22a which is to face the positive-electrode plate 21 on either side, with the separator 23 between, when formed into the electrode body 20, and a second negative-electrode part 22b which is to form the innermost circumference of the electrode body 20 and face the positive-electrode plate 21 only on one side, with the

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separator 23 between, when formed into the electrode body 20, the second negative-electrode part 22b being lower in negative-electrode active material density than the first negative-electrode part 22a.

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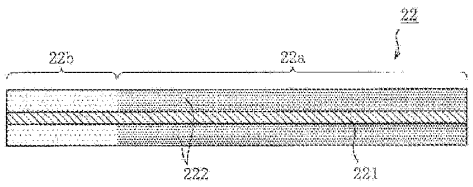
权利要求书 1 页 说明书 6 页 附图 5 页

(54)发明名称

负极板、包括该负极板的圆筒形电池

(57)摘要

本发明是将电极体(20)收纳在有底圆筒形状的外壳(10)内的圆筒形电池的负极板(22)，所述电极体(20)将正极板(21)和负极板(22)夹着隔板(23)进行层叠，然后卷成涡旋状并使负极板(22)处于外侧，所述负极板(22)包括：第一负极部(22a)，该第一负极部(22a)在构成电极体(20)的状态下双面隔着隔板(23)与正极板(21)相对；以及第二负极部(22b)，该第二负极部(22b)是成为电极体(20)的最内周的部分，在构成电极体(20)的状态下，仅单面隔着隔板(23)与正极板(21)相对，其负极活性物质的密度比第一负极部(22a)要低。



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1. 一种负极板 (22)，所述负极板 (22) 是圆筒形电池 (1) 的负极板 (22)，所述圆筒形电池 (1) 将电极体 (20) 收纳在有底圆筒形状的外壳 (10) 内，所述电极体 (20) 包含保持正极活性物质的正极板 (21)、保持负极活性物质 (222) 的所述负极板 (22)，以及对所述正极板 (21) 和所述负极板 (22) 进行分离的隔板 (23)，并将所述正极板 (21) 和所述负极板 (22) 夹着所述隔板 (23) 进行层叠，然后卷成涡旋状并使所述负极板 (22) 处于外侧，所述负极板 (22) 的特征在于，包括：

第一负极部 (22a)，该第一负极部 (22a) 在构成所述电极体 (20) 的状态下双面隔着所述隔板 (23) 与所述正极板 (21) 相对；以及

第二负极部 (22b)，该第二负极部 (22b) 是成为所述电极体 (20) 的最内周的部分，在构成所述电极体 (20) 的状态下，仅单面隔着所述隔板 (23) 与所述正极板 (21) 相对，其负极活性物质 (222) 的密度比所述第一负极部 (22a) 要低。

2. 如权利要求 1 所述的负极板 (22)，其特征在于，

所述第二负极部 (22b) 的负极活性物质 (222) 的密度超过所述第一负极部 (22a) 的负极活性物质 (222) 的密度的 0%、且为 75% 以下。

3. 如权利要求 2 所述的负极板 (22)，其特征在于，

所述第二负极部 (22b) 的厚度比所述第一负极部 (22a) 的厚度要小。

4. 一种圆筒形电池 (1)，包括：电极体 (20)，该电极体 (20) 包含保持正极活性物质的正极板 (21)、保持负极活性物质 (222) 的负极板 (22)，以及对所述正极板 (21) 和所述负极板 (22) 进行分离的隔板 (23)，并将所述正极板 (21) 和所述负极板 (22) 夹着所述隔板 (23) 进行层叠，然后卷成涡旋状并使所述负极板 (22) 处于外侧；以及外壳 (10)，该外壳 (10) 呈有底圆筒形状，用于收纳所述电极体 (20)，所述圆筒形电池 (1) 的特征在于，所述负极板 (22) 包括：

第一负极部 (22a)，该第一负极部 (22a) 在构成所述电极体 (20) 的状态下双面隔着所述隔板 (23) 与所述正极板 (21) 相对；以及

第二负极部 (22b)，该第二负极部 (22b) 是成为所述电极体 (20) 的最内周的部分，在构成所述电极体 (20) 的状态下，仅单面隔着所述隔板 (23) 与所述正极板 (21) 相对，其负极活性物质 (222) 的密度比所述第一负极部 (22a) 要低。

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负极板、包括该负极板的圆筒形电池

技术领域

[0001] 本发明涉及将电极体收纳在有底圆筒形状的外壳内的圆筒形电池、及该圆筒形电池的负极板，上述电极体包含保持正极活性物质的正极板、保持负极活性物质的负极板、以及对正极板和负极板进行分离的隔板，并将正极板和负极板夹着隔板进行层叠，然后卷成涡旋状并使负极板处于外侧。

背景技术

[0002] 圆筒形的镍镉电池、镍氢电池、锂离子电池等将电极体收纳在有底圆筒形状的外壳内，上述电极体包含保持正极活性物质的正极板、保持负极活性物质的负极板，以及对正极板和负极板进行分离的隔板，并将正极板和负极板夹着隔板进行层叠，然后卷成涡旋状并使负极板处于外侧。在这样的圆筒形电池中，负极板例如使用将负极活性物质涂布于由冲孔金属等具有导电性的多孔体构成的负极芯体、并对其进行轧制等而制成的负极板。

[0003] 在这样的圆筒形电池中，作为以高容量化为目的的现有技术，例如公知有以下结构的圆筒形电池：成为电极体的最内周部和最外周部的部分的负极板的厚度是此外的部分的负极板的厚度的一半（参照日本专利特开平 06－267583 号公报）。此外，例如公知有使用以下负极板的圆筒形电池，该负极板相比在构成电极体的状态下仅单面隔着隔板与正极板相对的单面相对部的活性物质密度，使在构成电极体的状态下双面隔着隔板与正极板相对的双面相对部的活性物质密度降低（参照日本专利特开 2004－303484 号公报）。此外，例如公知有使正极板的厚度增大、且使负极板的构成电极体的最外周面的部分的厚度减小的结构（参照日本专利第 4359099 号公报）。

[0004] 上述的圆筒形电池大致经过以下的工序制造而成。首先，将正极板和负极板夹着隔板进行层叠，然后卷成涡旋状并使负极板处于外侧，从而构成电极体。接下来，将电极体收纳在有底圆筒形状的外壳内，将正极集电板安装在该电极体上。接下来，将电解液从形成于正极集电板中央的孔注入外壳，然后，安装正极引线等，最后，利用成为电池的正极的盖体对外壳进行密闭。

[0005] 如上所述，由于电解液从形成于正极集电板中央的孔注入，因此，注入电极体的中心部分的空间（在成为电极体的最内周的部分所产生的空间）内。由此，电解液从电极体的中心部分朝向外侧，一边浸透隔板、正极板及负极板，一边逐渐填充外壳。此时，若电解液对电极体的浸透不充分，则无法使整个电极体均匀地活性化，因此，有可能产生循环特性和高速放电特性下降。因此，在制造圆筒形电池时，需要使电解液充分浸透电极体。

[0006] 然而，例如，如日本专利特开 2004－303484 号公报记载的电池那样，若位于电极体的最内周的负极板的卷绕起始部分的负极活性物质的密度增高，则电解液相对于电极体的浸透性大幅下降，其结果是，填充所需量的电解液来使电解液充分浸透电极体需要花费大量时间。而且，若填充电解液所需的时间变长，则会因此产生圆筒形电池的制造效率下降这样的问题。

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发明内容

[0007] 本发明是为了解决这样的技术问题而实施的，其目的在于提高圆筒形电池的制造效率。

[0008] 为了实现上述目的，本发明的负极板是圆筒形电池的负极板，所述圆筒形电池将电极体收纳在有底圆筒形状的外壳内，所述电极体包含保持正极活性物质的正极板、保持负极活性物质的所述负极板，以及对所述正极板和所述负极板进行分离的隔板，并将所述正极板和所述负极板夹着所述隔板进行层叠，然后卷成涡旋状并使所述负极板处于外侧，所述负极板的特征在于，包括：第一负极部，该第一负极部在构成所述电极体的状态下双面隔着所述隔板与所述正极板相对；以及第二负极部，该第二负极部是成为所述电极体的最内周的部分，在构成所述电极体的状态下，仅单面隔着所述隔板与所述正极板相对，其负极活性物质的密度比所述第一负极部要低。

[0009] 负极板的第二负极部是在构成电极体的状态下仅单面隔着隔板与正极板相对的部分，是成为电极体的最内周的部分。而且，负极板的第二负极部的负极活性物质的密度比第一负极部的要低，因此，电解液的浸透性（浸透速度）相对较高。因此，在圆筒形电池的制造工序中，在将电解液注入电极体的中心部分的空间（在成为电极体的最内周的部分所产生的空间）内时，能提高电解液相对于该电极体的浸透性。由此，在圆筒形电池的制造工序中，能缩短将所需量的电解液填充到外壳内、并使电解液充分浸透电极体所需的时间。

[0010] 而且，若保持在负极板上的负极活性物质的总量与以往相同，则能填充于外壳的电解液的量当然也不变。这是由于，若以与以往相同的总量来降低第二负极部的负极活性物质密度，则第二负极部的负极活性物质的视在体积增大，因此，外壳的填充电解液的容积减少，而浸透第二负极部的负极活性物质内部的电解液的量相应地增加。即，即使降低第二负极部的负极活性物质密度，也能维持与以往相同的容量，因此，圆筒形电池的容量不会因本发明的负极板而下降。

[0011] 由此，根据本发明，能得到可提高圆筒形电池的制造效率这样的作用效果。

[0012] 此外，对于将正极板和负极板夹着隔板进行层叠、然后卷成涡旋状并使负极板处于外侧而构成的电极体，由于成为电极体的最内周的负极板的卷绕起始部分的卷绕直径最小，因此，对该部分作用有最大的负荷。因此，在圆筒形电池的制造工序中，在构成电极体时，最容易在其卷绕起始部分处的负极板上产生负极活性物质的剥离或断裂等。根据本发明，在构成电极体时成为卷绕起始部分的负极板的第二负极部的负极活性物质密度相对较低，因此，能提高柔软性。由此，在圆筒形电池的制造工序中，在构成电极体时，能降低在其卷绕起始部分处的负极板上产生负极活性物质的剥离或断裂等的可能性。

[0013] 此外，本发明所涉及的负极板的特征在于，进一步使所述第二负极部的负极活性物质的密度超过所述第一负极部的负极活性物质的密度的 0%、且为 75%以下。

[0014] 根据这样的特征，能进一步提高负极板的第二负极部（成为电极体的最内周的部分）中的电解液的浸透性，因此，在圆筒形电池的制造工序中，能进一步缩短将所需量的电解液填充到外壳内、并使电解液充分浸透电极体所需的时间。

[0015] 此外，本发明所涉及的负极板的特征在于，进一步使所述第二负极部的厚度比所述第一负极部的厚度要小。

[0016] 根据这样的特征，能提高电极体的体积效率，因此，能实现更高容量的圆筒形电

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池。

[0017] 本发明的圆筒形电池包括：电极体，该电极体包含保持正极活性物质的正极板、保持负极活性物质的负极板，以及对所述正极板和所述负极板进行分离的隔板，并将所述正极板和所述负极板夹着所述隔板进行层叠，然后卷成涡旋状并使所述负极板处于外侧；以及外壳，该外壳呈有底圆筒形状，用于收纳所述电极体，所述圆筒形电池的特征在于，所述负极板包含：第一负极部，该第一负极部在构成所述电极体的状态下双面隔着所述隔板与所述正极板相对；以及第二负极部，该第二负极部是成为所述电极体的最内周的部分，在构成所述电极体的状态下，仅单面隔着所述隔板与所述正极板相对，其负极活性物质的密度比所述第一负极部要低。

附图说明

[0018] 通过下述的详细说明以及仅由图面方式给出的附图将会更全面地理解本发明，因而上述说明和附图并非对本发明的限定，其中：

[0019] 图 1 是图示镍氢充电电池的纵向剖面的立体图。

[0020] 图 2 是表示镍氢充电电池中的正极板与正极集电板之间、以及负极板与负极集电板之间的连结部的剖视图。

[0021] 图 3 是图 1 的 I－I 线上的镍氢充电电池的横向剖视图。

[0022] 图 4 是负极板的主视剖视图。

[0023] 图 5 是示意图示负极板的制造工序的俯视图。

[0024] 图 6A 是图 5 的负极板材的 II－II 线上的剖视图。

[0025] 图 6B 是图 5 的负极板材的 III－III 线上的剖视图。

[0026] 图 7 是图示本发明所涉及的负极板的变形例的主视剖视图。

具体实施方式

[0027] 以下，参照附图对本发明的实施方式进行说明。

[0028] ＜镍氢充电电池的结构＞

[0029] 参照图 1 ～图 3 对镍氢充电电池 1 的结构进行说明。

[0030] 图 1 是图示镍氢充电电池 1 的纵向剖面的立体图。图 2 是图示镍氢充电电池 1 的横向剖面的俯视图。图 3 是图 1 的 I－I 线上的镍氢充电电池 1 的横向剖视图。

[0031] 作为“圆筒形电池”的一个示例的圆筒型镍氢充电电池 1 包括外壳 10、电极体 20、及盖结构体 30。外壳 10 是一端开口的有底圆筒形状的构件，并具有导电性。电极体 20 通过将正极板 21 和负极板 22 夹着隔板 23 进行层叠，然后卷成涡旋状并使负极板 22 处于外侧，而构成为近似圆筒状。盖结构体 30 是对外壳 10 的开口部进行封闭的结构体。将电极体 20 收纳在外壳 10 内，进一步填充碱性电解液（未图示），利用盖结构体 30 封闭外壳 10 的开口，从而构成镍氢充电电池 1。

[0032] 正极板 21 是非烧结式镍极，由正极芯体（未图示）和保持于正极芯体的正极合剂所构成。正极芯体由具有耐碱性的金属材料所构成。作为具有耐碱性的金属材料，例如可以使用镍。正极合剂由正极活性物质粒子、用于改善正极板的特性的各种添加剂粒子、以及用于将这些正极活性物质粒子及添加剂粒子的混合粒子粘接在正极芯体上的粘接剂所构成。

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[0033] 正极活性物质粒子是氢氧化镍粒子。氢氧化镍粒子也可以是镍的平均价数大于 2 的高次氢氧化镍粒子。此外，氢氧化镍粒子可以由钴、锌、镉等固溶而成，或表面也可以被钴化合物所被覆。添加剂除了氧化钇以外，可以使用氧化钴、金属钴、氢氧化钴等钴化合物；金属锌、氧化锌、氢氧化锌等锌化合物；以及氧化铒等稀土类化合物等。粘接剂可以使用亲水性或疏水性的聚合物等。更具体而言，粘接剂可以使用从羟丙基纤维素 (HPC)、羧甲基纤维素 (CMC)、聚丙烯酸钠 (SPA) 中选择的一种以上。对于粘接剂，例如针对 100 质量份的正极活性物质粒子，使用 0.1 质量份以上、0.5 质量份以下的粘接剂即可。

[0034] 负极板 22 通过使负极合剂保持在呈带状的导电性负极芯体（未图示）上面形成。负极芯体由具有多个通孔的片状金属材构成，例如，可以使用冲孔金属、金属粉末烧结体基板、多孔金属网、镍网等。尤其是冲孔金属、将金属粉末成型后进行烧结而成的金属粉末烧结体基板，对负极芯体较为适用。

[0035] 作为“负极活性物质”的负极合剂由能吸藏及放出氢的氢吸藏合金粒子和粘接剂所构成。氢吸藏合金粒子只要在电池充电时吸藏在碱性电解液中以电化学方式所产生的氢，且在放电时能容易地放出它的吸藏氢即可。对于这样的氢吸藏合金没有特别的限定，例如可以使用 $LaNi_5$ 或 $MmNi_5$(Mm 为混合稀土合金）等的 AB_5 类的材料。此外，负极合剂例如可以使用镉化合物来取代氢吸藏合金。粘接剂例如可以使用亲水性或疏水性的聚合物等。

[0036] 对于隔板 23，例如能将对聚酰胺纤维制无纺布、聚乙烯或聚丙烯等聚烯烃纤维制无纺布附加了亲水性官能团的材料用作隔板 23 的材料。

[0037] 盖结构体 30 包含盖板 31、绝缘密封垫片 32、阀芯 33、正极端子 34、压缩螺旋弹簧 35、正极引线 36、及正极集电板 37。盖板 31 呈近似圆形，在中央设有阀孔 311。在夹装有绝缘密封垫片 32 的状态下，对外壳 10 的开口边缘进行铆接加工，从而将盖板 31 固定在外壳 10 上。阀芯 33 是由橡胶与金属板贴合而成的构件，设置在盖板 31 的外表面上以封闭阀孔 311。正极端子 34 呈带凸缘的圆筒形状，以覆盖阀芯 33 的方式进行固定。压缩螺旋弹簧 35 收纳在正极端子 34 内，对阀芯 33 施力。正极引线 36 以折弯的状态进行设置，其一端被焊接在盖板 31 的内表面上，另一端被焊接在正极集电板 37 上。正极集电板 37 为圆板形状的构件，在中央形成有用于将碱性电解液注入外壳 10 的孔 371。

[0038] 正极板 21 的正极芯体在正极集电板 37 一侧的端部形成有连结部 211。在连结部 211 的径向内表面例如利用焊接或导电性粘接剂固定有由镍带等构成的带状的金属薄板 212。金属薄板 212 从连结部 211 突出而与正极集电板 37 抵接。即，正极集电板 37 与正极板 21 经由金属薄板 212 进行电连接。另一方面，负极板 22 在与构成镍氢充电电池 1 的负极端子的外壳 10 的内周面抵接的状态下，与该外壳 10 进行电连接。

[0039] ＜负极板的结构＞

[0040] 参照图 4 对本发明所涉及的负极板 22 的结构进行说明。

[0041] 图 4 是本发明所涉及的负极板 22 的主视剖视图。

[0042] 负极板 22 通过在负极芯体 221 的双面保持负极活性物质 222 而形成。负极板 22 包含第一负极部 22a 及第二负极部 22b。第一负极部 22a 是在构成电极体 20 的状态下双面隔着隔板 23 与正极板 21 相对的部分。第二负极部 22b 是成为电极体 20 的最内周的部分，是在构成电极体 20 的状态下仅单面隔着隔板 23 与正极板 21 相对的部分。

[0043] 负极板 22 的第二负极部 22b 的负极活性物质 222 的密度（以下称为“负极活性物

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质密度”）比第一负极部 22a 的负极活性物质密度要低。

[0044] 另外，第二负极部 22b 的负极活性物质密度也可以在整个第二负极部 22b 上不是均匀的。例如，即使第二负极部 22b 的负极活性物质密度不均匀，只要第二负极部 22b 的负极活性物质密度的平均密度比第一负极部 22a 的负极活性物质密度要低即可。

[0045] 具有上述结构的负极板 22 中，相比第一负极部 22a，第二负极部 22b 的碱性电解液的浸透性（浸透速度）更高。而且，负极板 22 的第二负极部 22b 是成为电极体 20 的最内周的部分。因此，在镍氢充电电池 1 的制造工序中，在将碱性电解液注入电极体 20 的中心部分的空间（在成为电极体 20 的最内周的部分所产生的空间）内时，能提高碱性电解液相对于该电极体 20 的浸透性。由此，在镍氢充电电池 1 的制造工序中，能缩短将所需量的碱性电解液填充到外壳 10 内、并使碱性电解液充分浸透电极体 20 所需的时间。

[0046] 而且，若保持于负极板 22 的负极活性物质 222 的总量与现有的相同，则能填充于外壳 10 的碱性电解液的量当然也不变。这是由于，若以与以往相同的总量来降低第二负极部 22b 的负极活性物质密度，则第二负极部 22b 的负极活性物质 222 的视在体积增大，因此，外壳 10 的填充碱性电解液的容积减少，而浸透第二负极部 22b 的负极活性物质 222 内部的碱性电解液的量相应地增加。即，即使降低第二负极部 22b 的负极活性物质密度，也能维持与以往相同的容量，因此，镍氢充电电池 1 的容量不会因本发明的负极板 22 而下降。

[0047] 由此，根据本发明，能提高圆筒型的镍氢充电电池等圆筒形电池的制造效率。

[0048] 此外，对于将正极板 21 和负极板 22 夹着隔板 23 进行层叠、然后卷成涡旋状并使负极板 22 处于外侧而构成的电极体 20，由于成为电极体 20 的最内周的负极板 22 的卷绕起始部分的卷绕直径最小，因此，对该部分作用有最大的负荷。因此，在镍氢充电电池 1 的制造工序中，在构成电极体 20 时，最容易在其卷绕起始部分处的负极板 22 上产生负极活性物质 222 的剥离或断裂等。与之不同的是，本发明所涉及的负极板 22 中，由于第二负极部 22b 的负极活性物质密度相对较低，因此，在构成该电极体 20 时，能提高成为卷绕起始部分的第二负极部 22b 的柔软性。由此，在镍氢充电电池 1 的制造工序中，在构成电极体 20 时，能降低在其卷绕起始部分处的负极板 22 上产生负极活性物质 222 的剥离或断裂等的可能性。

[0049] 对于本发明所涉及的负极板 22，优选为其第二负极部 22b 的负极活性物质密度超过第一负极部 22a 的负极活性物质密度的 0%、且为 75% 以下。由此，能进一步提高负极板 22 的第二负极部 22b 中的碱性电解液的浸透性。例如，本实施例的负极板 22 的第一负极部 22a 的负极活性物质密度为 5.20g / cm^3，第二负极部 22b 的负极活性物质密度为 3.90g / cm^3。

[0050] ＜负极板的制造方法＞

[0051] 参照图 5 及图 6 对本发明所涉及的负极板 22 的制造方法的一个示例进行说明。

[0052] 图 5 是示意图示负极板 22 的制造工序的俯视图。图 6 是负极板 22 的制造工序中的负极板材 40 的剖视图，图 6A 是图示图 5 的负极板材 40 的 II－II 线上的剖面的图，图 6B 是图示图 5 的负极板材 40 的 III－III 线上的剖面的图。

[0053] 首先，在冲孔金属等的负极芯材 41 的双面上涂布包含氢吸藏合金的浆状的负极活性物质 42 并使其干燥，从而制作出负极板材 40。此处，负极板材 40 的宽度方向的长度 W1 为与负极板 22 的卷绕方向的长度 L 大致相同的长度。将负极活性物质 42 向负极芯材

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41 进行涂布时，使与负极板 22 的第一负极部 22a 相对应的区域 A（以下，称为“第一负极区域 A”）的厚度 d1 比与负极板 22 的第二负极部 22b 相对应的区域 B（以下，称为“第二负极区域 B”）的厚度 d2 要大（图 6A）。

[0054] 接着，一边将负极板材 40 朝搬运方向 C 进行搬运，一边利用比负极板材 40 的宽度方向的长度 W1 要长的轧辊 50 进行轧制。如下所述那样对该负极板材 40 进行轧制：一边利用轧辊 50 对第一负极区域 A 和第二负极区域 B 同时进行轧制，一边使轧制后的负极活性物质 42 的厚度成为规定厚度 d3（图 6B）。由此，负极活性物质 42 的厚度相对较大的第一负极区域 A 的负极活性物质密度相对提高，负极活性物质 42 的厚度相对较小的第二负极区域 B 的负极活性物质密度相对降低。

[0055] 然后，利用切断装置在切断位置 D 对轧制后的负极板材 40 进行切断。更具体而言，将负极板材 40 切断成切断后的搬运方向 C 的长度成为负极板 22 的宽度方向的长度 W。通过像这样依次对负极板材 40 进行切断，能得到多个以下的负极板 22：卷绕方向的长度为 L、宽度方向的长度为 W、厚度为 d3，且第二负极部 22b 的负极活性物质密度比第一负极部 22a 的负极活性物质密度要低。

[0056] 负极板 22 的第一负极部 22a 的负极活性物质密度能通过变更负极板材 40 的第一负极区域 A 的轧制之前的厚度 d1 与轧制之后的厚度 d3 的比率来进行调节。同样，负极板 22 的第二负极部 22b 的负极活性物质密度能通过变更负极板材 40 的第二负极区域 B 的轧制之前的厚度 d2 与轧制之后的厚度 d3 的比率来进行调节。

[0057] ＜其他实施例、变形例＞

[0058] 例如，上述实施例中，对负极板 22 由第一负极部 22a 及第二负极部 22b 以相同的厚度 d3 形成的示例进行了说明，但本发明并不限于这样的方式。即，对于本发明所涉及的负极板 22，只要第二负极部 22b 的负极活性物质密度低于第一负极部 22a 的负极活性物质密度，第一负极部 22a 的厚度也可以与第二负极部 22b 的厚度不同。此外，第一负极部 22a 的厚度及第二负极部 22b 的厚度不一定必须是均匀的，也可以局部存在厚度不同的部分。

[0059] 图 7 是图示本发明所涉及的负极板 22 的变形例的主视剖视图。

[0060] 在该变形例的负极板 22 中，除了第二负极部 22b 的负极活性物质密度比第一负极部 22a 的负极活性物质密度要低以外，进一步使第二负极部 22b 的厚度 d4 比第一负极部 22a 的厚度 d5 要小。由此，通过减小第二负极部 22b 的厚度 d4，能提高外壳 10 中的电极体 20 的体积效率，因此，能实现更高容量的镍氢充电电池 1。

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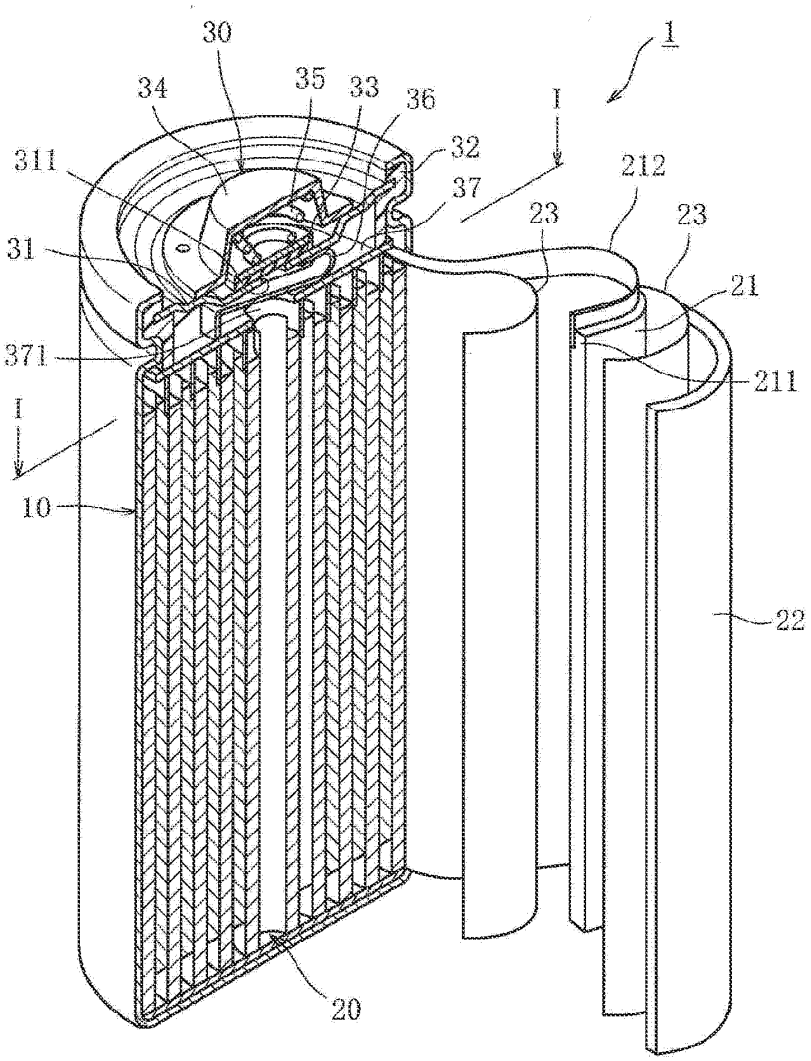


图 1

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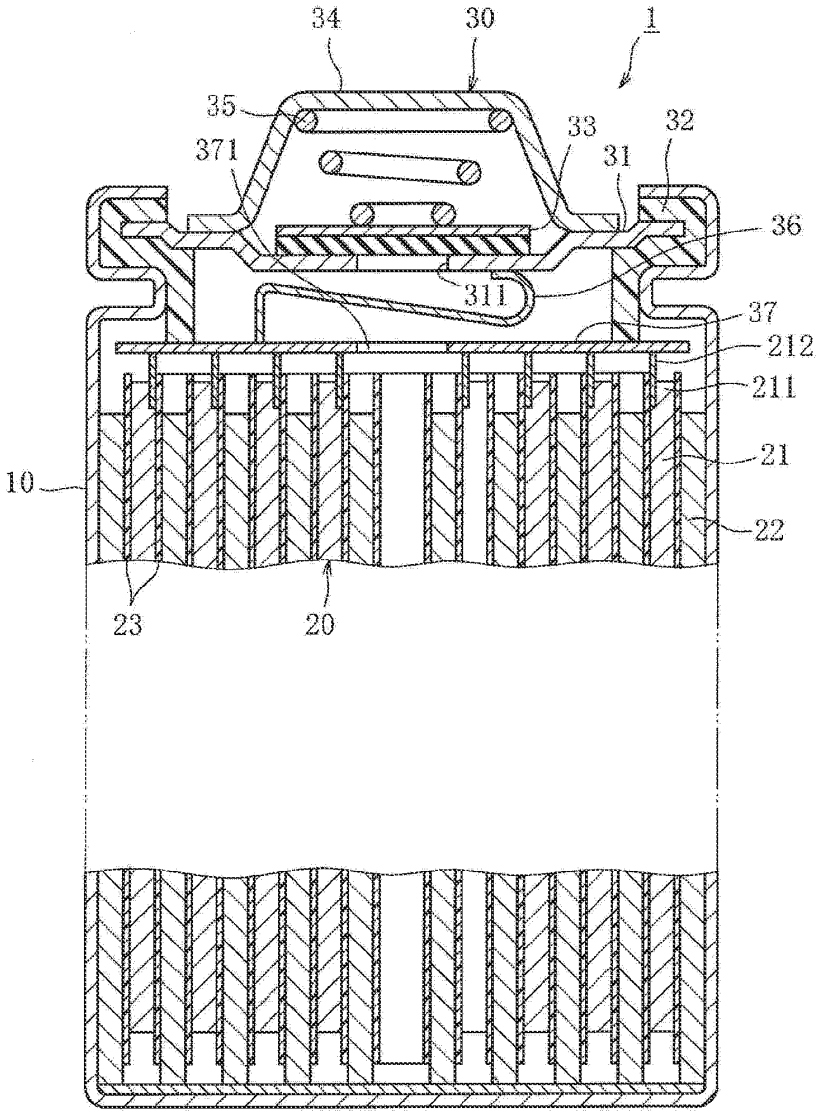


图 2

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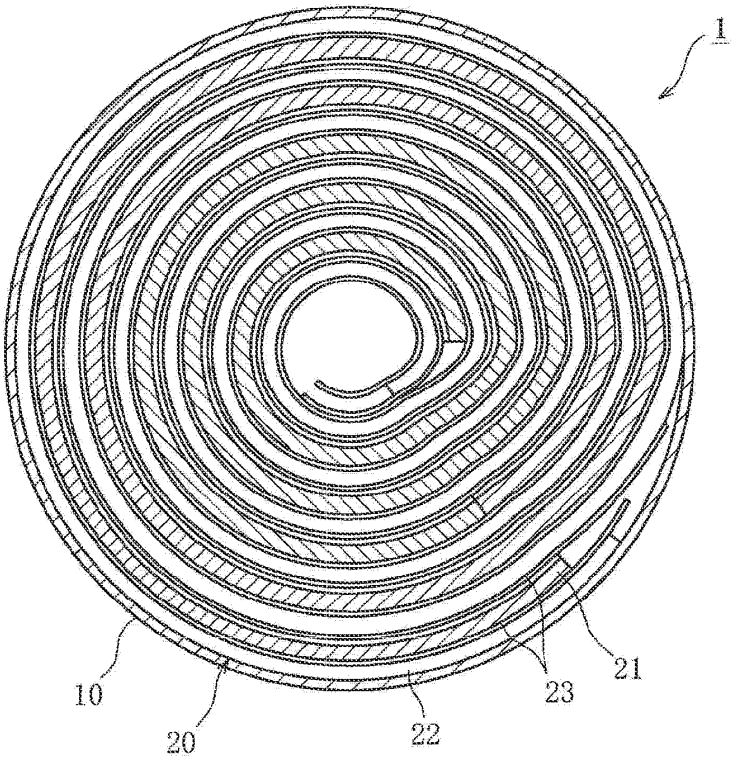


图 3

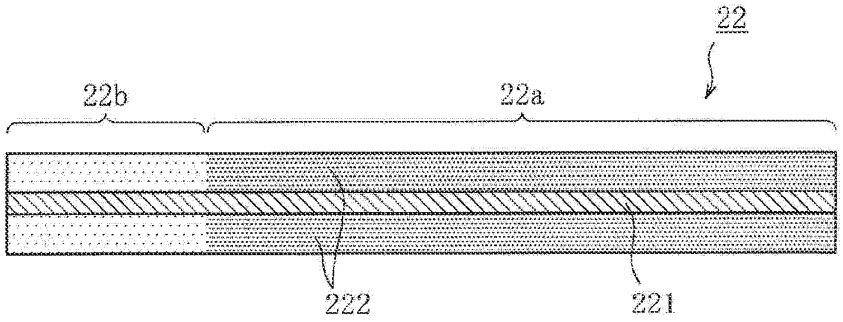


图 4

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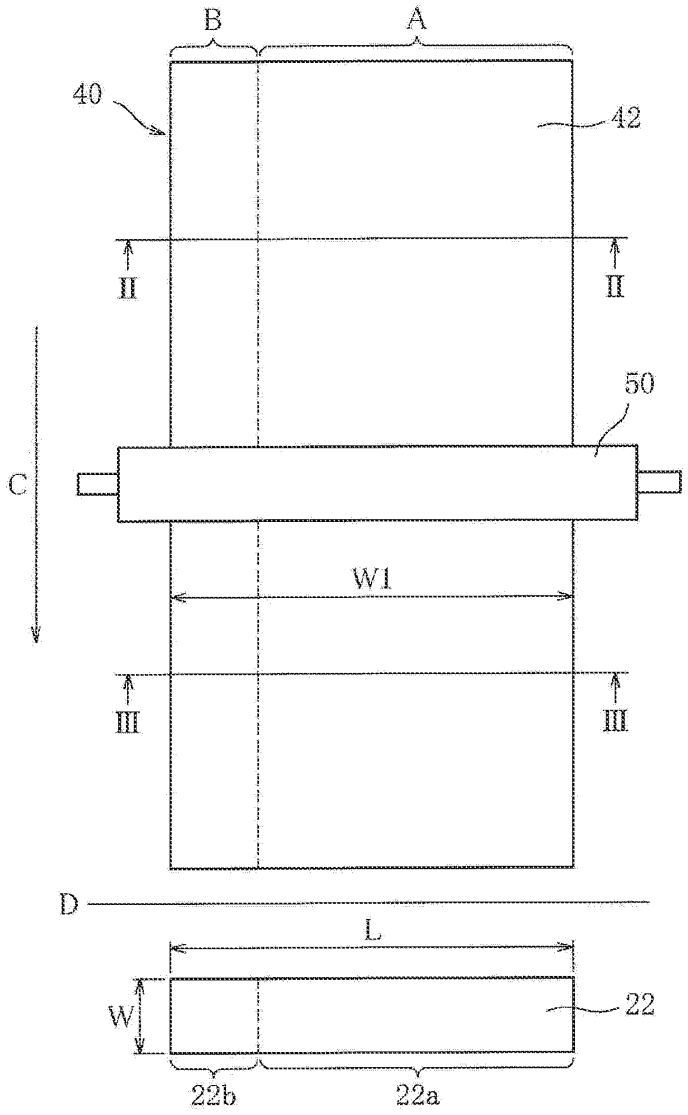


图 5

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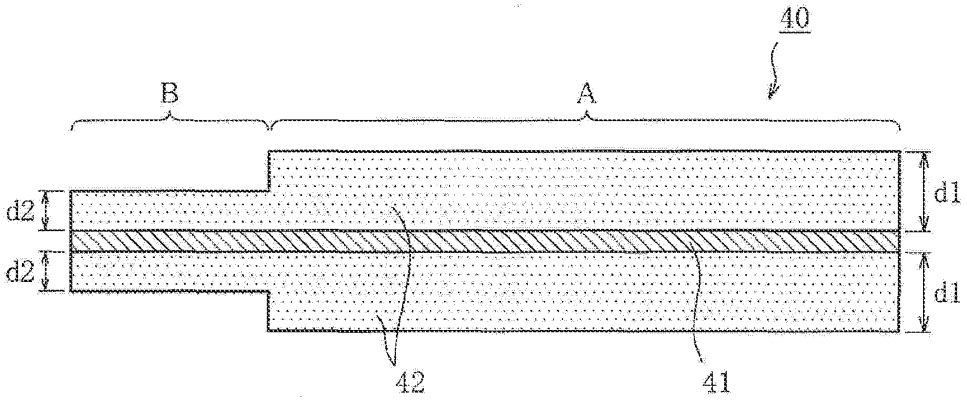


图 6A

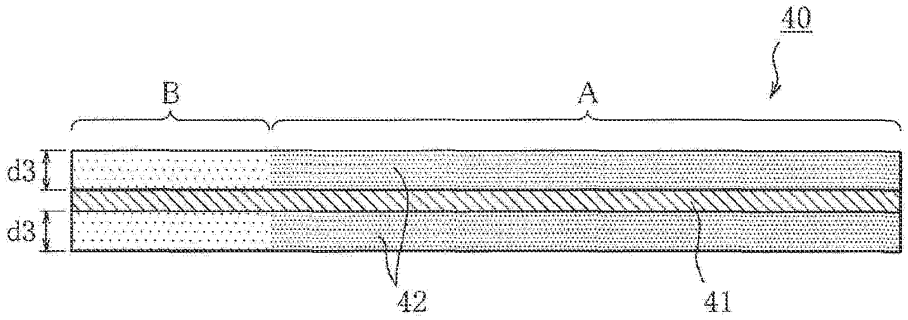


图 6B

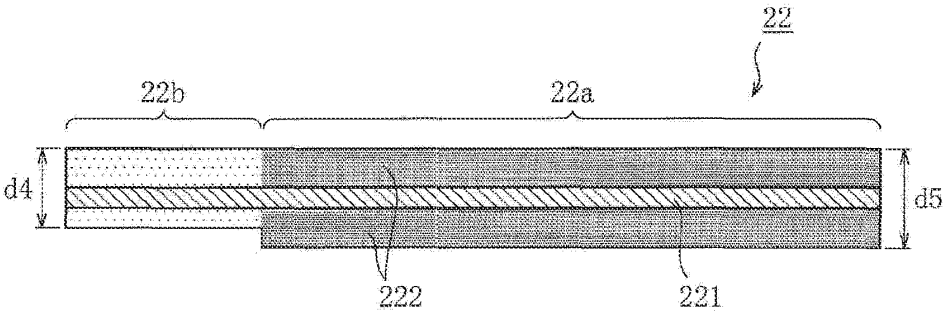


图 7

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Espacenet

Bibliographic data: CN110010902 (A) — 2019-07-12

Electrode pole piece and electrochemical device comprising same

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Applicant(s): NINGDE AMPEREX TECHNOLOGY LTD ± (宁德新能源科技有限公司)

Classification: - international: ***H01M10/0525; H01M4/66; H01M4/70***
- cooperative: **H01M10/052 (US)**; **H01M10/0525 (EP, CN)**; **H01M4/0404 (US)**; **H01M4/1393 (EP, US)**; **H01M4/366 (US)**; **H01M4/386 (EP)**; **H01M4/525 (EP)**; **H01M4/5825 (EP)**; **H01M4/587 (EP)**; **H01M4/66 (CN)**; **H01M4/667 (CN)**; **H01M4/70 (CN)**; H01M2004/021 (EP); H01M2004/027 (EP); H01M2004/028 (EP); Y02E60/10 (EP)

Application number: CN201910253064 20190329 Global Dossier

Priority number(s): CN201910253064 20190329

Also published as: US2020313171 (A1)

Abstract of CN110010902 (A)

The invention relates to an electrode pole piece and an electrochemical device comprising the same. The positive pole piece comprises a positive first region and a positive second region, and the unitarea capacity CsA2 of the positive second region is larger than or equal to the unit area capacity CsA1 of the positive first region. The negative pole piece comprises a negative first region and a negative second region, wherein the unit area capacity CsC2 of the negative second region is smaller than or equal to 98% of the unit area capacity CsC1 of the negative first region. When the positivepole piece and/or the negative pole piece are/or applied to the electrochemical device, the formation of the lithium dendrites can be effectively reduced, and the safety of the electrochemical devicecan be improved.

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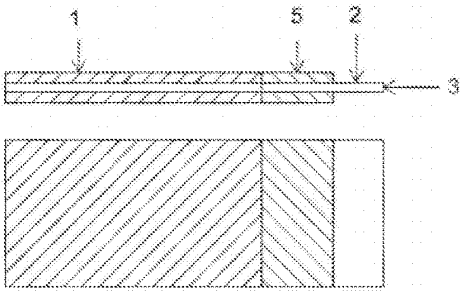
权利要求书2页 说明书17页 附图1页

(54)发明名称

电极极片和包含所述电极极片的电化学装置

(57)摘要

本申请涉及电极极片和包含所述电极极片的电化学装置。本申请所述的阳极极片包括阳极第一区和阳极第二区，其中所述阳极第二区的单位面积容量C_{SA2}大于或等于所述阳极第一区的单位面积容量C_{SA1}。本申请所述的阴极极片包括阴极第一区和阴极第二区，其中所述阴极第二区的单位面积容量C_{SC2}小于或等于所述阴极第一区的单位面积容量C_{SC1}的98%。当将本申请所述的阳极极片和/或阴极极片应用于电化学装置时，能够有效地降低锂枝晶的形成，改善电化学装置的安全性。



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1.一种阳极极片,其包括阳极第一区和阳极第二区,

其中所述阳极第二区的单位面积容量C_{SA2}大于或等于所述阳极第一区的单位面积容量C_{SA1}。

2.根据权利要求1所述的阳极极片,其中所述阳极第一区包括所述阳极极片的主体区,所述阳极第二区包括所述阳极极片的边缘区。

3.根据权利要求1所述的阳极极片,其中所述阳极第二区的阳极极片的厚度小于所述阳极第一区的阳极极片的厚度。

4.根据权利要求1所述的阳极极片,其中所述阳极第一区和所述阳极第二区分别包括不同的阳极活性物质。

5.根据权利要求1所述的阳极极片,其中

所述阳极第一区的阳极活性物质的理论比容量小于所述阳极第二区的阳极活性物质的理论比容量。

6.根据权利要求1所述的阳极极片,其还包括阳极第三区,

其中所述阳极第一区包括陶瓷。

7.根据权利要求1所述的阳极极片,其还包括阳极第四区,

其中所述阳极第四区的单位面积容量C_{SA4}大于或等于所述阳极第二区的单位面积容量C_{SA2}。

8.一种阴极极片,其包括阴极第一区和阴极第二区,

其中所述阴极第二区的单位面积容量C_{SC2}小于或等于所述阴极第一区的单位面积容量C_{SC1}的98%。

9.根据权利要求8所述的阴极极片,其中所述阴极第一区包括所述阴极极片的主体区,而所述阴极第二区包括所述阴极极片的边缘区。

10.根据权利要求8所述的阴极极片,其中所述阴极第二区的阴极极片的厚度小于所述阴极第一区的阴极极片的厚度。

11.根据权利要求8所述的阴极极片,其中所述阴极第一区和所述阴极第二区分别包括不同的阴极活性物质。

12.根据权利要求8所述的阴极极片,其中所述阴极第一区包括三元材料和/或钴酸锂,而所述阴极第二区包括磷酸铁锂。

13.根据权利要求8所述的阴极极片,其中

所述阴极第一区的阴极活性物质的理论比容量大于所述阴极第二区的阴极活性物质的理论比容量。

14.根据权利要求8所述的阴极极片,其还包括阴极第三区,

其中所述阴极第三区包括陶瓷。

15.根据权利要求8所述的阴极极片,其还包括阴极第四区,

其中所述阴极第四区的单位面积容量C_{SC4}小于或等于所述阴极第二区的单位面积容量C_{SC2}。

16.一种电芯,其包括:

阴极极片,所述阴极极片包括阴极第一区和阴极第二区;

阳极极片,所述阳极极片包括阳极第一区和阳极第二区;

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其中第一区的数值CB_1为所述阳极第一区的单位面积容量C_{SA1}与所述阴极第一区的单位面积容量C_{SC1}的比值，

其中第二区的数值CB_2为所述阳极第二区的单位面积容量C_{SA2}与所述阴极第二区的单位面积容量C_{SC2}的比值，且

其中$CB_2 \geq CB_1$。

17.根据权利要求16所述的电芯，其中所述阳极极片为权利要求1-5中的任一者所述阳极极片和/或所述阴极极片为权利要求8-13中的任一者所述的阴极极片。

18.根据权利要求16所述的电芯，其中所述阳极极片还包括阳极第三区和/或阳极第四区，

其中所述阳极第三区包括陶瓷，

其中所述阳极第四区的单位面积容量C_{SA4}大于或等于所述阳极第二区的单位面积容量C_{SA2}。

19.根据权利要求16所述的电芯，其中所述阴极极片还包括阴极第三区和/或阴极第四区，

其中所述阴极第三区包括陶瓷，

其中所述阴极第四区的单位面积容量C_{SC4}小于或等于所述阴极第二区的单位面积容量C_{SC2}。

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电极极片和包含所述电极极片的电化学装置

技术领域

[0001] 本申请涉及储能技术领域，尤其涉及电极极片和包含所述电极极片的电化学装置。

背景技术

[0002] 随着消费电子类的产品如笔记本电脑、手机、掌上游戏机、平板电脑、移动电源和无人机等的普及，人们对其中的电化学装置(例如，电池)的要求越来越严格。例如，人们不仅要求电池轻便，而且还要求电池拥有高容量和长的工作寿命。在众多的电池中，锂离子电池凭借其具有能量密度高、安全性高、自放电低、无记忆效应、工作寿命长等突出优点已经在市场上占据主流地位。

[0003] 然而，到目前为止，电化学装置的安全性仍无法得到有效的保障。例如，当锂离子电池经过长期的充放电循环后，锂离子电池的电极极片，尤其是阳极极片的表面上会析出锂而形成锂枝晶。锂枝晶的形成很大程度上会戳破阳极极片和阴极极片之间的隔离膜，导致阴极极片和阳极极片直接接触而发生电化学短路，从而大大降低电芯的安全性。因此，提高电化学装置的安全性是本领域重要的研究课题。

发明内容

[0004] 本申请提供一种电极极片以及包含所述电极极片的电芯和电化学装置以试图在至少某种程度上解决至少一个存在于相关领域中的问题。

[0005] 在一个实施例中，本申请提供了一种阳极极片，其包括阳极第一区和阳极第二区，所述阳极第二区的单位面积容量C_{SA2}大于或等于所述阳极第一区的单位面积容量C_{SA1}。

[0006] 在一些实施例中，所述阳极第一区包括所述阳极极片的主体区，所述阳极第二区包括所述阳极极片的边缘区。

[0007] 在一些实施例中，所述阳极第二区的阳极极片的厚度小于所述阳极第一区的阳极极片的厚度。

[0008] 在一些实施例中，所述阳极第一区和所述阳极第二区分别包括不同的阳极活性物质。

[0009] 在一些实施例中，所述阳极第一区的阳极活性物质的理论比容量小于所述阳极第二区的阳极活性物质的理论比容量。

[0010] 在一些实施例中，所述阳极极片还包括阳极第三区，所述阳极第三区包括陶瓷。

[0011] 在一些实施例中，所述阳极极片还包括阳极第四区，所述阳极第四区的单位面积容量C_{SA4}大于或等于所述阳极第二区的单位面积容量C_{SA2}。

[0012] 在一些实施例中，所述阳极第四区的阳极极片的厚度小于或等于所述阳极第二区的阳极极片的厚度。

[0013] 在一个实施例中，本申请提供了一种阴极极片，其包括阴极第一区和阴极第二区，所述阴极第二区的单位面积容量C_{SC2}小于或等于所述阴极第一区的单位面积容量C_{SC1}的

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98%。

[0014] 在一些实施例中，所述阴极第一区包括所述阴极极片的主体区，所述阴极第二区包括所述阴极极片的边缘区。

[0015] 在一些实施例中，所述阴极第二区的阴极极片的厚度小于所述阴极第一区的阴极极片的厚度。

[0016] 在一些实施例中，所述阴极第一区和所述阴极第二区分别包括不同的阴极活性物质。

[0017] 在一些实施例中，所述阴极第一区包括三元材料和/或钴酸锂，而所述阴极第二区包括磷酸铁锂。

[0018] 在一些实施例中，所述阴极第一区的阴极活性物质的理论比容量大于所述阴极第二区的阴极活性物质的理论比容量。

[0019] 在一些实施例中，所述阴极极片还包括阴极第三区，所述阴极第三区包括陶瓷。

[0020] 在一些实施例中，所述阴极极片还包括阴极第四区，所述阴极第四区的单位面积容量C_{SC4}小于或等于所述阴极第二区的单位面积容量C_{SC2}。

[0021] 在一些实施例中，所述阴极第四区的阴极极片的厚度小于或等于所述阴极第二区的阴极极片的厚度。

[0022] 在一个实施例中，本申请提供了一种电芯，其包括：阴极极片，所述阴极极片包括阴极第一区和阴极第二区；阳极极片，所述阳极极片包括阳极第一区和阳极第二区；第一区的数值CB_1为所述阳极第一区的单位面积容量C_{SA1}与所述阴极第一区的单位面积容量C_{SC1}的比值，其中第二区的数值CB_2为所述阳极第二区的单位面积容量C_{SA2}与所述阴极第二区的单位面积容量C_{SC2}的比值，且其中$CB_2 \geq CB_1$。

[0023] 在一些实施例中，所述电芯中的所述阳极极片为上述实施例所述的阳极极片。

[0024] 在一些实施例中，所述电芯中的所述阴极极片为上述实施例所述的阴极极片。

[0025] 在一些实施例中，所述电芯中的所述阳极极片还包括上述实施例所述的阳极第三区和/或阳极第四区，所述阳极第一区包括陶瓷，所述阳极第四区的单位面积容量C_{SA4}大于或等于所述阳极第二区的单位面积容量C_{SA2}。

[0026] 在一些实施例中，所述电芯中的所述阴极极片还包括上述实施例所述的阴极第三区和/或阴极第四区，所述阴极第三区包括陶瓷，所述阴极第四区的单位面积容量C_{SC4}小于或等于所述阴极第二区的单位面积容量C_{SC2}。

[0027] 本申请通过在所述电芯的极片不同区进行不同单位面积容量设置，改善了所述电芯的极片不同区域锂沉积不均匀的问题，降低了锂枝晶形成的概率、及发生电化学短路的可能性，从而大大提高电芯的安全性。本申请实施例的额外层面及优点将部分地在后续说明中描述、显示、或是经由本申请实施例的实施而阐释。

附图说明

[0028] 在下文中将简要地说明为了描述本申请实施例或现有技术所必要的附图以便于描述本申请的实施例。显而易见地，下文描述中的附图仅只是本申请中的部分实施例。对本领域技术人员而言，在不需要创造性劳动的前提下，依然可以根据这些附图中所例示的结构来获得其他实施例的附图。

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[0029] 图1示出了现有技术中的常见的电极极片的结构；

[0030] 图2示出了本申请的一些实施例中的经分区的电极极片的结构示意图。

[0031] 针对图1和2中的附图标记指代的含义，本申请说明如下：

[0032] 附图标记1指示主体区；

[0033] 附图标记2指示空箔区；

[0034] 附图标记3指示基材；

[0035] 附图标记4指示边缘薄区；

[0036] 附图标记5指示边缘区。

具体实施方式

[0037] 本申请的实施例将会被详细的描示在下文中。在本申请说明书全文中，将相同或相似的组件以及具有相同或相似的功能的组件通过类似附图标记来表示。在此所描述的有关附图的实施例为说明性质的、图解性质的且用于提供对本申请的基本理解。本申请的实施例不应该被解释为对本申请的限制。

[0038] 如本文中所使用，术语“大致”、“大体”、“大体上”、“实质”及“约”用以描述及说明小的变化。当与事件或情形结合使用时，所述术语可指代其中事件或情形精确发生的例子以及其中事件或情形极近似地发生的例子。举例来说，当结合数值使用时，术语可指代小于或等于所述数值的±10％的变化范围，例如小于或等于±5％、小于或等于±4％、小于或等于±3％、小于或等于±2％、小于或等于±1％、小于或等于±0.5％、小于或等于±0.1％、或小于或等于±0.05％。举例来说，如果两个数值之间的差值小于或等于所述值的平均值的±10％(例如小于或等于±5％、小于或等于±4％、小于或等于±3％、小于或等于±2％、小于或等于±1％、小于或等于±0.5％、小于或等于±0.1％、或小于或等于±0.05％)，那么可认为所述两个数值“大体上”相同。

[0039] 另外，有时在本文中以范围格式呈现量、比率和其它数值。应理解，此类范围格式是用于便利及简洁起见，且应灵活地理解，不仅包含明确地指定为范围限制的数值，而且包含涵盖于所述范围内的所有个别数值或子范围，如同明确地指定每一数值及子范围一般。

[0040] 术语“主体区”为涂敷主要的电极活性物质的区域或者涂敷电极活性物质的主要区域。例如，在本申请的一些实施例中，在电极极片的不同区域中分别涂敷不同的电极活性物质A和B，其中电极活性物质A为主要的电极活性物质，那么涂敷活性物质A的区域为主体区。再例如，在本申请的一些实施例中，在电极极片的不同区域C和D中涂敷相同的电极活性物质，其中区域C的面积大，那么区域C为主体区。

[0041] 术语“边缘区”为距离主体区边缘几毫米到几十毫米(例如约3mm至约40mm)的区域。在本申请的一些实施例中，边缘区可以，但不限制为，距离主体区边缘约30mm的区域、距离主体区边缘约20mm的区域、距离主体区边缘约10mm的区域、或者距离主体区边缘约5mm的区域。

[0042] 以锂离子电池为例，目前应用于锂离子电池的电极极片有多种结构类别，例如多极耳卷绕结构(MTW)、全极耳卷绕结构(FTW)、和叠片结构(Stack)等。通常，锂离子电池的电极极片包括基材(也称，集流体)和位于基材的至少一个表面上的电极活性物质，其中大多数的基材为金属材料以起到传递电子的作用，而电极活性物质则能够将化学能转化成电

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能。

[0043] 图1示出了现有技术中的常见的电极极片的结构。如图1所示，在制备电极极片的过程中，现有技术通常会将极片分为主体区1(也称，活性物质区)、边缘薄区4、和空箔区2(也称，极耳区)，其中主体区1和边缘薄区4表面涂覆有相同的电极活性物质，但边缘薄区4的电极活性物质厚度一般小于主体区1的电极活性物质的厚度，空箔区为距离基材3边缘几毫米至十几毫米的区域而不涂敷任何电极活性物质以用于附接极耳，或空箔区本身作为极耳。

[0044] 针对电极极片中的活性物质区，现有技术通常是不分区的。当将电极活性物质涂敷至活性物质区时，由于大多数的浆料呈现液体状态而具有流动性，这就导致相较于活性物质区，空箔区的电极活性物质较少且因此极片厚度较薄而形成边缘薄区4。

[0045] 对于阳极极片(也称，负极极片)而言，和活性物质区(也称，主体区)相比，当单位面积的阴极极片(也称，正极极片)释放相同数量的锂离子时，单位面积的阳极薄区的活性物质由于含有较少的活性物质而无法如主体区那样完全接收这些锂离子，由此会导致过量的锂离子“囤积”在阳极薄区的表面。在这种情形下，这些锂离子会在阳极薄区的表面上沉积形成锂枝晶。此外，由于边缘薄区4的厚度小于主体区1的厚度，这会导致阳极极片和阴极极片的边缘薄区难以形成紧密贴合，从而导致锂离子在阳极薄区的表面发生不均匀的沉积而形成锂枝晶。锂枝晶的形成很大程度上会戳破隔离膜，导致阴极极片和阳极极片直接接触而发生电化学短路，从而大大降低电芯的安全性。

[0046] 至少为了克服上述缺陷，本申请提出了经分区的阳极极片、经分区的阴极极片以及包含它们中的至少一者的电芯。其中通过将阳极极片和/或阴极极片分成多个区域并进行差异涂布，可以减轻电化学装置在充放电过程中的析锂程度，从而提高电化学装置的安全性。

[0047] 图2示出了本申请的其中一些实施例中的经分区的电极极片的结构示意图。如图2所示，在本申请的一些实施例中，所述电极极片包括基材3和在所述基材的至少一个表面上涂敷的电极活性物质，其中所述电极极片包括第一区(例如，主体区1)和第二区(例如，边缘区5)，且其中通过调整所述第一区和所述第二区的单位面积容量来实现上述目的。需要说明的是，图2仅是为了便于本领域技术人员更好地理解本申请所述的技术方案而绘制的电极极片的结构示意图，而本申请所述的电极极片并非在任何细节上均与图2所示相同。例如，图2中的边缘区5的厚度看起来与主体区1的厚度相同，而本申请所述的电极极片的边缘区5与主体区1的厚度可以相同也可以不同。

[0048] 一、阳极极片

[0049] 本申请的一个实施例提出了一种阳极极片，所述阳极极片包括阳极第一区和阳极第二区，其中所述阳极第二区的单位面积容量C_{SA2}大于或等于所述阳极第一区的单位面积容量C_{SA1}。在一些实施例中，所述阳极第一区包括所述阳极极片的主体区，而所述阳极第二区包括所述阳极极片的边缘区。在一些实施例中，所述阳极第二区的阳极极片的厚度小于所述阳极第一区的阳极极片的厚度。

[0050] 通过调整阳极极片薄区的单位面积容量以使其大于或等于阳极极片主体区的单位面积容量，阳极极片薄区能够具有至少与阳极极片主体区一样，甚至更强的“吸收”锂离子的能力。因此，当单位面积的阴极极片释放相同数量的锂离子时，单位面积的阳极薄区的

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活性物质能够如同主体区那样接收这些锂离子，而不会出现“过量锂离子囤积”的现象。据此，锂枝晶在阳极极片薄区表面形成的概率会大大降低，从而提高了电芯的安全性。

[0051] 在本申请的一些实施例中，所述阳极极片包括阳极基材(也称，阳极集流体)和位于阳极基材的至少一个表面上的阳极活性物质。在一些实施例中，所述阳极基材可为，但不限于，铜箔或镍箔。

[0052] 锂离子电池的阳极活性物质包括能够吸收和释放锂(Li)的阳极材料(下文中，有时称为“能够吸收/释放锂(Li)的阳极材料”)。能够吸收/释放锂(Li)的阳极材料可以包括但不限于：碳材料、金属化合物、氧化物、硫化物、锂的氮化物(例如LiN_3)、锂金属、与锂一起形成合金的金属和聚合物材料。

[0053] 碳材料可以包括但不限于：低石墨化的碳、易石墨化的碳、人造石墨、天然石墨、中间相碳微球、软碳、硬碳、热解碳、焦炭、玻璃碳、有机聚合物化合物烧结体、碳纤维和活性碳。其中，焦炭可以包括沥青焦炭、针状焦炭和石油焦炭。有机聚合物化合物烧结体指的是通过在适当的温度下煅烧聚合物材料(例如，苯酚塑料或者呋喃树脂)以使之碳化获得的材料，这些材料可以分为低石墨化碳或者易石墨化的碳。聚合物材料可以包括但不限于聚乙炔和聚吡咯。

[0054] 在能够吸收/释放锂(Li)的这些阳极材料中，更进一步地，选择充电和放电电压接近于锂金属的充电和放电电压的材料。这是因为阳极材料的充电和放电电压越低，锂离子电池越容易具有更高的能量密度。其中，阳极材料可以选择碳材料，因为在充电和放电时它们的晶体结构只有小的变化，因此，可以获得良好的循环特性以及大的充电和放电容量。尤其可以选择石墨，因为它可以给出大的电化学当量和高的能量密度。

[0055] 此外，能够吸收/释放锂(Li)的阳极材料可以包括单质锂金属、能够和锂(Li)一起形成合金的金属元素和半金属元素，包括这样的元素的合金和化合物等等。特别地，将它们和碳材料一起使用，因为在这种情况中，可以获得良好的循环特性以及高能量密度。除了包括两种或者多种金属元素的合金之外，这里使用的合金还包括包含一种或者多种金属元素和一种或者多种半金属元素的合金。所述合金可以处于以下状态固溶体、共晶晶体(共晶混合物)、金属间化合物及其混合物。

[0056] 金属元素和半金属元素的例子可以包括锡(Sn)、铅(Pb)、铝(Al)、铟(In)、硅(Si)、锌(Zn)、锑(Sb)、铋(Bi)、镉(Cd)、镁(Mg)、硼(B)、镓(Ga)、锗(Ge)、砷(As)、银(Ag)、锆(Zr)、钇(Y)和铪(Hf)。上述合金和化合物的例子可以包括具有化学式：$Ma_sMb_tLi_u$的材料和具有化学式：$Ma_pMc_qMd_r$的材料。在这些化学式中，Ma表示能够与锂一起形成合金的金属元素和半金属元素中的至少一种元素；Mb表示除锂和Ma之外的金属元素和半金属元素中的至少一种元素；Mc表示非金属元素中的至少一种元素；Md表示除Ma之外的金属元素和半金属元素中的至少一种元素；并且s、t、u、p、q和r满足$s>0$、$t\geq 0$、$u\geq 0$、$p>0$、$q>0$和$r\geq 0$。

[0057] 此外，可以在阳极中使用不包括锂(Li)的无机化合物，例如MnO_2、V_2O_5、V_6O_{13}、NiS和MoS。

[0058] 表1列举了一些锂离子电池的阳极材料及其比容量，其中可以基于这些阳极材料的比容量而选择相应的阳极活性物质将其涂敷于阳极第一区或阳极第二区。在本申请的一些实施例中，可以选择以下阳极活性物质中的一种，也可以选择以下阳极活性物质中的多种的混合物涂敷至阳极第一区。在本申请的一些实施例中，可以选择以下阳极活性物质中

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的一种，也可以选择以下阳极活性物质中的多种的混合物涂敷至阳极第二区。然而，应理解，表1只是示例性的列举了其中一些阳极材料，而本申请的实现并不仅限于所列举的阳极材料。此外，表1给出的比容量为阳极活性物质的实际能够实现的比容量，其中对阳极活性物质进行改性会使得比容量值发生小幅度的变化。

[0059] 表1

[0060]

阳极活性物质	本文缩写	比容量(mAh/g)	平均电压(vs Li/Li+)
石墨	Gr	370	0.1
石墨烯纳米片	GNS	740	0.1
软碳-250	SC-250	250	0.5
软碳-400	SC-400	400	0.5
硬碳	HC	450	0.5
SiOx-420(0≤x≤2)	SiOx-420	420	0.2
SiOx-1000(0≤x≤2)	SiOx-1000	1000	0.4
Si-C-450	SiC-450	450	0.2
Si-C-1000	SiC-1000	1000	0.4
Si-C-2000	SiC-2000	2000	0.4
$Li_4Ti_5O_{12}$	LTO	160	1.56
Li metal	Li	3860	0
Sn	Sn	980	0.4
Ge	Ge	960	0.4
SnO_2	SnO_2	780	0.4
TiO_2	TiO_2	360	1.5
Fe_2O_3	Fe_2O_3	1000	0.7
MoS_2	MoS_2	910	0.7

[0061] 在本申请的一些实施例中，所述阳极第一区和所述阳极第二区可以分别包括不同的阳极活性物质。在本申请的一些实施例中，所述阳极第一区的阳极活性物质的理论比容量小于所述阳极第二区的阳极活性物质的理论比容量。

[0062] 在本申请的一些实施例中，所述阳极极片还包括阳极第三区，其中阳极第三区安置于基材的边缘处而起到绝缘的作用以防止阴阳两极之间的短路。在一些实施例中，所述阳极第三区包括陶瓷，其中所述陶瓷的单位面积容量为0。

[0063] 在本申请的一些实施例中，所述阳极极片还包括阳极第四区，其中所述阳极第四区的单位面积容量C_{SA4}大于或等于所述阳极第二区的单位面积容量C_{SA2}。在本申请的一些实施例中，所述阳极第四区的阳极极片的厚度小于或等于所述阳极第二区的阳极极片的厚度。在本申请的一些实施例中，所述阳极第四区经布置以与阳极第二区相邻但远离阳极第一区。其中阳极第四区的设置原理与阳极第二区的设置原理类似，均是为了补偿薄区的面积比容量以提高薄区的嵌锂能力。

[0064] 在本申请的一些实施例中，所述阳极第一区包括阳极主体区，所述阳极第二区包括阳极边缘1区，而所述阳极第三区包括阳极边缘2区，其中所述阳极边缘2区与所述阳极边缘1区相邻但远离所述阳极主体区。

[0065] 在本申请的一些实施例中，所述阳极第四区可以包括与阳极第一区和阳极第二区均不同的阳极活性物质，也可以包括仅与阳极第一区不同但与阳极第二区相同的阳极活性

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物质。

[0066] 二、阴极极片

[0067] 本申请的一个实施例提出了一种阴极极片，所述阴极极片包括阴极第一区和阴极第二区，其中所述阴极第二区的单位面积容量C_{SC2}小于或等于所述阴极第一区的单位面积容量C_{SC1}的约98%。在一些实施例中，所述阴极第一区包括所述阴极极片的主体区，而所述阴极第二区包括所述阴极极片的边缘区。在一些实施例中，所述阴极第二区的阴极极片的厚度小于所述阴极第一区的阴极极片的厚度。

[0068] 通过调整阴极极片薄区的单位面积容量以使其小于或等于阴极极片主体区的单位面积容量的约98%，相较于单位面积的阴极极片主体区，单位面积的阴极极片薄区能够释放较少的锂离子。因此，单位面积的阳极薄区的活性物质只需要"负担"这些较少的锂离子即可，而不需要如同阳极主体区那样需要"负担"很多的锂离子。因此，阳极薄区不会出现"过量锂离子囤积"的现象。据此，锂枝晶在阳极极片薄区表面形成的概率会大大降低，从而提高了电芯的安全性。

[0069] 在本申请的一些实施例中，所述阴极第二区的单位面积容量C_{SC2}小于或等于所述阴极第一区的单位面积容量C_{SC1}的约95%、约90%、约85%、约80%、约75%、约70%、约65%、约60%、约55%或者约50%。

[0070] 在本申请的一些实施例中，所述阴极极片包括阴极基材(也称，阴极集流体)和位于阴极基材的至少一个表面上的阴极活性物质。在一些实施例中，所述阴极基材可为，但不限于，铝箔或镍箔。

[0071] 锂离子电池的阴极活性物质包括能够吸收和释放锂(Li)的阴极材料(下文中，有时称为"能够吸收/释放锂Li的阴极材料")。能够吸收/释放锂(Li)的阴极材料的实例可以包括但不限于：钴酸锂、三元材料、锰酸锂、磷酸锰铁锂、磷酸钒锂、磷酸钒氧锂、磷酸铁锂、钛酸锂和含锂锰基材料。

[0072] 在上述阴极材料中，钴酸锂的化学式可以，但不限制为，$Li_xCo_aM1_bO_{2-c}H_d$，其中M1选自由镍(Ni)、锰(Mn)、镁(Mg)、铝(Al)、硼(B)、钛(Ti)、钒(V)、铬(Cr)、铁(Fe)、铜(Cu)、锌(Zn)、钼(Mo)、锡(Sn)、钙(Ca)、锶(Sr)、钨(W)、钇(Y)、镧(La)、锆(Zr)、硅(Si)及其组合组成的群组，其中H选自由氟(F)、硫(S)、硼(B)、氮(N)或磷(P)及其组合组成的群组，其中x、a、b、c和d值分别在以下范围内：$0.8\leq x\leq 1.2$、$0.8\leq a\leq 1$、$0\leq b\leq 0.2$、$-0.1\leq c\leq 0.2$、$0\leq d\leq 0.2$。

[0073] 在上述阴极材料中，三元材料指的是含有锂元素、除了锂元素以外的三种不同的金属元素和氧元素组成的能够可逆地嵌入和脱出锂离子的材料。在一些实施例中，三元材料的化学式可以为$Li_yM2_eM3_fM4_gO_{2-h}$，其中，M2-M4选自由镍(Ni)、钴(Co)、锰(Mn)、镁(Mg)、铝(Al)、硼(B)、钛(Ti)、钒(V)、铬(Cr)、铁(Fe)、铜(Cu)、锌(Zn)、钼(Mo)、锡(Sn)、钙(Ca)、锶(Sr)、钨(W)、锆(Zr)、硅(Si)及其组合组成的群组，y、e、f、g和h值分别在以下范围内：$0.8\leq y\leq 1.2$、$0.3\leq e\leq 0.98$、$0.02\leq f\leq 0.7$、$0.02\leq g\leq 0.7$、$-0.1\leq h\leq 0.2$。在本申请的一些实施例中，所述三元材料包括镍钴锰酸锂和/或镍钴铝酸锂。

[0074] 在上述阴极材料中，锰酸锂的化学式为$Li_zMn_{2-p}M5_pO_{4-r}$，其中M5表示选自由钴(Co)、镍(Ni)、镁(Mg)、铝(Al)、硼(B)、钛(Ti)、钒(V)、铬(Cr)、铁(Fe)、铜(Cu)、锌(Zn)、钼(Mo)、锡(Sn)、钙(Ca)、锶(Sr)、钨(W)及其组合组成的群组，z、p和r值分别在以下范围内：$0.8\leq z\leq$

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1.2、0≤p<1.0和-0.2≤r≤0.2。

[0075] 表2列举了一些锂离子电池的阴极材料及其比容量，其中可以基于这些阴极材料的比容量而选择相应的阴极活性物质将其涂敷于阴极第一区或阴极第二区。在本申请的一些实施例中，可以选择以下阴极活性物质中的一种，也可以选择以下阴极活性物质中的多种的混合物涂敷至阴极第一区。在本申请的一些实施例中，可以选择以下阴极活性物质中的一种，也可以选择以下阴极活性物质中的多种的混合物涂敷至阴极第二区。然而，应理解，表2只是示例性的列举了其中一些阴极材料，而本申请的实现并不仅限于所列举的阴极材料。此外，表2给出的比容量为阴极活性物质的实际能够实现的比容量，其中对阴极活性物质进行改性会使得比容量值发生小幅度的变化。

[0076] 表2

[0077]

阴极活性物质	缩写	比容量 (mAh/g)	平均电压 (vs Li/Li+)
$LiCoO_2$-140	LCO-140	140	3.8
$LiCoO_2$-180	LCO-180	180	4.3
$LiCoO_2$-220	LCO-220	220	4.3
$LiMn_2O_4$	LMO	130	4.05
$LiFePO_4$	LFP	160	3.4
$LiCoPO_4$	LCP	130	4.8

[0078]

$LiNiO_2$	LNO	200	3.7
$LiNi_{0.33}Mn_{0.33}Co_{0.33}O_2$	NCM333	160	3.7
$LiNi_{0.5}Mn_{0.2}Co_{0.3}O_2$	NCM523	180	3.7
$LiNi_{0.6}Mn_{0.2}Co_{0.2}O_2$	NCM622	200	3.7
$LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$	NCM811	220	3.7
$yLi_2MnO_3(1-y)LiMO_2$(M=Ni,Co,Mn)-250(0≤y≤1)	Li-rich-250	250	3.75
$yLi_2MnO_3(1-y)LiMO_2$(M=Ni,Co,Mn)-280(0≤y≤1)	Li-rich-280	280	3.75
$yLi_2MnO_3(1-y)LiMO_2$(M=Ni,Co,Mn)-300(0≤y≤1)	Li-rich-300	300	3.75
$LiNi_{0.8}Co_{0.15}Al_{0.05}O_2$-180	NCA-180	180	3.7
$LiNi_{0.8}Co_{0.15}Al_{0.05}O_2$-200	NCA-200	200	3.7
$LiNi_{0.8}Co_{0.15}Al_{0.05}O_2$-220	NCA-220	220	3.7
$LiNi_{0.5}Mn_{1.5}O_4$	LNM	135	4.7
$Li_3V_2(PO_4)_3$	LVP	180	3.8

[0079] 在本申请的一些实施例中，所述阴极第一区和所述阴极第二区可以分别包括不同的阴极活性物质。在本申请的一些实施例中，所述阴极第一区包括三元材料和/或钴酸锂，而所述阴极第二区包括磷酸铁锂，其中三元材料和/或钴酸锂的单位面积比容量大于磷酸铁锂的单位面积比容量。

[0080] 在本申请的一些实施例中，所述阴极第一区的阴极活性物质的理论比容量大于所述阴极第二区的阴极活性物质的理论比容量。

[0081] 在本申请的一些实施例中，所述阴极极片还包括阴极第三区，其中阴极第三区安置于基材的边缘处而起到绝缘的作用以防止阴阳两极之间的短路。在一些实施例中，所述阴极第三区包括陶瓷，其中所述陶瓷的单位面积容量为0。

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[0082] 在本申请的一些实施例中，所述阴极极片还包括阴极第四区，其中所述阴极第四区的单位面积容量C_{SC4}小于或等于所述阴极第二区的单位面积容量C_{SC2}。在本申请的一些实施例中，所述阴极第四区经布置以与阴极第二区相邻但远离阴极第一区。在一些实施例中，所述阴极第四区的阴极极片的厚度小于或等于所述阴极第二区的阴极极片的厚度。其中阴极第四区的设置原理与阴极第二区的设置原理类似，均是为了减少阴极薄区脱出锂离子的数量。

[0083] 在本申请的一些实施例中，所述阴极第一区包括阴极主体区，所述阴极第二区包括阴极边缘1区，而所述阴极第三区包括阴极边缘2区，其中所述阴极边缘2区与所述阴极边缘1区相邻但远离所述阴极主体区。

[0084] 在本申请的一些实施例中，所述阴极第四区可以包括与阴极第一区和阴极第二区均不同的阳极活性物质，也可以包括仅与阴极第一区不同但与阴极第二区相同的阳极活性物质。

[0085] 三、电芯和电化学装置

[0086] 本申请的实施例还提出了一种电芯，所述电芯包括阴极极片和阳极极片，其中所述阴极极片包括阴极第一区和阴极第二区，其中所述阳极极片包括阳极第一区和阳极第二区。本申请将阳极极片的单位面积容量C_{SA}与阴极极片的单位面积容量C_{SC}的比值定义为电芯平衡值CB。其中为了提高阳极薄区的嵌锂能力或者为了降低阴极薄区的脱锂能力，本申请提出了薄区的CB值大于或等于厚区的CB值。

[0087] 具体地，在本申请所述的电芯中，将所述阳极第一区的单位面积容量C_{SA1}与所述阴极第一区的单位面积容量C_{SC1}的比值定义为第一区的数值CB_1，而将所述阳极第二区的单位面积容量C_{SA2}与所述阴极第二区的单位面积容量C_{SC2}的比值定义为第二区的数值CB_2，且其中$CB_2 \geqslant CB_1$。

[0088] 在本申请的一些实施例中，本申请所述的电芯包含本申请实施例所述的阴极极片和本申请实施例所述的阳极极片中的至少一者。具体的阴极极片和阳极极片的结构和组成请参见上文，在此不再赘述。

[0089] 在本申请的一些实施例中，所述电芯中的所述阳极极片还包括上述实施例所述的阳极第三区和/或阳极第四区。在一些实施例中，所述电芯中的所述阴极极片还包括上述实施例所述的阴极第三区和/或阴极第四区。

[0090] 在本申请的一些实施例中，当所述电芯的阳极极片包括阳极第四区而所述电芯的阴极极片包括阴极第四区时，进一步将所述阳极第四区的单位面积容量C_{SA4}与所述阴极第四区的单位面积容量C_{SC4}的比值定义为第四区的数值CB_4，其中CB_1、CB_2和CB_4的关系满足$CB_4 \geqslant CB_2 \geqslant CB_1$。

[0091] 本申请的一个实施例还提出了一种电化学装置，其包含本申请实施例所述的电芯。在一些实施例中，所述电化学装置包括锂离子电池。

[0092] 在一些实施例中，锂离子电池中的电芯还包括电解液。电解液的状态可以是凝胶态、固态和液态中的一种或多种。液态电解液包括锂盐和非水溶剂。

[0093] 锂盐选自$LiPF_6$、$LiBF_4$、$LiAsF_6$、$LiClO_4$、$LiB(C_6H_5)_4$、$LiCH_3SO_3$、$LiCF_3SO_3$、$LiN(SO_2CF_3)_2$、$LiC(SO_2CF_3)_3$、LiBOB和$LiPO_2F_2$中的一种或多种。例如，锂盐选用$LiPF_6$，因为它可以给出高的离子导电率并改善循环特性。

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[0094] 非水溶剂可为碳酸酯化合物、羧酸酯化合物、醚化合物、腈化合物、其它有机溶剂或它们的组合。

[0095] 碳酸酯化合物的实例为碳酸二乙酯(DEC)、碳酸二甲酯(DMC)、碳酸二丙酯(DPC)、碳酸甲丙酯(MPC)、碳酸乙丙酯(EPC)、碳酸甲乙酯(MEC)、碳酸亚乙酯(EC)、碳酸亚丙酯(PC)、碳酸亚丁酯(BC)、碳酸乙烯基亚乙酯(VEC)、碳酸氟代亚乙酯(FEC)、碳酸1,2-二氟亚乙酯、碳酸1,1-二氟亚乙酯、碳酸1,1,2-三氟亚乙酯、碳酸1,1,2,2-四氟亚乙酯、碳酸1-氟-2-甲基亚乙酯、碳酸1-氟-1-甲基亚乙酯、碳酸1,2-二氟-1-甲基亚乙酯、碳酸1,1,2-三氟-2-甲基亚乙酯、碳酸三氟甲基亚乙酯及其组合。

[0096] 在一些实施例中,基于电解液总重量,碳酸酯化合物的含量为约1重量%以上。在一些实施例中,碳酸酯化合物的含量为约3重量%以上。在一些实施例中,碳酸酯化合物的含量为约5重量%以上。在一些实施例中,碳酸酯化合物的含量为约10重量%以上。在一些实施例中,碳酸酯化合物的含量为约50重量%以上。在一些实施例中,碳酸酯化合物的含量为约58重量%以上。在一些实施例中,碳酸酯化合物的含量为约60重量%以下。在一些实施例中,碳酸酯化合物的含量为约50重量%以下。在一些实施例中,环状碳酸酯化合物的含量为约40重量%以下。在一些实施例中,碳酸酯化合物的含量为约1重量%-约60重量%。在一些实施例中,碳酸酯化合物的含量为约3重量%-约50重量%。

[0097] 羧酸酯化合物的实例为乙酸甲酯、乙酸乙酯、乙酸正丙酯、乙酸叔丁酯、丙酸甲酯、丙酸乙酯、丙酸丙酯、γ-丁内酯、癸内酯、戊内酯、甲瓦龙酸内酯、己内酯及其组合。

[0098] 在一些实施例中,基于电解液总重量,羧酸酯化合物的含量为约1重量%以上。在一些实施例中,羧酸酯化合物的含量为约3重量%以上。在一些实施例中,羧酸酯化合物的含量为约5重量%以上。在一些实施例中,羧酸酯化合物的含量为约10重量%以上。在一些实施例中,羧酸酯化合物的含量为约60重量%以下。在一些实施例中,羧酸酯化合物的含量为约50重量%以下。在一些实施例中,羧酸酯化合物的含量为约40重量%以下。在一些实施例中,羧酸酯化合物的含量为约1重量%-约60重量%。在一些实施例中,羧酸酯酯化合物的含量为约3重量%-约50重量%。

[0099] 醚化合物的实例为四氢呋喃、2-甲基四氢呋喃、1,3-二氧戊环、2-甲基1,3-二氧戊环、4-甲基1,3-二氧戊环、1,3-二氧六环、1,4-二氧六环、二甲氧基丙烷、二甲氧基甲烷、1,1-二甲氧基乙烷、1,2-二甲氧基乙烷、二乙氧基甲烷、1,1-二乙氧基乙烷、1,2-二乙氧基乙烷、乙氧基甲氧基甲烷、1,1-乙氧基甲氧基乙烷、1,2-乙氧基甲氧基乙烷、

[0100] $HCF_2CF_2CH_2OCF_2CF_2H$、$(CF_3)_2CFCF(CF_2CF_3)(OCH_3)$、$CF_3CHFCF_2CH(CH_3)OCF_2CHFCF_3$、$HCF_2CF_2CH_2OCF_2CF_2CF_2CF_2H$、$HCF_2CF_2OCH_2CF_3$、$HCF_2CF_2OCH_2CH_2OCF_2CF_2H$、$HCF_2CF_2OCH_2CH_2CH_2OCF_2CF_2H$及其组合。

[0101] 在一些实施例中,基于电解液总重量,醚化合物的含量为约0.01重量%以上。在一些实施例中,醚化合物的含量为约0.05重量%以上。在一些实施例中,醚化合物的含量为约1重量%以上。在一些实施例中,醚化合物的含量为约2重量%以上。在一些实施例中,醚化合物的含量为约10重量%以下。在一些实施例中,醚化合物的含量为约6重量%以下。在一些实施例中,醚化合物的含量为约5重量%以下。在一些实施例中,醚化合物的含量为约0.01重量%-约10重量%。在一些实施例中,醚化合物的含量为约1重量%-约6重量%。

[0102] 腈化合物的实例如丁二腈、戊二腈、己二腈、1,5-二氰基戊烷、1,6-二氰基己烷、1,

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7-二氰基庚烷、1,8-二氰基辛烷、1,9-二氰基壬烷、1,10-二氰基癸烷、1,12-二氰基十二烷、四甲基丁二腈、2-甲基戊二腈、2,4-二甲基戊二腈、2,2,4,4-四甲基戊二腈、1,4-二氰基戊烷、1,4-二氰基戊烷、2,5-二甲基-2,5-己烷二碳腈、2,6-二氰基庚烷、2,7-二氰基辛烷、2,8-二氰基壬烷、1,6-二氰基癸烷、1,2-二氰基苯、1,3-二氰基苯、1,4-二氰基苯、3,5-二氧杂-庚二腈、1,4-二(氰基乙氧基)丁烷、乙二醇二(2-氰基乙基)醚、二乙二醇二(2-氰基乙基)醚、三乙二醇二(2-氰基乙基)醚、四乙二醇二(2-氰基乙基)醚、3,6,9,12,15,18-六氧杂二十烷酸二腈、1,3-二(2-氰基乙氧基)丙烷、1,4-二(2-氰基乙氧基)丁烷、1,5-二(2-氰基乙氧基)戊烷、乙二醇二(4-氰基丁基)醚、1,3,5-戊三甲腈、1,2,3-丙三甲腈、1,3,6-己烷三腈、1,2,6-己烷三腈、1,2,3-三(2-氰基乙氧基)丙烷或1,2,4-三(2-氰基乙氧基)丁烷及其组合。

[0103] 在一些实施例中，基于电解液总重量，腈合物的含量为约0.01重量%以上。在一些实施例中，腈化合物的含量为约0.05重量%以上。在一些实施例中，腈化合物的含量为约1重量%以上。在一些实施例中，腈化合物的含量为约2重量%以上。在一些实施例中，二腈化合物的含量为约10重量%以下。在一些实施例中，腈化合物的含量为约6重量%以下。在一些实施例中，二腈化合物的含量为约5重量%以下。在一些实施例中，腈化合物的含量为约0.01重量%-约10重量%。在一些实施例中，腈化合物的含量为约1重量%-约6重量%。

[0104] 其它有机溶剂的实例为二甲亚砜、1,3-丙磺酸内酯、环丁砜、甲基环丁砜、1,3-二甲基-2-咪唑烷酮、N-甲基-2-吡咯烷酮、甲酰胺、二甲基甲酰胺、磷酸三甲酯、磷酸三乙酯、磷酸三辛酯、和磷酸三丙酯及其组合。

[0105] 在一些实施例中，锂离子电池的电芯还在阴极极片与阳极极片之间设有隔离膜以防止短路。本申请的电芯中使用的隔离膜的材料和形状没有特别限制，其可为任何现有技术中公开的技术。在一些实施例中，隔离膜包括由对本申请的电解液稳定的材料形成的聚合物或无机物等。

[0106] 例如隔离膜可包括基材层和表面处理层。基材层为具有多孔结构的无纺布、膜或复合膜，基材层的材料选自聚乙烯、聚丙烯、聚对苯二甲酸乙二醇酯和聚酰亚胺中的至少一种。具体的，可选用聚丙烯多孔膜、聚乙烯多孔膜、聚丙烯无纺布、聚乙烯无纺布或聚丙烯-聚乙烯-聚丙烯多孔复合膜。

[0107] 基材层的至少一个表面上设置有表面处理层，表面处理层可以是聚合物层或无机物层，也可以是混合聚合物与无机物所形成的层。

[0108] 无机物层包括无机颗粒和粘结剂，无机颗粒选自氧化铝、氧化硅、氧化镁、氧化钛、二氧化铪、氧化锡、二氧化铈、氧化镍、氧化锌、氧化钙、氧化锆、氧化钇、碳化硅、勃姆石、氢氧化铝、氢氧化镁、氢氧化钙和硫酸钡中的一种或几种的组合。粘结剂选自聚偏氟乙烯、偏氟乙烯-六氟丙烯的共聚物、聚酰胺、聚丙烯腈、聚丙烯酸酯、聚丙烯酸、聚丙烯酸盐、聚乙烯吡咯烷酮、聚乙烯醚、聚甲基丙烯酸甲酯、聚四氟乙烯和聚六氟丙烯中的一种或几种的组合。聚合物层中包含聚合物，聚合物的材料包括聚酰胺、聚丙烯腈、丙烯酸酯聚合物、聚丙烯酸、聚丙烯酸盐、聚乙烯吡咯烷酮、聚乙烯醚、聚偏氟乙烯或聚(偏氟乙烯-六氟丙烯)中的至少一种。

[0109] 隔离膜需要有机械稳健性以承受电极材料的拉伸和刺穿，且隔离膜孔径通常小于1微米。包括微孔聚合物膜，无纺布垫和无机膜的各种隔离膜已经用于锂离子电池中，其中

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基于微孔聚烯烃材料的聚合物膜是最常与电解液组合使用的隔离膜。微孔聚合物膜能够制成非常薄(通常约5μm-25μm)和高多孔性(通常约20%-50%)以降低电阻且提高离子传导性。同时,该聚合物膜仍然有机械稳健性。本领域技术人员当能理解,广泛使用于锂离子电池的各种隔离膜都适用于本申请。

[0110] 虽然上面以锂离子电池进行了举例说明,但是本领域技术人员在阅读本申请之后,能够想到本申请的阴极材料可以用于其他合适的电化学装置。这样的电化学装置包括发生电化学反应的任何装置,它的具体实例包括所有种类的一次电池、二次电池、燃料电池、太阳能电池或电容。特别地,所述电化学装置是锂二次电池,包括锂金属二次电池、锂离子二次电池、锂聚合物二次电池或锂离子聚合物二次电池。

[0111] 四、应用

[0112] 由本申请所述的电极极片制造的电化学装置适用于各种领域的电子设备。

[0113] 本申请的电化学装置的用途没有特别限定,其可用于现有技术中已知的任何用途。在一个实施例中,本申请的电化学装置可用于,但不限于,笔记本电脑、笔输入型计算机、移动电脑、电子书播放器、便携式电话、便携式传真机、便携式复印机、便携式打印机、头戴式立体声耳机、录像机、液晶电视、手提式清洁器、便携CD机、迷你光盘、收发机、电子记事本、计算器、存储卡、便携式录音机、收音机、备用电源、电机、汽车、摩托车、助力自行车、自行车、照明器具、玩具、游戏机、钟表、电动工具、闪光灯、照相机、家庭用大型蓄电池和锂离子电容器等。

[0114] 下面以锂离子电池为例并且结合具体的制备本申请阴极材料的实施例及对电化学装置的测式方式以用于说明本申请锂离子电池的制备及效能,本领域的技术人员将理解,本申请中描述的制备方法仅是实例,其他任何合适的制备方法均在本申请的范围内。

[0115] 五、实施例

[0116] 锂离子电池的制备

[0117] 采用以下制备方法将阴极活性物质制备成锂离子电池。具体的,将阴极活性物质、导电剂、粘结剂按一定的重量比在N-甲基吡咯烷酮中充分搅拌混合均匀制成阴极浆料,然后将所得阴极浆料均匀涂布在阴极集电体铝箔的正反两个表面上,之后在85℃下烘干,得到阴极活性材料层,之后经过冷压、分条、裁片、焊接阴极极耳,得到阴极极片。

[0118] 将阳极活性物质、粘结剂、分散剂按照一定的重量比在去离子水中充分搅拌混合均匀制成阳极浆料,之后将阳极浆料均匀涂覆在阳极集电体铜箔的正反两面上,然后在85℃下烘干,形成阳极活性材料层,然后进行冷压、分条、裁片、焊接阳极极耳,得到阳极极片。

[0119] 将锂盐$LiPF_6$与非水有机溶剂(碳酸乙烯酯(EC):碳酸二乙酯(DEC):碳酸亚丙酯(PC):丙酸丙酯(PP):碳酸亚乙烯酯(VC)=20:30:20:28:2,质量比)按质量比8:92配制而成的溶液作为锂离子电池的电解液。

[0120] 隔离膜采用陶瓷涂覆的聚乙烯(PE)材料隔离膜。

[0121] 将阴极极片、隔离膜、阳极极片按顺序叠好,使隔离膜处于正阳极中间起到隔离的作用。将电极组件置于包装壳中,注入电解液并封装,进行化成之后制成最终的锂离子电池。

[0122] 电极极片的厚度测试

[0123] 使用0.1μm高精度数显千分尺(Mitutoyo牌)进行极片厚度测量。将装配好的电芯

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进行拆解，取出电极极片并用DEC溶剂洗去表面残留物；用无尘纸擦拭千分尺测试头去除异物保证测试精度；将极片放入千分尺测试头中，旋动千分尺手柄紧密接触极片，读出厚度数值。选取极片上的十个不同的点，测得十个厚度数据取平均值。

[0124] 以下将详细描述本申请所提供的电极极片的具体实施方式。

[0125] (一)实施例1-4和对比例1-4

[0126] 实施例1-4涉及对阴极极片进行分区涂布，而不对阳极极片进行分区涂布。以下将具体描述实施例1-4和对比例1-4中的阴极极片的制备方法：

[0127] 实施例1的电极极片的制备方法：

[0128] (1)制备浆料

[0129] 阴极NCM811/NCM523浆料：将阴极活性成分NCM811(220mAh/g)/NCM523(180mAh/g)、导电剂Super-P和粘结剂聚偏二氟乙烯PVDF按97％:1.5％:1.5％重量比例混合，并用适量的N-甲基吡咯烷酮稀释，然后在真空搅拌机中搅拌形成均匀的阴极浆料。

[0130] 阳极石墨浆料：将阳性活性成分石墨、粘结剂丁苯橡胶SBR和分散剂羧甲基纤维素CMC按97％:1％:2％重量比例混合，并用适量蒸馏水稀释，然后在真空搅拌机中搅拌形成均匀的阳极浆料。

[0131] (2)阴极分区涂布

[0132] 阴极分区涂布：按如下操作进行分区涂布，

[0133] A、通过主体涂布头将步骤(1)中制备的NCM811浆料单面涂布至铝箔的主体区(下称，第1区)，且通过边缘涂布头将步骤(1)中制备的NCM523浆料单面涂布至距离主体区边缘10mm的区域(下称，第2区)。将涂布好的单面极片放置85℃的高温烘箱中烘干；

[0134] B、对上述单面涂布的极片进行第二面涂布，涂布方法、区域和材料与步骤A所述相同。将涂布好的双面极片放置85℃的高温烘箱中烘干，获得实施例1所述的阴极极片。

[0135] (3)阳极涂布

[0136] C、将步骤(1)中制备的阳极浆料在铜箔基材上进行单面涂布，将涂布好的单面极片放置85℃的高温烘箱中烘干；

[0137] D、对上述单面涂布的极片进行第二面涂布，涂布方法、区域和材料与步骤C所述相同。将涂布好的双面极片放置85℃的高温烘箱中烘干，获得实施例1所述的阳极极片。

[0138] 实施例2的电极极片的制备方法：

[0139] 实施例2与实施例1的差异仅在于：将阴极极片第2区的活性物质替换成LCO-180(180mAh/g)。

[0140] 实施例3的电极极片的制备方法：

[0141] 实施例3与实施例1的差异仅在于：将阴极极片第1区的活性物质替换成LCO-180(180mAh/g)，将阴极极片第2区的活性物质替换成LFP(160mAh/g)。

[0142] 实施例4的电极极片的制备方法：

[0143] 实施例4与实施例1的差异仅在于：将阴极极片第2区的活性物质替换成50％NCM811与50％NCM523的混合物。

[0144] 对比例1-4的电极极片的制备方法：

[0145] 对比例1-4分别对应于实施例1-4，其中对比例1和实施例1的差异仅在于：不对阴极极片进行分区涂敷，仅按照常规工艺在铝箔主体区涂敷对应实施例中的阴极第1区的浆

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料。

[0146] 其中,实施例1-4和对比例1-4的阴极极片上的活性物质以及循环前后的阳极极片的厚度数据见下表3。

[0147] 表3

[0148]

	阴极极片第 1 区	阴极极片第 2 区	循环前阳极极片 1 区的厚度(μm)	循环前阳极极片 2 区的厚度(μm)	循环 500 次后阳极极片 1 区的厚度(μm)	循环 500 次后阳极极片 2 区的厚度(μm)
实施例 1	NCM811 (220mAh/g)	NCM523 (180mAh/g)	105.3	98.2	127.3	118.3

[0149]

对比例 1	NCM811 (220mAh/g)	NCM811 (220mAh/g)	105.9	98.7	128.1	145.0
实施例 2	NCM811 (220mAh/g)	LCO (180mAh/g)	93.5	83.9	116.8	106.8
对比例 2	NCM811 (220mAh/g)	NCM811 (220mAh/g)	93.1	85.1	119.8	137.8
实施例 3	LCO-180 (180mAh/g)	LFP (160mAh/g)	98.6	88.3	122.3	121.2
对比例 3	LCO-180 (180mAh/g)	LCO-180 (180mAh/g)	97.6	87.3	121.0	142.3
实施例 4	NCM811 (220mAh/g)	50%NCM811 +50%NCM523(200mAh/g)	102.3	92.5	126.0	126.9
对比例 4	NCM811 (220mAh/g)	NCM811 (220mAh/g)	102.9	93.5	125.6	148.9

[0150] *由于在锂离子电池中,相较于阴极极片,阳极极片的析锂现象比较严重,因此本申请采用阳极极片的厚度参数来衡量锂离子电池的析锂程度,从而反映锂离子电池的安全性能。

[0151] 参见表3所示的实施例1-4和对比例1-4的数据可知,通过在阴极薄区涂敷比容量较小的阴极活性材料,能够有效地降低阳极极片的析锂程度,从而增强锂离子电池的安全性能。

[0152] (二)实施例5-7和对比例5-6

[0153] 实施例5-7和对比例5-6仅涉及对阳极极片进行分区涂布,而不对阴极极片进行分区涂布。以下将具体描述实施例5-7和对比例5-6中的阳极极片的制备方法:

[0154] 实施例5的电极极片的制备方法:

[0155] (1)制备浆料

[0156] 阳极石墨/GNS浆料:将阳性活性成分石墨(370mAh/g)/GNS(740mAh/g)、粘结剂丁苯橡胶SBR和分散剂羧甲基纤维素CMC按97%:1%:2%重量比例混合,并用适量蒸馏水稀释,然后在真空搅拌机中搅拌形成均匀的阳极浆料。

[0157] 阴极NCM811浆料:将阴极活性成分NCM811(220mAh/g)、导电剂Super-P和粘结剂聚

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偏二氟乙烯PVDF按97%:1.5%:1.5%重量比例混合，并用适量的N-甲基吡咯烷酮稀释，然后在真空搅拌机中搅拌形成均匀的阴极浆料。

[0158] (2)阳极分区涂布

[0159] 阳极分区涂布：按如下操作进行分区涂布，

[0160] A、通过主体涂布头将步骤(1)中制备的石墨(370mAh/g)浆料单面涂布至铜箔的主体区(下称，第1区)，而通过边缘涂布头将步骤(1)中制备的GNS(740mAh/g)浆料单面涂布至距离主体区边缘10mm的区域(下称，第2区)。将涂布好的单面极片放置85℃的高温烘箱中烘干；

[0161] B、对上述单面涂布的极片进行第二面涂布，涂布方法、区域和材料与步骤A所述相同。将涂布好的双面极片放置85℃的高温烘箱中烘干，获得实施例2所述的阳极极片。

[0162] (3)阴极涂布

[0163] C、将步骤(1)中制备的阴极浆料在铝箔基材上进行单面涂布，将涂布好的单面极片放置85℃的高温烘箱中烘干；

[0164] D、对上述单面涂布的极片进行第二面涂布，涂布方法、区域和材料与步骤C所述相同。将涂布好的双面极片放置85℃的高温烘箱中烘干，获得实施例5所述的阴极极片。

[0165] 实施例6-7的电极极片的制备方法：

[0166] 实施例6与实施例5的差异仅在于：将阳极极片第2区的活性物质替换成95wt%石墨与5wt%SiC-2000的混合物。

[0167] 实施例7与实施例5的差异仅在于：将阳极极片第1区的活性物质替换成90wt%石墨与10wt%HC的混合物，并将阳极极片第2区的活性物质替换成90wt%石墨与10wt%SiOx-1000的混合物。

[0168] 对比例5-6的电极极片的制备方法：

[0169] 对比例5对应实施例5和6。对比例5与实施例5和6的差异仅在于：不对阳极极片进行分区涂敷，仅按照常规工艺在铜箔主体区涂敷石墨(370mAh/g)浆料。

[0170] 对比例6对应实施例7。对比例6与实施例7的差异仅在于：不对阳极极片进行分区涂敷，仅按照常规工艺在铜箔主体区涂敷90wt%石墨与10wt%HC的混合物浆料。

[0171] 其中，实施例5-7和对比例5-6的阳极极片上的活性物质以及循环前后的阳极极片的厚度数据见下表4。

[0172] 表4

[0173]

	阳极极片第1区	阳极极片第2区	循环前阳极极片1区的厚度(μm)	循环前阳极极片2区的厚度(μm)	循环500次后阳极极片1区的厚度(μm)	循环500次后阳极极片2区的厚度(μm)
实施例5	Gr (370mAh/g)	GNS (740mAh/g)	119.1	112.9	132.2	135.1
实施	Gr	95wt%Gr+5w	76.2	72.4	93.5	91.6

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[0174]

例6	(370mAh/g)	f%SiC-2000 (452mAh/g)				
对比例5	Gr (370mAh/g)	Gr (370mAh/g)	118.5	112.5	131.9	150.8
实施例7	90wt%Gr+10wt%HC (378mAh/g)	90wt%Gr+10%SiOx-1000 (433mAh/g)	79.9	75.9	98.5	95.9
对比例6	90wt%Gr+10wt%HC (378mAh/g)	90wt%Gr+10wt%HC (378mAh/g)	76.9	71.9	93.6	116.9

[0175] 参见表4所示的实施例5-7和对比例5-6的数据可知，通过在阳极薄区涂敷比容量较大的阳极活性材料，能够有效地降低阳极极片的析锂程度，从而增强锂离子电池的安全性能。

[0176] (三)实施例8-10和对比例7-8

[0177] 实施例8-10和对比例7-8涉及分别对阳极极片和阴极极片进行分区涂布。其中实施例8-10和对比例7-8的活性物质和极片厚度的数据见表5。

[0178] 表5

[0179]

	阴极/阳极极片第1区	阴极/阳极极片第2区	循环前阳极极片1区的厚度(μm)	循环前阳极极片2区的厚度(μm)	循环500次后阳极极片1区的厚度(μm)	循环500次后阳极极片2区的厚度(μm)
实施例8	NCM811/Gr	NCM523/Si-C-450	82.1	75.9	98.7	92.2
实施例9	NCM811/Gr	LMO/HC	91.5	82.7	101.3	99.4
对比例7	NCM811/Gr	NCM811/Gr	91.9	83.1	100.7	119.4
实施例10	LCO-180/Gr	LFP/80wt%Gr+20wt%HC	93.1	84.0	105.3	103.8
对比例8	LCO-180/Gr	LCO-180/Gr	93.3	83.7	103.6	122.1

[0180] 参见表5所示的实施例8-10和对比例7-8的数据可知，通过在阴极薄区涂敷比容量较小的阴极活性材料且通过在阳极薄区涂敷比容量较大的阳极活性材料，能够有效地降低阳极极片的析锂程度，从而增强锂离子电池的安全性能。

[0181] (四)实施例11-14

[0182] 相较于上述实施例1-10，实施例11-14的电极极片进一步增加了第3区。其中第3区与第2区相邻但远离第1区。第3区为距离第2区的边缘10mm的区域。

[0183] 实施例11-14的电极极片的制备方法：

[0184] 实施例11与实施例1的差异仅在于：进一步将NCM333(160mAh/g)浆料涂敷阴极极片的第3区。其中，NCM333浆料的制备过程同NCM811浆料的制备过程。

[0185] 实施例12与实施例2的差异仅在于：进一步将LCO-140(140mAh/g)浆料涂敷阴极极片的第3区。其中，LCO-140浆料的制备过程同NCM811浆料的制备过程。

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[0186] 实施例13与实施例5的差异仅在于：进一步将SiOx-1000(1000mAh/g)浆料涂敷阳极极片的第3区。其中，SiOx-1000浆料的制备过程同石墨浆料的制备过程。

[0187] 实施例14与实施例8的差异仅在于：进一步将LMO(130mAh/g)浆料涂敷阴极极片的第3区并进一步将Si-C-2000(2000mAh/g)浆料涂敷阳极极片的第3区。其中，LMO浆料的制备过程同NCM811浆料的制备过程且Si-C-2000浆料的制备过程同石墨浆料的制备过程。

[0188] 其中实施例11-14的循环前后的锂离子电池的阳极极片厚度的数据见表6。

[0189] 表6

[0190]

	循环前阳极极片1区的厚度(μm)	循环前阳极极片2区的厚度(μm)	循环前阳极极片3区的厚度(μm)	循环500次后阳极极片1区的厚度(μm)	循环500次后阳极极片2区的厚度(μm)	循环500次后阳极极片3区的厚度(μm)
实施例11	105.5	98.5	97.6	126.2	117.5	115.9
实施例12	94.3	83.4	81.5	116.2	107.1	102.9
实施例13	120.5	112.4	110.8	133.3	135.6	136.9
实施例14	83.2	75.6	73.5	98.3	93.5	94.3

[0191] 参见表6的数据可知，经过500次充放电循环后，实施例11-14中的阳极极片的薄区厚度变化均不大。这说明了通过在阴极薄区涂敷比容量较小的阴极活性材料和/或通过在阳极薄区涂敷比容量较大的阳极活性材料，能够有效地降低阳极极片的析锂程度，从而增强锂离子电池的安全性能。

[0192] 整个说明书中对“一些实施例”、“部分实施例”、“一个实施例”、“另一举例”、“举例”、“具体举例”或“部分举例”的引用，其所代表的意思是在本申请中的至少一个实施例或举例包含了该实施例或举例中所描述的特定特征、结构、材料或特性。因此，在整个说明书中的各处所出现的描述，例如：“在一些实施例中”、“在实施例中”、“在一个实施例中”、“在另一个举例中”，“在一个举例中”、“在特定举例中”或“举例“，其不必然是引用本申请中的相同的实施例或示例。此外，本文中的特定特征、结构、材料或特性可以以任何合适的方式在一个或多个实施例或举例中结合。

[0193] 尽管已经演示和描述了说明性实施例，本领域技术人员应该理解上述实施例不能被解释为对本申请的限制，并且可以在不脱离本申请的精神、原理及范围的情况下对实施例进行改变，替代和修改。

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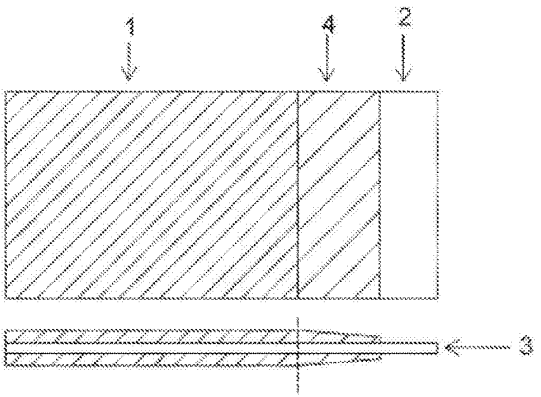


图1

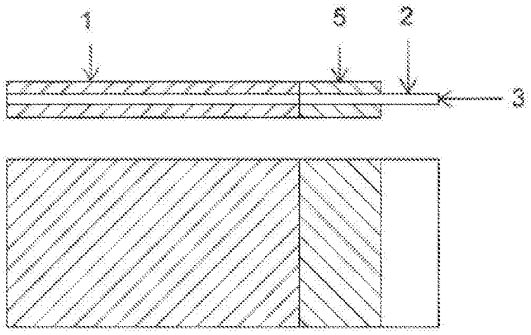


图2

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High-energy-density lithium ion battery and preparation method thereof

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Abstract of CN108023117 (A)

The invention relates to the field of a lithium ion battery, and specifically provides a high-energy-density lithium ion battery and a preparation method thereof. A negative electrode plate on the outermost layer of a cell of the high-energy-density lithium ion battery is a negative electrode plate with negative electrode paste on the single surface, wherein one side without paste is outward. Thenegative electrode plate on the outermost layer of the cell of the high-energy-density lithium ion battery is the negative electrode plate with negative electrode paste on the single surface, while the negative electrode plate on the outermost layer of the existing cell is the negative electrode plate with negative electrode paste on the two surfaces, so that the cell mass is lower than the existing cell mass and the battery capacity is unchanged; and the energy density is equal to capacity/mass, so that the energy density is improved and the cost is lower.

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权利要求书1页 说明书6页

(54)发明名称

高能量密度的锂离子电池及其制备方法

(57)摘要

本发明涉及锂离子电池领域，具体而言，提供了一种高能量密度的锂离子电池及其制备方法。所述高能量密度锂离子电池的电芯最外层的负极片为单面设置有负极浆料的负极片，且无浆料的一侧朝外。上述高能量密度锂离子电池的电芯最外层的负极片为单面设置有负极浆料的负极片，而现有的电芯最外层的负极片为双面设置有负极浆料的负极片，因此电芯的质量相对于现有的电芯质量更小，而电池的容量不变，能量密度为容量除以质量，因此能量密度得以提高，且成本更低。

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1.一种高能量密度锂离子电池，其特征在于，所述锂离子电池的电芯最外层的负极片为单面设置有负极浆料的负极片，且无浆料的一侧朝外。

2.权利要求1所述的高能量密度锂离子电池的制备方法，其特征在于，包括以下步骤：

(a)分别将正极浆料和负极浆料涂覆于正极集流体和负极集流体的两侧，然后进行干燥和压实，形成双面正极片和双面负极片；

(b)将负极浆料涂覆于负极集流体的一侧，然后进行干燥和压实，形成单面负极片；

(c)将双面正极片、双面负极片和单面负极片分别裁成所需要的尺寸并组装成电芯，其中单面负极片设置于最外层，且无浆料的一侧朝外；

(d)将电芯装入壳体内，然后向壳体内注入电解液，再封口，最后进行化成和分容即得所述高能量密度锂离子电池。

3.根据权利要求2所述的高能量密度锂离子电池的制备方法，其特征在于，步骤(a)中，将正极浆料涂覆于正极集流体的两侧，然后在110-140℃的温度下干燥，再采用对辊滚压，压实密度为2.3-2.8g/cm^3，形成双面正极片。

4.根据权利要求2所述的高能量密度锂离子电池的制备方法，其特征在于，步骤(a)中，将负极浆料涂覆于负极集流体的两侧，然后在95-110℃的温度下干燥，再采用对辊滚压，压实密度为1.5-2g/cm^3，形成双面负极片。

5.根据权利要求2所述的高能量密度锂离子电池的制备方法，其特征在于，步骤(b)中，将负极浆料涂覆于负极集流体的一侧，然后在95-110℃的温度下干燥，再采用对辊滚压，压实密度为1.5-2g/cm^3，形成单面负极片。

6.根据权利要求2-5任一项所述的高能量密度锂离子电池的制备方法，其特征在于，正极浆料包括正极材料，正极材料包括钴酸锂、锰酸锂、镍钴锰三元电池材料或磷酸铁锂中的至少一种。

7.根据权利要求6所述的高能量密度锂离子电池的制备方法，其特征在于，所述正极材料包括锰酸锂和磷酸铁锂的混合物。

8.根据权利要求7所述的高能量密度锂离子电池的制备方法，其特征在于，锰酸锂和磷酸铁锂的质量比为1:1～1:5。

9.根据权利要求2-5任一项所述的高能量密度锂离子电池的制备方法，其特征在于，负极浆料包括负极材料，负极材料包括天然石墨、人造石墨、碳硅负极材料、软碳或硬碳中的至少一种。

10.根据权利要求9所述的高能量密度锂离子电池的制备方法，其特征在于，所述负极材料包括人造石墨和硬碳的混合物。

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高能量密度的锂离子电池及其制备方法

技术领域

[0001] 本发明涉及锂离子电池领域，具体而言，涉及一种高能量密度的锂离子电池及其制备方法。

背景技术

[0002] 随着锂电池技术的不断更新和发展，其质轻、高容、长寿命的优点逐渐得到消费者的青睐。锂电池市场已经由手机扩展到相机、DVD、航膜、玩具等多种领域。近年来，锂离子电池由于具有电压高、循环使用次数多、存储时间长等优点，不仅在便携式电子设备上得到广泛应用，而且也广泛应用于电动汽车、电动自行车以及电动工具等大中型电动设备方面。

[0003] 随着智能手机和笔记本电脑等移动互联网设备的普及，电动自行车和电动摩托车等电动交通工具的推广，以及无人机和太空探测器等航空航天技术的发展，锂离子电池性能面临着更高的发展要求，而高能量密度已成为高性能锂离子电池的研究方向之一。

[0004] 有鉴于此，特提出本发明。

发明内容

[0005] 本发明的第一目的在于提供一种高能量密度锂离子电池，所述锂离子电池具有能量密度高和成本低的优点。

[0006] 本发明的第二目的在于提供一种高能量密度锂离子电池的制备方法，该方法工艺科学简单，可操作性强，采用上述方法制备得到的高能量密度锂离子电池具有能量密度更高、成本更低的优点。

[0007] 为了实现本发明的上述目的，特采用以下技术方案：

[0008] 第一方面，本发明提供了一种高能量密度锂离子电池，所述锂离子电池的电芯最外层的负极片为单面设置有负极浆料的负极片，且无浆料的一侧朝外。

[0009] 第二方面，本发明提供了一种上述高能量密度锂离子电池的制备方法，包括以下步骤：

[0010] (a)分别将正极浆料和负极浆料涂覆于正极集流体和负极集流体的两侧，然后进行干燥和压实，形成双面正极片和双面负极片；

[0011] (b)将负极浆料涂覆于负极集流体的一侧，然后进行干燥和压实，形成单面负极片；

[0012] (c)将双面正极片、双面负极片和单面负极片分别裁成所需要的尺寸并组装成电芯，其中单面负极片设置于最外层，且无浆料的一侧朝外；

[0013] (d)将电芯装入壳体内，然后向壳体内注入电解液，再封口，最后进行化成和分容即得所述高能量密度锂离子电池。

[0014] 作为进一步优选的技术方案，步骤(a)中，将正极浆料涂覆于正极集流体的两侧，然后在110-140℃的温度下干燥，再采用对辊滚压，压实密度为2.3-2.8g/cm^3，形成双面正极片。

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[0015] 作为进一步优选的技术方案，步骤(a)中，将负极浆料涂覆于负极集流体的两侧，然后在95-110℃的温度下干燥，再采用对辊滚压，压实密度为1.5-2g/cm^3，形成双面负极片。

[0016] 作为进一步优选的技术方案，步骤(b)中，将负极浆料涂覆于负极集流体的一侧，然后在95-110℃的温度下干燥，再采用对辊滚压，压实密度为1.5-2g/cm^3，形成单面负极片。

[0017] 作为进一步优选的技术方案，正极浆料包括正极材料，正极材料包括钴酸锂、锰酸锂、镍钴锰三元电池材料或磷酸铁锂中的至少一种。

[0018] 作为进一步优选的技术方案，所述正极材料包括锰酸锂和磷酸铁锂的混合物。

[0019] 作为进一步优选的技术方案，锰酸锂和磷酸铁锂的质量比为1:1～1:5。

[0020] 作为进一步优选的技术方案，负极浆料包括负极材料，负极材料包括天然石墨、人造石墨、碳硅负极材料、软碳或硬碳中的至少一种。

[0021] 作为进一步优选的技术方案，所述负极材料包括人造石墨和硬碳的混合物。

[0022] 与现有技术相比，本发明的有益效果为：

[0023] 本发明提供的高能量密度锂离子电池的电芯最外层的负极片为单面设置有负极浆料的负极片，而现有的电芯最外层的负极片为双面设置有负极浆料的负极片，因此电芯的质量相对于现有的电芯质量更小，而电池的容量不变，能量密度为容量除以质量，因此能量密度得以提高，且成本更低。其中，电池的容量不变的原因是：锂离子电池中正极片的个数少于负极片，即负极片是相对富裕的，因此电池的容量主要由正极片中的有效物质决定，其有效物质的含量并未改变，因此电池容量不变。

[0024] 本发明提供的高能量密度锂离子电池的制备方法中制备了两种不同的负极片，即双面负极片和单面负极片，工艺科学简单，可操作性强，采用上述方法制备得到的高能量密度锂离子电池具有能量密度更高、成本更低的优点。

具体实施方式

[0025] 下面将结合实施例对本发明的实施方案进行详细描述，但是本领域技术人员将会理解，下列实施例仅用于说明本发明，而不应视为限制本发明的范围。实施例中未注明具体条件者，按照常规条件或制造商建议的条件进行。

[0026] 第一方面，本发明提供了一种高能量密度锂离子电池，所述锂离子电池的电芯最外层的负极片为单面设置有负极浆料的负极片，且无浆料的一侧朝外。

[0027] 上述高能量密度锂离子电池的电芯最外层的负极片为单面设置有负极浆料的负极片，而现有的电芯最外层的负极片为双面设置有负极浆料的负极片，因此电芯的质量相对于现有的电芯质量更小，而电池的容量不变，能量密度为容量除以质量，因此能量密度得以提高，且成本更低。其中，电池的容量不变的原因是：锂离子电池中正极片的个数少于负极片，即负极片是相对富裕的，因此电池的容量主要由正极片中的有效物质决定，其有效物质的含量并未改变，因此电池容量不变。

[0028] 本发明中，“设置有负极浆料的负极片”应做广义理解：当电池为叠片式，上述负极片独立于其他负极片；当电池为卷绕式，上述负极片为整个负极片的端部，该端部仅单面设置有负极浆料。

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[0029] 应当理解的是，“电芯最外层的负极片”是指所有负极片中位于电芯最外层的负极片；“无浆料的一侧朝外”是指没有设置负极浆料的一侧朝向电芯的外侧。

[0030] 第二方面，本发明提供了一种上述高能量密度锂离子电池的制备方法，包括以下步骤：

[0031] (a)分别将正极浆料和负极浆料涂覆于正极集流体和负极集流体的两侧，然后进行干燥和压实，形成双面正极片和双面负极片；

[0032] (b)将负极浆料涂覆于负极集流体的一侧，然后进行干燥和压实，形成单面负极片；

[0033] (c)将双面正极片、双面负极片和单面负极片分别裁成所需要的尺寸并组装成电芯，其中单面负极片设置于最外层，且无浆料的一侧朝外；

[0034] (d)将电芯装入壳体内，然后向壳体内注入电解液，再封口，最后进行化成和分容即得所述高能量密度锂离子电池。

[0035] 上述高能量密度锂离子电池的制备方法中制备了两种不同的负极片，即双面负极片和单面负极片，工艺科学简单，可操作性强，采用上述方法制备得到的高能量密度锂离子电池具有能量密度更高、成本更低的优点。

[0036] 上述方法制备得到的为叠片式锂离子电池，相对于卷绕式锂离子电池，具有内阻低、高倍率放电容量高、放电平台高、容量密度高、能量密度高、厚度可控性高、不易变形和尺寸灵活的优点，应用范围更加广泛。

[0037] 电极片的干燥温度对于电极片有一定影响，干燥温度过低会增加干燥时间、延长生产周期，干燥温度过高则容易产生裂纹，影响产品性能；压实密度对电池性能有较大影响，压实密度与电极片比容量、效率、内阻以及电池循环性能有密切关系，在一定范围内，压实密度越大，电池的容量越高，然而当压实密度过大或过小，会不利于锂离子的嵌入和脱出。

[0038] 基于上述考量，在一种优选的实施方式中，步骤(a)中，将正极浆料涂覆于正极集流体的两侧，然后在110-140℃的温度下干燥，再采用对辊滚压，压实密度为2.3-2.8g/cm^3，形成双面正极片。上述干燥时的温度典型但非限制性的为110℃、115℃、120℃、125℃、130℃、135℃或140℃；上述压实密度典型但非限制性的为2.3g/cm^3、2.4g/cm^3、2.5g/cm^3、2.6g/cm^3、2.7g/cm^{3}或2.8g/cm^3。

[0039] 基于上述考量，在一种优选的实施方式中，步骤(a)中，将负极浆料涂覆于负极集流体的两侧，然后在95-110℃的温度下干燥，再采用对辊滚压，压实密度为1.5-2g/cm^3，形成双面负极片。上述干燥时的温度典型但非限制性的为95℃、96℃、98℃、100℃、102℃、104℃、106℃、108℃或110℃；上述压实密度典型但非限制性的为1.5g/cm^3、1.6g/cm^3、1.7g/cm^3、1.8g/cm^3、1.9g/cm^{3}或2g/cm^3。

[0040] 基于上述考量，在一种优选的实施方式中，步骤(b)中，将负极浆料涂覆于负极集流体的一侧，然后在95-110℃的温度下干燥，再采用对辊滚压，压实密度为1.5-2g/cm^3，形成单面负极片。上述干燥时的温度典型但非限制性的为95℃、96℃、98℃、100℃、102℃、104℃、106℃、108℃或110℃；上述压实密度典型但非限制性的为1.5g/cm^3、1.6g/cm^3、1.7g/cm^3、1.8g/cm^3、1.9g/cm^{3}或2g/cm^3。

[0041] 在一种优选的实施方式中，正极浆料包括正极材料，正极材料包括钴酸锂、锰酸

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锂、镍钴锰三元电池材料或磷酸铁锂中的至少一种。钴酸锂外观呈灰黑色粉末，电化学性能优越，首次放电比容量大于135mAh/g，振实密度大，有助于提高电池体积比容量，产品性能稳定、一致性好；锰酸锂具有价格低、电位高、环境友好、安全性能高等优点；镍钴锰三元电池材料成本低廉，克容量高(>150mAh/g)，工作电压与现有电解液匹配性好(4.1V)，安全性好；磷酸铁锂的理论比容量高达170mAh/g，是目前最安全的锂离子电池正极材料，不含任何对人体有害的重金属元素，寿命长，在100%DOD条件下，可以充放电2000次以上。

[0042] 本发明中的正极材料典型但非限制性的为钴酸锂，锰酸锂，镍钴锰三元电池材料，磷酸铁锂，钴酸锂和锰酸锂的混合物，锰酸锂和磷酸铁锂的混合物，镍钴锰三元电池材料和磷酸铁锂的混合物，钴酸锂、锰酸锂和镍钴锰三元电池材料的混合物，锰酸锂、镍钴锰三元电池材料和磷酸铁锂的混合物等。

[0043] 在一种优选的实施方式中，所述正极材料包括锰酸锂和磷酸铁锂的混合物。以锰酸锂和磷酸铁锂的混合物作为正极材料，不但能够使电池价格更加适中，而且高低温的循环性能更好。

[0044] 在一种优选的实施方式中，锰酸锂和磷酸铁锂的质量比为1:1～1:5。上述质量比典型但非限制性的为1:1、1:2、1:3、1:4或1:5。上述质量比的锰酸锂和磷酸铁锂的混合物为正极材料能够使电池的各项性能更加优异。

[0045] 在一种优选的实施方式中，负极浆料包括负极材料，负极材料包括天然石墨、人造石墨、碳硅负极材料、软碳或硬碳中的至少一种。天然石墨负极材料是采用天然鳞片状晶质石墨经粉碎、球化、分级、纯化、表面等工序处理得到，其高结晶度是天然形成的；人造石墨负极材料是将易石墨化的碳(如石油焦、针状焦、沥青焦等)在一定温度下煅烧，再经粉碎、分级、高温石墨化制得，其高结晶度是通过高温石墨化形成的；碳硅负极材料即碳硅复合负极材料，其结构主要有包覆型、嵌入型和掺杂型，纳米级的硅碳负极材料具有高储锂容量(其室温理论容量高达3580mAh/g)，远超石墨(372mAh/g)，具有良好的电子通道、较小的应变及促使SEI膜稳定生长的环境；软碳即易石墨化碳，是指在2000℃以上的高温条件下能石墨化的无定形碳，结晶度低、晶粒尺寸小、晶面间距较大、与电解液的相容性好、首次充放电的不可逆容量较高，输出电压较低，无明显的充放电平台电位，常见的软碳有石油焦和针状焦等；硬碳又称为难石墨化碳，是高分子聚合物的热解碳，这类碳在3000℃的高温也难以石墨化，硬碳有树脂碳、有机聚合物热解碳、碳黑等，其中聚糠醇树脂碳用作锂离子负极材料，比容量可达400mAh/g，其晶面间距适当，有利于锂的嵌入而不会引起结构显著膨胀，具有很好的充放电循环性能。

[0046] 本发明中的负极材料典型但非限制性的为天然石墨，人造石墨，碳硅负极材料，软碳，硬碳，天然石墨和人造石墨的混合物，人造石墨和硬碳的混合物，碳硅负极材料和软碳的混合物，软碳和硬碳的混合物，天然石墨、人造石墨和碳硅负极材料的混合物，碳硅负极材料、软碳和硬碳的混合物等。

[0047] 在一种优选的实施方式中，所述负极材料包括人造石墨和硬碳的混合物。进一步优选地，人造石墨和硬碳的质量比为4:1～1:2。上述质量比典型但非限制性的为4:1、3:1、2:1、1:1或1:2。上述质量比的人造石墨和硬碳的混合物为负极材料能够使电池的各项性能更加优异。

[0048] 应当理解的是，本发明中未提及的制备步骤及参数，如正极材料或负极材料的粒

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径、正极浆料或负极浆料中导电剂、粘结剂和溶剂的选用和加入量等均按照本领域的常规选择即可，本发明对此并不作特别限制。

[0049] 下面结合实施例和对比例对本发明做进一步详细的说明。

[0050] 实施例1

[0051] 一种高能量密度锂离子电池，所述锂离子电池的电芯最外层的负极片为单面设置有负极浆料的负极片，且无浆料的一侧朝外；

[0052] 上述高能量密度锂离子电池的制备方法包括以下步骤：

[0053] (a)分别将正极浆料和负极浆料涂覆于正极集流体和负极集流体的两侧，然后进行干燥和压实，形成双面正极片和双面负极片；双面正极片的干燥温度为105℃，压实密度为3.0g/cm^3；双面负极片的干燥温度为115℃，压实密度为2.5g/cm^3；

[0054] (b)将负极浆料涂覆于负极集流体的一侧，然后进行干燥和压实，形成单面负极片；单面负极片的干燥温度为115℃，压实密度为2.5g/cm^3；

[0055] 正极材料为钴酸锂；负极材料为天然石墨；

[0056] (c)将双面正极片、双面负极片和单面负极片分别裁成所需要的尺寸并组装成电芯，其中单面负极片设置于最外层，且无浆料的一侧朝外；

[0057] (d)将电芯装入壳体内，然后向壳体内注入电解液，再封口，最后进行化成和分容即得所述高能量密度锂离子电池。

[0058] 经锂电池分容柜检测，实施例1中的锂离子电池的容量为30.51Ah，能量密度为190.35Wh/kg，1C循环次数为2267次。

[0059] 实施例2

[0060] 一种高能量密度锂离子电池，与实施例1不同的是，双面正极片的干燥温度为120℃，压实密度为2.5g/cm^3；双面负极片的干燥温度为100℃，压实密度为1.8g/cm^3；单面负极片的干燥温度为100℃，压实密度为1.8g/cm^3；其余各步骤及参数均与实施例1相同。

[0061] 经锂电池分容柜检测，实施例2中的锂离子电池的容量为31.48Ah，能量密度为189.92Wh/kg，1C循环次数为2146次。

[0062] 实施例3

[0063] 一种高能量密度锂离子电池，与实施例1不同的是，双面正极片的干燥温度为110℃，压实密度为2.3g/cm^3；双面负极片的干燥温度为95℃，压实密度为1.5g/cm^3；单面负极片的干燥温度为95℃，压实密度为1.5g/cm^3；其余各步骤及参数均与实施例1相同。

[0064] 经锂电池分容柜检测，实施例3中的锂离子电池的容量为32.44Ah，能量密度为191.28Wh/kg，1C循环次数为2071次。

[0065] 实施例4

[0066] 一种高能量密度锂离子电池，与实施例1不同的是，双面正极片的干燥温度为140℃，压实密度为2.8g/cm^3；双面负极片的干燥温度为110℃，压实密度为2g/cm^3；单面负极片的干燥温度为110℃，压实密度为2g/cm^3；其余各步骤及参数均与实施例1相同。

[0067] 经锂电池分容柜检测，实施例4中的锂离子电池的容量为31.85Ah，能量密度为190.39Wh/kg，1C循环次数为2154次。

[0068] 实施例5

[0069] 一种高能量密度锂离子电池，与实施例1不同的是，正极材料为锰酸锂和磷酸铁锂

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的混合物，锰酸锂和磷酸铁锂的质量比为1:3；其余各步骤及参数均与实施例1相同。

[0070] 经锂电池分容柜检测，实施例5中的锂离子电池的容量为30.48Ah，能量密度为191.72Wh/kg，1C循环次数为2089次。

[0071] 实施例6

[0072] 一种高能量密度锂离子电池，与实施例1不同的是，负极材料为人造石墨和硬碳的混合物，人造石墨和硬碳的质量比为2:1；其余各步骤及参数均与实施例1相同。

[0073] 经锂电池分容柜检测，实施例6中的锂离子电池的容量为31.34Ah，能量密度为192.19Wh/kg，1C循环次数为2248次。

[0074] 实施例7

[0075] 种高能量密度锂离子电池，与实施例1不同的是，正极材料为锰酸锂和磷酸铁锂的混合物，锰酸锂和磷酸铁锂的质量比为1:3；负极材料为人造石墨和硬碳的混合物，人造石墨和硬碳的质量比为2:1；其余各步骤及参数均与实施例1相同。

[0076] 经锂电池分容柜检测，实施例7中的锂离子电池的容量为32.98Ah，能量密度为191.56Wh/kg，1C循环次数为2469次。

[0077] 对比例1

[0078] 一种锂离子电池，其制备方法包括以下步骤：

[0079] (a)分别将正极浆料和负极浆料涂覆于正极集流体和负极集流体的两侧，然后进行干燥和压实，形成双面正极片和双面负极片；双面正极片的干燥温度为105℃，压实密度为3.0g/cm^3；双面负极片的干燥温度为115℃，压实密度为2.5g/cm^3；

[0080] 正极材料为钴酸锂；负极材料为天然石墨；

[0081] (c)将双面正极片和双面负极片分别裁成所需要的尺寸并组装成电芯，其中单面负极片设置于最外层，且无浆料的一侧朝外；

[0082] (d)将电芯装入壳体内，然后向壳体内注入电解液，再封口，最后进行化成和分容即得所述高能量密度锂离子电池。

[0083] 经锂电池分容柜检测，对比例1中的锂离子电池的容量为31.69Ah，能量密度为170.43Wh/kg，1C循环次数为2058次。

[0084] 尽管已用具体实施例来说明和描述了本发明，然而应意识到，在不背离本发明的精神和范围的情况下可以作出许多其它的更改和修改。因此，这意味着在所附权利要求中包括属于本发明范围内的所有这些变化和修改。

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Espacenet

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Lithium ion battery

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The invention discloses a lithium ion battery and belongs to the technical field of lithium ion batteries. According to the lithium ion battery, a first leadtab is welded to the tail of a first pole piece, a second leadtab is welded to the tail of a second pole piece, double-sided coating areas are arranged on the heads of the first pole piece and the second pole piece correspondingly, and the heads of the first pole piece and the second pole piece are staggered by one fold to be wound. According to the lithium ion battery, two folds of single-sided coating areas and two folds of empty foil areas are totally obtained after the positive pole piece and the negative pole piece are added together, compared with an existing lithium ion battery, two folds of single-sided coating areas can bearedirectly reduced, under the situation that the density of the pole piece surfaces, the compaction density and the capacity are invariable, an inner-layer pole piece can be saved by one fold, a corresponding diaphragm can be saved by two folds, the thickness of the battery is decreased, and the energy density is obviously increased. The leadtabs of the lithium ion battery are welded to the tails ofthe pole pieces, after packaging, back steps are avoided at the leadtabs, and subsequent assembling of elements of protecting plates and the like is facilitated.

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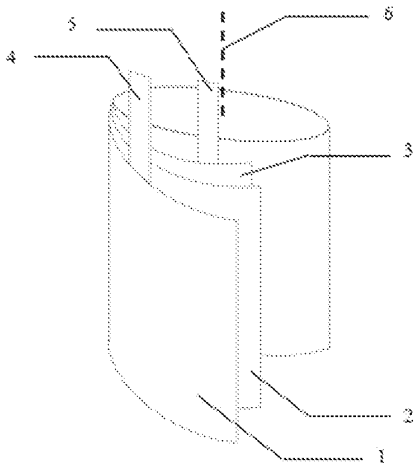
权利要求书1页 说明书3页 附图1页

(54)发明名称

一种锂离子电池

(57)摘要

一种锂离子电池，属于锂离子电池技术领域。所述的锂离子电池将第一极耳焊接在第一极片尾部，第二极耳焊接在第二极片尾部，第一极片和第二极片的头部均为双面涂布区，第一极片和第二极片的头部错开一折卷绕。本发明的锂离子电池，正、负极片相加共有2折单面涂布区和2折空箔区，与现有的锂离子电池相比，直接减少2折单面涂布区，在极片面密度与压实密度、容量不变的情况下，内层极片可节省1折，相应的隔膜节省2折，电池厚度减小，能量密度有明显提高。本发明的锂离子电池极耳焊接在极片尾部，封装后极耳处不存在背部台阶，利于后续保护板等元件的装配。



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1.一种锂离子电池，采用卷绕结构，其特征在于：所述的锂离子电池将第一极耳(4)焊接在第一极片尾部(1)，第二极耳(5)焊接在第二极片尾部(3)，第一极片和第二极片的头部均为双面涂布区，第一极片和第二极片的头部错开一折卷绕。

2.根据权利要求1所述的一种锂离子电池，其特征在于：所述的第一极片尾部(1)和第二极片尾部(3)均设置有空箔区，第一极片尾部(1)的空箔区用于焊接第一极耳(4)，第二极片尾部(3)的空箔区用于焊接第二极耳(5)，且第一极耳(4)和第二极耳(5)的探出方向均平行于卷绕轴线(6)方向。

3.根据权利要求2所述的一种锂离子电池，其特征在于：所述的第一极耳(4)焊接在第一极片尾部(1)空箔区的内侧或外侧，所述的第二极耳(5)焊接在第二极片尾部(3)空箔区的内侧或外侧。

4.根据权利要求1所述的一种锂离子电池，其特征在于：所述的第一极片尾部(1)为正极极片或负极极片。

5.根据权利要求1所述的一种锂离子电池，其特征在于：所述的锂离子电池的卷芯，第一极片为正极极片，收尾处最外侧的第一极片尾部(1)第一折是空箔区，第一极片尾部(1)第二折与第三折是单面涂布区，第一极片其他区域是双面涂布区；同时第二极片为负极极片，第二极片尾部(3)第一折是空箔区，第二极片其他区域是双面涂布区。

6.根据权利要求1所述的一种锂离子电池，其特征在于：所述的锂离子电池的卷芯，第一极片为负极极片，收尾处最外侧的第一极片尾部(1)第一折是空箔区，第一极片尾部(1)第二折与第三折是单面涂布区，第一极片其他区域是双面涂布区；同时第二极片为正极极片，第二极片尾部(3)第一折是空箔区，第二极片其他区域是双面涂布区。

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一种锂离子电池

技术领域

[0001] 本发明属于锂离子电池技术领域，具体涉及一种锂离子电池。

背景技术

[0002] 锂离子电池因具有能量密度高、循环寿命长、无记忆效应等优点，已经在消费类电子产品、电动汽车产品中取得广泛应用。商业化的大容量锂离子电池主要有两种结构：叠片结构与卷绕结构。动力电池主要采用叠片结构，而消费类电池主要采用卷绕结构。虽然目前的卷绕结构已经较为成熟，但其存在的一些缺陷是由结构特点决定的难以克服。第一，因为正、负极耳均焊接在极片头部，除了保留用于焊接极耳的空箔区（集流体两侧均没有电极材料），内层极片还必须保留2折单面涂布区（集流体一侧涂布电极材料）。现有结构通常正极片在外层、负极片在内层：正极片头部有1折空箔区、尾部有2折单面涂布区；负极片有1折空箔区、2折单面涂布区，均处在头部。单面涂布区过多导致电池的能量密度有所损失。第二，极耳焊接在极片头部，卷绕后极耳处在卷芯顶部正中间，在封装后背部台阶（极耳到电芯背部的垂直距离）难以避免，即电芯在一个平面平放时极耳不能紧贴平面，增大后续保护板等元件的装配难度，这在电芯厚度较大时尤其明显。

发明内容

[0003] 本发明的目的是为了解决目前锂离子电池的固有缺陷，提供一种能量密度高、无背部台阶的锂离子电池。

[0004] 为实现上述目的，本发明采取的技术方案如下：

一种锂离子电池，采用卷绕结构，所述的锂离子电池将第一极耳焊接在第一极片尾部，第二极耳焊接在第二极片尾部，第一极片和第二极片的头部均为双面涂布区，第一极片和第二极片的头部错开一折卷绕。

[0005] 本发明相对于现有技术的有益效果是：(1)本发明的锂离子电池，正、负极片相加共有2折单面涂布区和2折空箔区，与现有的锂离子电池相比，直接减少2折单面涂布区，在极片面密度与压实密度、容量不变的情况下，内层极片可节省1折，相应的隔膜节省2折，电池厚度减小，能量密度有明显提高。(2)本发明的锂离子电池极耳焊接在极片尾部，封装后极耳处不存在背部台阶，利于后续保护板等元件的装配。

附图说明

[0006] 图1为本发明的锂离子电池卷芯示意图，其中，1-第一极片尾部，2-隔膜，3-第二极片尾部，4-第一极耳，5-第二极耳，6-卷绕轴线。其中，如果1代表正极片尾部第一折，则3代表负极片尾部第一折、4代表正极耳、5代表负极耳；如果1代表负极片尾部第一折，则3代表正极片尾部第一折、4代表负极耳、5代表正极耳。

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具体实施方式

[0007] 下面结合附图和实施例对本发明的技术方案作进一步的说明，但并不局限于此，凡是对本发明技术方案进行修改或者等同替换，而不脱离本发明技术方案的精神和范围，均应涵盖在本发明的保护范围中。下述说明中所使用到的试剂、材料以及仪器如没有特殊的说明，均为常规试剂、常规材料以及常规仪器，均可商购获得，所涉及的试剂也可通过常规合成方法合成获得。

[0008] 具体实施方式一：如图1所示，本实施方式记载的是一种锂离子电池，采用卷绕结构，所述的锂离子电池将第一极耳4、第二极耳5分别焊接在卷芯最外侧一折的第一极片、第二极片上，即将第一极耳4焊接在第一极片尾部1，第二极耳5焊接在第二极片尾部3，同时去掉内层极片头部的单面涂布区，即第一极片和第二极片的头部均为双面涂布区，第一极片和第二极片的头部错开一折卷绕，保证极片头部的所有电极材料均可有效利用，第一极片和第二极片之间设置有隔膜2。

[0009] 具体实施方式二：具体实施方式一所述的一种锂离子电池，所述的第一极片尾部1和第二极片尾部3均设置有空箔区，第一极片尾部1的空箔区用于焊接第一极耳4，第二极片尾部3的空箔区用于焊接第二极耳5，且第一极耳4和第二极耳5的探出方向均平行于卷绕轴线6方向。

[0010] 具体实施方式三：具体实施方式二所述的一种锂离子电池，所述的第一极耳4焊接在第一极片尾部1空箔区的内侧或外侧，所述的第二极耳5焊接在第二极片尾部3空箔区的内侧或外侧。

[0011] 具体实施方式四：具体实施方式一所述的一种锂离子电池，所述的卷芯收尾处最外侧的第一极片尾部1为正极极片或负极极片。

[0012] 具体实施方式五：具体实施方式一所述的一种锂离子电池，所述的锂离子电池的卷芯，第一极片为正极极片，收尾处最外侧的第一极片尾部1第一折是空箔区，第一极片尾部1第二折与第三折是单面涂布区，第一极片其他区域是双面涂布区；同时第二极片为负极极片，第二极片尾部3第一折是空箔区，第二极片其他区域是双面涂布区。

[0013] 具体实施方式六：具体实施方式一所述的一种锂离子电池，所述的锂离子电池的卷芯，第一极片为负极极片，收尾处最外侧的第一极片尾部1第一折是空箔区，第一极片尾部1第二折与第三折是单面涂布区，第一极片其他区域是双面涂布区；同时第二极片为正极极片，第二极片尾部3第一折是空箔区，第二极片其他区域是双面涂布区。

[0014] 实施例1

制作具有本发明结构的锂离子电池，正极活性材料为钴酸锂，负极活性材料为石墨，电池设计容量4030mAh，卷芯收尾处最外侧是正极片尾部第一折。电池能量密度约738Wh/L，无背部台阶。

[0015] 对比例1

本对比例与实施例1的电池容量相同、极片活性材料的面密度与压实密度相同，差别仅在于：本对比例的电池按照传统常规结构设计制作。电池能量密度约728Wh/L，背部台阶1.2mm。

[0016] 实施例2

本实施例与实施例1的电池容量相同、极片活性材料的面密度与压实密度相同，差别仅

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在于：本实施例的卷芯收尾处最外侧是负极片尾部第一折。电池能量密度约738Wh/L，无背部台阶。

[0017] 对比例2

本对比例与实施例2的电池容量相同、极片活性材料的面密度与压实密度相同，差别仅在于：本对比例的电池按照传统常规结构设计制作。电池能量密度约728Wh/L，背部台阶1.2mm。可见，本发明的锂离子电池，能量密度更高，且没有背部台阶，利于后续保护板等元件的装配。

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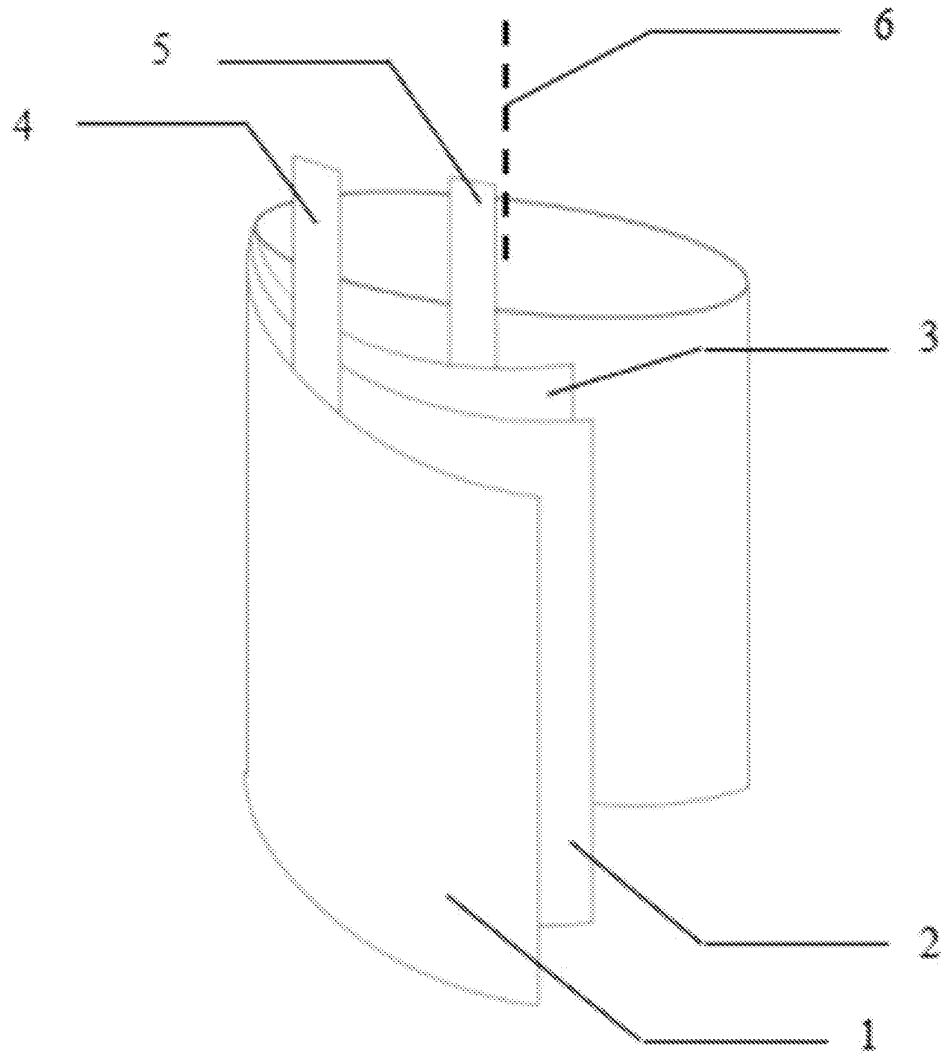


图1

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Espacenet

Bibliographic data: CN101934269 (A) — 2011-01-05

Coating process for cathode material lithium iron phosphate and lithium ion battery thereof

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Classification: **- international:** ***B05D7/14; B05D7/24; C01G53/04; H01M10/36; H01M2/26; H01M4/04; H01M4/36; H01M4/38; H01M4/48; H01M4/50; H01M4/52***

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Abstract of CN101934269 (A)

The invention discloses a coating process for a cathode material lithium iron phosphate and a lithium ion battery thereof. The coating process comprises the following steps of: coating a layer of mixed stock taking LixNiyCozMnpMqO2 as an active substance on a current collector aluminum foil, and oven-drying the mixed stock; and on such a basis, coating a layer of mixed stock taking the lithium iron phosphate material as the active substance, and oven-drying the mixed stock. The coating process for the lithium iron phosphate material can be applied to the production of cylindrical aluminum-shelled lithium ion batteries suitable for high-rate discharge, and has the advantages of solving the problem of material fall caused by poor bonding between the lithium iron phosphate material and the current collector aluminum foil and producing the high-quality rate-type lithium ion batteries, along with simplicity and reliability.

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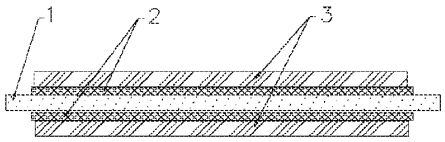
权利要求书 1 页 说明书 3 页 附图 2 页

(54)发明名称

一种正极磷酸亚铁锂材料的涂布工艺及其锂离子电池

(57)摘要

本发明公开的是一种正极磷酸亚铁锂材料的涂布工艺及其锂离子电池；先在集流体铝箔上涂一层以$Li_xNi_yCo_zMn_bM_dO_2$为活性物质的混合浆料，烘干；在此基础之上再涂一层以磷酸亚铁锂材料为活性物质的混合浆料，烘干；应用于上述磷酸亚铁锂材料的涂布工艺生产的一种适合大倍率放电圆柱型铝壳锂离子电池；非常有益的是，解决了磷酸亚铁锂材料与集流体铝箔粘接不好而产生的掉料现象，可以生产出高品质倍率型锂离子电池，工艺简单可靠。



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1. 一种正极磷酸亚铁锂材料的涂布工艺，包括集流体铝箔和涂层，其特征在于：

1) 先在所述集流体铝箔 (1) 两面各涂一层以 LixNiyCozMnpMqO2（其中 $0.9 \leqslant x \leqslant 1.2$，$0.3 \leqslant y \leqslant 0.6$，$0.1 \leqslant z \leqslant 0.6$，$0 \leqslant p \leqslant 0.5$，$0 \leqslant q \leqslant 0.05$，M 为 Mg，Al 等）为活性物质的混合浆料 (2)，烘干。

2) 再在 1) 的基础之上涂一层以磷酸亚铁锂材料为活性物质的混合浆料 (3)，烘干。

2. 根据权利要求 1 所述的一种正极磷酸亚铁锂材料的涂布工艺，其特征在于：所述混合浆料 (2) 的重量比例为活性物质：粘结剂：导电剂：添加剂＝(94-96)：(3-2)：(3-2)：(0-0.01)，溶剂为有机溶剂。

3. 根据权利要求 2 所述的一种正极磷酸亚铁锂材料的涂布工艺，其特征在于：所述混合浆料 (2) 单面涂层厚度控制在 20-50 微米。

4. 根据权利要求 1 所述的一种正极磷酸亚铁锂材料的涂布工艺，其特征在于：所述混合浆料 (3) 的重量比例为活性物质：粘结剂：导电剂：添加剂＝(90-92)：(7-4)：(3-4)：(0-0.01)，溶剂为有机溶剂。

5. 根据权利要求 4 所述的一种正极磷酸亚铁锂材料的涂布工艺，其特征在于：所述混合浆料 (3) 单面涂层厚度控制在 80-150 微米。

6. 根据权利要求 1 所述的一种正极磷酸亚铁锂材料的涂布工艺，其特征在于：所述烘干后的正电极实施滚压，压实密度为 1.9-2.2g/cm3。

7. 应用权利要求 1 制造的一种圆柱型铝壳锂离子电池：包括：正电极、负电极、壳体，其特征在于：正电极为集流体铝箔两面各涂有一层 LixNiyCozMnpMqO2 为活性物质的混合浆料 (2)，烘干；再涂一层以磷酸亚铁锂材料为活性物质的混合浆料 (3)，烘干；负电极为集流体铜箔上涂以人造石墨为活性物质的混合浆料，烘干；

8. 根据权利要求 7 所述的一种圆柱型铝壳锂离子电池，其特征在于：所述正电极压实厚度 180±2 微米；负电极压实厚度为 94±2 微米。

9. 根据权利要求 7 所述的一种圆柱型铝壳锂离子电池，其特征在于：所述负电极采用铜带连接负电极与壳体负极端子。

10. 根据权利要求 7 所述的一种圆柱型铝壳锂离子电池，其特征在于：所述壳体为圆柱形铝壳。

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技术领域

[0001] 本发明涉及一种锂离子电池制造领域，尤其是涉及一种正极磷酸亚铁锂材料的涂布工艺及其锂离子电池。

背景技术

[0002] 目前，用于便携式电动工具、电动马达、航模等需要高倍率放电的电池大多为镍镉电池所垄断，但由于该类电池使用了含有毒性的镉，对环境有严重的污染，另外《关于在电子电气设备中禁止使用某些有害物质指令》(ROHS 指令）的实施，要求投放欧盟市场的电气和电子产品不得含有铅、汞、镉、六价铬、多溴联苯和多溴联苯醚六种有害物质，所以世界各国正在逐步淘汰镍镉电池的生产和使用。锂离子电池以电压高、重量轻、寿命长且无污染成为镍镉电池的首选替代品。从锂离子电池的主要正极材料综合来看其高倍率放电时的性能，钴酸锂，镍钴锰酸锂的安全性能不过关，锰酸锂的高温性能不过关；从安全性和高温寿命角度来看最能适用的目前只有磷酸亚铁锂材料，但其密度小、颗粒小，比表面积很大，导致其与集流体铝箔的粘接性能较差，这无疑影响了其高倍率放电性能和使用寿命，解决磷酸亚铁锂材料的涂布粘接性能，制造出性能优良的适宜大倍率放电的锂离子电池成为燃眉之急。

发明内容

[0003] 本发明主要目的是解决磷酸亚铁锂材料与集流体铝箔粘接不牢的问题，提供一种正极磷酸亚铁锂材料的涂布工艺。

[0004] 本发明的另一个目的是采用上述工艺制造出一种性能优良的适宜大倍率放电的锂离子电池。

[0005] 本发明解决上述技术问题所采用的方法为：一种正极磷酸亚铁锂材料的涂布工艺：

[0006] 1) 先在集流体铝箔两面各涂一层以 $Li_xNi_yCo_zMn_pM_qO_2$（其中 $0.9 \leqslant x \leqslant 1.2$，$0.3 \leqslant y \leqslant 0.6$，$0.1 \leqslant z \leqslant 0.6$，$0 \leqslant p \leqslant 0.5$，$0 \leqslant q \leqslant 0.05$，M 为 Mg，Al 等）为活性物质的混合浆料，烘干；其混合浆料的重量比例分别为活性物质：粘结剂：导电剂：添加剂＝(94-96)：(3-2)：(3-2)：(0-0.01)，溶剂为有机溶剂；这种材料的比表面积小，密度大，粒度适中，易于涂布，与集流体铝箔粘接牢固，并且该材料的放电平台与磷酸亚铁锂材料的放电平台最为接近。

[0007] 2) 在此基础之上再涂一层以磷酸亚铁锂材料为活性物质的混合浆料，烘干；其混合浆料的重量比例分别为活性物质：粘结剂：导电剂：添加剂＝(90-92)：(7-4)：(3-4)：(0-0.01)，溶剂为有机溶剂；这种分层涂布使得磷酸亚铁锂材料通过与第一层材料的粘接再与集流体铝箔导通，这样磷酸亚铁锂材料就能实现更好地粘结，避免了因磷酸亚铁锂材料密度小、比表面积大而与集流体铝箔粘结效果不良造成的极片大量掉料现象，降低了电池的内阻和电化学极化，大大提高了电池的倍率放电性能和循

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环寿命。

[0008] 作为优选，所述 $Li_xNi_yCo_zMn_pM_qO_2$ 混合浆料单面涂层厚度应控制在 20-50 微米；磷酸亚铁锂混合浆料单面涂层控制在 80-150 微米。

[0009] 作为优选，所述正电极整体压实体密度处于 1.9-2.2g/cm^3。

[0010] 作为优选，所述正电极压实厚度 180±2 微米。

[0011] 作为优选，所述所述负电极压实厚度为 94±2 微米。

[0012] 应用于上述磷酸亚铁锂材料的涂布工艺生产的一种适合大倍率放电圆柱型铝壳锂离子电池：包括：正极、负极、壳体，其特征在于：在集流体铝箔两面各涂有一层 $Li_xNi_yCo_zMn_pM_qO$，烘干；再涂一层以磷酸亚铁锂材料为活性物质的混合浆料，烘干、滚压作为正极；在铜箔上涂以人造石墨为活性物质的混合浆料，烘干、滚压负电极；以圆柱形铝壳为壳体，并辅以 PP、PE 复合隔膜、有机电解液制作可大倍率放电的锂离子电池电芯。

[0013] 作为优选，负电极采用铜带连接负电极与壳体负极端子，以降低内阻，减小电池在倍率放电时产生的热量。

[0014] 作为优选，壳体采用铝壳，减轻电池的重量，提升电池重量比能量。

[0015] 因此，本发明一种磷酸亚铁锂材料的涂布工艺及其所制作的大倍率放电圆柱型铝壳锂离子电池带来的有益效果是：解决了磷酸亚铁锂材料与集流体铝箔粘接不好而产生的掉料现象，可以生产出高品质倍率型锂离子电池，工艺简单可靠。

附图说明

[0016] 附图 1 是本发明一种磷酸亚铁锂材料的涂布示意图；

[0017] 附图 2 是本发明锂离子电池正电极极片示意图；

[0018] 附图 3 是本发明锂离子电池负电极极耳示意图；

[0019] 附图 4 是本发明锂离子电池外观示意图；

具体实施方式：

[0020] 下面结合附图对本发明实施例进行详细说明。

[0021] 实施例以 18650 铝壳倍率型锂离子电池为例：

[0022] 1) 在 18 微米铝箔 1 上涂覆一层以 $LiNi_{1/3}Co_{1/3}Mn_{1/3}AlO_2$ 为活性物质的混合浆料 2，涂覆厚度 22±2 微米，烘干。混合浆料 2 配比为 $LiNi_{1/3}Co_{1/3}Mn_{1/3}AlO_2$ ：PVDF(HSV900) ：C-B(V7) ：草酸＝ 96 ： 2 ： 2 ： 0.008，溶剂为 NMP(N- 甲基吡咯烷酮)；

[0023] 2) 在 $LiNi_{1/3}Co_{1/3}Mn_{1/3}AlO_2$ 的表面再涂一层以磷酸亚铁锂材料为活性物质的混合浆料 3，涂覆厚度 100±2 微米（单面），烘干。混合浆料 3 的比例为 $LiFePO_4$ ：PVDF(HSV900) ：S-P ：草酸＝ 90 ： 7 ： 3 ： 0.01，溶剂为 NMP(N- 甲基吡咯烷酮)，见图一。

[0024] 3) 用辊压机将正电极压实至厚度为 180±2 微米（双面），将正电极裁切成宽度 55±0.2 毫米，长度 660±1 毫米的极片 5，用超声焊焊接铝带引线 4 两条，见图二。

[0025] 4) 在 10 微米压延铜箔上涂覆一层以人造石墨为活性物质的混合浆料，涂覆厚度 75±2 微米（单面），烘干作为负极。混合浆料配比为 C(人造石墨) ：PVDF(HSV900) ：S-P ：草酸＝ 96 ： 3 ： 1 ： 0.008，溶剂为 NMP(N- 甲基吡咯烷酮)。

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或混合浆料配比为 C（人造石墨）：CMC：SBR（以固含量计）：S-P = 96：1：2：1，溶剂为去离子水；

[0026] 5）用辊压机将负电极压实至厚度为 94±2 微米（双面），将负电极裁切成宽度 57±0.2 毫米，长度 712±1 毫米的极片 6，用铆焊机焊接铜带引线 7 两条，见图三。

[0027] 6）采用宇部 20 微米（厚）*60 毫米（宽）隔膜卷绕，卷绕使用半自动卷绕机，卷针直径 3.0 毫米；

[0028] 7）将卷芯装入 18650 圆柱形铝壳 8，用超声焊焊接正极耳，高能储能电阻焊焊接负极耳；

[0029] 8）用激光焊焊接上下盖板，干燥，注电解液 5.5±0.1 克，电解液为 $LiPF_6$(1Mol)/EC-DMC-EMC+VC 有机电解液，充电，封孔 9，电池制作完成，见图四。

[0030] 9）该电池的倍率放电性能表如下：

[0031]

项目\放电倍率	1C	10C	15C	20C
放电容量/mAh	1275	1218	1181	1125
比率	100%	95.53%	92.63%	88.24%
备注	测试均为1C充电			

[0032] 本文中所描述的具体实施例仅仅是对本发明精神作举例说明，本发明所属技术领域的技术人员可以对所描述的具体实施例做各种各样的修改或补充或采用类似的方式替代，但并不会偏离本发明的精神或者超越所附权利要求书所定义的范围。

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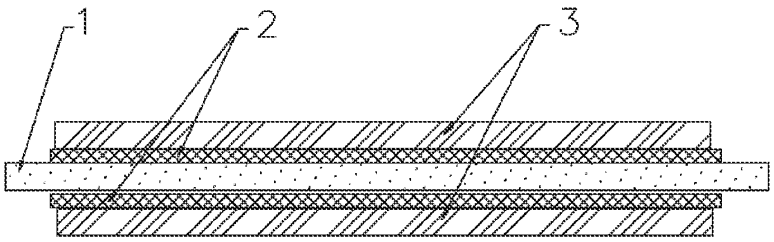


图 1

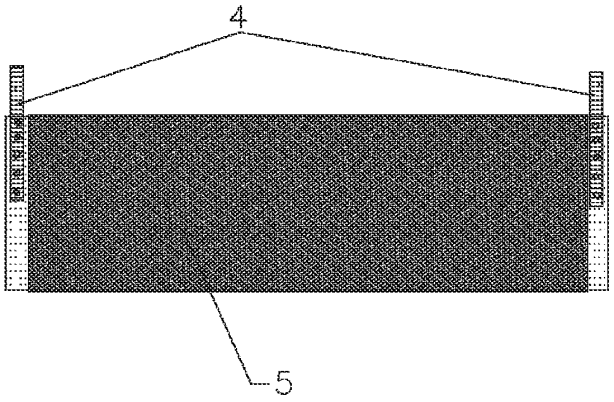


图 2

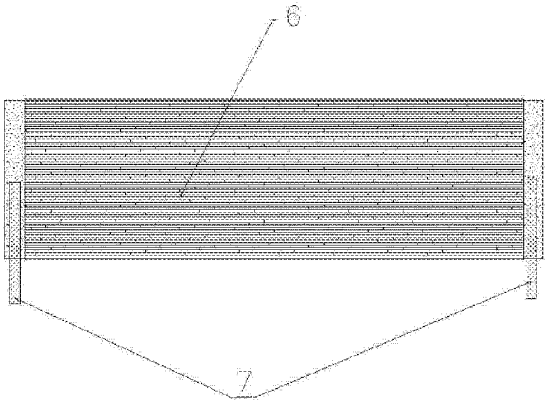


图 3

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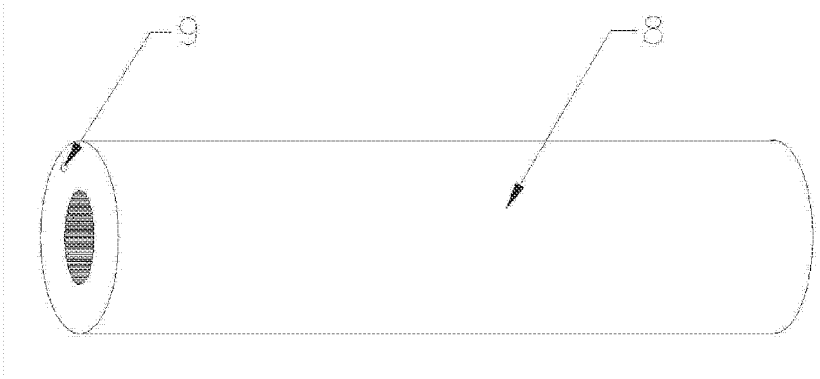


图 4

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Espacenet

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Applicant(s): SONY CORP ± (SONY CORPORATION)

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- cooperative: **H01M10/0525 (EP, US)**; **H01M10/0587 (CN, KR)**; **H01M10/44 (KR)**; **H01M4/02 (KR)**; **H01M4/133 (EP, US)**; **H01M4/364 (EP, US)**; **H01M4/366 (EP, CN, US)**; **H01M4/587 (EP, US)**; **H01M4/62 (KR)**; **H01M4/64 (KR)**; H01M2220/20 (CN); Y02E60/10 (EP, US); Y02P70/50 (EP); Y02T10/70 (US)

Application number: CN201310554554 20131108 Global Dossier

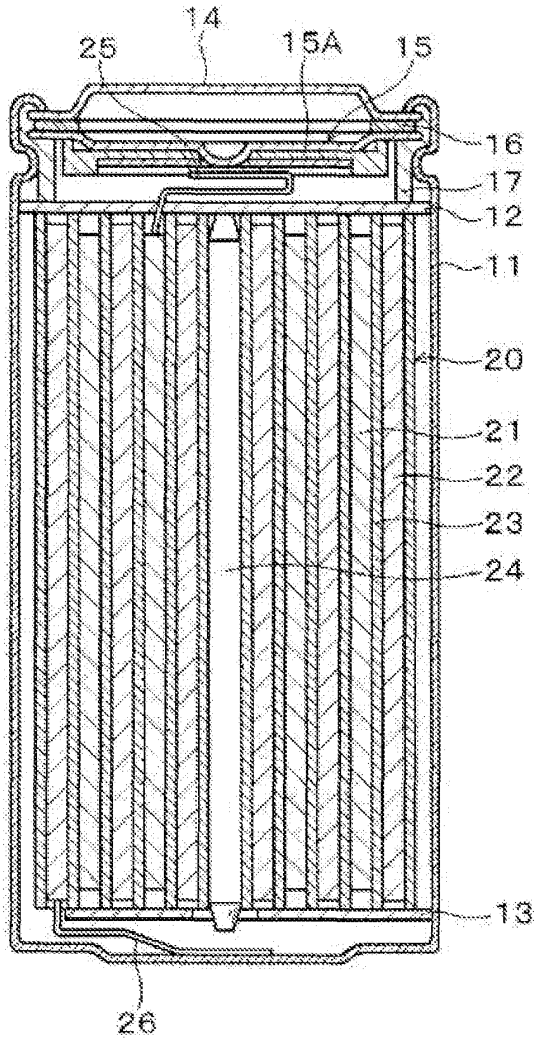
Priority number(s): JP20120252200 20121116

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Abstract of CN103825044 (A)

The present invention relates to a battery, a battery pack, an electronic apparatus, an electric power storage apparatus, and an electric power system, wherein, provided is an anode that includes an anode double side coating section; a first anode single-side coating section; and an anode double side non-coating section, the anode double side non-coating section, the first anode single-side coating section, and the anode double side coating section are provided in this order from a first end on the side of spiral winding start of the anode, and in an anode, ('Area density of an anode mixture layer on the first main surface side of the first anode single-side coating section')/('Area density of the anode mixture layer on the first main surface side of sections other than the first anode single-side coating section') is equal to or more than about 1.2.

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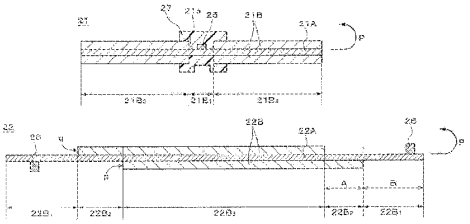
权利要求书4页 说明书30页 附图9页

(54)发明名称

电池、电池组、电子设备、蓄电装置及电力系统

(57)摘要

本发明涉及电池、电池组、电子设备、蓄电装置及电力系统，其中，提供一种负极，包括负极双面涂布部分；第一负极单面涂布部分；和负极双面非涂布部分，所述负极双面非涂布部分、所述第一负极单面涂布部分、和所述负极双面涂布部分顺次从所述负极的螺旋卷绕开始侧的第一端提供，在负极中，(“第一负极单面涂布部分的第一主表面侧上的负极混合物层的面积密度)/(“所述第一负极单面涂布部分以外的部分的第一主表面侧上的负极混合物层的面积密度”)等于或大于1.2。



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1. 一种电池，其包括螺旋卷绕电极体，所述螺旋卷绕电极体包括螺旋卷绕的正极和负极，其中，

所述负极包括：

负极双面涂布部分，在其中，负极混合物层形成在负极集电体的两个主表面上；

第一负极单面涂布部分，在其中，所述负极混合物层仅形成在所述负极集电体的所述两个主表面中的位于外周侧上的第一主表面上；以及

负极双面非涂布部分，在其中，所述负极集电体的两个表面暴露，

所述负极双面非涂布部分、所述第一负极单面涂布部分和所述负极双面涂布部分依次从所述负极的螺旋卷绕开始侧的第一端进行设置，并且

在形成在所述负极集电体的所述第一主表面上的第一主表面侧上的所述负极混合物层中，所述第一负极单面涂布部分的所述第一主表面侧上的所述负极混合物层的面积密度比等于或大于 1.2，所述面积密度比由下面的表达式表达，

[表达式]

所述第一主表面侧上的所述负极混合物层的面积密度比 =(“所述第一负极单面涂布部分的所述第一主表面侧上的所述负极混合物层的面积密度”)/(“所述第一负极单面涂布部分以外的部分的所述第一主表面侧上的所述负极混合物层的面积密度”)。

2. 根据权利要求 1 所述的电池，还包括第二负极单面涂布部分，在其中，所述负极混合物层仅形成在所述负极集电体的所述两个主表面中的位于内周侧上的第二主表面上，其中，

所述第二负极单面涂布部分和所述负极双面非涂布部分依次从所述负极双面涂布部分的螺旋卷绕结束侧上的第一端到所述负极的螺旋卷绕结束侧上的第二端进行设置。

3. 根据权利要求 1 所述的电池，其中

所述正极包括：

正极双面涂布部分，在其中，正极混合物层形成在正极集电体的两个主表面上；以及

正极双面非涂布部分，在其中，所述正极集电体的两个表面暴露，并且

所述正极双面涂布部分、所述正极双面非涂布部分和所述正极双面涂布部分依次从所述正极的螺旋卷绕开始侧的第一端到所述正极的螺旋卷绕结束侧的第二端进行设置。

4. 根据权利要求 3 所述的电池，其中

所述双面非涂布部分基本上布置在所述正极的中心，并且，

引线接合到位于内周侧上的所述正极双面非涂布部分的所述正极集电体的暴露表面。

5. 根据权利要求 3 所述的电池，其中，

所述双面非涂布部分基本上布置在所述正极的中心，并且，

引线接合到位于外周侧上的所述正极双面非涂布部分的所述正极集电体的暴露表面。

6. 根据权利要求 1 所述的电池，其中，所述第一主表面侧上的所述负极混合物层的面积密度比是 1.2 至 1.7。

7. 根据权利要求 1 所述的电池，其中，所述第一负极单面涂布部分的宽度是 6mm 到 21mm。

8. 根据权利要求 1 所述的电池，其中，当所述第一负极单面涂布部分的宽度是 A，所述螺旋卷绕开始侧上的所述负极双面非涂布部分的宽度是 B，且所述螺旋卷绕电极体的最内

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圆周直径是 M 时，满足 0.5M ≤ A ≤ 1.8M 和 0.2M ≤ B ≤ 2.2M。

9. 根据权利要求 1 所述的电池，其中，仅一个连接到所述负极的引线设置在负极集电体的螺旋卷绕结束侧的端部。

10. 一种电池组，其设置有电池、被配置为控制所述电池的控制部分和容纳所述电池的外封装件，

所述电池包括：

螺旋卷绕电极体，所述螺旋卷绕电极体包括螺旋卷绕的正极和负极，其中，

所述负极包括：

负极双面涂布部分，在其中，负极混合物层形成在负极集电体的两个主表面上；

第一负极单面涂布部分，在其中，所述负极混合物层仅形成在所述负极集电体的所述两个主表面中的位于外周侧上的第一主表面上；以及

负极双面非涂布部分，在其中，所述负极集电体的两个表面暴露，

所述负极双面非涂布部分、所述第一负极单面涂布部分和所述负极双面涂布部分依次从所述负极的螺旋卷绕开始侧的第一端进行设置，并且

在形成在所述负极集电体的所述第一主表面上的第一主表面侧上的负极混合物层中，所述第一负极单面涂布部分的所述第一主表面侧上的所述负极混合物层的面积密度比等于或大于 1.2，所述面积密度比由下面的表达式表达，

[表达式]

所述第一主表面侧上的所述负极混合物层的面积密度比 =(“所述第一负极单面涂布部分的所述第一主表面侧上的所述负极混合物层的面积密度”)/(“所述第一负极单面涂布部分以外的部分的所述第一主表面侧上的所述负极混合物层的面积密度”)。

11. 一种电子设备，其设置有电池并被配置为从所述电池接收电力，

所述电池包括：

螺旋卷绕电极体，所述螺旋卷绕电极体包括螺旋卷绕的正极和负极，其中，

所述负极包括：

负极双面涂布部分，在其中，负极混合物层形成在负极集电体的两个主表面上；

第一负极单面涂布部分，在其中，所述负极混合物层仅形成在所述负极集电体的所述两个主表面中的位于外周侧上的第一主表面上；以及

负极双面非涂布部分，在其中，所述负极集电体的两个表面暴露，

所述负极双面非涂布部分、所述第一负极单面涂布部分和所述负极双面涂布部分依次从所述负极的螺旋卷绕开始侧的第一端进行设置，并且

在形成在所述负极集电体的所述第一主表面上的第一主表面侧上的所述负极混合物层中，所述第一负极单面涂布部分的所述第一主表面侧上的所述负极混合物层的面积密度比等于或大于 1.2，所述面积密度比由下面的表达式表达，

[表达式]

所述第一主表面侧上的所述负极混合物层的面积密度比 =(“所述第一负极单面涂布部分的所述第一主表面侧上的所述负极混合物层的面积密度”)/(“所述第一负极单面涂布部分以外的部分的所述第一主表面侧上的所述负极混合物层的面积密度”)。

12. 一种电动车辆，其设置有：电池；转换设备，被配置为将从所述电池供应的电力转

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换为车辆的驱动力；和控制设备，被配置为基于所述电池的信息进行有关车辆控制的信息处理，

所述电池包括：

螺旋卷绕电极体，所述螺旋卷绕电极体包括螺旋卷绕的正极和负极，其中，

所述负极包括：

负极双面涂布部分，在其中，负极混合物层形成在负极集电体的两个主表面上；

第一负极单面涂布部分，在其中，所述负极混合物层仅形成在所述负极集电体的所述两个主表面中的位于外周侧上的第一主表面上；以及

负极双面非涂布部分，在其中，所述负极集电体的两个表面暴露，

所述负极双面非涂布部分、所述第一负极单面涂布部分和所述负极双面涂布部分依次从所述负极的螺旋卷绕开始侧的第一端进行设置，并且

在形成在所述负极集电体的所述第一主表面上的第一主表面侧上的所述负极混合物层中，所述第一负极单面涂布部分的所述第一主表面侧上的所述负极混合物层的面积密度比等于或大于 1.2，所述面积密度比由下面的表达式表达，

[表达式]

所述第一主表面侧上的所述负极混合物层的面积密度比 =(“所述第一负极单面涂布部分的所述第一主表面侧上的所述负极混合物层的面积密度”)/(“所述第一负极单面涂布部分以外的部分的所述第一主表面侧上的所述负极混合物层的面积密度”)。

13. 一种蓄电设备，其设置有电池并被配置将电力供应至连接到所述电池的电子设备，

所述电池包括：

螺旋卷绕电极体，所述螺旋卷绕电极体包括螺旋卷绕的正极和负极，其中，

所述负极包括：

负极双面涂布部分，在其中，负极混合物层形成在负极集电体的两个主表面上；

第一负极单面涂布部分，在其中，所述负极混合物层仅形成在所述负极集电体的所述两个主表面中的位于外周侧上的第一主表面上；以及

负极双面非涂布部分，在其中，所述负极集电体的两个表面暴露，

所述负极双面非涂布部分、所述第一负极单面涂布部分和所述负极双面涂布部分依次从所述负极的螺旋卷绕开始侧的第一端进行设置，并且

在形成在所述负极集电体的所述第一主表面上的第一主表面侧上的所述负极混合物层中，所述第一负极单面涂布部分的所述第一主表面侧上的所述负极混合物层的面积密度比等于或大于 1.2，所述面积密度比由下面的表达式表达，

[表达式]

所述第一主表面侧上的所述负极混合物层的面积密度比 =(“所述第一负极单面涂布部分的所述第一主表面侧上的所述负极混合物层的面积密度”)/(“所述第一负极单面涂布部分以外的部分的所述第一主表面侧上的所述负极混合物层的面积密度”)。

14. 根据权利要求 13 所述的蓄电设备，包括电力信息控制设备，所述电力信息控制设备通过网络将信号传输至其它设备和从所述其他设备接收信号，其中，所述蓄电设备基于由所述电力信息控制设备接收的信息进行所述电池的充放电控制。

15. 一种电力系统，所述电力系统被配置为从电池接收电力，或在其中所述电力从发电

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设备或电力网供应至所述电池，

所述电池包括：

螺旋卷绕电极体，所述螺旋卷绕电极体包括螺旋卷绕的正极和负极，其中，

所述负极包括：

负极双面涂布部分，在其中，负极混合物层形成在负极集电体的两个主表面上；

第一负极单面涂布部分，在其中，所述负极混合物层仅形成在所述负极集电体的所述两个主表面中的位于外周侧上的第一主表面上；以及

负极双面非涂布部分，在其中，所述负极集电体的两个表面暴露，

所述负极双面非涂布部分、所述第一负极单面涂布部分和所述负极双面涂布部分依次从所述负极的螺旋卷绕开始侧的第一端进行设置，并且

在形成在所述负极集电体的所述第一主表面上的第一主表面侧上的负极混合物层中，所述第一负极单面涂布部分的所述第一主表面侧上的所述负极混合物层的面积密度比等于或大于 1.2，所述面积密度比由下面的表达式表达，

[表达式]

所述第一主表面侧上的所述负极混合物层的面积密度比 =(“所述第一负极单面涂布部分的所述第一主表面侧上的所述负极混合物层的面积密度”)/(“所述第一负极单面涂布部分以外的部分的所述第一主表面侧上的所述负极混合物层的面积密度”)。

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电池、电池组、电子设备、蓄电装置及电力系统

[0001] 相关申请的交叉引用

[0002] 本申请要求于 2012 年 11 月 16 日提交的日本优先权专利申请 JP2012-252200 的权益，其全部内容在此通过引用的方式并入本文。

技术领域

[0003] 本技术涉及电池、电池组、电子设备、电动车辆、蓄电设备和电力系统。

背景技术

[0004] 使用非水电解溶液的电池，特别是锂离子二次电池可提供比铅电池和镍镉电池（其为使用水性电解溶液的现有二次电池）具有更高的能量密度。因此，锂离子二次电池的期待度已经增加，且市场已经显著增加。特别而言，最近几年，由于锂离子二次电池的特性（诸如轻重量和高能量密度）适合用于电动汽车和混合动力电动汽车，所以已经积极地进行了对旨在在尺寸上增加锂离子二次电池并实现其高输出的研究。

[0005] 特别而言，为了使用具有较高输出的电池单元，已经建议采用一种结构，其中混合物层形成在正极引线的两侧。由此，能够降低电池电阻并获得用于高输出的专用电池单元。

[0006] 在日本未经审查的专利申请公开号 H4-12471（JP H4-12471A）、H10-79245（JP H10-79245A）、H11-329408（JP H11-329408A）、H10-228930（JP H10-228930A）、2007-305598（JP2007-305598A）、2008-234855（JP2008-234855A）、2001-110453（JP2001-110453A）、2000-195556（JP2000-195556A）和 2001-351610（JP2001-351610A）中，公开了电极等的配置技术。

发明内容

[0007] 电池最好具有有利的循环特性。

[0008] 最好能够提供电池、电池组、电子设备、电动车辆、蓄电设备和电力系统，使其能够提供有利的循环特性。

[0009] 根据本技术的一个实施例，提供了一种电池，其包括螺旋卷绕电极体，螺旋卷绕电极体包括螺旋卷绕的正极和负极，其中，负极包括：负极双面涂布部分，在其中，负极混合物层形成在负极集电体的两个主表面上；第一负极单面涂布部分，在其中，负极混合物层仅形成在负极集电体的两个主表面中的位于外周侧上的第一主表面上；以及负极双面非涂布部分，在其中，负极集电体的两个表面暴露，负极双面非涂布部分、第一负极单面涂布部分、和负极双面涂布部分依次从负极的螺旋卷绕开始侧的第一端进行设置，并且在形成在负极集电体的第一主表面上的第一主表面侧上的负极混合物层中，第一负极单面涂布部分的第一主表面侧上的负极混合物层的面积密度比等于或大于 1.2，面积密度比由下面的表达式表达，

[0010] ［表达式］

[0011] 第一主表面侧上的负极混合物层的面积密度比 =(“第一负极单面涂布部分的第一

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主表面侧上的负极混合物层的面积密度”)/(“第一负极单面涂布部分以外的部分的第一主表面侧上的负极混合物层的面积密度”)。

[0012] 根据本技术的一个实施例，提供了一种电池组，其设置有电池、被配置为控制电池的控制部分和容纳电池的外封装件，电池包括：螺旋卷绕电极体，螺旋卷绕电极体包括螺旋卷绕的正极和负极，其中，负极包括：负极双面涂布部分，在其中，负极混合物层形成在负极集电体的两个主表面上；第一负极单面涂布部分，在其中，负极混合物层仅形成在负极集电体的两个主表面中的位于外周侧上的第一主表面上；以及负极双面非涂布部分，在其中，负极集电体的两个表面暴露，负极双面非涂布部分、第一负极单面涂布部分、和负极双面涂布部分依次从负极的螺旋卷绕开始侧的第一端进行设置，并且在形成在负极集电体的第一主表面上的第一主表面侧上的负极混合物层中，第一负极单面涂布部分的第一主表面侧上的负极混合物层的面积密度比等于或大于 1.2，面积密度比由下面的表达式表达，

[0013] [表达式]

[0014] 第一主表面侧上的负极混合物层的面积密度比 =(“第一负极单面涂布部分的第一主表面侧上的负极混合物层的面积密度”)/(“第一负极单面涂布部分以外的部分的第一主表面侧上的负极混合物层的面积密度”)。

[0015] 根据本技术的一个实施例，提供了一种电子设备，其设置有电池并被配置为从电池接收电力，电池包括：螺旋卷绕电极体，螺旋卷绕电极体包括螺旋卷绕的正极和负极，其中，负极包括：负极双面涂布部分，在其中，负极混合物层形成在负极集电体的两个主表面上；第一负极单面涂布部分，在其中，负极混合物层仅形成在负极集电体的两个主表面中的位于外周侧上的第一主表面上；以及负极双面非涂布部分，在其中，负极集电体的两个表面暴露，负极双面非涂布部分、第一负极单面涂布部分、和负极双面涂布部分依次从负极的螺旋卷绕开始侧的第一端进行设置，并且在形成在负极集电体的第一主表面上的第一主表面侧上的负极混合物层中，第一负极单面涂布部分的第一主表面侧上的负极混合物层的面积密度比等于或大于 1.2，面积密度比由下面的表达式表达，

[0016] [表达式]

[0017] 第一主表面侧上的负极混合物层的面积密度比 =(“第一负极单面涂布部分的第一主表面侧上的负极混合物层的面积密度”)/(“第一负极单面涂布部分以外的部分的第一主表面侧上的负极混合物层的面积密度”)。

[0018] 根据本技术的一个实施例，提供了一种电动车辆，其设置有：电池；转换设备，被配置为将从电池供应的电力转换为车辆的驱动力；和控制设备，被配置为基于电池的信息进行有关车辆控制的信息处理，电池包括：螺旋卷绕电极体，螺旋卷绕电极体包括螺旋卷绕的正极和负极，其中，负极包括：负极双面涂布部分，在其中，负极混合物层形成在负极集电体的两个主表面上；第一负极单面涂布部分，在其中，负极混合物层仅形成在负极集电体的两个主表面中的位于外周侧上的第一主表面上；以及负极双面非涂布部分，在其中，负极集电体的两个表面暴露，负极双面非涂布部分、第一负极单面涂布部分、和负极双面涂布部分依次从负极的螺旋卷绕开始侧的第一端进行设置，并且在形成在负极集电体的第一主表面上的第一主表面侧上的负极混合物层中，第一负极单面涂布部分的第一主表面侧上的负极混合物层的面积密度比等于或大于 1.2，面积密度比由下面的表达式表达，

[0019] [表达式]

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[0020] 第一主表面侧上的负极混合物层的面积密度比 =(“第一负极单面涂布部分的第一主表面侧上的负极混合物层的面积密度”)/(“第一负极单面涂布部分以外的部分的第一主表面侧上的负极混合物层的面积密度”)。

[0021] 根据本技术的一个实施例，提供了一种蓄电设备，其设置有电池并被配置将电力供应至连接到电池的电子设备，电池包括：螺旋卷绕电极体，螺旋卷绕电极体包括螺旋卷绕的正极和负极，其中，负极包括：负极双面涂布部分，在其中，负极混合物层形成在负极集电体的两个主表面上；第一负极单面涂布部分，在其中，负极混合物层仅形成在负极集电体的两个主表面中的位于外周侧上的第一主表面上；以及负极双面非涂布部分，在其中，负极集电体的两个表面暴露，负极双面非涂布部分、第一负极单面涂布部分、和负极双面涂布部分依次从负极的螺旋卷绕开始侧的第一端进行设置，并且在形成在负极集电体的第一主表面上的第一主表面侧上的负极混合物层中，第一负极单面涂布部分的第一主表面侧上的负极混合物层的面积密度比等于或大于 1.2，面积密度比由下面的表达式表达，

[0022] [表达式]

[0023] 第一主表面侧上的负极混合物层的面积密度比 =(“第一负极单面涂布部分的第一主表面侧上的负极混合物层的面积密度”)/(“第一负极单面涂布部分以外的部分的第一主表面侧上的负极混合物层的面积密度”)。

[0024] 根据本技术的一个实施例，提供了一种电力系统，电力系统被配置为从电池接收电力，或在其中电力从发电设备或电力网供应至电池，电池包括：螺旋卷绕电极体，螺旋卷绕电极体包括螺旋卷绕的正极和负极，其中，负极包括：负极双面涂布部分，在其中，负极混合物层形成在负极集电体的两个主表面上；第一负极单面涂布部分，在其中，负极混合物层仅形成在负极集电体的两个主表面中的位于外周侧上的第一主表面上；以及负极双面非涂布部分，在其中，负极集电体的两个表面暴露，负极双面非涂布部分、第一负极单面涂布部分、和负极双面涂布部分依次从负极的螺旋卷绕开始侧的第一端进行设置，并且在形成在负极集电体的第一主表面上的第一主表面侧上的负极混合物层中，第一负极单面涂布部分的第一主表面侧上的负极混合物层的面积密度比等于或大于 1.2，面积密度比由下面的表达式表达，

[0025] [表达式]

[0026] 第一主表面侧上的负极混合物层的面积密度比 =(“第一负极单面涂布部分的第一主表面侧上的负极混合物层的面积密度”)/(“第一负极单面涂布部分以外的部分的第一主表面侧上的负极混合物层的面积密度”)。

[0027] 在本技术的实施例中，由于第一负极单面涂布部分的第一主表面侧上的负极混合物层上的面积密度比等于或大于 1.2，所以可获得有利的循环特性。

[0028] 根据本技术的实施例，可获得有利的循环特性。

[0029] 应理解，前面的一般描述和下面的详细描述是示例性的，并且旨在提供如所要求保护的技术的进一步解释。

附图说明

[0030] 附图被包括以提供对本公开的进一步理解，并且被并入并构成本说明书的一部分。附图示出实施例，并与说明书一起用来解释本技术的原理。

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[0031] 图 1 是示出根据本技术的实施例的非水电解质电池的配置的实例的横截面图。

[0032] 图 2 是示出图 1 中所示的螺旋卷绕电极体的放大部分的横截面图。

[0033] 图 3 是示出螺旋卷绕电极体的螺旋卷绕表面的横截面图。

[0034] 图 4A 是示出螺旋卷绕之前正极的横截面配置的横截面图，且图 4B 是示出螺旋卷绕之前负极的横截面配置的横截面图。

[0035] 图 5A 是示出螺旋卷绕之前现有正极的横截面配置的横截面图，且图 5B 是示出螺旋卷绕之前现有负极的横截面配置的横截面图。

[0036] 图 6A 是示出螺旋卷绕之前现有正极的横截面配置的横截面图，且图 6B 是示出螺旋卷绕之前现有负极的横截面配置的横截面图。

[0037] 图 7 是示出根据本技术的实施例的电池组的配置的实例的方框图。

[0038] 图 8 是示出其中根据本技术的实施例的非水电解质电池应用到住宅电力存储系统的实例的示意图。

[0039] 图 9 是粗略地示出应用本技术的实施例的串联式混合动力系统的混合动力车辆的配置的实例的示意图。

[0040] 图 10 是示出根据本技术的实施例的非水电解质电池的另一实例的螺旋卷绕电极体的螺旋卷绕表面的横截面图。

具体实施方式

[0041] 将参考附图在下面描述本技术的实施例。将按以下顺序给出描述。

[0042] 1. 第一实施例(圆柱型电池的实例)

[0043] 2. 第二实施例(使用电池的电池组的实例)

[0044] 3. 第三实施例(使用电池的蓄电系统等的实例)

[0045] 4. 其它实施方案(修改)

[0046] [1. 第一实施例]

[0047] [电池的配置]

[0048] 将参考附图给出根据本技术的第一实施例的非水电解质电池的描述。附图示出根据本技术的第一实施例的非水电解质电池的横截面结构。图 2 示出图 1 中所示的螺旋卷绕电极体 20 的放大部分的横截面图。图 3 是示出螺旋卷绕电极体的螺旋卷绕表面的横截面图。在图 3 中，未示出隔板。

[0049] 非水电解质电池可以是例如二次电池，其能够充电和放电，诸如锂离子二次电池，在其中负极 22 的容量基于作为电极反应物的锂的插入和提取而表示。

[0050] 如图 1 所示，非水电解质电池主要包含螺旋卷绕电极体 20，在其中正极 21 和负极 22 在之间层叠隔板 23 并螺旋卷绕；和电池壳 11 内的一对绝缘板 12 和 13，其形状使基本中空圆柱体。使用圆柱形电池壳 11 的电池结构可被称为圆柱型。

[0051] 例如，电池壳 11 可具有中空结构，其电池壳 11 的一端关闭，而电池壳 11 的另一端打开。电池壳 11 可由例如铁(Fe)、铝(Al)、它们合金或类似物制成。应注意，在其中电池壳 11 由铁制成的情况下，例如，在电池壳 11 的表面可被镀上镍(Ni)或类似物。一对绝缘板 12 和 13 被布置在之间以夹持螺旋卷绕电极体 20，并垂直延伸到螺旋卷绕电极体 20 的螺旋卷绕圆周表面。

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[0052] 在电池壳 11 的开口端，电池盖 14、安全阀机构 15 和正温度系数装置（PTC 装置）16 通过与密封垫片 17 型锻而附接。由此，电池壳 11 被气密密封。电池盖 14 可由例如类似于电池壳 11 的材料制成。安全阀机构 15 和 PTC 装置 16 提供在电池盖 14 的内部。安全阀机构 15 通过 PTC 装置 16 电连接到电池盖 14。在安全阀机构 15 中，在内部压力通过内部短路、外部加热等成为目标电平或更高电平的情况下，盘片 15A 反转以切断电池盖 14 和螺旋卷绕电极体 20 之间的电连接。PTC 装置 16 可防止由于随着温度的上升而增加电阻（限制电流）而由大电流引起异常发热。垫片 17 可由例如绝缘材料制成。垫片 17 的表面可涂布有例如沥青。

[0053] 如图 2 和图 3 所示，螺旋卷绕电极体 20 可通过以下方式获得：在带状正极 21 和带状负极 22 之间层叠隔板 23 并螺旋卷绕所得到的层叠体。

[0054] 在螺旋卷绕电极体 20 的中心中，插入中心销 24。在螺旋卷绕电极体 20 中，由铝或类似材料制成的引线 25 连接到正极 21，且由镍或类似物制成的引线 26 连接到负极 22。引线 25 通过焊接等附接到安全阀机构 15，从而电连接到电池盖 14。引线 26 通过焊接等附接到电池壳 11，并从而电连接到电池壳 11。在图 1 中，未示出图 3 中的螺旋卷绕电极体 20 的螺旋卷绕开始侧上的引线 26。

[0055] ［正极和负极的配置］

[0056] 图 4A 是示出螺旋卷绕之前正极的横截面配置的横截面图。图 4B 是示出螺旋卷绕之前负极的横截面配置的横截面图。应注意，可通过从图中的每个右侧上的每个电极端在箭头 P 的方向上螺旋卷绕正极和负极获得螺旋卷绕电极体 20。

[0057] ［正极］

[0058] 如图 4A 所示，在正极 21 中，双面涂布部分 $21B_3$（其中正极混合物层 21B 形成在正极集电体 21A 的两个主表面上）、双面非涂布部分 $21B_1$（其中正极混合物层 21B 未形成在正极集电体 21A 的两个主表面中任一个上，且正极集电体 21A 的两个主表面暴露）、和双面涂布部分 $21B_3$（其中正极混合物层 21B 形成在正极集电体 21A 的两个主表面上）以顺次从螺旋卷绕开始侧上的一端至螺旋卷绕结束侧上的另一端提供。双面非涂布部分 $21B_1$ 在纵向方向上基本提供在正极 21 的中心中。

[0059] 在双面非涂布部分 $21B_1$ 中，可提供形状是例如矩形的引线 25。正极 21 具有一种结构，其中正极混合物层 21B 被布置在引线 25 的左侧和右侧。引线 25 可通过使用例如超声波焊接或类似方法的焊接接合到正极集电体 21A 的另一主表面侧上的暴露表面 21a。需注意，在螺旋卷绕之后的螺旋卷绕电极体 20 中，正极集电体 21A 的两个主表面中的一个主表面位于外周侧上，且其另一主表面位于内周侧。引线 25 可接合到正极集电体 21A 的一个主表面侧上的暴露表面 21a 而不是其另一主表面侧上的暴露表面 21a。

[0060] ［保护带］

[0061] 保护带 27 覆盖正极集电体 21A 的所述一个主表面侧上的正极集电体 21A 的暴露表面 21a，并覆盖正极集电体 21A 的暴露表面 21a 和正极集电体 21A 的另一主表面侧上的引线 25。保护带 27 可防止在例如隔板和 / 或类似物在电池失调时分裂时发生电池热致击穿，且正极 21 与负极 22 接触。保护带 27 可以是例如树脂带或类似物。

[0062] ［正极集电体］

[0063] 正极集电体 21A 可处于例如箔片状态，且可由金属材料（诸如铝、镍、不锈钢等）制

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成。

[0064] [正极混合物层]

[0065] 正极混合物层 21B 包含能够嵌入和脱嵌作为正极活性材料的锂的一种或多种正极材料。正极活性材料层 21B 还可根据需要包含其它材料，诸如粘合剂和电导体。

[0066] 作为能够嵌入和脱嵌锂的正极材料，例如，含锂化合物，诸如氧化锂、锂磷氧化物、氮化锂，和含锂的层间化合物可以是合适的，且它们的混合物中的两种或多种也可使用。为了增加能量密度，含锂化合物、过渡金属元素和氧(O)可以是优选的。这样的含锂化合物的实例可包括具有由式(1)表示的层状盐结构的锂复合氧化物，和具有由式(2)表示的橄榄石结构的锂复合磷酸盐。作为含锂化合物，包含选自包括作为过渡金属元素的钴(Co)、镍(Ni)、锰(Mn)和铁(Fe)的组中的一种或多种元素的化合物可以是更优选的。这样的含锂化合物的实例可包括具有由式(3)、式(4)和式(5)中的任何表示的层状盐结构的锂复合氧化物、具有由式(6)表示的尖晶石结构的锂复合氧化物，和具有由式(7)表示的橄榄石结构的锂复合磷酸盐。其具体实例可包括 $LiNi_{x1}Co_{y1}M_{z1}O_2$ (在式中，M 是 Al 和过渡金属(不包括 Ni 和 Co)中的一个或多个；x1 满足 $0<x1<1$，y1 满足 $0<y1<1$，z1 满足 $0<z1<1$，且 x1、y1 和 z1 满足 $x1+y1+z1=1$)、$LiNi_{0.50}Co_{0.20}Mn_{0.30}O_2$、$Li_aCoO_2$($a \approx 1$)、$Li_bNiO_2$($b \approx 1$)、$Li_{c1}Ni_{c2}Co_{1-c2}O_2$($c \approx 1$，$0<c2<1$)、$Li_dMn_2O_4$($d \approx 1$)和 Li_eFePO_4($e \approx 1$)中的一个或多个。

[0067] $Li_pNi_{(1-q-r)}Mn_qM1_rO_{(2-y)}X_z$… (1)

[0068] 在式中，M1 表示选自包括除了(Ni)和锰(Mn)之外的第 2 族元素至第 15 族元素的组中的一种或多种元素；X 表示选自包括除了氧(O)之外的第 16 族元素至和 17 族元素的组中的一种或多种元素；且 p、q、r、y 和 z 是 $0 \leqslant p \leqslant 1.5$、$0 \leqslant q \leqslant 1.0$、$0 \leqslant r \leqslant 1.0$、$-0.10 \leqslant y \leqslant 0.20$ 和 $0 \leqslant z \leqslant 0.2$ 范围内的值。

[0069] $Li_aM2_bPO_4$… (2)

[0070] 在式中，M2 表示选自包括第 2 族元素至第 15 族元素的组中的一种或多种元素；且 a 和 b 是 $0 \leqslant a \leqslant 2.0$ 且 $0.5 \leqslant z \leqslant 2.0$ 范围内的值。

[0071] $Li_fMn_{(1-g-h)}Ni_gM3_hO_{(2-j)}F_k$… (3)

[0072] 在式中，M3 表示选自包括钴(Co)、镁(Mg)、铝(Al)、硼(B)、钛(Ti)、钒(V)、铬(Cr)、铁(Fe)、铜(Cu)、锌(Zn)、锆(Zr)、钼(Mo)、锡(Sn)、钙(Ca)、锶(Sr)和钨(W)的组中的一种或多种元素；且 f、g、h、j 和 k 分别是 $0.8 \leqslant f \leqslant 1.2$、$0 \leqslant g \leqslant 0.5$、$0 \leqslant h \leqslant 0.5$、$g+h<1$、$-0.1 \leqslant j \leqslant 0.2$ 和 $0 \leqslant k \leqslant 0.1$ 范围内的值。需注意，锂组合物可根据充放电状态而变化，且 f 值表示在完全放电状态下的值。

[0073] $Li_mNi_{(1-n)}M4_nO_{(2-p)}F_q$… (4)

[0074] 在式中，M4 表示选自包括钴(Co)、锰(Mn)、镁(Mg)、铝(Al)、硼(B)、钛(Ti)、钒(V)、铬(Cr)、铁(Fe)、铜(Cu)、锌(Zn)、钼(Mo)、锡(Sn)、钙(Ca)、锶(Sr)和钨(W)的组中的一种或多种元素；且 m、n、p 和 q 是 $0.8 \leqslant m \leqslant 1.2$、$0.005 \leqslant n \leqslant 0.5$、$-0.1 \leqslant p \leqslant 0.2$ 和 $0 \leqslant q \leqslant 0.1$ 范围内的值。需注意，锂组合物可根据充放电状态而变化，且 m 值表示在完全放电状态下的值。

[0075] $Li_tCo_{(1-s)}M5_sO_{(2-u)}F_u$… (5)

[0076] 在式中，M5 表示选自包括镍(Ni)、锰(Mn)、镁(Mg)、铝(Al)、硼(B)、钛(Ti)、钒(V)、铬(Cr)、铁(Fe)、铜(Cu)、锌(Zn)、钼(Mo)、锡(Sn)、钙(Ca)、锶(Sr)和钨(W)的组中的

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一种或多种元素；且r、s、t和u是0.8≤r≤1.2、0<s≤0.5、-0.1≤t≤0.2和0≤u≤0.1范围内的值。需注意，锂组合物可根据充放电状态而变化，且r值表示在完全放电状态下的值。

[0077] $Li_vMn_{2-w}M6_wO_xF_y$… (6)

[0078] 在式中，M6表示选自包括钴(Co)、镍(Ni)、镁(Mg)、铝(Al)、硼(B)、钛(Ti)、钒(V)、铬(Cr)、铁(Fe)、铜(Cu)、锌(Zn)、钼(Mo)、锡(Sn)、钙(Ca)、锶(Sr)和钨(W)的组中的一种或多种元素；且v、w、x和y是0.9≤v≤1.1、0≤w≤0.6、3.7≤x≤4.1和0≤y≤0.1范围内的值。需注意，锂组合物可根据充放电状态而变化，且v值表示在完全放电状态下的值。

[0079] Li_zM7PO_4… (7)

[0080] 在式中，M7表示选自包括钴(Co)、锰(Mn)、铁(Fe)、镍(Ni)、镁(Mg)、铝(Al)、硼(B)、钛(Ti)、钒(V)、铌(Nb)、铜(Cu)、锌(Zn)、钼(Mo)、钙(Ca)、锶(Sr)、钨(W)和锆(Zr)的组中的一种或多种元素；且z是0.9≤z≤1.1范围内的值。需注意，锂组合物可根据充放电状态而变化，且z值表示在完全放电状态下的值。

[0081] 除此之外，能够嵌入和脱嵌锂的正极材料的实例可包括不包含锂的无机化合物，诸如MnO_2、V_2O_5、V_6O_{13}、NiS和MoS。

[0082] 能够嵌入和脱嵌锂的正极材料可以是前述实例以外的材料。此外，前述例示的正极材料中的两种或更多种的混合物可用作任意的组合。

[0083] [粘合剂]

[0084] 粘合剂的实例可包括合成橡胶，诸如苯乙烯-丁二烯类橡胶、氟类橡胶，和三元乙丙胶；和聚合物材料，诸如聚偏二氟乙烯。可以单独使用其中的一种，或可以使用其中多种的混合物。

[0085] [电导体]

[0086] 电导体的实例可包括碳材料，诸如石墨和炭黑。可以单独使用其中一种，或可以使用其中多种的混合物。电导体可以是金属材料、导电聚合物或类似物，只要该材料具有导电性即可。

[0087] [负极]

[0088] 如图4B中所示，在负极22中，负极混合物层22B提供在负极集电体22A的一个主表面和另一主表面每个上。在负极22中，由箭头p指示的负极混合物层22B提供在负极集电体22A的一个主表面上，且由箭头q指示的负极混合物层22B提供在负极集电体22A的另一主表面上。在螺旋卷绕之后的螺旋卷绕电极体20中，负极集电体22A的两个主表面中的一个主表面位于外周侧，且其另一主表面位于内周侧。

[0089] 负极22具有双面非涂布部分$22B_1$，在其中负极混合物层22B未形成在负极集电体22A的一个主表面和另一主表面上；和单面涂布部分$22B_2$，在其中负极混合物层22B仅形成在负极集电体的一个主表面和另一主表面上。此外，负极22具有双面涂布部分$22B_3$，在其中负极混合物层22B形成在负极集电体22A的两个主表面上。

[0090] 在负极22中，双面非涂布部分$22B_1$、单面涂布部分$22B_2$、双面涂布部分$22B_3$、单面涂布部分$22B_2$和双面非涂布部分$22B_1$中以顺次从螺旋卷绕开始侧上的一端到螺旋卷绕结束侧的另一端提供。在螺旋卷绕之后，在螺旋卷绕开始侧上的单面涂布部分$22B_2$中，负极

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混合物层 22B 仅形成在一个主表面上以成为负极集电体 22A 的两个主表面外的外周侧。相反，在螺旋卷绕结束侧上的单面涂布部分 $22B_2$ 中，负极混合物层 22B 仅形成在另一主表面上以成为负极集电体 22A 的两个主表面外的内周侧。在螺旋卷绕开始侧上的双面非涂布部分 $22B_1$ 中，引线 26 接合到负极集电体 22A 的另一主表面。在螺旋卷绕结束侧上的双面非涂布部分 $22B_1$ 中，引线 26 接合到负极集电体 22A 的所述一个主表面。

[0091] ［负极混合物层的面积密度］

[0092] 在形成在负极集电体 22A 的一个主表面上的由箭头 p 指示的一个主表面侧上的负极混合物层 22B 中，螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的一个主表面侧上的负极混合物层 22B 的面积密度比（由下面的表达式获得的面积密度比）等于或大于 1.2，且可优选为 1.2 至 1.7，包括两个端点。

[0093] ［表达式］

[0094] “螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的一个主表面侧上的负极混合物层 22B 的面积密度比”=（“螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的一个主表面侧上的负极混合物层 22B 的面积密度比”）/（“螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 以外的部分的一个主表面侧上的负极混合物层 22B 的面积密度”）

[0095] 在其中前述螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的面积密度比小于 1.2 的情况下，在其中作为负极利用率在结构上最高的部分的螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 中，不允许负极利用率充分降低，且循环特性降低。在其中前述螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的面积密度比大于 1.7 的情况下，允许负极利用率充分降低。然而，在这种情况下，螺旋卷绕电极体的宽度增加，从而导致能量密度上的缺点。此外，在这种情况下，额外量的活性材料是必要的，因此，成本会增加。需注意，在例如一旦组装电池单元、对电池单元充电、对电池单元放电直到电压达到 2.5V、拆卸电池单元和随后用溶剂（诸如 DMC（碳酸二甲酯））浸渍拆卸的电池单元达预定时间（诸如 30 分钟）为止之后，可进行测量面积密度。

[0096] ［螺旋卷绕开始侧上的单面涂布部分的宽度］

[0097] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的宽度（图 4B 中的宽度 A）可优选为从 6mm 到 21mm，包括两个端点。在其中螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的宽度小于 6mm 的情况下，不太可能获得防止在循环和 / 或类似的过程中电极表面上发生不正常的 Li 沉淀的效果。在螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的宽度大于 21mm 的情况下，正极混合物存在于相对其中未形成负极 22 的螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的负极混合物层 22B 的侧的部分上。因此，在这种情况下，在循环的时候，在负极 22 的螺旋卷绕开始侧上的单面涂布部分 22B2 中，可能的是，金属（诸如 Li）在负极集电体 22A 上异常析出，从而导致降低了安全性。

[0098] 其中螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的宽度是 A；螺旋卷绕开始侧上的双面非涂布部 $21B_1$ 的宽度（图 4B 中的宽度 B）是 B；螺旋卷绕电极体 20 的最内圆周直径是 M，可优选满足 $0.5M \leqslant A \leqslant 1.8M$ 和 $0.2M \leqslant B \leqslant 2.2M$。在其中不满足前述条件的情况下，在卷绕电极时，电极褶皱可能会在螺旋卷绕开始侧上的双面非涂布部分 $21B_1$ 和螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 中产生，可产生卷绕间隙，且电池的爆炸、热失控，和 / 或类似事故可能会在循环期间发生。在满足前述条件的情况下，可获得其中不产生电极褶皱、卷绕间隙等的电池。需注意，在这个实例中，可在拆卸电池单元之后可在视觉上检测电极褶皱、卷绕

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间隙等。此外，螺旋卷绕电极体 20 的最内圆周直径 M 是通过以下获得的值：“其中在螺旋卷绕开始侧上直径最小的部分的半径 ×2× 圆周率”，且该值可例如通过以下来获得：在拆卸电池后用游标卡尺测量或通过 X- 射线 CT（计算机断层扫描）扫描或类似方法测量螺旋卷绕电极体 20 的横截面图像。

[0099] 负极集电体 22A 可例如处于例如箔片状态，且可由金属材料（诸如铜、镍和不锈钢）制成。

[0100] 负极混合物层 22B 包含能够嵌入和脱嵌作为负极活性材料的锂的一种或多种负极材料。负极活性材料层 22B 还可根据需要包含其它材料，诸如粘合剂和电导体。

[0101] 在负极混合物层 22B 中，例如，为了防止在充电和放电时锂金属无意地析出，负极材料的充电容量可优选大于正极 21 的充电容量。需注意，可以使用类似于正极 21 中描述的粘合剂和导电体。

[0102] 能够嵌入和脱嵌锂的负极材料的实例包括碳材料。碳材料的实例可包括非石墨化碳、石墨化碳，人造石墨（诸如 MCMB（中间相碳微球））、天然石墨、热解碳类、焦炭类、石墨类、玻璃状碳类、有机聚合化合物烧成体、炭黑、碳纤维和活性炭。焦炭的实例可包括沥青焦炭、针状焦炭和石油焦。通过在合适的温度下烧制和碳化聚合物材料（诸如酚醛树脂和呋喃树脂）可获得有机聚合化合物烧成体。某些有机聚合化合物烧成体分为非石墨化碳或石墨化碳。

[0103] 除了前述碳材料之外，能够嵌入和脱嵌锂的负极材料的实例可包括能够嵌入和脱嵌锂并具有作为构成元素的金属元素和类金属元素中的一种或多种的材料，因为由此可获得高能量密度。这种负极材料可以是单体、合金，或金属元素或类金属元素的化合物，或它们的部分或全部可具有一个或多个相位。需注意，除了包括两种或多种金属元素的材料之外，在本技术的实施例中的“合金”还包括包含一种或多种金属元素和一种或多种金属元素的材料。此外，“合金”可包含非金属元素。它们的结构的实例可包括固溶体、共晶（低共熔混合物）、金属间化合物，和其中两种或多种共存的结构。

[0104] 前述金属元素和前述金属元素的实例可包括能够与锂形成合金的金属元素和类金属元素。其具体实例可包括镁（Mg）、硼（B）、铝（Al）、镓（Ga）、铟（In）、硅（Si）、锗（Ge）、锡（Sn）、铅（Pb）、铋（Bi）、镉（Cd）、银（Ag）、锌（Zn）、铪（Hf）、锆（Zr）、钇（Y）、钯（Pd）和铂（Pt）。特别而言，硅、锡或者它们两者可是优选的，且硅可是更优选的。其原因之一是硅和锡都具有嵌入和脱嵌锂的优异能力，因此，可提供高能量密度。

[0105] 包含硅、锡或两者的负极材料的实例可包括单体、合金，和硅的化合物中的任何；单体、合金，和锡的化合物中的任何；和其部分或全部都具有一个或多个相位（phase）的材料。

[0106] 硅的合金的实例可包括包含选自包括锡（Sn）、镍（Ni）、铜（Cu）、铁（Fe）、钴（Co）、锰（Mn）、锌（Zn）、铟（In）、银（Ag）、钛（Ti）、锗（Ge）、铋（Bi）、锑（Sb）和铬（Cr）的组中的一种或多种元素的合金，作为硅以外的第二构成元素。锡的合金的实例可包括包含选自包括硅（Si）、镍（Ni）、铜（Cu）、铁（Fe）、钴（Co）、锰（Mn）、锌（Zn）、铟（In）、银（Ag）、钛（Ti）、锗（Ge）、铋（Bi）、锑（Sb）和铬（Cr）的组中的一种或多种元素的合金，作为锡（Sn）以外的第二构成元素。

[0107] 锡化合物和硅化合物的实例可包括包含氧（O）或碳（C）的化合物。锡化合物和硅

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化合物中的任何可包含除了锡(Sn)或硅(Si)之外的前述第二构成元素。

[0108] 特别而言,作为包含硅(Si)、锡(Sn)或两者的负极材料,例如,作为第一构成元素的包含除了锡(Sn)之外的材料第二构成元素和第三构成元素的材料可是优选的。不用说,这样的负极材料可与任何前述负极材料一起使用。第二构成元素的实施例可包括选自包括(Co)、铁(Fe)、镁(Mg)、钛(Ti)、钒(V)、铬(Cr)、锰(Mn)、镍(Ni)、铜(Cu)、锌(Zn)、镓(Ga)、锆(Zr)、铌(Nb)、钼(Mo)、银(Ag)、铟(In)、铈(Ce)、铪(Hf)、钽(Ta)、钨(W)、铋(Bi)和硅(Si)的组的一种或多种元素。第三构成元素的实例可包括选自包括硼(B)、碳(C)、铝(Al)和磷(P)的组中的一种或多种元素。在其中包含第二构成元素和第三构成元素的情况下,可提高循环特性。

[0109] 特别而言,作为构成元素的包含锡(Sn)、钴(Co)和碳(C)的含SnCoC材料可是优选的。含SnCoC材料的组合物可以是例如如下。即,碳(C)的含量可以是9.9质量%(mass%)至29.7质量%,包括两个端点,且钴(Co)相对于锡(Sn)和钴(Co)的总和(Co/(Sn+Co))可在从30质量%至70质量%的范围内,包括两个端点。在这样的组成范围中,可获得高能量密度,并且可获得优异循环特性。

[0110] 含SnCoC材料在必要时可进一步包含其它元素。作为这样的其它元素,例如,硅(Si)、铁(Fe)、镍(Ni)、铬(Cr)、铟(In)、铌(Nb)、锗(Ge)、钛(Ti)、钼(Mo)、铝(Al)、磷(P)、镓(Ga)、铋(Bi)、或类似元素可是优选的。含SnCoC材料可包含有这些元素中的一种或多种,从而由此可进一步提高容量特性或循环特性。

[0111] 含SnCoC材料具有包含硅(Sn)、钴(Co)和碳(C)的相位。这样的相位可优选具有低结晶结构或无定形结构。此外,在含SnCoC材料中,作为构成元素的碳的部分或全部可作为构成元素被优选结合到金属元素和类金属元素中的一个。其中原因之一是如下。可通过锡(Sn)的凝聚或结晶的和/或类似情况降低循环特性。可通过将碳结合到其它元素来抑制这种凝聚或结晶。

[0112] 用于检查元素的结合状态的测量方法的实例可包括X-射线光电子能谱法(XPS)。在XPS中,在其中进行能量校准以便在84.0eV下获得金原子的4f轨道(Au4f)的峰的设备中,在石墨的情况下,碳的1s轨道(C1s)的峰被示为在284.5eV下,且在表面污染碳的情况下,碳的1s轨道(C1s)的峰被示出在284.8eV下。与此相反,在其中碳元素的电荷密度高的情况下,例如,当碳结合到金属元素或类金属元素时,C1s的峰被示于低于284.5eV的区域中。即,在其中为含SnCoC材料所获得的C1s的合成波的峰被示于低于284.5eV的区域中,在含SnCoC材料中包含的部分或全部碳(C)结合到金属元素和类金属元素中的一个,作为其它构成元素。

[0113] 需注意,在XPS中,例如,C1s的峰可被用于校准频谱的能量轴。一般而言,由于在材料表面上存在表面污染碳,所以表面污染碳的C1s峰被认为是284.8eV,这被用作能源标准。在XPS测量中,可获得C1s的峰的波形,作为包括表面污染碳的峰和含SnCoC材料中碳的峰的形式。因此,例如,可使用市售的软件进行分析,以隔离表面污染碳的峰与含SnCoC材料中碳的峰。在波形分析中,存在最低结合能侧上的主峰的位置是能量标准(284.8eV)。

[0114] 此外,能够嵌入和脱嵌锂的负极材料的实例可包括金属氧化物、聚合化合物,和能够嵌入和脱嵌锂的类似物。金属氧化物的实例可包括钛酸锂($Li_4Ti_5O_{12}$)、氧化铁、氧化钌和氧化钼。聚合化合物的实例可包括聚乙炔、聚苯胺和聚吡咯。

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[0115] 需注意，能够嵌入和脱嵌锂的负极材料可以是前述材料以外的材料。此外，前述负极材料中的两种或多种的混合物可与任意组合使用。

[0116] 负极混合物层 22B 可由例如气相沉积法、液相沉积法、喷涂法、烧制法和涂布法中的任何方法形成，且可使用它们中的两种或多种方法的组合。在其中负极活性材料层 22B 由气相沉积法、液相沉积法、喷涂法、烧制法和它们中的两种或多种方法的组合中的任何方法形成的情况下，负极活性材料层 22B 和负极集电体 22A 之间的接口的部分或全部可优选是合金的。具体而言，在接口中，负极集电体 22A 的构成元素可优选扩散到负极活性材料层 22B 中，负极活性材料层 22B 的构成元素可优选扩散到负极集电体 22A 中，或负极集电体 22A 和负极活性材料层 22B 的构成元素可优选地扩散到彼此。其中原因之一是，允许抑制由于与充电和放电相关联的负极活性材料层 22B 的膨胀和收缩引起的破损，并允许提高负极活性材料层 22B 和负极集电体 22A 之间的电子传导性。

[0117] 汽相沉积法的实例可包括物理沉积法和化学沉积法。更具体而言，其实例可包括真空蒸镀法、溅射法、离子镀法、激光烧蚀法、热化学气相沉积（CVD）法和等离子化学气相沉积法。液相沉积方法的实例可包括已知的方法，诸如电解镀敷法和非电解镀敷法。烧制法可以是例如一种方法，其中与粘合剂和/或类似物混合的颗粒负极活性材料分散在溶剂中，负极集电体 22A 随后被涂布所得物，在高于粘合剂和/或类似物的熔点的温度下进行热处理。作为烧制法，可使用已知的方法。烧制法的实例可包括气氛烧制法、反应烧制法和热压烧制法。

[0118] [隔板]

[0119] 隔板 23 分离正极 21 与负极 22，并传递锂离子，同时防止由两个电极接触造成的电流短路。隔板 23 可以是例如由合成树脂（诸如聚四氟乙烯、聚丙烯和聚乙烯）制成的多孔膜、由陶瓷制成的多孔膜，或类似物。隔板 23 可以是其中两种或多种类型的多孔膜层叠的层叠膜。隔板 23 由作为液体电解质的电解溶液浸渍。

[0120] [电解溶液]

[0121] 通过在非水溶剂中溶解电解质盐来获得电解溶液。离子传导性由电解质盐的电解离解示出。隔板 23 由电解溶液浸渍。电解溶液没有特别限定，可以使用现有的非水溶剂类电解溶液或类似物。

[0122] [电解质盐]

[0123] 电解质盐的实例可包括六氟磷酸锂（$LiPF_6$）、二（五氟乙烷磺酰）酰亚胺锂（$Li(C_2F_5SO_2)_2N$）、高氯酸锂（$LiClO_4$）、六氟砷酸锂（$LiAsF_6$）、四氟硼酸锂（$LiBF_4$）、三氟甲磺酸锂（$LiSO_3CF_3$）、双（三氟甲磺酰基）酰亚胺锂（$Li(CF_3SO_2)_2N$）、三（三氟甲磺酰基）甲基锂（$LiC(SO_2CF_3)_3$）、氯化锂（LiCl）、溴化锂（LiBr）、$LiB(C_6H_5)_4$、$LiCH_3SO_3$、$LiCF_3SO_3$、$LiN(SO_2CF_3)_2$、$LiAlCl_4$、$LiSiF_6$、二氟草酸-O,O′]硼酸锂，和锂二草酸硼酸。特别而言，$LiPF_6$可是优选的，从而由此可获得高离子传导性，从而允许提高循环特性。可单独使用选自前述实例的任何电解质盐，或可使用它们中的多个的混合物。

[0124] [非水溶剂]

[0125] 电解质盐溶于其中的非水溶剂的实例可包括碳酸亚乙酯、碳酸亚丙酯、碳酸亚丁酯、碳酸亚乙烯酯、碳酸二甲酯、碳酸二乙酯、碳酸甲乙酯、4-氟-1,3-二氧戊环-2-酮、γ-丁内酯、γ-戊内酯、1,2-二甲氧基乙烷、四氢呋喃、2-甲基四氢呋喃、1,3-二氧戊环、

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4- 甲基 -1,3- 二氧戊环、乙酸甲酯、丙酸甲酯、丙酸乙酯、乙腈、戊二腈、己二腈、甲氧基乙腈、3- 甲氧基丙腈、N,N- 二甲基甲酰胺、N- 甲基吡咯烷酮、N- 甲基恶唑烷酮、硝基甲烷、硝基乙烷、环丁砜、二甲亚砜、磷酸三甲酯、磷酸三乙酯、亚硫酸亚乙酯、常温熔融盐(诸如双三氟甲基磺酰胺(bistrifluoromethylsulfonylimide)和三甲基己基铵(trimethylhexylammonium))。特别而言,碳酸亚乙酯、碳酸丙烯酯、碳酸亚乙烯酯、4- 氟 -1,3- 二氧戊环 -2- 酮、碳酸二甲酯、碳酸甲乙酯和亚硫酸亚乙酯可是优选的,从而由此可获得优异的充放电容量特性和优异的充放电循环特性。可单独使用任何溶剂,或可使用它们中的多个的混合物。

[0126] [制造电池的方法]

[0127] 可例如通过以下制造方法制造非水电解质电池。

[0128] [正极的制造]

[0129] 首先,制作正极 21。首先,正极活性材料、粘合剂和电导体混合以制备正极混合物。此后,正极混合物分散在有机溶剂中以获得糊状正极混合物浆料。随后,由刮刀、棒式涂布机等对正极集电体 21A 的两个主表面的预定区域均匀地涂布正极混合物浆料,并对其干燥。最后,由辊压机和 / 或类似机器将所得物压缩成型,同时根据需要加热,以形成正极混合物层 21B。在这种情况下,压缩成型可重复几次。

[0130] [负极的制造]

[0131] 接下来,制作负极 22。首先,负极活性材料、粘合剂和电导体根据需要而混合以制备负极混合物。此后,负极混合物分散在有机溶剂中以获得糊状负极混合物浆料。随后,由刮刀、棒式涂布机等对负极集电体 22A 的两个主表面的预定区域均匀地涂布负极混合物浆料,并使其干燥。最后,由辊压机和 / 或类似机器将所得物压缩成型,同时根据需要加热,以形成负极混合物层 22B。

[0132] 需注意,负极 22 可如下制造。首先,制备由电解铜箔等制成的负极集电体 22A。此后,通过气相沉积法(诸如蒸镀法)使负极材料沉积在负极集电体 22A 的两个表面上,以形成多个负极活性材料颗粒。此后,根据需要,可由液相沉积法(诸如液相沉淀法)形成含氧化物的膜,或通过液相沉积方法(诸如电解电镀法)形成金属材料,或可形成含氧化物的膜和金属材料两者,并由此形成负极混合物层 22B。

[0133] [电池的组装]

[0134] 非水电解质电池的组装如下。首先,引线 25 通过焊接和 / 或类似方法附接到正极集电体 21A,引线 26 通过焊接和 / 或类似方法附接到负极集电体 22A。此外,保护带 27 被提供在预定位置处。

[0135] 随后,在正极 21 和负极 22 之间层叠隔板 23 并螺旋卷绕,从而制作螺旋卷绕电极体 20。此后,中心销 24 插入螺旋卷绕电极体的中心。此后,螺旋卷绕电极体 20 被夹持在一对绝缘板 12 和 13 之间,并包含在电池壳 11 中。引线 25 的末端通过焊接附接至安全阀机构 15,且引线 26 的末端通过焊接附接到电池壳 11。

[0136] 随后,前述电解质溶液被注入到电池壳 11 中,且隔板 23 由电解溶液浸渍。最后,在电池壳 11 的开口端处,电池盖 14、安全阀机构 15 和 PTC 装置 16 通过与垫片 17 型锻而固定。由此完成非水电解质电池。

[0137] [本技术的实施例的效果和与现有技术的比较]

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[0138] 在如上所述的本技术的第一实施例中，通过降低负极 22 的螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的负极利用率，允许防止在循环期间在电极表面上的异常锂沉淀，从而由此可获得有利的循环特性。

[0139] 为了增加电池单元的容量，有必要在预定空间中填充更大量的正极活性材料。此外，有必要增加负极利用率以便提高能量密度。然而，在螺旋卷绕结构中，负极的螺旋卷绕开始侧上的单面涂布部分是其中负极利用率在结构上最高的部分。因此，在这样的部分中，在循环期间电极表面上的金属锂异常析出等可能会发生。相反，在本技术的实施例中，通过降低负极的螺旋卷绕开始侧上的单面涂布部分的负极利用率，可抑制在循环期间在电极表面上的金属锂异常析出等。其结果是，可获得有利的循环特性。

[0140] 与此相反，在背景技术中描述的 JP H4-12471A 中，提到了电极板的内周侧上的厚度(活性材料量)和电极板的外周侧上的厚度(活性材料量)之间的差。然而，在 JP H4-12471A 中，没有给出在电极板的一个主表面侧上在纵向方向改变活性材料量的事实的描述，这不同于本技术的实施例中的描述。例如，在 JP H10-79245A 中，虽然提到其中矩形电极板的一个或多个端部厚的结构(活性材料量大)，但是没有给出正极和负极的最佳相对布置结构的描述，这不同于本技术的实施例中的描述。例如，在 JPH11-329408A 中，虽然提到了涂布长度和非涂布长度之间的比，但是没有给出给出本技术的实施例中所描述的正极和负极的最佳相对布置结构的描述。例如，在 JP H10-228930A 和 JP2007-305598A 中，虽然提到了在前表面的涂布端和后表面的涂布端之间具有间隙的电极板，但是没有给出本技术的实施例中所描述的正极和负极的最佳相对布置结构的描述。例如，在 JP2008-234855A 中，虽然提到了在正极板的中间部分的附近具有引线的结构，但是没有给出本技术的实施例中所描述的正极和负极的最佳相对布置结构的描述。例如，在 JP2001-110453A 中，虽然给出了其中负极集电体槽位于负极集电体槽(两个)之间的大致中间部分中的结构，其与负极集电体槽相隔的距离相等，但是没有给出面积密度和循环特性之间的关系的描述，这不同于本技术的实施例中的描述。例如，在 JP2000-195556A 中，虽然给出了其中单面涂布部分的一个或多个电路的结构(单面涂布部分的混合物密度为其它部分的 0.7 至 0.96 倍，且其混合物重量与其它部分重量相同)存在于负极最外周部分，单面涂层的位置不同于本技术的实施例的位置，且其功能和效果也不同于本技术的实施例的那些。例如，在 JP2001-351610A 中，给出了其中表面 B 的涂布开始的位置与其中表面 A 的涂布完成的端部分离 3mm 或更多的事实的描述，因此可抑制突出部的参数。此外，在 JP2001-351610A 中，虽然给出了涂布厚度根据涂布头和电极板之间的间隙的变化而改变的事实的描述，但是没有给出电池结构、面积密度和循环特性之间的关系的描述，这不同于本技术的实施例中的描述。

[0141] 此外，根据本技术的实施例的电极的配置实例不同于下面描述的现有电极的配置。图 5A 是示出螺旋卷绕之前现有正极的横截面配置的横截面图。图 5B 是示出螺旋卷绕之前现有负极的横截面配置的横截面图。在现有的电极中，正极 21 的配置类似于本技术的实施例的配置，而负极 22 的配置不同于本技术的实施例的配置。即，在现有的负极 22 中，双面非涂布部分 $22B_1$ 和双面涂布部分 $22B_3$ 顺次从螺旋卷绕开始侧上的一端提供。与根据本技术的实施例的负极 22 不同，单面涂布部分 $22B_2$ 不提供在位于负极 22 的中心的双面涂布部分 $22B_3$ 和位于螺旋卷绕开始侧的双面非涂布部分 $22B_1$ 之间。

[0142] 在图 5A 和图 5B 中所示的电极配置中，在双面涂布部分 $22B_3$ 中，形成在负极集电

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体 22A 的一个主表面上的负极混合物层 22B 的一部分成为不对电极反应产生贡献的无用部分，从而导致降低能量密度。

[0143] 图 6A 是示出螺旋卷绕之前现有正极的横截面配置的横截面图。图 6B 是示出螺旋卷绕之前现有负极的横截面配置的横截面图。在这个实例中，正极 21 和负极 22 的配置不同于本技术的实施例的那些。即，在现有正极 21 中，双面非涂布部分 $21B_1$、单面涂布部分 $21B_2$、双面涂布部分 $21B_3$、双面非涂布部分 $21B_1$ 和双面涂布部分 $21B_3$ 顺次从螺旋卷绕开始侧上的一端至螺旋卷绕结束侧上的另一端提供，与根据本技术的实施例的正极 21 不同。此外，在现有的负极 22 中，双面非涂布部分 $22B_1$ 和双面涂布部分 $22B_3$ 以该顺序从螺旋卷绕开始侧上的一端提供。与根据本技术的实施例的负极 22 不同，单面涂布部分 22B2 不提供在位于负极 22 的中心的双面涂布部分 $22B_3$ 和位于螺旋卷绕开始侧的双面非涂布部分 $22B_1$ 之间。

[0144] 在图 6A 和图 6B 中所示的电极配置中，在双面涂布部分 $22B_3$ 中，形成在负极集电体 22A 的一个主表面上的负极混合物层 22B 的一部分成为不对电极反应产生贡献的无用部分，从而导致降低能量密度。

[0145] 2. 第二实施例

[0146] [电池组的实例]

[0147] 图 7 是示出当根据本技术的实施例的非水电解质电池（以下被适当简称为“二次电池”）应用于电池组时电路配置的实例的方框图。电池组包括组装电池 301、外封装件、包括充电控制开关 302a 和放电控制开关 303a 的开关部分 304、电流检测电阻 307、温度检测装置 308，和控制部分 310。

[0148] 此外，电池组包括正极端子 321 和负极端子 322。在充电时，正极端子 321 和负极端子 322 连接到电池充电器的正极端子和负极端子，并因此进行充电。与此相反，在使用电子设备时，正极端子 321 和负极端子 322 连接到电子设备的正极端子和负极端子，并因此进行放电。

[0149] 在组装电池 301 中，多个二次电池 301a 串联和 / 或并联连接。每个二次电池 301a 是根据本技术的实施例的二次电池。在图 7 中，作为实例示出其中六个二次电池 301a 以两个并联和三个串联（2P3S）的方式连接的情况。然而，除此之外，可采用任何其它连接方法，诸如 n 个并联和和 m 个串联（n 和 m 是整数）。

[0150] 开关部分 304 包括充电控制开关 302a、二极管 302b、放电控制开关 303a 和二极管 303b，并由控制部分 310 控制。二极管 302b 的极性处于与在从正极端子 321 到组装电池 301 的方向上流动的充电电流相反的方向上，和相对于在从负极端子 322 到组装电池 301 的方向上流动的放电电流的前向方向上。二极管 303b 的极性处于相对于充电电流的前向方向上和与放电电流相反的方向上。需注意，尽管在该实例中，开关部分提供在正侧，但是开关部分也可提供在负侧。

[0151] 当电池电压成为过充电检测电压时，充电控制开关 302a 被控制以断开，使得通过充放电控制部分使充电电流不会流入组装电池 301 的电流通路。在充电控制开关 302a 断开之后，可通过二极管 302b 仅启动放电。此外，当大电流在放电时流过时，充电控制开关 302a 被控制以断开，使得通过控制部分 310 阻止充电电流在组装电池 301 的电流通路中流动。

[0152] 当电池电压变为过放电检测电压时，放电控制开关 303a 被控制以断开，以通过控

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制部分 310 使放电电流不会流入组装电池 301 的电流通路。在放电控制开关 303a 断开之后，可通过二极管 303b 仅启动充电。此外，当大电流在放电时流过时，放电控制开关 303a 被控制以断开，使得通过控制部分 310 阻止放电电流在组装电池 301 的电流通路中流动。

[0153] 温度检测装置 308 可以是例如热敏电阻。温度检测装置 308 提供在组装电池 301 的附近、测量组装电池 301 的温度，并将所测量的温度供应至控制部分 310。电压检测部分 311 测量组装电池 301 的电压和每个二次电池 301a 的电压，对所测量的电压进行模拟到数字的转换，并将所得结果供应到控制部分 310。电流测量部分 313 使用电流检测电阻 307 测量电流，并将所测量的电流供应到控制部分 310。

[0154] 开关控制部分 314 基于从电压检测部分 311 和电流测量部分 313 输入的电压和电流控制开关部分 304 的充电控制开关 302a 和放电控制开关 303a。在其中二次电池 301a 的任何电压变得等于或高于过充电检测电压或过放电检测电压的情况下，或在其中大电流迅速流过的情况下，开关控制部分 314 将控制信号发送到开关部分 304，并因此可防止过充电、过放电和过电流充电和放电。

[0155] 例如，在二次电池是锂离子二次电池的情况下，过充电检测电压可被确定为例如 4.20±0.05V，且过放电检测电压可被确定为例如 2.4±0.1V。

[0156] 作为充放电开关，例如，可以使用半导体开关，诸如 MOSFET。在这种情况下，MOSFET 的寄生二极管起到二极管 302b 和 303b 的功能。在其中 P 沟道 FET 被用作充放电开关的情况下，开关控制部分 314 将控制信号 DO 和 CO 供应至充电控制开关 302a 和放电控制开关 303a 的各自栅极。在 P 沟道的情况下，充电控制开关 302a 和放电控制开关 303a 由低于源极电位预定值或更多的栅极电位闭合。即，在正常充电和放电操作中，控制信号 DO 和 CO 被设置为低电平，且充电控制开关 302a 和放电控制开关 303a 闭合。

[0157] 例如，在过充电或过放电的情况下，控制信号 CO 和 DO 可被设置为高电平，且充电控制开关 302a 和放电控制开关 303a 可断开。

[0158] 存储器 317 可以是 RAM 或 ROM，并且可以是例如作为非易失性存储器的 EPROM（可擦除可编程只读存储器），或类似物。存储器 317 预先存储由控制部分 310 计算的数值、在制造步骤中测量的各自二次电池 301a 的初始状态下的电池的内部电阻值和类似值等，并可适当地改写值。此外，通过在存储器 317 中存储各自二次电池 301a 的满充电容量，例如，允许剩余容量由控制部分 310 一起计算。

[0159] 温度检测部分 318 使用温度检测装置 308 测量温度、在异常发热时控制充电和放电，或在计算剩余容量时进行校正。

[0160] [3. 第三实施例]

[0161] 前述非水电解质电池、和使用相同电池的电池组、电池单元、电池模块可安装到诸如电子设备、电动车辆和蓄电设备的设备上或者也可用于将电力供应至这样的设备。

[0162] 电子设备的实例可包括笔记本个人计算机、PDA（个人数字助理）、移动电话、无绳手机、视频摄像机、数字静态相机、电子书、电子词典、音乐播放器、收音机、耳机、游戏机、导航系统、记忆卡、心脏起搏器、助听器、电动工具、电动剃须刀、冰箱、空调、电视、立体声音响、热水器、微波炉、洗碗机、洗衣机、烘干机、灯、玩具、医疗设备、机器人、负载调节器和交通灯。

[0163] 此外，电动车辆的实例可包括铁路车辆、高尔夫车、电动拖车、电动汽车（包括混合

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动力汽车)。前述非水电解质电池、和使用相同电池的电池组、电池单元、电池模块可用作这些电动车辆的驱动电力源或辅助电力源。

[0164] 蓄电设备的实例可包括用于为建筑物(诸如房子)或为发电设施蓄电的电力源。

[0165] 在前述应用实例中,将在下面给出蓄电系统的具体实例的描述,其中每个系统都使用根据本技术的实施例的前述非水电解质电池应用于其的蓄电设备。

[0166] 蓄电系统的配置的实例可包括以下系统。第一蓄电系统是其中蓄电设备由可再生能源产生电力的发电设备充电的蓄电系统。第二电力存储系统是其中电力被供应至连接到蓄电设备的电子设备的蓄电设备。第三蓄电系统是从蓄电设备供应电力的电子设备。这些蓄电系统中的每一个都可作为与外部电力供应网一起合作有效地供应电力的系统而实施。

[0167] 此外,第四蓄电系统是电动车辆,其具有:从蓄电设备供应电力并将电力转换成车辆的驱动力的转换设备;和控制设备,其基于蓄电设备的信息进行车辆控制的信息处理。第五蓄电系统是这样一种电力系统,其包括电力信息发射器/接收器部分,该发射器/接收器部分通过网络向其它设备发送信号和从其他设备接收信号,该电力系统基于由发射器/接收器部分接收的信息进行前述蓄电设备的充放电控制。第六蓄电系统是这样一种电力系统,其中从前述蓄电设备供应电力,且从发电设备或电力网将电力供应至蓄电设备。

[0168] [3-1. 作为应用实例的住宅中的蓄电系统]

[0169] 将参考图 8 给出其中使用根据本技术的实施例的非水电解质电池的蓄电设备被被应用到住宅的蓄电系统的实例。例如,在住宅 401 的蓄电系统 400 中,通过电力网 409、信息网 412、智能仪表 407、电力枢纽 408 和/或类似物将电力从集中电力系统 402(诸如热发电系统 402a、核发电系统 402b,和水发电系统 402c)供应到蓄电设备 403。除此之外,电力被从独立的电力源(诸如家用发电设备 404)供应到蓄电设备 403。供应到蓄电设备 403 的电力被存储。使用蓄电设备 403,用于住宅 401 的电力被供应至住宅 401。蓄电系统不仅可用于住宅 401,而且也可用于其它建筑物。

[0170] 住宅 401 设有发电设备 404、电力消耗设备 405、蓄电设备 403、控制各设备的控制设备 410、智能电表 407,和获取各种信息的传感器 411。各个设备通过电力网 409 和信息网 412 连接。作为发电设备 404,可使用太阳能电池、燃料电池,和/或类似电池。产生的电力被供应至电力消耗设备 405 和/或蓄电设备 403。电力消耗设备 405 的实例可包括冰箱 405a、空调 405b、电视 405c 和淋浴器 405d。此外,电力消耗装置 405 的实例可包括 406 电动车辆。电动车辆 406 的实例可包括电动汽车 406a、混合动力汽车 406b 和电动摩托车 406c。

[0171] 根据本技术的实施例的非水电解质电池被应用到蓄电设备 403。根据本技术的实施例的非水电解质电池可以是例如前述锂离子二次电池。智能电表 407 具有如下功能:测量商用电力的使用量和将所测量的使用量发送到电力公司。电力网 409 可以是直流馈电、交流馈电和非接触馈电,或它们的组合中的一种。

[0172] 各种传感器 411 的实例可包括运动传感器、照度传感器、目标传感器、电力消耗传感器、振动传感器、接触传感器、温度传感器,和红外传感器。从各种传感器 411 获取的信息被发送至控制设备 410。由于可感知到来自传感器 411 的信息,天气状态、人的状态,和/或类似状态,所以电力消耗设备 405 被自动控制,且允许能源消耗最小化。此外,允许控制设备 410 通过互联网将住宅 401 的信息发送到外部电力公司和/或类似地方。

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[0173] 电力枢纽 408 进行处理，诸如分支化电力线和 AC/DC 转换。连接到控制设备 410 的信息网络 412 的通信方法的实例可包括使用通信接口，(诸如 UART (通用异步接收器 - 收发器)) 的方法和利用基于无线通信标准的 (蓝牙、ZigBee 和 Wi-Fi) 传感器网络的方法。蓝牙方法适用于多媒体通信，并允许一对多的通信。ZigBee 采用 IEEE (电气和电子工程师协会) 802.15.4 物理层。IEEE802.15.4 是被称为 PAN (个人域网络) 或 W (无线) PAN 的短距离无线网络标准的名字。

[0174] 控制设备 410 连接到外部服务器 413。服务器 413 可由住宅 401、电力公司和服务提供商中的任一个进行管理。从服务器 413 发送和由其接收的信息的实例可包括消费者电力信息、生活模式信息、电费、天气信息、自然灾害信息和电力交易的信息。这样的信息可从家用电力消耗设备 (诸如电视) 发送或由其接收，或可从宅外设备 (诸如移动电话) 发送或由其接收。这样的信息可被显示在具有显示功能的设备上，诸如电视、移动电话和 PDA (个人数字助理)。

[0175] 控制各自部分的控制设备 410 由 CPU (中央处理单元)、RAM (随机存取存储器)、ROM (只读存储器) 和 / 或类似存储器形成。在这个实例中，控制设备 410 被存储在蓄电设备 40 中。控制设备 410 通过信息网 412 连接到蓄电设备 403、家用发电设备 404、电力消耗设备 405、各种传感器 411 和服务器 413。例如，控制设备 410 可具有调整商用电力的使用量和发电量的功能。需注意，除此之外，控制设备 410 可具有在电力市场进行电力交易的功能。

[0176] 如上所述，不仅允许由集中电力系统 402 (诸如热发电系统 402a、核发电系统 402b 和水发电系统 402c) 产生的电力，而且也允许由家用发电设备 404 (太阳能发电或风力发电) 产生的电力被存储在蓄电设备 403 中。因此，即使由家用发电设备 404 产生的电力是可变的，也允许执行控制，使得在外部发送的电力量变成恒定的，或者可根据需要进行放电。例如，通过太阳能发电获得的电力可存储在蓄电设备 403 中，而在电费便宜的午夜的电力可被存储在蓄电设备 403 中且由蓄电设备 403 存储的电力可在电费昂贵的日间期间可被充电和使用。

[0177] 在这个实例中，已经给出了其中控制设备 410 被存储在蓄电设备 403 中的实例的描述。然而，控制设备 410 可被存储在智能电表 407 中，且本身可配置。此外，蓄电系统 400 可用于住宅区的多个家庭，或可用于多个独户住房。

[0178] [3-2. 作为应用实例的车辆中的蓄电系统]

[0179] 将参考图 9 给出其中本技术的实施例应用到车辆的蓄电系统的实例的描述。图 9 示意地示出采用本公开的实施例应用于其的串联式混合动力系统的混合动力车辆的配置的实例。串联式混合动力系统是汽车，其通过使用由通过发动机移动的发电机产生的电力或曾经存储在电池中的该电力的电力 / 驱动力转换设备运行。

[0180] 在混合式车辆 500 中，发动机 501、发电机 502、电力 / 驱动力转换设备 503、驱动轮 504a、驱动轮 504b、车轮 505a、车轮 505b、电池 508、车辆控制设备 509、各种传感器 510 和充电入口 511 都包括在内。根据本公开的实施例的前述非水电解液电池应用于电池 508。

[0181] 混合动力汽车 500 使用电力 / 驱动力转换设备 503 作为动力源而运行。电力 / 驱动力转换设备 503 的实例可包括电机。电力 / 驱动力转换设备 503 由电池 508 的电力来操作，并且电力 / 驱动力转换设备 503 的转矩 (torque) 被传送到驱动轮 504a 和 504b。需注意，通过在需要的地方使用直流 - 交流 (DC-AC) 转换或逆转换 (AC-DC 转换)，电力 / 驱动力

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转换设备 503 可使作交流电机或直流电机。各种传感器 510 通过车辆控制设备 509 控制发动机频率，并控制未示出的节流阀的开放程度(节流阀开度水平)。各种传感器 510 可包括速度传感器、加速度传感器、发动机频率传感器和 / 或类似传感器。

[0182] 发动机 501 的转矩被传送到发电机 502。允许由于转矩而由发电机 502 产生的电力被存储在电池 508 中。

[0183] 当混合动力车辆 500 的速度由未示出的制动机构降低时，减速时的阻力作为转矩被添加到电力 / 驱动力转换设备 503，且允许由于转矩而由电力 / 驱动力转换设备 503 产生的再生电力被存储在电池 508 中。

[0184] 电池 508 可连接到混合动力车辆 500 的外部电力源，从而可通过作为输入端口的充电入口 511 从外部电力源供应电力，并且可存储所接收的电力。

[0185] 虽然未示出，但是基于二次电池的信息进行车辆控制的信息处理的信息处理设备可被包括在内。这样的信息处理设备的实例可包括基于剩余电池容量的信息进行剩余电池容量的显示的信息处理设备。

[0186] 已经给出了使用由发动机操作的发电机产生的电力或作为实例曾经被存储在电池中的这样电力的电机运行的串联式混合动力汽车的描述。然而，本技术的实施例可有效适用于并联式混合动力汽车，其通过切换以下三种方法而使用：仅由发动机运行、仅由电机运行，和使用发动机和电机的两个输出作为驱动源适当地由发动机和电机运行。此外，本技术的实施例可有效适用于所谓的电动车辆，其在不使用发动机的情况下仅由驱动电机的驱动运行。

[0187] [实例]

[0188] 将在下面详细描述本技术的实施例的具体实例。然而，本技术的实施例不限于此。

[0189] [实例 1]

[0190] [负极的制作]

[0191] 96 质量份作为负极活性材料的粉碎石墨粉末，2 份质量作为粘合剂的 SBR (苯乙烯 - 丁二烯橡胶)、2 质量份 CMC (羧甲基纤维素)，和作为溶剂的离子交换水混合，以制备负极混合物浆料。接下来，由 12μm 厚的铜箔制成的负极集电体的单一表面上均匀地涂布负极混合物浆料，进一步，其另一表面上均匀地涂布负极混合物浆料，将所得物干燥，并由辊压机压模成型，使得混合物层具有预定密度，以形成负极混合物层。最后，压制的电极被切分为具有预定宽度的形状，Ni 引线通过超声波焊接附接到集电体上以制作负极。

[0192] 在制作负极时，调节负极混合物层的形成区域和负极混合物层的面积密度，并形成双面非涂布部分 $22B_1$、单面涂布部分 $22B_2$ 和双面涂布部分 $22B_3$，如图 4B 所示。在螺旋卷绕之后，在螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 中，负极混合物层 22B 仅形成在一个主表面上以成为负极集电体 22A 的两个主表面中的外周侧。与此相反，在螺旋卷绕结束侧上的单面涂布部分 $22B_2$ 中，负极混合物层 22B 仅形成在的另一主表面上以成为负极集电体 22A 的两个主表面中的内周侧。

[0193] 在形成在负极集电体 22A 的一个主表面侧上的由箭头 p 指示的一个主表面侧上的负极混合物层 22B 中，由下面表达式获得的螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的一个主表面侧上的负极混合物层 22B 的面积密度比被设置为 1.36。需注意，可在例如组装电池单元、对电池单元充电、对电池单元放电直到电压达到 2.5V、拆卸电池、随后由 DMC (碳酸二

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甲酯）溶剂浸渍拆卸的电池单元达预定时间（30 分钟）之后测量面积密度。

[0194] ［表达式］

[0195] “螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的一个主表面侧上的负极混合物层 22B 的面积密度比 =（“螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的一个主表面侧上的负极混合物层 22B 的面积密度”）/（“螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 以外的部分的该一个主表面侧上的负极混合物层 22B 的面积密度”）。

[0196] 在下面的描述中，在某些情况下，“螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的一个主表面侧上的负极混合物层 22B 的面积密度比”可简称为“螺旋卷绕开始侧上的单面涂布部 $22B_2$ 的面积密度比”。此外，在某些情况下，“螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的一个主表面侧上的负极混合物层 22B 的面积密度”可简称为“螺旋卷绕开始侧上的单面涂布部分 22B2 的面积密度”。另外，在某些情况下，“螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 以外的部分的该一个主表面侧上的负极混合物层 22B 的面积密度”可简称为“螺旋卷绕开始侧上的单面的涂布部分 $22B_2$ 以外的部分的面积密度。

[0197] 此外，负极 22 的螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的宽度 A 和负极 22 的螺旋卷绕开始侧上的双面非涂布部分 $22B_1$ 的宽度 B 为如下。需注意，在调整负极混合物层的前述面积密度时，“螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的面积密度”和“螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 以外的部分的面积密度”作如下调整。

[0198] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的面积密度：19.5mg/cm^2

[0199] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 以外的部分的面积密度：14.3mg/cm^2

[0200] 宽度 A：14mm

[0201] 宽度 B：17mm

[0202] ［正极的制作］

[0203] 95 质量份正极活性材料、2.5 质量份作为电导体的石墨，和 2.5 质量份作为粘合剂的聚偏二氟乙烯（PVDF）混合以获得正极混合物。混合物分散在作为溶剂的 N- 甲基 -2- 吡咯烷酮中，以获得糊状正极混合物浆料。接下来，不包括正极引线部分，由 15μm 厚的带状铝箔制成的正极集电体的单一表面被间断地均匀涂布正极混合物浆料，将所得物干燥。此外，不包括正极引线部分，其另一表面被间断地涂布正极混合物浆料，将所得物干燥并由辊压机压模成型，以形成正极混合物层。压制的电极被切分为具有预定宽度的形状。此后，100μm 厚的 Al 引线通过超声波焊接附接到集电体，中间的间断部分（双面非涂布部分）的引线和 Al 集电体的暴露部分覆盖着 PI（聚酰亚胺）带，并由此制作正极电极。此外，电极在螺旋卷绕开始侧和螺旋卷绕结束侧上的层叠部分被切断，使得除了在正极板的中心中的非涂布部分以外，不存在非涂布部分。

[0204] ［电解溶液的制作］

[0205] 作为电解溶液，使用包含通过在体积比为 2:2:6 下混合碳酸亚乙酯（EC）、碳酸甲乙酯（EMC）和碳酸二甲酯（DMC）所获得的混合溶剂和作为电解质盐的六氟磷酸锂（$LiPF_6$）的溶液。电解溶液中的六氟磷酸锂（$LiPF_6$）的浓度为 1mol/dm^3。

[0206] ［隔板］

[0207] 作为隔膜，使用由 20μm 厚的聚乙烯制成的多孔膜。

[0208] ［试验电池的制作］

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[0209] 在组装二次电池时，正极和负极在之间层叠隔板并螺旋卷绕。此后，螺旋卷绕体的端部分通过胶带固定以制作螺旋卷绕电极体。此时，螺旋卷绕电极体的最内圆周直径 M 被设置为 11.5mm。

[0210] 随后，中心销被插入螺旋卷绕电极体的中心。随后，螺旋卷绕电极体被夹持在一对绝缘板之间，并被包含在镀镍的铁电池壳中。在这种情况下，正极引线的一个末端通过焊接附接到安全阀机构，且负极引线的一个末端通过焊接附接到电池壳。随后，通过减压方法将电解溶液注入到电池壳中，且隔板由电解溶液浸渍。最后，在电池壳的开口端，电池盖、安全阀机构和 PTC 装置通过与密封垫片 17 型锻而固定。从而完成圆柱型二次电池（直径：18mm，高度：65mm）。

[0211] [实例 2]

[0212] 在制作负极时，负极混合物层的形成区域和负极混合物层的面积密度被调整如下。除了这一点之外，与实例 1 一样来制作二次电池。

[0213] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的面积密度：24.3mg/cm^2

[0214] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 以外的部分的面积密度：14.3mg/cm^2

[0215] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的面积密度比：1.70

[0216] 宽度 A：9mm

[0217] 宽度 B：17mm

[0218] [实例 3]

[0219] 在制作负极时，负极混合物层的形成区域和负极混合物层的面积密度被调整如下。除了这一点之外，与实例 1 一样来制作二次电池。

[0220] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的面积密度：21.3mg/cm^2

[0221] 螺旋卷绕开始侧上的单面涂布部分 22B2 以外的部分的面积密度：14.3mg/cm^2

[0222] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的面积密度比：1.49

[0223] 宽度 A：14mm

[0224] 宽度 B：5mm

[0225] [实例 4]

[0226] 在制作负极时，负极混合物层的形成区域和负极混合物层的面积密度被调整如下。此外，螺旋卷绕电极体的最内圆周直径 M 是 9.4mm。除了这一点之外，与实例 1 一样来制作二次电池。

[0227] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的面积密度：21.3mg/cm^2

[0228] 螺旋卷绕开始侧上的单面涂布部 $22B_2$ 以外的部分的面积密度：14.3mg/cm^2

[0229] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的面积密度比：1.49

[0230] 宽度 A：12mm

[0231] 宽度 B：15mm

[0232] [实例 5]

[0233] 在制作负极时，负极混合物层的形成区域和负极混合物层的面积密度被调整如下。除了这一点之外，与实例 1 一样来制作二次电池。

[0234] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的面积密度：12.4mg/cm^2

[0235] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 以外的部分的面积密度：7.3mg/cm^2

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[0236] 螺旋卷绕开始侧上的单面涂布部 $22B_2$ 的面积密度比 :1.70

[0237] 宽度 A :6mm

[0238] 宽度 B :2mm

[0239] [实例 6]

[0240] 在制作负极时,负极混合物层的形成区域和负极混合物层的面积密度被调整如下。除了这一点之外,与实例 1 一样来制作二次电池。

[0241] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的面积密度 :11.2mg/cm^2

[0242] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 以外的部分的面积密度 :7.3mg/cm^2

[0243] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的面积密度比 :1.53

[0244] 宽度 A :14mm

[0245] 宽度 B :17mm

[0246] [实例 7]

[0247] 在制作负极时,负极混合物层的形成区域和负极混合物层的面积密度被调整如下。除了这一点之外,与实例 1 一样来制作二次电池。

[0248] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的面积密度 :9.8mg/cm^2

[0249] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 以外的部分的面积密度 :7.3mg/cm^2

[0250] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的面积密度比 :1.34

[0251] 宽度 A :14mm

[0252] 宽度 B :17mm

[0253] [实例 8]

[0254] 在制作负极时,负极混合物层的形成区域和负极混合物层的面积密度被调整如下。除了这一点之外,与实例 1 一样来制作二次电池。

[0255] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的面积密度 :8.5mg/cm^2

[0256] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 以外的部分的面积密度 :7.1mg/cm^2

[0257] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的面积密度比 :1.20

[0258] 宽度 A :14mm

[0259] 宽度 B :17mm

[0260] [实例 9]

[0261] 在制作负极时,负极混合物层的形成区域和负极混合物层的面积密度被调整如下。除了这一点之外,与实例 1 一样来制作二次电池。

[0262] 螺旋卷绕开始侧的上单面涂布部分 $22B_2$ 的面积密度 :11.2mg/cm^2

[0263] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 以外的的部分的面积密度 :7.3mg/cm^2

[0264] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的面积密度比 :1.53

[0265] 宽度 A :21mm

[0266] 宽度 B :17mm

[0267] [实例 10]

[0268] 在制作负极时,负极混合物层的形成区域和负极混合物层的面积密度被调整如下。除了这一点之外,与实例 1 一样来制作二次电池。

[0269] 螺旋卷绕开始侧的上单面涂布部分 $22B_2$ 的面积密度 :11.2mg/cm^2

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[0270] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 以外的的部分的面积密度 :7.3mg/cm^2

[0271] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的面积密度比 :1.53

[0272] 宽度 A :14mm

[0273] 宽度 B :5mm

[0274] [实例 11]

[0275] 在制作负极时,负极混合物层的形成区域和负极混合物层的面积密度被调整如下。除了这一点之外,与实例 1 一样来制作二次电池。

[0276] 螺旋卷绕开始侧的上单面涂布部分 $22B_2$ 的面积密度 :11.2mg/cm^2

[0277] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 以外的的部分的面积密度 :7.3mg/cm^2

[0278] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的面积密度比 :1.53

[0279] 宽度 A :14mm

[0280] 宽度 B :25mm

[0281] [实例 12]

[0282] 在制作负极时,负极混合物层的形成区域和负极混合物层的面积密度被调整如下。除了这一点之外,与实例 1 一样来制作二次电池。

[0283] 螺旋卷绕开始侧的上单面涂布部分 $22B_2$ 的面积密度 :11.2mg/cm^2

[0284] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 以外的的部分的面积密度 :7.3mg/cm^2

[0285] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的面积密度比 :1.53

[0286] 宽度 A :14mm

[0287] 宽度 B :28mm

[0288] [实例 13]

[0289] 在制作负极时,负极混合物层的形成区域和负极混合物层的面积密度被调整如下。除了这一点之外,与实例 1 一样来制作二次电池。

[0290] 螺旋卷绕开始侧的上单面涂布部分 $22B_2$ 的面积密度 :21.3mg/cm^2

[0291] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 以外的的部分的面积密度 :14.3mg/cm^2

[0292] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的面积密度比 :1.49

[0293] 宽度 A :14mm

[0294] 宽度 B :1mm

[0295] [实例 14]

[0296] 在制作负极时,负极混合物层的形成区域和负极混合物层的面积密度被调整如下。除了这一点之外,与实例 1 一样来制作二次电池。

[0297] 螺旋卷绕开始侧的上单面涂布部分 $22B_2$ 的面积密度 :11.2mg/cm^2

[0298] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 以外的的部分的面积密度 :7.3mg/cm^2

[0299] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的面积密度比 :1.53

[0300] 宽度 A :25mm

[0301] 宽度 B :17mm

[0302] [比较实例 1]

[0303] 在制作负极时,负极混合物层的形成区域和负极混合物层的面积密度被调整如下。除了这一点之外,与实例 1 一样来制作二次电池。

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[0304] 螺旋卷绕开始侧的上单面涂布部分 $22B_2$ 的面积密度 :15.2mg/cm^2

[0305] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 以外的的部分的面积密度 :14.3mg/cm^2

[0306] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的面积密度比 :1.06

[0307] 宽度 A :14mm

[0308] 宽度 B :17mm

[0309] [比较实例 2]

[0310] 在制作负极时,负极混合物层的形成区域和负极混合物层的面积密度被调整如下。除了这一点之外,与实例 1 一样来制作二次电池。

[0311] 螺旋卷绕开始侧的上单面涂布部分 $22B_2$ 的面积密度 :10.4mg/cm^2

[0312] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 以外的的部分的面积密度 :10.4mg/cm^2

[0313] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的面积密度比 :1.00

[0314] 宽度答 :3mm

[0315] 宽度 B :17mm

[0316] [比较实例 3]

[0317] 在制作负极时,负极混合物层的形成区域和负极混合物层的面积密度被调整如下。除了这一点之外,与实例 1 一样来制作二次电池。

[0318] 螺旋卷绕开始侧的上单面涂布部分 $22B_2$ 的面积密度 :8.3mg/cm^2

[0319] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 以外的的部分的面积密度 :7.3mg/cm^2

[0320] 螺旋卷绕开始侧上的单面涂布部分 $22B_2$ 的面积密度比 :1.14

[0321] 宽度答 :3mm

[0322] 宽度 B :17mm

[0323] [试验电池的评估]

[0324] 对于所制作的二次电池,进行“充放电循环特性的测量”和“在螺旋卷绕时检查卷绕间隙和电极褶皱”,且对其结果进行了评估。

[0325] [a. 充放电循环特性的测量]

[0326] 在 23 摄氏度的环境温度中在 1A 的恒定电流下对各自实例和各自比较实例的试验电池进行充电,直至电池电压达到 4.2V 为止。随后,在恒定电压 4.2V 下对各自实例和各自比较实例的试验电池进行充电。此后,在 5A 的恒定电流下对各自实例和各自比较实例的试验电池进行放电,直至电池电压达到 2.5V 为止,且对初始放电时的电池容量(初始放电容量)进行了测量。在前述条件下重复充放电循环,并测量 500 次循环后的放电容量。获得循环保持率(% =[(500 次循环后的放电容量) / (初始放电容量)]×100。

[0327] [b. 在螺旋卷绕时的检查卷绕间隙和电极褶皱]

[0328] 接下来,在循环 500 次之后,将电池单元拆卸,并检查电极卷绕间隙和电极褶皱。在实施 1 至 11 和比较实例 1 中,检查到无电极卷绕间隙和无电极褶皱。与此相反,在实例 12 至 14 和比较例 2 至 3 中,确认了在螺旋卷绕时的电极褶皱。

[0329] 实例 1 至 14 和比较例 1 至 3 的评估结果示于表 1 中。

[0330] [表 1]

[0331]

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	单面涂布部分的一个主表面上的负极混合物层		单面涂布部分以外的部分的一个主表面上的负极混合物层	A (mm)	B (mm)	M (mm)	比 (A/M)	比 (B/M)	螺旋卷绕时的卷绕褶皱	循环保持率 (%)
	面积密度 (mg/cm^2)	面积密度比	面积密度 (mg/cm^2)							
实例1	19.5	1.36	14.3	14	17	11.5	1.2	1.5	不存在	87
实例2	24.3	1.70	14.3	9	17	11.5	0.8	1.5	不存在	85
实例3	21.3	1.49	14.3	14	5	11.5	1.2	0.4	不存在	87

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[0332]

实例4	21.3	1.49	14.3	12	15	9.4	1.3	1.6	不存在	87
实例5	12.4	1.70	7.3	6	2	11.5	0.5	0.2	不存在	90
实例6	11.2	1.53	7.3	14	17	11.5	1.2	1.5	不存在	93
实例7	9.8	1.34	7.3	14	17	11.5	1.2	1.5	不存在	95
实例8	8.5	1.20	7.1	14	17	11.5	1.2	1.5	不存在	91
实例9	11.2	1.53	7.3	21	17	11.5	1.8	1.5	不存在	93
实例10	11.2	1.53	7.3	14	5	11.5	1.2	0.4	不存在	89
实例11	11.2	1.53	7.3	14	25	11.5	1.2	2.2	不存在	93
实例12	11.2	1.53	7.3	14	28	11.5	1.2	2.4	存在	91
实例13	21.3	1.49	14.3	14	1	11.5	1.2	0.1	存在	82
实例14	11.2	1.53	7.3	25	17	11.5	2.2	1.5	存在	88
比较例1	15.2	1.06	14.3	14	17	11.5	1.2	1.5	不存在	54
比较	10.4	1.00	10.4	3	17	11.5	0.3	1.5	存在	63

[0333]

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例2										
比较例3	8.3	1.14	7.3	3	17	11.5	0.3	1.5	存在	68

[0334] 如表1中所示，在实例1至实例14中，螺旋卷绕开始侧上的每个单面涂布部分中的每个面积密度比等于或大于1.20，因此，每个循环保持率是有利的。于此相反，在比较实例1至比较实例3中，螺旋卷绕开始侧上的单面涂布部分中的每个面积密度比小于1.20，因此，每个循环保持率是不好的。在实例12和实例13中，每个B/M都在不在0.2至2.2的范围，包括两个端点，在螺旋卷绕时产生卷绕间隙和电极褶皱。在比较实例2、比较实例3和实例14中，每个A/M都在不在0.5至1.8的范围，包括两个端点，因此在螺旋卷绕时产生卷绕间隙和电极褶皱。

[0335] 4. 其它实施例

[0336] 本技术不限于前述优选实施例，且可在不脱离本发明范围的情况下进行各种修改或适用。

[0337] 例如，在前述实施例和实例中描述的数值、结构、形状、材料、原料、制造过程等仅仅是示例。必要时，数值、结构、形状、材料、原料、制造过程等与前述实施例和实例的那些不同。

[0338] 此外，前述实施例和实例的结构、方法、步骤、形状、材料、数值等可在不脱离本发明范围的情况下彼此结合。

[0339] 在前述实施例中，螺旋卷绕电极体包括正极、负极和位于正极和负极之间并防止正极和负极之间的短路的隔板。然而，可使用离子导体(诸如凝胶电解质和固体电解质)来代替隔板。此外，螺旋卷绕电极体可一起包括离子导体(诸如其中聚合化合物由电解溶液溶胀的凝胶电解质和固体电解质)和隔板。此外，本技术不仅适用于二次电池，而言也适用于一次电池。

[0340] 此外，在前述实施例和实例中，已经给出了其中使用电池壳外封装构件的情况的描述。然而，可使用薄膜状外封装构件。

[0341] 在前述实施例中，已经给出了圆柱型非水电解质电池的描述，在所述圆柱型非水电解质电池中，连接到负极的一个引线26提供在带状负极集电体的螺旋卷绕结束侧上的端部中，且连接到负极的另一个引线26提供在带状负极集电体的螺旋卷绕开始侧上的端部中。然而，负极引线26的配置不限于此。例如，连接到负极的仅一个引线26可提供在带状负极集电体的螺旋卷绕结束侧上的端部中。图10示出具有这样配置的圆柱型非水电解质电池的另一实例中的螺旋卷绕电极体的螺旋卷绕表面的横截面图。如图10所示，在螺旋卷绕电极体20中，连接到负极22的仅一个引线26提供在带状负极集电体22A的螺旋卷绕结束侧上的端部。

[0342] 根据本公开的上述示例性实施例可能实现至少以下配置。

[0343] (1)一种电池，其包括螺旋卷绕电极体，所述螺旋卷绕电极体包括螺旋卷绕的正极和负极，其中，

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[0344] 所述负极包括：

[0345] 负极双面涂布部分，在其中，负极混合物层形成在负极集电体的两个主表面上；

[0346] 第一负极单面涂布部分，在其中，所述负极混合物层仅形成在所述负极集电体的所述两个主表面中的位于外周侧上的第一主表面上；以及

[0347] 负极双面非涂布部分，在其中，所述负极集电体的所述两个表面暴露，

[0348] 所述负极双面非涂布部分、所述第一负极单面涂布部分、和所述负极双面涂布部分依次从所述负极的螺旋卷绕开始侧的第一端进行设置，并且

[0349] 在形成在所述负极集电体的所述第一主表面上的第一主表面侧上的所述负极混合物层中，所述第一负极单面涂布部分的所述第一主表面侧上的所述负极混合物层的面积密度比等于或大于 1.2，所述面积密度比由下面的表达式表达，

[0350] [表达式]

[0351] 所述第一主表面侧上的所述负极混合物层的面积密度比 =(“所述第一负极单面涂布部分的所述第一主表面侧上的所述负极混合物层的面积密度”)/(“所述第一负极单面涂布部分以外的部分的所述第一主表面侧上的所述负极混合物层的面积密度”)。

[0352] (2)根据(1)所述的电池，其还包括第二负极单面涂布部分，在其中，所述负极混合物层仅形成在所述负极集电体的所述两个主表面中的位于内周侧上的第二主表面上，其中，

[0353] 所述第二负极单面涂布部分和所述负极双面非涂布部分依次从所述负极双面涂布部分的螺旋卷绕结束侧上的第一端到所述负极的螺旋卷绕结束侧上的第二端进行设置。

[0354] (3)根据(1)或(2)所述的电池，其中

[0355] 所述正极包括：

[0356] 正极双面涂布部分，在其中，正极混合物层形成在正极集电体的两个主表面上；以及

[0357] 正极双面非涂布部分，在其中，所述正极集电体的两个表面暴露，并且

[0358] 所述正极双面涂布部分、所述正极双面非涂布部分和所述正极双面涂布部分依次从所述正极的螺旋卷绕开始侧的第一端到所述正极的螺旋卷绕结束侧的第二端进行设置。

[0359] (4)根据(3)所述的电池，其中

[0360] 所述双面非涂布部分基本上布置在所述正极的中心，并且，

[0361] 引线接合到位于内周侧上的所述正极双面非涂布部分的所述正极集电体的暴露表面。

[0362] (5)根据(3)所述的电池，其中，

[0363] 所述双面非涂布部分基本上布置在所述正极的中心，并且，

[0364] 引线接合到位于外周侧上的所述正极双面非涂布部分的所述正极集电体的暴露表面。

[0365] (6)根据(1)到(5)中的任一个所述的电池，其中，所述第一主表面侧上的所述负极混合物层的面积密度比是 1.2 至 1.7。

[0366] (7)根据(1)到(6)中的任一个所述的电池，其中，所述第一负极单面涂布部分的宽度是 6mm 到 21mm。

[0367] (8)根据(1)到(7)中的任一个所述的电池，其中，当所述第一负极单面涂布部分

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的宽度是A，所述螺旋卷绕开始侧上的所述负极双面非涂布部分的宽度是B，且所述螺旋卷绕电极体的最内圆周直径是M时，满足 0.5M ≤ A ≤ 1.8M 和 0.2M ≤ B ≤ 2.2M。

[0368] （9）一种电池组，其设置有电池、被配置为控制所述电池的控制部分和容纳所述电池的外封装件，

[0369] 所述电池包括：

[0370] 螺旋卷绕电极体，所述螺旋卷绕电极体包括螺旋卷绕的正极和负极，其中，

[0371] 所述负极包括：

[0372] 负极双面涂布部分，在其中，负极混合物层形成在负极集电体的两个主表面上；

[0373] 第一负极单面涂布部分，在其中，所述负极混合物层仅形成在所述负极集电体的所述两个主表面中的位于外周侧上的第一主表面上；以及

[0374] 负极双面非涂布部分，在其中，所述负极集电体的所述两个表面暴露，

[0375] 所述负极双面非涂布部分、所述第一负极单面涂布部分、和所述负极双面涂布部分依次从所述负极的螺旋卷绕开始侧的第一端进行设置，并且

[0376] 在形成在所述负极集电体的所述第一主表面上的第一主表面侧上的所述负极混合物层中，所述第一负极单面涂布部分的所述第一主表面侧上的所述负极混合物层的面积密度比等于或大于 1.2，所述面积密度比由下面的表达式表达，

[0377] ［表达式］

[0378] 所述第一主表面侧上的所述负极混合物层的面积密度比 =（“所述第一负极单面涂布部分的所述第一主表面侧上的所述负极混合物层的面积密度”）/（“所述第一负极单面涂布部分以外的部分的所述第一主表面侧上的所述负极混合物层的面积密度”）。

[0379] （10）一种电子设备，其设置有电池并被配置为从电池接收电力，

[0380] 电池包括：

[0381] 螺旋卷绕电极体，所述螺旋卷绕电极体包括螺旋卷绕的正极和负极，其中，

[0382] 所述负极包括：

[0383] 负极双面涂布部分，在其中，负极混合物层形成在负极集电体的两个主表面上；

[0384] 第一负极单面涂布部分，在其中，所述负极混合物层仅形成在所述负极集电体的所述两个主表面中的位于外周侧上的第一主表面上；以及

[0385] 负极双面非涂布部分，在其中，所述负极集电体的所述两个表面暴露，

[0386] 所述负极双面非涂布部分、所述第一负极单面涂布部分、和所述负极双面涂布部分依次从所述负极的螺旋卷绕开始侧的第一端进行设置，并且

[0387] 在形成在所述负极集电体的所述第一主表面上的第一主表面侧上的所述负极混合物层中，所述第一负极单面涂布部分的所述第一主表面侧上的所述负极混合物层的面积密度比等于或大于 1.2，所述面积密度比由下面的表达式表达，

[0388] ［表达式］

[0389] 所述第一主表面侧上的所述负极混合物层的面积密度比 =（“所述第一负极单面涂布部分的所述第一主表面侧上的所述负极混合物层的面积密度”）/（“所述第一负极单面涂布部分以外的部分的所述第一主表面侧上的所述负极混合物层的面积密度”）。

[0390] （11）一种电动车辆，其设置有：电池；转换设备，其被配置为将从电池供应的电力转换为车辆的驱动力；和控制设备，其被配置为基于电池的信息处理车辆控制的信息，

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[0391] 所述电池包括：

[0392] 螺旋卷绕电极体，所述螺旋卷绕电极体包括螺旋卷绕的正极和负极，其中

[0393] 所述负极包括：

[0394] 负极双面涂布部分，在其中，负极混合物层形成在负极集电体的两个主表面上；

[0395] 第一负极单面涂布部分，在其中，所述负极混合物层仅形成在所述负极集电体的所述两个主表面中的位于外周侧上的第一主表面上；以及

[0396] 负极双面非涂布部分，在其中，所述负极集电体的所述两个表面暴露，

[0397] 所述负极双面非涂布部分、所述第一负极单面涂布部分、和所述负极双面涂布部分依次从所述负极的螺旋卷绕开始侧的第一端进行设置，并且

[0398] 在形成在所述负极集电体的所述第一主表面上的第一主表面侧上的所述负极混合物层中，所述第一负极单面涂布部分的所述第一主表面侧上的所述负极混合物层的面积密度比等于或大于 1.2，所述面积密度比由下面的表达式表达，

[0399] [表达式]

[0400] 所述第一主表面侧上的所述负极混合物层的面积密度比 =(“所述第一负极单面涂布部分的所述第一主表面侧上的所述负极混合物层的面积密度”)/(“所述第一负极单面涂布部分以外的部分的所述第一主表面侧上的所述负极混合物层的面积密度”)。

[0401] (12)一种蓄电设备，其设置有电池并被配置将电力供应至连接到所述电池的电子设备，

[0402] 所述电池包括：

[0403] 螺旋卷绕电极体，所述螺旋卷绕电极体包括螺旋卷绕的正极和负极，其中，

[0404] 所述负极包括：

[0405] 负极双面涂布部分，在其中，负极混合物层形成在负极集电体的两个主表面上；

[0406] 第一负极单面涂布部分，在其中，所述负极混合物层仅形成在所述负极集电体的所述两个主表面中的位于外周侧上的第一主表面上；以及

[0407] 负极双面非涂布部分，在其中，所述负极集电体的所述两个表面暴露，

[0408] 所述负极双面非涂布部分、所述第一负极单面涂布部分、和所述负极双面涂布部分依次从所述负极的螺旋卷绕开始侧的第一端进行设置，并且

[0409] 在形成在所述负极集电体的所述第一主表面上的第一主表面侧上的所述负极混合物层中，所述第一负极单面涂布部分的所述第一主表面侧上的所述负极混合物层的面积密度比等于或大于 1.2，所述面积密度比由下面的表达式表达，

[0410] [表达式]

[0411] 所述第一主表面侧上的所述负极混合物层的面积密度比 =(“所述第一负极单面涂布部分的所述第一主表面侧上的所述负极混合物层的面积密度”)/(“所述第一负极单面涂布部分以外的部分的所述第一主表面侧上的所述负极混合物层的面积密度”)。

[0412] (13)根据 12 所述的蓄电设备，其包括电力信息控制设备，所述电力信息控制设备通过网络将信号传输至其它设备和从所述其他设备接收信号，其中，所述蓄电设备基于由所述电力信息控制设备接收的信息进行所述电池的充放电控制。

[0413] (14)一种电力系统，所述电力系统被配置为从电池接收电力，或在其中所述电力从发电设备或电力网供应至所述电池，

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[0414] 所述电池包括：

[0415] 螺旋卷绕电极体，所述螺旋卷绕电极体包括螺旋卷绕的正极和负极，其中，

[0416] 所述负极包括：

[0417] 负极双面涂布部分，在其中，负极混合物层形成在负极集电体的两个主表面上；

[0418] 第一负极单面涂布部分，在其中，所述负极混合物层仅形成在所述负极集电体的所述两个主表面中的位于外周侧上的第一主表面上；以及

[0419] 负极双面非涂布部分，在其中，所述负极集电体的所述两个表面暴露，

[0420] 所述负极双面非涂布部分、所述第一负极单面涂布部分、和所述负极双面涂布部分依次从所述负极的螺旋卷绕开始侧的第一端进行设置，并且

[0421] 在形成在所述负极集电体的所述第一主表面上的第一主表面侧上的所述负极混合物层中，所述第一负极单面涂布部分的所述第一主表面侧上的所述负极混合物层的面积密度比等于或大于 1.2，所述面积密度比由下面的表达式表达，

[0422] [表达式]

[0423] 所述第一主表面侧上的所述负极混合物层的面积密度比 =(“所述第一负极单面涂布部分的所述第一主表面侧上的所述负极混合物层的面积密度”)/(“所述第一负极单面涂布部分以外的部分的所述第一主表面侧上的所述负极混合物层的面积密度”)。

[0424] 本领域技术人员应理解，在本领域中，根据设计要求和其它因素可能会出现各种修改、组合、子组合和替换，只要它们在所附权利要求或其等同物的范围内即可。

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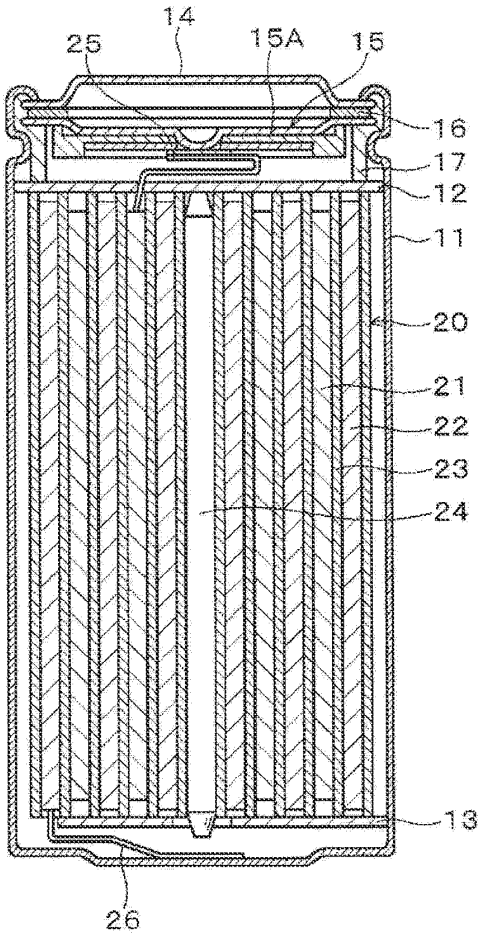


图 1

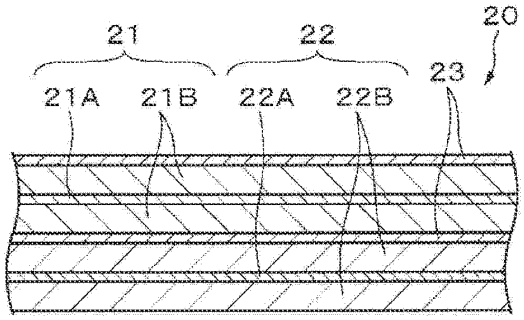


图 2

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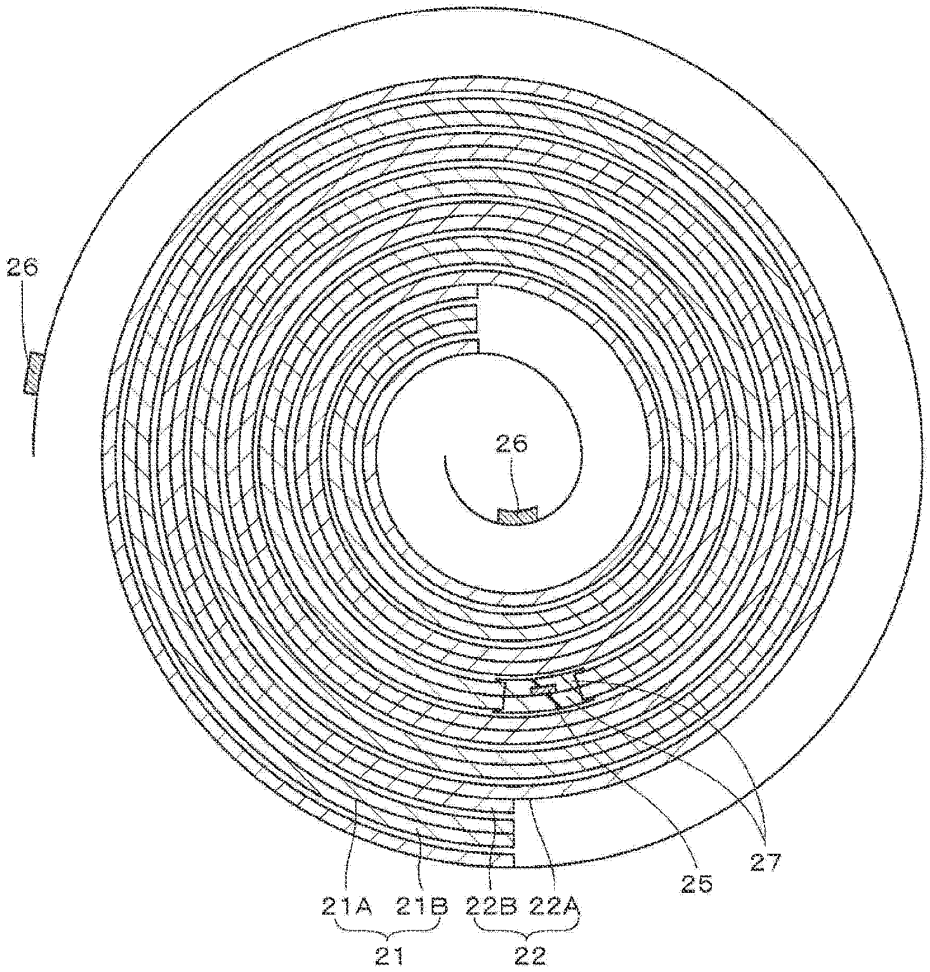


图 3

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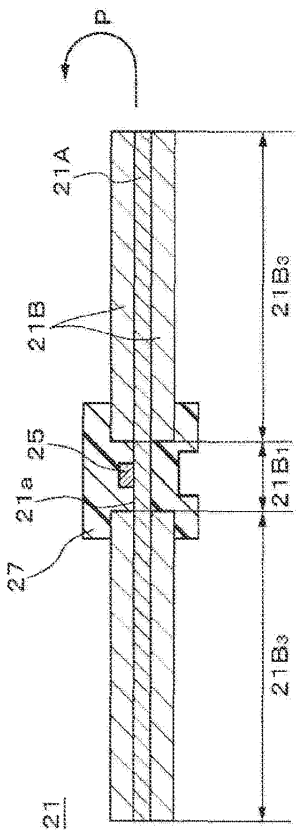


图 4A

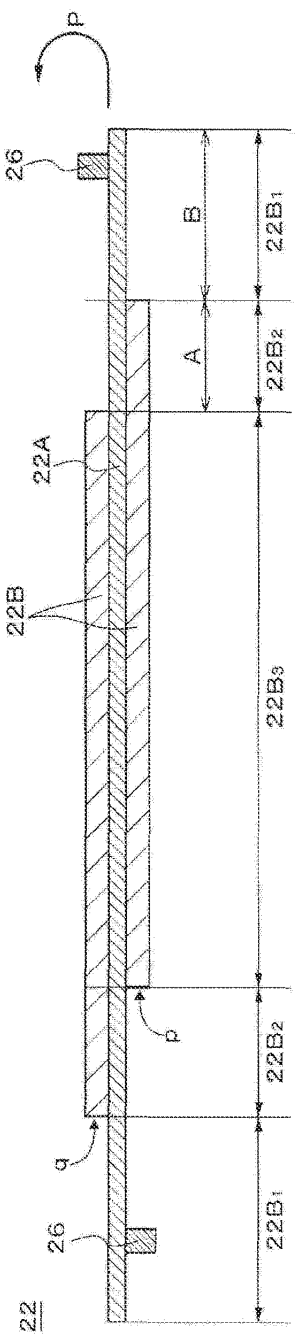


图 4B

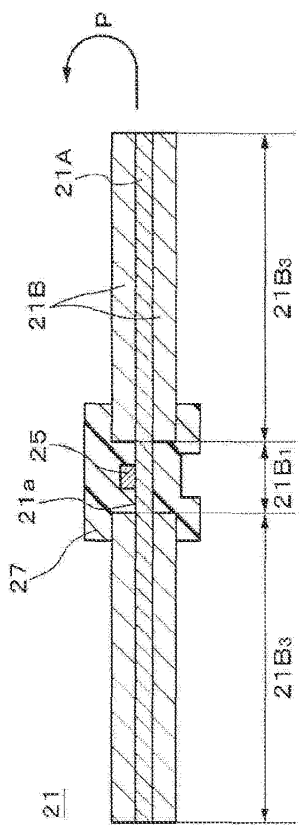


图 5A

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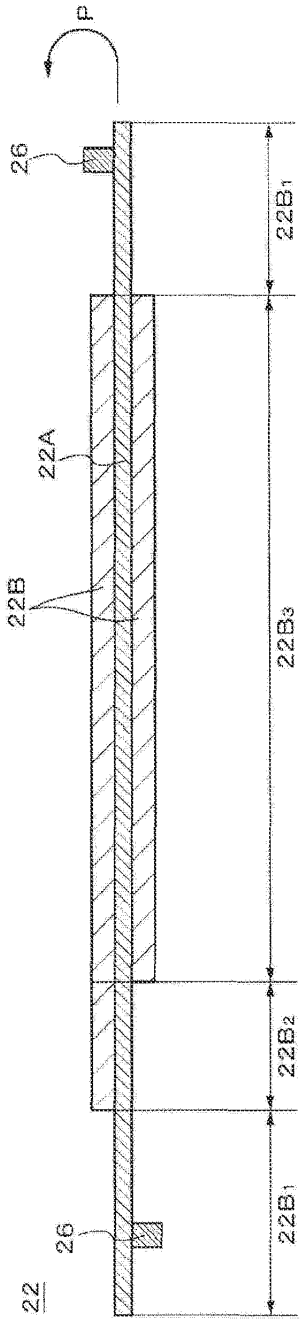


图 5B

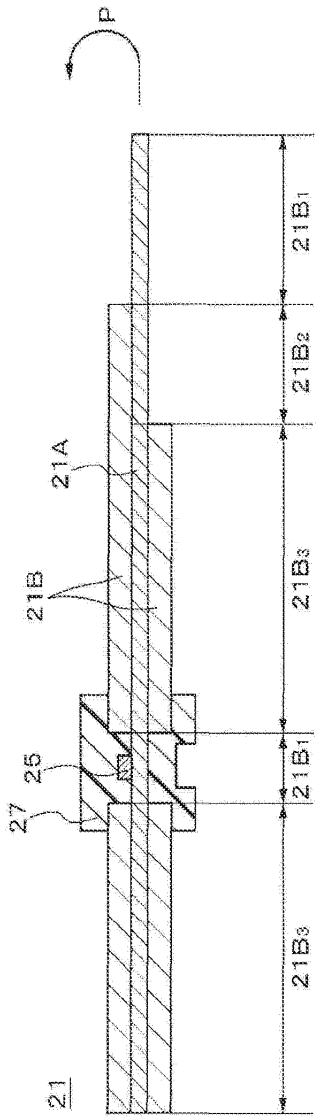


图 6A

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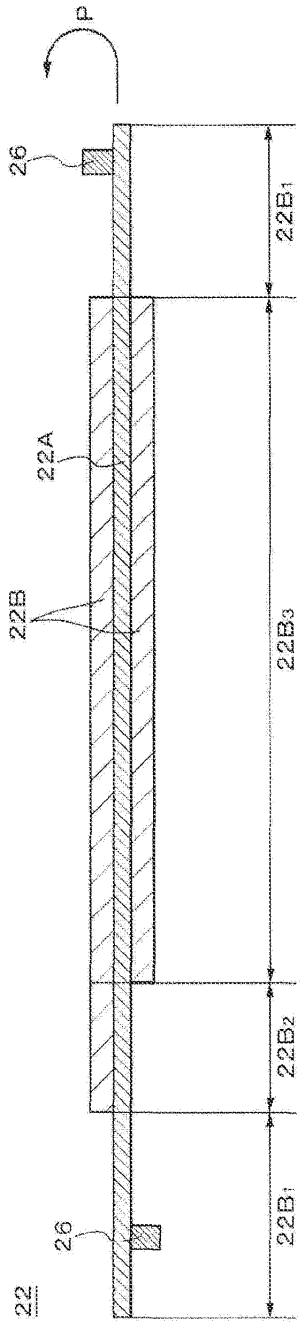


图 6B

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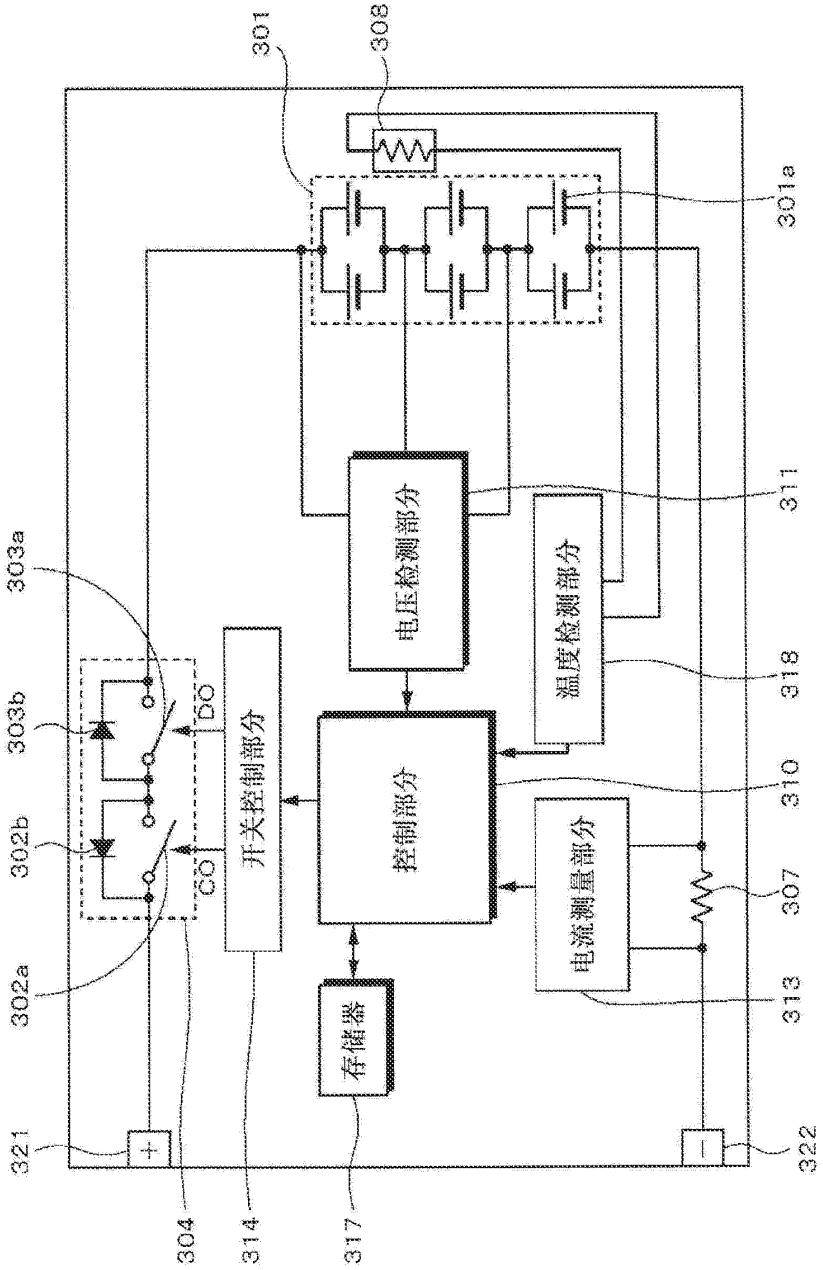


图 7

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401
404
402
集中电力系统
热发电系统
核发电系统
水发电系统
402a
402b
402c
各种传感器
411
408
407
电力枢纽
智能电表
409
412
405d
405
405a
406
410
电力消耗设备
控制设备
电动车辆
洗浴设备
冰箱
蓄电设备
403
电视
空调
电动汽车
混合动力汽车
电动摩托车
405c
405b
406a
406b
406c
413
服务器
400

图 8

42

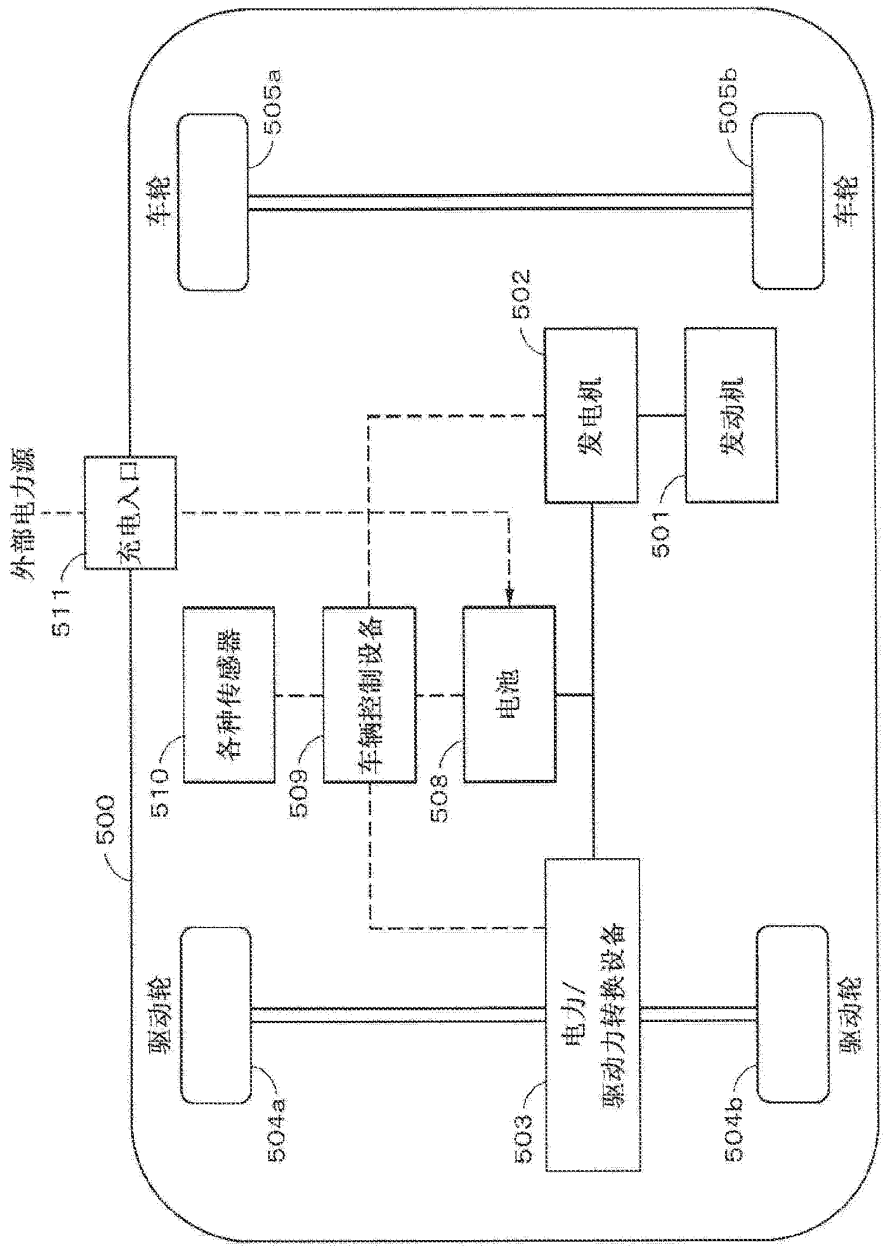


图 9

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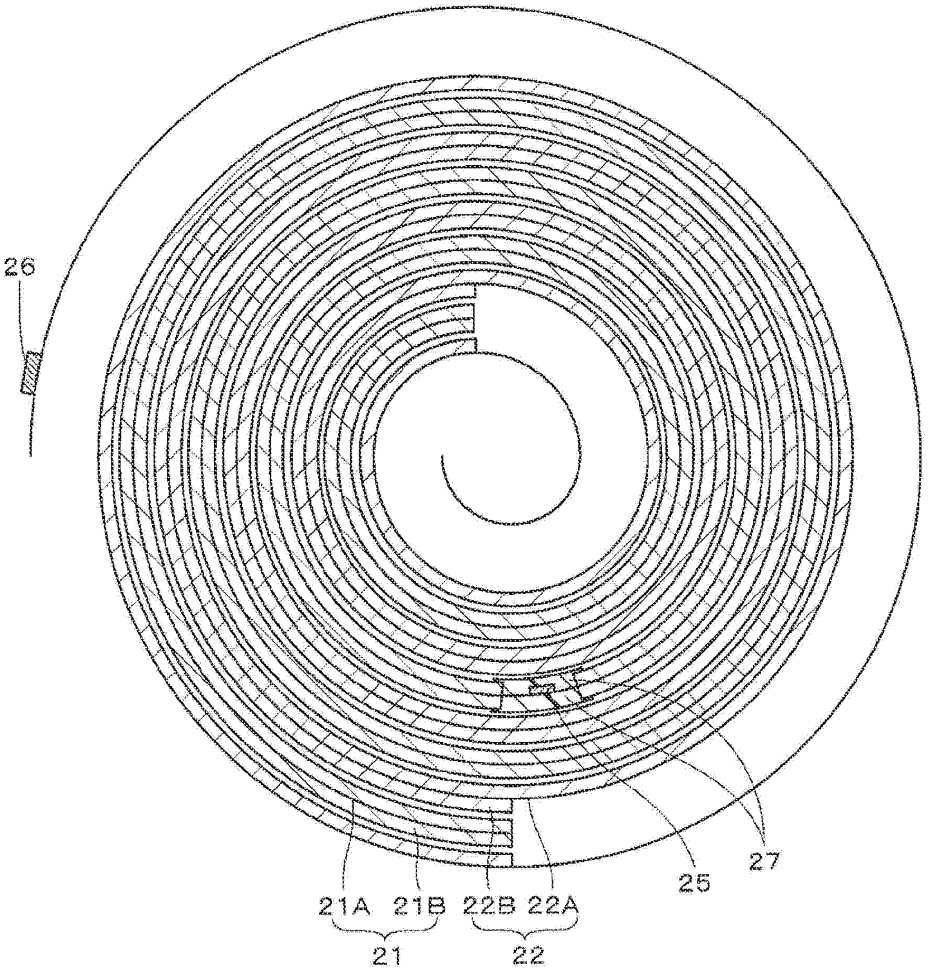


图 10

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Espacenet

Bibliographic data: CN205376669 (U) — 2016-07-06

a lithium-ion battery cell and a lithium-ion battery containing the battery

Inventor(s): when talking, ; cheng sheng, ; li huifang, ; yang fan

Applicant(s): ningde new energy technology co., ltd

Classification: **- international:** ***H01M10/0525; H01M10/0583; H01M4/13***
- cooperative: Y02E60/10 (EP); Y02P70/50 (EP)

Application number: CN20162099936U 20160201

Priority number(s): CN20162099936U 20160201

Abstract of CN205376669 (U)

the present application relates to the field of lithium-ion batteries, specifically, to a lithium-ion battery cell and a lithium-ion battery comprising the battery. the battery cell comprises a first pole piece, a diaphragm and a second pole piece that are successively stacked and wound; the tail of the first pole piece leaves an empty foil area, the empty foil area is located on the outer periphery of the bare battery cell and at least wraps the bare cell in a circle, the surface of the surface of the second pole piece opposite the empty foil area is not coated with a second active substance, so that the collector fluid of the first pole piece and the collector fluid of the second pole piece form a gilet region. when the battery cell is misused, the gilet area can prioritize short circuit or spike contact to avoid safety issues such as combustion or explosion. in this application, the head of the active substance coating area of the first pole sheet is single-sided, the tail is double-sided, and the head of the active substance coating area of the second pole piece is double-sided and the tail is single-sided, thereby achieving an increase in energy density.

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(19)中华人民共和国国家知识产权局

(12)实用新型专利

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(22)申请日 2016.02.01

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代理人 王刚 龚敏

(51)Int.Cl.
H01M 10/0583(2010.01)
H01M 10/0525(2010.01)
H01M 4/13(2010.01)

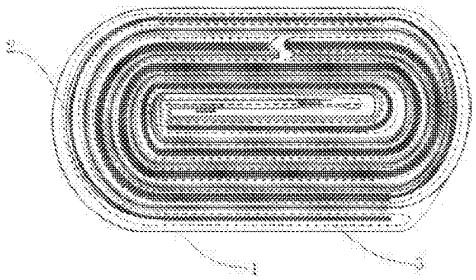
权利要求书1页 说明书4页 附图4页

(54)实用新型名称

一种锂离子电池电芯及含有该电芯的锂离子电池

(57)摘要

本申请涉及锂离子电池领域，具体讲，涉及一种锂离子电池电芯及含有该电芯的锂离子电池。电芯包括依次叠置并卷绕的第一极片、隔膜和第二极片；第一极片的尾部留有空箔区，空箔区位于裸电芯的外周面并至少包裹所述裸电芯一圈，第二极片的尾部与空箔区相对的面的表面未涂覆第二活性物质，从而使第一极片的集流体与第二极片的集流体之间形成马甲区。当电芯遭到滥用时，马甲区可优先发生短路或穿钉式接触，避免燃烧或爆炸等安全问题。本申请中第一极片的活性物质涂覆区的头部为单面、尾部为双面，第二极片的活性物质涂覆区的头部为双面、尾部为单面，从而实现能量密度的提升。



CN 205376669 U

1.一种锂离子电池电芯,包括外壳、外壳内部的由第一极片、隔膜和第二极片依次叠置并卷绕构成的裸电芯,

所述第一极片包括第一集流体和涂覆于第一集流体两表面的第一活性物质,

所述第二极片包括第二集流体和涂覆于第二集流体两表面的第二活性物质,

其特征在于,所述第一极片的尾部留有空箔区,所述第一极片的空箔区位于所述裸电芯的外周面并至少包裹所述裸电芯一圈,所述第二极片的尾部与所述第一极片的空箔区相对的面的表面未涂覆第二活性物质。

2.根据权利要求1所述的锂离子电池电芯,其特征在于,所述电芯的外周面由所述第一极片的空箔区卷绕包裹一圈至两圈。

3.根据权利要求1所述的锂离子电池电芯,其特征在于,在所述电芯内部,所述第一极片和所述第二极片的头部重叠以第一极片和第二极片开始卷绕形成的半圈为电芯的第一圈,并以第一极片为内环卷绕依次形成电芯的第二圈和第三圈;所述第一极片和所述第二极片的第一圈两表面均未涂覆活性物质。

4.根据权利要求3所述的锂离子电池电芯,其特征在于,所述第二极片的第二圈两表面均涂覆第二活性物质。

5.根据权利要求3所述的锂离子电池电芯,其特征在于,所述第一极片的第二圈与第一圈相对的面的表面未涂覆第一活性物质。

6.根据权利要求5所述的锂离子电池电芯,其特征在于,所述第一极片的第三圈两表面均涂覆第一活性物质。

7.根据权利要求1~6任意一项所述的锂离子电池电芯,其特征在于,所述第一活性物质连续涂覆于第一集流体两表面,所述第二活性物质连续涂覆于第二集流体两表面。

8.根据权利要求1~6任意一项所述的锂离子电池电芯,其特征在于,所述第一极片为正极片,所述第二极片为负极片;

所述第一集流体为正极集流体,所述第二集流体为负极集流体;

所述第一活性物质为正极活性物质,所述第二活性物质为负极活性物质。

9.根据权利要求1~6任意一项所述的锂离子电池电芯,其特征在于,所述第一极片为负极片,所述第二极片为正极片;

所述第一集流体为负极集流体,所述第二集流体为正极集流体;

所述第一活性物质为负极活性物质,所述第二活性物质为正极活性物质。

10.一种锂离子电池,其特征在于,所述电池包括电池外壳及密封在电池外壳中的锂离子电池电芯,其中,所述锂离子电池电芯为权利要求1~6任意一项所述的锂离子电池电芯。

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一种锂离子电池电芯及含有该电芯的锂离子电池

技术领域

[0001] 本申请涉及锂离子电池领域，具体讲，涉及一种锂离子电池电芯及含有该电芯的锂离子电池。

背景技术

[0002] 锂离子电池是一种新型的二次充电电池。目前市场上广泛应用的锂离子电池，都由裸电芯和外壳组成。其中，电芯为活性部件，一般由正极片、负极片以及设置在正极片和负极片之间的隔膜层叠或者卷绕而成。正极片包括正极集流体及涂覆在正极集流体表面的正极活性物质；负极片包括负极集流体及涂覆在负极集流体表面的负极活性物质。

[0003] 随着商业化电池的进一步发展，锂离子电池对于能量密度和滥用性能的要求进一步提高，但目前的一些滥用改善手段均需要牺牲能量密度。目前传统的卷绕方式中，裸电芯负极头部为活性材料涂覆的单面区，尾部为活性材料涂覆的双面区；正极头部为活性材料涂覆的双面区，尾部为活性材料涂覆的单面区，并采用铝箔收尾。该卷绕方式具有牺牲能量密度的缺点。

[0004] 针对现有技术的缺陷，特提出本申请。

发明内容

[0005] 本实用新型提出一种锂离子电池电芯，可以提升电芯的抗滥用性能。

[0006] 本实用新型第一方面提出的锂离子电池电芯，包括外壳、外壳内部的由第一极片、隔膜和第二极片依次叠置并卷绕构成的裸电芯；所述第一极片包括第一集流体和涂覆于第一集流体两表面的第一活性物质，所述第二极片包括第二集流体和涂覆于第二集流体两表面的第二活性物质；

[0007] 所述第一极片的尾部留有空箔区，所述第一极片的空箔区位于裸电芯的外周面并至少包裹裸电芯一圈，所述第二极片的尾部与所述第一极片的空箔区相对的面的表面未涂覆第二活性物质。

[0008] 优选的，所述电芯的外周面由所述第一极片的空箔区包裹一圈至两圈。

[0009] 优选的，在电芯的内部，所述第一极片和所述第二极片的头部重叠并以第一极片和第二极片开始卷绕形成的半圈为电芯的第一圈，并以第一极片为内环卷绕依次形成电芯的第二圈和第三圈；所述第一极片和所述第二极片的第一圈两表面均未涂覆活性物质。

[0010] 优选的，所述第二极片的第二圈两表面均涂覆第二活性物质。

[0011] 优选的，所述第一极片的第二圈与第一圈相对的面的表面未涂覆第一活性物质。

[0012] 优选的，所述第一极片的第三圈两表面均涂覆第一活性物质。

[0013] 优选的，所述第一活性物质连续涂覆于第一集流体两表面，所述第二活性物质连续涂覆于第二集流体两表面。

[0014] 优选的，所述第一极片为正极片，所述第二极片为负极片；所述第一集流体为正极集流体，所述第二集流体为负极集流体；所述第一活性物质为正极活性物质，所述第二活性

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物质为负极活性物质。

[0015] 优选的，所述第一极片为负极片，所述第二极片为正极片；所述第一集流体为负极集流体，所述第二集流体为正极集流体；所述第一活性物质为负极活性物质，所述第二活性物质为正极活性物质。

[0016] 本实用新型另一方面提出一种锂离子电池，所述电池包括电池外壳及密封在电池外壳中的锂离子电池电芯，其中，所述锂离子电池电芯为本申请的锂离子电池电芯。

[0017] 本申请提供的技术方案可以达到以下有益效果：

[0018] 为了兼顾能量密度及滥用性能，本申请采用了一种新型的卷绕方式，首先，电芯的尾部空绕1～2圈第一极片的无活性物质的空箔区，并且与第一极片空箔区对应的第二极片为单面涂覆，即第二极片的尾部为单面区，从而使第一极片的集流体与第二极片的集流体之间形成马甲区。当电芯遭到滥用时，马甲区可以优先发生短路，而避免燃烧或爆炸等安全问题。

[0019] 其次，本申请为了进一步提高电芯的能量密度，针对电芯中心的卷绕方式也进行了改进。本申请中第一极片的头部为单面区，尾部为双面区；第二极片的头部为双面区，尾部为单面区，第一极片的头部为单面区设置于头部，第一极片单面区膜长变小，即短面膜长可增长，从而实现能量密度的提升。

附图说明

[0020] 图1为传统卷绕方式示意图；

[0021] 图2为传统卷绕方式的正极极片示意图；

[0022] 图3为传统卷绕方式的负极极片示意图；

[0023] 图4为本申请一具体实施方式中的卷绕方式示意图；

[0024] 图5为本申请卷绕方式的正极极片示意图；

[0025] 图6为本申请卷绕方式的负极极片示意图；

[0026] 图7为实施例1的Nail测试结果曲线；

[0027] 图8为对比例1的Nail测试结果曲线；

[0028] 图9为本申请又一具体实施方式中的卷绕方式示意图。

[0029] 附图说明：

[0030] 1-第一极片；

[0031] 2-第二极片；

[0032] 3-隔膜。

[0033] 此处的附图被并入说明书中并构成本说明书的一部分，示出了符合本申请的实施例，并与说明书一起用于解释本申请的原理。

具体实施方式

[0034] 下面通过具体的实施例并结合附图对本申请做进一步的详细描述。文中所述“前”、“后”、“左”、“右”、“上”、“下”均以附图中的锂离子电池裸电芯及极片的放置状态为参照。

[0035] 本申请中的裸电芯是由第一极片、隔膜和第二极片依次叠置并卷绕而成，其中，极

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片卷绕开始的一端为极片的头部，极片卷绕结束的一端为极片的尾部。

[0036] 图1为目前传统的卷绕方式，包括依次叠置并卷绕的正极极片、隔膜和负极极片，电芯的外周由正极极片的单面涂覆区卷绕包裹，并由正极极片的无涂覆区的一小段包绕封口，无涂覆区域的长度小于电芯外周周长，一般为电芯外周周长的1/4～1/2。图2为传统的卷绕方式的正极极片示意图，正极极片的头部为双面区，尾部为单面错位区，极片头部具有一段空铝区，极片部具有一段空铝区。图3为传统的卷绕方式的负极极片示意图，负极极片的头部为单面错位区，尾部为双面区。传统卷绕方式将正极极片和负极极片重叠后开始卷绕，并以负极极片为内环进行卷绕。

[0037] 本实用新型第一方面提出的锂离子电池电芯，如图4和图9所示，裸电芯包括依次叠置并卷绕的正极片、隔膜和负极片；正极片包括正极集流体和涂覆于正极集流体两表面的正极活性物质，负极片包括负极集流体和涂覆于负极集流体两表面的负极活性物质；正极片的集流体为铝片，负极片的集流体为铜片。

[0038] 本申请裸电芯中正极片的尾部留有空铝区，负极片的尾部为单面涂覆；空铝区位于裸电芯的外周面并至少包裹裸电芯一圈，负极片尾部与空铝区相对的面的表面未涂覆负极活性物质，即与空铝区对应的负极片为单面涂覆区，空铝区与无活性物质的铜片之间形成马甲区，在发生滥用时优先发生短路或穿钉式接触，从而避免燃烧或爆炸等安全问题。并且经实验证实：铜箔与铝发生穿钉式接触，安全性能最高。该马甲的形成只增加了至少一层铝箔，大大降低了能量密度的损失。虽然厚度方面增加至少一层铝箔，但因为正极膜长的增加使得能量密度没有损失。

[0039] 优选的，电芯的外周由空铝区包裹1～2周，并优选1.25～1.5周。空铝区长度为至少一周就即满足上述功能要求，在产品设计中可根据实际需要再延长1/4周至1/2周以便收尾和固定，保证空铝区的完全覆盖。如图9所示，空铝区包裹1.5周左右，可以绕过电芯弯折处，使空铝区更好的与电芯表面更好的固定。

[0040] 优选的，在电芯的内部，正极片和负极片的头部重叠，以正极片和负极片开始卷绕形成的半圈为电芯的第一圈，并以正极片为内环卷绕依次形成电芯的第二圈和第三圈；正极片和负极片的第一圈均为空白区，两表面均未涂覆活性物质。从负极片的第二圈开始，两表面均涂覆活性物质。正极片的第二圈与第一圈相对的面的表面未涂覆活性物质，即正极片的第二圈为单片涂覆。从正极片的第三圈开始，两表面均涂覆活性物质。正极单面区放在头部，正极单面区膜长变小，即短面膜长可增长，从而实现能量密度的提升。

[0041] 如图5所示，正极片的头部为单面错位区，而尾部则为双面区，同时尾部空白铝箔增场。如图6所示，负极片的头部为双面区，而尾部则为单面错位区。其中，单面区、空白区的长度可根据电池的尺寸进行相应的调整。

[0042] 在上述电芯中，正极活性材料与负极活性材料均为连续涂覆。其中，根据电池的具体需要，上述正极片与负极片之间可进行互换。

[0043] 实施例1

[0044] 正极片的制备：以NMP为溶剂，将95％wt％的正极活性物质钴酸锂、2wt％的粘结剂PVDF、3％wt的导电剂石墨按比例加入NMO中，搅拌成粘度范围为2500～8000pa·s的正极浆料。将该正极浆料涂布在铝箔上，经过干燥，冷压，得到压实密度为4.15g/cc。如图5所示，A面膜长388.5mm，B面厚膜长为326mm。

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[0045] 负极片的制备：以去离子水为溶剂，将95wt％的负极活性物质石墨、2wt％的粘结剂SBR、2wt％的导电剂石墨和1wt％的增稠剂CMC加入去离子水中，搅拌成粘度范围为1000～3500pa·s的负极浆料。将该负极浆料涂布在铜箔上面，干燥，冷压得到压实密度1.65g/cc。如图6中所示，负极极片的头部为双面区，而尾部则为单面错位区。A面膜长324.5mm，B面厚膜长为400mm。

[0046] 所采用的隔离膜厚度为11um的PP/PE/PP三层复合多孔隔离膜。

[0047] 电解液是浓度为1mol/L的$LiPF_6$溶液。溶剂为EC、PC和DEC的混合溶剂，三者的比例为1:1:1。

[0048] 电池的组装：将正极片、隔离膜及负极片进行卷绕，经过封装、注液、化成，抽气成型制得高能量密度二次电池。

[0049] 卷绕方式如图4所示：在电芯的内部，正极片和负极片的头部重叠以正极片和负极片开始卷绕形成的半圈为电芯的第一圈，以正极片为内环卷绕依次形成电芯的第二圈和第三圈；正极片和负极片的第一圈均为空白区；从负极片的第二圈开始，两表面均涂覆活性物质；正极片的第二圈为单面涂覆，且与第一圈相对的面的表面未涂覆活性物质，并从第三圈开始，两表面均涂覆活性物质。电芯的外周由正极片的尾部的空铝区包裹1周，并延长一段作为收尾，即与空铝区对应的负极片为单面涂覆区。

[0050] 对比例1：

[0051] 按照实施例1的方法制备锂离子电池，不同之处在于：

[0052] 如图2所示，正极极片的头部为双面区，尾部为单面错位区，A面膜长为390mm，B面膜长为313mm，尾部空铝箔长度为23mm。

[0053] 如图3所示，负极极片的头部为单面错位区，尾部为双面区，A面膜长为325mm，B面膜长为392mm。

[0054] 卷绕方式如图1所示。传统卷绕方式将正极极片和负极极片重叠后开始卷绕，并以负极片为内环进行卷绕，以正极片和负极片开始卷绕形成的半圈为电芯的第一圈，以负极片为内环卷绕依次形成电芯的第二圈和第一圈；正极片和负极片的第一圈均为空白区；从正极片的第二圈开始，两表面均涂覆活性物质；负极片的第二圈为单面涂覆，且与第一圈相对的面的表面未涂覆活性物质，并从第三圈开始，两表面均涂覆活性物质。电芯的外周由正极片的单面涂覆区卷绕包裹，并由正极片的无涂覆区的一小段包绕封口，无涂覆区域的长度小于电芯外周周长，一般为电芯外周周长的1/4～1/2。

[0055] 将实施例1和对比例1制备得到的电池进行Nail测试：

[0056] 检测方法为：温度25℃，钉子直径2.5mm，穿刺速度100mm/s。

[0057] 实验结果为：对比例的通过率为0/5，实施例1的通过率为5/5。

[0058] 其中图7和图8分别为实施例1和对比例1的Nail测试曲线。

[0059] 本申请虽然以较佳实施例公开如上，但并不是用来限定权利要求，任何本领域技术人员在不脱离本申请构思的前提下，都可以做出若干可能的变动和修改，因此本申请的保护范围应当以本申请权利要求所界定的范围为准。

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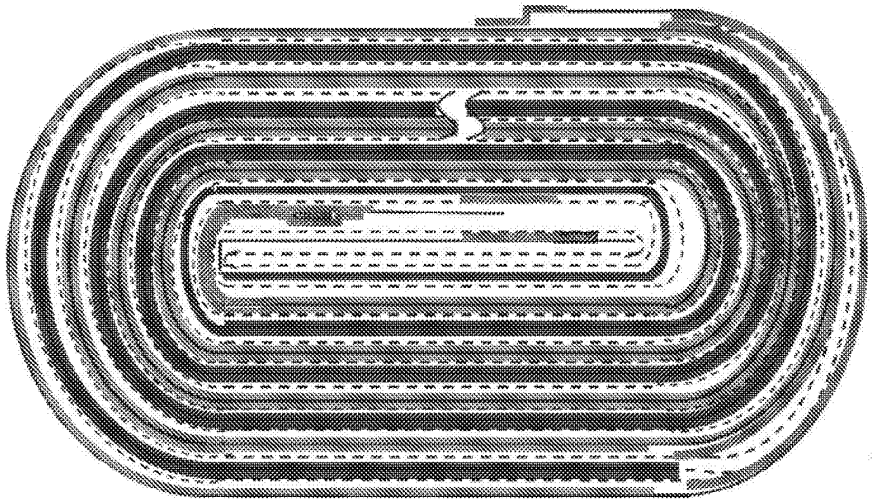


图1



图2



图3

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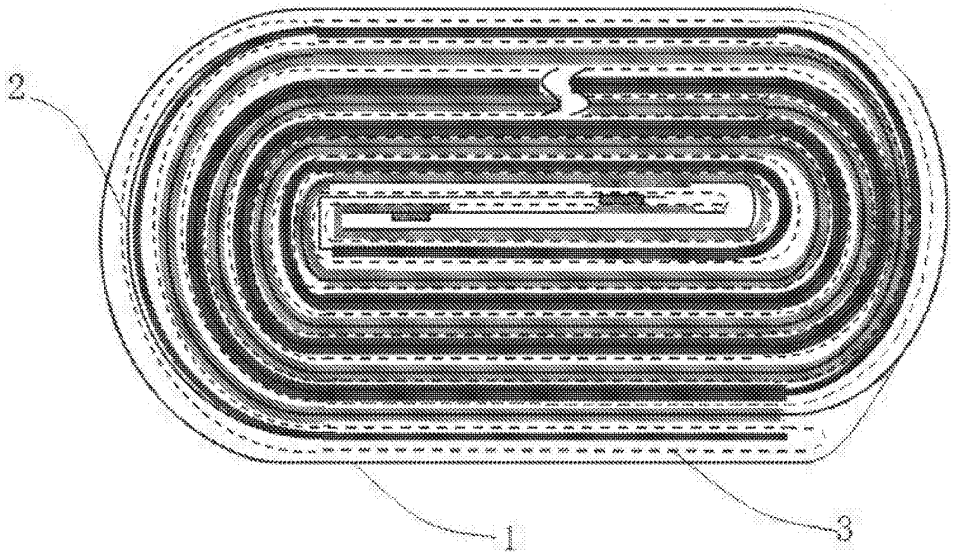


图4

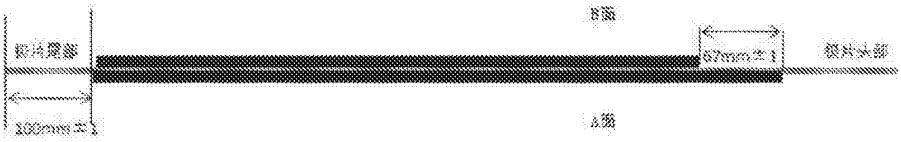


图5

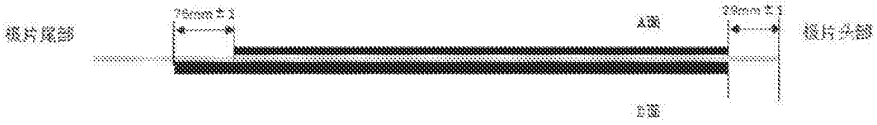


图6

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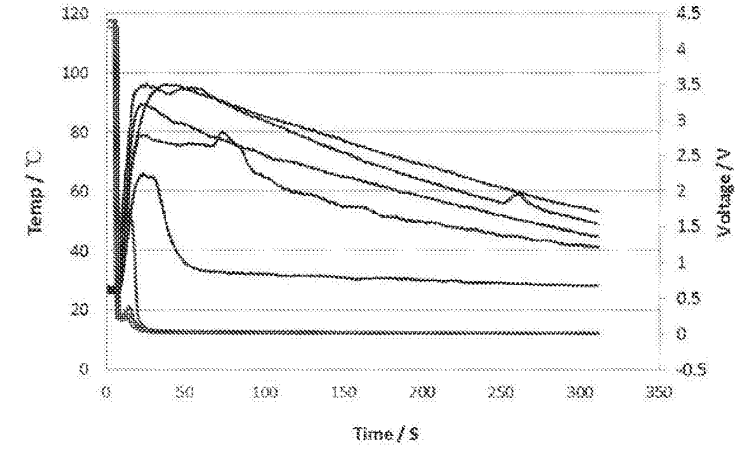


图7

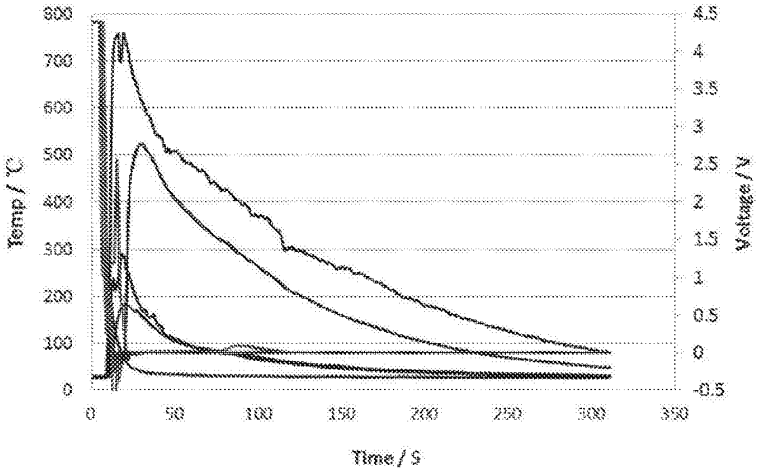


图8

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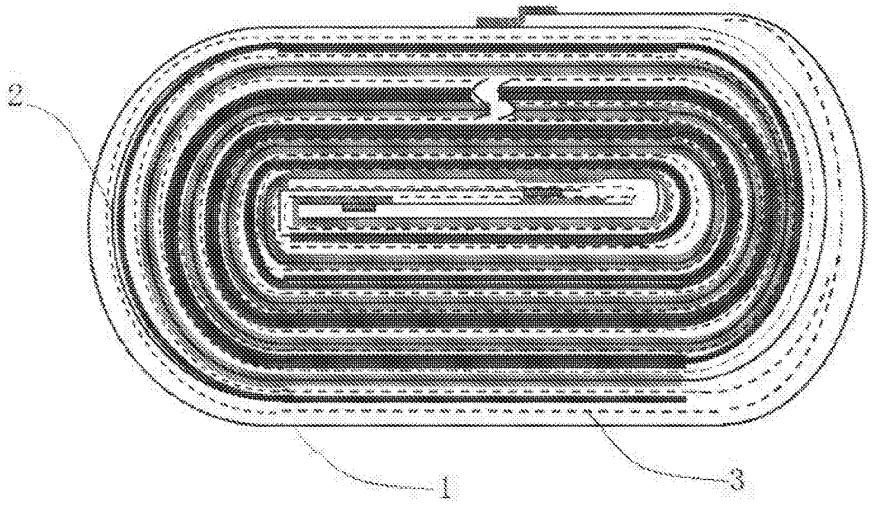


图9

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Espacenet

Bibliographic data: CN101944607 (A) — 2011-01-12

Preparation method of negative plate of chemical battery

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Classification: - international: ***H01M4/26; H01M4/28***
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Abstract of CN101944607 (A)

The invention relates to a preparation method of a negative plate of a chemical battery, which comprises the steps of sizing, drying and rolling, wherein the sizing step is continuous, double-side sizing and single-side sizing are operated alternatively, and the single-side sizing is adopted on a surface which has no corresponding positive surface; and that the double-side sizing and the single-side sizing are operated alternatively refers to that the double-side sizing is adopted on a section of the negative plate, the single-side sizing is adopted on a next section, then the double-side sizing is adopted again, and the cycle is repeated.

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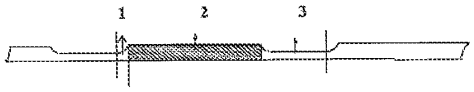
权利要求书 1 页 说明书 4 页 附图 1 页

(54)发明名称

一种化学电池负极片的制备方法

(57)摘要

一种化学电池负极片的制备方法，包括上浆、烘干、辊压，其中所述上浆是连续的，双面上浆和单面上浆交叉进行，在无正极面与之对应的一面采用单面上浆；所述双面上浆和单面上浆交叉进行是指负极片的一段上采用双面上浆，在接下来的一段采用单面上浆，接下来又是双面上浆，如此循环进行。



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1. 一种化学电池负极片的制备方法，包括上浆、烘干、辊压，其特征在于：所述上浆是连续的，双面上浆和单面上浆交叉进行，在无正极面与之对应的一面采用单面上浆；所述双面上浆和单面上浆交叉进行是指负极片的一段上采用双面上浆，在接下来的一段采用单面上浆，接下来又是双面上浆，如此循环进行。

2. 如权利要求 1 所述的化学电池负极片的制备方法，其特征在于：所述连续上浆采用刮浆模具实现。

3. 如权利要求 2 所述的化学电池负极片的制备方法，其特征在于：所述刮浆模具包括两个刮刀，一端刮刀固定，另一端刮刀为由数控设备调节控制的活动刮刀。通过活动刮刀实现所述双面上浆和单面上浆之间的曲面过渡。

4. 如权利要求 2 所述的化学电池负极片的制造方法，其特征在于：所述刮浆模具设置在装有浆料的料斗上方，所述料斗中设有固定基带走向的导向轴，在浆料液面下 5-20mm 处，将基带穿过导向轴进入料斗刮浆成型。

5. 如权利要求 3 所述的化学电池负极片的制造方法，其特征在于：所述刮浆模具根据工艺要求随时调整两刀口之间的距离和单面上浆的长度，所述两刀口之间的距离用于控制上浆料，所述单面上浆、双面上浆的长度根据设计工艺确定。

6. 如权利要求 1-5 中任一权利要求所述的化学电池负极片的制造方法，其特征在于：所述负极片的密度为 6.20-6.60g/cm^3。

7. 如权利要求 1 所述的化学电池负极片的制造方法，其特征在于：所述的辊压是在滚轮左右平行且中心轴线位于同一水平面上的辊压机中进行。

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一种化学电池负极片的制备方法

技术领域

[0001] 本发明涉及一种化学电池负极片的制备方法。

背景技术

[0002] 传统化学电池负极片制备方法如下：将负极浆料或粉料涂覆或填充到负极基体上，碾压，裁切后进入装配工序。装配中，采用卷绕方式时，负极最里面一圈的靠卷芯一面和最外面一圈的靠圆筒一面都无正极面与之对应；采用叠片方式时，最外面的两片的靠壳体一面无正极面与之对应。由于电池正负极的反应是液固界面反应，离子是在正负极之间以最小的距离参与或最小的阻力进行传递，如果负极或正极的某一面不是正面对应相应的正极或负极参与反应，其活性物质利用率比较低。中国专利 CN1297031C 公告的《圆筒行碱性蓄电池》、CN1301564C 公告的《圆筒形碱性蓄电池》、CN2570999Y 公告的《碱性二次电池》分别对提高电池负极非正面面对正极部分的利用率较低进行了改进，但关于如何实现没有提出方法及可行性存在问题；CN101552335A 公告的《一种负极片的制作方法》采用单面上浆方式制作时，存在以下问题：

[0003] 1. 负极片采用横向单面上浆，即在极片宽度方向上单面上浆，极片宽度方向在极片卷绕时成为卷绕的长度方向，即制片后根据要求将极带裁切成要求长度的极片，然后制片后必须先裁切才能进行焊接极耳等，无法实现自动焊极耳和自动贴胶等操作，成为无法实现自动化的控制因素。

[0004] 2. 极片单面上浆和双面上浆之间没有过渡，极片厚度上存在一定的梯度，卷绕过程中容易产生裂纹，甚至断裂。

[0005] 3. 横向单面上浆，因为同一平面内极片厚度不同，所以必须采用特制的滚压机对辊，即两个对滚轮中必须有一个滚轮有两段不同的直径，这对设备提出了更高的要求，且极带经过滚轮时的定位要求非常严格，否则会导致极带厚度跟滚轮直径不匹配，压坏极带。

[0006] 4. 此种方法只能在尾端无正极片对应的一面上单面上浆，实际上头端与卷针对应的也有一段负极片无正极片与之对应。

[0007] 因此，行业内一直在寻求好的解决方法，克服上述不足。

发明内容

[0008] 本发明是为了解决现有技术中存在的自动化程度不高，极片厚度上存在一定的梯度，卷绕过程中容易产生裂纹，甚至断裂，对设备提出了更高的要求等问题，提供了一种新的化学电池负极片的制备方法，克服了现有技术中存在的缺陷，这种方法对设备要求低、自动化程度高且极片柔韧性好。

[0009] 本发明是采用如下技术方案实现的：

[0010] 一种化学电池负极片的制备方法，包括上浆、烘干、辊压，其中所述上浆是连续的，双面上浆和单面上浆交叉进行，在无正极面与之对应的一面采用单面上浆；所述双面上浆和单面上浆交叉进行是指负极片的一段上采用双面上浆，在接下来的一段采用单面上浆，

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接下来又是双面上浆，如此循环进行。

[0011] 上述的化学电池负极片的制备方法，其中所述连续上浆采用刮浆模具实现。

[0012] 上述的化学电池负极片的制备方法，其中所述刮浆模具包括两个刮刀，一端刮刀固定，另一端刮刀为由数控设备调节控制的活动刮刀。通过活动刮刀实现所述双面上浆和单面上浆之间的曲面过渡。

[0013] 上述的化学电池负极片的制造方法，其中所述刮浆模具设置在装有浆料的料斗上方，所述料斗中设有固定基带走向的导向轴，在浆料液面下 5-20mm 处，将基带穿过导向轴进入料斗刮浆成型。

[0014] 上述的化学电池负极片的制造方法，其特征在于：所述刮浆模具根据工艺要求随时调整两刀口之间的距离和单面上浆的长度，所述两刀口之间的距离用于控制上浆料，所述单面上浆、双面上浆的长度根据设计工艺确定。

[0015] 上述的化学电池负极片的制造方法，其中所述负极片的密度为 6.20-6.60g/cm^3。

[0016] 上述的化学电池负极片的制造方法，其中所述的辊压是在滚轮左右平行且中心轴线位于同一水平面上的辊压机中进行。

[0017] 在技术方案中，因为所述活性物质和添加剂都是现有的制造电池极片的材料，所述得浆料也是现有技术中极片的材料，因此在说明书中不再展开进行详细说明。

[0018] 由数控设备调节控制的活动刮刀，数控设备为现有技术中任何可以控制刀具伸缩的设备，根据工艺的要求，设定刀口之间的距离，并设定好伸缩的时间，实现双面上浆和单面上浆交叉进行。

[0019] 本发明与现有技术相比，具有以下优点及有益效果：在无正极片与之对应的负极片的头端和尾端都实现单面上浆；连续上浆，在无正极面与之对应的负极面上没有浆料，可以提高负极活性物质的利用率，降低成本；降低电池卷绕的松紧度，提高合格率；上浆过程能够连续进行，且在滚压后可直接进入自动焊极耳、自动贴胶等工序，能够实现整个制片过程的自动化，得到成型负极片；双面上浆和单面上浆之间采用圆弧过渡，在极片厚度的卷绕过程中可以避免过渡处的断裂；上浆后采用常规对辊机对辊，无需特殊处理，易于实现。具有广阔的工业应用前景。

附图说明

[0020] 以下附图仅旨在于对本发明做示意性说明和解释，并不限定本发明的范围。其中：

[0021] 图 1 是本发明所述的一种化学电池负极片的制备方法中所述负极片示意图；

[0022] 图 2 是本发明所述的一种化学电池负极片的制备方法中所述刮浆模具结构示意图；

[0023] 图 3 是本发明所述的一种化学电池极负片的制备方法的实施例 1 的极组示意图；其中 8 为负极刮粉面，9 为负极前段，10 为正极尾端，11 为卷绕针，12 为隔膜，12 为正极前段。

具体实施方式

[0024] 为了对本发明的技术特征、目的和效果有更加清楚的理解，现对照附图说明本发

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明的具体实施方式。

[0025] 实施例 1

[0026] 如图 1 所示的 AA2500HC 电池，结构分为负极刮粉面 1、负极前段 2、正极尾端 3、卷绕针 4、隔膜 5、正极前段 6。正极、隔膜、负极相互层叠卷绕，负极最里面一圈靠卷芯，最后一圈靠钢壳。

[0027] 正极片的制作方法：将商品化的球形氢氧化镍与钴粉按 95 ： 5 的比例配比，混合均匀，然后填充到发泡镍中，经滚压、裁切成 95mm×43mm×0.68mm，正极中含活性物质总量为 10.0g。

[0028] 负极片的制备，包括混浆、连续上浆、烘干、滚压、自动焊极耳、自动贴胶、裁切。

[0029] 制备浆料是将商品化的 AB5 贮氢合金，与 CMC 水溶液混合，制成负极浆料。

[0030] 然后采用连续上浆将浆料涂布到基体钢带 5 表面，制成尺寸为 133×44×0.34mm 负极片，如图 2 所示的两面上浆负极片区 1 的长度为 85mm，与钢壳接触的不上浆部分即尾端单面上浆负极片区 2 的长度为 42mm，与卷针接触的不上浆部分即头端单面上浆负极片区 3 的长度为 6mm。活性物质总量为 10.5g。

[0031] 连续上浆采用如图 3 所示的刮浆模具 4、6，刮浆模具 4、6 设置在装有浆料的料斗中间上方，料斗中设有固定钢带走向的导向轴 7，在浆料液面下 20mm 处，将钢带 11 穿过导向轴 7 进入料斗刮浆成型，导向轴 7 起到定位的作用，减少发生不规则变形，刮浆模具的一端刮刀 4 固定，另一端刮刀 6 为活动刮刀，由数控设备（由 PLC 程序控制，可以购买）调节控制，活动刮刀用于实现单面上浆，可以根据工艺要求随时调整两刀口之间的距离和单面上浆的长度，两刀口之间的距离用于控制上浆料，由符合工艺设计的上浆量决定，本实施例的工艺要求是双面上浆长度 85mm，单面上浆长度 42+6 ＝ 48mm；双面上浆刮刀距离为 1.0mm，单面上浆刮刀距离为 0.5mm)，因此按照工艺要求设定。

[0032] 上浆后的极片在 100℃干燥 10min。然后经过对辊机滚压，然后自动焊极耳、自动贴胶，然后裁切成前段单面上浆长度为 6mm、中间双面上浆长度为 85mm、末端单面上浆长度为 42mm 的极片。

[0033] 电池的制作方法，将隔膜置于上述正负极片中间按次序叠好，其中负极片单面上浆的一面朝径向外侧，使其卷绕后不上浆一面对着卷芯和钢壳，然后卷绕成螺旋状，做成电池极组，再将极组装入 AA 圆形电池的钢壳中，注入 LiOH、NaOH、KOH 三元电解液，最后封口制成 AA2500 的镍氢电池。

[0034] 为了对比，对照电池的正极片和隔膜均匀实施方法相同，负极片的配方和材料也相同，不同的是对照电池采用传统的上浆方式，即整个极片都是双面上浆，经过烘干、滚压、裁切成 133×44×0.34mm 的负极片，活性物质总量为 11.55g。电池制作方式也相同。

[0035] 具体实施方式制作的电池与对照电池的物理比较情况如下表：

[0036]

负极片尺寸	刮粉后体积减少	刮粉后电池卷装松紧度下降	刮粉后节约合金粉
133×44×0.34mm	10.6%	3.2%	10%

[0037] 基体实施方案制作的电池与对照电池性能比较如下：

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[0038] (1)0.2C 容量测定

[0039] 按照 IEC61951 :2003 的规定,在环境温度 20±5℃的情况下,电池以 0.1C 电流充电 16 小时,搁置 1-4 小时,然后用 0.2C 电流放电至 1.0V,测试电池的容量。

[0040] (2) 循环寿命测试

[0041] 在环境温度 20±5℃的情况下,电池以 1C 电流充电,以 -ΔV≥5mV 为结束条件,然后搁置 1 小时,再用 1C 电流放电至 1.0V,为一个循环,当某个循环的放电容量低于初始容量的 60%时结束循环,测定所发生的循环次数。

[0042] 测试设备为擎天 BS-9360。

[0043] 测试结果如下表 :

[0044]

	容量 (mAh)	寿命 (循环次数)
实施案例 1	2560	350
对照电池	2500	300

[0045] 有上表可见,实施案例的容量和循环寿命都比参照电池好,是因为电池的松紧度较低,有利于充放过程中减少对隔膜的压缩,从而有利于隔膜保液,且能够在有效反应的正负上分配更多的电解液。

[0046] 以上所述仅为本发明示意性的具体实施方式,并非用以限定发明的范围。对于本发明所属技术领域的普通技术人员来说,在不脱离本发明的构思和原则的前提下所作的等同变化、修改与结合,均应属于本发明保护的范围。

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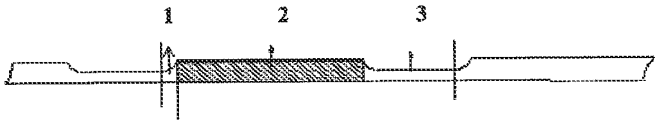


图 1

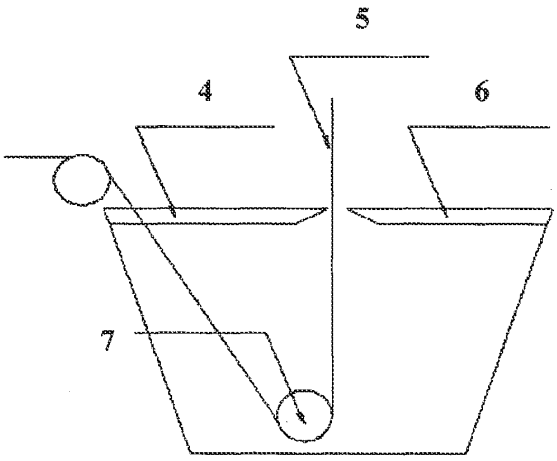


图 2

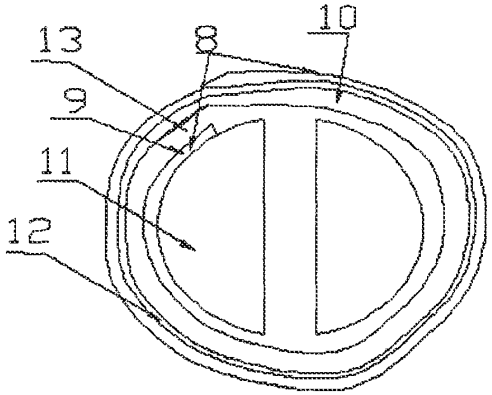


图 3

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Espacenet

Bibliographic data: CN108701807 (A) — 2018-10-23

METHODS FOR ALKALIATING ROLL ANODES

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Applicant(s): NANOSCALE COMPONENTS INC ± (那诺思卡乐康母庞特公司)

Classification: - international: *C25D11/00; C25D11/02; H01M4/04; H01M4/13*
- cooperative: C25D5/022 (EP, US); C25D5/18 (EP, KR, US); C25D5/611 (EP, KR, US); C25D7/0642 (KR, US); C25D7/0657 (KR, US); H01M10/0525 (KR); H01M4/0452 (EP, KR, US); H01M4/1393 (EP, KR, US); H01M4/1395 (EP, KR, US); H01M10/052 (EP, US); H01M2004/021 (US); Y02E60/10 (EP)

Application number: CN20168081464 20161208 Global Dossier

Priority number(s): US201562265090P 20151209 ; WO2016US65550 20161208

Also published as: CA3040251 (A1) EP3387687 (A1) EP3387687 (A4) EP3387687 (B1) EP3972010 (A1) more

Abstract of CN108701807 (A)

The present invention relates to processes that may be used singly or in combination to prevent lithium (or alkali metal) plating or dendrite buildup on bare substrate areas or edges of electrode rolls during alkaliation of a battery or electrochemical cell anode composed of a conductive substrate and coatings, in which the electrode rolls may be coated on one or both sides and may have exposed substrate on edges, or on continuous or discontinuous portions of either or both substrate surfaces.

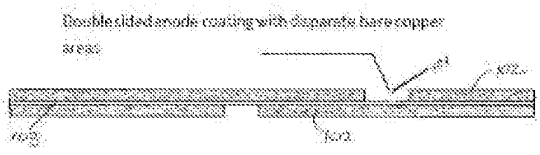


FIG. 1

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H01M 4/13(2006.01)

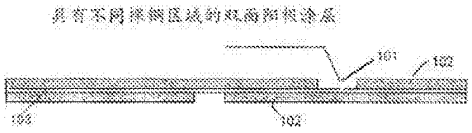
权利要求书3页 说明书9页 附图4页

(54)发明名称

用于碱化辊阳极的方法

(57)摘要

本发明涉及可以单独使用或组合使用的方法，从而在由导电基底和涂层组成的电池或电化学电池阳极的碱化过程中，防止在电极辊的裸露的基底区域或边缘上锂(或碱金属)电镀或枝晶沉积，其中所述电极辊可以在一侧或两侧进行涂覆，并且可以在边缘上或在基底的任一或两个表面连续或不连续的部分上具有裸露的基底。



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1.一种用于对阳极进行碱化来生产碱化阳极的电化学方法，其特征在于裸露的基底区域不含有碱金属，包括下述步骤：

a.将阳极置于含有碱金属盐的非水电解液中，其中所述阳极包含一种导电基底，所述导电基底包含至少一个表面，所述表面的特征在于至少一个在其上具有碱化涂层的区域和至少一个不含碱化涂层的区域；

b.施加正向还原电流以使阳极碱化足够的时间从而在具有碱化涂层的区域中至少部分地碱化阳极；

c.保持由步骤(b)所制备的阳极在溶液中，并且任选地，施加反向氧化电流用以从裸露的基底区域除去任何碱金属沉积物；以及

d.重复步骤b和/或c。

2.根据权利要求1所述的方法，其中所述碱化的阳极达到在0.1mAh/cm^{2}至10mAh/cm^{2}之间的剂量，并且表现出没有碱金属沉积物。

3.根据权利要求2所述的方法，其中所述步骤b和步骤c重复至少大约3次，优选地至少大约5次，更为优选地至少大约20次。

4.根据权利要求3所述的方法，其中，在基本上不存在电流的情况下，所述阳极在至少一个步骤C中保持足够的时间，以允许至少一些碱金属扩散至碱化涂层中。

5.根据权利要求3或4所述的方法，其中，通过至少一次步骤B产生的产品包括一种含有碱金属沉积的裸露基底区域。

6.根据权利要求5所述的方法，其中一种反向氧化电流应用于在至少一次步骤C中从裸露基底区域去除任何碱金属沉积。

7.根据权利要求6所述的方法，其中所述碱金属沉积包含枝晶。

8.根据在前权利要求中任一项所述的方法，其中所述碱化涂层是不连续的。

9.根据在前权利要求中任一项所述的方法，其中所述阳极是一种辊阳极。

10.根据在前权利要求中任一项所述的方法，其中至少一个不含检查涂层的区域包括所述阳极的边界和/或一种垂直于并连接于所述阳极边界的带段，并且具有暴露的导电基底。

11.根据在前权利要求中任一项所述的方法，其中所述碱金属盐是由氯化锂组成。

12.根据在前权利要求中任一项所述的方法，其中所述导电基底是铜或者镍。

13.根据在前权利要求中任一项所述的方法，其中所述碱化涂层由石墨或者硅或者它们的共混物组成。

14.根据在前权利要求中任一项所述的方法，其中所述碱化涂层是在导电基底的两个表面上。

15.根据在前权利要求中任一项所述的方法，其中所述裸露基底区域是沿导电基底的边缘设置。

16.根据在前权利要求中任一项所述的方法，其中所述正向还原电流和所述反向氧化电流是DC。

17.根据在前权利要求中任一项所述的方法，其中所述正向还原电流和所述反向氧化电流是AC。

18.根据在前权利要求中任一项所述的方法，其中所述反向电流和所述正向电流的比

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率是固定的。

19.根据在前权利要求中任一项所述的方法，其中所述反向电流和所述正向电流的比率提高。

20.根据在前权利要求中任一项所述的方法，其中所述反向时间持续和正向时间持续的比率是固定的。

21.根据在前权利要求中任一项所述的方法，其中所述反向时间持续和正向时间持续的比率提高。

22.根据在前权利要求中任一项所述的方法，其中步骤b是在1毫秒至15分钟之间。

23.根据权利要求22所述的方法，其中步骤b是在1厘秒至5分钟之间。

24.根据权利要求23所述的方法，其中步骤b是在1秒至3分钟之间。

25.根据在前权利要求中任一项所述的方法，其中步骤c是在1毫秒至15分钟之间。

26.根据权利要求25所述的方法，其中步骤c是在1厘秒至5分钟之间。

27.根据权利要求26所述的方法，其中步骤c是在1秒至3分钟之间。

28.根据在前权利要求中任一项所述的方法，其中所述正向还原电流比反向氧化电流高1至8倍。

29.根据在前权利要求中任一项所述的方法，其中所述正向还原电流比反向氧化电流高大约2倍。

30.根据在前权利要求中任一项所述的方法，其中所述正向还原电流密度是在0.1mA/cm^2至10mA/cm^2之间。

31.根据在前权利要求中任一项所述的方法，其中所述正向还原电流密度为大约1mA/cm^2。

32.根据在前权利要求中任一项所述的方法，其中所述反向氧化电流密度是在0.1mA/cm^2至1.2mA/cm^2之间。

33.根据在前权利要求中任一项所述的方法，其中所述方向氧化电流密度为大约0.6mA/cm^2。

34.根据在前权利要求中任一项所述的方法，其中所述反向氧化电流脉冲的持续时间是在所述正向还原电流脉冲持续时间的1%至100%之间。

35.根据权利要求34所述的方法，其中所述反向氧化电流脉冲的持续时间是在所述正向还原电流脉冲持续时间的5%至30%之间。

36.根据权利要求35所述的方法，其中所述反向氧化电流脉冲的持续时间是所述正向还原电流脉冲持续时间的大约20%。

37.根据权利要求35所述的方法，其中所述反向氧化电流脉冲的持续时间是所述正向还原电流脉冲时间的大约15%。

38.根据权利要求36所述的方法，其中所述反向氧化电流脉冲的持续时间为大约30秒，并且所述正向还原电流脉冲的持续时间为大约150秒。

39.根据在前权利要求中任一项所述的方法，其中边缘保护装置、介质场孔或者屏蔽安装至阳极的每一个裸露边缘的上方和下方。

40.一种用于碱化阳极的电化学方法，包括下述步骤：

a.将边缘保护装置、介电场孔或屏蔽装置设置在阳极的每个暴露边缘的上方和下方；

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b.将阳极置于含有碱金属盐的非水电解质溶液中，其中所述阳极包括导电基底，所述导电基底包括至少一个表面、在所述至少一个表面上的碱化涂层；以及

c.将正向还原电流施加至溶液中用以碱化阳极。

41.根据权利要求40所述的方法，其中所述边缘保护装置、介电场孔或屏蔽装置是由一种介电材料构成，所述介电材料是与非水电解质溶液相容。

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[0001] 相关申请

[0002] 本申请要求保护2015年12月9日提交的申请号为62/265,090的美国临时申请的权益。上述申请的全部教导内容已通过引用的方式并入到本文。

[0003] 发明背景

[0004] 石墨作为一种常见的阳极材料，通常被用于制造锂离子电池。通常情况下，将石墨涂覆在一种铜基底或铂上，但也可以使用其他的锂非活性金属。石墨提供了大约370mAh/g的可逆容量，并且在构建固体电解质中间相(SEI)层时会遭受到大约5％的不可逆容量损失。目前，已经引入了一种具有更高容量的阳极材料，该阳极材料能够很大程度上增加锂离子电池的比容量。例如，非晶硅能够提供高达3500mAh/g(Obrovac MN和Krause LJ，2007；可逆循环的结晶硅粉，J.Electrochem.Soc.154:A103-A108)。

[0005] 由于在锂离子电池中使用的阳极材料最初是不含锂的，因此阴极材料通常提供了在电池循环和不可逆循环损失(IRCL)的所有的锂。不幸的是，硅表现出高达25％的IRCL。这意味着电池的25％的可循环容量将变得不可用，并且这种既昂贵又重的阴极将无法得到充分的应用。

[0006] 已经通过尝试以下方法来向阳极材料中添加额外的锂：a)将一种锂金属薄层添加到电池中；b)通过在非水且干燥环境中的电解，将锂添加到阳极活性材料中；c)将锂分散至阳极材料中，例如在稳定的金属粉末中，或者SLMP(FMC Corporation,Philadelphia,PA)中；以及d)在组装过程中将供锂物质添加到电池中。这里引用US 8,133,374 B2作为这些方法中部分方法的综述。2015年1月6日提交的USSN 14/590,573、由Grant等人于2015年7月9日提交的名称为“Method of Alkaliating”的美国公开号为2015019184的专利申请，上述文献的全部内容均已通过引用并入本文，并且详细描述了用于电化学锂化的方法和装置的细节。

[0007] 对于商业环境中的阳极辊，所期望的基底是在其某些部分是未被涂覆的，用以适应随后的电池组装方法，例如接头焊接、切割，或者用于其他目的。阳极辊被定义为一种具有足够长度以进行滚动的阳极材料。附图1显示出了一种具有涂层102的共阳极基底101的边缘视图，其中裸铜区域存在于所述基底的两个面上，因而有利于螺旋卷绕电池封装技术。在另一种情况下，所述裸铜可以暴露在所述辊的一个或两个边缘103上，以适应有切割构成、电极片堆叠的电池的焊接。在另一种情况下，可能需要使用宽的阳极辊(例如，30-60cm)用于针对消费电子设备的小电池有效制备。在这种情况下，这些较大的阳极辊的内表面将包含许多个以行或者列形式存在的裸铜区域，并且外部或边缘也可能需要保护。在这些所有情况下，在阳极辊的电化学锂化期间，需要保护任何裸露基底区域避免经受锂金属的沉积。如果可以滚动处理这些和其他配置的话，则可以实现批量化生产。

[0008] US 8,133,374 B2教导了一种应用电解来锂化阳极基底的方法，其中参考电极检测裸铜区域，以便在裸铜区域通过时“关闭”电流。但是该文献所记载的内容并没有教导怎样在两面均涂覆了的阳极上进行，因此在大多数商业目的中对于阳极辊是双面的而言是不切实际的。其次，该文献也没有教导如何避免在基底边缘上电镀锂或树枝状晶体结构。由于

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场强集中在电解槽中的基底边缘上，因此US 8,133,374 B2是不切实际的，原因在于它不能够保护边缘。

发明内容

[0009] 本发明涉及生产碱化阳极的电化学方法，所述碱化阳极的特征在于具有无碱金属的裸露基底区域，其能够被用于在由导电基底和涂层组成的电池或电化学电池阳极的碱化过程中单独使用或组合使用，用以防止在裸露的基底区域或电极辊的边缘上的锂(或碱金属)电镀或枝晶沉积，其中所述电极辊可以在其一侧或两侧上进行涂覆，并且可以在边缘上或在任一个或两个基底表面的连续或不连续部分上具有暴露的基底。根据本发明所述的任何方法，不含一种碱化涂层的其它区域具有裸露的导电基底，其包括阳极的周边和/或垂直于并连接阳极周边的带。在美国申请号为13/688,912的专利申请中描述了所述溶液和设备的细节，该文献已通过引用并入本文。在一个实施方案中，所述涂层是一种碱化涂层，其中碱化涂层是任何用于接收碱化离子的涂层，并且所述涂层优选由石墨或者硅或者它们二者的组合组成。

[0010] 在碱化阳极的生产过程中，可能发生碱金属在裸露或者暴露的导电基底上的沉积。一种用来防止锂(或碱金属)电镀或枝晶沉积至包括裸露基底区域的涂覆电极上的方法是正向/反向电流方法。将一种导电基底保持在含有锂(或碱金属)盐的非水电解质溶液中，所述导电基底至少在一侧上被涂覆。导电基底涂层是由一种活性材料层构成，所述活性材料层能够吸收和释放锂离子。所述涂层可以优选为石墨或其他形式的碳、或者硅、锡等等，或者它们的组合，并且所述涂层区域优选为在基底上不连续。无论这种材料是否是元素物质、合金、化合物、固溶体和含有含硅材料或含锡材料的复合活性材料中的任何一种，这些材料都可以发挥本发明所述的效果。所述裸露或暴露的区域可以是基底的边缘、任何表面边缘或者在任一或两个表面上的任意内部区域，并且所述裸露区域可以被图案化的从而便于将所述片材切割成较小的阳极材料，或者留下用于焊接的区域。例如，所述裸露区域可以沿着基底的宽度或沿着基底卷的长度规则地进行条纹化。本发明提供农了一种用于制造涂覆电极的方法。

[0011] 所述工作对电极可以连接到一种电源D.C.电源的正极侧。所述导电基底可以连接到电源的负极侧。电流在工作电极和导电基底之间通过电极之间的电解质溶液体积进行流通。从而在工作电极处产生氧化电流，同时在导电基底处产生还原电流。在导电基底上的这种还原电流提供了在涂覆电极和暴露的基底上的锂沉积。所述还原电流进行周期性地中断，并且相对于还原电流进行短时间持续被迫逆转(氧化电流)。通过这种方式，在还原电流阶段期间沉积在裸露导电基底上(例如在铜导电基底上)的锂能够在氧化阶段期间被去除。这种技术在内部和外部裸露导电基底区域上工作良好，例如在裸铜导电基底上，并且不论它们在阳极基底辊内的位置如何。与涂覆区域相比，在阳极表面处的所述氧化电流将有利于将锂从暴露的基底区域中去除，这是由于与嵌入的锂相比，电镀锂的电化学势更大。通过以这种方式锂化整个电极，当电流的反转有利于从裸露的基底表面和边缘去除锂时，能够在电池组装之前，对用于补偿IRCL(或用于其他目的)的锂量进行控制，并且成功地预合金化或预先嵌入至电极活性材料中。由于用于焊接、切割或其他目的的清洁的无锂区域，使得电池组装的后续步骤变得更安全和实用。

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[0012] 应当理解的是，术语“锂化”或“锂化反应”是通用术语“碱化”或“碱化反应”的更具体的情况。换句话说，应当理解在本发明说明书中使用的术语“锂化”或“锂化反应”是一种包括“碱化”或“碱化反应”的替代实施方案，反之亦然。

[0013] 一种在电池或电化学电池阳极碱化的过程中用于防止在裸露基底区域和涂覆的电极边缘上沉积锂(或碱金属)电镀或树枝状晶体的第二种方法，其中所述电极可以在一侧或两侧进行涂覆，是一种休息周期法。所述休息周期法包括与零电压脉冲(休息期)交替的正向(还原)电压脉冲，该方法在交替的正向电压脉冲和零电压脉冲的延长循环中继续。所述休息周期法可以单独实施，或者与正向/反向电流方法组合实施。

[0014] 一种在电池或电化学电池阳极碱化期间防止在裸露基底区域和涂覆电极边缘上的碱金属电镀的第三种方法是边缘防护方法，其中所述电极可以在一侧或两侧进行涂覆。边缘防护装置由一种介电材料构成，所述介电材料是与所用溶剂兼容，并且所述边缘防护装置安装在辊阳极的每个暴露边缘的上方和下方，以防止裸露基底边缘的碱化。所述边缘保护方法可以通过使用休息周期法、正向/反向电流方法、休息周期法与正向/反向电流方法结合法，或者仅使用正向(还原)电流和无休息周期进行实施。

附图说明

[0015] 本发明的前述和其他目的、特征和优点将结合下面附图中所示出的本发明优选的实施方案更加具体的进行描述，从而使其变得更为显而易见，正如附图中所示的那样，其中相同的附图标记在不同的视图中指代相同的部分。附图不一定是按比例绘制的，而是将重点放在示出本发明的原理上。

[0016] 附图1.具有裸铜区域的双面阳极涂层的图示。

[0017] 附图2.阳极上还原阶段的锂通量大小的图示。

[0018] 附图3.阳极上氧化阶段的锂通量大小的图示。

[0019] 附图4.在1mA/cm^2下，氧化和还原脉冲期间的电压幅值的图示。

[0020] 附图5.使用AC电源，在1mA/cm^2下的氧化和还原脉冲期间的电压幅值的说明。

[0021] 附图6.在还原模式下的辊阳极分布的说明。所述辊阳极601是从辊阳极筒602移除，引导至含有液体电解质607的槽608中。在对电极604之间，其可操作地连接至电源605，并且返回至所述辊阳极重卷606。滚子603有助于引导阳极。

[0022] 附图7.通过介电场光阑的辊阳极锂化的图示。

[0023] 附图8.作为涂覆的阳极材料的较低电化学电势的函数的在对电极和辊阳极之间的磁通线的图示。

[0024] 附图9.作为开口铜区域的过电压和尺寸的函数的锂枝晶形成的图示。

具体实施方案

[0025] 本发明涉及用于阳极碱化的方法，以防止在阳极导电基底的裸露基底区域或者边缘上的碱金属电镀或枝晶沉积，其中所述阳极包括电极或电极辊。在一个实施方案中，一种裸露的基底区域沿着阳极导电基底的边缘来设置。阳极可以由涂覆在导电基底上的锂活性材料构成，所述导电基底例如铜、镍等。在一个实施方案中，阳极是锂嵌入阳极。包含锂嵌入阳极的材料的示例包括但不限于碳和石墨、氧化锡、硅、氧化硅、聚偏二氟乙烯(PVDF)粘合

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剂以及它们的混合物。在另一个实施方案中，锂嵌入阳极材料选自由石墨、焦炭和中间碳所组成的组中。可以替换的是，可以将一种锂合金化材料沉积或者电镀等方式至导电基底上。在一个实施例中，所述合金材料包括但不限于锡、铝、硅或者锗。仅出于说明的目的，所述涂覆导体材料的辊或者活性合金材料的辊将被称为辊阳极。

[0026] 在一个实施方案中，本发明涉及一种用于对阳极进行碱化来生产碱化阳极的电化学方法，其特征在于裸露的基底区域不含有碱金属，包括下述步骤：

[0027] a.将阳极置于含有碱金属盐的非水电解液中，其中所述阳极包含一种导电基底，所述导电基底包含至少一个表面，所述表面的特征在于至少一个在其上具有碱化涂层的区域和至少一个不含碱化涂层的区域；

[0028] b.施加正向还原电流以使阳极碱化足够的时间从而在具有碱化涂层的区域中至少部分地碱化阳极；

[0029] c.保持由步骤(b)所制备的阳极在溶液中，并且任选地，施加反向氧化电流用以从裸露的基底区域除去任何碱金属沉积物；以及

[0030] d.重复步骤b和/或c。

[0031] 在一个实施方案中，将步骤b和步骤c重复至少大约两次。在优选的实施方案中，将步骤b和步骤c重复至少大约三次。在更优选的实施方案中，将步骤b和步骤c重复至少大约五次、至少大约十次、或者更优选地至少大约20次。在另一个实施方案中，在基本上不存在电流的情况下，将阳极保持在至少一个步骤c中足够的时间，以允许至少一些碱金属扩散至碱化涂层中。

[0032] 一种用于制造涂覆电极的方法包括步骤：清洁导电基底表面；以连续或不连续的图案方式将具有活性材料的浆料涂覆至基底的第一面上；对涂覆材料的第一面进行干燥；以连续或不连续的图案方式将活性材料涂覆至导电基底的第二面；对涂覆材料的第二面进行干燥；将涂覆的导电基底压延和切割成最终的形状和尺寸。

[0033] 所述辊阳极被引导穿过一种电化学槽，所述电化学槽是由至少一个对电极、含有碱金属盐的非水溶液和辊组成，以引导和完成到所述辊阳极的循环。非水溶液包含一种添加到电解质中的有机溶剂，所述有机溶剂是一种用于溶解无机离子盐的电解质。一种非水溶剂的典型实例是碳酸亚丁酯、碳酸亚丙酯、碳酸亚乙酯、碳酸亚乙烯酯、碳酸乙烯基亚乙酯、碳酸二甲酯、碳酸二乙酯、碳酸二丙酯、碳酸甲乙酯、乙腈、γ-丁内酯(GBL)、三甘醇二甲醚、四甘醇二甲醚、二甲基亚砜、二氧戊环、环丁砜、室温离子液体(RTIL)及它们的混合物。在一个实施方案中，一种非水溶剂选自由碳酸亚乙酯、碳酸亚乙烯、碳酸乙烯基亚乙酯、GBL及它们的混合物所组成的组中。在第二个实施方案中，一种非水溶剂是GBL。所述术语碱金属盐是指一种无机盐，所述无机盐适用于在非水溶剂中使用。包含碱金属盐的合适碱金属阳离子的实例是选自由Li^+、Na^+、K^+、Rb^+、Cs^+、Fr^+及它们的混合物所组成的组中的那些。包含碱金属盐的合适卤素阴离子的实例是选自由F^-、Cl^-、Br^-、I^-及它们的混合物所组成的组中的那些。在一个实施方案中，碱金属盐选自由LiF、LiCl、LiBr、NaF、NaCl、NaBr、KF、KCl、KBr及它们的混合物所组成的组中。其他盐例如$LiNO_3$也可以被使用，但在优选的实施方案中，所述碱金属盐是卤化物LiCl。

[0034] 在足够低的电流密度下，活性阳极材料的锂化将发生，而不电镀覆裸露的基底区域。在低电流密度下，在裸露基底和阳极活性材料的锂化电位之间具有存在足够的电化学

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电势差，用以避免锂金属沉积至裸铜区域上。在一个实施方案中，所述还原阶段处于低于0.1mA/cm^{2}的低电流密度。

[0035] 但是，在用于制备的实际电流密度下，“过电位”就变得重要。当添加到阳极锂化的过电位是足够的，用于将锂化金属沉积至裸露基底区域和边缘上的理论电压，即使在一次锂化步骤之后，其中一种用于碱化阳极的正向还原电流被施加至足以在具有碱化涂层的区域中至少部分地碱化阳极的时间。换句话说，“过电位”旨在表明，所述电压在上述步骤(b)期间足以使锂或者碱金属沉积、或者电镀至所述裸露基底上，除了已经被涂覆的基底的锂化之外。在附图2中表明了，其中箭头指出在涂覆的基底102和未涂覆的基底103上的锂沉积的相对大小。附图2中还指出了对电极104。在一个实施方案中，所述还原阶段(例如，步骤(b))是在0.1mA/cm^{2}和10mA/cm^{2}之间的电流下进行。在另一个实施方案中，所述还原阶段是在0.5mA/cm^{2}和3.0mA/cm^{2}之间的电流下进行。在一个更优选的实施方案中，所述还原阶段是在1.0mA/cm^{2}和1.4mA/cm^{2}之间的电流下进行。

[0036] 以这种方式电镀在裸铜区域上的锂金属可以被移除，对对锂化阳极活性材料基本没有影响。阳极氧化(反转)阶段期间的通量大小能够有利于锂从锂电镀金属区域(对应于未涂覆的基底101)的损失，在锂从阳极活性材料(对应于涂覆的基底102)的损失之上。附图3。在阳极氧化期间，一些锂离子从阳极活性材料中除去，但是所述锂电镀金属区域是有利的，由于在阳极活性材料中与插入的锂的电位(相对于氢参考为-2.8伏)相比，由箭头尺寸表示。在一个实施方案中，氧化阶段是在0.1mA/cm^{2}和2.4mA/cm^{2}之间的电流下进行。在优选的实施方案中，氧化阶段是在0.1mA/cm^{2}和1.2mA/cm^{2}之间的电流下进行。在甚至更优选的实施方案中，氧化阶段是在0.1mA/cm^{2}和0.8mA/cm^{2}之间的电流下进行。在最优选的实施方案中，氧化阶段是在0.6mA/cm^{2}的电流下进行。

[0037] 正向和反向电流密度和持续时间的大小将受到裸露基底区域和反电极的尺度的影响。例如，一种LiCl电解质源将会在碳对电极上均匀地氧化氯。由于涂覆的阳极材料的较低的电化学电势，如在附图8中所示，Li^+离子流向阳极活性材料，用焊剂线105表示。在各个开口铜区域上的电压分布受到影响。在附图9所给出的示例中，在两个开口铜区域上的电压分布在表面上方7mm处进行记录。所述电化学电池具有2cm深，并且所述小铜区107为5mm并且所述大铜区108为6mm宽。一旦电压超过临界电压，例如相对于Ag/AgCl为-3.2V，Li^0将开始在铜上形成。换句话说，“临界电压”指的是在裸露基底上能够引起锂沉积所需要的电压。通过观察，较大的开口铜区域的中心区域显示出碱金属沉积物的第一迹象，以锂枝晶106形式。在该实施例中，所述较小的区域保持清洁。

[0038] 通常，正向电流与反向电流的持续时间比约为8:1。在一个实施方案中，正向电流(还原)持续时间与反向电流(氧化)持续时间的比率是固定的，并且是在5:1和20:1之间。在更优选的实施方案中，所述固定比例为8:1。因此，正向到反向电流的例子包括，但不限于1.4mA/cm^{2}的固定正向电流和0.6mA/cm^{2}的固定反向电流；以一种固定的正向电流为1.2mA/cm^2，并且一种固定的反向电流为0.2mA/cm^2。

[0039] 一个正向(还原)电流脉冲和一个反向(氧化)电流脉冲的组合持续时间的总和代表一个循环。所述循环可以连续或不连续地进行重复。所述循环可以是在1纳秒到2个小时之间。优选的循环长度包括在1微秒至60分钟之间、在1毫秒至30分钟之间、在1厘秒至10分钟以及在1秒之间至6分钟之间。在一个实施方案中，所述循环时间选自1至6分钟。

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[0040] 基于正向电流或还原电流的过电压和持续时间(即时间长度或脉冲周期),锂将沉积在暴露的、未涂覆的或者裸露的基底区域和边缘上。反转电流可以去除(通过从Li^0氧化成Li^+)这些沉积物。在还原和氧化阶段期间的脉冲周期的持续时间是重要的,因为所述沉积物能够通过在还原阶段期间使用较短的脉冲周期进行抑制或限制。这将缩短氧化阶段所需的时间,并且将有助于提高所述方法的生产量。在一个实施方案中,一种还原阶段的脉冲周期持续时间足以使具有碱化涂层的区域中的阳极至少部分进行碱化,该脉冲周期持续时间是在1纳秒至1小时之间。优选的脉冲周期是在1微秒至30分钟之间、在1毫秒至15分钟之间、在1厘秒至5分钟之间、在1秒至3分钟之间,以及在1秒至1分钟之间。在第二实施方案中,氧化阶段的脉冲周期持续时间是在1纳秒和1小时之间。优选的脉冲周期是在1微秒至30分钟之间、在1毫秒至15分钟之间、在1厘秒至5分钟之间、在1秒至3分钟之间以及在1秒至1分钟之间。

[0041] 在另一个实施方案中,一种反向(氧化)电流脉冲的持续时间足以在任何区域中和不含碱化涂层的边缘上除去在阳极导电基底上的碱金属沉积物和枝晶,所述持续时间是在所述正向(还原)电流脉冲的持续时间的1%至100%之间、在所述正向(还原)电流脉冲的持续时间的1%至40%之间、在所述正向(还原)电流脉冲的持续时间的5%至30%之间或者在所述正向(还原)电流脉冲的持续时间的5%至20%之间。在另一个实施方案中,反向(氧化)电流脉冲的持续时间是在正向(还原)电流脉冲的持续时间的15%或20%之间。在另一个实施方案中,反向(氧化)电流脉冲的持续时间是在正向(还原)电流脉冲的持续时间的10%和15%之间。在一个实施方案中,正向和反向电流作为DC提供。在第二实施方案中,正向和反向电流作为AC提供。本发明所述的方法允许同时使用AC和DC两种。

[0042] 作为进一步的实施例,由电源(例如,Kiethley型号2220-30-1双通道)产生的还原电流可以通过嵌入锂的方式应用于阳极。第一通道是在还原脉冲中的辊阳极的0.5mA/cm^2和2.0mA/cm^2之间的电流密度下进行操作,时间在1纳秒至1小时之间。在一个实施方案中,第一通道是在1mA/cm^2的电流密度下操作60秒,然后第二通道是在0.6mA/cm^2下的反向(氧化)电流方向上操作还原脉冲周期的10%时间(附图4;6秒)。较短或者较长的周期可以通过定时电路进行控制。

[0043] 在该电流(例如1mA/cm^2)下的还原阶段期间内,操作电压变为大约6伏(附图4)。在反向电流模式中,所述电压变为大约1伏。这样的电压取决于在反转或去锂化阶段期间的锂化相中盐的离解(阳极上的还原)和在同上的Li^0至Li^+的氧化。所产生的电压也必须限制在电解质溶剂的范围内(例如,小于7伏)。

[0044] 不同的电极运动速度和持续时间能够在正向/反向电流方法中被应用。通常,速度和持续时间将随所需的锂化剂量、设备尺寸和活性阳极速率特性进行改变。优选的速度是在0.02米/分钟至12米/分钟之间。更优选的速度是在0.1米/分钟至3米/分钟之间。电极锂化的优选持续时间是在10分钟至500分钟之间。更优选的持续时间是在60分钟至120分钟之间。

[0045] 预锂化的辊阳极被纯溶剂冲洗用以除去残留的盐含量,重新卷绕,并且然后任选地在真空烘箱中进行溶剂干燥。然后,将预锂化的辊阳极在干燥环境中进行切割,成为用于卷绕、袋或棱柱形电池组件的形状。

[0046] 通过这种方式锂化整个电极,通过电流反转去除裸露基底表面和边缘上的任何锂

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金属沉积物，在电池组装之前，可以将用以补偿IRCL(或用于其他目的)的适当量的锂成功地进行预合金化或预嵌入至电极活性材料之中。由于用于焊接、切割或其他目的的清洁的无锂区域，电池组装的后续步骤变得更安全和实用。

[0047] 反向电流步骤的速率和持续时间可以在整个锂化过程中进行调整，从而获得更快的通过量并缩短整个过程锂化持续时间。这还可以用于在锂化的早期阶段保护任何暴露的基底表面，从而使其免受过度氧化/腐蚀。在锂化的初始阶段期间(例如，总目标剂量的第一个20％)，由于基底本身的氧化，反向电流实际上可能对暴露的基底造成损害。在初始阶段，将锂嵌入到活性阳极材料中所需的过电压低于嵌入锂作为在全部嵌入锂增加的剂量时所需的过电压。这种较低的过电压要求减少，甚至可以消除，暴露在基底表面上的锂电镀。如果此时阳极辊暴露于电流反转中，那么在基底表面处的氧化反应可能导致的是基底材料的氧化而不是锂的去除。这种氧化反应可能导致基底的腐蚀和机械故障，或者将引起在基底/活性阳极材料界面处产生电隔离膜，这将降低成品锂离子电池的操作效率。

[0048] 为了防止这种情况发生，可以在整个预锂化过程的整个持续时间内调整时间比和正向/反向电流比。在一个实施方案中，整个过程的正向/反向持续时间比可以保持恒定或者固定在8:1，但是反向循环的电流密度可以增加，其随着总剂量从0到0.6mA/cm^2增加而增加，此时在整个过程中，所述正向电流密度保持恒定或者固定在1.2mA/cm^2。在另一个实施方案中，所述正向/反向电流密度比可以在整个预锂化过程中保持固定或恒定，而反向/正向持续时间比可以从零增加到某个预定值，比如1:8。这两个实施方案也可以进行组合，其中所述反向电流密度随总剂量增加并且所述反向/正向持续时间比也随总剂量增加。不论是与恒定持续时间相比还是与恒定正向/反向电流比相比，这些方法都能够保护暴露的基底免受表面氧化，同时增加有效平均正向电流速率。一种AC电源也可以被应用，如果施加偏置电压，以便一种还原状态在大多数时间被应用(附图5)。

[0049] 在某些情况下，当短脉冲周期应用于在还原阶段期间时，在裸露基底区域和边缘上的锂沉积能够通过仅使用静止步骤而不是电流反转来进行消除。在这种情况下，所述短电荷转移至扩散阻碍了在基底表面上形成松散的锂金属形态。对于短脉冲的使用，可以使用脉冲电源，例如Dynatronix制造的DuPR10-1-3型。休息周期法包括与零电压脉冲(休息周期)交替的正向(还原)电压脉冲，该过程在交替正向电压脉冲和零电压脉冲的延长循环上继续。例如，使用Dynatronix模型DuPR10-1-3的休息周期法，正向(还原)电压脉冲可以是在Vmax的4V和Vmax的+100V之间。更优选的正向电压脉冲是为在Vmax的4V以及Vmax的8V。足以在具有碱化涂层的区域中至少部分地碱化阳极的正向(还原)电压脉冲周期的优选持续时间是在2毫秒至1000毫秒之间。更优选的电压脉冲周期持续时间是在10毫秒至800毫秒之间。甚至更优选的电压脉冲周期的持续时间是在100毫秒和500毫秒之间。零电压脉冲周期(休息周期)的优选持续时间是在2毫秒和1000毫秒之间。更优选的零电压脉冲持续时间是在10毫秒和800毫秒之间。甚至更优选的零电压脉冲持续时间是在100毫秒和500毫秒之间。

[0050] 正向电压脉冲和零电压脉冲的组合重复循环的总持续时间是在1分钟至1000分钟之间。更优选的重复循环持续时间是在10分钟至500分钟之间。更优选的重复循环持续时间是在30分钟至100分钟之间。所述循环可以连续或不连续地重复。

[0051] 为了确定样品的锂容量，将样品安装在隔板和锂箔上以形成半电池。在电解质中浸泡24小时后，施加电流以使样品进行脱锂至在锂之上几伏，例如高于锂的0.5、1.0、1.5、

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2.0、2.5和3.0伏。优选的电流密度是在C/5和C/30之间。更优选的电流密度是在C/10和C/20之间。

[0052] 本发明还提供了防止在电极辊阳极的裸露表面或边缘上沉积锂(或碱金属)。实施方案包括使用边缘保护装置、介电场孔或安装在辊阳极的每个暴露边缘上方和下方的屏蔽装置。

[0053] 在一个实施方案中，本发明涉及一种用于碱化阳极的电化学方法，包括以下步骤：

[0054] a.将边缘保护装置、介电场孔或屏蔽设置在阳极的每个暴露边缘的上方和下方；

[0055] b.将阳极置于含有碱金属盐的非水电解质溶液中，其中所述阳极包括导电基底，所述导电基底包括至少一个表面、在所述至少一个表面上的碱化涂层；以及

[0056] c.将正向还原电流施加至溶液中用以碱化阳极。

[0057] 所述边缘保护装置或者介电场孔是由与所用溶剂相容的介电材料构成。在GBL溶剂的情况下，所述防护装置是由聚乙烯制成。也可以使用其它相容的塑料或材料例如陶瓷，如果它们与溶剂相容并且能够提供相同的场还原水平。场还原剂量是通过测量在基底或阳极辊边缘或裸特征上的所得剂量来进行确定。由于局部电场是在屏蔽层和阳极辊之间的区域进行还原，因此较低的剂量或者锂电镀可以在该区域中发生。所述边缘保护方法可以使用休息周期法、正向/反向电流法、休息周期法与正向/反向电流法相结合法、或者仅用正向(还原)电流和无休止期法。所述边缘保护方法的优点在于更快的处理时间、降低的成本和优异的电极碱化应用，其中裸露基底仅存在于阳极边缘附近或沿着阳极边缘。

[0058] 根据本发明所述的全部方法可知，所得到的净剂量在0.1mAh/cm^2和10mAh/cm^2之间。

[0059] 实施例

[0060] 实施例1.在休息周期法之后应用正向/反向方法

[0061] 一种4.6×3.2cm^2面积的阳极电极安装在框架中，并且放置于具有2cm间距的对电极之间，所述阳极电极在其铜基底两侧涂覆有石墨-硅共混物的图案使得在每一侧的一个长边上裸露0.5cm的边缘(大约10％的裸铜)。在25℃下，用GBL溶剂和0.5M氯化锂溶液对电极进行包封。将二氧化碳鼓泡通入溶液中。使用Maccor 4200电池测试仪，大约150秒时产生了一种0.9mA/cm^2的正向(还原)电流密度，显示出+6V的电池电压(附图6)。在休息周期30秒之后立即进行该脉冲，产生0V的电池电压。在预锂化的早期阶段，在阳极中存在最小量的嵌入的Li，并且因此电流饭庄在此时尚未引入。在引入正向/反向脉冲方法前，正向/静止脉冲连续进行4个周期。使用Maccor 4200电池测试仪，然后所述休息周期是用一种电流密度为1mA/cm^2的电流反转(氧化)脉冲进行代替，持续30秒。所述正向和反向电流或脉冲进行连续地重复，直到得到所需的剂量，同时抑制裸铜区域上的任何锂沉积。这种方法产生具有裸Cu区域的预锂化阳极，其中裸铜区域不含Li^0金属颗粒。

[0062] 实施例2.应用休息周期法

[0063] 一种4.6×3.2cm^2的面积阳极电极安装在框架中，并且放置于具有2cm间距的对电极之间，所述阳极电极在其铜基底两侧涂覆有石墨-硅共混物的图案使得在每一侧的一个长边上裸露0.5cm的边缘(大约10％的裸铜)。在25℃下，用GBL溶剂和0.5M氯化锂溶液对电极进行包封。将二氧化碳鼓泡通入溶液中。使用前面提到的Dynatronix(DUPR10)电源产生正向(还原)电流和休息周期。所述脉冲被定义为V_{max}的+6V，持续时间为500毫秒(还原)，在

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0V下500毫秒的休息中周期。这些脉冲被连续地重复90分钟。这种方法制备具有预锂化的阳极，所述预锂化阳极具有未含Li^0金属颗粒的裸铜区域。对2.5cm^2的电极样品进行切割并安装在隔膜和锂箔上从而形成半电池。在电解液中浸泡24小时后，施加0.20mA/cm^2的电流密度用来对所述样品进行脱锂至超过锂的0.9V，从而确定所述样品的预锂化的锂容量。根据上述方法，所产生的剂量大约为1.5mAh/cm^2，并且所述裸铜区域不具有沉积的锂。

[0064] 实施例3.改变正向/反向电流比

[0065] 将一种6cm宽的铜基底放置于具有两厘米间距的对电极之间，对所述5cm的铜基底的两侧用石墨-硅共混物进行涂覆。在25℃下，用GBL溶剂和0.5M氯化锂溶液对电极进行包封。将二氧化碳鼓泡通入溶液中。总处理时间为90分钟。对于处理时间的前25％，会产生155秒的1.2mA/cm^2的正向(还原)电流。在0.15mA/cm^2的反向电流持续25秒之后，该脉冲紧立即进行。对于处理时间的第二个25％，会产生155秒的1mA/cm^2的正向(还原)电流。在0.3mA/cm^2的反向电流持续25秒后，该脉冲紧立即进行。对于处理时间的第三个25％，会产生155秒的1mA/cm^2的正向(还原)电流。在0.6mA/cm^2的反向电流持续25秒后，该脉冲紧立即进行。对于处理时间的最后一个25％，会产生155秒的1.0mA/cm^2的正向(还原)电流。在0.8mA/cm^2的反向电流持续25秒后，该脉冲紧立即进行。所述正向和反向电流或者脉冲进行连续地重复，直到得到所需的剂量，同时抑制裸铜区域上的任何锂沉积。在这个实施例中，所述电极运动的速度大约为113cm/hr。将一种样品切割并且安装至隔膜和锂箔上，从而形成一种半电池。在电解液中浸泡24小时后，0.25mA/cm^2的电流被应用于对样品进行脱锂至超过锂的2伏特，从而确定所述样品的锂容量。所述净用量大约为0.62mAh/cm^2，并且所述裸铜区域不具有沉积的锂。

[0066] 实施例4.边缘保护装置防护

[0067] 将一种铜基底的6cm宽的辊放置于具有两厘米间距的对电极之间，对所述5cm的辊的两个表面用石墨-硅共混物进行涂覆，从而一种1cm的未涂覆留边保留在所述铜的边缘上。如附图7所示，一种高密度聚乙烯边缘防护装置703是沿着活性对电极704的表面进行安装，其从框架边缘延伸至铜从而涂覆过度覆盖所述裸铜。在25℃下，用GBL溶剂和0.5M氯化锂盐溶液对电极进行包封。将二氧化碳鼓泡通入溶液中。会产生155秒的1.2mA/cm^2的正向(还原)电流。所期望的锂化剂量是在涂覆区域获得，如随后的半电池测试所确定的。在预锂化期间可目视观察到对所述裸铜表面保护使其避免锂沉积，并且随后通过将蒸馏水放置在裸铜边缘并发现所述蒸馏水与锂没有可见的反应而被证实。

[0068] 本发明涉及的专利和科学文献确立了本技术领域技术人员可用的全部知识。所有在本发明中应用的美国专利、发表或者未发表的美国专利申请、都通过在此引述并合并于本发明中。在此引用的所有公开的外国专利文献以及外国专利申请的全部内容在此引入作为参考。在此引用的其他所有公开的参考书、文献、手稿、以及科技文献的全部内容在此引入作为参考。

[0069] 虽然本发明已参照其优选实施方案进行特别示出和描述，但本领域的技术人员应当理解，在不脱离附加要求保护的本发明所涵盖范围的情况下，可以在形式和细节上进行各种变化。还应当理解的是，本发明在这里所描述的实施方案中没有相互排斥的，并且可以在不偏离所附权利要求所要求涵盖的本发明范围的情况下，能够以各种方式组合，并且本发明将包含所有落入其所附权利要求所保护范围内的实施方案。

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具有不同裸铜区域的双面阳极涂层

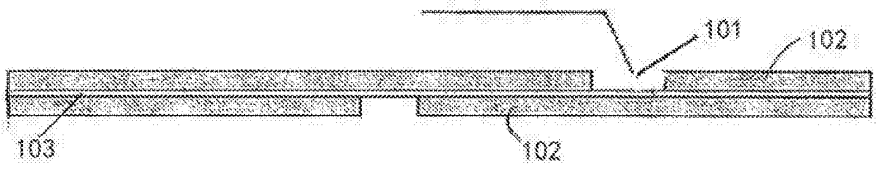


图1

还原在阳极还原期间，锂通量大小是由于阳极活性材料较低的电势

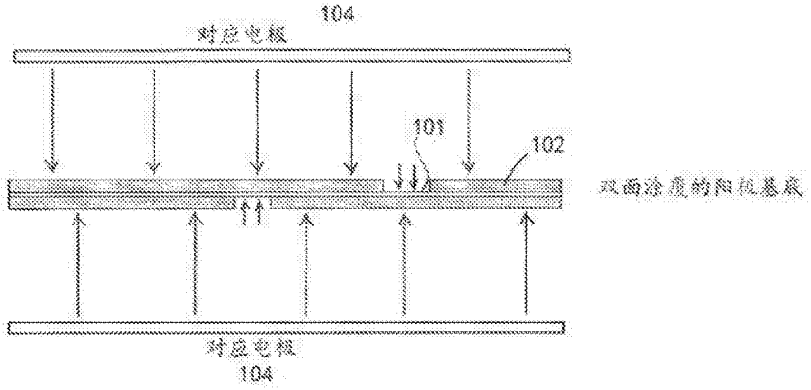


图2

在氧化期间，锂通量大小是由于阳极活性材料较高的电势

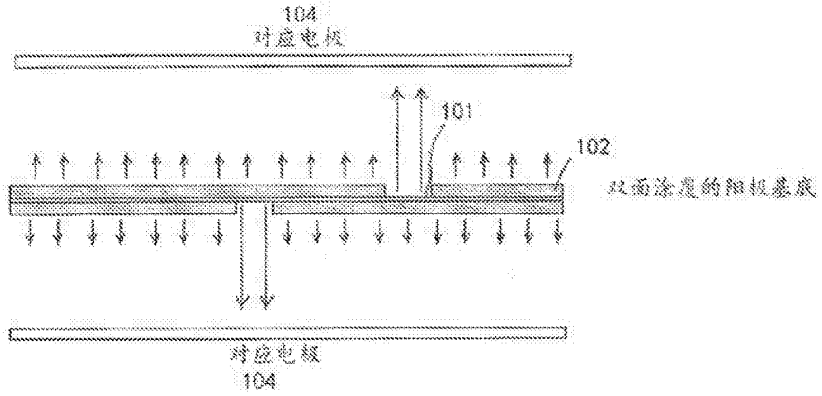


图3

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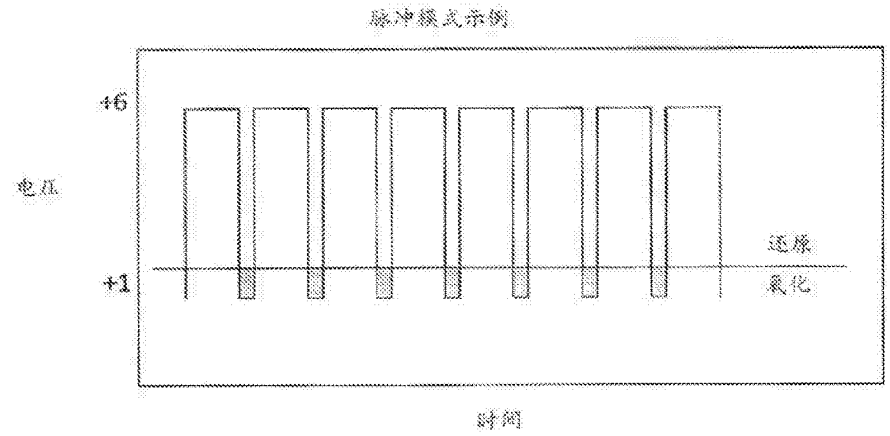


图4

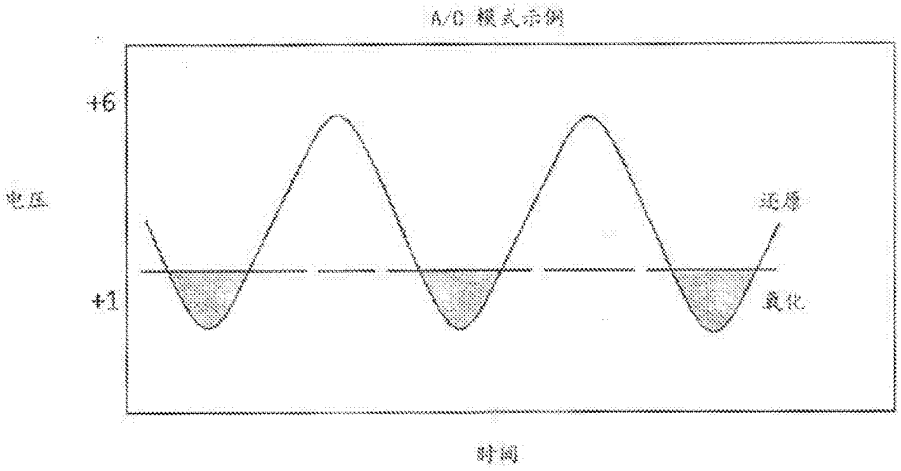


图5

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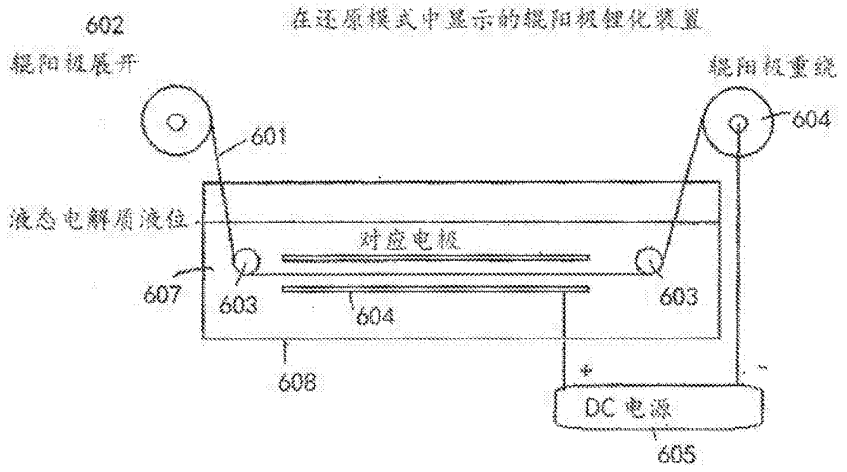


图6

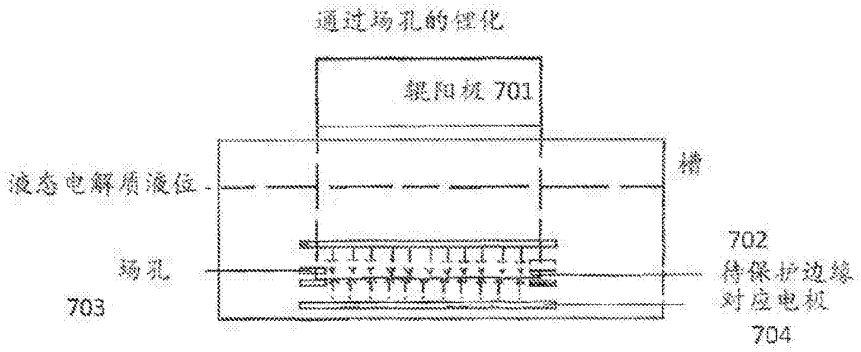


图7

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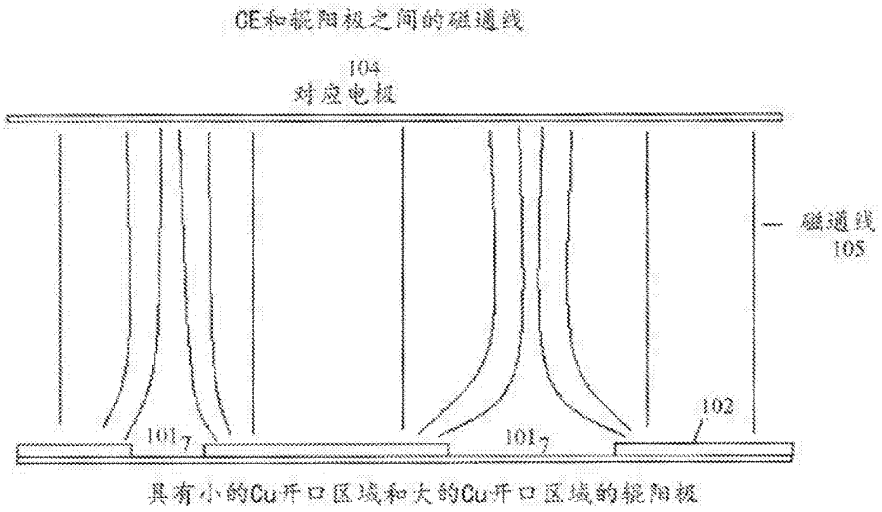


图8

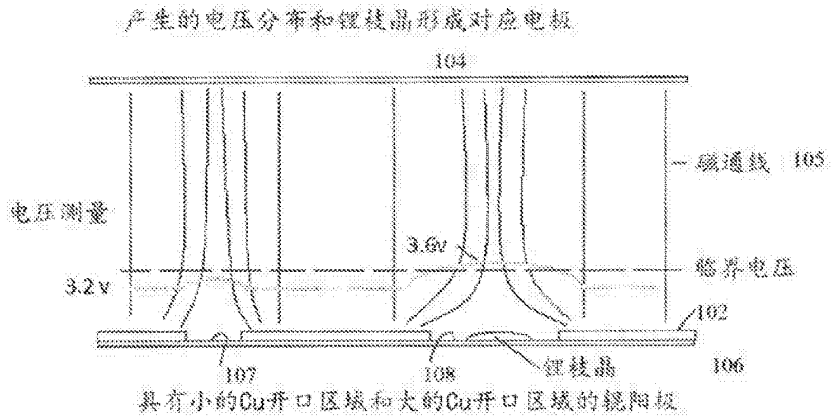


图9

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Espacenet

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METHODS FOR ALKALIATING ROLL ANODES

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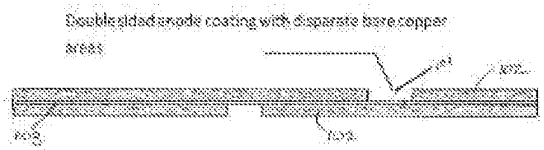


FIG. 1

The present invention relates to processes that may be used singly or in combination to prevent lithium (or alkali metal) plating or dendrite buildup on bare substrate areas or edges of electrode rolls during alkaliation of a battery or electrochemical cell anode composed of a conductive substrate and coatings, in which the electrode rolls may be coated on one or both sides and may have exposed substrate on edges, or on continuous or discontinuous portions of either or both substrate surfaces.

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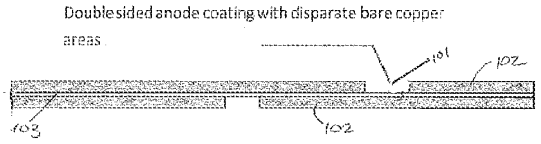


FIG. 1

(57) Abstract: The present invention relates to processes that may be used singly or in combination to prevent lithium (or alkali metal) plating or dendrite buildup on bare substrate areas or edges of electrode rolls during alkaliation of a battery or electrochemical cell anode composed of a conductive substrate and coatings, in which the electrode rolls may be coated on one or both sides and may have exposed substrate on edges, or on continuous or discontinuous portions of either or both substrate surfaces.

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METHODS FOR ALKALIATING ROLL ANODES

RELATED APPLICATION

This application claims the benefit of U.S. Provisional Application No. 62/265,090, filed on December 9, 2015. The entire teachings of the above application are incorporated herein by reference.

BACKGROUND OF THE INVENTION

Graphite is the most common anode material used to make lithium ion batteries. It is usually coated on a copper substrate or foil, but other lithium inactive metals may be used. Graphite offers a reversible capacity of about 370 mAh/gram, and suffers an irreversible capacity loss of about 5% to building a solid electrolyte interphase (SEI) layer. Recently, higher capacity anode materials have been introduced that could greatly increase the specific capacity of the lithium ion battery. For example, amorphous silicon can provide as much as 3500 mAh/gram (Obrovac MN and Krause LJ, 2007. Reversible cycling of crystalline silicon powder. *J. Electrochem. Soc.* 154: A103-A108).

Since anode materials used in lithium ion batteries do not contain lithium initially, cathode materials usually supply all of the lithium used in battery cycling and irreversible cycle loss (IRCL). Unfortunately, silicon exhibits an IRCL of up to 25%. This would mean that 25% of the cycle able capacity of the battery would become unavailable and the expensive and heavy cathode would be underutilized.

There have been attempts to add extra lithium to anode material by: a) adding a thin layer of lithium metal to the cell; b) adding lithium to the anode active material by electrolysis in a non-aqueous and dry environment; c) dispersing lithium into the anode material as in stabilized lithium metal powder, or SLMP (FMC Corporation, Philadelphia, PA); and d) adding lithium donating substances to the battery electrolyte during assembly. US 8,133,374 B2 is referenced here as a partial review of some of these methods. USSN 14/590,573 filed January 6, 2015, published as US Publication No. 2015019184 on July 9, 2015 entitled Method of Alkaliating Electrodes by Grant et al., is incorporated by reference in its entirety and for details of a process and an apparatus for electrochemical lithiation.

For anode rolls in commercial environments, it is desirable that some portion of substrate be uncoated in order to accommodate subsequent cell assembly methods, such as tab welding, slitting, or for other purposes. An anode roll is defined as an anode material which is of sufficient length to roll. Figure 1 shows edge view of a common anode substrate

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101 with a coating 102 where bare copper areas are present on both faces of the substrate in order to facilitate a spiral wound cell packaging technique. In another situation, the bare copper may be exposed on one or both edges 103 of the roll to accommodate the welding of cells constructed with cut, stacked electrode sheets. In yet another case, it may be desirable to use wide anode rolls (e.g. 30-60cm) for efficient production of small cells for consumer electronics devices. In such a case, interior surfaces of these larger anode rolls would contain many bare copper areas in rows or columns, and the exterior or edges might also need to be protected. In all these cases, any bare substrate area needs to be protected from lithium metal buildup during the electrochemical lithiation of the anode roll. If these and other configurations could be processed roll to roll, then mass production could be realized.

US 8,133,374 B2 teaches a way to use electrolysis to lithiate an anode substrate where a reference electrode detects areas of bare copper in order to "turn off" the current while the bare copper area is passing. It does not teach how this can be done on an anode coated on both sides, and hence is impractical for most commercial purposes in which anode rolls are double-sided. It also does not teach how to avoid lithium plating or dendrite buildup on the edges of a substrate. Since field strength concentrates on the substrate edges in an electrolysis bath, US 8,133,374 B2 is impractical in that it does not protect the edges.

SUMMARY OF THE INVENTION

The present invention relates to electrochemical processes that produce alkaliated anodes characterized by bare substrate areas free of alkali metals, which may be used singly or in combination to prevent lithium (or alkali metal) plating or dendrite buildup on bare substrate areas or edges of electrode rolls during alkaliation of a battery or electrochemical cell anode composed of a conductive substrate and coatings, in which the electrode rolls may be coated on one or both sides and may have exposed substrate on edges or on continuous or discontinuous portions of either or both substrate surfaces. Other areas free of an alkaliation coating according to any of the processes of the invention have exposed conductive substrate, and comprise the perimeter of the anode and/or a band perpendicular to and connecting the perimeters of the anode. Details of solutions and apparatus are described in U.S. Application No. 13/688,912, which is incorporated herein by reference. In one embodiment the coating is an alkaliation coating, wherein an alkaliation coating is any coating for receiving alkaliation ions, said coating preferably being comprised of graphite or silicon or a combination thereof.

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Deposition of alkali metal on bare or exposed conductive substrate during production of alkaliated anodes can occur. A process to prevent lithium (or alkali metal) plating or dendrite buildup on coated electrodes comprising bare substrate areas is the forward/reverse current method. A conductive substrate coated on at least one side is held in a non-aqueous electrolyte solution containing lithium (or alkali metal) salt. Conductive substrate coatings are comprised of an active material layer capable of absorbing and releasing lithium ions. Coatings may preferably be graphite or other forms of carbon, or silicon, tin or the like, or combinations thereof, and the coating area is preferably discontinuous on the substrate. Such materials can exert the effect of the present invention regardless of whether such a material is any of an elemental substance, an alloy, a compound, a solid solution and a composite active material containing a silicon-containing material or a tin-containing material. The bare or exposed areas can be the substrate edges, any surface margins or any inner areas on either or both surfaces, and bare areas can be patterned to facilitate cutting the sheet to smaller anode materials, or to leave areas for welding. For example, the bare areas can be regularly striped across the width of the substrate or along the length of the substrate roll. A method for manufacturing a coated electrode is presented.

The working counter electrode can be connected to the positive side of a power D.C. power supply. The conductive substrate can be connected to the negative side of the power supply. A current is passed between the working electrode and the conductive substrate through the electrolyte solution volume between the electrodes. This produces an oxidizing current at the working electrode and a reducing current at the conductive substrate. This reducing current at the conductive substrate provides for the lithium deposition on the coated electrode and the exposed substrate. The reducing current is interrupted periodically and forced to reverse (oxidizing current) with a short duration with respect to the reducing current duration. In this way, lithium that deposits on the bare conductive substrate, such as on a copper conductive substrate, during the reducing current phase is removed during the oxidizing phase. This technique works well on interior and exterior bare conductive substrate areas, such as on a bare copper conductive substrate, regardless of their position within the anode substrate roll. The oxidizing current at the anode surface will favor lithium removal from exposed substrate areas compared to coated areas due to the larger electro-chemical potential of plated lithium compared to intercalated lithium. By lithiating the whole electrode in this way, with current reversal favoring the removal of lithium from the bare substrate surfaces and edges, the amount of lithium to compensate for IRCL (or for

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other purposes) can be controlled and successfully pre-alloyed or pre-intercalated into the electrode active material prior to cell assembly. Subsequent steps of cell assembly are made safer and practical due to clean, lithium-free areas for welding, slitting or other purposes.

It is understood that the terms "lithiate" or "lithiation" are more specific cases of the general terms "alkaliate" or "alkaliation." In other words, it is to be understood that where the term "lithiate" or "lithiation" is used in the specification, an alternative embodiment includes "alkaliate " or "alkaliation" and vice versa.

A second process to prevent lithium (or alkali metal) plating or dendrite buildup on bare substrate areas and edges of coated electrodes during alkaliation of a battery or electrochemical cell anode, in which the electrode may be coated on one or both sides, is the rest period method. The rest period method comprises forward (reducing) voltage pulses alternating with zero voltage pulses (rest period), the process continuing over extended cycles of alternating forward voltage pulses and zero voltage pulses. The rest period method may be performed alone, or in combination with the forward/reverse current method.

A third process to prevent alkali metal plating on bare substrate areas and edges of coated electrodes during alkaliation of a battery or electrochemical cell anode, in which the electrode may be coated on one or both sides, is the edge guard method. Edge guards are constructed of a dielectric material that is compatible with the solvent used, and are mounted above and below each exposed edge of the roll anode to prevent alkaliation of bare substrate edges. The edge guard method may be performed using the rest period method, the forward/reverse current method, the rest period method in combination with the forward/reverse current method, or with only forward (reducing) current and no rest period.

DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention, as illustrated in the accompanying drawings in which like reference characters refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention.

Figure 1. Illustration of double sided anode coating with bare copper areas.

Figure 2. Illustration of lithium flux magnitude during reduction phase at anode.

Figure 3. Illustration of lithium flux magnitude during oxidation phase at anode.

Figure 4. Illustration of voltage magnitudes during oxidation and reduction pulse periods at $1 mA/cm^2$.

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Figure 5. Illustration of voltage magnitudes during oxidation and reduction pulse periods at 1mA/cm^2 using an AC source.

Figure 6. Illustration of roll anode arrangement in reduction mode. The roll anode 601 is removed from the roll anode unwind 602, directed into a tank 608 containing the liquid electrolyte 607, between the counter electrodes 604, which are operably connected to a power supply 605, and returned to the roll anode rewind 606. Rollers 603 assist in directing the anode.

Figure 7. Illustration of lithiation of roll anode through dielectric field apertures.

Figure 8. Illustration of flux lines between counter electrode and roll anode as a function of lower electrochemical potential of the coated anode material.

Figure 9. Illustration of lithium dendrite formation as a function of overvoltage and dimension of the open copper area.

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to methods for alkaliation of an anode to prevent alkali metal plating or dendrite buildup on bare substrate areas or edges of the anode's conductive substrate, wherein the anode comprises an electrode or electrode roll. In one embodiment, a bare substrate area is located along the edges of the anode's conductive substrate. Anodes can be comprised of lithium-active material coated on a conductive substrate such as copper, nickel, etc. In one embodiment, anodes are lithium-intercalating anodes. Examples of materials that comprise lithium-intercalating anodes include but are not limited to carbon and graphite, tin oxide, silicon, silicon oxide, polyvinylidene difluoride (PVDF) binder, and mixtures thereof. In a further embodiment, lithium-intercalating anode materials are selected from graphite, cokes, and mesocarbons. Alternatively, a lithium alloying material can be deposited or plated, etc. on a conductive substrate. In one embodiment, the alloying materials include but are not limited to tin, aluminum, silicon or germanium. For purposes of the description only, the roll of coated conductor material or the roll of active alloying material will be referred to as the roll anode.

In one embodiment, the invention relates to an electrochemical process to alkaliate an anode to produce an alkaliated anode characterized by bare substrate areas free of alkali metals comprising the steps of:

a. Subjecting an anode to a non-aqueous electrolytic solution comprising an alkali metal salt, wherein said anode comprises a conductive substrate comprising at

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least one surface characterized by at least one area having an alkaliation coating thereon and at least one area that is free of an alkaliation coating;

b. Applying a forward reducing current to alkaliate the anode for a time sufficient to at least partially alkaliate the anode in the areas having an alkaliation coating;

c. Maintaining the anode produced by step (b) in the solution and, optionally, applying a reversed oxidative current to remove any alkali metal deposits from the bare substrate areas; and

d. Repeating steps b and/or c.

In one embodiment, steps b and c are repeated at least about two times. In a preferred embodiment, steps b and c are repeated at least about three times. In a more preferred embodiment, steps b and c are repeated at least about five times, at least about ten times or, more preferably, at least about 20 times. In a further embodiment, the anode is maintained in at least one step c in the substantial absence of current for a time sufficient to permit diffusion of at least some of the alkali metal into the alkaliation coating.

A method for manufacture of a coated electrode comprises the steps of cleaning the surfaces of a conductive substrate; coating a slurry with the active material onto one side of the substrate in a continuous or dis-continuous pattern; drying the first side of the coated material; coating the second side of the conductive substrate with the active material in a continuous or dis-continuous pattern; drying the second side of the coated material; calendaring and slitting the coated conductive substrate into final shape and size.

The roll anode is directed through an electrochemical tank composed of at least one counter electrode, a non-aqueous solution containing an alkali metal salt, and rollers to guide and complete the circuit to the roll anode. Non-aqueous solutions comprise an organic solvent(s) added to an electrolyte which serves the purpose of solvating the inorganic ion salt. Typical examples of a non-aqueous solvents are butylene carbonate, propylene carbonate, ethylene carbonate, vinylene carbonate, vinyl ethylene carbonate, dimethyl carbonate, diethyl carbonate, dipropyl carbonate, methyl ethyl carbonate, acetonitrile, gamma-butyrolactone (GBL), triglyme, tetraglyme, dimethylsulfoxide, dioxolane, sulfolane, room temperature ionic liquids (RTIL) and mixtures thereof. In one embodiment, a non-aqueous solvent is selected from ethylene carbonate, vinylene carbonate, vinyl ethylene carbonate, GBL, and mixtures thereof. In a second embodiment, a non-aqueous solvent is GBL. The term alkali metal salt refers to an inorganic salt which is suitable for use in a non-aqueous solvent. Examples of suitable alkali metal cations comprising an alkali metal salt

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are those selected from Li^+, Na^+, K^+, Rb^+, Cs^+, Fr^+, and mixtures thereof. Examples of suitable halogen anions comprising an alkali metal salt are those selected from F^-, Cl^-, Br^-, I^-, and mixtures thereof. In one embodiment, the alkali metal salt is selected from LiF, LiCl, LiBr, NaF, NaCl, NaBr, KF, KCl, KBr, and mixtures thereof. Other salts such as $LiNO_3$ may be used, but in the preferred embodiment, the alkali metal salt is the halide LiCl.

At sufficiently low current densities, lithiation of active anode material will occur without plating bare substrate areas. There is enough electrochemical potential difference between the lithiation potential of bare substrate and anode-active material at low current densities to avoid deposition of lithium metal on the bare copper areas. In one embodiment, the reduction phase is at low current densities under 0.1 mA/cm^2.

However, at practical current densities for manufacturing, "over-potential" becomes necessary. This over-potential is enough when added to the anode lithiation theoretical voltage to deposit lithium metal onto the bare substrate areas and edges, even after one lithiation step, wherein a forward reducing current to alkaliate the anode is applied for a time sufficient to at least partially alkaliate the anode in the areas having an alkaliation coating. In other words, "over-potential" is intended to mean the voltage sufficient to cause lithium or alkali metal deposition, or plating, onto the bare substrate, in addition to lithiation of the coated substrate, during step (b) above. This is illustrated in Figure 2 where the arrows depict the relative magnitude of lithium deposition on the coated substrate 102 and uncoated substrate 103. Also shown in Figure 2 are the counter electrodes 104. In one embodiment, the reduction phase (e.g., step (b)) is performed at a current between 0.1 mA/cm^2 and 10 mA/cm^2. In another embodiment, the reduction phase is performed at a current between 0.5 mA/cm^2 and 3.0 mA/cm^2. In a more preferred embodiment, the reduction phase is performed between 1.0 mA/cm^2 and 1.4 mA/cm^2.

Lithium metal plated on bare copper areas in this manner can be removed with little impact on lithiated anode-active material. Flux magnitudes during the anode oxidation (reversal) phase can favor the loss of lithium from lithium-plated metal areas (corresponding to the uncoated substrate 101) over loss from the anode-active material (corresponding to the coated substrate 102). Figure 3. During anode oxidation, some lithium ions are removed from the anode-active material, but the lithium-plated metal areas are favored due to their larger potential (-3.0 volts with regard to a hydrogen reference) compared to the potential of intercalated lithium (-2.8 volts with regard to a hydrogen reference) in the anode active material, illustrated by the arrow size. In one embodiment, the oxidation phase is performed at a current between 0.1 mA/cm^2 and 2.4 mA/cm^2. In a

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preferred embodiment, the oxidation phase is performed between 0.1 mA/cm^2 and 1.2 mA/cm^2. In an even more preferred embodiment, the oxidation phase is performed between 0.1 mA/cm^2 and 0.8 mA/cm^2. In a most preferred embodiment, the oxidation phase is performed at 0.6 mA/cm^2.

The magnitude of forward and reverse current densities and durations will be affected by the scale of the bare substrate areas and counter electrodes. For the sake of example, a LiCl electrolyte source will oxidize chlorine evenly across a carbon counter electrode. Due to the lower electrochemical potential of the coated anode material, Li^+ ions flow toward the anode active material as shown in Figure 8, depicted with flux lines 105. The voltage profiles across the various open copper areas are affected. In the example shown in Figure 9, a voltage profile over two open copper areas is recorded at 7mm above the surface. The electrochemical cell is 2cm deep, and the small copper area 107 is 5mm and the large copper area 108 is 6mm wide. As soon as the voltage exceeds a critical voltage, e.g., -3.2 V *vs.* Ag/AgCl, Li^0 will begin to form on copper. In other words, the "critical voltage" is the voltage required to cause lithium deposition on the bare substrate. By observation, the center region of the larger open copper area shows the first signs of alkali metal deposits in the form of lithium dendrites 106. The smaller area remained clear in this example.

Typically, the duration ratio of forward current to reversed current is about 8:1. In one embodiment, ratios of forward current (reducing) duration to reversed current (oxidizing) duration are fixed, and between 5:1 and 20:1. In a more preferred embodiment, the fixed ratio is 8:1. Accordingly, examples of forward to reversed currents include, but are not limited to, a fixed forward current of 1.4 mA/cm^2, and a fixed reversed current of 0.6 mA/cm^2; a fixed forward current of 1.2 mA/cm^2, and a fixed reversed current of 0.2 mA/cm^2.

The sum of the combined durations of one forward (reducing) current pulse and one reverse (oxidizing) current pulse represents one cycle. The cycles can be repeated continuously or discontinuously. Cycles can be between 1 nanosecond and 2 hours in length. Preferred cycle lengths include between 1 microsecond and 60 minutes, between 1 millisecond and 30 minutes, between 1 centisecond and 10 minutes, and between 1 second and 6 minutes. In one embodiment, the cycle times are selected from between 1 to 6 minutes.

Depending on the over voltage and the duration (i.e. length of time, or pulse period) of the forward or reducing currents, lithium will deposit on the exposed, uncoated or bare,

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substrate areas and edges. Reversal currents can remove (via oxidation from Li^0 to Li^+) these deposits. The durations of pulse periods during the reduction and oxidizing phases are important since deposits can be inhibited or limited by using shorter pulse periods during the reduction phase. This will shorten the time required during the oxidation phase and will help to increase the throughput of the process. In one embodiment, the pulse period duration of a reduction phase sufficient to at least partially alkaliate the anode in the areas having an alkaliation coating is between 1 nanosecond and 1 hour in length. Preferred pulse periods are between 1 microsecond and 30 minutes, between 1 millisecond and 15 minutes, between 1 centisecond and 5 minutes, between 1 second and 3 minutes, and between 1 second and 1 minute. In a second embodiment, the pulse period duration of an oxidizing phase is between 1 nanosecond and 1 hour in length. Preferred pulse periods are between 1 microsecond and 30 minutes, between 1 millisecond and 15 minutes, between 1 centisecond and 5 minutes, between 1 second and 3 minutes, and between 1 second and 1 minute.

In a further embodiment, the duration of a reverse (oxidizing) current pulse is sufficient to remove alkali metal deposits and dendrites from the anode conductive substrate in any areas and edges free of an alkaliation coating is between 1% and 100% the duration of the forward (reducing) current pulse, between 1% and 40% the duration of the forward (reducing) current pulse, between 5% and 30% the duration of the forward (reducing) current pulse, or between 5% and 20% the duration of the forward (reducing) current pulse. In a preferred embodiment, the duration of a reverse (oxidizing) current pulse is 15% or 20% the duration of the forward (reducing) current pulse. In another embodiment, the duration of the reverse (oxidizing) current pulse is between 10% and 15% the duration of the forward (reducing) current pulse. In one embodiment, the forward and reverse currents are supplied as DC. In a second embodiment, the forward and reverse currents are supplied as AC. The methods of the invention allow for the use of both AC and DC.

By way of further example, reducing current produced by a power supply, such as a Kiethley model 2220-30-1 dual channel, can be applied to the anode in such a way as to intercalate the lithium. A first channel is operated with a current density of between 0.5 mA/cm^2 and 2.0 mA/cm^2 of roll anode in the reduction pulse, for between 1 nanosecond and 1 hour in length. In one embodiment, a first channel is operated with current density of 1 mA/cm^2 for 60 seconds, then a second channel is operated at 0.6 mA/cm^2 in the reverse (oxidizing) current direction for 10% of the reduction pulse period (Figure 4; 6 seconds). Shorter or longer periods may be controlled by a timing circuit.

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During the reduction phase at this current (e.g. 1 mA/cm^2), the voltage of operation becomes about 6 volts (Figure 4). In the reverse current mode, the voltage becomes about 1 volt. These voltages are governed by the dissociation of salt in the lithiation phase (reduction on the anode) and oxidation of Li^0 to Li^+ on the copper during the reversal or de-lithiation phase. The resulting voltages must also be limited within the range of the electrolyte solvent (e.g. less than 7 volts).

Various speeds and durations of electrode movement can be used during the forward/reverse current method. In general, speeds and durations will vary with desired lithiation dosages, machine size, and active anode rate characteristics. Preferred speeds are between 0.02 meter/minute and 12 meters/minute. More preferred speeds are between 0.1 meter/minute and 3 meters/minute. Preferred time durations of electrode lithiation are between 10 minutes and 500 minutes. More preferred time durations are between 60 minutes and 120 minutes.

The pre-lithiated roll anode is rinsed with pure solvent to remove residual salt content, rewound, and then optionally dried of solvent in a vacuum oven. The pre-lithiated roll anode is then cut into shapes for wind up, pouch or prismatic cell assembly in a dry environment.

By lithiating the whole electrode in this way, with current reversal removing any lithium metal deposits on the bare substrate surfaces and edges, the appropriate amount of lithium to compensate for IRCL (or for other purposes) can be successfully pre-alloyed or pre-intercalated into the electrode active material prior to cell assembly. Subsequent steps of cell assembly are made safer and practical due to clean, lithium-free areas for welding, slitting or other purposes.

The rate and duration of the reverse current steps can be modified throughout the lithiation process to obtain a faster throughput and shorten the overall process lithiation duration time. This can also serve to protect any exposed substrate surfaces from excess oxidation/corrosion during the early phases of lithiation. During the initial phases of lithiation (e.g. 1st 20% of total target dosage), reverse currents can actually be damaging to the exposed substrate due to oxidation of the substrate itself. In the initial phase, the required overvoltage to intercalate lithium into the active anode material is lower than the overvoltage required to intercalate lithium as the dosage of the total intercalated lithium increases. This lower overvoltage requirement reduces, and can even eliminate, the plating of lithium on exposed substrate surfaces. If the anode roll is exposed to current reversal at this point, then the oxidation at the substrate surface may cause oxidation of the substrate

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material instead of removal of lithium. This oxidation may cause corrosion and mechanical failure of the substrate or will result in electrical isolating films to be generated at the substrate/active anode material interface which will reduce operating efficiency of the finished lithium ion cells.

To prevent this from happening, the time ratio and the forward/reverse current ratio can be modified throughout the duration of the overall pre-lithiation process. In one embodiment, the forward/reverse time duration ratio for the entire process may remain constant or fixed at 8:1, but the current density for the reverse cycle may increase as total dosage increases from zero to 0.6 mA/cm^2 while the forward current density remains constant or fixed at 1.2 mA/cm^2 for the entire process. In another embodiment, the forward/reverse current density ratio may remain fixed or constant throughout the overall pre-lithiation process, while the reverse/forward time duration ratio may increase from zero to some predetermined value, say 1:8. These two embodiments may also be combined where the reverse current density increases over with total dosage and the reverse/forward time duration ratio also increases with total dosage. These methods protect the exposed substrate from surface oxidation while increasing the effective average forward current rate compared to either constant time duration ratios or constant forward/reverse current ratios. An AC source can be used also if there is a biasing voltage applied so that a reducing state is applied most of the time (Figure 5).

In some cases where short pulse periods are used during the reduction phase, lithium deposition on bare substrate areas and edges is eliminated by using only a rest step instead of current reversal. In this case, the short charge transfer to the diffused lithium discourages the formation of loose lithium metal morphology on the surface of the substrate. For use of short pulses, a pulse power supply, such as Model DuPR10-1-3 made by Dynatronix, can be used. The rest period method comprises forward (reducing) voltage pulses alternating with zero voltage pulses (rest periods), the process continuing over extended cycles of alternating forward voltage pulses and zero voltage pulses. For example, using the rest period method with the Dynatronix Model DuPR10-1-3, forward (reducing) voltage pulses can be between 4V for Vmax and +100V for Vmax. More preferred forward voltage pulses are between 4V for Vmax and 8V for Vmax. Preferred durations of forward (reducing) voltage pulse periods sufficient to at least partially alkaliate the anode in the areas having an alkaliation coating are between 2 milliseconds and 1000 milliseconds. More preferred durations of voltage pulse periods are between 10 milliseconds and 800 milliseconds. Even more preferred durations of voltage pulse periods are between 100 milliseconds and 500 milliseconds.

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Preferred durations of zero voltage pulse periods (rest periods) are between 2 milliseconds and 1000 milliseconds. More preferred durations of zero voltage pulses are between 10 milliseconds and 800 milliseconds. Even more preferred durations of zero voltage pulses are between 100 milliseconds and 500 milliseconds.

The total duration of combined repeating cycles of forward voltage pulses and zero voltage pulses is between 1 minute and 1000 minutes. A more preferred duration of repeating cycles is between 10 minutes and 500 minutes. An even more preferred duration of repeating cycles is between 30 minutes and 100 minutes. The cycles can be repeated continuously or discontinuously.

To determine lithium capacity of a sample, the sample is mounted against a separator and lithium foil to form a half cell. After soaking in electrolyte for 24 hours, a current is applied to de-lithiate the sample to a few volts above lithium, such as 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0 volts above lithium. Preferred current densities are between C/5 and C/30. More preferred current densities are between C/10 and C/20.

The present invention also provides for the prevention of lithium (or alkali metal) deposition on bare surfaces or edges of electrode roll anodes. Embodiments include the use of edge guard apertures, dielectric field apertures, or shields mounted above and below each exposed edge of the roll anode.

In one embodiment, the invention relates to an electrochemical process to alkaliate an anode comprising the steps of:

a. Positioning edge guard apertures, dielectric field apertures, or shields above and below each exposed edge of the anode;
b. Subjecting an anode to a non-aqueous electrolytic solution comprising an alkali metal salt, wherein said anode comprises a conductive substrate comprising at least one surface, an alkaliation coating on the at least one surface; and
c. Applying a forward reducing current through the solution to alkaliate the anode.

The edge guards or field apertures are constructed of dielectric material that is compatible with the solvent used. In the case of GBL solvent, the guards are made of polyethylene. Other compatible plastics or material such as ceramics may also be used if they are compatible with the solvent and offer the same level of field reduction. The amount of field reduction is determined by surveying the resultant dosage on the substrate or anode roll edges or bare features. The local electric field is reduced in the area between the shield and the anode roll and therefore lower dosage or lithium plating can take place in this area.

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The edge guard method may be performed using the rest period method, the forward/reverse current method, the rest period method in combination with the forward/reverse current method, or with only forward (reducing) current and no rest period. Advantages of the edge guard method include faster processing time, reduced costs, and excellent application to alkaliation of electrodes, wherein bare substrate is present only near or along the edges of the anode.

According to all the methods of the invention, net dosages achieved are between 0.1 mAh/cm^2 and 10 mAh/cm^2.

EXAMPLES

Example 1. Using Forward/Reverse Method following Rest Period Method

A 4.6 x 3.2 cm^2 area anode electrode, coated in a pattern with a graphite – silicon blend on both sides of a copper substrate so that a 0.5 cm margin was bare on the one long edge of each side (approximately 10% bare copper), was mounted in a frame and placed between counter electrodes using 2 cm spacing. A GBL solvent and 0.5M LiCl salt solution held at 25°C enveloped the electrodes. Carbon dioxide was bubbled through the solution. Using a Maccor 4200 battery tester, a forward (reducing) current density of 0.9 mA/cm^2 was produced for 150 seconds exhibiting a cell voltage of +6 V (Figure 6). This pulse was immediately followed by a rest period for 30 seconds producing a cell voltage of 0 V. At the early stages of pre-lithiation, there is a minimum amount of intercalated Li in the anode and therefore current reversal was not yet introduced. Forward / rest pulses were carried out for 4 consecutive cycles before introducing forward / reverse pulse method. The rest period was then substituted with a current reversal (oxidation) pulse with a current density of 1.0 mA/cm^2 for a 30 second period using a Maccor 4200 battery tester. The forward and reverse currents or pulses were repeated continuously until the desired dosage was achieved while inhibiting any lithium deposition on the bare copper areas. This method produces pre-lithiated anodes with bare Cu areas that do not contain Li^0 metal particles.

Example 2. Using Rest Period Method

A 4.6 x 3.2 cm^2 area anode electrode, coated in a pattern with a graphite – silicon blend on both sides of a copper substrate so that a 0.5 cm margin was bare on the one long edge of each side (approximately 10% bare copper), was mounted in a frame and placed between counter electrodes using 2 cm spacing. A GBL solvent and 0.5M LiCl salt solution held at 25°C enveloped the electrodes. Carbon dioxide was bubbled through the solution. Forward (reducing) currents and rest periods were produced with the use of the previously

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mentioned Dynatronix (DuPR10) power supply. The pulses were defined as +6 V for V_{max} with a duration of 500 milliseconds (reducing), and rest period of 500 milliseconds at 0 V. These pulses were repeated continuously for 90 minutes. This method produces pre-lithiated anodes with bare Cu areas with no Li^0 metal particles. A 2.5 cm^2 electrode sample was cut and mounted against separators and lithium foil to form a half cell. After soaking in electrolyte for 24 hours, a current density of 0.20 mA/cm^2 was applied to de-lithiate the sample to 0.9 V above lithium to determine the pre-lithiated lithium capacity of the sample. According to the method, the dosage produced was approximately 1.5 mAh/cm^2, and the bare copper areas were clear of deposited lithium.

Example 3. Varying Forward/Reverse Current Ratios

A 6 cm wide copper substrate, 5 cm of which are coated on both sides with a graphite – silicon blend, was placed between counter electrodes using two centimeter spacing. A GBL solvent and .5M LiCl salt solution held at 25 degrees C enveloped the electrodes. Carbon dioxide was bubbled through the solution. Total process time was 90 minutes. For the first 25% of the process time, a forward (reducing) current of 1.2 mA/cm^2 was produced for 155 seconds. This pulse was immediately followed by a reverse current of 0.15 mA/cm^2 for a duration of 25 seconds. For the second 25% of the process time, a forward (reducing) current of 1.0 mA/cm^2 was produced for 155 seconds. This pulse was immediately followed by a reverse current of 0.3 mA/cm^2 for a duration of 25 seconds. For the third 25% of the process time, a forward (reducing) current of 1.0 mA/cm^2 was produced for 155 seconds. This pulse was immediately followed by a reverse current of 0.6 mA/cm^2 for a duration of 25 seconds. For the last 25% of the process time, a forward (reducing) current of 1.0 mA/cm^2 was produced for 155 seconds. This pulse was immediately followed by a reverse current of 0.8 mA/cm^2 for a duration of 25 seconds. The forward and reverse currents or pulses were repeated continuously until the desired dosage was achieved while inhibiting any lithium deposition on the bare copper areas. In this example, the speed of the electrode movement was about 113 cm/hr. A sample was cut and mounted against a separator and lithium foil to form a half cell. After soaking in electrolyte for 24 hours, a current of .25 mA/cm^2 was used to de-lithiate the sample to 2 volts above lithium to determine the lithium capacity of the sample. The net dosage was about 0.62 mAh/cm^2 and the bare copper areas were clear of deposited lithium.

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Example 4. Edge Guard Protection

A 6 cm wide roll 701 of copper substrate, 5 cm of which was coated on both faces with a graphite-silicon composition so that a 1 cm uncoated margin remained on one edge of the copper, was placed between counter electrodes using two centimeter spacing. A high density polyethylene edge guard 703 was mounted along the face of the active counter electrode 704 originating from the edge of the frame extending to the copper to coating transition covering the bare copper, as shown in Figure 7. A GBL solvent and .5M LiCl salt solution held at 25 degrees C enveloped the electrodes. Carbon dioxide was bubbled through the solution. A forward (reducing) current of 1.2 mA/cm^2 was produced for 116.4 minutes. The desired lithiation dosage was achieved in the coated area as determined by subsequent half cell testing. Protection of the bare copper surfaces from lithium deposition was visually observed during pre-lithiation and was confirmed subsequently by placing distilled water on the bare copper edge and finding no visible reaction of the water with lithium.

The patent and scientific literature referred to herein establishes the knowledge that is available to those with skill in the art. All United States patents and published or unpublished United States patent applications cited herein are incorporated by reference. All published foreign patents and patent applications cited herein are hereby incorporated by reference. All other published references, documents, manuscripts and scientific literature cited herein are hereby incorporated by reference.

While this invention has been particularly shown and described with references to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the invention encompassed by the appended claims. It will also be understood that none of the embodiments described herein are mutually exclusive and may be combined in various ways without departing from the scope of the invention encompassed by the appended claims, and that the invention will include all embodiments falling within the scope of the appended claims.

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CLAIMS

What is claimed is:

1. An electrochemical process to alkaliate an anode to produce an alkaliated anode characterized by bare substrate areas free of alkali metals comprising the steps of:
   a. Subjecting an anode to a non-aqueous electrolytic solution comprising an alkali metal salt, wherein said anode comprises a conductive substrate comprising at least one surface characterized by at least one area having an alkaliation coating thereon and at least one area that is free of an alkaliation coating;
   b. Applying a forward reducing current to alkaliate the anode for a time sufficient to at least partially alkaliate the anode in the areas having an alkaliation coating;
   c. Maintaining the anode produced by step (b) in the solution and, optionally, applying a reversed oxidative current to remove any alkali metal deposits from the bare substrate areas; and
   d. Repeating steps b and/or c.

2. The process of claim 1, wherein the alkaliated anode achieves a dosage of between 0.1 mAh/cm^2 and 10 mAh/cm^2, and exhibits no alkali metal deposits.

3. The process of claim 2, wherein the steps b and c are repeated at least about 3 times, preferably at least about 5 times, more preferably at least about 20 times.

4. The process of claim 3, wherein the anode is maintained in at least one step c in the substantial absence of current for a time sufficient to permit diffusion of at least some of the alkali metal into the alkaliation coating.

5. The process of claim 3 or 4, wherein the product produced by at least one step b comprises a bare substrate area comprising alkali metal deposits.

6. The process of claim 5, wherein a reversed oxidative current is applied to remove any alkali metal deposits from the bare substrate areas in at least one step c.

7. The process of claim 6, wherein the alkali metal deposits comprises dendrites.

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8. The process of any one of the preceding claims, wherein the alkaliation coating is discontinuous.

9. The process of any one of the preceding claims, wherein the anode is a roll anode.

10. The process of any one of the preceding claims, wherein the at least one area free of alkaliation coating comprises the perimeter of the anode and/or a band perpendicular to and connecting the perimeters of the anode and has exposed conductive substrate.

11. The process of any one of the preceding claims, wherein the alkali metal salt is comprised of lithium chloride.

12. The process of any one of the preceding claims, wherein the conductive substrate is copper or nickel.

13. The process of any one of the preceding claims, wherein the alkaliation coating is comprised of graphite or silicon or blends thereof.

14. The process of any one of the preceding claims, wherein the alkaliation coating is on two surfaces of the conductive substrate.

15. The process of any one of the preceding claims wherein the bare substrate area is located along the edges of the conductive substrate.

16. The process of any one of the preceding claims, wherein the forward reducing current and the reversed oxidative current are DC.

17. The process of any one of the preceding claims, wherein the forward reducing current and the reversed oxidative current are AC.

18. The process of any one of the preceding claims, wherein the ratio of the reverse and forward current is fixed.

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19. The process of any one of the preceding claims, wherein the ratio of the reverse and forward current increases.

20. The process of any one of the preceding claims, wherein the ratio of the reverse and forward time duration is fixed.

21. The process of any one of the preceding claims, wherein the ratio of the reverse and forward time duration increases.

22. The process of any one of the preceding claims, wherein step b is between 1 millisecond and 15 minutes.

23. The process of claim 22, wherein step b is between 1 centisecond and 5 minutes.

24. The process of claim 23, wherein step b is between 1 second and 3 minutes.

25. The process of any one of the preceding claims, wherein step c is between 1 millisecond and 15 minutes.

26. The process of claim 25, wherein step c is between 1 centisecond and 5 minutes.

27. The process of claim 26, wherein step c is between 1 second and 3 minutes.

28. The process of any one of the preceding claims, wherein the forward reducing current is between 1 and 8 times greater than the reversed oxidative current.

29. The process of any one of the preceding claims, wherein the forward reducing current is about 2 times greater than the reversed oxidative current.

30. The process of any one of the preceding claims, wherein the forward reducing current density is between 0.1 mA/cm^2 and 10 mA/cm^2.

31. The process of any one of the preceding claims, wherein the forward reducing current density is about 1 mA/cm^2.

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32. The process of any one of the preceding claims, wherein the reversed oxidative current density is between 0.1mA/cm^2 and 1.2 mA/cm^2.

33. The process of any one of the preceding claims, wherein the reversed oxidative current density is about 0.6 mA/cm^2.

34. The process of any one of the preceding claims, wherein the duration of the reversed oxidative current pulses is between 1% and 100% the time of the forward reducing current pulses.

35. The process of claim 34, wherein the duration of the reversed oxidative current pulses is between 5% and 30% the time of the forward reducing current pulses.

36. The process of claim 35, wherein the duration of the reversed oxidative current pulses is about 20% the time of the forward reducing current pulses.

37. The process of claim 35, wherein the duration of the reversed oxidative current pulses is about 15% the time of the forward reducing current pulses.

38. The process of claim 36, wherein the duration of the reversed oxidative current pulses is about 30 seconds, and the duration of the forward reducing current pulses is about 150 seconds.

39. The process of any one of the preceding claims, wherein edge guard apertures, dielectric field apertures, or shields are mounted above and below each exposed edge of the anode.

40. An electrochemical process to alkaliate an anode comprising the steps of:
    a. Positioning edge guard apertures, dielectric field apertures, or shields above and below each exposed edge of the anode;
    b. Subjecting an anode to a non-aqueous electrolytic solution comprising an alkali metal salt, wherein said anode comprises a conductive substrate comprising at least one surface, an alkaliation coating on the at least one surface; and
    c. Applying a forward reducing current through the solution to alkaliate the anode.

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41. The process of claim 40, wherein the edge guard apertures, dielectric field apertures, or shields are comprised of a dielectric material that is compatible with the non-aqueous electrolytic solution.

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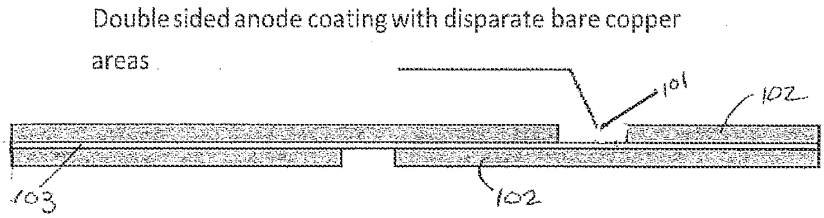

Double sided anode coating with disparate bare copper areas
101
102
103
102

FIG. 1

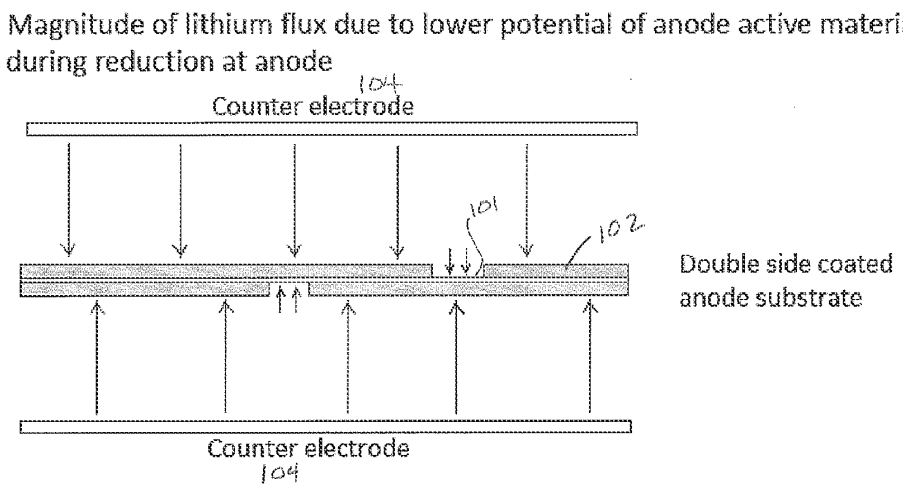

Magnitude of lithium flux due to lower potential of anode active material during reduction at anode
104
Counter electrode
101
102
Double side coated anode substrate
Counter electrode
104

FIG. 2

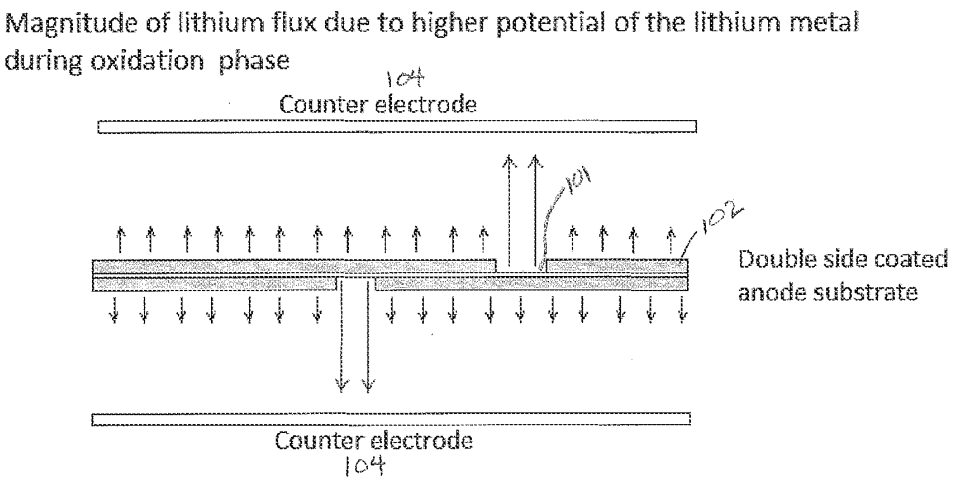

Magnitude of lithium flux due to higher potential of the lithium metal during oxidation phase
104
Counter electrode
101
102
Double side coated anode substrate
Counter electrode
104

FIG. 3

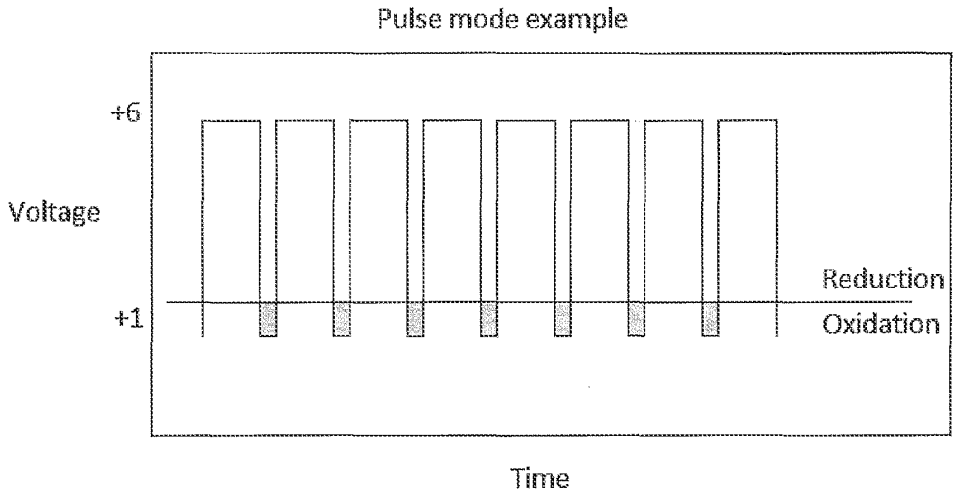


FIG. 4

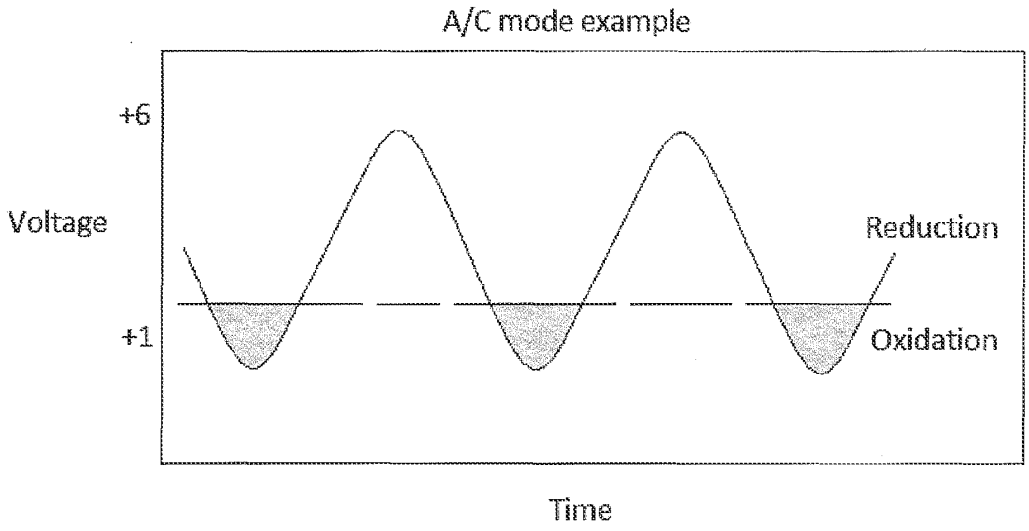


FIG. 5

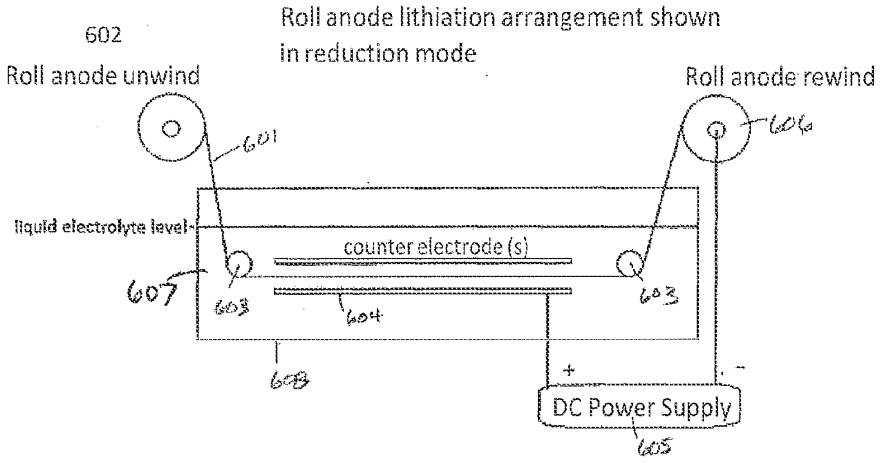

602
Roll anode lithiation arrangement shown in reduction mode
Roll anode unwind
Roll anode rewind
601
606
liquid electrolyte level
counter electrode (s)
607
603
603
604
603
608
+
-
DC Power Supply
605

FIG. 6

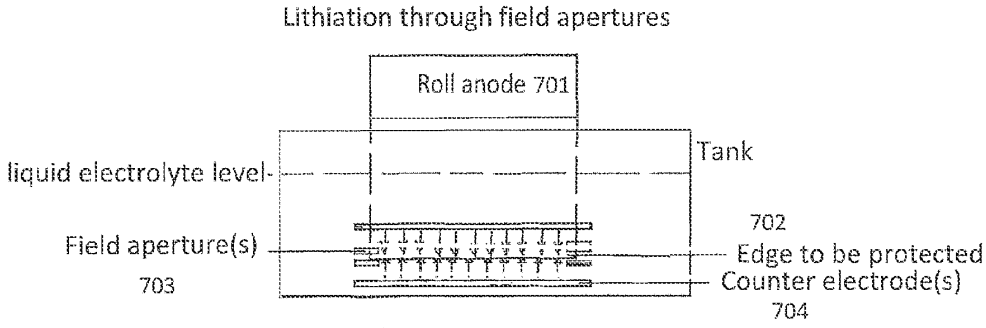

Lithiation through field apertures
Roll anode 701
Tank
liquid electrolyte level
Field aperture(s)
703
702
Edge to be protected
Counter electrode(s)
704

FIG. 7

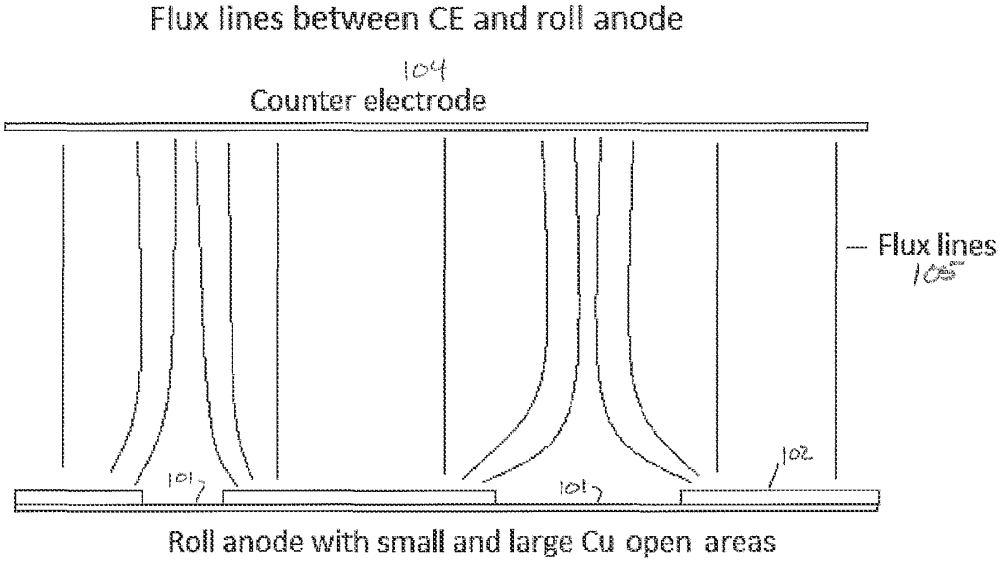

Flux lines between CE and roll anode
104
Counter electrode
Flux lines
105
101
101
102
Roll anode with small and large Cu open areas

FIG. 8

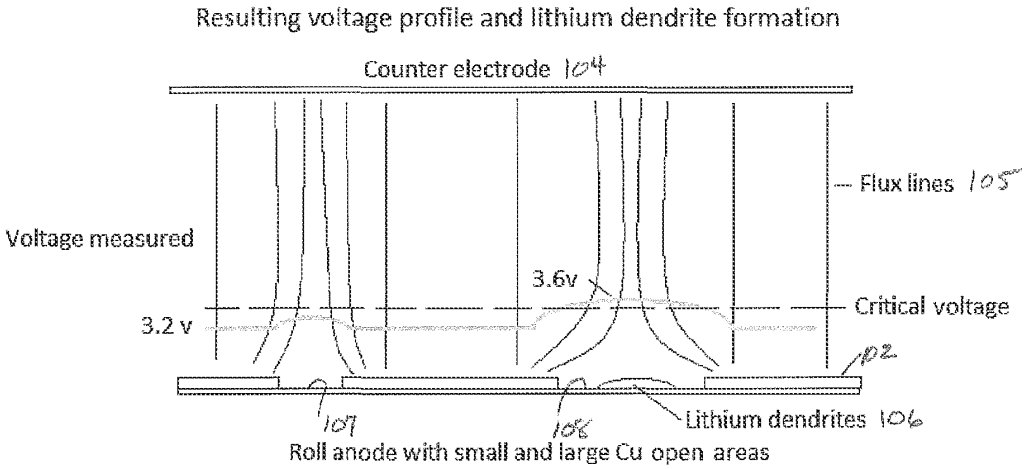

Resulting voltage profile and lithium dendrite formation
Counter electrode 104
Flux lines 105
Voltage measured
3.6v
Critical voltage
3.2 v
102
107
106
Lithium dendrites 106
Roll anode with small and large Cu open areas

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/065550

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - H01M 4/04; C25D 11/00; C25D 11/02; H01M 4/13 (2017.01)

CPC - H01M 4/0442; C25D 9/00; C25D 11/00; C25D 11/022; H01M 4/04; H01M 4/0438; H01M 4/045 (2017.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

USPC - 204/194; 204/196.010; 205/50; 205/57; 205/59; 205/230 (keyword delimited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2008/0073217 A1 (TAKEZAWA) 27 March 2008 (27.03.2008) entire document	1-7, 40, 41
Y	US 2011/0038497 A1 (CHAE et al) 17 February 2011 (17.02.2011) entire document	1-7
Y	US 5,372,687 A (POHTO et al) 13 December 1994 (13.12.1994) entire document	40, 41
A	US 6,084,796 A (KOZICKI et al) 04 July 2000 (04.07.2000) entire document	1-7, 40, 41

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
01 February 2017	17 FEB 2017
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300	Authorized officer Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/065550

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 8-39
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Zhuhai CosMX Battery Co. - EX1002
Zhuhai CosMX Battery Co. v. Ningde Amperex Tech. Ltd.
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TRANSLATION

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2019/130465

A. CLASSIFICATION OF SUBJECT MATTER

H01M 4/13(2010.01)i; H01M 4/36(2006.01)i; H01M 4/583(2010.01)i; H01M 4/38(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT; WPI; EPODOC; CNKI: 电极, 阴极, 负极, 硅, 石墨, 密度, 质量, 层, 活性材料, electrode, anode, cathode, nagative, positive, pole, si, silicon, graphite, density, layer, active material

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 109841794 A (NINGDE AMPEREX TECHNOLOGY LTD.) 04 June 2019 (2019-06-04) description, paragraphs 0037-0055, 0063-0076, 0088-0091, 0146-0157, figures 1-2	1-11
A	CN 102683751 A (ZHEJIANG ZHENLONG BATTERY CO., LTD.) 19 September 2012 (2012-09-19) entire document	1-11
A	CN 102856538 A (FDK TWICELL CO., LTD.) 02 January 2013 (2013-01-02) entire document	1-11
A	US 2013171502 A1 (CHEN, Guorong et al.) 04 July 2013 (2013-07-04) entire document	1-11
A	CN 110010902 A (NINGDE AMPEREX TECHNOLOGY LTD.) 12 July 2019 (2019-07-12) entire document	1-11
A	US 2019305317 A1 (NEC CORPORATION) 03 October 2019 (2019-10-03) entire document	1-11

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 August 2020	**16 September 2020**
Name and mailing address of the ISA/CN **China National Intellectual Property Administration (ISA/CN)** **No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088** **China** Facsimile No. **(86-10)62019451**	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

TRANSLATION

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2019/130465

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	109841794	A	04 June 2019	None			
CN	102683751	A	19 September 2012	CN	102683751	B	25 March 2015
CN	102856538	A	02 January 2013	JP	5660625	B2	28 January 2015
				EP	2541662	A2	02 January 2013
				US	2013004853	A1	03 January 2013
				EP	2541662	A3	25 December 2013
				CN	102856538	B	17 August 2016
				US	8815451	B2	26 August 2014
				JP	2013016260	A	24 January 2013
US	2013171502	A1	04 July 2013	None			
CN	110010902	A	12 July 2019	None			
US	2019305317	A1	03 October 2019	JP	2019530183	A	17 October 2019
				WO	2018066110	A1	12 April 2018

Zhuhai CosMX Battery Co. - EX1002
Zhuhai CosMX Battery Co. v. Ningde Amperex Tech. Ltd.
IPR2026-00401 - Page 273 of 436

专 利 合 作 条 约

PCT

国际检索报告

(PCT第18条和细则43和44)

申请人或代理人的档案号 LV33036	关于后续行为	见PCT/ISA/220表和 适用时，见下面第5项
国际申请号 PCT/CN2019/130465	国际申请日 (年/月/日) 2019年 12月 31日	(最早的)优先权日 (年/月/日) 2019年 12月 11日
申请人 宁德新能源科技有限公司		

按照条约第18条，本国际检索报告由本国际检索单位做出并送交申请人。报告副本送交国际局。

本国际检索报告总计 4 页。

☐ 它还附有本报告所引用的各现有技术文件的副本。

1. 报告的基础

a. 关于语言，进行国际检索基于：

☑ 国际申请提交时使用的语言。

☐ 该国际申请的_____语言译文，为了国际检索的目的提供该种语言的译文(细则12.3(a)和23.1(b))。

b. ☐ 本国际检索报告考虑了本单位许可或被通知的根据细则91所做出的明显错误更正(细则43.6之二(a))。

c. ☐ 关于国际申请中公开的任何核苷酸和/或氨基酸序列，见第I栏。

2. ☐ 某些权利要求被认为是不能检索的(见第II栏)。

3. ☐ 缺乏发明的单一性(见第III栏)。

4. 关于发明名称，

☑ 同意申请人提出的发明名称。

☐ 发明名称由本单位确定如下：

5. 关于摘要，

☐ 同意申请人提出的摘要。

☑ 根据细则38.2(b)，摘要由本单位制定，如第IV栏中所示。自本国际检索报告发文日起一个月内，申请人可以向本单位提出意见。

6. 关于附图，

a. 随摘要一起公布的附图是： 1

☑ 按照申请人建议的。

☐ 由本单位选择的，因为申请人没有建议一幅图。

☐ 由本单位选择的，因为该图能更好地表示发明的特征。

b. ☐ 没有与摘要一起公布的附图

Zhuhai CosMX Battery Co. - EX1002
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IPR2026-00401 - Page 274 of 436

第IV栏　　摘要正文(续第1页第5项)

提供一种负极(10)及包含所述负极(10)的电化学装置及电子装置。所述负极(10)包括：负极集流体(101)、第一负极活性材料层(102)以及第二负极活性材料层(103)。所述第一负极活性材料层(102)单面设置在所述负极集流体(101)的第一部分，且所述第二负极活性材料层(103)双面设置在所述负极集流体(101)的不同于所述第一部分的第二部分，其中所述第一负极活性材料层(102)与所述第二负极活性材料层(103)在所述负极集流体(101)上的单位面积重量的比值为0.47至0.52，且所述第一负极活性材料层(102)与所述第二负极活性材料层(103)的压实密度的比值为0.9至1.1。通过采用上述负极(10)能够从负极结构方向改善电化学装置的极化和析锂，从而提升电化学装置的循环性能和安全性能。

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Zhuhai CosMX Battery Co. v. Ningde Amperex Tech. Ltd.
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国际检索报告

国际申请号
PCT/CN2019/130465

A. 主题的分类

H01M 4/13(2010.01)i; H01M 4/36(2006.01)i; H01M 4/583(2010.01)i; H01M 4/38(2006.01)i

按照国际专利分类(IPC)或者同时按照国家分类和IPC两种分类

B. 检索领域

检索的最低限度文献(标明分类系统和分类号)

H01M

包含在检索领域中的除最低限度文献以外的检索文献

在国际检索时查阅的电子数据库(数据库的名称，和使用的检索词（如使用））

CNPAT;WPI;EPODOC;CNKI:电极，阴极，负极，硅，石墨，密度，质量，层，活性材料，electrode, anode, cathode, nagative, positive, pole, si, silicon, graphite, density, layer, active material

C. 相关文件

类 型*	引用文件，必要时，指明相关段落	相关的权利要求
A	CN 109841794 A (宁德新能源科技有限公司) 2019年 6月 4日 (2019-06-04) 说明书第0037 0055，0063 0076，0088 0091，0146 0157段，图1 2	1-11
A	CN 102683751 A (浙江振龙电源股份有限公司) 2012年 9月 19日 (2012-09-19) 全文	1-11
A	CN 102856538 A (FDKTWICELL株式会社) 2013年 1月 2日 (2013-01-02) 全文	1-11
A	US 2013171502 A1 (CHEN, Guorong等) 2013年 7月 4日 (2013-07-04) 全文	1-11
A	CN 110010902 A (宁德新能源科技有限公司) 2019年 7月 12日 (2019-07-12) 全文	1-11
A	US 2019305317 A1 (NEC CORPORATION) 2019年 10月 3日 (2019-10-03) 全文	1-11

☐ 其余文件在C栏的续页中列出。

☑ 见同族专利附件。

* 引用文件的具体类型：

"A" 认为不特别相关的表示了现有技术一般状态的文件

"E" 在国际申请日的当天或之后公布的在先申请或专利

"L" 可能对优先权要求构成怀疑的文件，或为确定另一篇引用文件的公布日而引用的或者因其他特殊理由而引用的文件（如具体说明的）

"O" 涉及口头公开、使用、展览或其他方式公开的文件

"P" 公布日先于国际申请日但迟于所要求的优先权日的文件

"T" 在申请日或优先权日之后公布，与申请不相抵触，但为了理解发明之理论或原理的在后文件

"X" 特别相关的文件，单独考虑该文件，认定要求保护的发明不是新颖的或不具有创造性

"Y" 特别相关的文件，当该文件与另一篇或者多篇该类文件结合并且这种结合对于本领域技术人员为显而易见时，要求保护的发明不具有创造性

"&" 同族专利的文件

国际检索实际完成的日期	国际检索报告邮寄日期
2020年 8月 26日	2020年 9月 16日
ISA/CN的名称和邮寄地址 中国国家知识产权局(ISA/CN) 中国北京市海淀区蓟门桥西土城路6号 100088 传真号 (86-10)62019451	受权官员 曹鹏 电话号码 86-(10)-53961289

PCT/ISA/210 表(第2页) (2015年1月)

国际检索报告
关于同族专利的信息

国际申请号
PCT/CN2019/130465

检索报告引用的专利文件			公布日 (年/月/日)	同族专利			公布日 (年/月/日)
CN	109841794	A	2019年 6月 4日	无			
CN	102683751	A	2012年 9月 19日	CN	102683751	B	2015年 3月 25日
CN	102856538	A	2013年 1月 2日	JP	5660625	B2	2015年 1月 28日
				EP	2541662	A2	2013年 1月 2日
				US	2013004853	A1	2013年 1月 3日
				EP	2541662	A3	2013年 12月 25日
				CN	102856538	B	2016年 8月 17日
				US	8815451	B2	2014年 8月 26日
				JP	2013016260	A	2013年 1月 24日
US	2013171502	A1	2013年 7月 4日	无			
CN	110010902	A	2019年 7月 12日	无			
US	2019305317	A1	2019年 10月 3日	JP	2019530183	A	2019年 10月 17日
				WO	2018066110	A1	2018年 4月 12日

Zhuhai CosMX Battery Co. - EX1002
Zhuhai CosMX Battery Co. v. Ningde Amperex Tech. Ltd.
IPR2026-00401 - Page 277 of 436

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	NEGATIVE ELECTRODE AND ELECTROCHEMICAL APPARATUS CONTAINING SAME, AND ELECTRONIC APPARATUS
First Named Inventor/Applicant Name:	Ting YI
Filer:	Timothy Joseph Maier/Beatriz Sanchez
Attorney Docket Number:	14850059US

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
UTILITY APPLICATION FILING	1011	1	320	320
UTILITY SEARCH FEE	1111	1	700	700
UTILITY EXAMINATION FEE	1311	1	800	800
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**1820**

Electronic Acknowledgement Receipt	
EFS ID:	45342930
Application Number:	17707129
International Application Number:	
Confirmation Number:	6210
Title of Invention:	NEGATIVE ELECTRODE AND ELECTROCHEMICAL APPARATUS CONTAINING SAME, AND ELECTRONIC APPARATUS
First Named Inventor/Applicant Name:	Ting YI
Customer Number:	62008
Filer:	Timothy Joseph Maier/Beatriz Sanchez
Filer Authorized By:	Timothy Joseph Maier
Attorney Docket Number:	14850059US
Receipt Date:	29-MAR-2022
Filing Date:	
Time Stamp:	14:48:44
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1820
RAM confirmation Number	E20223SE49073203
Deposit Account	505976
Authorized User	Beatriz Sanchez
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

37 CFR 1.19 (Document supply fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal of New Application	Transmittal.pdf	275718 d2ab4075387153d3220240e7a5cdcb3b72b6d7e2	no	2
Warnings:					
Information:					
2	Application Data Sheet	ADS.pdf	1256237 9d944fedd7ef47fa23d30ac2eed5e566373e28f0	no	9
Warnings:					
Information:					
3		Specification_.pdf	198305 450c8b66938bcbfb4a142ea017d18de533d07965	yes	30

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Specification	1	26
	Claims	27	29
	Abstract	30	30

Warnings:					
Information:					
4	Drawings-only black and white line drawings	Drawings_.pdf	240111 e8d7154e36544c54ecc94bb3f8ddd1c4daece542	no	2
Warnings:					
Information:					
5	Oath or Declaration filed	Declaration_.pdf	3637244 f4ff45653929dcd1c476c2a9a10a3da72348e7b5	no	6

Warnings:					
Information:					
6	Power of Attorney	POA_.pdf	218221 afccfc8a111f6d895ad3ce9cf6c5240dcba82078	no	2
Warnings:					
Information:					
7	Information Disclosure Statement (IDS) Form (SB08)	IDS.pdf	1008719 ba635a656323df68d1266d2bad422006f9698645	no	5
Warnings:					
Information:					
8	Foreign Reference	FR1_CN109841794A.pdf	4041499 03117e5da8c961c0c789f47c3452affc6ab70771	no	23
Warnings:					
Information:					
9	Foreign Reference	FR2_CN102683751A.pdf	1907226 d8138b8963606a601a9a2fda41636a782c8b05db	no	13
Warnings:					
Information:					
10	Foreign Reference	FR3_CN102856538A.pdf	2298494 96f45007270250ddf90e8ebdb68fe7d036f377b8	no	15
Warnings:					
Information:					
11	Foreign Reference	FR4_CN110010902A.pdf	3800779 c1ac047042660917767a4d098df1b838937af31b	no	22
Warnings:					
Information:					
12	Foreign Reference	FR5_CN108023117A.pdf	253166 db4c17ea57fac540046bee47f2e70226aa714f38	no	9
Warnings:					
Information:					

13	Foreign Reference	FR6_CN109378480A.pdf	258768 07de63435bbd95935d480a75e8aa56efaa1145dd	no	7
Warnings:					
Information:					
14	Foreign Reference	FR7_CN101934269A.pdf	918788 01264ea4ef71f615da80a7bb846ba895e2243fa7	no	8
Warnings:					
Information:					
15	Foreign Reference	FR8_CN103825044A.pdf	8011191 08e69314c1286dcc35e72cd17eb81e4877fbdd3a	no	46
Warnings:					
Information:					
16	Foreign Reference	FR9_CN205376669U.pdf	1494341 2f07d46ad09a6d6a5dbfcd59b359894417cec531	no	11
Warnings:					
Information:					
17	Foreign Reference	FR10_CN101944607A.pdf	967436 d58c9e5d1b8a3f9240f16f49acb5496718173b59	no	8
Warnings:					
Information:					
18	Foreign Reference	FR11_CN108701807A.pdf	3058692 1f726bbd20da23e34103fd2954c309160acc9288	no	18
Warnings:					
Information:					
19	Foreign Reference	FR12_EP3387687A1.pdf	150555 e0e243826421be7eeadd63a85d029448a5366b48	no	2
Warnings:					
Information:					

20	Foreign Reference	FR13_WO2017100415A1.pdf	3210434 809dd307ae361d478fd82d38f7ddfc03ae2bfc3c	no	32
Warnings:					
Information:					
21	Non Patent Literature	NPL1_ISR210_with_EnglishTranslation.pdf	562603 37956c65c52a6f14315ae13a6dedd40293b526d7	no	6
Warnings:					
Information:					
22	Non Patent Literature	NPL2_First_ChineseOA_with_EnglishTranslation.pdf	1235243 1fba4f38221634bcc60f6d42b42826b2f87c3e6d	no	11
Warnings:					
Information:					
23	Non Patent Literature	NPL3_NotificationtoGrant_with_PartialEnglishTranslation.pdf	569436 b907745f930d87f7ff453d629c98166616bb3eed	no	6
Warnings:					
Information:					
24	Fee Worksheet (SB06)	fee-info.pdf	44277 e997f61c01c5961d9a9d29e7951b7d27ae7e004b	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	39617483		

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If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
17/707,129	03/29/2022	1726	1820	14850059US	11	2

CONFIRMATION NO. 6210

62008
MAIER & MAIER, PLLC
345 SOUTH PATRICK STREET
ALEXANDRIA, VA 22314

FILING RECEIPT

OC000000132988851

Date Mailed: 04/06/2022

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

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Inventor(s)

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Assignment For Published Patent Application

NINGDE AMPEREX TECHNOLOGY LIMITED, Ningde, CHINA

Power of Attorney: The patent practitioners associated with Customer Number 62008

Domestic Priority data as claimed by applicant

This application is a CON of PCT/CN2019/130465 12/31/2019

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)
CHINA 201911267132.X 12/11/2019 Access Code Provided

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

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Request to Retrieve - This application either claims priority to one or more applications filed in an intellectual property Office that participates in the Priority Document Exchange (PDX) program or contains a proper **Request to Retrieve Electronic Priority Application(s)** (PTO/SB/38 or its equivalent). Consequently, the USPTO will attempt to electronically retrieve these priority documents.

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The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 17/707,129**

Projected Publication Date: 07/14/2022

Non-Publication Request: No

Early Publication Request: No

Title

NEGATIVE ELECTRODE AND ELECTROCHEMICAL APPARATUS CONTAINING SAME, AND ELECTRONIC APPARATUS

Preliminary Class

429

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

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Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

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patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

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Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 17/707,129

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	320
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	700
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	800
TOTAL CLAIMS (37 CFR 1.16(i))	11 minus 20 =	*			OR	x 100 =	0.00
INDEPENDENT CLAIMS (37 CFR 1.16(h))	2 minus 3 =	*				x 480 =	0.00
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0.00
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	1820

APPLICATION AS AMENDED - PART II

AMENDMENT A

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

AMENDMENT B

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE($)	ADDITIONAL FEE($)		RATE($)	ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

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证　　明

本证明之附件是向本局提交的下列专利申请文件副本。

申　　请　　号：201911267132.X

申　请　类　型：发明专利

发明 创造 名称：负极和包含所述负极的电化学装置及电子装置

申　　请　　日：2019 年 12 月 11 日

申　　请　　人：宁德新能源科技有限公司

发明人或设计人：易婷、崔航、谢远森

局长

申长雨

2019 年 12 月 18 日

权　利　要　求　书

1、一种负极，其包括：

负极集流体；

第一负极活性材料层，所述第一负极活性材料层单面设置在所述负极集流体的第一部分；以及

第二负极活性材料层，所述第二负极活性材料层双面设置在所述负极集流体的不同于所述第一部分的第二部分，

其中所述第一负极活性材料层与所述第二负极活性材料层在所述负极集流体上的单位面积重量的比值为 0.47 至 0.52，且所述第一负极活性材料层与所述第二负极活性材料层的压实密度的比值为 0.9 至 1.1。

2、根据权利要求 1 所述的负极，其中所述第一负极活性材料层和所述第二负极活性材料层各自独立地包含硅基材料及石墨，其中所述硅基材料选自由氧化硅、硅碳及其组合所组成的群组。

3、根据权利要求 2 所述的负极，其中所述第一负极活性材料层和所述第二负极活性材料层中所述硅基材料的重量以所述硅基材料及所述石墨的总重量计为大于或等于 5%且小于 100%。

4、根据权利要求 2 所述的负极，其中所述硅基材料的型态包括晶态、非晶态或其组合，其中所述第一负极活性材料层的颗粒度 Dv50 为 8.0 μm 至 20 μm，且所述第二负极活性材料层的颗粒度 Dv50 为 8.0 μm 至 20 μm。

5、根据权利要求 2 至 4 中任一权利要求所述的负极，其中所述硅基材料在拉曼光谱中，在 500 cm^{-1}±10 cm^{-1} 的波数上的峰高度与在 1350 cm^{-1}±10 cm^{-1} 的波数上的峰高度的比值大于 0。

6、根据权利要求 2 至 4 中任一权利要求所述的负极，其中所述硅基材料进一步包含碳包覆层。

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7、根据权利要求 2 至 4 中任一权利要求所述的负极，其中所述第一负极活性材料层和所述第二负极活性材料层各自独立地包含粘结剂及导电剂，其中所述粘结剂包括选自由聚丙烯酸酯、聚酰亚胺、聚酰胺、聚酰胺酰亚胺、聚偏氟乙烯、丁苯橡胶、海藻酸钠、聚乙烯醇、聚四氟乙烯、聚丙烯腈、羧甲基纤维素钠、羧甲基纤维素钾及其组合所组成的群组，且所述导电剂包括选自由导电炭黑、乙炔黑、科琴黑、石墨烯及其组成所组成的群组。

8、根据权利要求 7 所述的负极，其中，以所述第一负极活性材料层的总重量计，所述第一负极活性材料层中的所述硅基材料及所述石墨的总重量为 94%~96%，所述粘结剂的重量为 2.8%至 4.0%，且所述导电剂的重量为 0.4%至 1.6%；以及

以所述第二负极活性材料层的总重量计，所述第二负极活性材料层中的所述硅基材料及所述石墨的总重量为 94%~96%，所述粘结剂的重量为 2.8%至 4.0%，且所述导电剂的重量为 0.4%至 1.6%。

9、根据权利要求 1 所述的负极，其中所述第一负极活性材料层的厚度为 40 μm 至 60 μm，且所述第二负极活性材料层的单层厚度为 40 μm 至 60 μm。

10、一种电化学装置，其包括：

正极；

隔离膜；以及

根据权利要求 1 至 9 中任一项所述的负极。

11、一种电子装置，其包含权利要求 10 所述的电化学装置。

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说　　明　　书

负极和包含所述负极的电化学装置及电子装置

技术领域

本申请涉及储能技术领域，尤其涉及负极以及包括所述负极的电化学装置及电子装置。

背景技术

随着移动电子技术的高速发展，人们使用诸如手机、平板、笔记本电脑、无人机等的移动电子装置的频率和体验要求越来越高。因此，为电子装置提供能源的电化学装置（例如，锂离子电池）需要表现出更高的能量密度、更大的倍率、更高的安全性以及在反复充放电过程后更小的容量衰减。

锂离子电池在循环过程中由于负极的极化导致锂金属的析出，是损害锂离子电池的循环性能的其中一个主要原因。有鉴于此，需要降低负极在电池循环过程中的极化，而对负极结构作进一步的研究及优化是其中一个可行的解决方案。

发明内容

本申请提供一种负极和包含所述负极的电化学装置及电子装置以试图在至少某种程度上解决至少一个存在于相关领域中的问题。

根据本申请的一个方面，本申请提供了一种负极，所述负极包括：负极集流体、第一负极活性材料层以及第二负极活性材料层。所述第一负极活性材料层单面设置在所述负极集流体的第一部分，且所述第二负极活性材料层双面设置在所述负极集流体的不同于所述第一部分的第二部分，其中所述第一负极活性材料层与所述第二负极活性材料层在所述负极集流体上的单位面积重量的比值 K 为约 0.47 至 0.52，且所述第一负极活性材料层与所述第二负极活性材料层的压实密度的比值 R 为约 0.9 至 1.1。

根据本申请的另一个方面，本申请提供了一种电化学装置，其包括：正极、隔离膜以及上述负极。

根据本申请的另一个方面，本申请提供了一种电子装置，所述电子装置包含上述的

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电化学装置。

本申请实施例的额外层面及优点将部分地在后续说明中描述、显示、或是经由本申请实施例的实施而阐释。

附图说明

在下文中将简要地说明为了描述本申请实施例或现有技术所必要的附图以便于描述本申请的实施例。显而易见地，下文描述中的附图仅只是本申请中的部分实施例。对本领域技术人员而言，在不需要创造性劳动的前提下，依然可以根据这些附图中所例示的结构来获得其他实施例的附图。

图 1 为本申请实施例的负极的结构示意图。

图 2 为硅基材料与石墨的混合而成的负极活性材料冷压前后的示意图。

图 3 为本申请实施例 4 与对比例 2 的循环容量曲线图。

具体实施方式

本申请的实施例将会被详细的描示在下文中。在本申请说明书全文中，将相同或相似的组件以及具有相同或相似的功能的组件通过类似附图标记来表示。在此所描述的有关附图的实施例为说明性质的、图解性质的且用于提供对本申请的基本理解。本申请的实施例不应该被解释为对本申请的限制。

如本文中所使用，术语“大致”、“大体上”、“实质”及“约”用以描述及说明小的变化。当与事件或情形结合使用时，所述术语可指代其中事件或情形精确发生的例子以及其中事件或情形极近似地发生的例子。举例来说，当结合数值使用时，术语可指代小于或等于所述数值的±10%的变化范围，例如小于或等于±5%、小于或等于±4%、小于或等于±3%、小于或等于±2%、小于或等于±1%、小于或等于±0.5%、小于或等于±0.1%、或小于或等于±0.05%。举例来说，如果两个数值之间的差值小于或等于所述值的平均值的±10% (例如小于或等于±5%、小于或等于±4%、小于或等于±3%、小于或等于±2%、小于或等于±1%、小于或等于±0.5%、小于或等于±0.1%、或小于或等于±0.05%)，那么可认为所述两个数值“大体上”相同。

在本说明书中，除非经特别指定或限定之外，相对性的用词例如：“中央的”、“纵向

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的”、“侧向的”、“前方的”、“后方的”、“右方的”、“左方的”、“内部的”、“外部的”、“较低的”、“较高的”、“水平的”、“垂直的”、“高于”、“低于”、“上方的”、“下方的”、“顶部的”、“底部的”以及其衍生性的用词（例如“水平地”、“向下地”、“向上地”等等）应该解释成引用在讨论中所描述或在附图中所描示的方向。这些相对性的用词仅用于描述上的方便，且并不要求将本申请以特定的方向建构或操作。

另外，有时在本文中以范围格式呈现量、比率和其它数值。应理解，此类范围格式是用于便利及简洁起见，且应灵活地理解，不仅包含明确地指定为范围限制的数值，而且包含涵盖于所述范围内的所有个别数值或子范围，如同明确地指定每一数值及子范围一般。

在具体实施方式及权利要求书中，由术语“中的至少一者”、“中的至少一个”、“中的至少一种”或其他相似术语所连接的项目的列表可意味着所列项目的任何组合。例如，如果列出项目 A 及 B，那么短语“A 及 B 中的至少一者”意味着仅 A；仅 B；或 A 及 B。在另一实例中，如果列出项目 A、B 及 C，那么短语“A、B 及 C 中的至少一者”意味着仅 A；或仅 B；仅 C；A 及 B (排除 C)；A 及 C (排除 B)；B 及 C (排除 A)；或 A、B 及 C 的全部。项目 A 可包含单个元件或多个元件。项目 B 可包含单个元件或多个元件。项目 C 可包含单个元件或多个元件。

在现有技术中，为了追求最佳的能量密度，以及制备工艺上的稳定及简便，对卷绕式的电极组件会采用在极片的中间部分双面设置活性材料并在极片的端部单面设置活性材料的设计。参考图 1，由于制备工艺上的限制，现有技术中的锂离子电池的锂金属往往会在负极活性材料的单面设置的区域 102A 以及双面设置的区域与其相邻的区域（占整个负极活性材料层涂布区域 10%面积的区域）103A 析出（下文中，术语“析锂”为锂金属的析出）。

同时，替换具有更高克容量的负极活性材料也是提高能量密度的一个办法，其中硅具有高的理论克容量(4200mAh/g)，在锂离子电池中的应用有着广阔的前景。但硅基材料在充放电循环过程中，由于导电性差，锂离子嵌入和脱出时容易在负极表面聚集造成析锂。同时，由于硅基材料的受热膨胀率高，当采用中间部分双面设置活性材料并在负极的端部单面设置活性材料的负极设计时，更容易导致单面设置的区域与双面设置的区域的交界处受热变形，进而加剧析锂。析锂代表锂离子电池中锂离子的损失，造成电池容量损失，并加速循环衰减，使得锂离子电池的循环性能降低。另外，析锂可能会造成正极的锂离子过量脱出以补充损失的锂离子，进而破坏正极结构。

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本申请通过调控单双面活性材料层的设置重量以及冷压过程中单双面活性材料层的压实密度比例，从负极结构方向改善极化和析锂，提升锂离子电池的循环性和安全性。

图 1 为本申请实施例的负极的结构示意图。

根据本申请的一个方面，本申请提供了一种负极 10，其包括：负极集流体 101、第一负极活性材料层 102 及第二负极活性材料层 103，所述第一负极活性材料层 102 单面设置在所述负极集流体 10 的第一部分；以及第二负极活性材料层 103，所述第二负极活性材料层 103 双面设置在所述负极集流体 10 的不同于所述第一部分的第二部分，其中所述第一负极活性材料层 102 与所述第二负极活性材料层 103 在所述负极集流体 10 上的单位面积重量的比值 K 为约 0.47 至约 0.52，且所述第一负极活性材料层 102 与所述第二负极活性材料层 103 的压实密度的比值 R 为约 0.9 至约 1.1。

在另一些实施例中，所述第一负极活性材料层 102 与所述第二负极活性材料层 103 在所述负极集流体 10 上的单位面积重量的比值为约 0.5，且所述第一负极活性材料层与所述第二负极活性材料层的压实密度的比值为约 0.97 至约 1.0。

在循环过程中，当负极活性材料层在负极集流体上的单位面积重量不一致，会造成具有不同单位面积重量的活性材料层分布的电流密度不均匀，负极电流密度不均匀时，会造成锂离子的滞留情况不一样，电流密度大则锂离子传输受限的情况下更容易在表面滞留，造成析锂。当第一负极活性材料层 102 与所述第二负极活性材料层 103 在所述负极集流体 10 上的单位面积重量越一致时，能够保持负极的电流密度分布，进而降低析锂的状况。

在本文中，术语“压实密度”为单位面积集流体上的活性材料的重量除以冷压后活性材料层在集流体表面垂直方向上的总厚度。

图 2 为硅基材料与石墨的混合而成的负极活性材料冷压前后的示意图。

如图 2 所示，硅基材料与石墨的混合而成的负极活性材料在冷压前通过 X 射线衍法测定后 110 晶面衍射峰的强度 C110 较高，代表冷压前的负极活性材料的晶体结构排列呈 110 晶面。而在冷压后，随著压实密度越来越高则负极活性材料通过 X 射线衍法测定后 004 晶面衍射峰的强度 C004 也随著增加，代表随著压实密度的提高负极活性材料的晶体结构排列也会逐渐倾向于 004 晶面。当负极活性材料的晶体结构排列呈 004 晶面时，锂离子嵌入与脱出的阻力较大。因此，负极活性物质层的压实密度越高，就越容易析锂。

当第一负极活性材料层 102 与所述第二负极活性材料层 103 的压实密度越一致时，

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其在负极活性材料的单面设置的区域 102A 以及双面设置的区域与其相邻的区域 103A 处的析锂状况则越平均。因此，不容易造成负极活性材料的单面设置的区域 102A 或是双面设置的区域与其相邻的区域 103A 任何单一处大量的析锂，进而降低析锂的状况，并提升电化学装置的循环性能。

在一些实施例中，所述第一负极活性材料层与所述第二负极活性材料层的压实密度各自独立的为约 1.3 g/cm^3 至约 2.0g/cm^3。

在一些实施例中，所述第一负极活性材料层和所述第二负极活性材料层各自独立地包含硅基材料及石墨，其中所述硅基材料选自由氧化硅、硅碳及其组合所组成的群组。在一些实施例中，氧化硅为通式 SiO_x 所代表，其中 $0.5 \leqslant x \leqslant 1.6$。

在一些实施例中，所述第一负极活性材料层和所述第二负极活性材料层中所述硅基材料的重量以所述硅基材料及所述石墨的总重量计为大于或等于约 5%且小于约 100%。在另一些实施例中，所述第一负极活性材料层和所述第二负极活性材料层中所述硅基材料的重量为约 10%至约 40%。在另一些实施例中，所述第一负极活性材料层和所述第二负极活性材料层中所述硅基材料的重量为约 15%。

由于所述第一负极活性材料层与所述第二负极活性材料层的负极活性材料包含所述硅基材料和所述石墨。其中，所述硅基材料的 Dv99 较小，一般小于约 20 μm，但是石墨的 Dv99 较大，一般可达到约 30μm 以上，极片压实的厚度至少要比单颗颗粒的粒径要大，不然颗粒会被压碎，导致循环衰减加速。

在一些实施例中，所述第一负极活性材料层与所述第二负极活性材料层的单层厚度各自独立的为约 40 μm 至约 60 μm。在一些实施例中，所述第二负极活性材料层的总厚度为约 80 μm 至约 120 μm。

在一些实施例中，所述第一负极活性材料层和所述第二负极活性材料层的颗粒度 Dv50 为约 8.0 μm 至约 20 μm。在另一些实施例中，所述第一负极活性材料层和所述第二负极活性材料层的颗粒度 Dv50 大致为，例如，约 8.0 μm、约 9.0 μm、约 10.0 μm、约 12.0 μm、约 14.0 μm、约 16.0 μm、约 18.0 μm、约 20.0 μm 或这些数值中任意两者组成的范围。

在一些实施例中，所述硅基材料的型态包括晶态、非晶态或其组合。

在一些实施例中，所述硅基材料的颗粒度 Dv50 为约 4.0 μm 至约 10 μm。在另一些实施例中，所述硅基材料的颗粒度 Dv50 大致为，例如，约 4.0 μm、约 5.0 μm、约 6.0 μm、

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约 7.0 μm、约 8.0 μm、约 9.0 μm、约 10.0 μm 或这些数值中任意两者组成的范围。

在一些实施例中，所述硅基材料进一步包含碳包覆层。

在一些实施例中，所述硅基材料在拉曼光谱（Jobin Yvon LabRAM HR 光谱仪，波长；532 nm，测试范围：50 cm^{-1}~2000 cm^{-1}）中，在约 500 cm^{-1}±10 cm^{-1} 的波数上的峰高度与在约 1350 cm^{-1}±10 cm^{-1} 的波数上的峰高度的比值大于 0。其中，在约 500 cm^{-1} 处的波数上表现出的是硅的拉曼特征峰，在约 1350 cm^{-1} 处的波数上是硅表面包覆层碳的特征峰。

在一些实施例中，所述第一负极活性材料层和所述第二负极活性材料层各自独立地包含粘结剂及导电剂，其中所述粘结剂包括选自由聚丙烯酸酯、聚酰亚胺、聚酰胺、聚酰胺酰亚胺、聚偏氟乙烯、丁苯橡胶、海藻酸钠、聚乙烯醇、聚四氟乙烯、聚丙烯腈、羧甲基纤维素钠、羧甲基纤维素钾及其组合所组成的群组，且所述导电剂包括选自由导电炭黑、乙炔黑、科琴黑、石墨烯及其组成所组成的群组。

应理解，本领域技术人员可以根据实际需要选择添加本领域任何常规的粘结剂或导电剂，而不受期限制。

在一些实施例中，以所述第一负极活性材料层的总重量计，所述第一负极活性材料层中的所述硅基材料及所述石墨的总重量为约 94%至约 96%，所述粘结剂的重量为约 2.8%至约 4.0%，且所述导电剂的重量为约 0.4%至约 1.6%。

在一些实施例中，以所述第二负极活性材料层的总重量计，所述第二负极活性材料层中的所述硅基材料及所述石墨的总重量为约 94%至约 96%，所述粘结剂的重量为约 2.8%至约 4.0%，且所述导电剂的重量为约 0.4%至约 1.6%。

在一些实施例中，本申请负极的制备方法包括以下步骤：

取一定量的硅基材料与石墨，将其与粘结剂、导电剂按固定重量比混合后，融入去离子水中搅拌均匀。搅拌后，通过筛选得到混合浆料。其中，混合浆料的粘度为约 2500 mPa.S 至约 4000 mPa.S 之间，固含量为约 35%至约 50%。

将混合浆料分别涂布于铜箔集流体上，其中单面涂布的部分的单位面积重量为约 65 g/m^2 至约 130 g/m^2，双面涂布的部分的单位面积重量为约 130 g/m^2 至约 260 g/m^2，并进行烘干。烘干后，进行冷压处理，以得到第一负极活性材料层与第二负极活性材料层其中第二负极活性材料层的压实密度为约 1.3 g/cm^3 至约 2.0 g/cm^3，第一负极活性材料层与第

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二负极活性材料层的压实密度比例 R 为约 0.9 至约 1.1，，随后通过裁切程序后得到负极。

应理解，本申请实施例中的负极的制备方法中的各步骤，在不违背本申请的精神下，可以根据具体需要选择或替换本领域的其他的常规处理方法，而不受其限制。

根据本申请的另一个方面，本申请的一些实施例还提供了包括本申请负极的电化学装置。在一些实施例中，所述电化学装置为锂离子电池。所述锂离子电池包括：上述实施例中的负极、隔离膜以及正极，隔离膜设置于正极与负极之间。

在一些实施例中，所述正极集流体可以为铝箔或镍箔，所述负极集流体可为铜箔或镍箔，然而，可以采用本领域常用的其他正极集流体及负极集流体，而不受其限制。

在一些实施例中，正极包括能够吸收和释放锂（Li）的正极材料（下文中，有时称为“能够吸收/释放锂 Li 的正极材料”）。能够吸收/释放锂（Li）的正极材料的实例可以包括钴酸锂、镍钴锰酸锂、镍钴铝酸锂、锰酸锂、磷酸锰铁锂、磷酸钒锂、磷酸钒氧锂、磷酸铁锂、钛酸锂和富锂锰基材料中的一种或多种。

在上述正极材料中，钴酸锂的化学式可以为 $Li_yCo_aM1_bO_{2-c}$，其中，M1 表示选自镍（Ni）、锰（Mn）、镁（Mg）、铝（Al）、硼(B)、钛(Ti)、钒(V)、铬(Cr)、铁（Fe）、铜（Cu）、锌（Zn）、钼（Mo）、锡（Sn）、钙（Ca）、锶（Sr）、钨（W）、钇（Y）、镧（La）、锆（Zr）和硅（Si）中的至少一种，y、a、b 和 c 值分别在以下范围内：$0.8\leq y\leq 1.2$、$0.8\leq a\leq 1$、$0\leq b\leq 0.2$、$-0.1\leq c\leq 0.2$；

在上述正极材料中，镍钴锰酸锂或镍钴铝酸锂的化学式可以为 $Li_zNi_dM2_eO_{2-f}$，其中，M2 表示选自钴（Co）、锰（Mn）、镁（Mg）、铝（Al）、硼（B）、钛（Ti）、钒（V）、铬（Cr）、铁（Fe）、铜（Cu）、锌（Zn）、钼（Mo）、锡（Sn）、钙（Ca）、锶（Sr）、钨（W）、锆（Zr）和硅（Si）中的至少一种，z、d、e 和 f 值分别在以下范围内：$0.8\leq z\leq 1.2$、$0.3\leq d\leq 0.98$、$0.02\leq e\leq 0.7$、$-0.1\leq f\leq 0.2$；

在上述正极材料中，锰酸锂的化学式为 $Li_uMn_{2-g}M3_gO_{4-h}$，其中 M3 表示选自钴（Co）、镍（Ni）、镁（Mg）、铝（Al）、硼（B）、钛（Ti）、钒（V）、铬（Cr）、铁（Fe）、铜（Cu）、锌（Zn）、钼（Mo）、锡（Sn）、钙（Ca）、锶（Sr）和钨（W）中的至少一种，z、g 和 h 值分别在以下范围内：$0.8\leq u\leq 1.2$、$0\leq g<1.0$ 和 $-0.2\leq h\leq 0.2$。

在一些实施例中，所述正极能够进一步包含粘结剂及导电剂中的至少一种。应理解，本领域技术人员可以根据实际需要选择本领域常规的粘结剂及导电剂，而不受其限制。

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在一些实施例中，隔离膜包括，但不限于，选自聚乙烯、聚丙烯、聚对苯二甲酸乙二醇酯、聚酰亚胺和芳纶中的至少一种。举例来说，聚乙烯包括选自高密度聚乙烯、低密度聚乙烯和超高分子量聚乙烯中的至少一种组分。尤其是聚乙烯和聚丙烯，它们对防止短路具有良好的作用，并可以通过关断效应改善电池的稳定性。

本申请的锂离子电池还包括电解质，所述电解质可以是凝胶电解质、固态电解质和电解液中的一种或多种，电解液包括锂盐和非水溶剂。

在一些实施例中，所述锂盐选自 $LiPF_6$、$LiBF_4$、$LiAsF_6$、$LiClO_4$、$LiB(C_6H_5)_4$、$LiCH_3SO_3$、$LiCF_3SO_3$、$LiN(SO_2CF_3)_2$、$LiC(SO_2CF_3)_3$、$LiSiF_6$、LiBOB 和二氟硼酸锂中的一种或多种。举例来说，锂盐选用 $LiPF_6$，因为它可以给出高的离子导电率并改善循环特性。

所述非水溶剂可为碳酸酯化合物、羧酸酯化合物、醚化合物、其它有机溶剂或它们的组合。

上述碳酸酯化合物可为链状碳酸酯化合物、环状碳酸酯化合物、氟代碳酸酯化合物或其组合。

上述其它有机溶剂的实例为二甲亚砜、1,2-二氧戊环、环丁砜、甲基环丁砜、1,3-二甲基-2-咪唑烷酮、N-甲基-2-吡咯烷酮、甲酰胺、二甲基甲酰胺、乙腈、磷酸三甲酯、磷酸三乙酯、磷酸三辛酯、和磷酸酯及其组合。

在一些实施例中，非水溶剂选自由碳酸乙烯酯、碳酸丙烯酯、碳酸二乙酯、碳酸二甲酯、碳酸甲乙酯、碳酸亚丙酯、醋酸甲酯、丙酸乙酯、氟代碳酸乙烯酯及其组合所组成的群组。

应理解，本申请实施例中的负极、正极、隔离膜以及锂离子电池的制备方法，在不违背本申请的精神下，可以根据具体需要选择本领域任何合适的常规方法，而不受其限制。在制造电化学装置的方法的一个实施方案中，所述锂离子电池的制备方法包括：将上述实施例中的负极、隔离膜及正极按顺序卷绕、折叠或堆叠成电极组件，将所述电极组件装入例如铝塑膜中，并注入电解液，随后进行真空封装、静置、化成、整形等工序，以获得锂离子电池。

虽然上面以锂离子电池进行了举例说明，但是本领域技术人员在阅读本申请之后，能够想到由本申请的负极可以用于其他合适的电化学装置。这样的电化学装置包括发生电化学反应的任何装置，它的具体实例包括所有种类的一次电池、二次电池、燃料电池、太阳能电池或电容。特别地，该电化学装置是锂二次电池，包括锂金属二次电池、锂离

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子二次电池、锂聚合物二次电池或锂离子聚合物二次电池。

本申请的一些实施例进一步提供了一种电子装置，所述电子装置包含本申请实施例中的电化学装置。

本申请实施例的电子装置没有特别限定，其可以是用于现有技术中已知的任何电子装置。在一些实施例中，所述电子装置可以包括，但不限于，笔记本电脑、笔输入型计算机、移动电脑、电子书播放器、便携式电话、便携式传真机、便携式复印机、便携式打印机、头戴式立体声耳机、录像机、液晶电视、手提式清洁器、便携 CD 机、迷你光盘、收发机、电子记事本、计算器、存储卡、便携式录音机、收音机、备用电源、电机、汽车、摩托车、助力自行车、自行车、照明器具、玩具、游戏机、钟表、电动工具、闪光灯、照相机、家庭用大型蓄电池和锂离子电容器等。

具体实施例

下面列举了一些具体实施例和对比例并分别对其负极进行单位重量及压实密度测试并对其电化学装置（锂离子电池）进行循环性能测试及析锂测试以更好地对本申请的技术方案进行说明。

一、测试方法

激光粒度分析：

激光粒度测试是根据不同大小的颗粒能使激光产生不同强度散射的原理来测试粒度分布的。表征颗粒粒度特性的主要指标有 Dn10、Dv10、Dv50、Dv90、Dv99 等等，其中，Dv50 被称为颗粒度，表示样品在体积基准的粒度分布中，从小粒度算起、体积累积达到总体积 50%时的粒度。本申请实施例及对比例采用 Mastersizer 3000 激光粒度分布测试仪分析样品的颗粒的粒度：将负极活性材料的样品分散在 100mL 的分散剂（去离子水）中，使遮光度达到 8~12%。随后在超声强度为 40KHz 及 180w 下对样品进行超声处理 5 分钟。待超声处理后，将对样品进行激光粒度分布分析，得到粒度分布数据。

单位重量及压实密度测试：

从待测负极上的第一负极活性材料层与第二负极活性材料层沿负极集流体表面分别取得面积为 1540.25 mm^2 的小圆片的活性材料样品。在去除负极集流体后，记录其负极活性材料的重量。每组取 12 处不同位置的活性材料样品，并计算第一负极活性材料层与第二负极活性材料层的单位面积重量。

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量测负极上的第一负极活性材料层与第二负极活性材料层在集流体表面垂直方向上的总厚度（去除集流体厚度）。每组取 12 处不同位置的活性材料样品，并计算第一负极活性材料层与第二负极活性材料层的压实密度。压实密度＝负极活性材料的重量/在集流体表面垂直方向上的总厚度。

循环性能测试：

将以下实施例及对比例的锂离子电池置于 25℃±2℃的恒温箱中静置 2 小时，以 0.5 C 恒流充电至 4.45 V，然后以 4.45 V 恒压充电至 0.02 C 并静置 15 分钟；再以 0.5 C 恒流放电至 3.0 V，此为一次充放电循环过程，记录锂离子电池首次循环的放电容量；而后按上述方法重复进行充放电循环过程，并记录每次充放电循环过程的放电容量，随后将其与首次循环的放电容量比较得到循环容量曲线。

每组取 4 块锂离子电池，计算锂离子电池的容量保持率的平均值。锂离子电池的循环保持率＝第 400 次循环的放电容量（mAh）/首次循环后的放电容量（mAh）×100%。

析锂测试：

将以下实施例及对比例的锂离子电池置于 25℃±2℃的恒温箱中静置 2 小时，以 0.5 C 恒流放电至 3.00 V。静置 5 分钟后，以 0.7 C 恒流充电至 4.45 V，然后以 4.45 V 恒压充电至 0.02 C。此为一次析锂测试循环，重复 10 次上述析锂测试循环后，将锂离子电池以 0.5 C 恒流放电至 3.00 V，后拆解锂离子电池并计算析锂面积（呈灰色）占负极活性材料层的面积的比值 S。根据满充负极析锂面积（呈灰色）与负极活性材料层的面积的比值 S 来判断析锂的程度：小于 3%为轻微析锂、3%至 5%为析锂、大于 5%为严重析锂。

二、制备方法

正极的制备

将钴酸锂（$LiCoO_2$）、导电炭黑、聚偏二氟乙烯(PVDF)按重量比 96.7：1.7：1.6 的比例溶于 N-甲基吡咯烷酮（NMP）溶液中，形成正极浆料。采用铝箔作为正极集流体，将正极浆料涂覆于正极集流体上，经过干燥、冷压、裁切程序后得到正极。

电解液的制备

在含水量小于 10 ppm 的环境下，将六氟磷酸锂、氟代碳酸乙烯酯（FEC）与非水有机溶剂（碳酸乙烯酯（EC）：碳酸二甲酯（DMC）：碳酸二乙酯（DEC）=1：1：1，

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重量比）配制成氟代碳酸乙烯酯的重量浓度为 10wt%且六氟磷酸锂浓度为 1 mol/L 的电解液。

锂离子电池的制备

采用以聚乙烯（PE）多孔聚合薄膜作为隔离膜。将上述正极、隔离膜与以下实施例与对比例的负极的依顺序堆叠，使隔离膜处于正极与负极中间起到隔离的作用，然后卷绕成电极组件。随后将该电极组件装入铝塑膜包装袋中，并在 80℃下脱去水分后，获得干电极组件。随后将上述电解液注入干电极组件中，经过真空封装、静置、化成、整形等工序，即完成以下各实施例和对比例的锂离子电池的制备。

实施例 1

将 400 克的 SiO_x（$0.5 \leqslant x \leqslant 1.6$）、2400 克的人造石墨和 35 克的导电碳黑加入到搅拌器中，在公转速度为 20 圈/分钟下搅拌 120 分钟。随后，将 95 克的聚丙烯酸加入到搅拌中的混合物内，在公转速度为 20 圈/分钟及自转转速为 1200 圈/分钟下搅拌 60 分钟，再加入去离子水搅拌 120 分钟，得到混合浆料。将混合浆料用 170 目双层筛网过滤，即得到负极浆料。

采用铜箔作为负极集流体，将所述负极浆料涂布于负极集流体上，其中单面涂布的部分的单位面积重量为 76.6 g/m^2，双面涂布的部分的单位面积重量为 153.2 g/m^2，两者的涂布重量比 K 为 0.5 并进行烘干。烘干后，进行冷压处理，以得到第一负极活性材料层与第二负极活性材料层，其中第二负极活性材料层的压实密度为 1.78 g/cm^3，第一负极活性材料层与第二负极活性材料层的压实密度比例 R 为 0.9，随后通过裁切程序后得到负极。

实施例 2

与实施例 1 的制备方式相同，不同的地方是实施例 2 中第一负极活性材料层与第二负极活性材料层的压实密度比例 R 为 0.95。

实施例 3

与实施例 1 的制备方式相同，不同的地方是实施例 3 中第一负极活性材料层与第二负极活性材料层的压实密度比例 R 为 0.97。

实施例 4

与实施例 1 的制备方式相同，不同的地方是实施例 4 中第一负极活性材料层与第二

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负极活性材料层的压实密度比例 R 为 1.0。

实施例 5

与实施例 1 的制备方式相同，不同的地方是实施例 5 中第一负极活性材料层与第二负极活性材料层的压实密度比例 R 为 1.1。

实施例 6

与实施例 1 的制备方式相同，不同的地方是实施例 6 中单面涂布的部分的单位面积重量为 76.6 g/m^2，两者单位面积上的涂布重量比 K 为 0.47。

实施例 7

与实施例 1 的制备方式相同，不同的地方是实施例 7 中单面涂布的部分的单位面积重量为 76.6 g/m^2，两者单位面积上的涂布重量比 K 为 0.52。

实施例 8

与实施例 1 的制备方式相同，不同的地方是实施例 8 中采用的硅基材料为 400 克的硅碳（SiC）。

对比例 1

与实施例 1 的制备方式相同，不同的地方是对比例 1 中第一负极活性材料层与第二负极活性材料层的压实密度比例 R 为 0.85。

对比例 2

与实施例 1 的制备方式相同，不同的地方是对比例 2 中第一负极活性材料层与第二负极活性材料层的压实密度比例 R 为 1.5。

对比例 3

与实施例 1 的制备方式相同，不同的地方是对比例 3 中单面涂布的部分的单位面积重量为 76.6 g/m^2，两者单位面积上的涂布重量比 K 为 0.4。

对比例 4

与实施例 1 的制备方式相同，不同的地方是对比例 4 中单面涂布的部分的单位面积重量为 76.6 g/m^2，两者单位面积上的涂布重量比 K 为 0.55。

对比例 5

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与对比例 1 的制备方式相同，不同的地方是对比例 5 中采用的硅基材料为 400 克的硅碳（SiC）。

对比例 6

与实施例 1 的制备方式相同，不同的地方是对比例 6 中采用的硅基材料为 400 克的硅碳（SiC），且第一负极活性材料层与第二负极活性材料层的压实密度比例 R 为 1.2。

对以上实施例及对比例的负极，并对其进行单位重量及压实密度测试。随后对锂离子电池进行循环性能测试以及存储膨胀率测试，并记录其测试结果。

实施例 1-8 及对比例 1-6 的负极的统计数值及通过单位重量及压实密度测试、循环性能测试及析锂测试的结果如下表 1 所示。

表 1

实施例/对比例	硅基材料	新鲜负极 K 值	新鲜负极 R 值	循环保持率（-）	400 圈循环后 K 值	400 圈循环后 R 值	400 圈循环后第一负极活性材料层区域（102A）S 值	400 圈循环后第二负极活性材料层与第一负极活性材料层的相邻区域（103A）S 值	析锂测试循环 S 值
实施例 1	氧化硅	0.5	0.9	90.3%	0.5	0.88	0	2.8%	2.6%
实施例 2	氧化硅	0.5	0.95	91.1%	0.5	0.94	0	1.6%	2.0%
实施例 3	氧化硅	0.5	0.97	91.7%	0.5	0.96	0	0	0
实施例 4	氧化硅	0.5	1.0	92.1%	0.5	1.0	0	0	0
实施例 5	氧化硅	0.5	1.1	91.9%	0.5	1.12	2.4%	0	2.5%
实施例 6	氧化硅	0.47	1.0	89.7%	0.47	0.95	2.7%	0	2.8%
实施例 7	氧化硅	0.52	1.0	90.6%	0.52	1.08	0	1.8%	2.0%
实施例 8	硅碳	0.5	1.0	89%	0.5	1.0	0	0	0
对比例 1	氧化硅	0.5	0.85	83.4%	0.5	0.78	2.0%	3.3%	20%
对比例 2	氧化硅	0.5	1.5	80.3%	0.5	1.6	6%	4.5%	22%
对比例 3	氧化硅	0.4	1.0	77.5%	0.4	0.83	8%	2.5%	30%
对比例 4	氧化硅	0.55	1.0	82.5%	0.55	1.1	2.6%	8.9%	26%
对比例 5	硅碳	0.5	0.85	73.1%	0.5	0.72	2.7%	4.3%	28%
对比例 6	硅碳	0.5	1.2	79%	0.5	1.4	3.4%	3.1%	24%

如表 1 所示，本申请实施例相较于其对应对比例能够有效的降低负极上的析锂现象，同时提升锂离子电池的循环容量保持率。

通过比较实施例 1-5 和 8 与对比例 1、2、5 和 6 可知，第一负极活性材料层与第二负极活性材料层的压实密度比值 R 越接近 1，则越能够降低负极的析锂情况。其中，当第一负极活性材料层与第二负极活性材料层的单位面积重量比值 K 为 0.5 时，由于极片

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涂布重量均匀，第一负极活性材料层与第二负极活性材料层之间的电流密度相同， 此时 R 值＜1 时表明第一负极活性材料层区域的压实密度较低，锂离子更容易在第一负极活性材料层区域嵌入和脱出，所以第一负极活性材料层区域不存在析锂。当 R＞1 时表明第一负极活性材料层区域的压实密度较大，锂离子脱嵌阻力更大，更容易在第一负极活性材料层区域析锂。

图 3 为本申请实施例 4 与对比例 2 的循环容量曲线图。

如图 3 所示，实施例 4 中的新鲜的负极的第一负极活性材料层与第二负极活性材料层的压实密度比值 R 为 1。经过 400 圈循环后，其由于其压实密度一致，不容易产生膨胀变形其 R 值并没有太多的变化。因此，实施例 4 的锂离子电池能够在循环过程中一直保持极高的容量保持率。相对的，对比例 2 的负极的压实密度比值 R 为 1.5，在经过 400 圈循环后，原先不一致的压实密度会导致负极上第一负极活性材料层与第二负极活性材料层的硅基材料含量不同，进而导致其膨胀率不一致，加剧压实密度的变化。因此，对比例 2 的锂离子电池的容量保持率会急速的下降。

通过比较实施例 4、6 和 7 与对比例 3 和 4 可知，第一负极活性材料层与第二负极活性材料层的单位面积重量比值 K 越接近 0.5 则越能够降低负极的析锂情况。当 K＜0.5 时，表明第一负极活性材料层区域的负极活性材料较少，导致循环过程中第一负极活性材料层区域的电流密度大，更容易析锂；当 K＞0.5 时，表明第一负极活性材料层区域的负极活性材料较多，导致循环过程中第一负极活性材料层区域的电流密度小，不易析锂。

通过上述实施例及对比例的比较，可以清楚的理解本申请的负极通过控制第一负极活性材料层与第二负极活性材料层的单位面积重量比值 K 与压实密度比值 R，能够有效的降低析锂的程度，从而提高其锂离子电池的循环性能。

整个说明书中对“一些实施例”、“部分实施例”、“一个实施例”、“另一举例”、“举例”、“具体举例”或“部分举例”的引用，其所代表的意思是在本申请中的至少一个实施例或举例包含了该实施例或举例中所描述的特定特征、结构、材料或特性。因此，在整个说明书中的各处所出现的描述，例如：“在一些实施例中”、“在实施例中”、“在一个实施例中”、“在另一个举例中”，“在一个举例中”、“在特定举例中”或“举例“，其不必然是引用本申请中的相同的实施例或示例。此外，本文中的特定特征、结构、材料或特性可以以任何合适的方式在一个或多个实施例或举例中结合。

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尽管已经演示和描述了说明性实施例，本领域技术人员应该理解上述实施例不能被解释为对本申请的限制，并且可以在不脱离本申请的精神、原理及范围的情况下对实施例进行改变，替代和修改。

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说　明　书　附　图

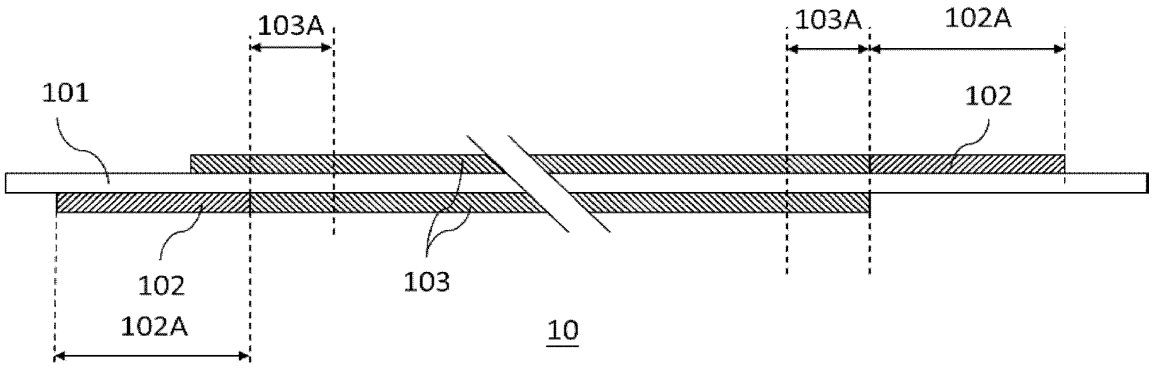


图 1

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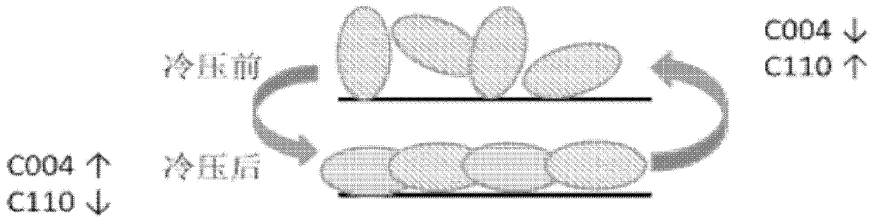


图 2

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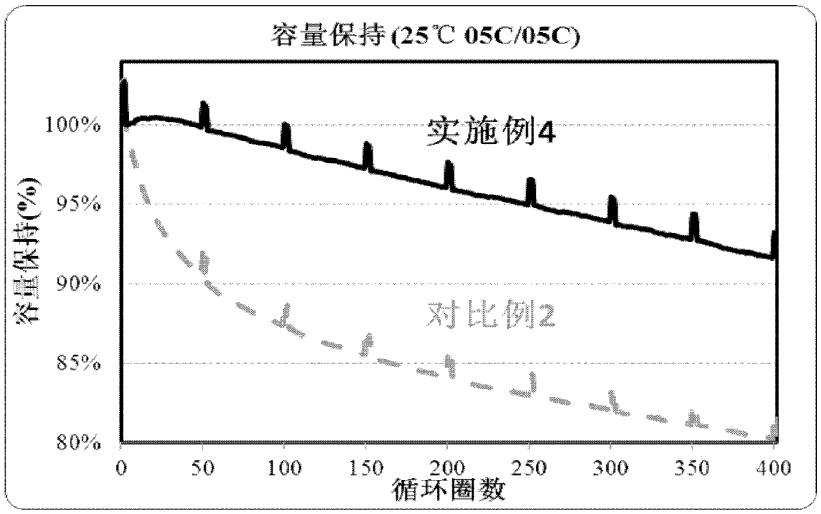


图 3

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
17/707,129	03/29/2022	Ting YI	14850059US

CONFIRMATION NO. 6210

62008
MAIER & MAIER, PLLC
345 SOUTH PATRICK STREET
ALEXANDRIA, VA 22314

PUBLICATION NOTICE

OC000000135166635

Title:NEGATIVE ELECTRODE AND ELECTROCHEMICAL APPARATUS CONTAINING SAME, AND ELECTRONIC APPARATUS

Publication No.US-2022-0223851-A1
Publication Date:07/14/2022

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Notice of References Cited	Application/Control No. 17/707,129	Applicant(s)/Patent Under Reexamination Yl et al.	
	Examiner ZIHENG LU	Art Unit 1752	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date YYYY-MM-DD	Name	CPC Classification	US Classification
*	A	US-20190148762-A1	2019-05-16	Torita; Koji	H01M10/0525	429/209
*	B	US-20140227562-A1	2014-08-14	Kamizori; Haruki	H01M50/574	429/7
*	C	US-20170033355-A1	2017-02-02	KONDO; Takeshi	H01G11/24	1/1
*	D	US-20180316001-A1	2018-11-01	KIM; Deokhyun	H01M4/625	1/1
	E					
	F					
	G					
	H					
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date YYYY-MM-DD	Country	Name	CPC Classification
	N	JP-2012248282-A	2012-12-13	JP	MORIMOTO T	
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in YYYY-MM-DD format are publication dates. Classifications may be US or foreign.

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Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/707,129	YI et al.
	Examiner	**Art Unit**
	ZIHENG LU	1752

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	08/30/2024								
	1	✓								
	2	✓								
	3	✓								
	4	✓								
	5	✓								
	6	✓								
	7	✓								
	8	✓								
	9	✓								
	10	✓								
	11	✓								

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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/707,129	YI et al.
	Examiner	Art Unit
	ZIHENG LU	1752

CPC - Searched*		
Symbol	Date	Examiner
H01M4/386, H01M4/583, H01M4/623, H01M10/0525, H01M2004/021, H01M2004/027	08/30/2024	ZL

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
Inventor and Assignee Search	08/30/2024	ZL
Classification + Text Search	08/30/2024	ZL
Consulted with Primary Maria Laios	08/30/2024	ZL

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner

/ZIHENG LU/ Examiner, Art Unit 1752	

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PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L1	1001	((("NINGDE") near3 ("AMPEREX") near3 ("TECHNOLOGY") near3 ("LIMITED"))).AS,AANM.	(US-PGPUB; USPAT)	OR	ON	ON	2024/08/27 02:01 PM
L2	1521	((("YI") near3 ("Ting")) OR (("CUI") near3 ("Hang")) OR (("XIE") near3 ("Yuansen"))).INV.	(US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT)	OR	ON	ON	2024/08/27 02:01 PM
L3	130218	(H01M4/386 OR H01M4/583 OR H01M4/623 OR H01M10/0525 OR H01M2004/021 OR H01M2004/027).cpc.	(US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT)	OR	ON	ON	2024/08/27 02:02 PM
L4	13103	H01M2004/021.cpc.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:03 PM
L5	5802	("negative electrode" anode) WITH second WITH "active material" WITH layer	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:04 PM
L6	1397	L4 AND L5	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:04 PM
L7	40	L1 AND L6	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:04 PM
L8	1825	(("negative electrode" anode) WITH second WITH "active material" WITH layer).clm.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:05 PM
L9	45	L8 AND L1	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:05 PM
L10	19	L8 AND L1 AND L4	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:05 PM
L11	1416	((("YI") near3 ("Ting")) OR (("CUI") near3 ("Hang")) OR (("XIE") near3 ("Yuansen"))).INV.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:05 PM
L12	4	L11 AND L8 AND L4	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:06 PM
L13	538	L4 AND L8	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:10 PM
L14	32	(second near3(negative "negative electrode" anode) near2 "active	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:16 PM

		material layer") WITH ((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO))					
L15	6170	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO))	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:19 PM
L16	538	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO)) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector")	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:20 PM
L17	272	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO) WITH graphite) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector")	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:21 PM
L18	43	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO) WITH graphite) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND second near3 "active material layer"	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:41 PM
L19	8	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO) WITH graphite) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND offset near3 "active	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 03:04 PM

		material layer"					
L20	9	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO) WITH graphite) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND offset near3 "active material layer"	(FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/08/27 03:04 PM
L21	16	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO) WITH graphite) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND uneven near3 "active material layer"	(FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/08/27 03:05 PM
L22	0	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO) WITH graphite) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND uneven near3 "active material layer"	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 03:10 PM
L23	238	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO) WITH graphite) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND second near3 "active material layer"	(FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/08/27 03:10 PM
L24	7	((negative "negative electrode" anode) near2 "active material" WITH	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 03:15 PM

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		("silicon oxide" SiO) WITH graphite) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND extended near3 "active material layer"					
L25	8	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO) WITH graphite) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND extended near3 "active material layer"	(FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO))	OR	ON	ON	2024/08/27 03:23 PM
L26	4	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO) WITH graphite) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND second NEAR region WITH "active material layer"	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/28 10:30 AM
L27	47	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO) WITH graphite) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND second NEAR region WITH "active material layer"	(FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO))	OR	ON	ON	2024/08/28 10:30 AM
L28	1	"205376669".pn.	(FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR,	OR	ON	ON	2024/08/28 10:32 AM

			HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO))				
L29	4	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO) WITH graphite) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND tail WITH "active material layer"	(FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO))	OR	ON	ON	2024/08/28 11:06 AM
L30	0	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO) WITH graphite) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND tail WITH "active material layer"	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/28 11:07 AM
L31	21	((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND tail WITH "active material layer"	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/28 11:07 AM
L32	42	(Artificial Intelligence) More like doc: US-20220052386-A1 Text: (US-11848422-B2 OR CN-111916844-B OR CN-111916844-A OR EP-4089757-B1 OR EP-4089757-A1 OR CN-115668526-A OR CN-116325278-A OR EP-4068418-A1 OR CN-114122315-A OR CN-111916845-B OR	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO;	OR	ON	ON	2024/08/28 11:08 AM

		CN-111916845-A OR EP-4089760-A1 OR EP-4053960-B1 OR CN-113097441-A OR WO-2022206877-A1 OR EP-4053960-A1 OR CN-118043990-A OR JP-7106190-B2 OR KR-20200028750-A OR CN-114050325-A).did.	JPO; DERWENT; IBM_TDB)				
L33	1218	((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND one WITH side WITH "active material layer"	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/28 11:11 AM
L34	151	((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND single WITH side WITH "active material layer"	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/28 11:11 AM
L35	0	"201400141303".pn.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS)	OR	ON	ON	2024/08/28 12:36 PM
L36	3	"20140141303".pn.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS)	OR	ON	ON	2024/08/28 12:36 PM
L37	1	"20140141303".pn.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/28 12:42 PM

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L38	127	"active material layer" WITH (single NEAR side) WITH "current collector"	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/28 01:30 PM
L39	11	"active material layer" WITH (single NEAR side) WITH "current collector" WITH region	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/28 01:30 PM
L40	78	"active material layer" WITH (single NEAR side) WITH "current collector" WITH region	(FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/08/28 01:33 PM
L41	0	coating WITH (single NEAR side) WITH "current collector" WITH region	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/28 02:25 PM
L42	83	coating WITH (single NEAR side) WITH "current collector" WITH region	(FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/08/28 02:25 PM
L43	32	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO) WITH graphite) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND second near3 "active material layer" AND (negative "negative electrode" anode) near2 "active material" WITH thickness	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/28 02:54 PM

L44	923	"active material layer" WITH "current collector" WITH (insulated uncoated tape)	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 08:51 AM
L45	583	"active material layer" WITH "current collector" WITH uncoated	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 08:51 AM
L46	356	negative WITH "active material layer" WITH "current collector" WITH uncoated	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 08:51 AM
L47	0	negative WITH "active material layer" WITH "current collector" WITH uncoated AND "active material" WITH (SiO "silicon oxide") WITH graphtie	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 08:52 AM
L48	22	negative WITH "active material layer" WITH "current collector" WITH uncoated AND "active material" WITH (SiO "silicon oxide")	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 08:52 AM
L49	100	negative WITH "active material layer" WITH "current collector" WITH uncoated AND "active material layer" WITH "current collector" WITH (both two) WITH (sides side)	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 09:12 AM
L50	1285	(negative anode) WITH "active material" WITH (SiO "silicon oxide") near5 graphite	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 09:23 AM
L51	125	(negative anode) WITH "active material" WITH (SiO "silicon oxide") near5 graphite AND (SiO "silicon oxide") WITH coating WITH carbon	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 09:23 AM
L52	85	(negative anode) WITH "active material" WITH (SiO "silicon oxide") near5 graphite AND (SiO "silicon oxide") WITH coating WITH carbon AND (SiO "silicon oxide") WITH (size volume d50)	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 09:33 AM
L53	119	(negative anode) WITH "active material" WITH	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 10:08 AM

		(SiO "silicon oxide") WITH coating WITH carbon AND coating WITH carbon WITH (improve$4 benefit advantage higher better increas$3)					
L54	45	(negative anode) WITH "active material" WITH (SiO "silicon oxide") WITH coating WITH carbon AND coating WITH carbon WITH (improve$4 benefit advantage higher better increas$3) AND (SiO "silicon oxide") near3 (amorphous crystalline)	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 10:17 AM
L55	8	"active material" WITH (SiO "silicon oxide") AND (SiO "silicon oxide") WITH ("D/G")	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 02:27 PM
L56	11	"active material" WITH (SiO "silicon oxide") AND (SiO "silicon oxide") WITH ("1350")	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 02:28 PM
L57	2	"active material" WITH (SiO "silicon oxide") AND (SiO "silicon oxide") SAME ("500" AND "1350")	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 02:28 PM
L58	96	"active material" WITH (SiO "silicon oxide") AND (SiO "silicon oxide") SAME ("500" AND "1350")	(FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO))	OR	ON	ON	2024/08/29 02:28 PM
L59	4	"active material" WITH (SiO "silicon oxide") AND (SiO "silicon oxide") SAME peak SAME ("500" AND "1350")	(FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH,	OR	ON	ON	2024/08/29 02:29 PM

			TN, TR, TW, UA, VN, WO))				
L60	1072	"active material" WITH (SiO "silicon oxide") AND (SiO "silicon oxide") SAME raman	(FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO))	OR	ON	ON	2024/08/29 02:29 PM
L61	214	"active material" WITH (SiO "silicon oxide") AND (SiO "silicon oxide") SAME raman	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 02:29 PM
L62	84	"active material" WITH (SiO "silicon oxide") AND (SiO "silicon oxide") WITH raman	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 02:29 PM
L63	217	(SiO "silicon oxide") WITH raman	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 02:33 PM
L64	87	H01M$.cpc. AND (SiO "silicon oxide") WITH raman	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 02:33 PM
L65	1574	("negative electrode" anode) WITH (SiO "silicon oxide") WITH graphite AND ("negative electrode" anode) WITH (conductive near3 (agent additive))	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/30 12:45 PM
L66	635	("negative electrode" anode) WITH (SiO "silicon oxide") WITH graphite AND ("negative electrode" anode) WITH (conductive near3 (agent additive)) AND (conductive near3 (agent additive)) WITH (increas$3 advantag$5 benefit improv$4 better)	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/30 12:45 PM
L67	760	(SiO "silicon oxide") WITH "active material" WITH (amorphous crystalline)	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/09/03 10:30 AM
L68	409	(SiO "silicon oxide") WITH "active material" WITH (amorphous crystalline) NOT ((SiO	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/09/03 10:31 AM

		"silicon oxide") WITH "active material" WITH ((amorphous crystalline) near3 carbon))					

PE2E SEARCH - Search History (Interference)

There are no Interference searches to show.

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	
Filing Date	2022-03-29
First Named Inventor	Ting YI
Art Unit	TBD
Examiner Name	TBD
Attorney Docket Number	14850059US

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Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20130171502	A1	2013-07-04	CHEN GUORONG ET AL	Cited in NPL cite No. 1
	2	20190305317	A1	2019-10-03	NEC CORPORATION	Cited in NPL cite No. 1
	3	20070048615	A1	2007-03-01	PANASONIC CORPORATION	Cited in NPL cite No. 2

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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	109841794	CN	A	2019-06-04	NINGDE AMPEREX TECHNOLOGY LTD	Cited in NPL cite No. 1; English Abstract Attached	

EFS Web 2.1.18

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /Z.L./

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2022-03-29
	First Named Inventor	Ting YI
	Art Unit	TBD
	Examiner Name	TBD
	Attorney Docket Number	14850059US

	2	102683751	CN	A	2012-09-19	ZHEJIANG ZHENLONG BATTERY CO LTD	Cited in NPL cite No. 1; English Abstract Attached	
	3	102856538	CN	A	2013-01-02	FDK TWICELL CO LTD	Cited in NPL cite No. 1 & 2; English Abstract Attached	
	4	110010902	CN	A	2019-07-12	NINGDE AMPEREX TECHNOLOGY LTD	Cited in NPL cite No. 1; English Abstract Attached	
	5	108023117	CN	A	2018-05-11	BEIJING NAT BATTERY TECH CO LTD	English Abstract Attached	
	6	109378480	CN	A	2019-02-22	ZHUHAI COSLIGHT BATTERY CO LTD	English Abstract Attached	
	7	101934269	CN	A	2011-01-05	NINGBO VEKEN BATTERY CO LTD	Cited in NPL Cite No. 3; English Abstract Attached	
	8	103825044	CN	A	2014-05-28	SONY CORPORATION	Cited in NPL Cite No. 2; English Abstract Attached	
	9	205376669	CN	U	2016-07-06	NINGDE NEW ENERGY TECHNOLOGY CO LTD	Cited in NPL Cite No. 2; English Abstract Attached	
	10	101944607	CN	A	2011-01-12	HUNAN CORUN NEW ENERGY CO LTD	Cited in NPL Cite No. 2; English Abstract Attached	
	11	108701807	CN	A	2018-10-23	NANOSCALE COMPONENTS INC	Cited in NPL Cite No. 2; English Abstract Attached	
	12	3387687	EP	A1	2018-10-17	NANOSCALE COMPONENTS INC	Cited in NPL Cite No. 2 & Corresponding to WO2017100415; English Abstract Attached	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /Z.L./

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2022-03-29
	First Named Inventor	Ting YI
	Art Unit	TBD
	Examiner Name	TBD
	Attorney Docket Number	14850059US

	13	2017100415	WO	A1	2017-06-15	NANOSCALE COMPONENTS INC	Corresponding to EP3387687	

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NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	International Search Report mailed September 16, 2020, corresponding to International Application No. PCT/CN2019/130465; 6 pages (with English translation).	☒
	2	First Office Action issued September 23, 2020, corresponding to Chinese Application No. 201911267132.X; 6 pages (with English Translation).	☒
	3	Notification to Grant Patent Right for Invention issued April 1, 2021, corresponding to Chines Application No. 201911267132.X; 6 pages (with English Translation).	☒

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EXAMINER SIGNATURE

Examiner Signature	/ZIHENG LU/	Date Considered	09/03/2024

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2022-03-29
	First Named Inventor	Ting YI
	Art Unit	TBD
	Examiner Name	TBD
	Attorney Docket Number	14850059US

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Timothy J. Maier/	Date (YYYY-MM-DD)	2022-03-29
Name/Print	Timothy J. Maier	Registration Number	51,986

This collection of information is required by 37 CFR 1.97 and 1.98. 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 1 hour 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.**

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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:

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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.

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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.

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Zhuhai CosMX Battery Co. v. Ningde Amperex Tech. Ltd.
IPR2026-00401 - Page 332 of 436

Bibliographic Data

Application No: 17/707,129

Foreign Priority claimed: (•) Yes ( ) No

35 USC 119 (a-d) conditions met: [✓] Yes [ ] No [ ] Met After Allowance

Verified and Acknowledged: /ZIHENG LU/ Examiner's Signature | Initials

Title: NEGATIVE ELECTRODE AND ELECTROCHEMICAL APPARATUS CONTAINING SAME, AND ELECTRONIC APPARATUS

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
03/29/2022	429	1752	14850059US
RULE			

APPLICANTS

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INVENTORS

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Hang CUI, Ningde, CHINA

Yuansen XIE, Ningde, CHINA

CONTINUING DATA

This application is a CON of PCT/CN2019/130465 12/31/2019

FOREIGN APPLICATIONS

CHINA CN201911267132.X 12/11/2019

IF REQUIRED, FOREIGN LICENSE GRANTED**

04/05/2022

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UNITED STATES

FILING FEE RECEIVED

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(P2012-248282A)
(43)公開日　平成24年12月13日(2012.12.13)

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H01M 10/0566	(2010.01)	H01M 10/00	111	5H029
H01M 4/13	(2010.01)	H01M 4/02	101	5H050
H01M 4/66	(2006.01)	H01M 4/66	A	

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(22)出願日　平成23年5月25日 (2011.5.25)

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Fターム(参考) 5H017 AA03　CC01　EE01　HH03

最終頁に続く

(54)【発明の名称】非水電解質二次電池

(57)【要約】
【課題】負極集電体としての銅箔の厚さが薄く、充放電サイクルを繰り返しても電池容量が低下し難く、かつ電池の膨れが小さい非水電解質二次電池を提供すること。
【解決手段】正極極板と銅箔２２の両面に負極活物質層２３が塗布された負極極板１２Ａとがセパレータを介して巻回された巻回電極体と、非水溶媒中に電解質塩を有する非水電解質と、を備える非水電解質二次電池において、負極極板１２Ａの巻き始め側の端部の外周側及び内周側には銅箔からなる集電体２２が露出された負極集電体露出部２４が設けられ、この負極集電体露出部２４は、外周側露出部２４ａよりも内周側露出部２４ｂの方が長く形成されて外周側露出部２４ａには負極活物質層２３の片面塗布部２５が形成され、内周側露出部２４ｂ４には、内周側の負極活物質層２３の塗布端部２６に接する位置から外周側片面塗布部２５を越える領域にわたって、補強層２７が形成されている。
【選択図】図２

図2A

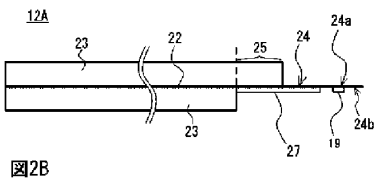


図2B

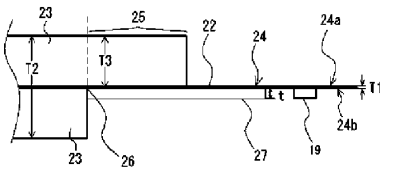
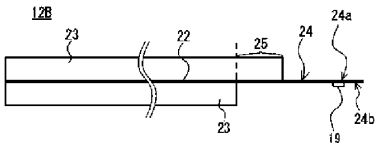


図2C



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【特許請求の範囲】
【請求項１】
金属箔の両面に正極活物質層が塗布された正極極板と銅箔の両面に負極活物質層が塗布された負極極板とがセパレータを介して巻回された巻回電極体と、非水溶媒中に電解質塩を有する非水電解質と、を備える非水電解質二次電池において、
前記負極極板の巻き始め側の端部の外周側及び内周側には前記銅箔が露出された負極集電体露出部が設けられ、
前記負極集電体露出部は、前記銅箔の外周側よりも内周側の方が長く形成されて前記外周側には前記負極活物質層の片面塗布部が形成され、
前記内周側の前記負極集電体露出部には、前記内周側の前記負極活物質層の塗布端部に接する位置から前記外周側の前記負極活物質層の片面塗布部を越える領域にわたって、補強層が形成されていることを特徴とする非水電解質二次電池。
【請求項２】
前記補強層は、ポリオレフィン樹脂と無機フィラーとの混合物からなることを特徴とする請求項１に記載の非水電解質二次電池。
【請求項３】
前記補強層は、厚さが１μｍ以上３０μｍ以下であることを特徴とする請求項１に記載の非水電解質二次電池。
【請求項４】
前記銅箔は、厚さが７μｍ以下５μｍ以上であることを特徴とする請求項１に記載の非水電解質二次電池。
【発明の詳細な説明】
【技術分野】
【０００１】
本発明は、非水電解質二次電池に関し、特に負極集電体としての銅箔の厚さが薄く、充放電サイクルを繰り返しても電池容量が低下し難く、かつ電池の膨れが小さい非水電解質二次電池に関する。
【背景技術】
【０００２】
今日の携帯電話機、携帯型パーソナルコンピューター、携帯型音楽プレイヤー等の携帯型電子機器の駆動電源として、さらには、ハイブリッド電気自動車（ＨＥＶ）や電気自動車（ＥＶ）用の電源として、高エネルギー密度を有し、高容量であるリチウムイオン二次電池に代表される非水電解質二次電池が広く利用されている。これらの非水電解質二次電池は、正極極板と負極極板との間にセパレータを挟んで巻回して巻回電極体を作製し、角形非水電解質二次電池の場合にはさらに巻回電極体を押し潰すことによって偏平状の巻回電極体を作製し、電池外装体内に挿入することにより作製されている。
【０００３】
近年、電池の高容量化に伴い、正極活物質や負極活物質の高密度充填化が行われるようになり、電池質量の増大化が進んでいる。そのため、電池の軽量化の目的で、各種電池構成材料の軽量化が追求されており、その中で最も比重が大きい負極集電体として使用されている銅箔に関してもより薄くすることが要求されている。すなわち、負極集電体としての銅箔の厚さを薄くすれば、その分だけ同一の容積の電池外装体内に充填することができる正極活物質量及び負極活物質量を増大させることができるため、電池容量の増大化を達成することができる。
【０００４】
しかしながら、負極集電体としての銅箔を薄くすると、それに伴って銅箔の強度が低下するため、充放電時の負極活物質の膨張収縮により負極極板に歪みが生じやすくなり、それによりサイクル特性が低下すると共に電池の膨れも大きくなるという問題点が存在している。このような負極極板の歪みは、特に片面にのみ負極活物質が塗布されている部分で生じ易い。しかも、この片面にのみ負極活物質が塗布されている部分は、巻回電極体の巻

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始め部に形成されると、電池外装体内に密閉されている巻回電極体全体に影響を及ぼすので、充放電サイクルを繰り返した際の電池容量の低下が大きくなること及び電池膨れが大きくなることの原因となる。

【０００５】

一方、下記特許文献１には、非水電解質二次電池の内部短絡を回避して安全性を向上することを目的として、正極極板及び負極極板の表面を、それぞれの極板の活物質が塗布されていない集電体の表面をも含めて、多孔質電子絶縁層によって被覆した例が示されている。また、上記特許文献２には、非水電解質二次電池の内部短絡脆弱部による内部短絡の発生を抑制すると共に、従来例のような内部短絡脆弱部にテープを貼付した場合よりも電池容量の増大化を達成することを目的として、正極極板及び負極極板のそれぞれの活物質が塗布されていない集電体の表面を、無機粒子とバインダー高分子とを含む多孔性活性層でコーティングした例が示されている。さらに、上記特許文献３には、非水電解質二次電池において、過放電時に負極電位が上昇して負極合剤が塗布されていない負極集電体としての銅箔が溶解することを抑制し、充放電サイクルを繰り返しても電池容量が低下し難くなるようにすることを目的として、負極合剤が塗布されていない負極集電体の表面全体を樹脂等の絶縁材で被覆するようにした例が示されている。

【先行技術文献】

【特許文献】

【０００６】

【特許文献１】国際公開ＷＯ２００５／０６７０８０号公報

【特許文献２】特表２００９－５１８８０８号公報

【特許文献３】特開２００４－１４６２２２号公報

【発明の概要】

【発明が解決しようとする課題】

【０００７】

上記特許文献１及び２に示されている非水電解質二次電池によれば、一応内部短絡の発生を抑制して電池の安全性を向上することができるという効果を奏する。また、上記特許文献３に示されている非水電解質２次電池によれば、負極集電体としての銅箔の溶解が抑制されるために、一応充放電サイクルを繰り返しても電池容量が低下し難くなるという効果を奏する。

【０００８】

しかしながら、上記特許文献１～３に記載されている発明では、少なくとも負極合剤が塗布されていない負極集電体の表面全体が多孔質絶縁層ないし樹脂等の絶縁材で被覆されているため、負極集電体としての銅箔の厚さを薄くしても、多孔質絶縁層ないし樹脂等の絶縁材によって銅箔の強度が高くなっているために上述のような充放電時の負極活物質の膨張収縮による電極体の歪みは生じ難いが、電池外装体内で多孔質絶縁層ないし樹脂等の絶縁材の占める容積が大きくなるので、その分だけ電池容量が低下するという課題が存在している。

【０００９】

そこで、発明者等は、負極集電体としての銅箔の厚さを薄くしても、充放電時の負極活物質の膨張収縮による負極極板の歪みが生じ難くすると共に、電池容量を大きくすることができる構成について種々検討した結果、負極合剤が塗布されていない負極集電体の表面への絶縁物からなる補強層の形成領域を見直すことによって、達成し得ることを見出し、本発明を完成するに至ったのである。

【００１０】

すなわち、本発明は、負極集電体としての銅箔の厚さが薄く、充放電サイクルを繰り返しても電池容量が低下し難く、かつ電池の膨れが小さい非水電解質二次電池を提供することを目的とする。

【課題を解決するための手段】

【００１１】

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上記目的を達成するため、本発明の非水電解質二次電池は、
金属箔の両面に正極活物質層が塗布された正極極板と銅箔の両面に負極活物質層が塗布された負極極板とがセパレータを介して巻回された巻回電極体と、非水溶媒中に電解質塩を有する非水電解質と、を備える非水電解質二次電池において、
前記負極極板の巻き始め側の端部の外周側及び内周側には前記銅箔が露出された負極集電体露出部が設けられ、
前記負極集電体露出部は、前記銅箔の外周側よりも内周側の方が長く形成されて前記外周側には前記負極活物質層の片面塗布部が形成され、
前記内周側の前記負極集電体露出部には、前記内周側の前記負極活物質層の塗布端部に接する位置から前記外周側の前記負極活物質層の片面塗布部を越える領域にわたって、補強層が形成されていることを特徴とする。

【００１２】
本発明の非水電解質二次電池においては、補強層を銅箔の内周側の負極活物質層の塗布端部に接する位置から外周側の負極活物質層の片面塗布部を越える領域にわたって形成することで、銅箔の巻き始め側の端部の内周側の強度を高くすることができるため、負極集電体としての銅箔の厚さを従来例のものよりも薄く形成しても、充放電サイクルを繰り返した際に負極極板に歪みが発生し難くなり、電池の膨れが小さくなる。加えて、負極極板自体の厚さを薄くすることができるので、その分だけ巻回電極体を形成する際に同一容積内の巻回数を多くすることができ、電池の容量を大きくすることができる。

【００１３】
また、前記補強層は、ポリオレフィン樹脂と無機フィラーとの混合物からなることが好ましい。

【００１４】
ポリエチレン、ポリプロピレン等のポリオレフィン樹脂は非水溶媒によって膨潤し難く、また、無機フィラーの添加によってポリオレフィン樹脂の強度が高くなる。そのため、本発明の非水電解質二次電池によれば、非水電解質に膨潤し難く、強度が高い補強層が得られる。なお、無機フィラーとしては、酸化チタン（TiO_2）、酸化アルミニウム（Al_2O_3）、酸化ケイ素（SiO_2）、酸化ジルコニウム（ZrO_2）等を用いることができるが、電池内での安定性、リチウムとの反応性やコストを考慮すれば、酸化アルミニウム及びルチル型の酸化チタンが特に好ましい。

【００１５】
また、前記補強層は、厚さが１μｍ以上３０μｍ以下であることが好ましい。

【００１６】
本発明の非水電解質二次電池によれば、補強層の厚さを１μｍ以上３０μｍで形成することで、負極集電体露出部の強度を高くすることができる。なお、補強層の厚さが１μｍより薄いと補強の効果が弱くなる。補強層の厚さは合剤層厚さよりも薄くすることで電極体の厚みを不必要に厚くなることを防止できる一方で、補強層の厚さが３０μｍより厚いと、銅箔の補強はできるが、銅箔の露出部の厚さが厚くなるので、巻回電極体の巻始め部の形成が困難となる。より好ましい補強層の厚さは、１μｍ以上１０μｍ以下である。

【００１７】
また、前記銅箔は、厚さが７μｍ以下５μｍ以上であることが好ましい。

【００１８】
本発明の非水電解質二次電池によれば、銅箔の厚さを７μｍ以下５μｍ以上に形成しても、補強層を塗布することで銅箔の巻き始め側の端部の強度を高くすることができるので、負極極板自体をより薄く形成することができ、巻回数を多くすることで、電池の容量をさらに大きくすることができるとともに、電池の膨化を小さくすることができる。なお、銅箔の厚さが７μｍを越えると従来例のものと相違が認められなくなり、また、銅箔の厚さが５μｍ未満であると負極集電体の強度が足りず、負極極板の歪みが大きくなって電池の膨れが大きくなるので好ましくない。より好ましい銅箔の厚さは７μｍ以下６μｍ以上である。

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【図面の簡単な説明】
【００１９】
【図１】各実施例及び比較例で各種電池特性の測定に用いた角形非水電解質二次電池を縦方向に切断して示す斜視図である。
【図２】図２Ａは実施例１、２及び比較例３に共通する負極極板の模式側面図であり、図２Ｂは図２Ａの部分拡大図であり、図２Ｃは比較例１、２及び４に共通する負極極板の模式側面図である。
【発明を実施するための形態】
【００２０】
以下、本発明を実施するための形態を各種実施例及び比較例を用いて詳細に説明する。ただし、以下に示す各実施例は、本発明の技術思想を具体化するための一例として角形非水電解質二次電池を例示するものであって、本発明をこれらの実施例に特定することを意図するものではなく、本発明は、円筒形非水電解質二次電池等、特許請求の範囲に示した技術思想を逸脱することなく種々の変更を行ったものにも均しく適用し得るものである。
【００２１】
「角形非水電解質二次電池の構成」
最初に、実施例１、２及び比較例１～４に共通する角形非水電解質二次電池１０の構成について、図１を用いて説明する。この角形非水電解質二次電池１０は、正極極板１１と負極極板１２とがセパレータ１３を介して巻回された偏平状の巻回電極体１４を、角形の電池外装缶１５の内部に収容し、封口板１６によって電池外装缶１５を密閉したものである。巻回電極体１４は、ここでは正極極板１１が最外周に位置して露出するように巻回されており、露出した最外周の正極極板１１は、正極端子を兼ねる電池外装缶１５の内面に直接接触し、電気的に接続されている。また、負極極板１２は、封口板１６の中央に形成され、絶縁体１７を介して取り付けられた負極端子１８に対して負極タブ１９を介して電気的に接続されている。
【００２２】
そして、電池外装缶１５は、正極極板１１と電気的に接続されているので、負極極板１２と電池外装缶１５との短絡を防止するために、巻回電極体１４の上端と封口板１６との間に絶縁スペーサ２０を挿入することにより、負極極板１２と電池外装缶１５とを電気的に絶縁状態にしている。この角形非水電解質二次電池１０は、巻回電極体１４を電池外装缶１５内に挿入した後、封口板１６を電池外装缶１５の開口部にレーザ溶接し、その後電解液注液孔２１から非水電解液を注液し、この電解液注液孔２１を密閉することにより作製される。
【００２３】
［正極極板の作製］
正極極板は次のようにして作製した。正極活物質としてのコバルト酸リチウム（$LiCoO_2$）９５質量部と、導電剤としての炭素５質量部とを混合した。この混合物９５質量％と、結着剤としてのポリビニリデンフルオライド（ＰＶＤＦ）５質量％とを、Ｎ－メチル－２－ピロリドン（ＮＭＰ）に分散させて、正極活物質スラリーを調製した。次に、厚み１５μｍのアルミニウム箔からなる正極芯体の両面に、この正極活物質スラリーを均一な厚みで塗布した。この極板を乾燥機内に通してスラリー作製時に必要であったＮＭＰを除去した。この後、ロールプレス機を用いて圧縮し、実施例１、２及び比較例１～４に共通する正極極板を作製した。
【００２４】
［負極の作製］
負極極板１２は次のようにして作製した。黒鉛粉末が９５質量％，増粘剤としてのカルボキシメチルセルロース（ＣＭＣ）が３質量％、結着剤としてのスチレン－ブタジエンゴム（ＳＢＲ）が２質量％、をそれぞれ水に分散させスラリーを調整した。このスラリーを銅箔からなる集電体の両面にドクターブレード法により塗布、乾燥し、銅箔からなる集電体の両面に負極活物質層を形成した。その後，圧縮ローラーを用いて定圧圧縮し、所定厚

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さの負極極板を作製した。

【００２５】

なお、負極スラリーの塗布位置は、実施例１、２及び比較例１～４共に、銅箔からなる集電体の巻き始め側の端部に外周側及び内周側に負極集電体露出部が形成され、この負極集電体露出部は、外周側よりも内周側の方が長さが長くなるように形成され、外周側に片面のみ負極活物質層が形成された片面塗布部が形成されている。さらに、実施例１、２及び比較例３の負極極板においては、銅箔からなる集電体の内周側に、負極活物質層の塗布端部に接する位置から外周側の負極活物質層の片面塗布部を越える領域にわたって、酸化チタンからなる無機フィラーとポリプロピレンとを溶剤としてのＮＭＰに添加することによってスラリーを塗布し、ＮＭＰを乾燥除去して所定厚さの補強層を形成することにより、負極極板を形成した。これらの各負極極板の具体的構成及び厚さについては後述する。

【００２６】

なお、各実施例及び比較例においては、正極極板及び負極極板の塗布量は、設計基準となるセル充電電圧４．２Ｖ（正極充電電位はリチウム基準で４．３Ｖ）において、正極極板と負極極板の対向する部分での充電容量比（負極充電容量／正極充電容量）が１．１となるように調整した。

【００２７】

このようにして作製された各実施例及び比較例の負極極板の具体的構成を図２を用いて説明する。なお、図２Ａは実施例１、２及び比較例３に共通する負極極板の模式側面図であり、図２Ｂは図２Ａの部分拡大図であり、図２Ｃは比較例１、２及び４に共通する負極極板の模式側面図である。

【００２８】

実施例１、２及び比較例３に共通する負極極板１２Ａは、図２Ａ及び図２Ｂに示したように、厚さＴ１の銅箔からなる集電体２２が用いられており、この銅箔からなる集電体２２の両面には所定厚さに負極活物質層２３が形成されている。そして、銅箔からなる集電体２２の巻き始め側の端部に外周側露出部２４ａ及び内周側露出部２４ｂからなる負極集電体露出部２４が形成され、この負極集電体露出部２４は、外周側露出部２４ａよりも内周側露出部２４ｂの方が長さが長くなるように形成され、外周側に片面のみ負極活物質層２３が形成された片面塗布部２５が形成されている。また、負極集電体露出部２４には、内周側露出部２４ｂの端部に負極タブ１９が溶接されている。

【００２９】

そして、負極集電体露出部２４の内周側露出部２４ｂには、負極活物質層２３の塗布端部２６から外周側露出部２４ａの片面塗布部２５の領域を越えて負極タブ１９に近い位置まで、補強層２７が形成されている。ここで、両面に負極活物質層２３が形成された両面塗布部の銅箔からなる集電体２２を含む厚さをＴ２、片面にのみ負極活物質層２３が形成された片面塗布部２５の銅箔からなる集電体２２を含む厚さをＴ３とし、また、実施例１、２及び比較例３に共通に補強層２７の厚さｔ＝２μｍとした。

【００３０】

また、実施例１、２及び比較例３におけるそれぞれの具体的寸法は、実施例１ではＴ１＝７μｍ、Ｔ２＝１４０μｍ、Ｔ３＝７４μｍとし、実施例２ではＴ１＝６μｍ、Ｔ２＝１３９μｍ、Ｔ３＝７３μｍとし、また、比較例３ではＴ１＝８μｍ、Ｔ２＝１４１μｍ、Ｔ３＝７５μｍとした。

【００３１】

さらに、比較例１、２及び４の負極極板１２Ｂは、図２Ｃに示したように、補強層が形成されていない以外は実施例１、２及び比較例３に共通する負極極板１２Ａと同様の構成を備えている。比較例１、２及び４におけるそれぞれの具体的寸法は、比較例１ではＴ１＝７μｍ、Ｔ２＝１４０μｍ、Ｔ３＝７４μｍとし、比較例２ではＴ１＝８μｍ、Ｔ２＝１４１μｍ、Ｔ３＝７５μｍとし、また、比較例４ではＴ１＝６μｍ、Ｔ２＝１３９μｍ、Ｔ３＝７３μｍとした。これらの実施例１、２及び比較例１～４の負極極板１２Ａ、１２Ｂのそれぞれの具体的寸法を下記表１に纏めて示した。

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【００３２】
［セパレータの作製］
ポリエチレン混合物と無機微粉体及び可塑剤を混練・加熱溶融しながらシート状に成形した後、無機微粉体及び可塑剤をそれぞれ抽出除去及び乾燥し、透気度・膜厚・孔径を所定のものになるように延伸し、貼り合わせることによって実施例１、２及び比較例１～４に共通して用いる微多孔膜セパレータを作成した。
【００３３】
［電極体の作製］
上述のようにして作製された正極極板と負極極板とをセパレータを介して互いに絶縁しながら巻き取り機により捲回し、絶縁性の巻き止めテープを取り付けてプレスすることにより、偏平状巻回電極体を完成させた。
【００３４】
［非水電解質の調整］
エチレンカーボネート（ＥＣ）とエチルメチルカーボネート（ＭＥＣ）とジエチルカーボネート（ＤＥＣ）とを、体積比２０：５０：３０の割合（１気圧、２５℃に換算）で混合した非水溶媒に、電解質塩としての$LiPF_6$を０．９ｍｏｌ／Ｌの割合で溶解したものを非水電解質とした。
【００３５】
［電池の作製］
上述のようにして作製した偏平状巻回電極体と非水電解質とを、アルミニウム製の角形外装缶内に挿入し、外装缶の開口部に封口板を嵌め合わせレーザ溶接して、実施例１、２及び比較例１～４の高さ４３ｍｍ、幅３４ｍｍ、厚み４．３ｍｍの角形非水電解質二次電池としてのリチウムイオン二次電池を作製した。得られた電池の設計容量は７５０ｍＡｈである。
【００３６】
［電池特性の測定］
上述のようにして作製された実施例１、２及び比較例１～４の各電池について、それぞれ３個ずつ、以下に示す条件でサイクル特性及び電池膨れ量の測定を行った。
【００３７】
〔サイクル特性〕
２５℃において、１Ｉｔ＝７５０ｍＡの定電流で電池電圧が４．２０Ｖとなるまで充電し、電池電圧が４．２Ｖに達した後は４．２０Ｖの定電圧で充電電流が（１／５０）Ｉｔ＝１５ｍＡとなるまで充電して満充電状態とし、その後、２５℃で７５０ｍＡの定電流で電圧が２．７５Ｖとなるまで放電した。この時の放電容量を１サイクル目放電容量として求めた。そして、この条件で３００サイクルの充放電を行い、３００サイクル目の放電容量を「３００サイクル目放電容量」として求め、以下の式に基づいてサイクル特性としての容量維持率を算出した。

容量維持率（％）
＝（３００サイクル目放電容量／１サイクル目放電容量）×１００

そして、求めた容量維持率（％）は、比較例１の値を１００とした場合の相対値、すなわち「相対容量維持率」として表した。結果を纏めて表１に示した。
【００３８】
電池の膨れ量は、以下の式により算出した。
膨れ量（％）＝（３００サイクル後の電池厚み／最初の電池厚み）×１００
そして、求めた膨れ量（％）は、比較例１の値を１００とした場合の相対値、すなわち「相対膨れ率」として表した。結果を纏めて表１に示した。
【００３９】

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【表１】

	銅箔の厚さ T1（μm）	両面塗布部厚さ T2（μm）	片面塗布部厚さ T3（μm）	補強材*の有無	相対容量維持率	相対膨れ率
実施例１	７	１４０	７４	○	１０２	１０４
実施例２	６	１３９	７３	○	１０３	１０３
比較例１	７	１４０	７４	×	１００	１０６
比較例２	８	１４１	７５	×	１００	１０５
比較例３	８	１４１	７５	○	１００	１０５
比較例４	６	１３９	７３	×	９９	１０７

*) 厚さｔ＝２μｍ

【００４０】

表１に示した結果から、以下のことがわかる。すなわち、銅箔の厚さＴ１＝７μｍである実施例１及び比較例１の結果から、補強材が存在している実施例１の電池の方が、補強材が存在していない比較例１の電池よりも相対容量維持率が大きく、また、相対膨れ率も小さく、良好な結果が得られている。このような傾向は、銅箔の厚さＴ１＝６μｍであり、補強材が形成されている実施例２及び補強材が形成されていない比較例１の電池の場合においても同様に認められる。これらのことは、比較例１及び４の電池では、銅箔の厚さが薄いため、片面塗布部の強度不足により、充放電サイクル時の負極活物質の膨張収縮に伴って負極極板にひずみが生じたことに起因するものであり、実施例１及び２は片面塗布部の強度不足が補強材によって補われたために、良好な相対容量維持率及び相対膨れ率として表した充放電サイクル特性を示したものと考えられる。

【００４１】

ただ、銅箔の厚さＴ１＝８μｍであり、補強材が形成されている比較例３及び補強材が形成されていない比較例２の電池の場合では、相対容量維持率及び相対膨れ率共に相違は生じなかった。このことは、銅箔の厚さＴ１＝８μｍになると、銅箔の強度が十分であるため、補強材の有無によって相違が生じなかったことを意味する。したがって、本発明のように補強材を形成することに技術的意義が生じるのは、銅箔の厚さＴ１が７μ以下の場合であることがわかる。なお、銅箔の厚さが５μｍ未満となると、銅箔の強度が弱くなりすぎて、巻回電極体形時に切断してしまうことが多くなるため、好ましくない。そのため、本発明においては、銅箔の厚さは、７μｍ以下５μｍ以上であることが好ましく、より好ましくは７μｍ以下６μｍ以上である。

【００４２】

また、上記実施例１及び２では補強層の厚さを２μｍとした例を示したが、補強層は片面塗布部の強度を補うために形成されるものであるから、薄くてもそれなりの補強強度向上効果を奏するが、余り厚くなると銅箔の補強はできるが、銅箔の露出部の厚さが厚くなるので、巻回電極体の巻始め部の形成が困難となる。そのため、本発明における補強層の厚さは、合剤層厚さよりも薄く、１μｍ以上３０μｍ以下が好ましく、より好ましくは１μｍ以上１０μｍ以下である。

【００４３】

また、上記実施例１及び２では、角形非水電解質二次電池の例を示したが、本発明は巻回電極体を備える非水電解質二次電池であれば同様の作用効果を奏するので、円筒状巻回電極体を使用した円筒形非水電解質二次電池の場合においても等しく適用可能である。

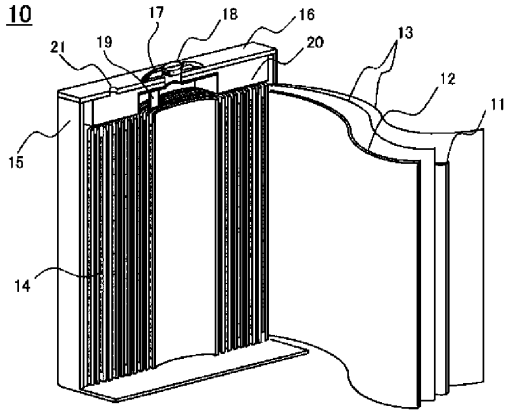
【符号の説明】

【００４４】

１０…非水電解質二次電池　１１…正極極板　１２…負極極板　１２Ａ…実施例１、２及び比較例３の負極極板　１２Ｂ…比較例１、２及び４の負極極板　１３…セパレータ　１４…巻回電極体　１５…電池外装缶　１６…封口板　１７…絶縁体　１８…負極端子　１９…負極タブ　２０…絶縁スペーサ　２１…電解液注液孔　２２…銅箔からなる集電体　２３…負極活物質層　２４…露出部　２４ａ…外周側露出部　２４ｂ…内周側露出部　２５…片面塗布部　２６…塗布端部　２７…補強層

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【図１】



【図２】

図2A

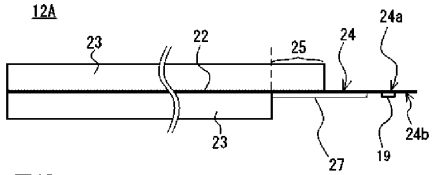


図2B

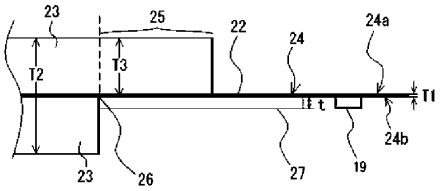
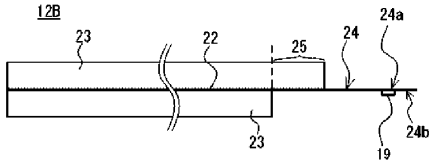


図2C



フロントページの続き

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CJ07 CJ08 CJ22 DJ07 DJ08 EJ03 EJ12 HJ04 HJ12
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EA12 EA23 EA24 EA27 EA28 EA30 FA05 GA09 GA10 GA22
HA04 HA12

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Bibliographic data: JP2012248282 (A) — 2012-12-13

NONAQUEOUS ELECTROLYTE SECONDARY BATTERY

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Classification: **- international:** ***H01M10/0566; H01M10/0587; H01M4/13; H01M4/66***
- cooperative: Y02E60/10 (EP); Y02P70/50 (EP)

Application number: JP20110116467 20110525 Global Dossier

Priority number(s): JP20110116467 20110525

Abstract of JP2012248282 (A)

PROBLEM TO BE SOLVED: To provide a nonaqueous electrolyte secondary battery in which the thickness of copper foil as a negative electrode collector is thin, battery capacity is difficult to fall even if a charge/discharge cycle is repeated, and swelling of a battery is small.SOLUTION: In the nonaqueous electrolyte secondary battery including a wound electrode body obtained by winding a positive electrode plate and a negative electrode plate 12A in which both surfaces of copper foil 22 are coated with a negative electrode active material layer 23 through a separator, and a nonaqueous electrolyte having electrolyte salt in a nonaqueous solvent, a negative electrode collector exposing part 24 with a collector 22 made of copper foil exposed is provided on an outer circumferential side and an inner circumferential side of an end of a winding start side of the negative electrode plate 12A. In the negative electrode collector exposing part 24, an inner circumferential side exposure part 24b is formed longer than an outer circumferential side exposure part 24a, a one-side application part 25 of the negative electrode active material layer 23 is formed on the outer circumferential side exposure side 24a, and a reinforcement layer 27 is formed on the inner circumferential side exposure part 24b over a region from a position in contact with an application end 26 of the inner electrode active material layer 23 of an inner circumferential side beyond the outer circumferential one-side application part 25.

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DESCRIPTION JP2012248282A

10 Non-aqueous electrolyte secondary battery

[0001]

14 The present invention relates to a nonaqueous electrolyte secondary battery, and more particularly to a nonaqueous electrolyte secondary battery in which the thickness of a copper foil as a negative electrode current collector is thin, the battery capacity is not easily reduced even with repeated charge/discharge cycles, and swelling of the battery is small.

[0002]

21 2. Description of the Related Art Nowadays, nonaqueous electrolyte secondary batteries, typified by lithium ion secondary batteries, which have high energy density and high capacity, are widely used as driving power sources for portable electronic devices such as mobile phones, portable personal computers, and portable music players, and further as power sources for hybrid electric vehicles (HEVs) and electric vehicles (EVs). These nonaqueous electrolyte secondary batteries are produced by sandwiching a separator between a positive electrode plate and a negative electrode plate and winding them to produce a wound electrode body, and in the case of a rectangular nonaqueous electrolyte secondary battery, further compressing the wound electrode body to produce a flattened wound electrode body, which is then inserted into a battery exterior body.

[0003]

34 In recent years, as the capacity of batteries has increased, positive electrode active materials and negative electrode active materials have been packed at higher densities, leading to an increase in the mass of batteries.

37 Therefore, in order to reduce the weight of batteries, weight reductions in various battery

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constituent materials are being pursued, and there is a demand to make the copper foil used as the negative electrode current collector, which has the largest specific gravity among the materials, thinner. In other words, by reducing the thickness of the copper foil used as the negative electrode current collector, the amount of positive electrode active material and the amount of negative electrode active material that can be packed into a battery exterior body of the same volume can be increased accordingly, thereby achieving an increase in battery capacity.

[0004]

49 However, when the copper foil used as the negative electrode current collector is made thinner, the strength of the copper foil decreases accordingly, and the negative electrode plate is more likely to be distorted due to the expansion and contraction of the negative electrode active material during charging and discharging. This leads to problems such as reduced cycle characteristics and increased swelling of the battery.

54 Such distortion of the negative electrode plate is particularly likely to occur in a portion where the negative electrode active material is applied to only one side. Furthermore, if this portion in which the negative electrode active material is applied to only one side is formed at the beginning of winding of the wound electrode body, it will affect the entire wound electrode body that is sealed within the battery outer casing, causing a significant decrease in battery capacity and significant battery swelling when charge-discharge cycles are repeated.

[0005]

63 On the other hand, the following Patent Document 1 shows an example in which the surfaces of the positive and negative electrode plates, including the surfaces of the current collectors of each electrode plate that are not coated with the active material, are covered with a porous electronic insulating layer for the purpose of avoiding an internal short circuit in a nonaqueous electrolyte secondary battery and improving safety.

68 Furthermore, the above-mentioned Patent Document 2 discloses an example in which the surfaces of the current collectors of the positive and negative electrode plates, on which no active material is applied, are coated with a porous active layer containing inorganic particles and a binder polymer, for the purposes of suppressing the occurrence of internal short-circuits due to internal short-circuit vulnerable parts of a nonaqueous electrolyte secondary battery and achieving an increase in battery capacity compared to the conventional example in which tape is applied to the internal short-circuit vulnerable parts. Furthermore, the above-mentioned Patent Document 3 discloses an example in which, in a nonaqueous electrolyte secondary battery, the entire surface of the negative electrode current collector to which the negative electrode mixture is not applied is covered with an insulating material such as a resin, for the purpose of suppressing dissolution of the copper foil serving as the negative electrode current collector to which the negative electrode mixture is not applied due to an increase in the negative electrode potential during overdischarge, and making it difficult for the battery

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capacity to decrease even when charge/discharge cycles are repeated.

[0006]

98 国際公開ＷＯ２００５／０６７０８０号公報

99 特表２００９－５１８８０８号公報

100 特開２００４－１４６２２２号公報

[0007]

104 The nonaqueous electrolyte secondary batteries disclosed in the above-mentioned Patent Documents 1 and 2 have the effect of suppressing the occurrence of internal short circuits and improving the safety of the battery.

107 In addition, according to the nonaqueous electrolyte secondary battery disclosed in Patent Document 3, dissolution of the copper foil serving as the negative electrode current collector is suppressed, so that the battery capacity is unlikely to decrease even if the charge/discharge cycle is repeated.

[0008]

114 However, in the inventions described in the above Patent Documents 1 to 3, at least the entire surface of the negative electrode current collector on which the negative electrode mixture is not applied is covered with an insulating material such as a porous insulating layer or resin. Therefore, even if the thickness of the copper foil used as the negative electrode current collector is reduced, the strength of the copper foil is increased by the insulating material such as a porous insulating layer or resin. As a result, the electrode body is unlikely to be distorted due to the expansion and contraction of the negative electrode active material during charging and discharging as described above. However, the volume occupied by the insulating material such as a porous insulating layer or resin within the battery exterior increases, which causes a problem of a corresponding decrease in battery capacity.

[0009]

127 Therefore, the inventors conducted various studies on a configuration that can prevent distortion of the negative electrode plate due to expansion and contraction of the negative electrode active material during charging and discharging and increase the battery capacity even if the thickness of the copper foil used as the negative electrode current collector is reduced, and as a result, they found that this can be achieved by reconsidering the formation area of a reinforcing layer made of an insulator on the surface of the negative electrode current collector on which the negative electrode mixture is not applied, and thus completed the present invention.

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[0010]

139 That is, an object of the present invention is to provide a nonaqueous electrolyte secondary battery in which the thickness of the copper foil as the negative electrode current collector is thin, the battery capacity is not easily reduced even with repeated charge/discharge cycles, and swelling of the battery is small.

[0011]

146 In order to achieve the above object, the nonaqueous electrolyte secondary battery of the present invention comprises a wound electrode body in which a positive electrode plate having a positive electrode active material layer applied to both sides of a metal foil and a negative electrode plate having a negative electrode active material layer applied to both sides of a copper foil are wound with a separator interposed therebetween, and a nonaqueous electrolyte containing an electrolyte salt in a nonaqueous solvent, wherein a negative electrode current collector exposed portion in which the copper foil is exposed is provided on the outer circumferential side and the inner circumferential side of an end portion on a winding start side of the negative electrode plate, the negative electrode current collector exposed portion is formed longer on the inner circumferential side than on the outer circumferential side of the copper foil, and a one-sided coated portion of the negative electrode active material layer is formed on the outer circumferential side, and a reinforcing layer is formed on the negative electrode current collector exposed portion on the inner circumferential side over a region from a position contacting the coated end of the negative electrode active material layer on the inner circumferential side and beyond the one-sided coated portion of the negative electrode active material layer on the outer circumferential side.

[0012]

166 In the nonaqueous electrolyte secondary battery of the present invention, the reinforcing layer is formed over a region extending from a position in contact with the coated end of the negative electrode active material layer on the inner periphery of the copper foil to beyond the one-sided coated portion of the negative electrode active material layer on the outer periphery. This makes it possible to increase the strength of the inner periphery of the end portion at the start of winding the copper foil. Therefore, even if the thickness of the copper foil used as the negative electrode current collector is made thinner than that of the conventional example, distortion is less likely to occur in the negative electrode plate when charge-discharge cycles are repeated, and swelling of the battery is reduced.

175 In addition, since the thickness of the negative electrode plate itself can be made thinner, the number of windings within the same volume can be increased when forming a wound electrode body, thereby increasing the capacity of the battery.

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[0013]

182 The reinforcing layer is preferably made of a mixture of a polyolefin resin and an inorganic filler.

[0014]

187 Polyolefin resins such as polyethylene and polypropylene are difficult to swell with non-aqueous solvents, and the strength of the polyolefin resins is increased by the addition of inorganic fillers.

190 Therefore, the nonaqueous electrolyte secondary battery of the present invention provides a reinforcing layer that is resistant to swelling in the nonaqueous electrolyte and has high strength.

193 As the inorganic filler, titanium oxide (TiO₂), aluminum oxide (Al₂O₃), silicon oxide (SiO₂), zirconium oxide (ZrO₂), etc. can be used. However, taking into consideration the stability within the battery, reactivity with lithium, and cost, aluminum oxide and rutile-type titanium oxide are particularly preferred.

[0015]

201 The reinforcing layer preferably has a thickness of 1 μ m or more and 30 μ m or less.

[0016]

205 In the nonaqueous electrolyte secondary battery of the present invention, the reinforcing layer is formed to have a thickness of 1 μ m or more and 30 μ m or less, whereby the strength of the exposed portion of the negative electrode current collector can be increased.

208 If the thickness of the reinforcing layer is less than 1 μ m, the reinforcing effect is weakened.

209 By making the thickness of the reinforcing layer thinner than the thickness of the composite layer, it is possible to prevent the thickness of the electrode body from becoming unnecessarily thick. On the other hand, if the thickness of the reinforcing layer is thicker than 30 μ m, the copper foil can be reinforced, but the exposed part of the copper foil will be thick, making it difficult to form the start of winding of the wound electrode body.

214 The thickness of the reinforcing layer is more preferably 1 μ m or more and 10 μ m or less.

[0017]

218 The copper foil preferably has a thickness of 5 μ m or more and 7 μ m or less.

[0018]

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222 According to the nonaqueous electrolyte secondary battery of the present invention, even if the thickness of the copper foil is formed to be 5 μ m or more and not more than 7 μ m, the strength of the end portion on the winding start side of the copper foil can be increased by applying a reinforcing layer, so that the negative electrode plate itself can be made thinner, and by increasing the number of windings, the capacity of the battery can be further increased and swelling of the battery can be reduced.

222 If the thickness of the copper foil exceeds 7 μ m, no difference from the conventional example is recognized. If the thickness of the copper foil is less than 5 μ m, the strength of the negative electrode current collector is insufficient, which increases the distortion of the negative electrode plate and causes the battery to swell significantly, which is not preferable.

232 The thickness of the copper foil is more preferably 6 μ m or more and 7 μ m or less.

[0019]

236 FIG. 2 is a perspective view showing a prismatic nonaqueous electrolyte secondary battery used in measuring various battery characteristics in each of the Examples and Comparative Examples, cut in the longitudinal direction.

239 2A is a schematic side view of a negative electrode plate common to Examples 1 and 2 and Comparative Example 3, FIG. 2B is a partially enlarged view of FIG. 2A, and FIG. 2C is a schematic side view of a negative electrode plate common to Comparative Examples 1, 2 and 4.

[0020]

246 Hereinafter, the embodiment of the present invention will be described in detail with reference to various examples and comparative examples.

248 However, each of the embodiments described below illustrates a prismatic nonaqueous electrolyte secondary battery as an example for embodying the technical concept of the present invention, and is not intended to limit the present invention to these embodiments. The present invention may be equally applied to cylindrical nonaqueous electrolyte secondary batteries and other batteries that have been modified in various ways without departing from the technical concept set forth in the claims.

[0021]

257 "Configuration of Prismatic Nonaqueous Electrolyte Secondary Battery" First, the configuration of a prismatic nonaqueous electrolyte secondary battery 10 common to Examples 1 and 2 and Comparative Examples 1 to 4 will be described with reference to FIG.

260 This rectangular nonaqueous electrolyte secondary battery 10 is configured such that a flat wound electrode body 14, in which a positive electrode plate 11 and a negative electrode plate 12 are wound with a separator 13 interposed therebetween, is housed inside a rectangular battery outer can 15, and the battery outer can 15 is sealed with a sealing plate

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16.

268 The wound electrode body 14 is wound so that the positive electrode plate 11 is located at the outermost periphery and exposed, and the exposed outermost positive electrode plate 11 is in direct contact with and electrically connected to the inner surface of the battery outer can 15, which also serves as the positive electrode terminal.

273 The negative electrode plate 12 is formed in the center of the sealing plate 16 and is electrically connected via a negative electrode tab 19 to a negative electrode terminal 18 attached via an insulator 17 .

[0022]

279 Since the battery outer can 15 is electrically connected to the positive electrode plate 11, in order to prevent a short circuit between the negative electrode plate 12 and the battery outer can 15, an insulating spacer 20 is inserted between the upper end of the wound electrode body 14 and the sealing plate 16, thereby electrically insulating the negative electrode plate 12 and the battery outer can 15.

284 This prismatic nonaqueous electrolyte secondary battery 10 is produced by inserting the wound electrode body 14 into a battery outer can 15, laser welding the sealing plate 16 to the opening of the battery outer can 15, and then injecting nonaqueous electrolyte through an electrolyte injection hole 21 and sealing the electrolyte injection hole 21.

[0023]

291 [Preparation of Positive Electrode Plate] The positive electrode plate was prepared as follows.

292 95 parts by mass of lithium cobalt oxide (LiCoO₂) as a positive electrode active material and 5 parts by mass of carbon as a conductive agent were mixed.

294 95% by mass of this mixture and 5% by mass of polyvinylidene fluoride (PVDF) as a binder were dispersed in N-methyl-2-pyrrolidone (NMP) to prepare a positive electrode active material slurry.

297 Next, this positive electrode active material slurry was applied in a uniform thickness onto both sides of a positive electrode core made of aluminum foil having a thickness of 15 μ m.

299 The electrode plate was passed through a dryer to remove the NMP required for preparing the slurry.

301 Thereafter, the mixture was compressed using a roll press to prepare a positive electrode plate common to Examples 1 and 2 and Comparative Examples 1 to 4.

[0024]

306 [Preparation of Negative Electrode] The negative electrode plate 12 was prepared as follows.

307 A slurry was prepared by dispersing 95% by mass of graphite powder, 3% by mass of carboxymethyl cellulose (CMC) as a thickener, and 2% by mass of styrene-butadiene rubber (SBR) as a binder in water.

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310 This slurry was applied to both sides of a copper foil current collector by a doctor blade method and dried to form negative electrode active material layers on both sides of the copper foil current collector.

310 Thereafter, a compression roller was used to compress the mixture at a constant pressure to produce a negative electrode plate of a predetermined thickness.

[0025]

318 In addition, in all of Examples 1 and 2 and Comparative Examples 1 to 4, the position at which the negative electrode slurry was applied was such that a negative electrode current collector exposed portion was formed on the outer and inner sides of the end portion at the start of winding of the copper foil current collector, and this negative electrode current collector exposed portion was formed so that the length was longer on the inner side than on the outer side, and a one-sided application portion was formed on the outer side in which a negative electrode active material layer was formed on only one side.

325 Furthermore, in the negative electrode plates of Examples 1 and 2 and Comparative Example 3, a slurry was applied to the inner periphery of a current collector made of copper foil from a position contacting the coated end of the negative electrode active material layer to a region beyond the one-sided coated portion of the negative electrode active material layer on the outer periphery, by adding an inorganic filler made of titanium oxide and polypropylene to NMP as a solvent, and the NMP was dried and removed to form a reinforcing layer of a predetermined thickness, thereby forming a negative electrode plate.

332 The specific configuration and thickness of each of these negative electrodes will be described later.

[0026]

337 In each of the Examples and Comparative Examples, the coating amounts of the positive and negative electrode plates were adjusted so that the charge capacity ratio (negative electrode charge capacity/positive electrode charge capacity) at the opposing portions of the positive and negative electrode plates was 1.1 at a design standard cell charge voltage of 4.2 V (positive electrode charge potential: 4.3 V based on lithium).

[0027]

345 The specific configuration of the negative electrode plate thus fabricated in each of the Examples and Comparative Examples will be described with reference to FIG.

347 2A is a schematic side view of a negative electrode plate common to Examples 1 and 2 and Comparative Example 3, FIG. 2B is a partially enlarged view of FIG. 2A, and FIG. 2C is a schematic side view of a negative electrode plate common to Comparative Examples 1, 2, and 4.

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[0028]

355 The negative electrode plate 12A common to Examples 1 and 2 and Comparative Example 3 uses a current collector 22 made of copper foil having a thickness T1, as shown in Figs. 2A and 2B, and a negative electrode active material layer 23 is formed to a predetermined thickness on both sides of the current collector 22 made of copper foil.

359 A negative electrode current collector exposed portion 24 consisting of an outer circumferential side exposed portion 24a and an inner circumferential side exposed portion 24b is formed at the end portion on the winding start side of the current collector 22 made of copper foil, and this negative electrode current collector exposed portion 24 is formed such that the inner circumferential side exposed portion 24b is longer in length than the outer circumferential side exposed portion 24a, and a one-sided coating portion 25 in which a negative electrode active material layer 23 is formed on only one side on the outer circumferential side is formed.

367 Furthermore, the negative electrode current collector exposed portion 24 has a negative electrode tab 19 welded to an end portion of the inner periphery exposed portion 24b.

[0029]

372 A reinforcing layer 27 is formed on the inner peripheral exposed portion 24b of the negative electrode current collector exposed portion 24, extending from the coated end portion 26 of the negative electrode active material layer 23, beyond the area of the one-sided coated portion 25 of the outer peripheral exposed portion 24a, to a position close to the negative electrode tab 19.

377 Here, the thickness including the current collector 22 made of copper foil of the double-sided coated portion in which the negative electrode active material layer 23 is formed on both sides is defined as T2, and the thickness including the current collector 22 made of copper foil of the single-sided coated portion 25 in which the negative electrode active material layer 23 is formed on only one side is defined as T3. In addition, the thickness t of the reinforcing layer 27 was set to 2 μ m in common to Examples 1 and 2 and Comparative Example 3.

[0030]

387 In addition, the specific dimensions in Examples 1 and 2 and Comparative Example 3 were as follows: in Example 1, T1 = 7 μ m, T2 = 140 μ m, T3 = 74 μ m; in Example 2, T1 = 6 μ m, T2 = 139 μ m, T3 = 73 μ m; and in Comparative Example 3, T1 = 8 μ m, T2 = 141 μ m, T3 = 75 μ m.

[0031]

394 Furthermore, the negative electrode plate 12B of Comparative Examples 1, 2, and 4 has the

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same configuration as the negative electrode plate 12A common to Examples 1, 2, and Comparative Example 3, except that no reinforcing layer is formed, as shown in FIG. 2C.

396 The specific dimensions in Comparative Examples 1, 2, and 4 were as follows: T1 = 7 μ m, T2 = 140 μ m, T3 = 74 μ m in Comparative Example 1; T1 = 8 μ m, T2 = 141 μ m, T3 = 75 μ m in Comparative Example 2; and T1 = 6 μ m, T2 = 139 μ m, T3 = 73 μ m in Comparative Example 4.

402 The specific dimensions of the negative electrode plates 12A and 12B of Examples 1 and 2 and Comparative Examples 1 to 4 are summarized in Table 1 below.

[0032]

407 [Preparation of separator] The polyethylene mixture, inorganic fine powder, and plasticizer were kneaded and heated to melt them into a sheet, and then the inorganic fine powder and plasticizer were extracted and removed, respectively, and the sheet was dried. The sheet was stretched to have a predetermined air permeability, film thickness, and pore size, and then laminated to prepare a microporous membrane separator commonly used in Examples 1 and 2 and Comparative Examples 1 to 4.

[0033]

416 [Preparation of Electrode Body] The positive and negative electrode plates prepared as described above were wound by a winding machine while being insulated from each other via a separator, and an insulating stop tape was attached and pressed to complete a flat wound electrode body.

[0034]

423 [Preparation of non-aqueous electrolyte] A non-aqueous solvent was prepared by mixing ethylene carbonate (EC), ethyl methyl carbonate (MEC), and diethyl carbonate (DEC) in a volume ratio of 20:50:30 (calculated at 1 atmospheric pressure and 25° C.), and LiPF₆ was dissolved as an electrolyte salt in a ratio of 0.9 mol/L to prepare a non-aqueous electrolyte.

[0035]

431 [Fabrication of Battery] The flat wound electrode body and nonaqueous electrolyte prepared as described above were inserted into a rectangular aluminum outer can, and a sealing plate was fitted into the opening of the outer can and laser welded to fabricate lithium ion secondary batteries as rectangular nonaqueous electrolyte secondary batteries of Examples 1 and 2 and Comparative Examples 1 to 4 having a height of 43 mm, a width of 34 mm, and a thickness of 4.3 mm.

437 The resulting battery has a design capacity of 750 mAh.

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[0036]

441 [Measurement of Battery Characteristics] For each of the batteries of Examples 1 and 2 and Comparative Examples 1 to 4 fabricated as described above, three batteries each were subjected to measurement of cycle characteristics and battery swelling amount under the conditions shown below.

[0037]

448 [Cycle characteristics] The battery was charged at 25° C. at a constant current of 1 It = 750 mA until the battery voltage reached 4.20 V. After the battery voltage reached 4.2 V, the battery was charged at a constant voltage of 4.20 V until the charging current reached (1/50) It = 15 mA to reach a fully charged state, and then discharged at a constant current of 750 mA at 25° C. until the voltage reached 2.75 V.

453 The discharge capacity at this time was determined as the first cycle discharge capacity.

454 Then, 300 cycles of charge and discharge were performed under these conditions, the discharge capacity at the 300th cycle was determined as the "300th cycle discharge capacity", and the capacity retention rate as the cycle characteristic was calculated based on the following formula.

458 Capacity retention rate (%)=(300th cycle discharge capacity/1st cycle discharge capacity)× 100 The capacity retention rate (%) thus determined was expressed as a relative value with the value of Comparative Example 1 taken as 100, that is, as a " relative capacity retention rate" .

462 The results are summarized in Table 1.

[0038]

466 The amount of swelling of the battery was calculated according to the following formula.

467 Swelling amount (%)=(battery thickness after 300 cycles/initial battery thickness)× 100 The calculated swell amount (%) was expressed as a relative value with the value of Comparative Example 1 taken as 100, that is, as a "relative swell rate."

470 The results are summarized in Table 1.

[0040]

474 The results shown in Table 1 reveal the following:

475 That is, from the results of Example 1 and Comparative Example 1 in which the copper foil thickness T1 = 7 μ m, the battery of Example 1 in which a reinforcing material is present has a higher relative capacity maintenance rate and a smaller relative swelling rate than the battery of Comparative Example 1 in which a reinforcing material is not present, and thus a better result is obtained.

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480 This tendency is also observed in the case of the battery of Example 2 in which the copper foil thickness T1 is 6 μm and a reinforcing material is formed, and in the case of Comparative Example 1 in which no reinforcing material is formed.

480 These are due to the fact that in the batteries of Comparative Examples 1 and 4, the thickness of the copper foil was thin, and therefore the strength of the one-sided coated portion was insufficient, causing distortion of the negative electrode plate due to the expansion and contraction of the negative electrode active material during charge-discharge cycles.It is considered that in Examples 1 and 2, the strength insufficiency of the one-sided coated portion was compensated for by the reinforcing material, which is why they showed good charge-discharge cycle characteristics expressed as relative capacity retention rate and relative swelling rate.

[0041]

494 However, in the case of the battery of Comparative Example 3 in which the copper foil thickness T1 was 8 μm and a reinforcing material was formed, and the battery of Comparative Example 2 in which a reinforcing material was not formed, there was no difference in either the relative capacity retention rate or the relative swelling rate.

498 This means that when the copper foil thickness T1 was 8 μm, the strength of the copper foil was sufficient, so that there was no difference whether or not a reinforcing material was used.

501 Therefore, it is evident that the formation of the reinforcing material as in the present invention has a technical significance when the thickness T1 of the copper foil is 7 μm or less.

504 Incidentally, if the thickness of the copper foil is less than 5 μm, the strength of the copper foil becomes too weak, and it is likely to break during the formation of the wound electrode body, which is undesirable.

507 Therefore, in the present invention, the thickness of the copper foil is preferably 5 μm or more and 7 μm or less, and more preferably 6 μm or more and 7 μm or less.

[0042]

512 In addition, in the above Examples 1 and 2, the reinforcing layer has a thickness of 2 μm. Since the reinforcing layer is formed to supplement the strength of the one-sided coating portion, even if it is thin, it can achieve a certain degree of effect in improving the reinforcing strength. However, if the reinforcing layer is too thick, although the copper foil can be reinforced, the exposed portion of the copper foil will be thick, making it difficult to form the start of winding of the wound electrode body.

518 Therefore, the thickness of the reinforcing layer in the present invention is thinner than the thickness of the mixture layer, and is preferably 1 μm or more and 30 μm or less, and more preferably 1 μm or more and 10 μm or less.

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[0043]

525 In addition, although the above-mentioned Examples 1 and 2 show examples of a rectangular nonaqueous electrolyte secondary battery, the present invention can achieve the same effects as long as the battery is a nonaqueous electrolyte secondary battery including a wound electrode body, and is therefore equally applicable to a cylindrical nonaqueous electrolyte secondary battery using a cylindrical wound electrode body.

[0044]

533 DESCRIPTION OF SYMBOLS 10...Non-aqueous electrolyte secondary battery 11...Positive electrode plate 12...Negative electrode plate 12A...Negative electrode plate of Examples 1 and 2 and Comparative Example 3 12B...Negative electrode plate of Comparative Examples 1, 2 and 4 13...Separator 14...Wound electrode body 15...Battery outer can 16...Sealing plate 17...Insulator 18...Negative electrode terminal 19...Negative electrode tab 20...Insulating spacer 21...Electrolyte injection hole 22...Current collector made of copper foil 23...Negative electrode active material layer 24...Exposed portion 24a...Outer peripheral exposed portion 24b...Inner peripheral exposed portion 25...Single-sided coated portion 26...Coated end portion 27...Reinforcing layer

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CLAIMS JP2012248282A

1.

13 a nonaqueous electrolyte secondary battery comprising: a wound electrode body in which a positive electrode plate having a positive electrode active material layer applied to both sides of a metal foil and a negative electrode plate having a negative electrode active material layer applied to both sides of a copper foil are wound with a separator interposed therebetween; and a nonaqueous electrolyte containing an electrolyte salt in a nonaqueous solvent; wherein a negative electrode current collector exposed portion in which the copper foil is exposed is provided on the outer circumferential side and the inner circumferential side of an end portion on a winding start side of the negative electrode plate, the negative electrode current collector exposed portion is formed longer on the inner circumferential side than on the outer circumferential side of the copper foil, and a one-sided coated portion of the negative electrode active material layer is formed on the outer circumferential side, and a reinforcing layer is formed on the negative electrode current collector exposed portion on the inner circumferential side over a region from a position contacting the coated end of the negative electrode active material layer on the inner circumferential side and extending beyond the one-sided coated portion of the negative electrode active material layer on the outer circumferential side.

2.

32 The nonaqueous electrolyte secondary battery according to claim 1, wherein the reinforcing layer is made of a mixture of a polyolefin resin and an inorganic filler.

3.

37 2. The nonaqueous electrolyte secondary battery according to claim 1, wherein the reinforcing

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layer has a thickness of 1 μm or more and 30 μm or less.

4.

43 2. The nonaqueous electrolyte secondary battery according to claim 1, wherein the copper foil has a thickness of 5 to 7 μm.

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Status

1)☑ Responsive to communication(s) filed on 29 March 2022.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL.** 2b) ☑ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5) ☑ Claim(s) 1-11 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 1-11 is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☑ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☑ All b)☐ Some** c)☐ None of the:

1.☑ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☑ Notice of References Cited (PTO-892)

2) ☑ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.

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Notice of Pre-AIA or AIA Status

1. The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

Claim Interpretation

In Claims 1 and 10, "compacted density" is interpreted in accordance with the instant specification as described in paragraph 0025: the weight of active material per unit area on the current collector divided by the thickness of the active material layer(s) in a direction perpendicular to the surface of the current collector.

In Claim 4, Dv50 is interpreted in accordance with the instant specification as described in paragraph 0068: a particle size when a volume of a sample reaches 50% of a total volume from a small particle size in a volume-based particle size distribution.

Claim Rejections - 35 USC § 102

2. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (a)(1) the claimed invention was patented, described in a printed publication, or in public use, on sale, or otherwise available to the public before the effective filing date of the claimed invention.

3. Claim(s) 1 and 10 is/are rejected under 35 U.S.C. 102(a)(1) as being anticipated by Morimoto et al. (JP 2012248282 A, machine translation provided), hereby referred to as Morimoto.

Regarding Claims 1 and 10, Morimoto teaches a negative electrode (0024) comprising a negative current collector (0024; Figs. 2A-C, part 22). There is a first negative active material layer arranged on one side of a first portion of the current collector (0028; Figs. 2A-C, part 25) and a second negative active material layer, wherein the second negative active material is arranged on two sides of a second portion, different from the first portion, of the negative current collector (0028; Figs. 2A-C, part 23).

The first negative active material layer is made of the same material as the second negative active material layer (0024), meaning that different in the weight per unit area for both active material layers is proportional to the difference in thickness between the first and second layer. An embodiment is provided where the thickness of the first layer and current collector is 74 μm and the thickness of the second layer and current collector is 140 μm (0029, 0030). The thickness of the current collector is 7μm (0030), meaning that the thickness of the first layer is 67 μm and the thickness of the second layer is 133 μm. Thus, the ratio of weight per unit area of the first active material layer to the weight per unit area of the second active material layer would be 67/133, or about 0.503.

As the first active material layer has roughly 0.503 the weight per unit area as the second active material layer but is also 0.503 as thick, the ratio of the compacted density of the first negative active material layer to the compacted density of the second negative active material layer is 1.

Morimoto also teaches a battery (electrochemical apparatus) comprising a positive electrode, separator, and the aforementioned negative electrode (0033, 0035) (**Claim 10**).

Claim Rejections - 35 USC § 103

4. The following is a quotation of 35 U.S.C. 103 which forms the basis for all obviousness rejections set forth in this Office action:

> A patent for a claimed invention may not be obtained, notwithstanding that the claimed invention is not identically disclosed as set forth in section 102, if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains. Patentability shall not be negated by the manner in which the invention was made.

5. Claim(s) 2-3 and 9 is/are rejected under 35 U.S.C. 103 as being unpatentable over Morimoto (JP 2012248282 A) in view of Torita et al. (US 20190148762 A1), hereby referred to as Torita.

Regarding Claim 2, Morimoto teaches the negative electrode according to Claim 1. Morimoto teaches that both active material layers comprise graphite (0024) but does not teach that they also comprise a silicon-based material.

Torita teaches that it is known to use silicon oxide in combination with graphite-based carbon material for a negative electrode active material (0004). This combination provides the benefit of high capacity (0004) while reducing any decrease in cycle capacity retention (0019).

Torita and Morimoto are considered analogous to the claimed invention as both relate to the same field of endeavor, namely negative electrodes for lithium batteries.

Therefore, it would have been obvious to one of ordinary skill before the effective filing date of the invention to have modified the active material (graphite) of Morimoto to include

silicon oxide as taught by Torita in order to provide high capacity while reducing any decrease in cycle capacity retention.

Regarding Claim 3, modified Morimoto teaches the negative electrode according to Claim 2. Torita teaches that the silicon oxide can be included in an amount of 2 mass% to 10 mass% based on the total mass of the graphite-based carbon material and silicon oxide (0024). Within this range, an excellent balance can be obtained between initial capacity and cycle capacity retention (0025). This range would overlap the claimed range of greater than or equal to 5% and less than 100%.

It would have been obvious to one of ordinary skill in the art before the effective filing date of the claimed invention to have added the silicon oxide of modified Morimoto in an amount of 2 mass% to 10 mass% based on the total mass of the graphite-based carbon material and silicon oxide as taught by Torita in order to provide an excellent balance can be obtained between initial capacity and cycle capacity retention.

Furthermore, it would have obvious to one of ordinary skill in the art before the effective filing date of the claimed invention to have routinely selected the overlapping portions of the disclosed ranges because selection of overlapping portions of ranges has been held to be a prima facie case of obviousness (see MPEP 2144.05 (I)).

Regarding Claim 9, modified Morimoto teaches the negative electrode of Claims 1 and 2. Morimoto does not teach that a thickness of the first negative active material layer is 40 μm

to 60 μm, or that a single-layer thickness of the second negative active material layer is 40 μm to 60 μm.

Torita teaches that a negative active material layer comprising silicon oxide and graphite can have a thickness between 50 μm and 250 μm (0054). This range would overlap the claimed range of 40 μm to 60 μm.

It would have been obvious to one of ordinary skill in the art before the effective filing date of the claimed invention to have modified the thickness of the first active material layer and single-layer thickness of the second negative active material layer of Morimoto with the thickness taught by Torita as it is a known thickness for an active material comprising silicon oxide and graphite.

Furthermore, it would have obvious to one of ordinary skill in the art before the effective filing date of the claimed invention to have routinely selected the overlapping portions of the disclosed ranges because selection of overlapping portions of ranges has been held to be a prima facie case of obviousness (see MPEP 2144.05 (I)).

6. Claim(s) 4 is/are rejected under 35 U.S.C. 103 as being unpatentable over Morimoto (JP 2012248282 A) and Torita (US 20190148762 A1) as applied to claim 2 above, and further in view of Kim et al. (US 20180316001 A1), hereby referred to as Kim.

Regarding Claim 4, modified Morimoto teaches the negative electrode according to Claim 2. Torita teaches that silicon oxide can have a volume-based D50 (0060), which is the

same as a Dv50, between 1 µm and 20 µm in order to improve the filing factor of the active material layer (0065). This range would overlap the claimed range of 8 µm to 20 µm.

It would have been obvious to one of ordinary skill in the art before the effective filing date of the claimed invention to have modified the volume-based D50 of the silicon oxide of modified Morimoto to be between 1 µm and 20 µm as taught by Torita in order to improve the filing factor of the active material layers.

Furthermore, it would have obvious to one of ordinary skill in the art before the effective filing date of the claimed invention to have routinely selected the overlapping portions of the disclosed ranges because selection of overlapping portions of ranges has been held to be a prima facie case of obviousness (see MPEP 2144.05 (I)).

Modified Morimoto does not disclose the form of the silicon-based material (silicon oxide).

Kim teaches that silicon oxide used as a negative electrode active material can have a crystalline form (0033) or an amorphous form (0051).

Kim is considered analogous to the claimed invention as it relates to the same field of endeavor, namely silicon-based active materials for lithium batteries.

Therefore, it would have been obvious to one of ordinary skill in the art before the effective filing date of the claimed invention to have modified the silicon oxide of modified Morimoto to have a crystalline form or an amorphous form as those are known forms for a silicon oxide active material.

7. Claim(s) 5 and 6 is/are rejected under 35 U.S.C. 103 as being unpatentable over Morimoto (JP 2012248282 A) and Torita (US 20190148762 A1) as applied to claim 2 above, and further in view of Kamizori et al. (US 20140227562 A1), hereby referred to as Kamizori.

Regarding Claims 5 and 6, modified Morimoto teaches the negative electrode of Claim 2. Torita teaches that silicon oxide can have a coating of an element such as carbon on the surface but does not provide any motivation to do so (0062).

Kamizori teaches that a carbon coating layer can be applied to the surface of a silicon oxide active material to improve the load characteristics when used in a battery (0050).

Kamizori is considered analogous to the claimed invention because it relates to the same field of endeavor, namely silicon oxide-based materials for negative electrodes.

Therefore, it would have been obvious to one of ordinary skill in the art before the effective filing date of the invention to have modified the silicon oxide of modified Morimoto by applying a carbon coating layer as taught by Torita and Kamizori in order to increase conductivity and/or to provide structural support (**Claim 6**).

Furthermore, Kamizori teaches that a SiO/C composite, such as silicon oxide coated with carbon (0050), would have peaks in the Raman spectrum at 510 cm^{-1} and 1343 cm^{-1} (0129).

Thus, the carbon coated silicon oxide active material of modified Morimoto would have a ratio of a peak height at a wavenumber of 500 +/- 10 cm^{-1} to a peak height at a wavenumber of 1350 +/- 10 cm^{-1} in a Raman spectrum that is greater than 0 (**Claim 5**).

8. Claim(s) 7 and 8 is/are rejected under 35 U.S.C. 103 as being unpatentable over Morimoto (JP 2012248282 A) and Torita (US 20190148762 A1) as applied to claim 2 above, and further in view of Kondo et al., (US 20170033355 A1), hereby referred to as Kondo.

Regarding Claim 7, modified Morimoto teaches that the negative electrode according to Claim 2. Morimoto teaches that the first and second negative active material layers comprise styrene-butadiene as a binder (0024). Similarly, Torita teaches that styrene-butadiene rubber is a suitable binder for a silicon oxide/graphite active material (0069).

Torita teaches that a negative electrode active material layer can contain a conductive material such as carbon black or acetylene black (0068). Conductive materials/additives such as carbon black or acetylene black increase conductivity of an electrode (Kondo, 0076).

Kondo is considered analogous to the claimed invention because it relates to the same field of endeavor, namely negative electrodes for lithium batteries.

Therefore, it would have been obvious to one of ordinary skill in the art before the effective filing date of the invention to have modified the negative electrode active material layer of modified Morimoto to include a conductive material as taught by Torita in order to increase the conductivity of an electrode.

Regarding Claim 8, modified Morimoto teaches the negative electrode according to Claim 7. Torita teaches that a binder, such as styrene-butadiene rubber, can be added in amount of 1 to 10 parts by mass relative to 100 parts by mass of the silicon oxide/graphite active material (0068, 0069). Torita also teaches that a conductive material can be added in an

amount of 1 to 10 parts by mass relative to 100 parts by mass of the silicon oxide/graphite active material. These ranges would lead to first and second active material layers comprising active materials, binders, and conductive materials within the claimed ranges of 94% to 96% by weight, 2.8% to 4.0% by weight, and 0.4% to 1.6% by weight of the total weight of the negative active material layer, respectively.

It would have been obvious to one of ordinary skill in the art before the effective filing date of the claimed invention to have modified the active material layers of modified Morimoto with the compositions taught by Torita as they are known compositions for active material layers comprising a silicon oxide/graphite active material.

Furthermore, it would have obvious to one of ordinary skill in the art before the effective filing date of the claimed invention to have routinely selected the overlapping portions of the disclosed ranges because selection of overlapping portions of ranges has been held to be a prima facie case of obviousness (see MPEP 2144.05 (I)).

9. Claim(s) 11 is/are rejected under 35 U.S.C. 103 as being unpatentable over Morimoto (JP 2012248282 A).

Regarding Claim 11, Morimoto teaches the electrochemical apparatus (battery) of Claim 10. Morimoto also teaches that electrochemical apparatuses (batteries) can be used in electronic devices (electronic apparatuses) but does not provide any embodiment where the electrochemical apparatus of Claim 10 is used in that manner.

It would have been obvious to one of ordinary skill in the art before the effective filing date of the claimed invention to have used the electrochemical apparatus (battery) of Morimoto in an electronic apparatus as it is a known use of electrochemical apparatuses.

Conclusion

10. Any inquiry concerning this communication or earlier communications from the examiner should be directed to ZIHENG LU whose telephone number is (703)756-1077. The examiner can normally be reached Monday-Friday 8:30 - 5 ET.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Jonathan Leong can be reached on (571) 270-1292. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of published or unpublished applications may be obtained from Patent Center. Unpublished application information in Patent Center is available to registered users. To file and manage patent submissions in Patent Center, visit: https://patentcenter.uspto.gov. Visit https://www.uspto.gov/patents/apply/patent-center for more information about Patent Center and https://www.uspto.gov/patents/docx for information about filing in DOCX format. For additional questions, contact the Electronic

Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO

Customer Service Representative, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/ZIHENG LU/
Examiner, Art Unit 1752

/Maria Laios/
Primary Examiner, Art Unit 1727

PTO/SB/06 (09-11)
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 17/707,129	Filing Date 03/29/2022	☐ To be Mailed

ENTITY: ☑ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

	(Column 1)	(Column 2)			
FOR	NUMBER FILED	NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $100 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $480 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	12/05/2024	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 12	Minus	** 20	= 0		x $100 =	0
	Independent (37 CFR 1.16(h))	* 2	Minus	*** 3	= 0		x $480 =	0
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	0

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	LIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/KIM R WATSON/
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".	
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.	

This collection of information is required by 37 CFR 1.16. 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 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.

IN THE UNITED STATES PATENT & TRADEMARK OFFICE

In re Patent Application of: NINGDE AMPEREX TECHNOLOGY LIMITED U.S. Patent Application No.: 17/707,129 Filed: March 29, 2022 Title: NEGATIVE ELECTRODE AND ELECTROCHEMICAL APPARATUS CONTAINING SAME, AND ELECTRONIC APPARATUS	Confirmation No.: 6210 Art Unit: 1752 Examiner: ZIHENG NMN LU Attorney Docket No.: 14850059US

AMENDMENT AND RESPONSE

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

December 5, 2024

Dear Commissioner:

In response to the Office Action mailed September 6, 2024, Applicant respectfully requests reconsideration of the Application in view of the following Amendments and Remarks

Amendments to the Claims begin on page 2.

Remarks follow the above-mentioned amendments.

AMENDMENTS TO THE CLAIMS/CLAIM LIST

Please **CANCEL** claim 9 without prejudice or disclaimer.

Please **AMEND** claims 1 and 10 as shown below.

Please **ADD** claims 12 and 13 as shown below.

The following list of claims replaces any prior listing of claims:

1. (Currently Amended) A negative electrode, comprising:

a negative current collector;

a first negative active material layer, wherein the first negative active material layer is arranged on one side of a first portion of the negative current collector; and

a second negative active material layer, wherein the second negative active material layer is arranged on two sides of a second portion of the negative current collector, wherein the second portion of the negative current collector is different from the first portion[[,]] of the negative current collector;

wherein a ratio of a weight per unit area of the first negative active material layer to a weight per unit area of the second negative active material layer on the negative current collector is 0.47 to 0.52, and a ratio of a compacted density of the first negative active material layer to a compacted density of the second negative active material layer is 0.9 to 1.1;

wherein a thickness of the first negative active material layer is 40 μm to 60 μm, and a thickness of the second negative active material layer on each of the two sides of the second portion is 40 μm to 60 μm.

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2. (Original) The negative electrode according to claim 1, wherein the first negative active material layer and the second negative active material layer each independently comprise a silicon-based material and graphite, wherein the silicon-based material is selected from the group consisting of silicon oxide, silicon carbon, and a combination thereof.

3. (Original) The negative electrode according to claim 2, wherein a weight of the silicon-based material in the first negative active material layer and the second negative active material layer is greater than or equal to 5% and less than 100%, based on a total weight of the silicon-based material and the graphite.

4. (Original) The negative electrode according to claim 2, wherein a form of the silicon-based material comprises a crystalline state, an amorphous state, or a combination thereof, wherein the first negative active material layer has a particle size Dv50 of 8.0 μm to 20 μm, and the second negative active material layer has a particle size Dv50 of 8.0 μm to 20 μm.

5. (Original) The negative electrode according to claim 2, wherein for the silicon-based material, a ratio of a peak height at a wavenumber of 500 cm^{-1} ± -10 cm^{-1} to a peak height at a wavenumber of 1350 cm^{-1} ± 10 cm^{-1} in a Raman spectrum is greater than 0.

6. (Original) The negative electrode according to claim 2, wherein the silicon-based material further comprises a carbon coating layer.

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7. (Original) The negative electrode according to claim 2, wherein the first negative active material layer and the second negative active material layer each independently comprise a binder and a conductive agent; wherein the binder comprises a material selected from the group consisting of polyacrylate, polyimide, polyamide, polyamideimide, polyvinylidene fluoride, styrene-butadiene rubber, sodium alginate, polyvinyl alcohol, polytetrafluoroethylene, polyacrylonitrile, sodium carboxymethyl cellulose, potassium carboxymethyl cellulose, and a combination thereof; and the conductive agent comprises a material selected from the group consisting of conductive carbon black, acetylene black, Ketjen black, graphene, and a combination thereof.

8. (Original) The negative electrode according to claim 7, wherein based on a total weight of the first negative active material layer, the total weight of the silicon-based material and the graphite in the first negative active material layer is 94% to 96%, a weight of the binder is 2.8% to 4.0%, and a weight of the conductive agent is 0.4% to 1.6%; and

based on a total weight of the second negative active material layer, the total weight of the silicon-based material and the graphite in the second negative active material layer is 94% to 96%, the weight of the binder is 2.8% to 4.0%, and the weight of the conductive agent is 0.4% to 1.6%.

9. (Canceled)

10. (Currently Amended) An electrochemical apparatus, comprising:

a positive electrode;

a separator; and

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a negative electrode;

wherein the negative electrode comprises a negative current collector; a first negative active material layer, wherein the first negative active material layer is arranged on one side of a first portion of the negative current collector; and a second negative active material layer, wherein the second negative active material layers are arranged on two sides of a second portion of the negative current collector, wherein the second portion of the negative current collector is different from the first portion[[,]] of the negative current collector,

wherein a ratio of a weight per unit area of the first negative active material layer to a weight per unit area of the second negative active material layer on the negative current collector is 0.47 to 0.52, and a ratio of a compacted density of the first negative active material layer to a compacted density of the second negative active material layer is 0.9 to 1.1;

wherein a thickness of the first negative active material layer is 40 μm to 60 μm, and a thickness of the second negative active material layer on each of the two sides of the second portion is 40 μm to 60 μm.

11. (Original) An electronic apparatus, comprising the electrochemical apparatus according to claim 10.

12. (New) The negative electrode according to claim 1, the weight per unit area of the first negative active material layer on the first portion is 65 g/m^2 to 130 g/m^2, and the weight per unit area of the second negative active material layer on the second portion is 130 g/m^2 to 260 g/m^2.

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13. (New) The electrochemical apparatus according to claim 10, the weight per unit area of the first negative active material layer on the first portion is 65 g/m^2 to 130 g/m^2, and the weight per unit area of the second negative active material layer on the second portion is 130 g/m^2 to 260 g/m^2.

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REMARKS

Favorable reconsideration of this Application, in light of the following discussion, is respectfully requested. Claims 1-11 were originally presented. Claims 1 and 10 have been amended, and new claims 12 and 13 have been added. Claim 9 has been canceled without prejudice or disclaimer. Accordingly, claims 1-8 and 10-13 are pending in the present Application. Applicant submits that upon entry of the present Response, claims 1-8 and 10-13 are in condition for allowance. Moreover, the Applicant submits that no new matter has been introduced by the foregoing amendments.

Rejections under 35 U.S.C. §102

In the outstanding Office Action, claims 1 and 10 were rejected under 35 U.S.C. § 102(a)(1) as being anticipated by JP 2012248282 to Morimoto, et al. ("Morimoto").

Addressing now the rejection of claims 1 and 10 under 35 U.S.C. § 102(a)(1) as being anticipated by Morimoto, this rejection is respectfully traversed. Independent claims 1 and 10 have been amended by incorporating the thickness feature from claim 9 to overcome the rejection under 35 U.S.C. § 102(a)(1). This amendment introduces a limitation: "wherein a thickness of the first negative active material layer is 40 μm to 60 μm, and a thickness of the second negative active material layer on each of the two sides of the second portion is 40 μm to 60 μm", and clarifies that "the second portion of the negative current collector is different from the first portion[[,]] of the negative current collector". Accordingly, claim 9 has been canceled.

Claim 1 now recites:

A negative electrode, comprising:

a negative current collector;

a first negative active material layer, wherein the first negative active material layer is arranged on one side of a first portion of the negative current collector; and

a second negative active material layer, wherein the second negative active material layer is arranged on two sides of a second portion of the negative current collector, wherein the second portion of the negative current collector is different from the first portion of the negative current collector;

wherein a ratio of a weight per unit area of the first negative active material layer to a weight per unit area of the second negative active material layer on the negative current collector is 0.47 to 0.52, and a ratio of a compacted density of the first negative active material layer to a compacted density of the second negative active material layer is 0.9 to 1.1;

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wherein a thickness of the first negative active material layer is 40 μm to 60 μm, and a thickness of the second negative active material layer on each of the two sides of the second portion is 40 μm to 60 μm.

Claim 10 now recites:

An electrochemical apparatus, comprising:
a positive electrode;
a separator; and
a negative electrode;
wherein the negative electrode comprises a negative current collector; a first negative active material layer, wherein the first negative active material layer is arranged on one side of a first portion of the negative current collector; and a second negative active material layer, wherein the second negative active material layers are arranged on two sides of a second portion of the negative current collector, wherein the second portion of the negative current collector is different from the first portion of the negative current collector,
wherein a ratio of a weight per unit area of the first negative active material layer to a weight per unit area of the second negative active material layer on the negative current collector is 0.47 to 0.52, and a ratio of a compacted density of the first negative active material layer to a compacted density of the second negative active material layer is 0.9 to 1.1;
wherein a thickness of the first negative active material layer is 40 μm to 60 μm, and a thickness of the second negative active material layer on each of the two sides of the second portion is 40 μm to 60 μm.

However, and as acknowledged in the outstanding Office Action,[1] "Morimoto does not teach that a thickness of the first negative active material layer is 40 μm to 60 μm, or that a single-layer thickness of the second negative active material layer is 40 μm to 60 μm." Specifically, Morimoto at least fails to teach or suggest the claimed feature:

- *wherein a thickness of the first negative active material layer is 40 μm to 60 μm, and a thickness of the second negative active material layer on each of the two sides of the second portion is 40 μm to 60 μm*

In contrast, in Morimoto's embodiments shown in Table 1 and Figs. 2A-2C (attached below), the thickness of the first negative active material layer (Fig. 2: 25) is consistently about 67 μm (T3-T1), while the single-layer thickness of the second negative active material layer (Fig.2:

[1] See outstanding Office Action from page 5, line 21 to page 6, line 2.

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23) is consistently about 66.5 μm ((T2-T1)/2), both of which falls outside the claimed range of 40 μm to 60 μm.

【図２】

図2A

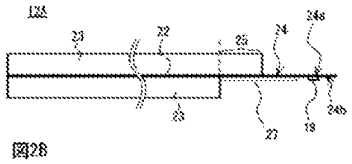


図2B

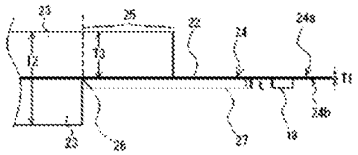
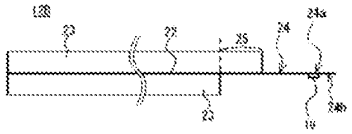


図2C



【表１】

	銅箔の厚さ T1（μm）	両面塗布部厚さ T2（μm）	片面塗布部厚さ T3（μm）	補強材*の有無	相対容量維持率	相対膨れ率
実施例１	7	１４０	７４	○	１０２	１０４
実施例２	6	１３９	７３	○	１０３	１０３
比較例１	7	１４０	７４	×	１００	１０５
比較例２	8	１４１	７６	×	１００	１０５
比較例３	8	１４１	７５	○	１００	１０５
比較例４	6	１３９	７３	×	９９	１０７

*) 厚さ t ≦ 2 μm

In view of the above, the cited prior art fails to teach or suggest every feature recited in Applicant's claims, so that Claims 1 and 10 are believed to be patentably distinguishable over the cited prior art. Accordingly, Applicant respectfully traverses, and requests reconsideration of, the rejections based on Morimoto.[2]

Rejections under 35 U.S.C. §103

In the outstanding Office Action, claims 2-3 and 9 stand rejected under 35 U.S.C. § 103 as unpatentable over Morimoto in view of U.S. Patent Application Publication No. 2019/0148762 to Torita, et al. ("Torita").

In the outstanding Office Action, claim 4 stands rejected under 35 U.S.C. § 103 as unpatentable over Morimoto and Torita as applied to claim 2, and further in view of U.S. Patent Application Publication No. 2018/0316001 to Kim, et al. ("Kim").

[2] See MPEP 2131: "A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference," (Citations omitted) (emphasis added). See also MPEP 2143.03: "All words in a claim must be considered in judging the patentability of that claim against the prior art."

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In the outstanding Office Action, claims 5 and 6 stand rejected under 35 U.S.C. § 103 as unpatentable over Morimoto and Torita as applied to claim 2, and further in view of U.S. Patent Application Publication No. 2014/0227562 to Kamizori, et al. ("Kamizori").

In the outstanding Office Action, claims 7 and 8 stand rejected under 35 U.S.C. § 103 as unpatentable over Morimoto and Torita as applied to claim 2, and further in view of U.S. Patent Application Publication No. 2017/0033355 to Kondo, et al. ("Kondo").

In the outstanding Office Action, claim 11 stands rejected under 35 U.S.C. § 103 as unpatentable over Morimoto.

Addressing now the rejection of claims 2-8 and 11 under 35 U.S.C. § 103 as unpatentable over Morimoto in view of Torita, and in view of any of Kim, Kamizori, and Kondo, this rejection is respectfully traversed. As previously mentioned, independent claims 1 and 10 have been amended to overcome the rejection under 35 U.S.C. § 103 by incorporating the feature from claim 9.

However, and as acknowledged in the outstanding Office Action,[3] "Morimoto does not teach that a thickness of the first negative active material layer is 40 μm to 60 μm, or that a single-layer thickness of the second negative active material layer is 40 μm to 60 μm." Specifically, Morimoto at least fails to teach or suggest the claimed feature:

- *wherein a thickness of the first negative active material layer is 40 μm to 60 μm, and a thickness of the second negative active material layer on each of the two sides of the second portion is 40 μm to 60 μm*

In rejecting claim 9, the outstanding Office Action relies on Torita's disclosure of a negative active material layer thickness of *"not smaller than 50 μm and not greater than 250 μm"* (paragraph [0054]).[4] Based on this, the Office Action considers that it would be obvious to modify Morimoto's thickness ranges by applying Torita's thickness range to arrive at the claimed invention, stating that selecting overlapping ranges is considered prima facie obviousness.[5] However, Applicant respectfully disagrees with this rejection for the following reasons.

[3] See outstanding Office Action from page 5, line 21 to page 6, line 2.
[4] See outstanding Office Action at page 6, lines 3-5.
[5] See outstanding Office Action at page 6, lines 6-14.

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The outstanding Office Action rejects claims 1 and 10 based on interpretation of Morimoto's thickness ratio for the single-layer first active material layer to the total thickness of the double-layer second active material layer (i.e., 67/133=0.503, see paragraphs [0029]-[0030]) as corresponding to the claimed ratio of weight per unit area of the first active material layer to the weight per unit area of the second active material layer. [6] The Office Action states that Morimoto teaches a first negative active material layer arranged on one side of a first portion of the current collector (0028; Figs. 2A-C, part 25) and a second negative active material layer, wherein the second negative active material is arranged on two sides of a second portion, different from the first portion, of the negative current collector (0028; Figs. 2A-C, part 23). [7]

The outstanding Office Action applies Morimoto's thickness ratio (67 μm /133 μm = 0.503) to assert that Morimoto inherently teaches the claimed ratio of the weight per unit area of the first active material layer to the second active material layer (0.47-0.52). [8] However, it simultaneously relies on Torita's thickness values (50-250 μm) to argue obviousness for the claimed thickness range (40 μm to 60 μm). This creates a logical inconsistency: it is unreasonable to establish the ratio using one set of thickness values from Morimoto while proposing to meet the claimed thickness ranges with an entirely different set of thickness values from Torita. The reliance on conflicting teachings to render the same variable (thickness) obvious highlights the non-obviousness of the claimed invention.

Furthermore, Torita provides no motivation to adapt its general thickness range to Morimoto's specific configuration of single-layer and double-layer coexistence. Torita discloses a negative active material layer 22 may be formed *on one surface or on both surfaces* of negative electrode current collector 21, with a thickness ranging from *not smaller than 50 μm to not greater than 250 μm.*[9] However, it does not Torita does not disclose or suggest Morimoto's distinct configuration, where the first negative active material layer is arranged on one side of the first portion, while the second negative active material layer is positioned on both sides of the second portion of the negative current collector. Torita also does not address how modifying these thicknesses would affect performance metrics such as capacity retention or cycling stability. As

[6] See outstanding Office Action at page 3, lines 8-20.
[7] See outstanding Office Action at page 3, lines 2-7.
[8] See outstanding Office Action at page 3, lines 8-20.
[9] See Torita, for example, at paragraph [0054].

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such, an ordinary skilled person in the art, upon reviewing Torita, would not be motivated to directly apply Torita's thickness range to Morimoto's configuration.

In rejecting a claim under 35 U.S.C. § 103, the USPTO must support its rejection by "substantial evidence" within the record,[10] and by "clear and particular" evidence[11] of a suggestion, teaching, or motivation to combine the teachings of different references. As discussed, there is no substantial evidence or clear motivation to modify the thicknesses of Morimoto's layers by incorporating Torita's thickness range. Without such evidence, and absent improper hindsight reconstruction, [12] a person of ordinary skill in the art would not be motivated to make the proposed modification.

Even assuming that Torita provides some motivation to modify the thickness range for a negative active material layer to *"not smaller than 50 μm and not greater than 250 μm"*, there is still no motivation to adjust the thicknesses for Morimoto's first and second negative active material layers to meet the specific "40 μm to 60 μm". As previously noted, Morimoto consistently discloses the thickness of the first negative active material layer (Fig. 2: 25) as approximately 67 μm (T3-T1), while the single-layer thickness of the second negative active material layer (Fig. 2: 23) is approximately 66.5 μm ((T2-T1)/2). [13] Both values fall outside the claimed range of 40 μm to 60 μm.

Additionally, according to the rejection, achieving the claimed weight per unit area ratio (0.47-0.52) would require the thickness of Morimoto's first negative active material layer (25) to be 67 μm and the total thickness of the second negative active material layer (23) to be 133 μm (single-layer thickness must be 66.5 μm), both falling outside the claimed range of 40 μm to 60

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[10] In re Gartside, 203 F3d 1305, 53 USPQ2d 1769 (Fed. Cir. 2000) (holding that, consistent with the Administrative Procedure Act at 5 USC 706(e), the CAFC reviews the Board's decisions based on factfindings, such as 35 U.S.C. § 103(a) rejections, using the <substantial evidence' standard because these decisions are confined to the factual record compiled by the Board.)

[11] In re Dembiczak, 175 F3d 994, 999, 50 USPQ2d 1614, 1617 (Fed. Cir. 1999) ("We have noted that evidence of a suggestion, teaching, or motivation to combine may flow from the prior art references themselves, the knowledge of one of ordinary skill in the art, or, in some cases, from the nature of the problem to be solved, although <the suggestion more often comes from the teachings of the pertinent references.' The range of sources available, however, does not diminish the requirement for actual evidence. That is, the showing must be clear and particular.") (emphasis added).

[12] See MPEP 2141, stating, as one of the tenets of patent law applying to 35 USC § 103, that "[t]he references must be viewed without the benefit of impermissible hindsight vision afforded by the claimed invention."

[13] See Morimoto, for example, at Table 1 and Figs. 2A-2C.

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μm. Therefore, even if Torita's thickness range of "not smaller than 50 μm and not greater than 250 μm" were applied to modify the thicknesses of Morimoto's layers, the resulting structure would fail to satisfy the claimed weight per unit area ratio of 0.47-0.52.

Therefore, even if the combination of Morimoto and Torita is assumed to be proper, the combination fails to teach every element of the claimed invention. Accordingly, Applicant respectfully traverses, and requests reconsideration of, this rejection based on these patents.[14]

Moreover, comparative data presented in Table 1 demonstrates that the claimed ratio of the weight per unit area of the first to the second negative active material layer (0.47 to 0.52) is critical to achieving unexpected results. Specifically:

- Examples 4, 6, and 7, with a weight per unit area ratio within the claimed range (i.e., the coating weight ratio K per unit area of the two, 0.47–0.52), exhibit significantly improved capacity retention during cycling.
- Comparative Examples 3 and 4, with ratios K outside the claimed range, show inferior performance under otherwise identical conditions (using the same the silicon based material and a constant R value of 1.0 for the ratio of the compacted density of the first negative active material layer to the compacted density of the second negative active material layer).

TABLE 1

Example/ Comparative Example	Silicon-based material	K value of first negative electrode	R value of first negative electrode	Capacity retention rate in cycling (—)	K value after 400 cycles	R value after 400 cycles	S value of the region (102A) of the first negative active material layer after 400 cycles	S value of the region (103A), adjacent to the first negative active material layer, of the second negative active material layer after 400 cycles	S value after lithium plating test cycles
Example 1	Silicon oxide	0.5	0.9	90.5%	0.5	0.86	0	2.8%	2.6%
Example 2	Silicon oxide	0.5	0.95	91.1%	0.5	0.94	0	1.6%	2.0%
Example 3	Silicon oxide	0.5	0.97	91.7%	0.5	0.96	0	0	0
Example 4	Silicon oxide	0.5	1.0	92.1%	0.5	1.0	0	0	0
Example 5	Silicon oxide	0.5	1.1	91.9%	0.5	1.13	2.4%	0	2.5%
Example 6	Silicon oxide	0.47	1.0	89.7%	0.47	0.95	2.2%	0	2.8%
Example 7	Silicon oxide	0.52	1.0	90.6%	0.52	1.08	0	1.8%	2.0%
Example 8	Silicon carbon	0.5	1.0	89%	0.5	1.0	0	0	0
Comparative Example 1	Silicon oxide	0.5	0.85	83.4%	0.5	0.78	2.9%	5.3%	29%
Comparative Example 2	Silicon oxide	0.5	1.5	80.3%	0.5	1.6	9%	4.5%	22%
Comparative Example 3	Silicon oxide	0.6	1.0	73.5%	0.4	0.82	8%	2.5%	36%
Comparative Example 4	Silicon oxide	0.55	1.0	82.3%	0.55	1.1	2.8%	8.9%	26%
Comparative Example 5	Silicon carbon	0.5	0.85	72.1%	0.5	0.72	2.7%	4.3%	28%
Comparative Example 6	Silicon carbon	0.5	1.2	79%	0.5	1.4	3.4%	3.1%	24%

[14] See MPEP 2142 stating, as one of the three "basic criteria [that] must be met" in order to establish a *prima facie* case of obviousness, that "the prior art reference (or references when combined) must teach or suggest all the claim limitations," (emphasis added). See also MPEP 2143.03: "All words in a claim must be considered in judging the patentability of that claim against the prior art."

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Therefore, the unexpected results presented here effectively rebut any assertion that the claimed ratio range is merely an optimization of known values, effectively overcoming the prima facie case of obviousness.

Kim, Kamizori, and Kondo do not address the deficiencies of Morimoto and Torita.

As a result, Applicant respectfully submits that independent claims 1 and 10 are patentable over Morimoto in view of Torita, and in further view of Kim, Kamizori, and Kondo. As claims 2-8 depend from independent claim 1, and claim 11 depends from independent claim 10, Applicant respectfully submits that claims 2-8 and 11 are likewise patentable over Morimoto in view of Torita, and in further view of Kim, Kamizori, and Kondo.

Accordingly, for at least the reasons set forth above, Applicant respectfully requests that the §103 rejections of claims 2-8 and 11 be withdrawn.

To advance prosecution, new dependent claims 12 and 13 have been introduced, specifying that "the weight per unit area of the first negative active material layer on the first portion is 65 g/m^2 to 130 g/m^2, and the weight per unit area of the second negative active material layer on the second portion is 130 g/m^2 to 260 g/m^2". Support for this amendment may be found, for example in paragraph [0046] of the present published specification. Morimoto, even in view of Torita, Kim, Kamizori, and Kondo, does not disclose any information regarding the weight per unit area of the single layer first active material layer and the double layer second negative active material layer. Therefore, claims 12 and 13 are believed to be non-obvious and patentable over the applied prior art.

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CONCLUSION

Consequently, in view of the present amendment and in light of the above discussion, the outstanding grounds of rejection are believed to have been overcome. The Application, as amended, is believed to be in condition of allowance. An early and favorable action to that effect is respectfully requested.

Respectfully submitted,

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December 5, 2024

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ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
17/707,129	**12/05/2024 12:56:40 PM Z ET**	**14850059US**

Title of Invention

NEGATIVE ELECTRODE AND ELECTROCHEMICAL APPARATUS CONTAINING SAME, AND ELECTRONIC APPARATUS

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	6210	FILED BY	Karina Fernandez
PATENT CENTER #	68241360	FILING DATE	03/29/2022
CUSTOMER #	62008	FIRST NAMED INVENTOR	Ting YI
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	Timothy Maier

Documents

TOTAL DOCUMENTS: 3

DOCUMENT		PAGES	DESCRIPTION	SIZE (KB)
PAT201909057US1_Response_PDF.pdf		15	-	511 KB
PAT201909057US1_Response_PDF-A....pdf	(1-1)	1	Amendment/Request for Reconsideration-After Non-Final Rejection	22 KB
PAT201909057US1_Response_PDF-CLM.pdf	(2-6)	5	Claims	51 KB
PAT201909057US1_Response_PDF-REM.pdf	(7-15)	9	Applicant Arguments/Remarks Made in an Amendment	467 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
PAT201909057US1_Response_PDF.pdf	CB2B99C6995A1361B539872B095DF27F481778180812B499464C7302C5A9CD78C8570BCB4965BF4D6ACF77ED9DBF79C8F91CCC8C55A28244032908E94366DD78
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PAT201909057US1_Response_PDF-CLM.pdf	295FBFA59C354741000AA754540A28C5AFF21E4CC5DB9200456EF1B8E8730D15C4C0DCDE6CC69C5FDE36519BCFA2C27EAA114C0E8094DFA564E145A2EC83D5C4
PAT201909057US1_Response_PDF-REM.pdf	001B2D782D264A911DFD03677861128AD0BC9422A92B5E56A4D1923B666CB7F05E438E0004275CF45C812AF462CF0EAA35806F8BBECF67045EC8A41F302200B7

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If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Notice of References Cited	Application/Control No. 17/707,129	Applicant(s)/Patent Under Reexamination Yl et al.	
	Examiner ZIHENG LU	Art Unit 1752	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date YYYY-MM-DD	Name	CPC Classification	US Classification
*	A	US-20230123455-A1	2023-04-20	HU; Xianfei	H01M4/364	429/231.95
	B					
	C					
	D					
	E					
	F					
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	I					
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	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date YYYY-MM-DD	Country	Name	CPC Classification
	N					
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	P					
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	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
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	V	
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	Examiner	Art Unit
	ZIHENG LU	1752

CPC - Searched*		
Symbol	Date	Examiner
H01M4/386, H01M4/583, H01M4/623, H01M10/0525, H01M2004/021, H01M2004/027	08/30/2024	ZL

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
Inventor and Assignee Search	08/30/2024	ZL
Classification + Text Search	08/30/2024	ZL
Consulted with Primary Maria Laios	08/30/2024	ZL
Updated Search	12/12/2024	ZL
IP.com Search	12/12/2024	ZL

/ZIHENG LU/ Examiner, Art Unit 1752	

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Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
H01M4	386		
H01M4	583		
H01M4	623		
H01M10	0525		
H01M2004	021		
H01M2004	027		

/ZIHENG LU/ Examiner, Art Unit 1752	

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CPC						
Symbol					Type	Version
H01M	/	4	/	386	F	2013-01-01
H01M	/	4	/	583	I	2013-01-01
H01M	/	4	/	623	I	2013-01-01
H01M	/	10	/	0525	I	2013-01-01
H01M	/	2004	/	021	A	2013-01-01
H01M	/	2004	/	027	A	2013-01-01

CPC Combination Sets							
Symbol					Type	Set	Ranking	Version
	/		/					

/ZIHENG LU/ Examiner, Art Unit 1752 (Assistant Examiner)	13 December 2024 (Date)	Total Claims Allowed: 12	
/Maria Laios/ Primary Examiner, Art Unit 1727 (Primary Examiner)	18 December 2024 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 1

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	Examiner	**Art Unit**
	ZIHENG LU	1752

INTERNATIONAL CLASSIFICATION				
CLAIMED				
H01M	/	4	/	38

NON-CLAIMED				
	/		/	

US ORIGINAL CLASSIFICATION	
CLASS	**SUBCLASS**
429	209

CROSS REFERENCES(S)						
CLASS	**SUBCLASS (ONE SUBCLASS PER BLOCK)**					

/ZIHENG LU/ Examiner, Art Unit 1752	13 December 2024	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	12	
/Maria Laios/ Primary Examiner, Art Unit 1727	18 December 2024	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1

U.S. Patent and Trademark Office — Part of Paper No.: 20241212

Zhuhai CosMX Battery Co. - EX1002
Zhuhai CosMX Battery Co. v. Ningde Amperex Tech. Ltd.
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Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/707,129	YI et al.
	Examiner	Art Unit
	ZIHENG LU	1752

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIMS

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1	11	11												
3	2	2	12												
4	3	12	13												
5	4														
6	5														
7	6														
8	7														
9	8														
10	10														

/ZIHENG LU/ Examiner, Art Unit 1752 (Assistant Examiner)	13 December 2024 (Date)	**Total Claims Allowed:** 12	
/Maria Laios/ Primary Examiner, Art Unit 1727 (Primary Examiner)	18 December 2024 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 1

U.S. Patent and Trademark Office Part of Paper No.: 20241212

Zhuhai CosMX Battery Co. - EX1002
Zhuhai CosMX Battery Co. v. Ningde Amperex Tech. Ltd.
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Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/707,129	YI et al.
	Examiner	**Art Unit**
	ZIHENG LU	1752

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	08/30/2024	12/13/2024							
	1	✓	=							
	2	✓	=							
	3	✓	=							
	4	✓	=							
	5	✓	=							
	6	✓	=							
	7	✓	=							
	8	✓	=							
	9	✓	-							
	10	✓	=							
	11	✓	=							
	12		=							
	13		=							

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Search History

Report Run Date: 2024-12-13 UTC
Searches: 4
Markers: 0

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Search #	Timestamp	Results	Page
1	2024-12-12 20:04 UTC	~17,501,384	3
2	2024-12-12 20:05 UTC	~28,776,985	4
3	2024-12-12 20:06 UTC	~21,682,329	4
4	2024-12-12 21:20 UTC	~21,682,317	4

Content: Patents + NPL (195)

US Patents | US Designs | US Applications | EPO Patents | EPO Applications | China Patents | China Applications | Japan Patents | Japan Applications | Korea Patents | Korea Applications | WIPO Applications | Argentina Patents | Argentina Applications | Brazil Patents | Brazil Applications | Canada Patents | Canada Applications | Chile Patents | Chile Applications | Colombia Applications | Costa Rica Applications | Cuba Patents | Cuba Applications | Dominican Republic Applications | Ecuador Patents | Ecuador Applications | El Salvador Applications | Guatemala Applications | Honduras Applications | Mexico Patents | Mexico Applications | Nicaragua Patents | Panama Applications | Peru Applications | Trinidad & Tobago Patents | Uruguay Applications | Austria Patents | Austria Applications | Belarus Patents | Belgium Patents | Belgium Applications | Bosnia & Herzegovina Patents | Bosnia & Herzegovina Applications | Bulgaria Patents | Bulgaria Applications | Croatia Patents | Croatia Applications | Czech Republic Patents | Czech Republic Applications | Czechoslovakia Patents | Czechoslovakia Applications | Denmark Patents | Denmark Applications | Estonia Patents | Estonia Applications | EUIPO Patents | Finland Patents | Finland Applications | France Patents | France Applications | Germany Patents | Germany Applications | Great Britain Patents | Great Britain Applications | Greece Patents | Greece Applications | Hungary Patents | Hungary Applications | Iceland Patents | Iceland Applications | Ireland Patents | Ireland Applications | Italy Patents | Italy Applications | Latvia Patents | Latvia Applications | Lithuania Patents | Lithuania Applications | Luxembourg Patents | Luxembourg Applications | Malta Patents | Monaco Patents | Montenegro Patents | Montenegro Applications | Netherlands Patents | Netherlands Applications | Norway Patents | Norway Applications | Poland Patents | Poland Applications | Portugal Patents | Portugal Applications | Republic of Moldova Patents | Republic of Moldova Applications | Romania Patents | Romania Applications | San Marino Patents | San Marino Applications | Serbia Patents | Serbia Applications | Slovakia Patents | Slovakia Applications | Slovenia Patents | Spain Patents | Spain Applications | Sweden Patents | Sweden Applications | Switzerland Patents | Switzerland Applications | Ukraine Patents | Yugoslavia/Serbia and Montenegro Patents | Yugoslavia/Serbia and Montenegro Applications | Armenia Patents | Australia Patents | Australia Applications | Cyprus Patents | Gulf Cooperation Council Patents | Hong Kong Patents | India Patents | India Applications | Indonesia Patents | Indonesia Applications | Israel Patents | Israel Applications | Jordan Patents | Jordan Applications | Kyrgyzstan Patents | Macao Applications | Malaysia Patents | Mongolia Patents | New Zealand Patents | Philippines Patents | Philippines Applications | Saudi Arabia Patents | Saudi Arabia Applications | Singapore Patents | Singapore Applications | Taiwan Patents | Taiwan Applications | Tajikistan Patents | Tajikistan Applications | Thailand Patents | Thailand Applications | Uzbekistan Patents | Vietnam Patents | Algeria Patents | ARIPO Patents | ARIPO Applications | Egypt Patents | Kenya Patents | Malawi Patents | Morocco Patents | Morocco Applications | OAPI Patents | South Africa Patents | Tunisia Applications | Zambia Patents | Zimbabwe Patents | EAPO Patents | EAPO Applications | Georgia Patents | Georgia Applications | Kazakhstan Patents | Kazakhstan Applications | Russia Patents | Russia Applications | Turkey Patents | Turkey Applications | IEEE Xplore Publications: IEEE Periodicals | IEEE Xplore Publications: IEEE Conferences | IEEE Xplore Publications: IEEE Standards | IEEE Xplore Publications: IEEE Early Access | IEEE Xplore Publications: SMPTE Periodicals | IEEE Xplore Publications: SMPTE Conferences | IEEE Xplore Publications: SMPTE Standards | IEEE Xplore Publications: MIT Press eBooks | IEEE Xplore Publications: Wiley-IEEE eBooks | IEEE Xplore Publications: IBM Periodicals | IEEE Xplore Publications: URSI Periodicals | IEEE Xplore Publications: VDE Conferences | IEEE Xplore Publications: Periodicals from China | IEEE Xplore Publications: Ericsson Technology Review | IEEE Xplore Publications: Manning Books | IEEE Xplore Publications: Packt Books | IP.com Prior Art Database: The IP.com Journal | IP.com Prior Art Database: Internet Society RFC | IP.com Prior Art Database: IBM TDB Archive | IP.com Prior Art Database: Legacy Journals | IP.com Prior Art Database: Software Patent Institute | OnePetro.org: Periodicals at OnePetro.org | OnePetro.org: Conferences at OnePetro.org | Other Literature: IBM Redbooks | Other Literature: PubMed Central | Other Literature: arXiv.org

1 **2024-12-12 20:04 UTC | ~17,501,384 results from**

De-Dup: Simple Family Numbers (PAT only) | **Relevance Cut-off:** None | **Sort:** Relevance

Main Concept: Text

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negative current collector with active material coated on both sides

Concept Modifiers: None

Filters: None

2 **2024-12-12 20:05 UTC | ~28,776,985 results from**

De-Dup: Simple Family Numbers (PAT only) | **Relevance Cut-off:** None | **Sort:** Relevance

Main Concept: Text
negative electrode where active material layer is coated on portion of current collector

Concept Modifiers: None

Filters: None

3 **2024-12-12 20:06 UTC | ~21,682,329 results from**

De-Dup: Simple Family Numbers (PAT only) | **Relevance Cut-off:** None | **Sort:** Relevance

Main Concept: Same as Search 2

Concept Modifiers: None

Filters (1):
Publication Date: To 2019-12-31

4 **2024-12-12 21:20 UTC | ~21,682,317 results from**

De-Dup: Simple Family Numbers (PAT only) | **Relevance Cut-off:** None | **Sort:** Relevance

Main Concept: Text
negative electrode where active material layer is coated on one side of current collector

Concept Modifiers: None

Filters: Same as Search 3

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Bibliographic Data

Application No: 17/707,129

Foreign Priority claimed: (•) Yes ( ) No

35 USC 119 (a-d) conditions met: [✓] Yes [ ] No [ ] Met After Allowance

Verified and Acknowledged: /ZIHENG LU/ Examiner's Signature | Initials

Title: NEGATIVE ELECTRODE AND ELECTROCHEMICAL APPARATUS CONTAINING SAME, AND ELECTRONIC APPARATUS

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
03/29/2022	429	1752	14850059US
RULE			

APPLICANTS

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INVENTORS

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Hang CUI, Ningde, CHINA

Yuansen XIE, Ningde, CHINA

CONTINUING DATA

This application is a CON of PCT/CN2019/130465 12/31/2019

FOREIGN APPLICATIONS

CHINA CN201911267132.X 12/11/2019

IF REQUIRED, FOREIGN LICENSE GRANTED**

04/05/2022

STATE OR COUNTRY

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UNITED STATES

FILING FEE RECEIVED

$1,820

PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L1	1001	((("NINGDE") near3 ("AMPEREX") near3 ("TECHNOLOGY") near3 ("LIMITED"))).AS,AANM.	(US-PGPUB; USPAT)	OR	ON	ON	2024/08/27 02:01 PM
L2	1521	((("YI") near3 ("Ting")) OR (("CUI") near3 ("Hang")) OR (("XIE") near3 ("Yuansen"))).INV.	(US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT)	OR	ON	ON	2024/08/27 02:01 PM
L3	130218	(H01M4/386 OR H01M4/583 OR H01M4/623 OR H01M10/0525 OR H01M2004/021 OR H01M2004/027).cpc.	(US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT)	OR	ON	ON	2024/08/27 02:02 PM
L4	13103	H01M2004/021.cpc.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:03 PM
L5	5802	("negative electrode" anode) WITH second WITH "active material" WITH layer	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:04 PM
L6	1397	L4 AND L5	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:04 PM
L7	40	L1 AND L6	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:04 PM
L8	1825	(("negative electrode" anode) WITH second WITH "active material" WITH layer).clm.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:05 PM
L9	45	L8 AND L1	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:05 PM
L10	19	L8 AND L1 AND L4	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:05 PM
L11	1416	((("YI") near3 ("Ting")) OR (("CUI") near3 ("Hang")) OR (("XIE") near3 ("Yuansen"))).INV.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:05 PM
L12	4	L11 AND L8 AND L4	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:06 PM
L13	538	L4 AND L8	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:10 PM
L14	32	(second near3(negative "negative electrode" anode) near2 "active	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:16 PM

		material layer") WITH ((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO))					
L15	6170	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO))	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:19 PM
L16	538	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO)) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector")	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:20 PM
L17	272	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO) WITH graphite) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector")	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:21 PM
L18	43	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO) WITH graphite) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND second near3 "active material layer"	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 02:41 PM
L19	8	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO) WITH graphite) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND offset near3 "active	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 03:04 PM

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		material layer"					
L20	9	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO) WITH graphite) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND offset near3 "active material layer"	(FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/08/27 03:04 PM
L21	16	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO) WITH graphite) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND uneven near3 "active material layer"	(FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/08/27 03:05 PM
L22	0	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO) WITH graphite) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND uneven near3 "active material layer"	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 03:10 PM
L23	238	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO) WITH graphite) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND second near3 "active material layer"	(FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/08/27 03:10 PM
L24	7	((negative "negative electrode" anode) near2 "active material" WITH	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/27 03:15 PM

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		("silicon oxide" SiO) WITH graphite) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND extended near3 "active material layer"					
L25	8	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO) WITH graphite) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND extended near3 "active material layer"	(FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO))	OR	ON	ON	2024/08/27 03:23 PM
L26	4	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO) WITH graphite) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND second NEAR region WITH "active material layer"	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/28 10:30 AM
L27	47	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO) WITH graphite) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND second NEAR region WITH "active material layer"	(FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO))	OR	ON	ON	2024/08/28 10:30 AM
L28	1	"205376669".pn.	(FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR,	OR	ON	ON	2024/08/28 10:32 AM

			HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO))				
L29	4	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO) WITH graphite) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND tail WITH "active material layer"	(FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO))	OR	ON	ON	2024/08/28 11:06 AM
L30	0	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO) WITH graphite) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND tail WITH "active material layer"	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/28 11:07 AM
L31	21	((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND tail WITH "active material layer"	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/28 11:07 AM
L32	42	(Artificial Intelligence) More like doc: US-20220052386-A1 Text: (US-11848422-B2 OR CN-111916844-B OR CN-111916844-A OR EP-4089757-B1 OR EP-4089757-A1 OR CN-115668526-A OR CN-116325278-A OR EP-4068418-A1 OR CN-114122315-A OR CN-111916845-B OR	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO;	OR	ON	ON	2024/08/28 11:08 AM

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		CN-111916845-A OR EP-4089760-A1 OR EP-4053960-B1 OR CN-113097441-A OR WO-2022206877-A1 OR EP-4053960-A1 OR CN-118043990-A OR JP-7106190-B2 OR KR-20200028750-A OR CN-114050325-A).did.	JPO; DERWENT; IBM_TDB)				
L33	1218	((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND one WITH side WITH "active material layer"	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/28 11:11 AM
L34	151	((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND single WITH side WITH "active material layer"	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/28 11:11 AM
L35	0	"201400141303".pn.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS)	OR	ON	ON	2024/08/28 12:36 PM
L36	3	"20140141303".pn.	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS)	OR	ON	ON	2024/08/28 12:36 PM
L37	1	"20140141303".pn.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/28 12:42 PM

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L38	127	"active material layer" WITH (single NEAR side) WITH "current collector"	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/28 01:30 PM
L39	11	"active material layer" WITH (single NEAR side) WITH "current collector" WITH region	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/28 01:30 PM
L40	78	"active material layer" WITH (single NEAR side) WITH "current collector" WITH region	(FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/08/28 01:33 PM
L41	0	coating WITH (single NEAR side) WITH "current collector" WITH region	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/28 02:25 PM
L42	83	coating WITH (single NEAR side) WITH "current collector" WITH region	(FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN))	OR	ON	ON	2024/08/28 02:25 PM
L43	32	((negative "negative electrode" anode) near2 "active material" WITH ("silicon oxide" SiO) WITH graphite) AND ((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND second near3 "active material layer" AND (negative "negative electrode" anode) near2 "active material" WITH thickness	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/28 02:54 PM

L44	923	"active material layer" WITH "current collector" WITH (insulated uncoated tape)	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 08:51 AM
L45	583	"active material layer" WITH "current collector" WITH uncoated	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 08:51 AM
L46	356	negative WITH "active material layer" WITH "current collector" WITH uncoated	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 08:51 AM
L47	0	negative WITH "active material layer" WITH "current collector" WITH uncoated AND "active material" WITH (SiO "silicon oxide") WITH graphtie	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 08:52 AM
L48	22	negative WITH "active material layer" WITH "current collector" WITH uncoated AND "active material" WITH (SiO "silicon oxide")	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 08:52 AM
L49	100	negative WITH "active material layer" WITH "current collector" WITH uncoated AND "active material layer" WITH "current collector" WITH (both two) WITH (sides side)	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 09:12 AM
L50	1285	(negative anode) WITH "active material" WITH (SiO "silicon oxide") near5 graphite	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 09:23 AM
L51	125	(negative anode) WITH "active material" WITH (SiO "silicon oxide") near5 graphite AND (SiO "silicon oxide") WITH coating WITH carbon	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 09:23 AM
L52	85	(negative anode) WITH "active material" WITH (SiO "silicon oxide") near5 graphite AND (SiO "silicon oxide") WITH coating WITH carbon AND (SiO "silicon oxide") WITH (size volume d50)	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 09:33 AM
L53	119	(negative anode) WITH "active material" WITH	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 10:08 AM

		(SiO "silicon oxide") WITH coating WITH carbon AND coating WITH carbon WITH (improve$4 benefit advantage higher better increas$3)					
L54	45	(negative anode) WITH "active material" WITH (SiO "silicon oxide") WITH coating WITH carbon AND coating WITH carbon WITH (improve$4 benefit advantage higher better increas$3) AND (SiO "silicon oxide") near3 (amorphous crystalline)	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 10:17 AM
L55	8	"active material" WITH (SiO "silicon oxide") AND (SiO "silicon oxide") WITH ("D/G")	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 02:27 PM
L56	11	"active material" WITH (SiO "silicon oxide") AND (SiO "silicon oxide") WITH ("1350")	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 02:28 PM
L57	2	"active material" WITH (SiO "silicon oxide") AND (SiO "silicon oxide") SAME ("500" AND "1350")	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 02:28 PM
L58	96	"active material" WITH (SiO "silicon oxide") AND (SiO "silicon oxide") SAME ("500" AND "1350")	(FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO))	OR	ON	ON	2024/08/29 02:28 PM
L59	4	"active material" WITH (SiO "silicon oxide") AND (SiO "silicon oxide") SAME peak SAME ("500" AND "1350")	(FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH,	OR	ON	ON	2024/08/29 02:29 PM

			TN, TR, TW, UA, VN, WO))				
L60	1072	"active material" WITH (SiO "silicon oxide") AND (SiO "silicon oxide") SAME raman	(FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO))	OR	ON	ON	2024/08/29 02:29 PM
L61	214	"active material" WITH (SiO "silicon oxide") AND (SiO "silicon oxide") SAME raman	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 02:29 PM
L62	84	"active material" WITH (SiO "silicon oxide") AND (SiO "silicon oxide") WITH raman	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 02:29 PM
L63	217	(SiO "silicon oxide") WITH raman	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 02:33 PM
L64	87	H01M$.cpc. AND (SiO "silicon oxide") WITH raman	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/29 02:33 PM
L65	1574	("negative electrode" anode) WITH (SiO "silicon oxide") WITH graphite AND ("negative electrode" anode) WITH (conductive near3 (agent additive))	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/30 12:45 PM
L66	635	("negative electrode" anode) WITH (SiO "silicon oxide") WITH graphite AND ("negative electrode" anode) WITH (conductive near3 (agent additive)) AND (conductive near3 (agent additive)) WITH (increas$3 advantag$5 benefit improv$4 better)	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/08/30 12:45 PM
L67	760	(SiO "silicon oxide") WITH "active material" WITH (amorphous crystalline)	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/09/03 10:30 AM
L68	409	(SiO "silicon oxide") WITH "active material" WITH (amorphous crystalline) NOT ((SiO	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/09/03 10:31 AM

		"silicon oxide") WITH "active material" WITH ((amorphous crystalline) near3 carbon))					
L69	260	((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND second near3 "active material layer"	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/12/12 11:53 AM
L70	232	((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND second near3 "active material layer" AND layer WITH thickness	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/12/12 11:53 AM
L71	179	((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND second near3 "active material layer" AND "active material" WITH one WITH side AND layer WITH thickness	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/12/12 01:24 PM
L72	1563	((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND second near3 "active material layer" AND "active material" WITH one WITH side AND layer WITH thickness	(FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO))	OR	ON	ON	2024/12/12 01:31 PM
L73	197	((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND second near3 "active material layer" AND "active material" WITH single near3 side AND layer WITH thickness	(FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH,	OR	ON	ON	2024/12/12 01:31 PM

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			TN, TR, TW, UA, VN, WO))				
L74	1430	((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND second near3 "active material layer" AND "active material" WITH one WITH side AND layer WITH thickness AND ratio	(FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO))	OR	ON	ON	2024/12/12 02:26 PM
L75	430	((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND second near3 "active material layer" AND "active material" WITH one WITH side AND layer WITH thickness AND ratio WITH density	(FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO))	OR	ON	ON	2024/12/12 02:26 PM
L76	293	((negative "negative electrode" anode) near2 "active material" WITH (both two either) WITH (sides side) WITH "current collector") AND second near3 "active material layer" AND "active material" WITH one WITH side AND layer WITH thickness AND "active material" WITH ratio WITH density	(FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO))	OR	ON	ON	2024/12/12 02:26 PM
L77	0	JP2009252349.pn.	(FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO))	OR	ON	ON	2024/12/12 03:58 PM
L78	0	JP20090252349.pn.	(FIT (AP, AT, AU, BE,	OR	ON	ON	2024/12/12

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			BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO))				03:58 PM
L79	0	"20090252349".pn.	(FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO))	OR	ON	ON	2024/12/12 03:58 PM
L80	1	"2009252349".pn.	(FIT (AP, AT, AU, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, MC, MD, MY, NL, NO, NZ, OA, PH, PL, PT, RO, RS, RU, SE, SG, SI, SK, SU, TH, TN, TR, TW, UA, VN, WO))	OR	ON	ON	2024/12/12 03:58 PM
L81	40	(Artificial Intelligence) More like doc: JP-2009252349-A Text: (WO-2012114904-A1 OR EP-2680345-A1 OR US-20130344389-A1 OR JP-2012174595-A OR JP-2009252349-A OR WO-2012114905-A1 OR WO-2019230298-A1 OR EP-2680346-B1 OR JP-WO2019230298-A1 OR US-9142831-B2 OR US-9543570-B2 OR JP-WO2019044168-A1 OR EP-3813178-B1 OR	(US-PGPUB; USPAT; USOCR; FIT (AU, AP, AT, BE, BG, BR, BY, CA, CH, CN, CS, CU, CZ, DD, DE, DK, EA, EE, EP, ES, FI, FR, GB, HR, HU, ID, IE, IL, IS, IT, JP, KR, LT, LU, LV, MA, OA, RU, SU, WO, MC, MD, MY, NL, NO, NZ, PH, PL, PT, RO, RS, SE, SG, SI, SK, TH, TN, TR, TW, UA, VN); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2024/12/12 04:00 PM

		US-20210091381-A1 OR JP-7301267-B2 OR US-20210257672-A1 OR JP-2012248282-A OR US-11557759-B2 OR JP-2024123839-A OR JP-2014207201-A).did.					
L82	1	"20230123455" .pn.	(US-PGPUB; USPAT; USOCR)	OR	ON	ON	2024/12/13 02:19 PM

PE2E SEARCH - Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
N1	60559	(H01M4/386 OR H01M4/583 OR H01M4/623 OR H01M10/0525 OR H01M2004/021 OR H01M2004/027).cpc.	(US-PGPUB; USPAT)	OR	ON	ON	2024/12/13 03:29 PM
N2	4168	(H01M4/386 OR H01M4/583 OR H01M4/623 OR H01M10/0525 OR H01M2004/021 OR H01M2004/027).cpc. AND "active material layer" WITH (first AND second)	(US-PGPUB; USPAT)	OR	ON	ON	2024/12/13 03:30 PM
N3	1919	(H01M4/386 OR H01M4/583 OR H01M4/623 OR H01M10/0525 OR H01M2004/021 OR H01M2004/027).cpc. AND ("active material layer" WITH (first AND second)).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2024/12/13 03:30 PM
N4	130	(H01M4/386 OR H01M4/583 OR H01M4/623 OR H01M10/0525 OR H01M2004/021 OR H01M2004/027).cpc. AND ("active material layer" WITH (first AND second)).clm. AND ("active material layer" WITH weight WITH ratio).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2024/12/13 03:31 PM
N5	7	(H01M4/386 OR H01M4/583 OR H01M4/623 OR H01M10/0525 OR	(US-PGPUB; USPAT)	OR	ON	ON	2024/12/13 03:31 PM

		H01M2004/021 OR H01M2004/027).cpc. AND ("active material layer" WITH (first AND second)).clm. AND ("active material layer" WITH weight WITH ratio).clm. AND ("active material layer" WITH density WITH ratio).clm.					

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NOTICE OF ALLOWANCE AND FEE(S) DUE

62008 7590 01/08/2025

MAIER & MAIER, PLLC
345 SOUTH PATRICK STREET
ALEXANDRIA, VA 22314

EXAMINER	
LU, ZIHENG NMN	
ART UNIT	PAPER NUMBER
1752	

DATE MAILED: 01/08/2025

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/707,129	03/29/2022	Ting YI	14850059US	6210

TITLE OF INVENTION: NEGATIVE ELECTRODE AND ELECTROCHEMICAL APPARATUS CONTAINING SAME, AND ELECTRONIC APPARATUS

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1200	$0.00	$0.00	$1200	04/08/2025

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 40% the amount of undiscounted fees, and micro entity fees are 20% the amount of undiscounted fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.

PTOL-85 (Rev. 11/23)

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Zhuhai CosMX Battery Co. v. Ningde Amperex Tech. Ltd.
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PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via the USPTO patent electronic filing system.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications. **Because electronic patent issuance may occur shortly after issue fee payment, any desired continuing application should preferably be filed prior to payment of this issue fee in order not to jeopardize copendency.**

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

62008 7590 01/08/2025
MAIER & MAIER, PLLC
345 SOUTH PATRICK STREET
ALEXANDRIA, VA 22314

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via the USPTO patent electronic filing system or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/707,129	03/29/2022	Ting YI	14850059US	6210

TITLE OF INVENTION: NEGATIVE ELECTRODE AND ELECTROCHEMICAL APPARATUS CONTAINING SAME, AND ELECTRONIC APPARATUS

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1200	$0.00	$0.00	$1200	04/08/2025

EXAMINER	ART UNIT	CLASS-SUBCLASS
LU, ZIHENG NMN	1752	429-209000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/AIA/122 or PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/AIA/47 or PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 _____
2 _____
3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. Fees submitted: ❑Issue Fee ❑Publication Fee (if required)

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

❑ Electronic Payment via the USPTO patent electronic filing system ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

❑ Applicant asserting small entity status. See 37 CFR 1.27

NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

❑ Applicant changing to regular undiscounted fee status.

NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

PTOL-85 Part B (11/23) Approved for use through 03/31/2026 OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Zhuhai CosMX Battery Co. - EX1002
Zhuhai CosMX Battery Co. v. Ningde Amperex Tech. Ltd.
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/707,129	03/29/2022	Ting YI	14850059US	6210

62008 7590 01/08/2025

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ALEXANDRIA, VA 22314

EXAMINER	
LU, ZIHENG NMN	

ART UNIT	PAPER NUMBER
1752	

DATE MAILED: 01/08/2025

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

PTOL-85 (Rev. 11/23)

Zhuhai CosMX Battery Co. - EX1002
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OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. 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, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. 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.

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. The United States Patent and Trademark Office (USPTO) collects the information in this record under authority of 35 U.S.C. 2. The USPTO's system of records is used to manage all applicant and owner information including name, citizenship, residence, post office address, and other information with respect to inventors and their legal representatives pertaining to the applicant's/ owner's activities in connection with the invention for which a patent is sought or has been granted. The applicable Privacy Act System of Records Notice for the information collected in this form is COMMERCE/PAT-TM-7 Patent Application Files, available in the Federal Register at 78 FR 19243 (March 29, 2013).
https://www.govinfo.gov/content/pkg/FR-2013-03-29/pdf/2013-07341.pdf

Routine uses of the information in this record may include disclosure to:

1) law enforcement, in the event that the system of records indicates a violation or potential violation of law;
2) a federal, state, local, or international agency, in response to its request;
3) a contractor of the USPTO having need for the information in order to perform a contract;
4) the Department of Justice for determination of whether the Freedom of Information Act (FOIA) requires disclosure of the record;
5) a Member of Congress submitting a request involving an individual to whom the record pertains, when the individual has requested the Member's assistance with respect to the subject matter of the record;
6) a court, magistrate, or administrative tribunal, in the course of presenting evidence, including disclosures to opposing counsel in the course of settlement negotiations;
7) the Administrator, General Services Administration (GSA), or their designee, during an inspection of records conducted by GSA under authority of 44 U.S.C. 2904 and 2906, in accordance with the GSA regulations and any other relevant (i.e., GSA or Commerce) directive, where such disclosure shall not be used to make determinations about individuals;
8) 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));
9) the Office of Personnel Management (OPM) for personnel research purposes; and
10) the Office of Management and Budget (OMB) for legislative coordination and clearance.

If you do not furnish the information requested on this form, the USPTO may not be able to process and/or examine your submission, which may result in termination of proceedings, abandonment of the application, and/or expiration of the patent.

Notice of Allowability	Application No. 17/707,129	Applicant(s) YI et al.	
	Examiner ZIHENG LU	Art Unit 1752	AIA (FITF) Status Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to 12/05/2024.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are 1-8 and 10-13 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information , please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☑ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☑ All b) ☐ Some* c) ☐ None of the:

   1. ☑ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☑ Notice of References Cited (PTO-892)
2. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☐ Examiner's Amendment/Comment
6. ☑ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/ZIHENG LU/ Examiner, Art Unit 1752	/Maria Laios/ Primary Examiner, Art Unit 1727

Zhuhai CosMX Battery Co. - EX1002
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Notice of Pre-AIA or AIA Status

1. The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

Response to Amendment

2. The amendments filed 12/05/24 have been entered. Claims 1 and 10 are amended, Claim 9 is cancelled, and Claims 12 and 13 are new. Support for the amended Claims can be found in original Claim 9 and paragraph 0045 of the instant specification.

Response to Arguments

3. Applicant's arguments with respect to claim(s) 1 have been considered but are moot in light of the allowable subject matter.

Applicant also argues unexpected results (See Pg. 13 of Applicant's Remarks dated 12/05/24) regarding the ratio of the weight per unit area of the first to the second active material layer (K value) and the capacity retention during cycling. Applicant claims that a K value within the claimed range (0.47 to 0.52) results in improved capacity retention during cycling. From the examples provided in Table 1 of the specification, it does not appear that the ratio K provides unexpected results by itself: Comparative Examples 1-2 and 5-6 have K values within the claimed range but display poor capacity retention rate compared to Examples 1-8.

However, it appears that there is an improvement in capacity retention when both the ratio of the weight per unit area of the first to the second active material layer (K value) and the

ratio of the compacted density of the first to the second active material layer (R value) are within the claimed ranges (see Allowable Subject Matter below).

Allowable Subject Matter

4. Claims 1-8 and 10-13 allowed.

5. The following is an examiner's statement of reasons for allowance:

There is sufficient evidence showing improved capacity retention rates when the ratio of a weight per unit area of the first negative active material layer to a weight per unit area of the second negative active material layer (K value) is 0.47 to 0.52, and a ratio of a compacted density of the first negative material layer to a compacted density of the second negative active material layer (R value) is 0.9 to 1.1.

Examples 1-8 show negative electrodes with K and R values within the claimed range. Comparative Examples 3 and 4 have K values outside the claimed range (0.47 to 0.52) and R values within the claimed range and Comparative Examples 1-2 and 5-6 have R values outside the claimed range (0.9 to 1.1) and K values within the claimed range. Examples 1-8 display improved capacity retention (89% - 92.1%) than Comparative Examples 1-6 (73.1% - 83.4%). The prior art does not teach or suggest this relationship.

The closest prior art is Hu (US 20230123455 A1).

Hu teaches a current collector with a first negative active material layer on one side of a first portion of the negative current collector (Fig. 1, portion with only one coated side) and a

second negative active material layer, on two sides of a second portion of the negative current collector, wherein the second portion of the negative current collector is different from the first portion of the current collector (Fig. 1, portion with both sides coated). As the coatings are made and applied in the same way (0064-0069), the only difference is that the first layer is coated on only one side while the second layer is coated on both sides. Thus, the ratio of the weight per unit area of the first layer to the second layer is 0.5 (first layer has half as much weight per unit area as it is only coated on one side of the current collector) and the ratio of the compacted densities of the first and second active material layers is 1 (first layer has half as much weight but also half as much volume) (Fig. 1). The thickness of the first active material layer can be from 40 microns to 360 microns and the thickness of the second active material layer on each side can be from 40 microns to 360 microns (0021).

However, Hu was filed after the effective filing date of the present invention.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Conclusion

1. Any inquiry concerning this communication or earlier communications from the examiner should be directed to ZIHENG LU whose telephone number is (703)756-1077. The examiner can normally be reached Monday-Friday 8:30 - 5 ET.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nicholas Smith can be reached on (571) 272-8760. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of published or unpublished applications may be obtained from Patent Center. Unpublished application information in Patent Center is available to registered users. To file and manage patent submissions in Patent Center, visit: https://patentcenter.uspto.gov. Visit https://www.uspto.gov/patents/apply/patent-center for more information about Patent Center and https://www.uspto.gov/patents/docx for information about filing in DOCX format. For additional questions, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/ZIHENG LU/
Examiner, Art Unit 1752
/Maria Laios/
Primary Examiner, Art Unit 1727

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via the USPTO patent electronic filing system.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications. **Because electronic patent issuance may occur shortly after issue fee payment, any desired continuing application should preferably be filed prior to payment of this issue fee in order not to jeopardize copendency.**

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

62### 759# 01/##/2025
MAIER & MAIER, PLLC
345 SOUTH PATRICK STREET
ALEXANDRIA, VA 22314

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via the USPTO patent electronic filing system or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/707,129	03/29/2022	Ting YI	14850059US	6210

TITLE OF INVENTION: NEGATIVE ELECTRODE AND ELECTROCHEMICAL APPARATUS CONTAINING SAME, AND ELECTRONIC APPARATUS

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1200	$0.00	$0.00	$1200	04/08/2025

EXAMINER	ART UNIT	CLASS-SUBCLASS
LU, ZIHENG NMN	1752	429-209000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/AIA/122 or PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/AIA/47 or PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Maier & Maier, PLLC
2
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: NINGDE AMPEREX TECHNOLOGY LIMITED
(B) RESIDENCE: (CITY and STATE OR COUNTRY): Ningde City, CHINA

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. Fees submitted: ☒ Issue Fee ☐ Publication Fee (if required)

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

☒ Electronic Payment via the USPTO patent electronic filing system ☐ Enclosed check ☐ Non-electronic payment by credit card (Attach form PTO-2038)

☒ The Director is hereby authorized to charge ~~the required fee(s)~~, any deficiency, or credit any overpayment to Deposit Account No. 50-5976

5. **Change in Entity Status** (from status indicated above)

☐ Applicant certifying micro entity status. See 37 CFR 1.29
NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

☐ Applicant asserting small entity status. See 37 CFR 1.27
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

☐ Applicant changing to regular undiscounted fee status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature /Timothy J. Maier/ Date April 7, 2025

Typed or printed name Timothy J. Maier Registration No. 51986

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UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC PAYMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
17/707,129	**04/07/2025 01:41:20 PM Z ET**	**14850059US**

Title of Invention

NEGATIVE ELECTRODE AND ELECTROCHEMICAL APPARATUS CONTAINING SAME, AND ELECTRONIC APPARATUS

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	6210	FILED BY	Mark Gambriel
PATENT CENTER #	69894023	AUTHORIZED BY	Timothy Maier
CUSTOMER #	62008	FILING DATE	03/29/2022
CORRESPONDENCE ADDRESS	-	FIRST NAMED INVENTOR	Ting YI

Payment Information

PAYMENT METHOD	PAYMENT TRANSACTION ID	PAYMENT AUTHORIZED BY
CARD / 8716	**E202547D41387729**	**Mark Gambriel**

FEE CODE	DESCRIPTION	ITEM PRICE($)	QUANTITY	ITEM TOTAL($)
1501	UTILITY ISSUE FEE	1200.00	1	1200.00
			TOTAL AMOUNT:	**$1,200.00**

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage

submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
17/707,129	**04/07/2025 01:41:20 PM Z ET**	**14850059US**

Title of Invention

NEGATIVE ELECTRODE AND ELECTROCHEMICAL APPARATUS CONTAINING SAME, AND ELECTRONIC APPARATUS

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	6210	FILED BY	Mark Gambriel
PATENT CENTER #	69894023	FILING DATE	03/29/2022
CUSTOMER #	62008	FIRST NAMED INVENTOR	Ting YI
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	Timothy Maier

Documents

TOTAL DOCUMENTS: 1

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
PAT201909057US1-Issue Fee Transmittal.pdf	1	Issue Fee Payment (PTO-85B)	118 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
PAT201909057US1-Issue Fee Transmittal.pdf	60C1348CB4A1EDA98612B87CCB91B836CED86D97865D087A9E8B2D05AD34D4E11A602DC16E6553E807229595675E94196FF9279FBC3A5B816ED3ECBDCE1B1A34

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

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New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
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.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	
	Filing Date	2022-03-29
	First Named Inventor	Ting YI
	Art Unit	TBD
	Examiner Name	TBD
	Attorney Docket Number	14850059US

U.S.PATENTS Remove

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	1					

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	1	20130171502	A1	2013-07-04	CHEN GUORONG ET AL	Cited in NPL cite No. 1
Change(s) applied to document, /M.E.G/ 1/15/2025	2	20190305317	A1	2019-10-03	Cheng et al. ~~NEC CORPORATION~~	Cited in NPL cite No. 1
	3	20070048615	A1	2007-03-01	Nagayama et al. ~~PANASONIC CORPORATION~~	Cited in NPL cite No. 2

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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	109841794	CN	A	2019-06-04	NINGDE AMPEREX TECHNOLOGY LTD	Cited in NPL cite No. 1; English Abstract Attached	

EFS Web 2.1.18

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /Z.L./

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UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/707,129	05/06/2025	12294082	14850059US	6210

62008 7590 04/16/2025

MAIER & MAIER, PLLC
345 SOUTH PATRICK STREET
ALEXANDRIA, VA 22314

ISSUE NOTIFICATION

The projected patent number and issue date are specified above. The patent will issue electronically. The electronically issued patent is the official patent grant pursuant to 35 U.S.C. § 153. The patent may be accessed on or after the issue date through Patent Center at https://patentcenter.uspto.gov/. The patent will be available in both the public and the private sides of Patent Center. Further assistance in electronically accessing the patent, or about Patent Center, is available by calling the Patent Electronic Business Center at 1-888-217-9197.

The USPTO is implementing electronic patent issuance with a transition period, during which period the USPTO will mail a ceremonial paper copy of the electronic patent grant to the correspondence address of record. Additional copies of the patent (i.e., certified and presentation copies) may be ordered for a fee from the USPTO's Certified Copy Center at https://certifiedcopycenter.uspto.gov/index.html. The Certified Copy Center may be reached at (800)972-6382.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 504 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Center (https://patentcenter.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Patents Stakeholder Experience (OPSE), Stakeholder Support Division (SSD) at (571)-272-4200.

INVENTOR(s) (Please see PATENT CENTER site https://patentcenter.uspto.gov for additional inventors):

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