UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/000,764	11/10/2020	10833355	DHNG001.005AUS	2445

20995 7590 10/21/2020

KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

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 192 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 Application Information Retrieval (PAIR) WEB site (http://pair.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 Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Jianjian Yi, Ningde, CHINA;
Ningde Amperex Technology Limited, Ningde, CHINA;
Xinzhi Zhang, Ningde, CHINA;
Zengbin Wei, Ningde, CHINA;
Xinghua Tao, Ningde, CHINA;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

IR103 (Rev. 10/09)

UNITED STATES PATENT AND TRADEMARK OFFICE

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 NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
16/000,764	06/05/2018	Jianjian Yi	DHNG001.005AUS

CONFIRMATION NO. 2445

POA ACCEPTANCE LETTER

20995
KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

OC000000120378299

Date Mailed: 10/05/2020

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 10/01/2020.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/dtdinh/

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

PTO/AIA/82A (07-13)
Approved for use through 01/31/2018. OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

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

Application Number	16/000764
Filing Date	June 5, 2018
First Named Inventor	Jianjian Yi
Title	POROUS FILM AND LITHIUM-ION BATTERY
Art Unit	1727
Examiner Name	Gary D. Harris
Attorney Docket Number	DHNG001.005AUS

SIGNATURE of Applicant or Patent Practitioner

Signature	/Xiaoyu Wang/	Date (Optional)	
Name	Xiaoyu Wang	Registration Number	75640
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 _____ forms are submitted.

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

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

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

PTO/AIA/82B (07-13)
Approved for use through 01/31/2018. OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number

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: 20995

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	Manager,Ningde Amperex Technology Limited		

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 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.

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 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 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.

Electronic Patent Application Fee Transmittal

Application Number:	16000764
Filing Date:	05-Jun-2018
Title of Invention:	POROUS FILM AND LITHIUM-ION BATTERY
First Named Inventor/Applicant Name:	Jianjian Yi
Filer:	Xiaoyu Wang/Priya Patel
Attorney Docket Number:	DHNG001.005AUS

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
UTILITY APPL ISSUE FEE	1501	1	1000	1000

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**1000**

Electronic Acknowledgement Receipt	
EFS ID:	40730225
Application Number:	16000764
International Application Number:	
Confirmation Number:	2445
Title of Invention:	POROUS FILM AND LITHIUM-ION BATTERY
First Named Inventor/Applicant Name:	Jianjian Yi
Customer Number:	20995
Filer:	Xiaoyu Wang/Gustavo Lopez
Filer Authorized By:	Xiaoyu Wang
Attorney Docket Number:	DHNG001.005AUS
Receipt Date:	01-OCT-2020
Filing Date:	05-JUN-2018
Time Stamp:	14:05:15
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1000
RAM confirmation Number	E202001E05549763
Deposit Account	111410
Authorized User	Gustavo Lopez
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)	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Post Allowance Communication - Incoming	Comments_DHNGO01.pdf	21138 fe8ce23ed4e42de4df9846a022784ce9fefc90da	no	2
Warnings:					
Information:					
2	Issue Fee Payment (PTO-85B)	Issue_Fee_DHNG001.pdf	198731 7e9de3a3353106e4f1854b05ff8d9c5d40e9d11d	no	1
Warnings:					
Information:					
3	Power of Attorney	POA_DHNG001.pdf	2374199 b4896b4bbc4bb40443e6d15b6213537c267e825c	no	3
Warnings:					
Information:					
4	Fee Worksheet (SB06)	fee-info.pdf	30165 5bf3ec5fd8d3b599adf8334f9db5af4cc181b371	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	2624233		

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 a 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.

Please Direct All Correspondence to Customer Number **20,995**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Inventor	:	Jianjian Yi
App. No.	:	16/000,764
Filed	:	June 5, 2018
For	:	POROUS FILM AND LITHIUM-ION BATTERY
Examiner	:	Harris, Gary D.
Art Unit	:	1727
Conf. No.	:	2445

COMMENTS ON STATEMENT OF REASONS FOR ALLOWANCE

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

In response to the Statement of Reasons for Allowance in the Notice of Allowance dated August 24, 2020, the Applicant respectfully submits the following comments. Applicant acknowledges the Statement of Reasons for Allowance in the above-referenced patent application and agrees that the claimed subject matter is patentable. However, Applicant takes no position regarding the Reasons for Allowance presented by the Examiner and therefore respectfully traverses them. Therefore, the Examiner's Reasons for Allowance should not be attributed to Applicant as an indication of the basis for Applicant's belief that the claims are patentable. Additionally, Applicant respectfully disagrees with the Examiner's Statement of Reasons for Allowance to the extent it may suggest that a given claim requires limitations that are not explicitly recited therein. And to the extent that the paraphrasing of the subject matter of the claims deviates from the actual language of the claims, Applicant respectfully reserves the right to disagree with the Reasons for Allowance. Also, to the extent that there is any implication that the patentability of the claims rests on the recitation of one or more features, Applicant respectfully disagrees with the Examiner's Statement because it is the combination of features that makes the claims patentable and not any particular feature or sub-combination of

elements. Applicant reserves the right to pursue at a later date any previously pending or other broader or narrower claims that capture any subject matter supported by the application's disclosure. Accordingly, reviewers of this or any child or related prosecution history shall not reasonably infer that the Applicants have made any disclaimers or disavowals of any subject matter.

Please charge any additional fees, including any fees for additional extension of time, or credit overpayment to Deposit Account No. 11-1410.

Dated: October 1, 2020

By: /Xiaoyu Wang/
Xiaoyu Wang
Registration No. 75,640
Patent Practitioner
(212) 849-3000

33498404

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

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 including the Patent, advance orders and notification of maintenance fees 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.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

20995 7590 08/24/2020
KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

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 EFS-Web 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.
16/000,764	06/05/2018	Jianjian Yi	DHNG001.005AUS	2445

TITLE OF INVENTION: POROUS FILM AND LITHIUM-ION BATTERY

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1000	$0.00	$0.00	$1000	11/24/2020

EXAMINER	ART UNIT	CLASS-SUBCLASS
HARRIS, GARY D	1727	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/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 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 Knobbe, Martens, Olson & Bear, LLP
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)
Ningde Amperex Technology Limited	Ningde, Fujian, 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) ☐ Advance Order - # of Copies _____

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

☒ Electronic Payment via EFS-Web ☐ 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. 11-1410

5. **Change in Entity Status** (from status indicated above)

☐ Applicant certifying micro entity status. See 37 CFR 1.29

☐ Applicant asserting small entity status. See 37 CFR 1.27

☐ Applicant changing to regular undiscounted fee status.

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.
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.
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 /Xiaoyu Wang/ Date 2020-10-01

Typed or printed name Xiaoyu Wang Registration No. 75640

Zhuhai CosMX Battery Co. - EX1014
Zhuhai CosMX Battery Co. v. Ningde Amperex Tech. Ltd.
Page 13 of 206

UNITED STATES PATENT AND TRADEMARK OFFICE

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

NOTICE OF ALLOWANCE AND FEE(S) DUE

20995 7590 08/24/2020
KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

EXAMINER	
HARRIS, GARY D	
ART UNIT	PAPER NUMBER
1727	

DATE MAILED: 08/24/2020

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/000,764	06/05/2018	Jianjian Yi	DHNG001.005AUS	2445

TITLE OF INVENTION: POROUS FILM AND LITHIUM-ION BATTERY

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1000	$0.00	$0.00	$1000	11/24/2020

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 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity 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 and an extra copy of the form should be submitted. 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. 02/11)

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

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 including the Patent, advance orders and notification of maintenance fees 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.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

20995 7590 08/24/2020
KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

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 EFS-Web 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.
16/000,764	06/05/2018	Jianjian Yi	DHNG001.005AUS	2445

TITLE OF INVENTION: POROUS FILM AND LITHIUM-ION BATTERY

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1000	$0.00	$0.00	$1000	11/24/2020

EXAMINER	ART UNIT	CLASS-SUBCLASS
HARRIS, GARY D	1727	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/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 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) ❑Advance Order - # of Copies _____

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

❑ Electronic Payment via EFS-Web ❑ 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

❑ Applicant asserting small entity status. See 37 CFR 1.27

❑ Applicant changing to regular undiscounted fee status.

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.
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.
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 (08-18) Approved for use through 01/31/2020 OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

UNITED STATES PATENT AND TRADEMARK OFFICE

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.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/000,764	06/05/2018	Jianjian Yi	DHNG001.005AUS	2445

20995 7590 08/24/2020

KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

EXAMINER	
HARRIS, GARY D	

ART UNIT	PAPER NUMBER
1727	

DATE MAILED: 08/24/2020

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. 02/11)

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. 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.

Notice of Allowability	Application No. 16/000,764	Applicant(s) Yi et al.	
	Examiner GARY D HARRIS	Art Unit 1727	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 remarks and amendment filed on 07/22/2020.
   ☐ 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 1-2 and 6-10 . 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 _____.

/GARY D HARRIS/
Primary Examiner, Art Unit 1727

Zhuhai CosMX Battery Co. - EX1014
Zhuhai CosMX Battery Co. v. Ningde Amperex Tech. Ltd.

Notice of Pre-AIA or AIA Status

The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

DETAILED ACTION

EXAMINER'S AMENDMENT

An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

The application has been amended as follows:

Claims 11-20 are cancelled in view of the restriction requirement filed on 04/10/2020.

Allowable Subject Matter

Claims 1-2 & 6-10 are allowed.

The following is an examiner's statement of reasons for allowance:

The art made of record Murata et al. US 2017/0194613 discloses a porous film (membrane, see abstract and title), comprising: a binder (see abstract); and inorganic particles [0073-0075]. The porous film comprises pores formed by the binder [0086] given pores are found within the binder and porous layer. The pores at least comprises a part of the inorganic particles (filler).

However, Murata fails to teach, suggest or render obvious the particles sizes and ranges as required in the independent claim and as argued by applicant in response filed 07/22/2020.

This application is in condition for allowance except for the presence of claims 11-20 directed to a lithium-ion battery non-elected without traverse in the response filed on 04/10/2020. Accordingly, Claims 11-20 have been canceled.

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

Any inquiry concerning this communication or earlier communications from the examiner should be directed to GARY D HARRIS whose telephone number is (571)272-6508. The examiner can normally be reached on Mon-Sat. 5:30AM-8PM EST (flex).

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Barbara Gilliam can be reached on (571)272-1330. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/GARY D HARRIS/
Primary Examiner, Art Unit 1727

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/000,764	Yi et al.
	Examiner	Art Unit
	GARY D HARRIS	1727

✓	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	04/17/2020	08/17/2020							
	1	✓	=							
	2	✓	=							
	3	✓	-							
	4	✓	-							
	5	✓	-							
	6	✓	=							
	7	✓	=							
	8	✓	=							
	9	✓	=							
	10	✓	=							
	11	÷	-							
	12	÷	-							
	13	÷	-							
	14	÷	-							
	15	÷	-							
	16	÷	-							
	17	÷	-							
	18	÷	-							
	19	÷	-							
	20	÷	-							

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/000,764	Yi et al.
	Examiner	**Art Unit**
	GARY D HARRIS	1727

CPC						
Symbol					**Type**	**Version**
H01M	/	10	/	0525	F	2013-01-01
H01M	/	4	/	623	I	2013-01-01
H01M	/	2	/	164	I	2013-01-01
H01M	/	4	/	583	I	2013-01-01
H01M	/	4	/	661	I	2013-01-01
H01M	/	2	/	145	I	2013-01-01
H01M	/	2004	/	028	A	2013-01-01
H01M	/	2004	/	027	A	2013-01-01

CPC Combination Sets							
Symbol					**Type**	**Set**	**Ranking**	**Version**
	/		/					

NONE (Assistant Examiner)	(Date)	**Total Claims Allowed:** 7	
/GARY D HARRIS/ Primary Examiner, Art Unit 1727 (Primary Examiner)	17 August 2020 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 2

U.S. Patent and Trademark Office — Part of Paper No.: 20200817

Zhuhai CosMX Battery Co. - EX1014
Zhuhai CosMX Battery Co. v. Ningde Amperex Tech. Ltd.
Page 23 of 206

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/000,764	Yi et al.
	Examiner	Art Unit
	GARY D HARRIS	1727

INTERNATIONAL CLASSIFICATION				
CLAIMED				
H01M	/	10	/	0525

NON-CLAIMED				
	/		/	

US ORIGINAL CLASSIFICATION	
CLASS	SUBCLASS
429	209

CROSS REFERENCES(S)						
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)					

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	7	
/GARY D HARRIS/ Primary Examiner, Art Unit 1727	17 August 2020	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2

U.S. Patent and Trademark Office — Part of Paper No.: 20200817

Zhuhai CosMX Battery Co. - EX1014
Zhuhai CosMX Battery Co. v. Ningde Amperex Tech. Ltd.
Page 24 of 206

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/000,764	Yi et al.
	Examiner	Art Unit
	GARY D HARRIS	1727

☐ 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	7	10	-	19										
2	2	-	11	-	20										
-	3	-	12												
-	4	-	13												
-	5	-	14												
3	6	-	15												
4	7	-	16												
5	8	-	17												
6	9	-	18												

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	7	
/GARY D HARRIS/ Primary Examiner, Art Unit 1727	17 August 2020	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2

U.S. Patent and Trademark Office Part of Paper No.: 20200817

Zhuhai CosMX Battery Co. - EX1014
Zhuhai CosMX Battery Co. v. Ningde Amperex Tech. Ltd.
Page 25 of 206

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/000,764	Yi et al.
	Examiner	Art Unit
	GARY D HARRIS	1727

CPC - Searched*		
Symbol	Date	Examiner
(H01M10/0525 H01M2/145 H01M4/661 H01M4/583 H01M2/164 H01M4/623 H01M2004/027 H01M2004/028 or H01M2/166 H01M2/1646 H01M2/1653 H01M2/16 H01M2/1606).cpc.	04/17/2020	gh

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner
429	209	04/17/2020	gh

* 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
Assignee, inventor name and key word search in EAST.	04/17/2020	gh
Updated EAST search based on amendments and remarks.	08/17/2020	gh

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
H01M	10/0525 4/623 2/164 4/583 4/661 2/145 2004/028 2004/027 2/1653 2/1646 2/166 2/1606 2/16	08/17/2020	gh
429	209	08/17/2020	gh

/GARY D HARRIS/ Primary Examiner, Art Unit 1727	

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L12	1,602,014	"11" and (binder, polyvinylidene adj fluoride, vinylidene adj fluoride$1hexafluoropropylene adj copolymer, polyamide, polyacrylonitrile, polyacrylate, polyacrylic adj acid, polyacrylic adj acid adj salt, sodium adj carboxymethylcellulose, polyvinylpyrrolidone, polyvinyl adj ether, polymethyl adj methacrylate, polytetrafluoroethylene, polyhexafluoropropylene)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/08/17 14:30
S2	2	(US-1234567-$ | US-28676403-$).DID.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 10:13
S3	5	(AI-1234567-$ | CN-103474602-$ | CN-205004376-$ | JP-1234567-$).DID.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 10:14
S4	2	"16000764"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 10:21
S5	19,457	porous with inorganic with particle	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:20
S6	67,912	(porous, pores, porosity) with binder	US-PGPUB; USPAT; USOCR; FPRS; EPO;	OR	ON	2020/04/17 11:20

			JPO; DERWENT; IBM_TDB			
S7	119,978	(porous, pores, porosity) with (nanometer, nm)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:21
S8	137,888	(porous, pores, porosity) with size with (micro, micron, micro$1meter ".mu.m")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:23
S9	5,978	S5 and S6	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:24
S10	7,350	S6 and S7	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:24
S11	19,936	S7 and S8	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:25
S12	1,316	S9 and S10	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:25
S13	2,183	S10 and S11	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO;	OR	ON	2020/04/17 11:25

			DERWENT; IBM_TDB			
S14	507	S12 and S13	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:25
S15	189,519	(H01M10/0525 or H01M2/145 or H01M4/661 or H01M4/583 or H01M2/164 or H01M4/623 or H01M2004/027 or H01M2004/028 or H01M2/166 or H01M2/1646 or H01M2/1653 or H01M2/16 or H01M2/1606).cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:26
S16	3,783	429/209.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:26
S17	191,425	S15 S16	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:26
S18	207	S14 and S17	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:27
S19	195	S18 and (alumina, silica, magnesia, titanium adj oxide, hafnium adj dioxide, tin adj oxide, cerium adj dioxide, nickel adj oxide, zirconia)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:30
S20	41	S18 and (magnesium adj hydroxide, calcium adj hydroxide, barium adj sulfate)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO;	OR	ON	2020/04/17 11:33

			DERWENT; IBM_TDB			
S21	58	S18 and (zinc adj oxide, calcium adj oxide)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:34
S22	196	S19 S20	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:35
S23	196	S21 S22	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:37
S24	189	S23 and (porous, pores, porosity) with binder same (film, layer, coat$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:38
S25	1	S24 and (porous, pores, porosity) with (nanometer, nm) with wall adj thickness	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:39
S26	1	S24 and (porous, pores, porosity) with (nanometer, nm) same wall adj thickness	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:40
S27	85	S24 and (porous, pores, porosity) with (nanometer, nm) same thickness	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO;	OR	ON	2020/04/17 11:40

			DERWENT; IBM_TDB			
S28	46	S27 and (porous, pores, porosity) with (average, avg) with size with (micro, micron, micro$1meter".mu.m")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:41
S29	46	S28 and (polyvinylidene adj fluoride, vinylidene adj fluoride$1hexafluoropropylene adj copolymer, polyamide, polyacrylonitrile, polyacrylate, polyacrylic adj acid, polyacrylic adj acid adj salt, sodium adj carboxymethylcellulose, polyvinylpyrrolidone, polyvinyl adj ether, polymethyl adj methacrylate, polytetrafluoroethylene, polyhexafluoropropylene)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:44
S30	35	S28 and binder same (polyvinylidene adj fluoride, vinylidene adj fluoride$1hexafluoropropylene adj copolymer, polyamide, polyacrylonitrile, polyacrylate, polyacrylic adj acid, polyacrylic adj acid adj salt, sodium adj carboxymethylcellulose, polyvinylpyrrolidone, polyvinyl adj ether, polymethyl adj methacrylate, polytetrafluoroethylene, polyhexafluoropropylene)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:45
S31	1	S30 and ("Dv10", "Dv50")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:47
S32	15	S30 and particle adj size same range	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:48
S33	1	S31 and particle adj size same range.clm.	US-PGPUB; USPAT; USOCR;	OR	ON	2020/04/17 11:52

			FPRS; EPO; JPO; DERWENT; IBM_TDB			
S34	1	S31 and (porous, pores, porosity) with binder same (film, layer, coat$3).clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:53
S35	2	"16000764"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 14:06

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	2,101	429/209.ccls.	US-PGPUB; USPAT	OR	ON	2020/08/17 14:08
L2	41,066	(H01M10/0525 or H01M4/623 or H01M2/164 or H01M4/583 or H01M4/661 or H01M2/145 or H01M2004/028 or H01M2004/027 or H01M2/1653 or H01M2/1646 or H01M2/166 or H01M2/1606 or H01M2/16).cpc.	US-PGPUB; USPAT	OR	ON	2020/08/17 14:09
L3	41,066	(H01M10/0525 H01M4/623 H01M2/164 H01M4/583 H01M4/661 H01M2/145 H01M2004/028 H01M2004/027 H01M2/1653 H01M2/1646 H01M2/166 H01M2/1606 H01M2/16).cpc.	US-PGPUB; USPAT	OR	ON	2020/08/17 14:10
L4	17,012	(porous, pores, porosity, nano$1porous) with binder same (film, layer, coat$3)	US-PGPUB; USPAT	OR	ON	2020/08/17 14:21
L5	102,753	(porous, pores, porosity, nano$1porous) same (thick$4, diameter) with (nm, nanometer, micro, micron, micrometer)	US-PGPUB; USPAT	OR	ON	2020/08/17 14:23
L6	4,655	4 and 5	US-PGPUB; USPAT	OR	ON	2020/08/17 14:24
L7	4,655	6 and (size, diameter, thick$4) with (nm, nanometer, micro, micron, micrometer)	US-PGPUB; USPAT	OR	ON	2020/08/17 14:25

L8	34	6 and (size, diameter, thick$4) with (nm, nanometer, micro, micron, micrometer) same Dv	US-PGPUB; USPAT	OR	ON	2020/08/17 14:26
L10	1,882	6 and (size, diameter, thick$4) with (nm, nanometer, micro, micron, micrometer) same (volume, accumulation, Dv)	US-PGPUB; USPAT	OR	ON	2020/08/17 14:27
L11	390	10 and (size, diameter, thick$4) with (micro, micron, micrometer) with (volume, accumulation, Dv)	US-PGPUB; USPAT	OR	ON	2020/08/17 14:28
L13	390	11 and (binder, polyvinylidene adj fluoride, vinylidene adj fluoride$1hexafluoropropylene adj copolymer, polyamide, polyacrylonitrile, polyacrylate, polyacrylic adj acid, polyacrylic adj acid adj salt, sodium adj carboxymethylcellulose, polyvinylpyrrolidone, polyvinyl adj ether, polymethyl adj methacrylate, polytetrafluoroethylene, polyhexafluoropropylene)	US-PGPUB; USPAT	OR	ON	2020/08/17 14:30
L14	233	11 and (binder, polyvinylidene adj fluoride, vinylidene adj fluoride$1hexafluoropropylene adj copolymer, polyamide, polyacrylonitrile, polyacrylate, polyacrylic adj acid, polyacrylic adj acid adj salt, sodium adj carboxymethylcellulose, polyvinylpyrrolidone, polyvinyl adj ether, polymethyl adj methacrylate, polytetrafluoroethylene, polyhexafluoropropylene).clm.	US-PGPUB; USPAT	OR	ON	2020/08/17 14:31
L15	70	14 and (size, diameter, thick$4) with (micro, micron, micrometer) with (volume, accumulation, Dv).clm.	US-PGPUB; USPAT	OR	ON	2020/08/17 14:32
L16	65	15 and (diameter, size, thick$4) same range	US-PGPUB; USPAT	OR	ON	2020/08/17 14:33
L17	43	16 and (diameter, size, thick$4) same range with (micro, micron, inch, inches)	US-PGPUB; USPAT	OR	ON	2020/08/17 14:34
L18	24	17 and (diameter, size, thick$4) same range with (micro, micron, inch, inches).clm.	US-PGPUB; USPAT	OR	ON	2020/08/17 14:35
L19	4	18 and (inorganic, alumina, silica, magnesia, titanium adj oxide, hafnium adj dioxide, tin adj oxide, cerium adj dioxide, nickel adj oxide, zirconia, zinc adj oxide, calcium adj oxide, boehmite, aluminum adj hydroxide, magnesium adj hydroxide, calcium adj hydroxide, barium adj sulfate) with (diameter, size, thick$4) same range with (micro, micron, inch, inches).clm.	US-PGPUB; USPAT	OR	ON	2020/08/17 14:38

L20	42,101	1, 2	US-PGPUB; USPAT	OR	ON	2020/08/17 14:39
L21	0	19 and 20	US-PGPUB; USPAT	OR	ON	2020/08/17 14:39
L22	6	18 and 20	US-PGPUB; USPAT	OR	ON	2020/08/17 14:40
S36	39,113	(H01M10/0525 H01M2/145 H01M4/661 H01M4/583 H01M2/164 H01M4/623 H01M2004/027 H01M2004/028 or H01M2/166 H01M2/1646 H01M2/1653 H01M2/16 H01M2/1606).cpc.	US-PGPUB; USPAT	OR	ON	2020/04/17 15:07
S37	2,101	429/209.ccls.	US-PGPUB; USPAT	OR	ON	2020/04/17 15:08

8/17/2020 2:41:52 PM
C:\Users\gharris\Documents\EAST\Workspaces\16000764.wsp

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BIB DATA SHEET

CONFIRMATION NO. 2445

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
16/000,764	06/05/2018	429	1727	DHNG001.005AUS

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**** CONTINUING DATA ***************************

**** FOREIGN APPLICATIONS ***************************
CHINA 201810322931.1 04/11/2018

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****
06/26/2018

Foreign Priority claimed ☑ Yes ☐ No 35 USC 119(a-d) conditions met ☑ Yes ☐ No Verified and Acknowledged /GARY D HARRIS/ Examiner's Signature	☐ Met after Allowance Initials	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
		CHINA	2	20	2

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TITLE
POROUS FILM AND LITHIUM-ION BATTERY

FILING FEE RECEIVED	FEES: Authority has been given in Paper	
1880	No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

BIB (Rev. 05/07).

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Inventor	:	Jianjian Yi
App. No.	:	16/000,764
Filed	:	June 5, 2018
For	:	POROUS FILM AND LITHIUM-ION BATTERY
Examiner	:	Harris, Gary D.
Art Unit	:	1727
Conf. No.	:	2445

AMENDMENT AND RESPONSE TO NON-FINAL OFFICE ACTION DATED APRIL 20, 2020

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

The Office Action mailed on April 22, 2020, has been carefully considered. In response thereto, Applicants hereby submit the following amendments and remarks.

Amendments to the Claims are reflected in the listing of claims which begins on page 2 of this paper.

Remarks/Argument begin on page 6 of this paper.

Amendments to the Claims

This listing of claims will replace all prior versions, and listings, of claims.

Listing of Claims

1. (Currently amended) A porous film, comprising:

a binder; and

inorganic particles;

wherein the porous film comprises pores formed by the binder, the pores at least comprises a part of the inorganic particles, and the average wall thickness between the pores is in a range of 20 nm to 500 nm, wherein the inorganic particles have particle sizes that Dv10 is in a range of 0.015 μm to 3 μm, Dv50 is in a range of 0.2 μm to 5 μm, Dv90 is in a range of 1 μm to 10 μm; Dv10 is less than Dv50, and Dv50 is less than Dv90; and the ratio of Dv90 to Dv10 is in a range of 2 to 100 .

2. (Original) The porous film according to claim 1, wherein the porous film has an average pore size of 0.3 μm to 20 μm.

3. (Cancelled)

4. (Cancelled)

5. (Cancelled)

6. (Original) The porous film according to claim 1, wherein a pore size distribution

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coefficient of the pores in the porous film is in a range of 1 to 5.

7. (Original) The porous film according to claim 1, wherein the inorganic particles are at least one of alumina, silica, magnesia, titanium oxide, hafnium dioxide, tin oxide, cerium dioxide, nickel oxide, zirconia, zinc oxide, calcium oxide, boehmite, aluminum hydroxide, magnesium hydroxide, calcium hydroxide, and barium sulfate.

8. (Original) The porous film according to claim 1, wherein the binder is at least one of polyvinylidene fluoride, vinylidene fluoride-hexafluoropropylene copolymer, polyamide, polyacrylonitrile, polyacrylate, polyacrylic acid, polyacrylic acid salt, sodium carboxymethylcellulose, polyvinylpyrrolidone, polyvinyl ether, polymethyl methacrylate, polytetrafluoroethylene and polyhexafluoropropylene.

9. (Original) The porous film according to claim 1, wherein the porous film has a porosity of 20% to 90%, and the porous film has a thickness of 0.2 to 10 μm.

10. (Original) The porous film according to claim 1, wherein a volume ratio of the inorganic particles to the binder is in a range of 0.2 to 3.0.

11. (Withdrawn) A lithium-ion battery, comprising:

a positive electrode;

a negative electrode;

a separator, arranged between the positive electrode and the negative electrode;

non-aqueous electrolyte; and

a porous film, comprising:

a binder; and

inorganic particles;

wherein the porous film comprises pores formed by the binder, the pores at least comprises a part of the inorganic particles, and the average wall thickness between the pores is in a range of 20 nm to 500 nm.

12. (Withdrawn) The lithium-ion battery according to claim 11, wherein the porous film has an average pore size of 0.3 μm to 20 μm.

13. (Withdrawn) The lithium-ion battery according to claim 11, wherein the inorganic particles have particle sizes that Dv10 is in a range of 0.015 μm to 3 μm, Dv50 is in a range of 0.2 μm to 5 μm, and Dv90 is in a range of 1 μm to 10 μm.

14. (Withdrawn) The lithium-ion battery according to claim 13, wherein Dv10 of the inorganic particles is less than Dv50 of the inorganic particles, and Dv50 of the inorganic particles is less than Dv90 of the inorganic particles.

15. (Withdrawn) The lithium-ion battery according to claim 11, wherein the inorganic particles have particle sizes that the ratio of Dv90 to Dv10 is in a range of 2 to 100.

16. (Withdrawn) The lithium-ion battery according to claim 11, wherein a pore size

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distribution coefficient of the pores in the porous film is in a range of 1 to 5.

17. (Withdrawn) The lithium-ion battery according to claim 11, wherein the inorganic particles are at least one of alumina, silica, magnesia, titanium oxide, hafnium dioxide, tin oxide, cerium dioxide, nickel oxide, zirconia, zinc oxide, calcium oxide, boehmite, aluminum hydroxide, magnesium hydroxide, calcium hydroxide, and barium sulfate.

18. (Withdrawn) The lithium-ion battery according to claim 11, wherein the binder is at least one of polyvinylidene fluoride, vinylidene fluoride-hexafluoropropylene copolymer, polyamide, polyacrylonitrile, polyacrylate, polyacrylic acid, polyacrylic acid salt, sodium carboxymethylcellulose, polyvinylpyrrolidone, polyvinyl ether, polymethyl methacrylate, polytetrafluoroethylene and polyhexafluoropropylene.

19. (Withdrawn) The lithium-ion battery according to claim 11, wherein the porous film has a porosity of 20% to 90%, and the porous film has a thickness of 0.2 to 10 μm, and a volume ratio of the inorganic particles to the binder is in a range of 0.2 to 3.0.

20. (Withdrawn) The lithium-ion battery according to claim 11, wherein the porous film is arranged on a surface of at least one of the positive electrode, the negative electrode and the separator.

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REMARKS

This paper is filed in response to the Office Action mailed April 22, 2020, (hereinafter "Office Action") in connection with the above-referenced application. By way of summary, Claims 1-10 were pending in the application, and Claims 11-20 were previously withdrawn. In this response, Claim 1 is being amended. Claims 3-5 have been cancelled. Applicant believes no new subject matter is being added. The amendments are being made in view of the interview to advance prosecution of the application, and not for patentability or patent eligibility purposes. Applicant reserves the right to pursue the previously pending claims in this or in a continuing application. Upon entry of the amendments, Claims 1-2 and 6-10 will be pending for consideration.

Rejections Under 35 U.S.C. §102

Claims 1-2 and 7-8 are rejected under 35 U.S.C. § 102 as being anticipated by US 2017/0194613 to Murata et al. Please see the "Rejection of Claims 1-10" section below.

Rejections Under 35 U.S.C. §103

Claims 3-6 and 9-10 are rejected under 35 U.S.C. § 103 as being unpatentable over US 2017/0194613 to Murata et al. Please see the "Rejection of Claims 1-10" section below.

Rejection of Claims 1-10

1. Regarding the comments on the original Claims 1-2, 7-8 in the Office Action

1.1 About Claim 1

The applicant respectfully submits that Murata does not disclose the porous film of Claim 1 comprising pores formed by the binder, the pores at least comprising a part of the inorganic

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particles, and the average wall thickness between the pores being in a range of 20 nm to 500 nm.

First of all, Murata discloses a multilayer porous membrane C (the alleged porous film in the office action). The multilayer porous film C comprises a porous membrane A and a porous layer B laminated on at least one surface of the porous membrane A. Referring to paragraphs 0073-0075 of Murata cited in the office action, the porous layer B comprises an inorganic filler and a resin binder. Next, referring to paragraph 0086 of Murata cited in the office action, it discloses the method of forming the porous layer B. That is, when part or all of the resin binder is dissolved in a solvent to prepare a solution, the solution is laminated on at least one surface of the porous membrane A, and the resin binder is bonded to the porous membrane A by, e.g., removing the solvent by immersion of the membrane in a poor solvent or drying of the membrane. However, the method of the porous layer B disclosed in the paragraph fails to disclose that the resin binder of the porous layer B forms a pore and the pore formed by the binder in the porous layer B at least comprises a part of the inorganic particles. There is no disclosure in Murata that the average wall thickness between the pores is in a range of 20 nm to 500 nm.

Secondly, the office action asserts that the average wall thickness between the pores is in a range of 20 nm to 500 nm in Claim 1, which inherent given the average particle size of the resin binder in Murata is not less than 50 nm. Applicant does not agree with it. Murata does not disclose that the resin binder of the porous layer B forms pores, nor does it disclose or teach that pores at least comprise a part of the inorganic particles. Further, a person skilled in the art could not directly obtain the average wall thickness between the holes formed by the binder simply by the particle size of the resin binder.

In summary, Claim 1 is novel over Murata.

1.2 About Claim 2

Claim 2 of this application further recites “the porous film has an average pore size of 0.3

μm to 20 μm". The pore size of pores defined in Claim 2 is the pore formed by the binder defined in claim 1. The pores at least comprise a part of the inorganic particles. The pores of the porous film have an average pore size of 0.3 μm to 20 μm.

According to paragraph 0122 of Murata cited in the office action, Murata only discloses that the pore size of the porous membrane A is 5 μm or less. However, the pore size of the porous membrane A could not correspond to the average pore size of the porous film in the present application. The specific reasons are as follows:

Firstly, Murata discloses that porous membrane A contains a polyolefin resin and additives. Referring to several methods of forming pores in porous membrane A disclosed in Murata (according to paragraph 0055), Murata does not disclose that the porous membrane A is a membrane formed of a binder and inorganic particles. In addition, Murata also does not disclose that the pores in the porous membrane A are formed of the binder, and inorganic particles are included in the pores. Therefore, the pores in the porous membrane A of Murata could not correspond to the pores in Claim 2.

Secondly, the pore size of the porous membrane A could not reflect the average pore size of the multilayer porous membrane C. Murata discloses that the multilayer porous membrane C includes a porous membrane A and a porous layer B laminated on at least one surface of the porous membrane A. Murata does not disclose that a pore is formed in the porous layer B, nor does it disclose the porous size in the porous layer B. Therefore, those skilled in the art could not obtain the average pore size of the multilayer porous membrane C simply by the average pore size of the porous membrane A.

Therefore, Claim 2 is also novel.

1.3 About Claims 7-8

Claims 7-8 depend from independent Claim 1. Therefore, Claims 7-8 are also novel.

2. Regarding the Amendments to Claim 1

Claims 3-5 have been incorporated into Claim 1, and amended Claim 1 recites the porous film including "the inorganic particles have particle sizes that Dv10 is in a range of 0.015 μm to 3 μm, Dv50 is in a range of 0.2 μm to 5 μm; Dv90 is in a range of 1 μm to 10 μm; Dv10 is less than Dv50, and Dv50 is less than Dv90; the ratio of Dv90 to Dv10 is in a range of 2 to 100."

In this application, the particle size of the inorganic particles defined above is helpful for obtaining a porous film structure with a larger average pore size and smaller average wall thickness between the adjacent pores. However, if the particle sizes of the inorganic particles are too small and are beyond this range, it is difficult to form a pore with a large average pore size. If the particle sizes of the inorganic particles are too large and are beyond this range, the surface of the formed porous film is not uniform, the strength of the porous film is decreased, and the adhesion force of the porous film is decreased. In addition, if Dv90/Dv10 is greater than 100, which will lead to the particle size distribution of the inorganic particles being too wide, the uniformity of the formed pores is poor, and polarization reactions will easily occur in the lithium-ion battery.

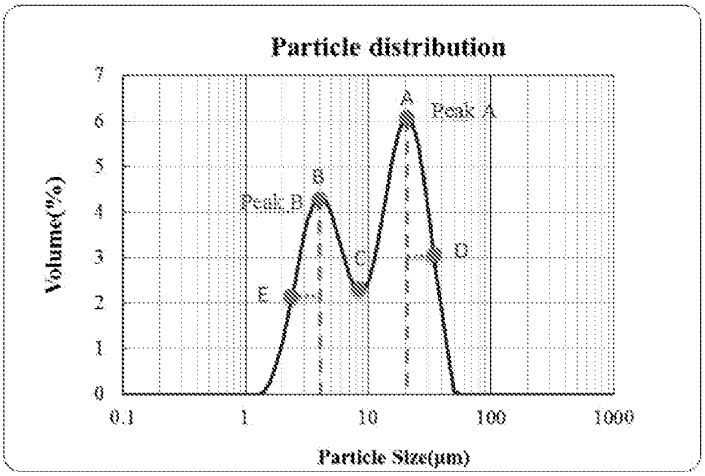
The Office Action asserts that the particle size distribution of the inorganic particles defined in Claims 3-5, which is inherent given the pore size of the porous membrane A in Murata. Applicant respectfully disagrees with the Examiner's assertion.

First, Murata discloses that porous membrane A contains a polyolefin resin and additives. However, Murata does not disclose that the porous membrane A is a membrane formed by a binder and inorganic particles. In addition, Murata also does not disclose that the pores of the porous membrane A are formed by the binder, and inorganic particles are included in the pores. Therefore, the pores in the porous membrane A of Murata could not correspond to the pores in this application.

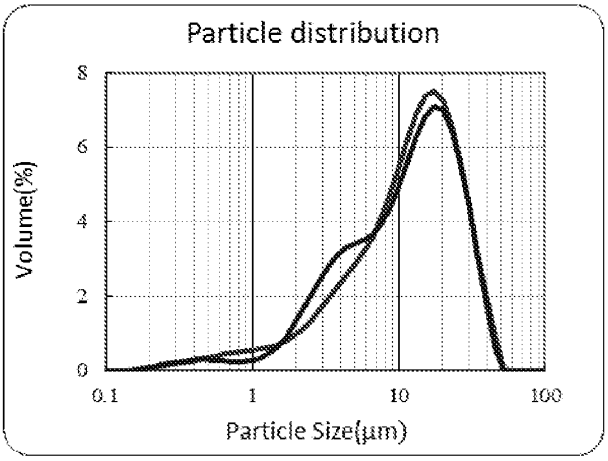
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Second, although the porous layer B disclosed in Murata includes inorganic particles and a binder, Murata does not disclose or teach the porous layer B comprises pores formed by the binder, nor does it disclose the particle size range of Dv10 Dv50, Dv90 of the inorganic particles or the ratio range of Dv90 and Dv10, which is not obvious to those skilled in the art. The specific reasons are as follows:

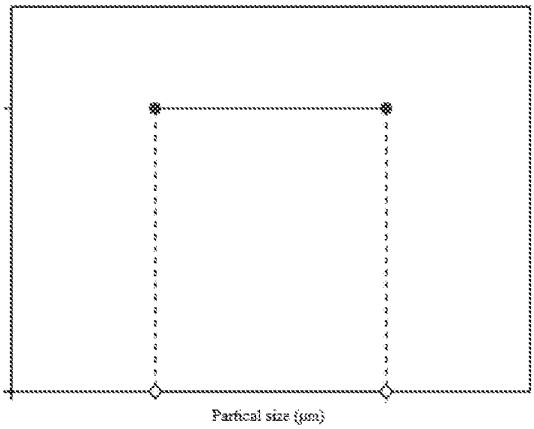
There can be thousands of particle size distribution curves, such as normal distribution, skew distribution, step distribution, saw-tooth distribution, uniform distribution, bimodal distribution, multimodal distribution, (particle size distribution diagram shown below), which requires defining the particle size distribution curve of the particles, that is, further defining the Dv10, Dv50, and Dv90 of the inorganic particles to further define the particle size distribution. Even if the Dv50 of normally distributions are the same, the Dv10 and Dv90 could be much different (as shown in Figure 5).



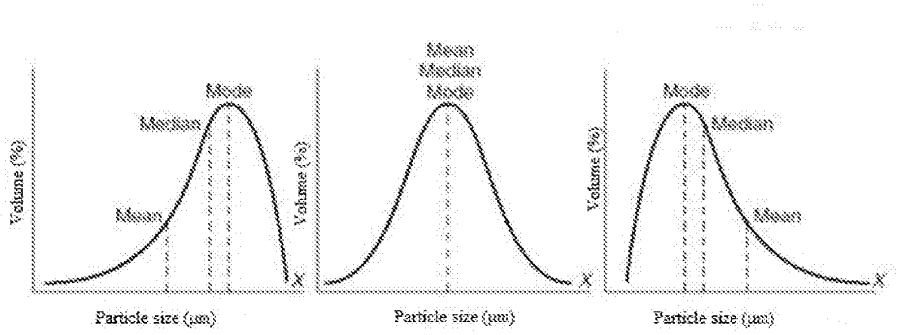
Bimodal distribution (Fig. 1)



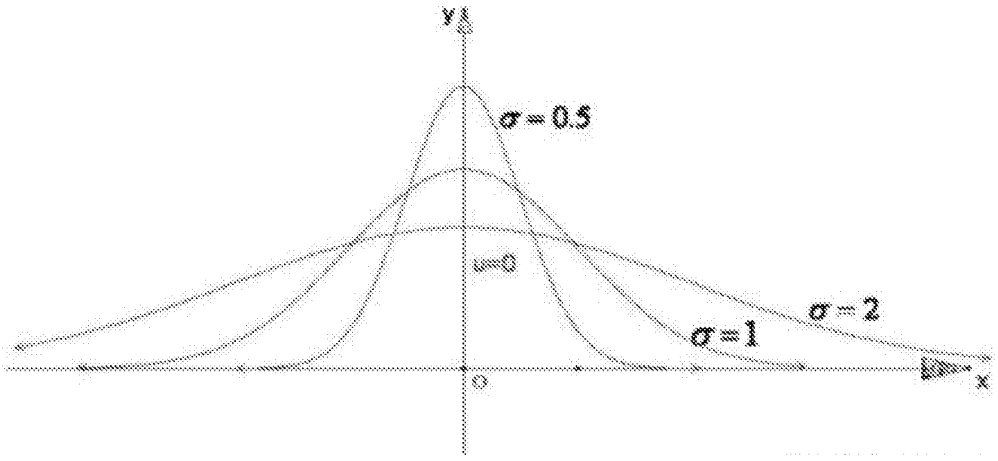
The black line is similar with bimodal distribution. (Fig. 2)



Uniform distribution (Fig. 3)



(Fig. 4)



(Fig. 5)

Finally, those skilled in the art cannot obtain the particle size of the inorganic particles only from the pore size. Referring to paragraph 0022 of this application, the specification of this application describes that the pore size of the porous membrane is related to the inorganic particles themselves. For example, the inorganic particles may contain polar functional groups selected from a hydroxyl group which is helpful for obtaining the pore structures with large average pore sizes and small average wall thickness between the adjacent pores. Referring to paragraph 0023 of this application, the specification of this application describes that the pore size of the porous membrane is related to the particle size distribution (as described in the second

paragraph of section 2.1). With reference to paragraph 0031, the specification of this application describes that the pore size of the porous membrane is related to the volume ratio of the inorganic particles to the binder in the porous film. If the volume ratio of them is lower than 0.2, the average pore size of the porous film is reduced. That is, the present application explains that the pore size of the porous membrane is related to the inorganic particles themselves, the particle size distribution, and the volume ratio of the inorganic particles to the binder. Therefore, a person skilled in the art could not directly obtain the particle size of the inorganic particles only from the size of the pore size in Murata.

To sum up, the amended Claim 1 is not obvious over Murata. Therefore, applicant respectfully submits that Murata fails to disclose or teach the above-recited claim elements in Claim 1 and a person having ordinary skill in the art will not be able to reach at the subject matter claimed in claim 1 of the instant application in view of Murata without involving inventive skill. Thus, Claim 1 is patentable over Murata.

Claims 2, and 6-10 depend from independent Claim 1. It is respectfully submitted that these dependent claims are patentable at least for the reasons explained above for Claim 1.

No Disclaimers or Disavowals

Although the present communication may include alterations to the application or claims, or characterizations of claim scope or referenced art, Applicant is not conceding in this application that previously pending claims are not patentable. Rather, any alterations or characterizations are being made to facilitate expeditious prosecution of this application. Applicant reserves the right to pursue at a later date any previously pending or other broader or narrower claims that capture any subject matter supported by the present disclosure, including subject matter found to be specifically disclaimed herein or by any prior prosecution. Accordingly, reviewers of this or any parent, child or related prosecution history shall not

reasonably infer that Applicant has made any disclaimers or disavowals of any subject matter supported by the present application.

Please charge any additional fees, including any fees for additional extension of time, or credit overpayment to Deposit Account No. 11-1410.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: July 22, 2020

By:/Xiaoyu Wang/

Xiaoyu Wang
Registration No. 75,640
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Electronic Acknowledgement Receipt	
EFS ID:	40073840
Application Number:	16000764
International Application Number:	
Confirmation Number:	2445
Title of Invention:	POROUS FILM AND LITHIUM-ION BATTERY
First Named Inventor/Applicant Name:	Jianjian Yi
Customer Number:	20995
Filer:	Xiaoyu Wang/Christina Graul
Filer Authorized By:	Xiaoyu Wang
Attorney Docket Number:	DHNG001.005AUS
Receipt Date:	22-JUL-2020
Filing Date:	05-JUN-2018
Time Stamp:	15:28:37
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		AMEND_DHNG001.pdf	227542 eef1a3409a51004567c0d808cc823680b8a05e7e	yes	14

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Amendment/Req. Reconsideration-After Non-Final Reject	1	1
	Claims	2	5
	Applicant Arguments/Remarks Made in an Amendment	6	14
Warnings:			
Information:			
	Total Files Size (in bytes):	227542	

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 a 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.

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 16/000,764	Filing Date 06/05/2018	☐ 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 $460 =	
☐ 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	07/22/2020	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 17	Minus	** 20	= 0		x $100 =	0
	Independent (37 CFR 1.16(h))	* 2	Minus	*** 3	= 0		x $460 =	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".	/PAMELA V THERATT/
*** 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.

Doc Code: ECOMM.AUTH/ECOMM.WTDW
Doc Description: Internet Communications Authorized/Internet Communications Authorization Withdrawn

PTO/SB/439 (11-15)

AUTHORIZATION FOR INTERNET COMMUNICATIONS IN A PATENT APPLICATION OR REQUEST TO WITHDRAW AUTHORIZATION FOR INTERNET COMMUNICATIONS		
	Application No.	16/000764
	Filing Date	June 5, 2018
	First Named Inventor	Jianjian Yi
	Art Unit	1727
	Examiner Name	Gary Harris
	Practitioner Docket No.	DHNG001.005AUS

To: Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

I. To authorize permission for Internet Communications.

☑ Recognizing that Internet communications are not secure, I hereby authorize the USPTO to communicate with the undersigned and practitioners in accordance with 37 CFR 1.33 and 37 CFR 1.34 concerning any subject matter of this application via video conferencing, instant messaging, or electronic mail. I understand that a copy of these communications will be made of record in the application file. (MPEP 502.03)

II. To withdraw authorization for Internet Communications.

☐ The authorization given on _____, to the USPTO to communicate with the undersigned and any practitioner in accordance with 37 CFR 1.33 and 37 CFR 1.34 concerning any subject matter of this application via Internet communications such as video conferencing, instant messaging, or electronic mail is hereby withdrawn. I understand that the withdrawal is effective when approved rather than when received.

I am the

☐ applicant.

☑ attorney or agent of record. Registration number 75640.

☐ attorney or agent acting under 37 CFR 1.34. Registration number _____.

/Xiaoyu Wang/ — Signature

2020-07-13 — Date

Xiaoyu Wang — Typed or printed name

212-849-3000 — Telephone Number

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. Juristic entities must be represented by a patent practitioner (see 37 CFR 1.31, which is applicable to any paper filed on or after September 16, 2012, that is presented on behalf of a juristic entity, regardless of application filing date). Submit multiple forms if more than one signature is required, see below*.

☑ * Total of 1 forms are submitted.

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.

Electronic Acknowledgement Receipt

EFS ID:	39981354
Application Number:	16000764
International Application Number:	
Confirmation Number:	2445
Title of Invention:	POROUS FILM AND LITHIUM-ION BATTERY
First Named Inventor/Applicant Name:	Jianjian Yi
Customer Number:	20995
Filer:	Xiaoyu Wang/Priya Patel
Filer Authorized By:	Xiaoyu Wang
Attorney Docket Number:	DHNG001.005AUS
Receipt Date:	13-JUL-2020
Filing Date:	05-JUN-2018
Time Stamp:	14:29:34
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Internet Communications Authorized	Internet_Auth.pdf	87069 7f5febb81a48f0b9e8118219b48b10a6b04025b5	no	2

Warnings:

Information:	
Total Files Size (in bytes):	87069

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 a 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

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.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/000,764	06/05/2018	Jianjian Yi	DHNG001.005AUS	2445

20995 7590 04/22/2020

KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

EXAMINER
HARRIS, GARY D

ART UNIT	PAPER NUMBER
1727	

NOTIFICATION DATE	DELIVERY MODE
04/22/2020	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

efiling@knobbe.com
jayna.cartee@knobbe.com

PTOL-90A (Rev. 04/07)

Office Action Summary	**Application No.** 16/000,764	**Applicant(s)** Yi et al.	
	Examiner GARY D HARRIS	**Art Unit** 1727	**AIA (FITF) Status** Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☑ Responsive to communication(s) filed on 10 April 2020.

☐ 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) 1-20 is/are pending in the application.

5a) Of the above claim(s) 11-20 is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 1-10 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 06/05/2018 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 07/16/2018.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.

POROUS FILM AND LITHIUM-ION BATTERY

Primary Examiner: Gary Harris Art Unit: 1727 April 17, 2020

DETAILED ACTION

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.

Priority

2. Receipt is acknowledged of certified copies of papers submitted under 35 U.S.C. 119(a)-(d), which papers have been placed of record in the file.

Information Disclosure Statement

3. The information disclosure statements (IDS) submitted on 07/16/2018 was considered by the examiner.

Drawings

4. The drawings were received on 06/05/2018. These drawings are acceptable.

Election/Restrictions

6. Claims 11-20 are withdrawn from further consideration pursuant to 37 CFR 1.142(b) as being drawn to a nonelected invention, there being no allowable generic or

linking claim. Election was made **without** traverse in the reply filed on 04/10/2020. The election restriction is made FINAL

Claim Rejections – 35 USC § 102

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.

6. **Claims 1-10 are rejected under 35 U.S.C. 102(a)(1) as being anticipated by Murata et al. US 2017/0194613.**

As to Claim 1, Murata discloses a porous film (membrane, see abstract and title), comprising: a binder (see abstract); and inorganic particles [0073-0075]. Wherein the porous film inherently comprises pores formed by the binder [0086]. This feature is inherent given pores are found within the binder and porous layer. See MPEP 2112.

The pores at least comprises a part of the inorganic particles (filler), and the inherent average wall thickness between the pores is in a range of 20 nm to 500 nm. This feature is inherent given the particle size of the resin is not less than 50nm [0092].

As to Claim 2, Murata discloses the porous film according to claim 1, wherein the porous film has an average pore size of 0.3 to 20 microns (not more than 5 microns [0122]).

As to Claim 7, Murata discloses the porous film according to claim 1, wherein the inorganic particles are at least one of alumina, silica, magnesia, titanium oxide, zirconia, zinc oxide, aluminum hydroxide and magnesium hydroxide [0073].

As to Claim 8, Murata discloses the porous film according to claim 1, wherein the binder is at least one of polyvinylidene fluoride, polyamide and polytetrafluoroethylene [0084].

Claim Rejections - 35 USC § 103

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 of this title, 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.

The factual inquiries set forth in *Graham v. John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966), that are applied for establishing a background for determining obviousness under pre-AIA 35 U.S.C. 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.
2. Ascertaining the differences between the prior art and the claims at issue.
3. Resolving the level of ordinary skill in the pertinent art.
4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

7. **Claims 3, 4, 5, 6, 9 & 10 are rejected under 35 U.S.C. 103 as being unpatentable over Murata et al. US 2017/0194613.**

As to Claim 3, Murata discloses the porous film according to claim 1, wherein the inorganic particles inherently have particle sizes that Dv10 is in a range of 0.015 to 3 microns, Dv50 is in a range of 0.2 to 5 microns, and Dv90 is in a range of 1 to 10 .mu.m [0122]. The Dv10, Dv50 & Dv90 are all inherent as the pore size is within a range of 0.1 to 3 microns. Finding an overlapping range is obvious to one skilled in the art.

Nevertheless, the subject matter as a whole would have been obvious to one having ordinary skill in the art at the time the invention was made, since it has been held that choosing the over lapping portion, of the range taught in the prior art and the range claimed by the applicant, has been held to be a *prima facie* case of obviousness, see *In re Malagari,* 182 USPQ 549.

As to Claim 4, Murata discloses the porous film according to claim 3, wherein Dv10 of the inorganic particles is inherently less than Dv50 of the inorganic particles, and Dv50 of the inorganic particles is less than Dv90 of the inorganic particles. The above features are inherent given the way particle size distributions are measured and given the particle sizes are similar they would have similar Dv10, Dv50 & Dv90's.

As to Claim 5, Murata discloses the porous film according to claim 1, wherein the inorganic particles inherently have particle sizes that the ratio of Dv90 to Dv10 is in a range of 2 to 100 (0.1 to 4 microns overlapping the range [0075]).

Nevertheless, the subject matter as a whole would have been obvious to one having ordinary skill in the art at the time the invention was made, since it has been held that choosing the over lapping portion, of the range taught in the prior art and the range

claimed by the applicant, has been held to be a *prima facie* case of obviousness, see *In re Malagari,* 182 USPQ 549.

As to Claim 6, Murata discloses the porous film according to claim 1.

Murata is silent to wherein a pore size distribution coefficient of the pores in the porous film is in a range of 1 to 5.

However, Murata discloses a tortuosity of 1.43 with number of pores equal to 203/micrometer^2. It would have been obvious to one skilled in the art before the invention to require the claimed range motivated to improve the puncture strength of the sheet [0229].

As to Claim 9, Murata discloses the porous film according to claim 1, wherein the porous film has a porosity of 20% to 90% [0192], and the porous film has a thickness of 0.2 to 10 microns [0038].

Nevertheless, the subject matter as a whole would have been obvious to one having ordinary skill in the art at the time the invention was made, since it has been held that choosing the over lapping portion, of the range taught in the prior art and the range claimed by the applicant, has been held to be a *prima facie* case of obviousness, see *In re Malagari,* 182 USPQ 549.

As to Claim 10, Murata discloses the porous film according to claim 1.

Murata is silent to wherein a volume ratio of the inorganic particles to the binder is in a range of 0.2 to 3.0.

However, it would be obvious to one skilled in the art before the filing date to require the particulars of the particles and binder motivated to provide a mixture of melt kneaded components [0202].

Further, the claim would have been obvious because the technique for improving a particular class of devices was part of the ordinary capabilities of a person of ordinary skill in the art, in view of the teaching of the technique for improvement in other situations. Stated differently, use of known technique to improve similar devices, product or feature in the same way is prima-facie obvious. KSR International Co. v. Teleflex Inc., 550 US- 82 USPQ2d 1385, 1396 (2007).

8. Figures, Paragraph, Column and line numbers are provided for convenience. However, the entire reference should be considered.

Conclusion

9. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Gary Harris whose telephone number is (571)272-6508. The examiner can normally be reached on Mon-Sat. 5:30AM-8PM EST (flex).

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Barbara Gilliam can be reached on (571)272-1330. The fax phone number for the organization where this application or proceeding is assigned is (571)273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/GARY D HARRIS/
Primary Examiner, Art Unit 1727

Notice of References Cited	Application/Control No. 16/000,764	Applicant(s)/Patent Under Reexamination Yi et al.	
	Examiner GARY D HARRIS	Art Unit 1727	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-20170194613-A1	07-2017	Murata; Hiroshi	B32B27/20	1/1
	B					
	C					
	D					
	E					
	F					
	G					
	H					
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	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 MM-YYYY format are publication dates. Classifications may be US or foreign.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/000,764	Yi et al.
	Examiner	Art Unit
	GARY D HARRIS	1727

CPC - Searched*		
Symbol	Date	Examiner
(H01M10/0525 H01M2/145 H01M4/661 H01M4/583 H01M2/164 H01M4/623 H01M2004/027 H01M2004/028 or H01M2/166 H01M2/1646 H01M2/1653 H01M2/16 H01M2/1606).cpc.	04/17/2020	gh

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner
429	209	04/17/2020	gh

* 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
Assignee, inventor name and key word search in EAST.	04/17/2020	gh

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner

/GARY D HARRIS/ Primary Examiner, Art Unit 1727	

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/000,764	Yi et al.
	Examiner	**Art Unit**
	GARY D HARRIS	1727

✓	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	04/17/2020								
	1	✓								
	2	✓								
	3	✓								
	4	✓								
	5	✓								
	6	✓								
	7	✓								
	8	✓								
	9	✓								
	10	✓								
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	18	÷								
	19	÷								
	20	÷								

Zhuhai CosMX Battery Co. - EX1014
Zhuhai CosMX Battery Co. v. Ningde Amperex Tech. Ltd.
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EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	2	"16000764"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 14:06
S2	2	(US-1234567-$ | US-28676403-$).DID.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 10:13
S3	5	(AI-1234567-$ | CN-103474602-$ | CN-205004376-$ | JP-1234567-$).DID.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 10:14
S4	2	"16000764"	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 10:21
S5	19457	porous with inorganic with particle	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:20

S6	67912	(porous, pores, porosity) with binder	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:20
S7	119978	(porous, pores, porosity) with (nanometer, nm)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:21
S8	137888	(porous, pores, porosity) with size with (micro, micron, micro$1meter".mu.m")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:23
S9	5978	S5 and S6	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:24
S10	7350	S6 and S7	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:24
S11	19936	S7 and S8	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:25

S12	1316	S9 and S10	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:25
S13	2183	S10 and S11	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:25
S14	507	S12 and S13	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:25
S15	189519	(H01M10/0525 or H01M2/145 or H01M4/661 or H01M4/583 or H01M2/164 or H01M4/623 or H01M2004/027 or H01M2004/028 or H01M2/166 or H01M2/1646 or H01M2/1653 or H01M2/16 or H01M2/1606).cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:26
S16	3783	429/209.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:26
S17	191425	S15 S16	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:26

S18	207	S14 and S17	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:27
S19	195	S18 and (alumina, silica, magnesia, titanium adj oxide, hafnium adj dioxide, tin adj oxide, cerium adj dioxide, nickel adj oxide, zirconia)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:30
S20	41	S18 and (magnesium adj hydroxide, calcium adj hydroxide, barium adj sulfate)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:33
S21	58	S18 and (zinc adj oxide, calcium adj oxide)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:34
S22	196	S19 S20	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:35
S23	196	S21 S22	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:37

S24	189	S23 and (porous, pores, porosity) with binder same (film, layer, coat$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:38
S25	1	S24 and (porous, pores, porosity) with (nanometer, nm) with wall adj thickness	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:39
S26	1	S24 and (porous, pores, porosity) with (nanometer, nm) same wall adj thickness	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:40
S27	85	S24 and (porous, pores, porosity) with (nanometer, nm) same thickness	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:40
S28	46	S27 and (porous, pores, porosity) with (average, avg) with size with (micro, micron, micro$1meter ".mu.m")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:41
S29	46	S28 and (polyvinylidene adj fluoride, vinylidene adj fluoride$1hexafluoropropylene adj copolymer, polyamide, polyacrylonitrile, polyacrylate, polyacrylic adj acid, polyacrylic adj acid adj salt, sodium adj carboxymethylcellulose, polyvinylpyrrolidone, polyvinyl adj ether, polymethyl adj methacrylate,	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:44

		polytetrafluoroethylene, polyhexafluoropropylene)				
S30	35	S28 and binder same (polyvinylidene adj fluoride, vinylidene adj fluoride$1hexafluoropropylene adj copolymer, polyamide, polyacrylonitrile, polyacrylate, polyacrylic adj acid, polyacrylic adj acid adj salt, sodium adj carboxymethylcellulose, polyvinylpyrrolidone, polyvinyl adj ether, polymethyl adj methacrylate, polytetrafluoroethylene, polyhexafluoropropylene)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:45
S31	1	S30 and ("Dv10", "Dv50")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:47
S32	15	S30 and particle adj size same range	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:48
S33	1	S31 and particle adj size same range.clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:52
S34	1	S31 and (porous, pores, porosity) with binder same (film, layer, coat$3).clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2020/04/17 11:53

EAST Search History (Interference)

<This search history is empty>

4/17/2020 3:06:11 PM
C:\Users\gharris\Documents\EAST\Workspaces\16000764.wsp

PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	16/000764
	Filing Date	June 5, 2018
	First Named Inventor	Jianjian Yi
	Art Unit	1726
(Multiple sheets used when necessary)	Examiner	Unassigned
SHEET 1 OF 1	Attorney Docket No.	DHNG001.005AUS

FOREIGN PATENT DOCUMENTS						
Examiner Initials	Cite No.	Foreign Patent Document *Country Code-Number-Kind Code* Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T[1]
	1	CN 103474602 A	12-25-2013	SHENZHEN TAIBAI TECHNOLOGY CO LTD		
	2	CN 205004376 U	01-27-2016	SHENZHEN HONGTAI BATTERY TECH CO LTD		

28676403

Examiner Signature	/GARY D HARRIS/	Date Considered	04/17/2020

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

T[1] - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /G.D.H/

REMARKS

Claims 1-20 were originally filed in the present application, of which claims 11-20 have been withdraw without prejudice or disclaimer. Consideration and allowance of pending claims 1-10 is respectfully requested.

The Examiner identified two groups for restriction:

I. Claims 1-10, drawn to a porous film, classified in H01M2/145.

II. Claims 11-20, drawn to a lithium-ion battery, classified in H01M10/0525.

Applicant elects, without traverse, Group I, which includes claims 1-10.

Please charge any additional fees, including any fees for additional extension of time, or credit overpayment to Deposit Account No. 11-1410.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: April 10, 2020

By:/Daniel J. Fischer/_____
Dan Fischer
Registration No. 68,043
Registered Practitioner
(212) 849-3000

32607618

AMENDMENTS TO THE CLAIMS

1. (**Original**) A porous film, comprising:

a binder; and

inorganic particles;

wherein the porous film comprises pores formed by the binder, the pores at least comprises a part of the inorganic particles, and the average wall thickness between the pores is in a range of 20 nm to 500 nm.

2. (**Original**) The porous film according to claim 1, wherein the porous film has an average pore size of 0.3 μm to 20 μm.

3. (**Original**) The porous film according to claim 1, wherein the inorganic particles have particle sizes that Dv10 is in a range of 0.015 μm to 3 μm, Dv50 is in a range of 0.2 μm to 5 μm, and Dv90 is in a range of 1 μm to 10 μm.

4. (**Original**) The porous film according to claim 3, wherein Dv10 of the inorganic particles is less than Dv50 of the inorganic particles, and Dv50 of the inorganic particles is less than Dv90 of the inorganic particles.

5. (**Original**) The porous film according to claim 1, wherein the inorganic particles have particle sizes that the ratio of Dv90 to Dv10 is in a range of 2 to 100.

6. (**Original**) The porous film according to claim 1, wherein a pore size distribution coefficient of the pores in the porous film is in a range of 1 to 5.

7. (**Original**) The porous film according to claim 1, wherein the inorganic particles are at least one of alumina, silica, magnesia, titanium oxide, hafnium dioxide, tin oxide, cerium dioxide, nickel oxide, zirconia, zinc oxide, calcium oxide, boehmite, aluminum hydroxide, magnesium hydroxide, calcium hydroxide, and barium sulfate.

8. (**Original**) The porous film according to claim 1, wherein the binder is at least one of polyvinylidene fluoride, vinylidene fluoride-hexafluoropropylene copolymer, polyamide, polyacrylonitrile, polyacrylate, polyacrylic acid, polyacrylic acid salt, sodium

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carboxymethylcellulose, polyvinylpyrrolidone, polyvinyl ether, polymethyl methacrylate, polytetrafluoroethylene and polyhexafluoropropylene.

9. (**Original**) The porous film according to claim 1, wherein the porous film has a porosity of 20% to 90%, and the porous film has a thickness of 0.2 to 10 μm.

10. (**Original**) The porous film according to claim 1, wherein a volume ratio of the inorganic particles to the binder is in a range of 0.2 to 3.0.

11. (**Withdrawn**) A lithium-ion battery, comprising:

a positive electrode;

a negative electrode;

a separator, arranged between the positive electrode and the negative electrode;

non-aqueous electrolyte; and

a porous film, comprising:

a binder; and

inorganic particles;

wherein the porous film comprises pores formed by the binder, the pores at least comprises a part of the inorganic particles, and the average wall thickness between the pores is in a range of 20 nm to 500 nm.

12. (**Withdrawn**) The lithium-ion battery according to claim 11, wherein the porous film has an average pore size of 0.3 μm to 20 μm.

13. (**Withdrawn**) The lithium-ion battery according to claim 11, wherein the inorganic particles have particle sizes that Dv10 is in a range of 0.015 μm to 3 μm, Dv50 is in a range of 0.2 μm to 5 μm, and Dv90 is in a range of 1 μm to 10 μm.

14. (**Withdrawn**) The lithium-ion battery according to claim 13, wherein Dv10 of the inorganic particles is less than Dv50 of the inorganic particles, and Dv50 of the inorganic particles is less than Dv90 of the inorganic particles.

15. (**Withdrawn**) The lithium-ion battery according to claim 11, wherein the inorganic particles have particle sizes that the ratio of Dv90 to Dv10 is in a range of 2 to 100.

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16. (**Withdrawn**) The lithium-ion battery according to claim 11, wherein a pore size distribution coefficient of the pores in the porous film is in a range of 1 to 5.

17. (**Withdrawn**) The lithium-ion battery according to claim 11, wherein the inorganic particles are at least one of alumina, silica, magnesia, titanium oxide, hafnium dioxide, tin oxide, cerium dioxide, nickel oxide, zirconia, zinc oxide, calcium oxide, boehmite, aluminum hydroxide, magnesium hydroxide, calcium hydroxide, and barium sulfate.

18. (**Withdrawn**) The lithium-ion battery according to claim 11, wherein the binder is at least one of polyvinylidene fluoride, vinylidene fluoride-hexafluoropropylene copolymer, polyamide, polyacrylonitrile, polyacrylate, polyacrylic acid, polyacrylic acid salt, sodium carboxymethylcellulose, polyvinylpyrrolidone, polyvinyl ether, polymethyl methacrylate, polytetrafluoroethylene and polyhexafluoropropylene.

19. (**Withdrawn**) The lithium-ion battery according to claim 11, wherein the porous film has a porosity of 20% to 90%, and the porous film has a thickness of 0.2 to 10 μm, and a volume ratio of the inorganic particles to the binder is in a range of 0.2 to 3.0.

20. (**Withdrawn**) The lithium-ion battery according to claim 11, wherein the porous film is arranged on a surface of at least one of the positive electrode, the negative electrode and the separator.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Inventor	:	Jianjian Yi
App. No.	:	16/000764
Filed	:	June 5, 2018
For	:	POROUS FILM AND LITHIUM-ION BATTERY
Examiner	:	Harris, Gary D.
Art Unit	:	1727
Conf. No.	:	2445

RESPONSE TO RESTRICTION REQUIREMENT

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

In response to the Restriction Requirement mailed on February 13, 2020, the Applicant submits the following:

Amendments to the Claims are reflected in the listing of claims which begins on page 2 of this paper.

Remarks/Arguments begin on page 5 of this paper.

Zhuhai CosMX Battery Co. - EX1014
Zhuhai CosMX Battery Co. v. Ningde Amperex Tech. Ltd.
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Electronic Acknowledgement Receipt	
EFS ID:	39126756
Application Number:	16000764
International Application Number:	
Confirmation Number:	2445
Title of Invention:	POROUS FILM AND LITHIUM-ION BATTERY
First Named Inventor/Applicant Name:	Jianjian Yi
Customer Number:	20995
Filer:	Daniel J. Fischer/Jennifer Neat
Filer Authorized By:	Daniel J. Fischer
Attorney Docket Number:	DHNG001.005AUS
Receipt Date:	10-APR-2020
Filing Date:	05-JUN-2018
Time Stamp:	15:56:32
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		rest_resp.pdf	120028 703581a6c9e227ee5f66cbf0fecf710bd0164309	yes	5

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Amendment/Req. Reconsideration-After Non-Final Reject	5	5
	Claims	2	4
	Response to Election / Restriction Filed	1	1
Warnings:			
Information:			
	Total Files Size (in bytes):	120028	

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 a 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.

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 16/000,764	Filing Date 06/05/2018	☐ 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 $460 =	
☐ 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	04/10/2020	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 20	Minus	** 20	= 0		x $100 =	0
	Independent (37 CFR 1.16(h))	* 2	Minus	*** 3	= 0		x $460 =	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.	SLIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/SONYA M WILLIAMS/
*** 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.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/000,764	06/05/2018	Jianjian Yi	DHNG001.005AUS	2445

20995 7590 02/13/2020

KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

EXAMINER	
HARRIS, GARY D	

ART UNIT	PAPER NUMBER
1727	

NOTIFICATION DATE	DELIVERY MODE
02/13/2020	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

efiling@knobbe.com
jayna.cartee@knobbe.com

PTOL-90A (Rev. 04/07)

Office Action Summary	**Application No.** 16/000,764	**Applicant(s)** Yi et al.	
	Examiner GARY D HARRIS	**Art Unit** 1727	**AIA (FITF) Status** Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 2 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☑ Responsive to communication(s) filed on 8/7/2018.

☐ 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) 1-20 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) _____ is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☑ Claim(s) 1-20 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 20200210.

4) ☐ Other: _____.

Notice of Pre-AIA or AIA Status

The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

DETAILED ACTION

Election/Restriction

Restriction to one of the following inventions is required under 35 U.S.C. 121:

I. Claims 1-10, drawn to a porous film, classified in H01M2/145.

II. Claims 11-20, drawn to a lithium-ion battery, classified in H01M10/0525.

The inventions are independent or distinct, each from the other because:

Inventions I and II are related as process of making and product made. The inventions are distinct if either or both of the following can be shown: (1) that the process as claimed can be used to make another and materially different product or (2) that the product as claimed can be made by another and materially different process (MPEP § 806.05(f)). In the instant case the process as claimed can be used to make another and materially different product such as a porous separator for a lead acid battery or battery other than a lithium-ion.

Restriction for examination purposes as indicated is proper because all the inventions listed in this action are independent or distinct for the reasons given above and there would be a serious search and/or examination burden if restriction were not required because one or more of the following reasons apply:

- *The inventions have acquired a separate status in the art in view of their different classification.*
- *The inventions have acquired a separate status in the art due to their recognized divergent subject matter.*

- *The inventions require a different field of search (e.g., searching different classes/subclasses or electronic resources, or employing different search strategies or search queries).*

Applicant is advised that the reply to this requirement to be complete must include (i) an election of a invention to be examined even though the requirement may be traversed (37 CFR 1.143) **and (ii) identification of the claims encompassing the elected invention**.

The election of an invention may be made with or without traverse. To reserve a right to petition, the election must be made with traverse. If the reply does not distinctly and specifically point out supposed errors in the restriction requirement, the election shall be treated as an election without traverse. Traversal must be presented at the time of election in order to be considered timely. Failure to timely traverse the requirement will result in the loss of right to petition under 37 CFR 1.144. If claims are added after the election, applicant must indicate which of these claims are readable upon the elected invention.

Should applicant traverse on the ground that the inventions are not patentably distinct, applicant should submit evidence or identify such evidence now of record showing the inventions to be obvious variants or clearly admit on the record that this is the case. In either instance, if the examiner finds one of the inventions unpatentable over the prior art, the evidence or admission may be used in a rejection under 35 U.S.C. 103 or pre-AIA 35 U.S.C. 103(a) of the other invention.

A telephone call was made to both Susan Natland & Dan Fischer on 02/10/2020 to request an oral election to the above restriction requirement, but did not result in an election being made.

Applicant is reminded that upon the cancellation of claims to a non-elected invention, the inventorship must be corrected in compliance with 37 CFR 1.48(a) if one or more of the currently named inventors is no longer an inventor of at least one claim remaining in the application. A request to correct inventorship under 37 CFR 1.48(a) must be accompanied by an application data sheet in accordance with 37 CFR 1.76 that identifies each inventor by his or her legal name and by the processing fee required under 37 CFR 1.17(i).

Applicant is reminded that upon the cancellation of claims to a non-elected invention, the inventorship must be corrected in compliance with 37 CFR 1.48(a) if one or more of the currently named inventors is no longer an inventor of at least one claim remaining in the application. A request to correct inventorship under 37 CFR 1.48(a) must be accompanied by an application data sheet in accordance with 37 CFR 1.76 that identifies each inventor by his or her legal name and by the processing fee required under 37 CFR 1.17(i).

The examiner has required restriction between product or apparatus claims and process claims. Where applicant elects claims directed to the product/apparatus, and all product/apparatus claims are subsequently found allowable, withdrawn process claims that include all the limitations of the allowable product/apparatus claims should be considered for rejoinder. All claims directed to a nonelected process invention must include all the limitations of an allowable product/apparatus claim for that process invention to be rejoined.

In the event of rejoinder, the requirement for restriction between the product/apparatus claims and the rejoined process claims will be withdrawn, and the

rejoined process claims will be fully examined for patentability in accordance with 37 CFR 1.104. Thus, to be allowable, the rejoined claims must meet all criteria for patentability including the requirements of 35 U.S.C. 101, 102, 103 and 112. Until all claims to the elected product/apparatus are found allowable, an otherwise proper restriction requirement between product/apparatus claims and process claims may be maintained. Withdrawn process claims that are not commensurate in scope with an allowable product/apparatus claim will not be rejoined. See MPEP § 821.04. Additionally, in order for rejoinder to occur, applicant is advised that the process claims should be amended during prosecution to require the limitations of the product/apparatus claims. **Failure to do so may result in no rejoinder.** Further, note that the prohibition against double patenting rejections of 35 U.S.C. 121 does not apply where the restriction requirement is withdrawn by the examiner before the patent issues. See MPEP § 804.01.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to GARY D HARRIS whose telephone number is (571)272-6508. The examiner can normally be reached on Mon-Sat. 5:30AM-8PM EST (flex).

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, Barbara Gilliam can be reached on 5712721220. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/GARY D HARRIS/
Primary Examiner, Art Unit 1727

Examiner-Initiated Interview Summary	Application No. 16/000,764	Applicant(s) Yi et al.	
	Examiner GARY D HARRIS	Art Unit 1727	AIA (FITF) Status Yes

All participants (applicant, applicant's representative, PTO personnel):

(1) GARY D. HARRIS. (3) Susan Natland.

(2) Dan Fischer. (4) _____.

Date of Interview: 10 February 2020.

Type: ☑ Telephonic ☐ Video Conference
☐ Personal [copy given to: ☐ applicant ☐ applicant's representative]

Exhibit shown or demonstration conducted: ☐ Yes ☐ No.
If Yes, brief description: _____.

Issues Discussed ☐ 101 ☐ 112 ☐ 102 ☐ 103 ☑ Others
(For each of the checked box(es) above, please describe below the issue and detailed description of the discussion)

Claim(s) discussed: 1-20.

Identification of prior art discussed: N/A.

Substance of Interview
(For each issue discussed, provide a detailed description and indicate if agreement was reached. Some topics may include: identification or clarification of a reference or a portion thereof, claim interpretation, proposed amendments, arguments of any applied references etc...)

Request for election between groups however, an election could not be made over the phone.

Applicant recordation instructions: It is not necessary for applicant to provide a separate record of the substance of interview.

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

☐ Attachment

/GARY D HARRIS/ Primary Examiner, Art Unit 1727	

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
16/000,764	06/05/2018	Jianjian Yi	DHNG001.005AUS

CONFIRMATION NO. 2445

PUBLICATION NOTICE

20995
KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

OC000000111948500

Title:POROUS FILM AND LITHIUM-ION BATTERY

Publication No.US-2019-0319300-A1
Publication Date:10/17/2019

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Public Records Division. The Public Records Division can be reached by telephone at (571) 272-3150 or (800) 972-6382, by facsimile at (571) 273-3250, by mail addressed to the United States Patent and Trademark Office, Public Records Division, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently https://portal.uspto.gov/pair/PublicPair. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

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STATE INTELLECTUAL PROPERTY OFFICE
OF THE PEOPLE'S REPUBLIC OF CHINA

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：201810322931.1

申　请　类　型：发明专利

发明 创造 名称：多孔膜和锂离子电池

申　　请　　日：2018 年 04 月 11 日

申　　请　　人：宁德新能源科技有限公司

发明人或设计人：易建建、张新枝、魏增斌、陶兴华

局长

申长雨

2018 年 08 月 08 日

2018103229311

权利要求书

1.一种多孔膜，包括:

粘结剂；以及

无机颗粒;

所述多孔膜含有由粘结剂形成的孔，所述孔中包括无机颗粒，所述孔之间的平均壁厚为20nm~500nm。

2.根据权利要求1所述的多孔膜，其中，所述多孔膜的平均孔径为0.3μm~20μm。

3.根据权利要求1所述的多孔膜，其中，所述无机颗粒的粒径满足:Dv10为0.015μm~3μm，Dv50为0.2μm~5μm，Dv90为1μm~10μm。

4.根据权利要求3所述的多孔膜，其中，所述无机颗粒的Dv10小于所述无机颗粒的Dv50，且所述无机颗粒的Dv50小于所述无机颗粒的Dv90。

5.根据权利要求1所述的多孔膜，其中，所述无机颗粒的粒径满足:Dv90与Dv10的比值为2~100。

6.根据权利要求1所述的多孔膜，其中，所述多孔膜中孔的孔径分布系数为1~5。

7.根据权利要求1所述的多孔膜，其中，所述无机颗粒选自氧化铝、二氧化硅、氧化镁、氧化钛、二氧化铪、氧化锡、二氧化铈、氧化镍、氧化锆、氧化锌、氧化钙、勃姆石、氢氧化铝、氢氧化镁、氢氧化钙和硫酸钡中的一种或多种。

8.根据权利要求1所述的多孔膜，其中，所述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、羧甲基纤维素钠、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多种。

9.根据权利要求1所述的多孔膜，其中，所述多孔膜的孔隙率为20%~90%，所述多孔膜的厚度为0.2~10μm。

10.根据权利要求1所述的多孔膜，其中，所述无机颗粒与所述粘结剂的体积比值为0.2~3.0。

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11.一种锂离子电池，包括:

正极极片;

负极极片;

隔离膜，位于所述正极极片和所述负极极片之间;

非水电解液;

以及多孔膜,所述多孔膜为根据权利要求 1-10 中任一项所述的多孔膜。

12.根据权利要求 11 所述的锂离子电池,所述多孔膜设置在正极极片、负极极片和隔离膜中的至少一个的表面。

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说明书

多孔膜和锂离子电池

技术领域

本申请涉及储能装置领域，更具体地，涉及多孔膜和锂离子电池。

背景技术

非水系二次电池特别是锂离子电池以其能量密度高、倍率性能好等特性，广泛应用于笔记本电脑、数码相机、摄像机和手机等便携式电子设备。近些年来锂离子电池作为新能源汽车的供电电源，也在推动锂离子电池技术的发展。锂离子电池在循环过程中，随着充放电的进行，电极与隔离膜之间会产生间隙，导致锂离子电池的循环容量减少，从而影响其使用寿命。因此，急需一种技术方案解决隔离膜和电极之间的间隙问题以提高锂离子电池的使用寿命。

发明内容

为了解决现有技术中存在的问题，本申请提供了一种多孔膜和锂离子电池。

根据本申请的第一方面，提供了一种多孔膜，包括：粘结剂；以及无机颗粒；所述多孔膜含有由粘结剂形成的孔，所述孔中包括无机颗粒，所述孔之间的平均壁厚为20nm~500nm。

在上述多孔膜中，所述多孔膜的平均孔径为0.3μm以上20μm以下。

在上述多孔膜中，所述无机颗粒的粒径满足：体积累积10%的粒径（Dv10）为0.015μm~3μm，体积累积50%的粒径（Dv50）为0.2μm~5μm，体积累积90%的粒径（Dv90）为1μm~10μm；所述体积累积10%的粒径（Dv10）是指，在体积基准的粒度分布中，从小粒径侧起、达到体积累积10%的粒径；所述体积累积50%的粒径（Dv50）是指，在体积基准的粒度分布中，从小粒径侧起、达到体积累积50%的粒径；所述体积累积

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90%的粒径（Dv90）是指，在体积基准的粒度分布中，从小粒径侧起、达到体积累积90%的粒径。

在上述多孔膜中，所述体积累积10%的粒径（Dv10）小于所述体积累积50%的粒径（Dv50），且所述体积累积50%的粒径（Dv50）小于所述体积累积90%的粒径（Dv90）。

在上述多孔膜中，所述无机颗粒的粒径满足：体积累积90%的粒径（Dv90）与体积累积10%的粒径（Dv10）的比值为2~100。

在上述多孔膜中，其中，所述多孔膜中孔的孔径分布系数（D）为1~5。

在上述多孔膜中，所述无机颗粒选自氧化铝、二氧化硅、氧化镁、氧化钛、二氧化铪、氧化锡、二氧化铈、氧化镍、氧化锆、氧化锌、氧化钙、勃姆石、氢氧化铝、氢氧化镁、氢氧化钙和硫酸钡中的一种或多种

在上述多孔膜中，所述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、羧甲基纤维素钠、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多种。

在上述多孔膜中，所述多孔膜的孔隙率为20%~90%，所述多孔膜的厚度为0.2~10μm。

在上述多孔膜中，所述无机颗粒与所述粘结剂的体积比值为0.2~3.0。

根据本申请的第二方面，提供了一种锂离子电池，包括：正极极片；负极极片；隔离膜，位于所述正极极片和所述负极极片之间；非水电解液；以及多孔膜，所述多孔膜为根据本申请的第一方面所述的多孔膜。

在上述锂离子电池中，所述多孔膜设置在正极极片、负极极片和隔离膜中的至少一个的表面。

本申请提供的多孔膜具有优异的粘结性，同时多孔膜的孔结构经过电解液浸泡后，仍能够得到很好的维持，从而降低多孔膜发生堵孔的概率，使锂离子电池具有高的离子电导率，极大地提高了锂离子电池的动力学性能，且提供的锂离子电池具有优异的倍率性能和循环性能。

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附图说明

图 1 为实施例 3 的多孔膜的下表面（即多孔膜远离多孔基材的表面）的孔结构的电镜图（1000 倍）。

图 2 为实施例 3 的多孔膜的下表面的孔结构的电镜图（5000 倍）。

图 3 为对比例 3 的多孔膜的下表面的孔结构的电镜图（1000 倍）。

具体实施方式

下面详细充分地说明示例性实施例，不过，这些示例性实施例可以用不同的方式来实施，并且，不应被解释为局限于本申请所阐述的这些实施例。相反，提供这些实施例的目的在于使本申请公开彻底和完整，以及将本申请的范围充分地传达给本领域所属技术人员。

根据本申请的第一方面，提供了一种多孔膜，包括粘结剂以及不同粒径的无机颗粒，所述无机颗粒被所述粘结剂固定。由于多孔膜包括粘结剂，因此具有良好的粘结性，可以避免多孔膜在锂离子电池使用过程中脱落，使锂离子电池具有较高的安全性能。同时多孔膜的平均孔径较大，孔径分布均匀，使得多孔膜具有良好的电解液扩散和吸收能力以及较高的离子电导率，可以减少锂离子电池内部的极化反应，从而提高了锂离子电池的动力学性能。另外，由于多孔膜中相邻孔之间的平均壁厚较小，在锂离子电池的制备过程中，多孔膜经过电解液浸泡过程后，可以避免粘结剂（通常为聚合物，例如聚偏氟乙烯）在电解液中溶胀将多孔膜的孔堵死，多孔膜中的孔结构能够得到较多的保留，保证了锂离子传输通道的畅通，减少了锂离子电池内部的极化反应，进一步提高了锂离子电池的动力学性能。另外，由于多孔膜孔中无机颗粒的存在，增强了孔结构的稳定性，使得在经过电解液浸泡过程以及化成阶段的高温高压过程后，孔结构不会软化闭合，而且降低了孔结构被压缩破坏的可能性，保证了锂离子的传输通道畅通，减少了锂离子电池内部的极化反应，保证了锂离子电池具有较高的动力学性能。

在多孔膜中，无机颗粒选自氧化铝、二氧化硅、氧化镁、氧化钛、二氧化铪、氧化锡、二氧化铈、氧化锆、氧化镍、氧化锌、氧化钙、勃姆石、

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氢氧化铝、氢氧化镁、氢氧化钙和硫酸钡中的一种或多种。其中，无机颗粒可以含有极性官能团，极性官能团选自羟基。含有极性官能团的无机颗粒的表面更容易在制备过程中与下文所述的凝固液内的非溶剂（第三溶剂）结合，有利于第三溶剂沿着无机颗粒表面扩散进入多孔膜，从而在无机颗粒的附近形成较大的孔结构，有利于得到平均孔径较大、相邻孔之间的平均壁厚较小的孔结构。

所述无机颗粒的粒径满足：体积累积 10%的粒径（Dv10）为 0.015μm~3μm，体积累积 50%的粒径（Dv50）为 0.2μm~5μm，体积累积 90%的粒径（Dv90）为 1μm~10μm；所述体积累积 10%的粒径（Dv10）是指，在体积基准的粒度分布中，从小粒径侧起、达到体积累积 10%的粒径；所述体积累积 50%的粒径（Dv50）是指，在体积基准的粒度分布中，从小粒径侧起、达到体积累积 50%的粒径；所述体积累积 90%的粒径（Dv90）是指，在体积基准的粒度分布中，从小粒径侧起、达到体积累积 90%的粒径。例如，选用大粒径单峰窄分布的无机颗粒，在多孔膜的形成过程中，能提高凝固液内的非溶剂（第三溶剂）与涂布液内的有机溶剂（第一溶剂）的交换速度，从而形成平均孔径较大、相邻孔之间的平均壁厚较小的多孔膜结构。在此范围内，若所述无机颗粒的粒径变小，则在多孔膜的形成过程中，凝固液内的非溶剂（第三溶剂）与涂布液内的有机溶剂（第一溶剂）的交换速度降低，孔结构的发展变慢，所形成的孔的平均孔径减小、相邻孔之间的平均壁厚增加；反之，若所述无机颗粒的粒径变大，凝固液内的非溶剂（第三溶剂）与涂布液内的有机溶剂（第一溶剂）的交换速度提高，孔结构的发展变快，则所形成的孔的平均孔径增大、相邻孔之间的平均壁厚减小。但是，若无机颗粒的粒径过小，超出该范围，则不利于凝固液内的非溶剂（第三溶剂）与涂布液内的有机溶剂（第一溶剂）的交换，难以形成平均孔径较大的孔；若无机颗粒的粒径过大，超出该范围，则所形成的多孔膜表面不均匀、多孔膜强度下降，多孔膜的粘结力下降。

在一些实施例中，所述无机颗粒粒径的 Dv10 为 1.0μm~1.6μm，Dv50 为 2.0μm~2.6μm，Dv90 为 3.0μm~4.0μm。

在上述多孔膜中，所述无机颗粒的粒径分布 Dv90/Dv10=2~100，如果

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Dv90/Dv10 大于 100，则会导致无机颗粒的粒径分布过宽，形成的孔的均匀性差，在锂离子电池中容易发生极化反应。

在上述多孔膜中，相邻孔之间的平均壁厚为 20nm~500nm，多孔膜的平均孔径为 0.3μm~20μm。本申请的多孔膜的平均孔径较大，使得多孔膜具有良好的电解液扩散和吸收能力以及较高的离子电导率，可以减少锂离子电池内部的极化反应，从而提高锂离子电池的动力学性能。另外，由于多孔膜中相邻孔之间的平均壁厚较小，在锂离子电池的制备过程中，多孔膜经过电解液浸泡过程后，可以避免粘结剂（通常为聚合物，例如聚偏氟乙烯）在电解液中溶胀将多孔膜的孔堵死，多孔膜中的孔结构能够得到较多的保留，保证了锂离子传输通道的畅通，减少了锂离子电池内部的极化反应，进一步提高了锂离子电池的动力学性能。

在上述多孔膜中，所述多孔膜中孔的孔径分布系数 D 为 1~5。R10 表示在孔径分布曲线中，从小孔径侧起、达到累积 10%的孔径（10%的孔的孔径小于该数值），R90 表示在孔径分布曲线中，从小孔径侧起、达到累积 90%的孔径（90%的孔的孔径小于该数值），孔径分布系数 D=R90/R10，孔径分布系数 D 越接近 1，表示多孔膜中的孔径越均匀，从而具有更好的倍率性能和循环性能。

在上述多孔膜中，所述多孔膜的厚度为 0.2μm~10μm，其中，若多孔膜的厚度较大，则多孔膜的透气性能变差，降低锂离子电池的动力学性能，若多孔膜的厚度较小，则多孔膜的粘结力降低，当其应用于锂离子电池中后，易因粘结力差而脱落，从而会导致锂离子电池的安全性能变差。在一些实施例中，所述多孔膜的厚度为 1μm~3μm。

在上述多孔膜中，所述多孔膜的孔隙率为 20%~90%。在一些实施例中，所述多孔膜的孔隙率为 40%~60%。

在上述多孔膜中，所述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、羧甲基纤维素钠、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多种。

在上述多孔膜中，所述多孔膜中无机颗粒与粘结剂的体积比值为

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0.2~3.0。二者的体积比值小于0.2，会导致多孔膜的平均孔径减小，孔隙率降低，锂离子电池的动力学性能急剧下降；二者的体积比值大于3.0，则会导致多孔膜的粘结力降低，当其应用于锂离子电池中后，较易于因粘结力差而脱落，从而会导致锂离子电池的安全性能变差。

根据本申请的第二方面，提供了一种多孔膜的制备方法，用于制备本申请第一方面所述的多孔膜，包括步骤：（1）将无机颗粒与粘结剂混合，然后加入第一溶剂并均匀搅拌，得到涂布液，其中粘结剂溶于第一溶剂中；（2）将涂布液均匀涂布在基体的至少一个表面上，形成湿膜；（3）将带有湿膜的基体浸入到凝固液中进行相转化，其中，凝固液包括第二溶剂和第三溶剂，第二溶剂与第三溶剂互溶；（4）相转化结束后进行干燥处理，得到表面设置有多孔膜的基体，其中，多孔膜中相邻孔之间的平均壁厚为20nm~500nm，多孔膜的平均孔径不小于0.3μm。

上述基体可以是隔离膜、正极极片和负极极片中的一种。

在上述多孔膜的制备方法中，利用相转化(即非溶剂致相分离法，NIPS)原理制备出多孔膜。其中，在步骤（1）得到的涂布液中，第一溶剂是油性的，粘结剂（例如聚偏二氟乙烯）可以溶于第一溶剂；在步骤（3）中的凝固液中含有的第三溶剂选自去离子水、乙醇、丙醇、丙酮、碳酸二甲酯、碳酸二乙酯中的一种或几种，而粘结剂不溶于第三溶剂（例如去离子水），因此将涂布液涂布在基体上再浸入凝固液中后，由于涂布液中的第一溶剂被萃取到凝固液内的第三溶剂（例如去离子水）中，涂布液中的粘结剂凝固析出，形成多孔膜。

在上述多孔膜的制备方法中，步骤（1）中，第一溶剂选自N-甲基吡咯烷酮（NMP）、二甲基乙酰胺（DMAC）、二甲基甲酰胺（DMF）、磷酸三乙酯（TEP）、二甲基亚砜（DMSO）中的一种或多种。其中，使用NMP形成的多孔膜的平均孔径最大、孔隙率最高；使用DMF形成的多孔膜的平均孔径最小、空隙率最低；使用DMAC形成的多孔膜的平均孔径以及孔隙率介于NMP和DMF之间。

在上述多孔膜的制备方法中，步骤（1）中的涂布液的固含量为7%~25%，在此范围内，涂布液的固含量增加，则涂布液的粘度升高，凝固液

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内的第三溶剂和涂布液中的第一溶剂的交换速度变慢，所形成的多孔膜的平均孔径以及孔隙率都降低；反之，则多孔膜的平均孔径以及孔隙率均升高。但是，若涂布液的固含量过高，超出此范围，则多孔膜的透气性不合要求，无法满足锂离子电池的使用；若涂布液的固含量过低，低于此范围，则多孔膜的强度下降，甚至难以在基体的表面成膜。在一些实施例中，涂布液的固含量为 10%～20%。

在上述多孔膜的制备方法中，步骤（1）中的涂布液的温度为 15℃～30℃。在一些实施例中，涂布液的温度为 20℃～25℃。

在上述多孔膜的制备方法中，步骤（2）中的涂布液的涂布可通过常用的涂布方法，例如，辊涂法、气刀涂法、棒涂法、刮条涂布法、凹版涂布法、丝网涂布法、口模涂法、微凹版涂布法、浸渍涂布法等，在一些实施例中，涂布液的涂布方式选自浸渍涂布法。

在上述制备方法中，步骤（3）中的第二溶剂选自 N-甲基吡咯烷酮（NMP）、二甲基乙酰胺（DMAC）、二甲基甲酰胺（DMF）、磷酸三乙酯（TEP）、二甲基亚砜（DMSO）中的一种或多种。步骤（3）中的第二溶剂与步骤（1）中加入的第一溶剂可相同。

在上述制备方法中，步骤（3）中，凝固液中第二溶剂的质量百分含量为 20%~60%。降低凝固液中第二溶剂的含量，有助于提升多孔膜的平均孔径以及孔隙率。但若第二溶剂的含量过低，则多孔膜的远离基体的表面会形成致密表皮，反而导致多孔膜的透气性变差，若第二溶剂的含量过高，则不能形成完整的多孔结构或者形成的多孔膜的平均孔径很低，壁厚很高。在一些实施例中，凝固液中第二溶剂的质量百分含量为 30%~40%。

在上述多孔膜的制备方法中，步骤（3）中的凝固液的温度为 15℃～30℃。在一些实施例中，凝固液的温度为 20℃～25℃。

在上述多孔膜的制备方法中，步骤（3）中，相转化的时间为 10s～90s。在一些实施例中，相转化的时间为 20s～60s。

在上述多孔膜的制备方法中，步骤（4）中，干燥温度为 60℃～70℃，干燥时间小于 1min。

根据本申请的第三方面，提供了一种包括根据本申请的第一方面所述

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的多孔膜的隔离膜。

其中，隔离膜包括多孔基材以及多孔膜。所述多孔膜设置于所述多孔基材的表面。在上述隔离膜中，所述多孔基材的种类没有具体地限制，可根据实际需求进行选择。具体地，所述多孔基材选自聚乙烯膜（PE）、聚丙烯膜（PP）、聚乙烯/聚丙烯双层膜（PE/PP）、聚丙烯/聚乙烯/聚丙烯三层膜（PP/PE/PP）、无纺布、聚酰亚胺、聚丙烯腈多孔膜（PAN）、玻璃纤维膜中的一种或多种。

本申请还提供了上述隔离膜的制备方法，用于制备本申请第三方面所述的隔离膜，包括步骤：（1）将无机颗粒与粘结剂混合，然后加入第一溶剂并均匀搅拌，得到涂布液，其中粘结剂溶于第一溶剂中；（2）将涂布液均匀涂布在多孔基材（例如聚乙烯）的表面上，形成湿膜；（3）将带有湿膜的多孔基材（例如聚乙烯）浸入到凝固液中进行相转化，其中，凝固液包括第二溶剂和第三溶剂，第二溶剂和第三溶剂互溶；（4）相转化结束后干燥，得到多孔基材（例如聚乙烯）表面设置有多孔膜的隔离膜，其中，多孔膜中相邻孔之间的平均壁厚为 20nm~500nm，多孔膜的平均孔径不小于 0.3μm。

在上述隔离膜的制备方法中，其制备过程参数设置与本申请第二方面的多孔膜的制备过程参数设置一致，仅需将基体设置为多孔基材即可。

根据本申请的第四方面，提供了包括根据本申请的第一方面所述的多孔膜的电极片。所述电极片包括集流体以及活性材料层。所述活性材料层设置于所述集流体的表面，且所述多孔膜设置于所述活性材料层远离集流体的表面上。

在上述电极片中，根据所使用的集流体和活性材料的不同，所述电极片既可以是正极极片也可以是负极极片。所述集流体的种类没有具体的限制，可根据实际需求进行选择，具体地，所述集流体选自铝箔、铜箔、镍箔、钛箔、银箔、镍铜合金箔、铝锆合金箔、不锈钢箔和石墨烯膜中的一种或多种。

本申请还提供了电极片的制备方法。用于制备本申请第四方面所述的电极片，包括步骤：（1）将无机颗粒与粘结剂混合，然后加入第一溶剂并

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均匀搅拌，得到涂布液，其中粘结剂溶于第一溶剂中；（2）将活性材料、导电剂、粘结剂混合，加入有机溶剂（例如N-甲基吡咯烷酮），在真空搅拌机作用下搅拌均匀，获得电极浆料，将电极浆料均匀涂覆于集流体上，然后干燥，以在集流体上形成活性材料层（电极片）；（3）将涂布液均匀涂布在电极片的表面上，形成湿膜；（4）将带有湿膜的电极片浸入到凝固液中进行相转化，其中，凝固液包括第二溶剂以及第三溶剂，第二溶剂与第三溶剂互溶；（5）相转化结束后干燥得到表面设置有多孔膜的电极片，其中，所述多孔膜中相邻孔之间的平均壁厚为 20nm~500nm，所述多孔膜的平均孔径不小于 0.3μm。上述电极片可以是正极极片，也可以是负极极片。

在上述电极片的制备方法中，其制备过程参数设置与根据本申请第二方面所述的多孔膜的制备过程参数设置一致。

根据本申请的第五方面，提供了一种锂离子电池。所述锂离子电池包括本申请第三方面所述的隔离膜，或包括本申请第四方面所述的电极片，或同时包括本申请第三方面所述的隔离膜以及本申请第四方面所述的电极片。所述电极片既可以是正极极片也可以是负极极片。

在上述锂离子电池中，正极极片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。

在上述正极材料中，钴酸锂的化学式可以为 $Li_xCo_aM1_bO_{2-c}$，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，x、a、b和c值分别在以下范围内：$0.8 \leqslant x \leqslant 1.2$、$0.8 \leqslant a \leqslant 1$、$0 \leqslant b \leqslant 0.2$、$-0.1 \leqslant c \leqslant 0.2$;

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 $Li_yNi_dM2_eO_{2-f}$，其中，M2表示选自钴（Co）、锰（Mn）、镁（Mg）、铝

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（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，y、d、e和f值分别在以下范围内：$0.8 \leqslant y \leqslant 1.2$、$0.3 \leqslant d \leqslant 0.98$、$0.02 \leqslant e \leqslant 0.7$、$-0.1 \leqslant f \leqslant 0.2$;

在上述正极材料中，锰酸锂的化学式为 $Li_zMn_{2-g}M3_gO_{4-h}$，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：$0.8 \leqslant z \leqslant 1.2$、$0 \leqslant g<1.0$ 和 $-0.2 \leqslant h \leqslant 0.2$。

负极极片包括能够吸收和释放锂（Li）的负极材料（下文中，有时称为“能够吸收/释放锂 Li 的负极材料”）。能够吸收/释放锂（Li）的负极材料的例子可以包括碳材料、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。碳材料的例子可以包括低石墨化的碳、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，将这些材料中的一些分成低石墨化碳或者易石墨化的碳。聚合物材料的例子可以包括聚乙炔和聚吡咯。

在能够吸收/释放锂（Li）的这些负极材料中，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。这是因为负极材料的充电和放电电压越低，电池越容易具有更高的能量密度。其中，负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。

此外，能够吸收/释放锂（Li）的负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，

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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。该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。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 $r\geq0$。此外，可以在负极中使用不包括锂（Li）的无机化合物，例如 MnO_2、V_2O_5、V_6O_{13}、NiS 和 MoS。

上述锂离子电池还包括电解质，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。

锂盐包括选自 $LiPF_6$、$LiBF_4$、$LiAsF_6$、$LiClO_4$、$LiB(C_6H_5)_4$、$LiCH_3SO_3$、$LiCF_3SO_3$、$LiN(SO_2CF_3)_2$、$LiC(SO_2CF_3)_3$、$LiSiF_6$、LiBOB 和二氟硼酸锂中的一种或多钟。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。

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。

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。

链状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）及其组合。所述环状碳酸酯化合物的实例为碳酸亚乙酯（EC）、碳酸亚丙酯（PC）、碳酸亚丁酯（BC）、碳酸乙烯基亚乙酯（VEC）及其

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组合。所述氟代碳酸酯化合物的实例为碳酸氟代亚乙酯（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。

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、γ-丁内酯、癸内酯、戊内酯、甲瓦龙酸内酯、己内酯、甲酸甲酯及其组合。

醚化合物的实例为二丁醚、四甘醇二甲醚、二甘醇二甲醚、1,2-二甲氧基乙烷、1,2-二乙氧基乙烷、乙氧基甲氧基乙烷、2-甲基四氢呋喃、四氢呋喃及其组合。

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。

将本申请的多孔膜应用于锂离子电池的电极组件不仅包括卷绕型，还可以是层压(堆积)型和折叠型。

下面结合实施例，进一步阐述本申请。应当理解，这些实施例仅用于说明本申请而不用于限制本申请的范围。在实施例中仅示出锂离子电池的电极组件为卷绕型的情况，但本申请不限于此。

在下述实施例中，所使用到的试剂、材料以及仪器如没有特殊的说明，均可商购获得。

实施例 1

（1）负极极片的制备

将负极活性材料人造石墨、粘结剂丁苯橡胶、导电剂导电炭黑（Super P）按质量比 92:3:5 与去离子水混合均匀制成负极浆料，之后将负极浆料均匀涂覆在负极集流体铜箔的正反两面上，然后在 85℃下烘干，形成负极活性材料层，然后进行冷压、分条、裁片、焊接负极极耳，得到负极极片。

（2）正极极片的制备

将正极活性材料钴酸锂（$LiCoO_2$）、粘结剂聚偏氟乙烯（PVDF）、导

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电剂导电炭黑（Super P）按质量比 97:1.5:1.5 溶于溶剂 N-甲基吡咯烷酮（NMP）中，搅拌均匀制成正极浆料，然后将正极浆料均匀涂布在正极集流体铝箔的正反两个表面上，之后在 85℃下烘干，得到正极活性材料层，之后经过冷压、分条、裁片、焊接正极极耳，得到正极极片。

（3）隔离膜的制备

将无机颗粒勃姆石与粘结剂聚偏氟乙烯按体积比值 1.2 混合，然后加入 N-甲基吡咯烷酮（第一溶剂）并均匀搅拌，得到涂布液，其中涂布液的固含量为 7%；采用浸渍涂布法将涂布液涂布于多孔基材（聚乙烯）上，形成湿膜；将带有湿膜的多孔基材（聚乙烯）浸入到含有去离子水（第三溶剂）和 N-甲基吡咯烷酮（NMP，第二溶剂）的凝固液中进行相转化，其中，凝固液中 N-甲基吡咯烷酮（第二溶剂）的质量百分含量为 40%，涂布液和凝固液的温度均为 25℃；浸入凝固液中 30s 后，放入烘箱于 60℃条件下烘干，得到带有多孔膜的隔离膜。其中，无机颗粒勃姆石的粒径分布：Dv10 为 0.9μm，Dv50 为 1.8μm 和 Dv90 为 3.0μm。

（4）电解液的制备

将锂盐 $LiPF_6$ 与非水有机溶剂（碳酸乙烯酯（EC）:碳酸二乙酯（DEC）:碳酸甲乙酯（EMC）:碳酸亚乙烯酯（VC）=8:85:5:2，质量比）按质量比 8:92 配制而成的溶液作为电解液。

（5）锂离子电池的制备

将正极极片、隔离膜以及负极极片卷绕后，得到电极组件，之后经过封装、注入电解液、化成、抽气成型，得到锂离子电池。

实施例 2

在该实施例中，负极极片、正极极片、电解液、锂离子电池的制备方法均与实施例 1 中所述的相应的制备方法相同。隔离膜的制备方法和实施例 1 中所述的制备方法一致，不同之处在于，涂布液的固含量为 10%。

实施例 3

在该实施例中，负极极片、正极极片、电解液、锂离子电池的制备方法均与实施例 1 中所述的相应的制备方法相同。隔离膜的制备方法和实施例 1 中所述的制备方法一致，不同之处在于，涂布液的固含量为 15%。

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实施例 4

在该实施例中，负极极片、正极极片、电解液、锂离子电池的制备方法均与实施例 1 中所述的相应的制备方法相同。隔离膜的制备方法和实施例 1 中所述的制备方法一致，不同之处在于，涂布液的固含量为 20%。

实施例 5

在该实施例中，负极极片、正极极片、电解液、锂离子电池的制备方法均与实施例 1 中所述的相应的制备方法相同。隔离膜的制备方法和实施例 1 中所述的制备方法一致，不同之处在于，涂布液的固含量为 25%。

实施例 6

在该实施例中，负极极片、正极极片、电解液、锂离子电池的制备方法均与实施例 1 中所述的相应的制备方法相同。隔离膜的制备方法和实施例 1 中所述的制备方法一致，不同之处在于，涂布液的固含量为 15%，并且选择二甲基乙酰胺（DMAC）作为第二溶剂。

实施例 7

在该实施例中，负极极片、正极极片、电解液、锂离子电池的制备方法均与实施例 1 中所述的相应的制备方法相同。隔离膜的制备方法和实施例 1 中所述的制备方法一致，不同之处在于，涂布液的固含量为 15%，并且选择二甲基甲酰胺（DMF）作为第二溶剂。

实施例 8

在该实施例中，负极极片、正极极片、电解液、锂离子电池的制备方法均与实施例 1 中所述的相应的制备方法相同。隔离膜的制备方法和实施例 1 中所述的制备方法一致，不同之处在于，涂布液的固含量为 15%，并且无机颗粒勃姆石的粒径分布：Dv10 为 0.015μm，Dv50 为 0.2μm，Dv90 为 1.5μm。

实施例 9

在该实施例中，负极极片、正极极片、电解液、锂离子电池的制备方法均与实施例 1 中所述的相应的制备方法相同。隔离膜的制备方法和实施例 1 中所述的制备方法一致，不同之处在于，涂布液的固含量为 15%，并且无机颗粒勃姆石的粒径分布：Dv10 为 0.2μm，Dv50 为 1.0μm，Dv90 为

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2.0μm。

实施例 10

在该实施例中，负极极片、正极极片、电解液、锂离子电池的制备方法均与实施例 1 中所述的相应的制备方法相同。隔离膜的制备方法和实施例 1 中所述的制备方法一致，不同之处在于，涂布液的固含量为 15%，并且无机颗粒勃姆石的粒径分布：Dv10 为 1.6μm，Dv50 为 2.6μm，Dv90 为 4.6μm。

实施例 11

在该实施例中，负极极片、正极极片、电解液、锂离子电池的制备方法均与实施例 1 中所述的相应的制备方法相同。隔离膜的制备方法和实施例 1 中所述的制备方法一致，不同之处在于，涂布液的固含量为 15%，并且无机颗粒勃姆石的粒径分布：Dv10 为 2.2μm，Dv50 为 3.5μm 和 Dv90 为 5.8μm。

实施例 12

在该实施例中，负极极片、正极极片、电解液、锂离子电池的制备方法均与实施例 1 中所述的相应的制备方法相同。隔离膜的制备方法和实施例 1 中所述的制备方法一致，不同之处在于，涂布液的固含量为 15%，并且无机颗粒勃姆石的粒径分布：Dv10 为 3.0μm，Dv50 为 5.0μm 和 Dv90 为 10.0μm。

实施例 13

在该实施例中，负极极片、正极极片、电解液、锂离子电池的制备方法均与实施例 1 中所述的相应的制备方法相同。隔离膜的制备方法和实施例 1 中所述的制备方法一致，不同之处在于，涂布液的固含量为 15%，并且凝固液中 N-甲基吡咯烷酮的质量百分含量为 20%。

实施例 14

在该实施例中，负极极片、正极极片、电解液、锂离子电池的制备方法均与实施例 1 中所述的相应的制备方法相同。隔离膜的制备方法和实施例 1 中所述的制备方法一致，不同之处在于，涂布液的固含量为 15%，并

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且凝固液中 N-甲基吡咯烷酮的质量百分含量为 60%。

实施例 15

在该实施例中，负极极片、正极极片、电解液、锂离子电池的制备方法均与实施例 1 中所述的相应的制备方法相同。隔离膜的制备方法和实施例 1 中所述的制备方法一致，不同之处在于，涂布液的固含量为 15%，并且选用氧化铝作为无机颗粒，氧化铝颗粒的粒径分布：Dv10 为 0.9μm，Dv50 为 1.8μm 和 Dv90 为 3.0μm。

实施例 16

在该实施例中，负极极片、正极极片、电解液、锂离子电池的制备方法均与实施例 1 中所述的相应的制备方法相同。隔离膜的制备方法和实施例 1 中所述的制备方法一致，不同之处在于，涂布液的固含量为 15%，并且选用氢氧化镁作为无机颗粒，氧化铝颗粒的粒径分布：Dv10 为 0.9μm，Dv50 为 1.8μm 和 Dv90 为 3.0μm。

实施例 17

（1）负极极片的制备

将负极活性材料人造石墨、粘结剂丁苯橡胶、导电剂导电炭黑（Super P）按质量比 92:3:5 与去离子水混合均匀制成负极浆料，之后将负极浆料均匀涂覆在负极集流体铜箔的正反两面上，然后在 85℃下烘干形成负极活性材料层，然后进行冷压、分条、裁片、焊接负极极耳，得到负极极片。

（2）正极极片的制备

将正极活性材料钴酸锂（$LiCoO_2$）、粘结剂聚偏氟乙烯（PVDF）、导电剂导电炭黑（Super P）按质量比 97:1.5:1.5 溶于溶剂 N-甲基吡咯烷酮（NMP）中，搅拌均匀制成正极浆料，然后将正极浆料均匀涂布在正极集流体铝箔的正反两个表面上，之后在 85℃下烘干后得到正极活性材料层；将无机颗粒勃姆石与粘结剂 PVDF 按体积比值 1.2 混合，然后加入 N-甲基吡咯烷酮（第一溶剂）并均匀搅拌，得到涂布液，其中，涂布液的固含量为 15%，采用浸渍涂布法将涂布液涂布于设置有正极活性材料层的正极集流体上，形成湿膜，之后浸入到含有去离子水（第三溶剂）及 N-甲基吡咯烷酮（第二溶剂）的凝固液中进行相转化，其中，凝固液中 N-甲基吡咯烷

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酮的质量百分含量为 40%，涂布液和凝固液的温度均为 25℃；浸入凝固液中 30s 后，进入烘箱于 60℃条件下烘干，之后经过冷压、分条、裁片、焊接正极极耳，得到带有多孔膜的正极极片。其中，无机颗粒勃姆石的粒径分布：Dv10 为 0.9μm，Dv50 为 1.8μm 和 Dv90 为 3.0μm。

（3）隔离膜的制备

以聚乙烯多孔基材作为隔离膜。

（4）电解液的制备

将锂盐 $LiPF_6$ 与非水有机溶剂（碳酸乙烯酯（EC）:碳酸二乙酯（DEC）:碳酸甲乙酯（EMC）:碳酸亚乙烯酯（VC）=8:85:5:2，质量比）按质量比 8:92 配制而成的溶液作为电解液。

（5）锂离子电池的制备

将正极极片、隔离膜以及负极极片卷绕后，得到电极组件，之后经过封装、注入电解液、化成、抽气成型，得到锂离子电池。

实施例 18

（1）负极极片的制备

将负极活性材料人造石墨、粘结剂丁苯橡胶、导电剂导电炭黑（Super P）按质量比 92:3:5 与溶剂 N-甲基吡咯烷酮（NMP）混合均匀制成负极浆料，之后将负极浆料均匀涂覆在负极集流体铜箔的正反两面上，然后在 85℃下烘干后形成负极活性材料层，将无机颗粒勃姆石与粘结剂 PVDF 按体积比值 1.2 混合，然后加入 N-甲基吡咯烷酮（第一溶剂）并均匀搅拌，得到涂布液，其中涂布液的固含量为 15%，采用浸渍涂布法将涂布液涂布于设置有负极活性材料层的负极集流体上，形成湿膜，之后浸入到含有去离子水（第三溶剂）及 N-甲基吡咯烷酮（第二溶剂）的凝固液中进行相转化，其中，凝固液中 N-甲基吡咯烷酮的质量百分含量为 40%，涂布液和凝固液的温度均为 25℃；浸入凝固液中 30s 后，进入烘箱于 60℃条件下烘干，之后经过冷压、分条、裁片、焊接负极极耳，得到负极极片。其中，无机颗粒勃姆石的粒径分布：Dv10 为 0.9μm，Dv50 为 1.8μm 和 Dv90 为 3.0μm。

（2）正极极片的制备

将正极活性材料钴酸锂（$LiCoO_2$）、粘结剂聚偏氟乙烯（PVDF）、导

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电剂导电炭黑（Super P）按质量比 97:1.5:1.5 溶于溶剂 N-甲基吡咯烷酮（NMP）中，搅拌均匀制成正极浆料，然后将正极浆料均匀涂布在正极集流体铝箔的正反两个表面上，之后在 85℃下烘干，得到正极活性材料层，之后经过冷压、分条、裁片、焊接正极极耳，得到正极极片。

（3）隔离膜的制备

以聚乙烯多孔基材作为隔离膜。

（4）电解液的制备

将锂盐 $LiPF_6$ 与非水有机溶剂（碳酸乙烯酯（EC）:碳酸二乙酯（DEC）:碳酸甲乙酯（EMC）:碳酸亚乙烯酯（VC）=8:85:5:2，质量比）按质量比 8:92 配制而成的溶液作为电解液。

（5）锂离子电池的制备

将正极极片、隔离膜以及负极极片卷绕后，得到电极组件，之后经过封装、注入电解液、化成、抽气成型，得到锂离子电池。

实施例 19

（1）负极极片的制备

将负极活性材料人造石墨、粘结剂丁苯橡胶、导电剂导电炭黑（Super P）按质量比 92:3:5 与溶剂 N-甲基吡咯烷酮（NMP）混合均匀制成负极浆料，之后将负极浆料均匀涂覆在负极集流体铜箔的正反两面上，然后在 85℃下烘干形成负极活性材料层，然后进行冷压、分条、裁片、焊接负极极耳，得到负极极片。

（2）正极极片的制备

将正极活性材料钴酸锂（$LiCoO_2$）、粘结剂聚偏氟乙烯（PVDF）、导电剂导电炭黑（Super P）按质量比 97:1.5:1.5 溶于 N-甲基吡咯烷酮（NMP）中，搅拌均匀制成正极浆料，然后将正极浆料均匀涂布在正极集流体铝箔的正反两个表面上，之后在 85℃下烘干，得到正极活性材料层；将无机颗粒勃姆石与粘结剂 PVDF 按体积比值 1.2 混合，然后加入 N-甲基吡咯烷酮（第一溶剂）并均匀搅拌，得到涂布液，其中，涂布液的固含量为 15%，采用浸渍涂布法将涂布液涂布于设置有正极活性材料层的正极集流体上，形成湿膜，之后浸入到含有去离子水（第三溶剂）及 N-甲基吡咯烷酮（第

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二溶剂）的凝固液中进行相转化，其中，凝固液中 N-甲基吡咯烷酮的质量百分含量为 40%，涂布液和凝固液的温度均为 25℃；浸入凝固液中 30s 后，进入烘箱于 60℃条件下烘干，之后经过冷压、分条、裁片、焊接正极极耳，得到带有多孔膜的正极极片。其中，无机颗粒勃姆石的粒径分布：Dv10 为 0.9μm，Dv50 为 1.8μm 和 Dv90 为 3.0μm。

（3）隔离膜的制备

将无机颗粒勃姆石与粘结剂 PVDF 按体积比值 1.2 混合，然后加入 N-甲基吡咯烷酮（第一溶剂）并均匀搅拌，得到涂布液，其中涂布液的固含量为 15%；采用浸渍涂布法将涂布液涂布于多孔基材（聚乙烯）上，形成湿膜；将带有湿膜的多孔基材（聚乙烯）浸入到含有去离子水（第三溶剂）及 N-甲基吡咯烷酮（第二溶剂）的凝固液中进行相转化，其中，凝固液中 N-甲基吡咯烷酮的质量百分含量为 40%，涂布液和凝固液的温度均为 25℃；浸入凝固液中 30s 后，进入烘箱于 60℃条件下烘干，得到带有多孔膜的隔离膜。其中，无机颗粒勃姆石的粒径分布：Dv10 为 0.9μm，Dv50 为 1.8μm 和 Dv90 为 3.0μm。

（4）电解液的制备

将锂盐 $LiPF_6$ 与非水有机溶剂（碳酸乙烯酯（EC）:碳酸二乙酯（DEC）:碳酸甲乙酯（EMC）:碳酸亚乙烯酯（VC）=8:85:5:2，质量比）按质量比 8:92 配制而成的溶液作为电解液。

（5）锂离子电池的制备

将正极极片、隔离膜以及负极极片卷绕后，得到电极组件，之后经过封装、注入电解液、化成、抽气成型，得到锂离子电池。

实施例 20

（1）负极极片的制备

将负极活性材料人造石墨、粘结剂丁苯橡胶、导电剂导电炭黑（Super P）按质量比 92:3:5 与溶剂 N-甲基吡咯烷酮（NMP）混合均匀制成负极浆料，之后将负极浆料均匀涂覆在负极集流体铜箔的正反两面上，然后在 85℃下烘干，形成负极活性材料层，将无机颗粒勃姆石与粘结剂 PVDF 按体积比值 1.2 混合，然后加入 N-甲基吡咯烷酮（第一溶剂）并均匀搅拌，得到

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涂布液，其中涂布液的固含量为 15%，采用浸渍涂布法将涂布液涂布于设置有负极活性材料层的负极集流体上，形成湿膜，之后浸入到含有去离子水（第三溶剂）及 N-甲基吡咯烷酮（第二溶剂）的凝固液中进行相转化，其中，凝固液中 N-甲基吡咯烷酮的质量百分含量为 40%，涂布液和凝固液的温度均为 25℃；浸入凝固液中 30s 后，进入烘箱于 60℃条件下烘干，之后经过冷压、分条、裁片、焊接负极极耳，得到带有多孔膜的负极极片。其中，无机颗粒勃姆石的粒径分布：Dv10 为 0.9μm，Dv50 为 1.8μm 和 Dv90 为 3.0μm。

（2）正极极片的制备

将正极活性材料钴酸锂（$LiCoO_2$）、粘结剂聚偏氟乙烯（PVDF）、导电剂导电炭黑（Super P）按质量比 97:1.5:1.5 溶于溶剂 N-甲基吡咯烷酮（NMP）中，搅拌均匀制成正极浆料，然后将正极浆料均匀涂布在正极集流体铝箔的正反两个表面上，之后在 85℃下烘干，得到正极活性材料层，之后经过冷压、分条、裁片、焊接正极极耳，得到正极极片。

（3）隔离膜的制备

将无机颗粒勃姆石与粘结剂 PVDF 按体积比值 1.2 混合，然后加入 N-甲基吡咯烷酮（第一溶剂）并均匀搅拌，得到涂布液，其中涂布液的固含量为 15%；采用浸渍涂布法将涂布液涂布于多孔基材（聚乙烯）上，形成湿膜；将带有湿膜的多孔基材（聚乙烯）浸入到含有去离子水（第三溶剂）及 N-甲基吡咯烷酮（第二溶剂）的凝固液中进行相转化，其中，凝固液中 N-甲基吡咯烷酮的质量百分含量为 40%，涂布液和凝固液的温度均为 25℃；浸入凝固液中 30s 后，进入烘箱于 60℃条件下烘干，得到带有多孔膜的隔离膜。其中，无机颗粒勃姆石的粒径分布：Dv10 为 0.9μm，Dv50 为 1.8μm 和 Dv90 为 3.0μm。

（4）电解液的制备

将锂盐 $LiPF_6$ 与非水有机溶剂（碳酸乙烯酯（EC）:碳酸二乙酯（DEC）:碳酸甲乙酯（EMC）:碳酸亚乙烯酯（VC）=8:85:5:2，质量比）按质量比 8:92 配制而成的溶液作为电解液。

（5）锂离子电池的制备

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将正极极片、隔离膜以及负极极片卷绕后，得到电极组件，之后经过封装、注入电解液、化成、抽气成型，得到锂离子电池。

对比例 1

在该对比例中，负极极片、正极极片、电解液、锂离子电池的制备方法均与实施例 1 中所述的相应的制备方法相同。

隔离膜的制备如下:

将勃姆石和聚偏氟乙烯按照体积比值 1.2 的量加入到去离子水中混合均匀制成浆料，并使浆料的固含量为 45%，然后用微凹涂布法将浆料均匀涂布到多孔基材（聚乙烯）的正反两个表面上，得到湿膜，湿膜经烘箱干燥后，得到隔离膜。其中，无机颗粒勃姆石的粒径分布：Dv10 为 0.9μm，Dv50 为 1.8μm 和 Dv90 为 3.0μm。

对比例 2

在该对比例中，负极极片、正极极片、电解液、锂离子电池的制备方法均与实施例 1 中所述的相应的制备方法相同。隔离膜的制备方法和实施例 1 中所述的制备方法一致，不同之处在于，涂布液的固含量为 4%。

对比例 3

在该对比例中，负极极片、正极极片、电解液、锂离子电池的制备方法均与实施例 1 中所述的相应的制备方法相同。隔离膜的制备方法和实施例 1 中所述的制备方法一致，不同之处在于，涂布液的固含量为 30%。

实施例 1-20 以及对比例 1-3 的参数如下表 1 所示。

表 1

	多孔膜位置	涂布液固含量	无机颗粒/μm				第二溶剂	凝固液中第二溶剂含量
			种类	Dv10	Dv50	Dv90		
实施例 1	隔离膜表面	7%	勃姆石	0.9	1.8	3.0	NMP	40%
实施例 2	隔离膜表面	10%	勃姆石	0.9	1.8	3.0	NMP	40%
实施例 3	隔离	15%	勃姆石	0.9	1.8	3.0	NMP	40%

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	膜表面							
实施例 4	隔离膜表面	20%	勃姆石	0.9	1.8	3.0	NMP	40%
实施例 5	隔离膜表面	25%	勃姆石	0.9	1.8	3.0	NMP	40%
实施例 3	隔离膜表面	15%	勃姆石	0.9	1.8	3.0	NMP	40%
实施例 6	隔离膜表面	15%	勃姆石	0.9	1.8	3.0	DMAC	40%
实施例 7	隔离膜表面	15%	勃姆石	0.9	1.8	3.0	DMF	40%
实施例 8	隔离膜表面	15%	勃姆石	0.015	0.2	1.5	NMP	40%
实施例 9	隔离膜表面	15%	勃姆石	0.2	1.0	2.0	NMP	40%
实施例 3	隔离膜表面	15%	勃姆石	0.9	1.8	3.0	NMP	40%
实施例 10	隔离膜表面	15%	勃姆石	1.6	2.6	4.6	NMP	40%
实施例 11	隔离膜表面	15%	勃姆石	2.2	3.5	5.8	NMP	40%
实施例 12	隔离膜表面	15%	勃姆石	3.0	5.0	10.0	NMP	40%
实施例 13	隔离膜表面	15%	勃姆石	0.9	1.8	3.0	NMP	20%
实施例 3	隔离膜表面	15%	勃姆石	0.9	1.8	3.0	NMP	40%

实施例 14	隔离膜表面	15%	勃姆石	0.9	1.8	3.0	NMP	60%
实施例 15	隔离膜表面	15%	氧化铝	0.9	1.8	3.0	NMP	40%
实施例 16	隔离膜表面	15%	氢氧化镁	0.9	1.8	3.0	NMP	40%
实施例 3	隔离膜表面	15%	勃姆石	0.9	1.8	3.0	NMP	40%
实施例 17	正极极片表面	15%	勃姆石	0.9	1.8	3.0	NMP	40%
实施例 18	负极极片表面	15%	勃姆石	0.9	1.8	3.0	NMP	40%
实施例 19	正极极片和隔离膜表面	15%	勃姆石	0.9	1.8	3.0	NMP	40%
实施例 20	负极极片和隔离膜表面	15%	勃姆石	0.9	1.8	3.0	NMP	40%
对比例 1	隔离膜表面	/	勃姆石	0.9	1.8	3.0	/	/
对比例 2	隔离膜表面	4%	勃姆石	0.9	1.8	3.0	NMP	40%
对比例 3	隔离膜表面	30%	勃姆石	0.9	1.8	3.0	NMP	40%

性能测试：

对实施例 1-20 和对比例 1-3 中制备的多孔膜和包括多孔膜的锂离子电

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池分别进行性能测试，测试方法如下：

（1）多孔膜的厚度测试

将设有多孔膜的隔离膜样品或电极片样品放置在测厚仪（Naitutoyo 公司的 VL-50 型 LITEMATIC）上，使用 5mm 的平底探头，探头行进速度为 50mm/min，压力为 0.01N。每个设有多孔膜的隔离膜样品或电极片样品测定 60 个厚度点，取厚度平均值作为测定值。多孔膜的厚度为涂布有多孔膜的隔离膜或电极片的厚度减去未涂布多孔膜的隔离膜样品或电极片样品的厚度，当有两层多孔膜时，还需除以 2，得到每层多孔膜的厚度。

（2）多孔膜的透气性能测试

裁取 100mm×100mm 的设有多孔膜的隔离膜样品，利用美国 Gurley 4110N 透气度测试仪，使用 100cc 的测试气体模式进行测试，记录测试气体全部通过设有多孔膜的隔离膜样品的时间，即为 Gurley 值。多孔膜的 Gurley 值为设有多孔膜的隔离膜的 Gurley 值减去未设有多孔膜的隔离膜（即纯多孔基材）的 Gurley 值。当电极片中包括多孔膜时，由于集流体本身不透气，因此无法按照此方法评估多孔膜的透气性。

（3）多孔膜的孔隙率测试

测量设有多孔膜的隔离膜样品或电极片样品的长度、宽度和厚度，采用前述方法得到多孔膜的厚度，计算得到多孔膜的表观体积 V1。利用真密度仪（micromeritics 公司的 AccuPyc Ⅱ 1340 型 Gas Pycnometer）测试设有多孔膜的隔离膜样品或电极片样品的真实体积 V20，并测试相同面积的未设有多孔膜的隔离膜样品或电极片样品的真实体积 V0，则多孔膜的真实体积 V2=V20-V0，多孔膜的孔隙率=1-V2/V1。

（4）多孔膜的平均孔径测试

用德国蔡司的 Sigma-02-33 型扫描电镜对多孔膜需要测量的区域进行观察并保存图片。测量图片中各孔的横向方向最大直径 L1 和纵向方向最大直径 L2，则该孔的孔径为（L1+L2)/2。测量 200 个相邻孔的孔径取平均值作为多孔膜的平均孔径。

（5）多孔膜的孔径分布系数测试

用德国蔡司的 Sigma-02-33 型扫描电镜对多孔膜需要测量的区域进行

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观察并保存图片。测量 200 个相邻孔的孔径，得到孔径分布曲线，R10 表示在孔径分布曲线中，从小孔径侧起、达到累积 10%的孔径（10%的孔的孔径小于该数值），R90 表示在孔径分布曲线中，从小孔径侧起、达到累积 90%的孔径（90%的孔的孔径小于该数值），孔径分布系数 D=R90/R10，其中 D 越接近 1，表明孔径的均匀性越好，D 越大，表明孔径的均匀性越差。

（6）多孔膜相邻孔之间的平均壁厚测试

用德国蔡司的 Sigma-02-33 型扫描电镜对多孔膜需要测量的区域进行观察并保存图片。测量 200 个相邻孔中的每两个相邻孔之间的壁厚，取其平均值为多孔膜相邻孔之间的平均壁厚。

（7）锂离子电池的倍率性能测试

在 25℃下，将锂离子电池以 0.2C 恒流放电至 3.0V，静置 10min，然后以 0.7C 恒流充电至 4.4V，接着再以 4.4V 恒压充电至 0.02C，静置 10min，进一步以 0.2C 恒流放电至电压为 3.0V，测量此时的放电容量，记为 Q1。然后以 0.7C 恒流充电至 4.4V，再恒压充电至 0.02C，静置 10min，以 2C 恒流放电至电压为 3.0V，测量此时的放电容量，记为 Q2。

锂离子电池 2C/0.2C 倍率性能（%）=Q2/Q1×100%。

（8）锂离子电池的循环性能测试

在 25℃下，将锂离子电池以 0.7C 恒流充电至 4.4V，再以 4.4V 恒压充电至 0.02C，静置 10min，以 1C 恒流放电至 3.0V，静置 10min，测量此时的放电容量，记为 Q3。以上述步骤作为一个循环充放电，进行 200 次循环，200 次循环后的放电容量记为 Q4。

锂离子电池循环 200 次后的容量保持率（%）=Q4/Q3×100%。

测试结果：

实施例 1-20 以及对比例 1-3 的测量结果如下表 2 所示。

表 2

	多孔膜						锂离子电池	
	Gurley 值 (s/100	厚度 (μm)	孔隙率	平均孔径(μm)	孔径分布系数 D	平均壁厚(nm)	倍率性能	循环性能

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	cc)							
实施例 1	24	2.4	58%	12	1.5	20	80.50%	86.70%
实施例 2	28	2.4	55%	7.8	2.1	90	84.20%	91.10%
实施例 3	32	2.4	53%	5	2.5	180	87.30%	95.30%
实施例 4	41	2.4	49%	3.6	3.6	320	83.90%	90.70%
实施例 5	55	2.4	46%	1.5	4.5	500	79.70%	85.30%
实施例 3	32	2.4	53%	5	2.5	180	87.30%	95.30%
实施例 6	35	2.4	52%	4.5	3	220	85.10%	92.30%
实施例 7	39	2.4	50%	3.7	3.2	300	82.90%	90.00%
实施例 8	45	2.4	48%	3.0	3.8	410	84.50%	91.50%
实施例 9	40	2.4	50%	4.0	3.4	320	85.40%	92.10%
实施例 3	32	2.4	53%	5	2.5	180	87.30%	95.30%
实施例 10	30	3.0	54%	5.5	2.2	160	86.30%	92.40%
实施例 11	28	4.0	55%	6.9	2.0	100	82.40%	89.80%
实施例 12	26	8.0	57%	8.9	1.8	70	80.20%	86.50%
实施例 13	39	2.4	51%	8.1	3.6	50	82.20%	89.30%
实施例 3	32	2.4	53%	5	2.5	180	87.30%	95.30%
实施例 14	34	2.4	52%	3.5	2.3	300	84.10%	90.20%
实施例 15	43	2.4	49%	2.5	3.0	240	80.20%	85.20%
实施例 16	38	2.4	51%	3.1	2.9	230	85.20%	89.70%
实施例 3	32	2.4	53%	5	2.5	180	87.30%	95.30%
实施例 17	/	2.4	53%	4.9	2.6	180	86.90%	94.60%
实施例 18	/	2.4	53%	5.1	2.6	180	87.20%	94.90%
实施例 19	/	2.4	53%	4.9	2.7	180	85.50%	93.50%
	32	2.4	53%	5	2.5	180		
实施例 20	/	2.4	53%	5.1	2.6	180	85.70%	92.90%
	32	2.4	53%	5	2.4	180		
对比例 1	36	2.4	46%	/	/	/	68.80%	70.10%
对比例 2	20	2.4	61%	18	1.3	12	73.70%	76.30%

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对比例 3	91	2.4	42%	0.5	5.3	600	72.70%	73.60%

从上述表 2 中的相关数据可以得知，本申请实施例提供的多孔膜具有较高的孔隙率，锂离子电池具有较好的倍率性能和循环性能。

从实施例 1-5 和对比例 2-3 的相关数据分析可知，涂布液的固含量增加，涂布液的粘度升高，凝固液内的非溶剂（第三溶剂）和涂布液内的有机溶剂（第一溶剂）的交换速度变慢，所形成的多孔膜的平均孔径降低，相邻孔之间的平均壁厚增加，多孔膜的孔隙率降低，透气性能变差。但是，若涂布液的固含量过低（例如，对比例 2），则多孔膜难以成膜，锂离子电池的电化学性能急剧下降。实施例 3 的多孔膜的平均孔径较大、孔径分布均匀且相邻孔之间的平均壁厚较小。若涂布液的固含量过高（例如，对比例 3），则多孔膜的孔隙率过低，透气性能很差，且参照图 3 可知，多孔膜中倾向于形成小孔径的结构，相邻孔之间的平均壁厚较大，严重影响锂离子电池的循环性能和倍率性能。

从实施例 3 和实施例 15、16 的相关数据分析可知，含有极性官能团的无机颗粒对锂离子电池的倍率性能和循环性能的改善更为显著。这是由于含有极性官能团的无机颗粒的表面更容易与凝固液内的非溶剂（第三溶剂）去离子水结合，有利于去离子水沿着无机颗粒表面扩散进入多孔膜，从而在无机颗粒的附近形成较大的孔结构，有利于得到平均孔径较大、相邻孔之间的平均壁厚较小的孔结构。

从实施例 3、实施例 6 和实施例 7 的相关数据分析可知，选用不同的有机溶剂（第二溶剂），则得到的多孔膜中的孔结构也不相同，其中，使用 NMP 形成的多孔膜的平均孔径最大、孔隙率最高；使用 DMF 形成的多孔膜的平均孔径最小、空隙率最低；使用 DMAC 则形成的多孔膜的平均孔径以及孔隙率介于 NMP 和 DMF 之间。

从实施例 3、实施例 8-12 的相关数据分析可知，无机颗粒的粒径对锂离子电池的倍率性能和循环性能的改善有影响，无机颗粒的粒径增加，凝固液内非溶剂（第三溶剂）与涂布液内的有机溶剂（第一溶剂）的交换速度提高，孔结构的发展变快，则所形成的孔的平均孔径增加、相邻孔之间

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的平均壁厚降低。

从实施例 3、13-14 的相关数据分析可知，凝固液中有机溶剂（第二溶剂）的含量对锂离子电池的倍率性能和循环性能也有较大影响，降低凝固液中有机溶剂（第二溶剂）的含量，有助于提升多孔膜的孔的平均孔径。从实施例 1、实施例 17-20 的相关数据分析可知，本申请的多孔膜既可以单独地形成于隔离膜、正极极片、负极极片上，也可以同时形成于隔离膜和正极极片以及隔离膜和负极极片上，不论何种情况锂离子电池均具有良好的倍率性能和循环性能。

本领域技术人员应理解，以上实施例仅是示例性实施例，在不背离本申请的精神和范围的情况下，可以进行多种变化、替换以及改变。

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说明书附图

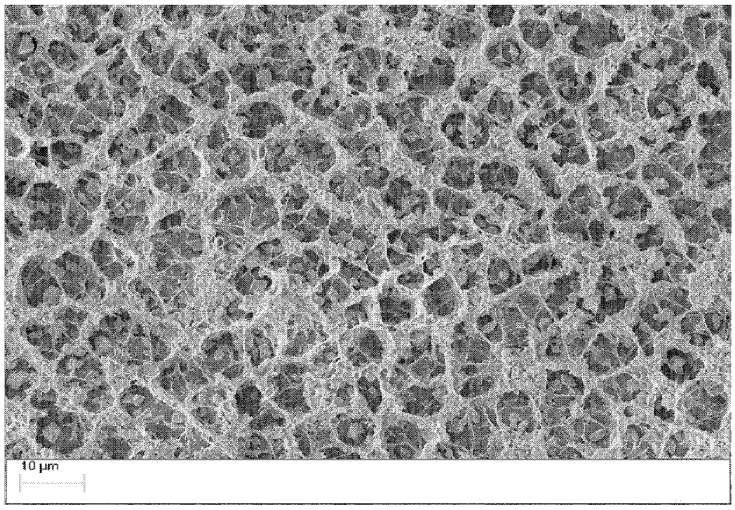


图 1

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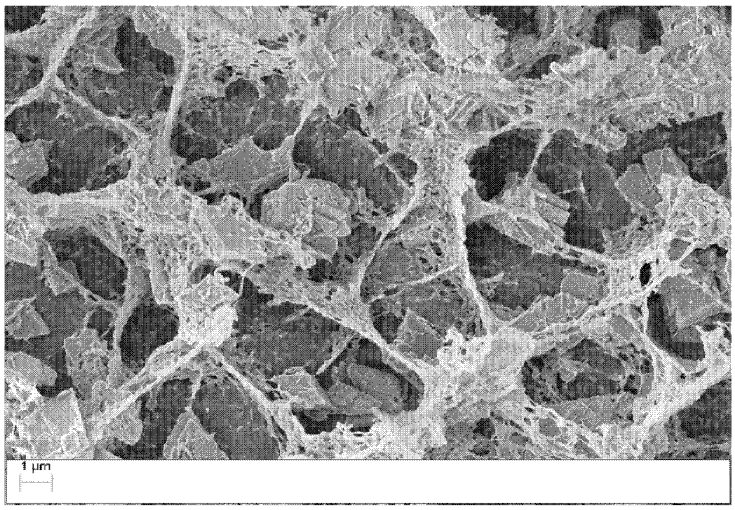


图 2

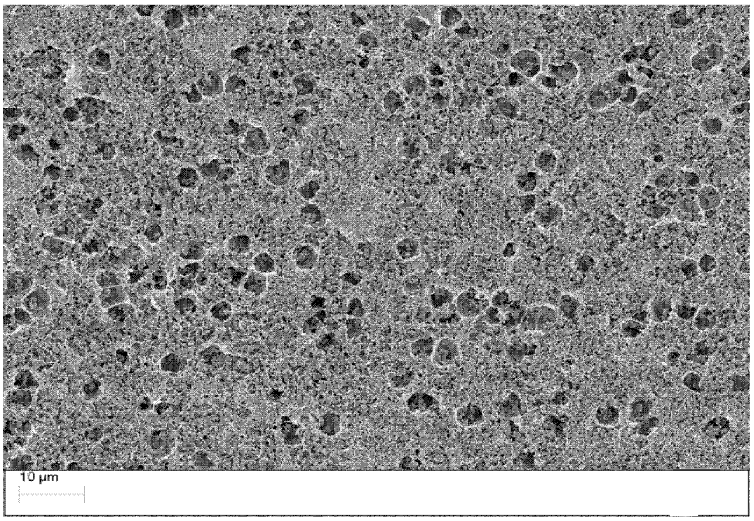


图 3

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DECLARATION TRANSMITTAL

First Inventor	:	Jianjian Yi
App. No.	:	16/000764
Filed	:	June 5, 2018
For	:	POROUS FILM AND LITHIUM-ION BATTERY
Examiner	:	Unassigned
Art Unit	:	1725
Conf. No.	:	2445

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

The above-captioned application was filed without a Declaration and/or Substitute Statement. Enclosed for filing in the above-identified application are:

(X) Declaration(s) for:
Jianjian Yi
Xinzhi Zhang
Zengbin Wei
Xinghua Tao

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: July 26, 2018

By: 

David Dremann
Registration No. 71,708
Registered Practitioner
Customer No. 20995
(949) 760-0404

28614848

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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	POROUS FILM AND LITHIUM-ION BATTERY

As the below named inventor, I hereby declare that:

This declaration is directed to:

- ☐ The attached application, or
- ☒ United States application or PCT international application number 16/000764 filed on June 5, 2018.

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:

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LEGAL NAME OF INVENTOR

Inventor: Xinghua Tao Date (Optional): JULY 24 2018

Signature: Tao Xinghua

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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LEGAL NAME OF INVENTOR

Inventor: Zengbin Wei Date (Optional): July 24 2018

Signature: Wei Zengbin

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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LEGAL NAME OF INVENTOR

Inventor: Jianjian Yi Date (Optional): July 24 2018

Signature: Yi JianJian

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

Title of Invention	POROUS FILM AND LITHIUM-ION BATTERY

As the below named inventor, I hereby declare that:

This declaration is directed to:

- ☐ The attached application, or
- ☒ United States application or PCT international application number 16/000764 filed on June 5, 2018.

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: Xinzhi Zhang Date (Optional): July 20 2018.

Signature: Zhang XinZhi

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Electronic Acknowledgement Receipt	
EFS ID:	33298342
Application Number:	16000764
International Application Number:	
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Title of Invention:	POROUS FILM AND LITHIUM-ION BATTERY
First Named Inventor/Applicant Name:	Jianjian Yi
Customer Number:	20995
Filer:	David Michael Dremann/Tony Do
Filer Authorized By:	David Michael Dremann
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1	Miscellaneous Incoming Letter	DHNG001005AUS_Dec_Trans.PDF	31112 9e65abe19077608a5f92071e7ba3afa1b4ece398	no	2

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If a new application is being filed and the application includes the necessary components for a 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.

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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.

New International Application Filed with the USPTO as a Receiving Office

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PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	16/000764
	Filing Date	June 5, 2018
	First Named Inventor	Jianjian Yi
	Art Unit	1726
(Multiple sheets used when necessary)	Examiner	Unassigned
SHEET 1 OF 1	Attorney Docket No.	DHNG001.005AUS

FOREIGN PATENT DOCUMENTS						
Examiner Initials	Cite No.	Foreign Patent Document *Country Code-Number-Kind Code* Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T[1]
	1	CN 103474602 A	12-25-2013	SHENZHEN TAIBAI TECHNOLOGY CO LTD		
	2	CN 205004376 U	01-27-2016	SHENZHEN HONGTAI BATTERY TECH CO LTD		

28676403

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

T[1] - Place a check mark in this area when an English language Translation is attached.

Espacenet

Bibliographic data: CN103474602 (A) — 2013-12-25

Pore-forming ceramic isolating membrane of lithium ion battery and preparation method thereof

Inventor(s):	GAO XUEYOU ± (GAO XUEYOU, ; 高学友)
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Classification:	**- international:** ***H01M2/16*** **- cooperative:**
Application number:	CN20131391112 20130830 Global Dossier
Priority number (s):	CN20131391112 20130830
Also published as:	CN103474602 (B)

Abstract of CN103474602 (A)

The invention discloses a pore-forming ceramic isolating membrane of a lithium ion battery. The pore-forming ceramic isolating membrane comprises an isolating membrane base material, wherein a porous ceramic coating is coated on single surface or double surfaces of the isolating membrane base material; the porous ceramic coating is formed by coating a sizing agent which contains nanometer ceramic powder, a binding agent as well as a pore-forming solvent on the isolating membrane base material, wherein dosage of the nanometer ceramic powder, the binding agent, a stabilizing agent and the pore-forming solvent in the sizing agent is respectively as follows in parts by weight: 88-93 parts of the nanometer ceramic powder, 4-6.5 parts of binding agent powder, 1-1.5 parts of the stabilizing agent, and 2-4 parts of the pore-forming solvent. According to the pore-forming ceramic isolating membrane of the lithium ion battery disclosed by the invention, an absorption rate of electrolyte is improved by improving a ceramic sizing agent, thereby facilitating transfer of lithium ions better, increasing inventory of the electrolyte in the battery and increasing hardness of the battery. Meanwhile, the problems that the ceramic layer is easy to drop on the isolating membrane and the coating thickness or the surface density is uneven are solved by the porous ceramic membrane coated by the novel sizing agent, and therefore, the safety performance of the battery is improved.

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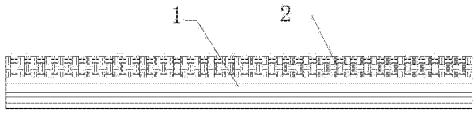
权利要求书1页 说明书5页 附图2页

(54)发明名称

一种锂离子电池造孔陶瓷隔离膜及其制备方法

(57)摘要

本发明公开了一种锂离子电池造孔陶瓷隔离膜,包括隔离膜基材,所述隔离膜基材单面或双面涂布有多孔陶瓷层,所述多孔陶瓷层是通过含有纳米陶瓷粉、粘结剂以及造孔溶剂的浆料涂布在隔离膜基材上而成,浆料中纳米陶瓷粉、粘结剂、稳定剂以及造孔溶剂的用量以重量份计分别为:纳米陶瓷粉 88-93 份,粘结剂份 4-6.5,稳定剂 1-1.5,造孔溶剂 2-4 份。本发明所述的锂离子电池造孔陶瓷隔离膜通过对陶瓷浆料改进,提高了电解液的吸收速度,更有利于锂离子的转移,增加了电池中电解液的保有量,增强了电池的硬度。同时,这种新的浆料涂布的多孔陶瓷膜解决了陶瓷层在隔离膜上易脱落、涂布厚度或面密度不均匀的问题,提高了电池的安全性能。



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1. 一种锂离子电池造孔陶瓷隔离膜，包括隔离膜基材，其特征在于：所述隔离膜基材单面或双面涂布有多孔陶瓷层，所述多孔陶瓷层是通过含有纳米陶瓷粉、造孔溶剂以及粘结剂的浆料涂布在隔离膜基材上而成，浆料中纳米陶瓷粉、粘结剂以及造孔溶剂的用量以重量份计分别为：纳米陶瓷粉 88-93 份，粘结剂份 4-6.5，稳定剂 1-1.5 份，造孔溶剂 2-4 份。

2. 根据权利要求 1 所述的锂离子电池造孔陶瓷隔离膜，其特征在于：所述浆料中纳米陶瓷粉、粘结剂、稳定剂、造孔溶剂的用量分别为 91 份、5.5 份、1 份、2.5 份。

3. 根据权利要求 1 所述的锂离子电池造孔陶瓷隔离膜，其特征在于：所述涂布的多孔陶瓷层厚度为 3-5μm。

4. 根据权利要求 1 所述的锂离子电池造孔陶瓷隔离膜，其特征在于：所述浆料固含量为 25-30%，浆料粘度为 40~50mpa·s。

5. 根据权利要求 1-3 任一项所述的锂离子电池造孔陶瓷隔离膜，其特征在于：所述纳米陶瓷粉为经过纳米化处理的 Al_2O_3 或 $BaSO_4$ 中的一种或两种以任意比混合。

6. 根据权利要求 1 所述的锂离子电池造孔陶瓷隔离膜，其特征在于：所述造孔溶剂为乙酸乙酯；所述粘结剂为聚丙烯酸酯，所述稳定剂为羧甲基纤维素钠。

7. 根据权利要求 1 所述的锂离子电池造孔陶瓷隔离膜，其特征在于：所述隔离膜基材为多孔单层或多层 PP 膜、PE 膜或 PP/PE 复合隔离膜中的一种，隔离膜基材的孔隙率为 40%~47%。

8. 一种如权利要求 1-7 任一项所述的锂离子电池造孔陶瓷隔离膜的涂布方法，其特征在于其工艺步骤如下：

1）陶瓷纳米化处理：将陶瓷原材料纳米化后烘烤、过筛，得到的纳米陶瓷粉备用；

2）浆料配制：按照上述比例将稳定剂加水溶解并搅拌后，加入得到的纳米陶瓷粉搅拌，依次加入粘结剂和造孔溶剂，继续搅拌反应；

3）涂布：升温凸版涂布机的烘箱，烘箱各段从前到后逐步提高温度，将浆料打入料槽中涂布在隔离膜基材的单面或双面，烘干即成。

9. 根据权利要求 8 所述的锂离子电池造孔陶瓷隔离膜的涂布方法，其特征在于：步骤 1）中烘箱的温度为 80-90℃，烘烤时间为 24-36 小时；步骤 2）中搅拌速度为 700-900r/min，搅拌反应时间为 1.5-2h。

10. 根据权利要求 8 所述的锂离子电池造孔陶瓷隔离膜的涂布方法，其特征在于：步骤 3）中烘箱各端的温度范围为 45-50℃。

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一种锂离子电池造孔陶瓷隔离膜及其制备方法

技术领域

[0001] 本发明涉及锂离子电池技术领域，具体涉及一种锂离子电池造孔陶瓷隔离膜及其涂布方法。

背景技术

[0002] 锂电池的燃烧甚至爆炸的根本原因是电池内部热失控制造成的，其中正负极片的短路是常见的问题，所以隔离膜在其中具有重要的隔离作用。隔离膜在锂电池中具有隔离电子、导通离子的作用，在隔离膜上涂上一层陶瓷层，当电池中有异物造成隔离膜破损时，短路点在高温度下不会因发热而扩大熔化，不会造成电极之间大面积短路，进而引起电池的燃烧甚至爆炸。随着贮能、电动汽车和电脑等用电器对锂离子电池的要求不断提高，锂离子充电电池单只容量和体积能量密度的不断提高，内部蓄积的能量越来越大，内部短路的危险性也在随之增大。当电池内部短路时，在高温下，陶瓷隔离膜的陶瓷层可以保持隔离膜完整的骨架结构，不因隔离膜基材熔化而失去分隔正负极片的作用，产生正负极片大面积短路。

[0003] 常见陶瓷隔离膜是在用干法或湿法工艺制造的单层或多层 PP、PE、PP/PE 复合隔离膜上涂附陶瓷层提高电池的安全性能，但在使用过程中常出现陶瓷层粘接不牢、吸液速度不够快等现象。有的陶瓷隔离膜在陶瓷层和隔离膜基材层之间加入高分子层，虽然保液性能有提高，但电池的离子通道有影响，且陶瓷层的厚度不够，安全性能不高等问题。

发明内容

[0004] 为了克服现有技术的缺陷，本发明的目的在于提供一种锂离子电池造孔陶瓷隔离膜，以提高锂电池的安全性能、吸液性能、保液性能、多孔陶瓷层的粘接性能以及锂离子通透性。

[0005] 本发明的另一目的在于提供一种锂离子电池造孔陶瓷隔离膜的制备方法，制造出的高安全造孔陶瓷隔离膜，提高锂离子电池的安全性能。

[0006] 为实现上述目的，本发明所采用的技术方案如下：

[0007] 一种锂离子电池造孔陶瓷隔离膜，包括隔离膜基材，所述隔离膜基材单面或双面涂布有多孔陶瓷层，所述多孔陶瓷层是通过含有纳米陶瓷粉、造孔溶剂以及粘结剂的浆料经凸版印刷机涂布而成，浆料中纳米陶瓷粉、造孔溶剂以及粘结剂的用量以重量份计分别为：纳米陶瓷粉 88-93 份，粘结剂份 4-6.5，稳定剂 1-1.5 份，造孔溶剂 2-4 份。

[0008] 本发明还可以通过以下方案实现：

[0009] 作为本发明的一种优选的方案，所述浆料中纳米陶瓷粉、粘结剂、稳定剂造孔溶剂的用量分别为 91 份、5.5 份、1 份，2.5 份。

[0010] 作为本发明的一种优选的方案，所述造孔陶瓷膜的多孔陶瓷层的涂层厚度为 3-5μm。本发明中，将多孔陶瓷层的厚度控制在上述范围之内，在提高多孔陶瓷膜保液能力的同时，也进一步提高了电池的安全性能；优选的所述多孔陶瓷层的厚度，小型电池（单体

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容量 5AH 以内，主要用于 3C 产品等）要求多孔陶瓷层单面涂层厚度为 3-4μm，大电池（单体容量 5AH 以上，主要用于动力电池、电动汽车电池、蓄能电池等）要求多孔陶瓷层单面涂层厚度为 5μm。

[0011] 为了控制涂布的厚度和均匀度，从而达到控制隔离膜质量的目的，作为本发明的一种优选的方案，所述浆料固含量为 25-30%，浆料粘度为 40 ～ 50mpa·s。当浆料粘度和固含量在上述范围时候，有利于凹版涂布机对涂布厚度和均匀度的控制。

[0012] 作为本发明的一种优选的方案，所述纳米陶瓷粉为经过纳米化处理的 Al_2O_3 或 $BaSO_4$ 中的一种或两种以任意比混合。

[0013] 在本发明中，所述造孔溶剂采用乙酸乙酯等低沸点的溶剂；这种低沸点溶剂具有水溶性兼油溶性，在材料中分散均匀，且密度小，所以在烘干过程中首先被蒸发掉，在陶瓷层表面形成微小的细密开孔，造孔隔离膜制作成电池后，为电解液的浸入提供更多的通道。所述粘结剂为聚丙烯酸酯，所述稳定剂为羧甲基纤维素钠。进一步的为了提高多孔陶瓷层的粘结性，所述稳定剂羧甲基纤维素钠的平均分子量 65 ～ 100 万左右，粘接剂聚丙烯酸酯的平均分子量为 30 ～ 120 万。

[0014] 作为本发明的一种优选的方案，所述隔离膜基材为干法或湿法多孔单层或多层 PP 膜、PE 膜或 PP/PE 复合隔离膜中的一种，隔离膜基材的孔隙率为 40% ～ 47%。

[0015] 一种锂离子电池造孔陶瓷隔离膜的涂布方法，其工艺步骤如下：

[0016] 1）陶瓷纳米化处理：将陶瓷原材料纳米化后烘烤、过筛，得到的纳米陶瓷粉备用；

[0017] 2）浆料配制：按照上述比例将稳定剂加水溶解并搅拌后，加入得到的纳米陶瓷粉搅拌，依次加入粘结剂和造孔溶剂，继续搅拌反应；

[0018] 3）涂布：升温涂布机的烘箱，烘箱各段从前到后逐步提高温度，将浆料打入料槽中涂布在隔离膜基材的单面或双面，通过烘箱烘干即成。

[0019] 上述方法中，作为优选的实施方案，所述步骤 1）中烘箱的温度为 80-90℃，烘烤时间为 24-36 小时；步骤 2）中搅拌速度为 700-900r/min，搅拌反应时间为 1.5-2h。

[0020] 上述方法中，作为优选的实施方案，步骤 3）中烘箱各端的温度范围为 45-50℃。

[0021] 相比现有技术，本发明的有益效果在于：本发明所述的锂离子电池造孔陶瓷隔离膜通过对陶瓷浆料的改造，造孔陶瓷层更有利于电解液的快速吸收和提高锂离子的转移速度，增加了电池电解液的保有量，又增强了电池的硬度；这种新配方浆料涂布出的多孔陶瓷膜解决了陶瓷层在隔离膜上易脱落、涂布厚度或面密度不均匀的问题。本发明不仅提高了电池的安全性能，同时也达到普通隔离膜制造的电池无法达到的性能。

[0022] 下面结合附图及具体实施方式对本发明作进一步详细说明。

附图说明

[0023] 图 1 为本发明一种实施方式的结构示意图；

[0024] 图 2 为本发明另一种实施方式的结构示意图；

[0025] 图 3 为隔离膜基材与本发明的造孔陶瓷膜后的隔离膜外观对比，其中（a）为隔离膜基材，（b）为造孔陶瓷隔离膜；

[0026] 图 4 为本发明的造孔陶瓷隔离膜的电镜图；

[0027] 图 5 为本发明的造孔陶瓷隔离膜与普通隔离膜的电铬铁穿刺对比示意图其中（c）

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为普通隔离膜，(d) 为造孔陶瓷隔离膜；

[0028] 图 6 为普通隔离膜与本发明的造孔陶瓷隔离膜电解液的浸润性的照片对比，其中 (e) 为普通隔离膜，(f) 为造孔陶瓷隔离膜。

具体实施方式

[0029] 如图 1 所示，一种实施方式中，本发明所述的锂离子电池造孔陶瓷隔离膜，包括隔离膜基材 1，所述隔离膜基材 1 双面涂布有多孔陶瓷膜 2，所述多孔陶瓷膜是通过含有纳米陶瓷粉、造孔溶剂以及粘结剂的浆料涂布而成，浆料中纳米陶瓷粉、造孔溶剂以及粘结剂的用量以重量份计分别为：纳米陶瓷粉 88-93 份，粘结剂份 4-6.5，稳定剂 1-1.5 份，造孔溶剂 2-4 份。

[0030] 如图 2 所示，另一中实施方式中，与上述方案的区别在于：本发明所述的所述隔离膜基材 1 单面涂布有多孔陶瓷层 2。

[0031] 以下是本发明制备锂离子电池造孔陶瓷隔离膜的具体实施例。

[0032] 实施例 1

[0033] 一种锂离子电池造孔陶瓷隔离膜，其是通过以下方法制备而成：

[0034] 1) 陶瓷纳米化处理：将 Al_2O_3 原料纳米化后于 85℃的烤箱中烘烤 36h，过筛，得到的纳米陶瓷粉备用；

[0035] 2) 浆料配制：取固含量 1.6% 的羧甲基纤维素钠溶液 93.75g，加去离子水 300g，以 800r/min 的转速搅拌 30min；然后加入步骤 1) 的纳米陶瓷粉 144g，以 800r/min 的转速搅拌 3h；加入聚丙烯酸酯 9g，加入造孔溶剂乙酸乙酯 3g，以 800r/min 的转速搅拌 1.5 ～ 2h；用微量去离子水调节浆料黏度为 47mpa·s，浆料固含量为 27.8%；

[0036] 3) 涂布：调试机器，并升温烘箱，涂布机各段的温度控制在 45 ～ 50℃范围内，烘箱各段从前到后逐步提高温度；将浆料打入料槽中，进行试涂，烘干后进行厚度和面密度测试，直到调节达到要求后，开始将浆料涂布在 PP 隔离膜基材上。

[0037] 实施例 2

[0038] 一种锂离子电池造孔陶瓷隔离膜，其是通过以下方法制备而成：

[0039] 1) 陶瓷纳米化处理：将 $BaSO_4$ 原料纳米化处理后于 85℃的烤箱中烘烤 24h，过筛，得到的纳米陶瓷粉备用；

[0040] 2) 浆料配制：取固含量 1.6% 的羧甲基纤维素钠溶液 125g，加去离子水 300g，以 800r/min 的转速搅拌 30min；然后加入步骤 1) 的纳米陶瓷粉 150g，以 800r/min 的转速搅拌 3h；加入聚丙烯酸酯 10g，加入造孔溶剂乙酸乙酯 4g，以 800r/min 的转速搅拌 1.5 ～ 2h；用微量去离子水调节浆料黏度为 48mpa·s；浆料固含量为 27.5%；

[0041] 3) 涂布：调试机器，并升温烘箱，涂布机各段的温度控制在 45 ～ 50℃范围内，烘箱各段从前到后逐步提高温度；将浆料打入料槽中，进行试涂，烘干后进行厚度和面密度测试，直到调节达到要求后，开始将浆料涂布在 PE 隔离膜基材上。

[0042] 实施例 3

[0043] 一种锂离子电池造孔陶瓷隔离膜，其是通过以下方法制备而成：

[0044] 1) 陶瓷纳米化处理：将原料 Al_2O_3 与 $BaSO_4$ 按照质量比为 1 ∶ 1 的比例混合后纳米化处理，于 85℃的烤箱中烘烤 24 ～ 36h，过筛，得到的纳米陶瓷粉备用；

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[0045] 2）浆料配制：取固含量 1.6% 的羧甲基纤维素溶液 93.75g，加去离子水 300g，以 800r/min 的转速搅拌 30min；然后加入步骤 1）的纳米陶瓷粉 145g，以 800r/min 的转速搅拌 3h；加入聚丙烯酸酯 9g，加入造孔溶剂乙酸乙酯 3.5g，以 800r/min 的转速搅拌 1.5 ～ 2h；用微量去离子水调节浆料黏度为 46mpa·s；浆料固含量为 27.3%；

[0046] 3）涂布：调试机器，并升温烘箱，涂布机各段的温度控制在 45 ～ 50℃范围内，烘箱各段从前到后逐步提高温度；将浆料打入料槽中，进行试涂，烘干后进行厚度和面密度测试，直到调节达到要求后，开始将浆料涂布在 PE/PP 复合隔离膜基材上。

[0047] 性能检测：

[0048] 1. 电铬铁穿刺实验：用电烙铁轻触穿刺隔离膜测试（测试条件：电烙铁温度 390℃），测试结果见示意图 5。

[0049] 图 5 的结果显示普通隔离膜在接触点直径明显扩大；本发明的造孔陶瓷膜接触点没有扩大。说明当在电芯内部微短路产生热量或着火点时，陶瓷隔离膜孔径不会继续增大，从而减小了燃烧的风险。

[0050] 2. 浸润性对比：将同一种电解液同时滴在普通陶瓷膜和本发明的造孔陶瓷隔离膜上（测试温度 27℃），测试结果见图 6。

[0051] 图 6 的结果显示在相同时间内电解液在普通陶瓷膜上的扩散速度明显比电解液在本发明的造孔陶瓷隔离膜上的扩散速度。说明本发明的造孔陶瓷隔离膜具有良好的吸液性能和离子通透性能，即具有良好的浸润性。

[0052] 3. 其他性能检测，检测结果见表 1。

[0053] 表 1

[0054]

项目		单位	规格和标准值				检验方法和仪器
外观			乳白色，平整光滑，无划痕，无色斑、无针孔				目测
厚度		um	12±3	16±3	20±3	24±3	千分尺
宽度		mm	根据需求指定				卡尺或投影仪
长度		mm	根据需求指定				收卷计米器
透气度		sec/100cc	190±60	250±60	290±60	320±60	透气度测定仪
孔隙率		%	45±5	45±5	45±5	45±5	GB/T21650.1-2008
穿刺强度		gf	≥320	≥450	≥500	≥550	GB/T23318-2009
拉伸强度	MD	Kgf/cm2	≥1000	≥1125	≥1200	≥1250	GB/T1040.3-2006
	TD		≥800	≥900	≥960	≥1000	

[0055]

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热收缩 130℃/0.5H	MD	%	≤4.0	≤4.0	≤4.0	≤4.0	取 1.5-1.0mm 的隔离膜，标记好测试点，经烘烤后，比较烘烤前后长度和宽度方向上的变化率。
	TD		≤4.0	≤4.0	≤4.0	≤4.0	
面密度		g/m3	10.6±3	12.9±3	14.8±3	17±3	取样器和电子天秤
弧度		mm	≤3.5	≤3.5	≤3.5	≤3.5	取 1 米长的隔离膜平铺在 1 米长的直钢尺上，确保隔离膜的两端同时对齐直钢尺的一边并固定。然后用卡尺在隔离膜的 0.5 米处测量隔离膜到直钢尺边缘的距离。

[0056] 备注：1. MD 指纵向(长度方向)；TD 指横向(宽度方向)

[0057] 2. 此标准是选用 PE 基材单面涂布陶瓷层厚 4μm 后的结果。不同的基材会有所不同。

[0058] 上述实施方式仅为本发明的优选实施方式，不能以此来限定本发明保护的范围，本领域的技术人员在本发明的基础上所做的任何非实质性的变化及替换均属于本发明所要求保护的范围。

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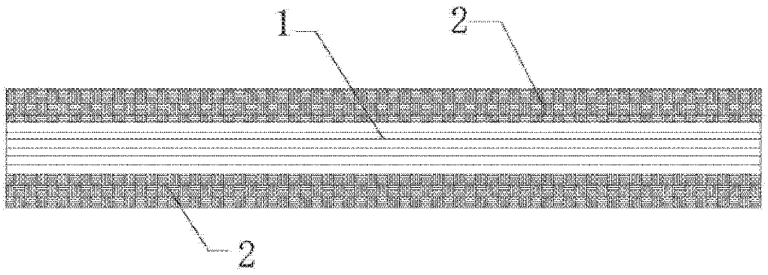


图 1

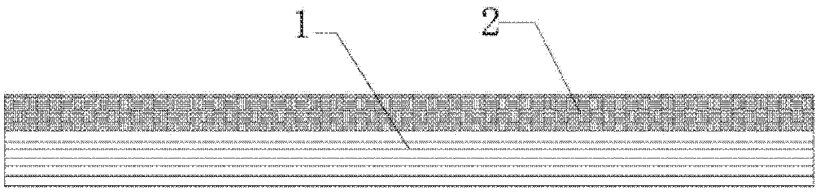


图 2

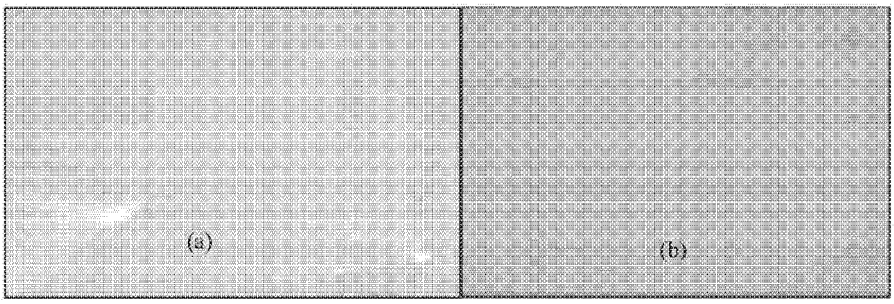


图 3

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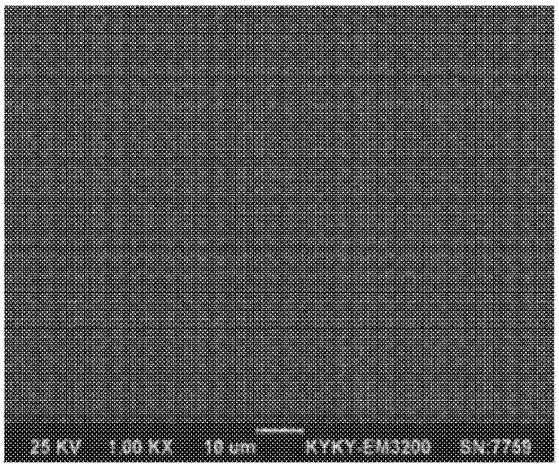


图 4



图 5

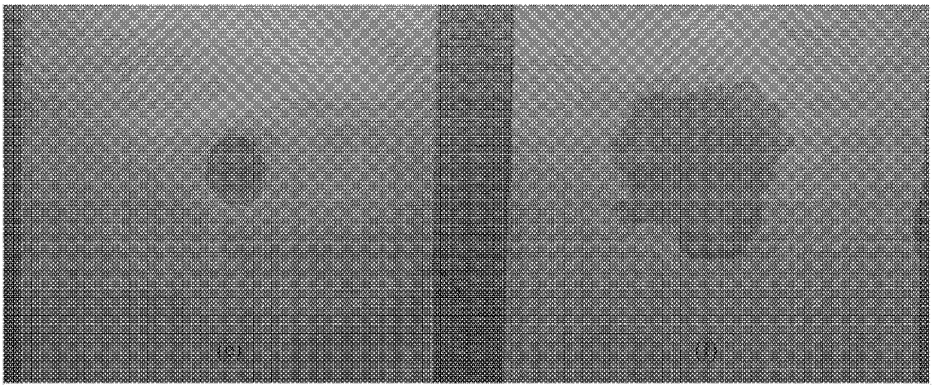


图 6

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Espacenet

Bibliographic data: CN205004376 (U) — 2016-01-27

Power battery's ceramic isolation membrane module for electric automobile

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Applicant(s):	SHENZHEN HONGTAI BATTERY TECH CO LTD ± (SHENZHEN HONGTAI BATTERY TECHNOLOGY CO., LTD)
Classification:	**- international:** ***H01M2/16*** **- cooperative:**
Application number:	CN20152792354U 20151013
Priority number (s):	CN20152792354U 20151013

Abstract of CN205004376 (U)

The utility model provides a power battery's ceramic isolation membrane module for electric automobile, this power battery's ceramic isolation membrane module for electric automobile includes: PP membrane layer, the symmetry sets up two inorganic ceramic layers of PP membrane layer both sides, the symmetry sets up the tie coat in two inorganic ceramic layer outsides. The beneficial effects of the utility model are that: the stability of the heat of diaphragm is improved, mechanical properties is used for putting forward unfamiliar high temperature resistance, security, cycle life, low self discharge nature.

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H01M 2/16(2006.01)

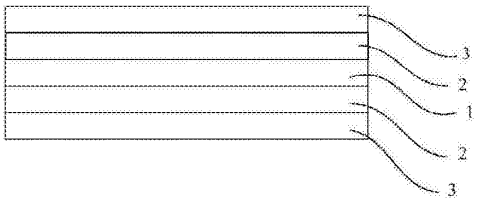
权利要求书1页 说明书2页 附图1页

(54)实用新型名称

一种电动汽车用动力电池的陶瓷隔离膜组件

(57)摘要

本实用新型提供了一种电动汽车用动力电池的陶瓷隔离膜组件，该电动汽车用动力电池的陶瓷隔离膜组件包括：PP隔膜层，对称设置在所述PP隔膜层两侧的两个无机陶瓷层，对称设置在所述两个无机陶瓷层外侧的粘结层。本实用新型的有益效果是：提高隔膜的热稳定性、机械性能，用来提隔膜的耐高温性、安全性、循环寿命、低自放电性。



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1. 一种电动汽车用动力电池的陶瓷隔离膜组件，其特征在于，包括：PP 隔膜层，对称设置在所述 PP 隔膜层两侧的两个无机陶瓷层，对称设置在所述两个无机陶瓷层外侧的粘结层。

2. 根据权利要求 1 所述的电动汽车用动力电池的陶瓷隔离膜组件，其特征在于，所述 PP 隔膜层的厚度为 16-40 微米。

3. 根据权利要求 2 所述的电动汽车用动力电池的陶瓷隔离膜组件，其特征在于，所述无机陶瓷层的厚度为 2-3 微米。

4. 根据权利要求 2 所述的电动汽车用动力电池的陶瓷隔离膜组件，其特征在于，所述粘结层的厚度为 2-3 微米。

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一种电动汽车用动力电池的陶瓷隔离膜组件

技术领域

[0001] 本实用新型涉及到电动车的技术领域，尤其涉及到一种电动汽车用动力电池的陶瓷隔离膜组件。

背景技术

[0002] 随着电动汽车行业的发展，动力电池逐渐成为电动汽车部件的核心，动力电池因其具有工作电压高、能量密度大、安全性好、无记忆效应、无污染等优点成为新能源开发的重点研究领域，在电动汽车、风光发电储能、太阳能发电储能、移动基站、空间技术、国防工业等诸多方面具有广阔的应用前景。

[0003] 目前，电动汽车对动力电池的安全性提出极高的要求，现在电动汽车用的动力电池基本使用的隔膜为三层 pp/pe/pp 复合微孔膜，或者单层 PP、PE 单层微孔膜、和涂布膜三种，由于隔膜厚度薄，一般为 16-40 μm 之前，在热稳定性方面差，高温后隔膜容易收缩给造成电池短路，机械性能不强，针刺后容易起火不齐，给电池的后续时候带来一定的安全隐患。

实用新型内容

[0004] 本实用新型的目的是为了克服现有技术的不足，提供了一种电动汽车用动力电池的陶瓷隔离膜组件。

[0005] 本实用新型是通过以上技术方案实现：

[0006] 本实用新型提供了一种电动汽车用动力电池的陶瓷隔离膜组件，该电动汽车用动力电池的陶瓷隔离膜组件包括：PP 隔膜层，对称设置在所述 PP 隔膜层两侧的两个无机陶瓷层，对称设置在所述两个无机陶瓷层外侧的粘结层。

[0007] 优选的，所述 PP 隔膜层的厚度为 16-40 微米。

[0008] 优选的，所述无机陶瓷层的厚度为 2-3 微米。

[0009] 优选的，所述粘结层的厚度为 2-3 微米。

[0010] 本实用新型的有益效果是：提高隔膜的热稳定性、机械性能，用来提隔膜的耐高温性、安全性、循环寿命、低自放电性。

附图说明

[0011] 图 1 是本实用新型实施例提供的电动汽车用动力电池的陶瓷隔离膜组件的结构示意图。

具体实施方式

[0012] 为了使本实用新型的目的、技术方案及优点更加清楚明白，以下结合附图及实施例，对本实用新型进行进一步详细说明。应当理解，此处所描述的具体实施例仅仅用以解释本实用新型，并不用于限定本实用新型。

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Page 150 of 206

[0013] 请参阅图 1，图 1 是本实用新型提供的电动汽车用动力电池的陶瓷隔离膜组件的结构示意图。

[0014] 本实用新型实施例提供了一种电动汽车用动力电池的陶瓷隔离膜组件，该电动汽车用动力电池的陶瓷隔离膜组件包括：PP 隔膜层 1，对称设置在所述 PP 隔膜层 1 两侧的两个无机陶瓷层 2，对称设置在所述两个无机陶瓷层 2 外侧的粘结层 3。

[0015] 具体的，所述 PP 隔膜层 1 的厚度为 16-40 微米。所述无机陶瓷层 2 的厚度为 2-3 微米。所述粘结层 3 的厚度为 2-3 微米。

[0016] 为了方便对本实用新型实施例提供的隔膜组件有清晰的了解，下面对其结构进行详细的说明。

[0017] 本实施例提供的电动汽车用动力电池陶瓷隔膜包括 PP 隔膜，厚度为 16-40 微米厚；上下两层隔膜处理无机陶瓷层 2，涂层厚度 2-3 微米的无机陶瓷层 2。

[0018] 将隔膜展开通过搅拌好的隔膜无机陶瓷氧化铝混合浆料，涂布完后并使用烘箱 70-90 度温度烘烤干，后在处理好的隔膜上涂一层 2-3 μm 的粘结层 3，烘烤干的隔膜再进行电池制作，无机陶瓷层 2 可提高隔膜的热稳定性、机械性能，用来提隔膜的耐高温性、安全性、循环寿命、低自放电性。粘结层 3 可将正极极片、负极极片和隔膜更好的粘合一起，增强动力电池的电化学性能，尤其是对减低内阻，提高电池化成的形成膜，提高耐高温性、安全性、循环寿命、低自放电性，更大的效果在于避免电动汽车使用过程中造成的短路等安全隐患。

[0019] 以上仅为本实用新型的较佳实施例而已，并不用以限制本实用新型，凡在本实用新型的精神和原则之内所作的任何修改、等同替换和改进等，均应包含在本实用新型的保护范围之内。

Zhuhai CosMX Battery Co. - EX1014
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Page 151 of 206

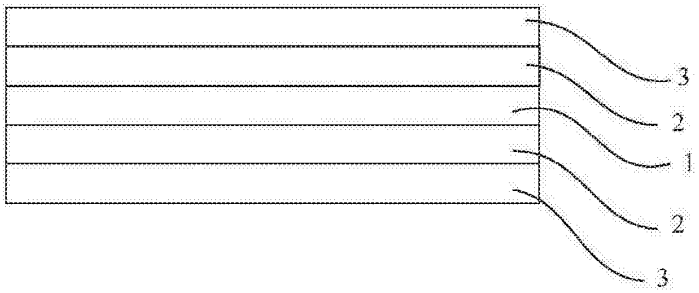


图 1

Zhuhai CosMX Battery Co. - EX1014
Zhuhai CosMX Battery Co. v. Ningde Amperex Tech. Ltd.
Page 152 of 206

Electronic Acknowledgement Receipt	
EFS ID:	33193265
Application Number:	16000764
International Application Number:	
Confirmation Number:	2445
Title of Invention:	POROUS FILM AND LITHIUM-ION BATTERY
First Named Inventor/Applicant Name:	Jianjian Yi
Customer Number:	20995
Filer:	David Michael Dremann/Blake Morgan
Filer Authorized By:	David Michael Dremann
Attorney Docket Number:	DHNG001.005AUS
Receipt Date:	16-JUL-2018
Filing Date:	05-JUN-2018
Time Stamp:	20:18:01
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	DHNG001005AUS_IDS_Trans.pdf	33840 e2b599973fc4891facae9771b6c9ac38c9420e66	no	2
Warnings:					

Information:					
2	Information Disclosure Statement (IDS) Form (SB08)	DHNG001005AUS_IDS_List.pdf	21575 2c304e606c4caacaa04f97d1daf73b31914aac4b	no	1
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
3	Foreign Reference	CN103474602A_Abs.pdf	1404179 f112dcb6e7ac3b570f17cbdf47ca55c394bd6295	no	11
Warnings:					
Information:					
4	Foreign Reference	CN205004376U_Abs.pdf	547377 53b9d6a02bf16d865a6006d5cc856cb7421268bd	no	6
Warnings:					
Information:					
			Total Files Size (in bytes):	2006971	

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 a 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.

INFORMATION DISCLOSURE STATEMENT

First Inventor	:	Jianjian Yi
App. No.	:	16/000764
Filed	:	June 5, 2018
For	:	POROUS FILM AND LITHIUM-ION BATTERY
Examiner	:	Unassigned
Art Unit	:	1726
Conf. No.	:	2445

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

References and Listing

Pursuant to 37 CFR 1.56, an Information Disclosure Statement listing references is provided herewith. Copies of any listed foreign and non-patent literature references are being submitted. Any foreign references may also include English abstract(s) and/or machine translation(s), but no representation is made as to their accuracy.

If the Examiner would like additional information regarding these references or if anything is unclear, the Examiner is invited to contact the undersigned for assistance.

No Disclaimers

To the extent that anything in the Information Disclosure Statement or the listed references could be construed as a disclaimer of any subject matter supported by the present application, Applicant hereby rescinds and retracts such disclaimer.

Timing of Disclosure

This Information Disclosure Statement is being filed within three months of the filing date or date of national phase entry, with an RCE or before receipt of a First Office Action after an RCE, and no fee is believed to be required.

Application No.: 16/000764
Filing Date: June 5, 2018

The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment, to Account No. 11-1410.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: July 16, 2018

By: _____

David Dremann
Registration No. 71,708
Registered Practitioner
Customer No. 20995
(949) 760-0404

28676449

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 16/000,764

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	300
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	660
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	760
TOTAL CLAIMS (37 CFR 1.16(i))	20 minus 20 =	*			OR	x 100 =	0.00
INDEPENDENT CLAIMS (37 CFR 1.16(h))	2 minus 3 =	*				x 460 =	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	1720

APPLICATION AS AMENDED - PART II

		(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($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	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	

		(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($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT B	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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United States Patent and Trademark Office
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P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
16/000,764	06/05/2018	Jianjian Yi	DHNG001.005AUS

CONFIRMATION NO. 2445

20995
KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

INFORMAL NOTICE

OC000000100582937

Date Mailed: 06/29/2018

INFORMATIONAL NOTICE TO APPLICANT

Applicant is notified that the above-identified application contains the deficiencies noted below. No period for reply is set forth in this notice for correction of these deficiencies. However, if a deficiency relates to the inventor's oath or declaration, the applicant must file an oath or declaration in compliance with 37 CFR 1.63, or a substitute statement in compliance with 37 CFR 1.64, executed by or with respect to each actual inventor no later than the expiration of the time period set in the "Notice of Allowability" to avoid abandonment. See 37 CFR 1.53(f).

The item(s) indicated below are also required and should be submitted with any reply to this notice to avoid further processing delays.

- A properly executed inventor's oath or declaration has not been received for the following inventor(s):
  Jianjian Yi
  Xinzhi Zhang
  Zengbin Wei
  Xinghua Tao

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/hteffera/

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UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
16/000,764	06/05/2018	1726	1880	DHNG001.005AUS	20	2

CONFIRMATION NO. 2445

20995
KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

FILING RECEIPT

OC000000100582936

Date Mailed: 06/29/2018

Receipt is acknowledged of this non-provisional 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 APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

Jianjian Yi, Ningde, CHINA;
Xinzhi Zhang, Ningde, CHINA;
Zengbin Wei, Ningde, CHINA;
Xinghua Tao, Ningde, CHINA;

Applicant(s)

Ningde Amperex Technology Limited, Ningde, CHINA;

Power of Attorney: None

Domestic Applications for which benefit is claimed - None.
A proper domestic benefit claim must be provided in an Application Data Sheet in order to constitute a claim for domestic benefit. See 37 CFR 1.76 and 1.78.

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 201810322931.1 04/11/2018

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

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.

If Required, Foreign Filing License Granted: 06/26/2018

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 16/000,764**

Projected Publication Date: 10/17/2019

Non-Publication Request: No

Early Publication Request: No

Title

POROUS FILM AND LITHIUM-ION BATTERY

Preliminary Class

429

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

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.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign 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.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific

countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

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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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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	DHNG001.005AUS
	Application Number	
Title of Invention	POROUS FILM AND LITHIUM-ION BATTERY	

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
	Jianjian		Yi	

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

City	Ningde, Fujian	Country of Residence	CN

Mailing Address of Inventor:

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Address 2			
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Postal Code	352100	**Country**	CN

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Xinzhi		Zhang	

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Mailing Address of Inventor:

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Address 2			
City	Ningde, Fujian	**State/Province**	
Postal Code	352100	**Country**	CN

Inventor 3 Remove

Legal Name

PTO/AIA/14 (11-15)
Approved for use through 04/30/2017. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	DHNG001.005AUS
	Application Number	
Title of Invention	POROUS FILM AND LITHIUM-ION BATTERY	

Prefix	Given Name	Middle Name	Family Name	Suffix
	Zengbin		Wei	

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

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Mailing Address of Inventor:

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Address 2			
City	Ningde, Fujian	State/Province	
Postal Code	352100	Country	CN

Inventor 4 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Xinghua		Tao	

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

City	Ningde, Fujian	Country of Residence	CN

Mailing Address of Inventor:

Address 1	No. 1, Xingang Road, Zhangwan Town, Jiaocheng Zone		
Address 2			
City	Ningde, Fujian	State/Province	
Postal Code	352100	Country	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	20995		
Email Address	efiling@knobbe.com	Add Email	Remove Email

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	DHNG001.005AUS
	Application Number	
Title of Invention	POROUS FILM AND LITHIUM-ION BATTERY	

Application Information:

Title of the Invention	POROUS FILM AND LITHIUM-ION BATTERY		
Attorney Docket Number	DHNG001.005AUS	**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).

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

Publication Information:

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

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

Representative Information:

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

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	20995		

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	DHNG001.005AUS
	Application Number	
Title of Invention	POROUS FILM AND LITHIUM-ION BATTERY	

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		Remove	
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)

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

Foreign Priority Information:

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

			Remove
Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)
201810322931.1	CN	2018-04-11	

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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	DHNG001.005AUS
	Application Number	
Title of Invention	POROUS FILM AND LITHIUM-ION BATTERY	

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.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	DHNG001.005AUS
	Application Number	
Title of Invention	POROUS FILM AND LITHIUM-ION BATTERY	

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

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		
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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.

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	DHNG001.005AUS
	Application Number	
Title of Invention	POROUS FILM AND LITHIUM-ION BATTERY	

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.

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

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1			
Address 2			
City		**State/Province**	
Country i		Postal Code	
Phone Number		Fax Number	
Email Address			

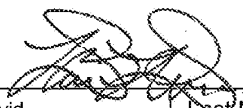
Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button.

Signature:

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				Date (YYYY-MM-DD)	2018-06-05
First Name	David	Last Name	Dremann	Registration Number	71,708

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

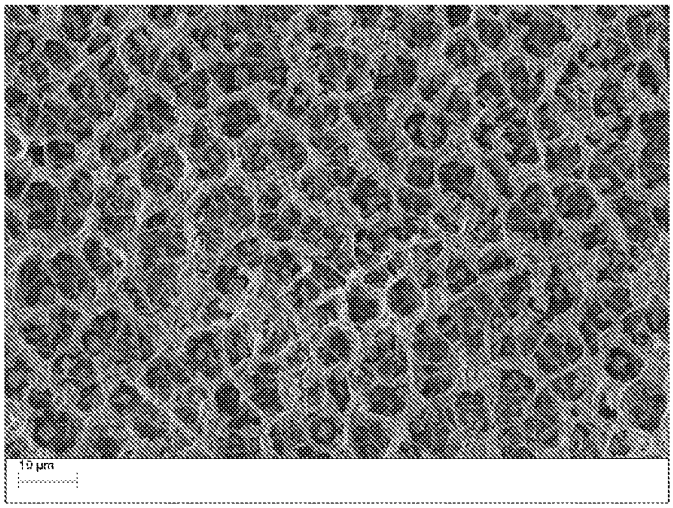


Figure 1

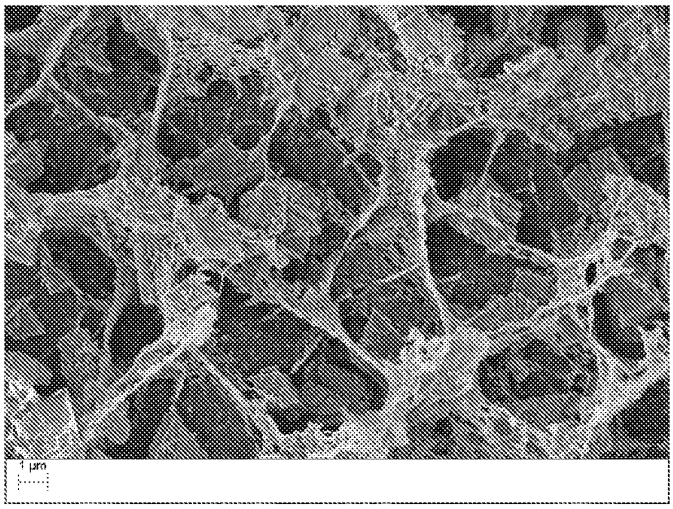


Figure 2

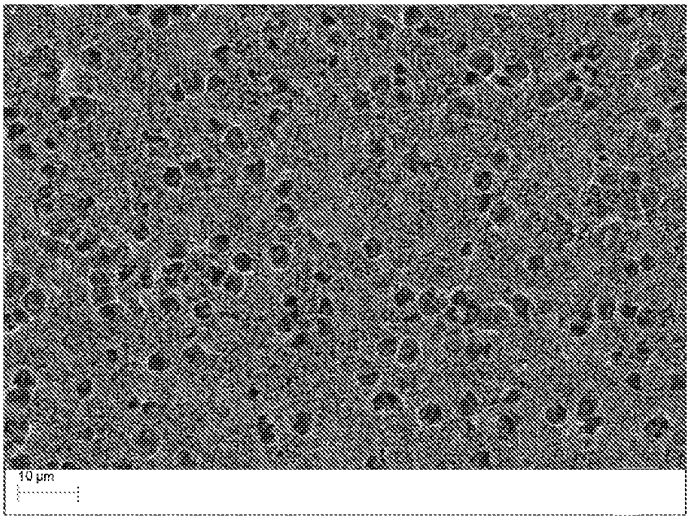


Figure 3

POROUS FILM AND LITHIUM-ION BATTERY

TECHNICAL FIELD

[001] The present application relates to the field of energy storage devices, and in particular, to a porous film and a lithium-ion battery.

BACKGROUND

[002] Non-aqueous secondary batteries, particularly lithium-ion batteries, are widely used in portable electronic devices such as notebook computers, digital cameras, camcorders, and cellphones due to their high energy density and good rate performance. In recent years, the application of lithium-ion batteries as the power supply for new energy vehicles is also promoting the development of lithium-ion battery technology. In the cycle process of the lithium-ion battery, with the progress of charging and discharging, a gap will be created between the electrode and the separator, resulting in a reduction of the cycle capacity of the lithium-ion battery and thereby having an influence on its service life. Therefore, there is an urgent need for a technical solution to solve the problem of the gap issue between the separator and the electrode so as to improve the service life of the lithium-ion battery.

SUMMARY OF THE APPLICATION

[003] In order to solve the problem in the prior art, a porous film and a lithium-ion battery are provided according to the present application.

[004] According to a first aspect of the application, a porous film is provided, comprising: a binder; and inorganic particles, wherein the porous film contains pores formed by the binder, the pores at least comprises a part of the inorganic particles, and the average wall thickness between the pores is in a range of 20 nm to 500 nm.

[005] In the porous film described above, the porous film has an average pore size of 0.3 μm to 20 μm.

[006] In the porous film described above, the inorganic particles have particle sizes such that particle size having a volume accumulation of 10% (Dv10) is in a range of 0.015 μm to 3 μm, particle size having a volume accumulation of 50% (Dv50) is in a range of 0.2 μm to 5 μm, and particle size having a volume accumulation of 90% (Dv90) is in a range of 1 μm to 10 μm. Particle size having a volume accumulation of 10% (Dv10) refers to particle sizes which reach 10% of the cumulative volume from the side of small particle size in the granularity distribution on a volume basis. Particle size having a volume accumulation of 50% (Dv50) refers to particle sizes which reach 50% of the cumulative volume from the side of small particle size in the granularity distribution on a volume basis. Particle size having a volume accumulation of 90% (Dv90) refers to particle sizes which reach 90% of the cumulative volume from the side of small particle size in the granularity distribution on a volume basis.

[007] In the porous film described above, particle size having a volume accumulation of 10% (Dv10) is less than particle size having a volume accumulation of 50% (Dv50), and particle size having a volume accumulation of 50% (Dv50) is less than particle size having a volume accumulation of 90% (Dv90).

[008] In the porous film described above, the particle sizes of the inorganic particles satisfy that: the ratio of particle size having a volume accumulation of 90% (Dv90) to particle size having

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a volume accumulation of 10% (Dv10) is in a range of 2 to 100.

[009] In the porous film described above, a pore size distribution coefficient (D) of the pores in the porous film is in a range of 1 to 5.

[0010] In the porous film described above, the inorganic particles are at least one of alumina, silica, magnesia, titanium oxide, hafnium dioxide, tin oxide, cerium dioxide, nickel oxide, zirconia, zinc oxide, calcium oxide, boehmite, aluminum hydroxide, magnesium hydroxide, calcium hydroxide, and barium sulfate.

[0011] In the porous film described above, the binder is at least one of polyvinylidene fluoride, vinylidene fluoride-hexafluoropropylene copolymer, polyamide, polyacrylonitrile, polyacrylate, polyacrylic acid, polyacrylic acid salt, sodium carboxymethylcellulose, polyvinylpyrrolidone, polyvinyl ether, polymethyl methacrylate, polytetrafluoroethylene and polyhexafluoropropylene.

[0012] In the porous film described above, the porous film has a porosity of 20% to 90%, and the porous film has a thickness of 0.2 to 10 μm.

[0013] In the porous film described above, a volume ratio of the inorganic particles to the binder is in a range of 0.2 to 3.0.

[0014] According to a second aspect of the application, a lithium-ion battery is provided, comprising: a positive electrode; a negative electrode; a separator arranged between the positive electrode and the negative electrode; and non-aqueous electrolyte; and a porous film, wherein the porous film is the porous film according to the first aspect of the application.

[0015] In the lithium-ion battery described above, the porous film is arranged on a surface of at least one of the positive electrode, the negative electrode and the separator.

[0016] The porous film provided by the application has excellent adhesion, and meanwhile the pore structure of the porous film can still be well maintained after being immersed in the electrolyte, thereby reducing the probability of pore blockage of the porous film and enabling the porous film to have high ionic conductivity. Therefore, the rate performance of the lithium-ion battery is greatly improved, and the provided lithium-ion battery has excellent rate performance and cycle performance.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

[0017] Figure 1 is an electronic microscope image (1000 times magnification) of the pore structure of the lower surface (namely, the surface of the porous film away from the porous substrate) of the porous film according to example 3.

[0018] Figure 2 is an electronic microscope image (5000 times magnification) of the pore structure of the lower surface of the porous film according to example 3.

[0019] Figure 3 is an electronic microscope image (1000 times magnification) of the pore structure of the lower surface of the porous film according to comparative example 3.

DETAILED DESCRIPTION OF THE PREFERRED EXAMPLES

[0020] Exemplary examples will be described in details below. While these exemplary examples may be implemented in various forms, the application should not be construed as limited to the examples of the application set forth herein. Rather, these examples are provided with the purpose of making the disclosure of the application thorough and complete and fully conveying the scope of the application to those skilled in the art.

[0021] According to a first aspect of the present application, a porous film is provided,

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comprising a binder and inorganic particles of different particle sizes, and the inorganic particles are fixed by the binder. Since the porous film comprises the binder, the porous film has good adhesion, which can prevent the porous film from detaching during the use of the lithium-ion battery, and enables the lithium-ion battery to have a high safety performance. Moreover, the average pore size of the porous film is larger and the pore sizes are distributed uniformly, so that the porous film has good electrolyte diffusion and absorption capability and high ionic conductivity, the polarization reaction inside the lithium-ion battery can be reduced, thereby improving the rate performance of the lithium-ion battery. In addition, since the average wall thickness between the adjacent pores in the porous film is low, the binder (usually a polymer, for example, polyvinylidene fluoride) can be prevented from swelling in the electrolyte and blocking the pores of the porous film after the porous film is subjected to the soaking process in the electrolyte during the preparation of the lithium-ion battery. Therefore, the pore structure in the porous film can be more retained, smoothness of the lithium ion transport channel is ensured, and the polarization reaction inside the lithium-ion battery is reduced, thereby the rate performance of the lithium-ion battery can be further improved. In addition, due to the presence of inorganic particles in the porous film, the stability of the pore structure is enhanced. Therefore, the pore structure is not softened and closed after the soaking process in the electrolyte and the high-temperature and high-pressure process in the forming stage, the possibility of the pore structure being compressed and damaged is reduced, smoothness of the lithium ion transport channel is ensured, and the polarization reaction inside the lithium-ion battery is reduced, ensuring that the lithium-ion battery has a high rate performance.

[0022] In the porous film, inorganic particles are at least one of alumina, silica, magnesia, titanium oxide, hafnium dioxide, tin oxide, cerium dioxide, zirconia, nickel oxide, zinc oxide, calcium oxide, boehmite, aluminum hydroxide, magnesium hydroxide, calcium hydroxide, and barium sulfate. The inorganic particles may contain polar functional groups selected from a hydroxyl group. The surface of the inorganic particles containing polar functional groups is more easily combined with the non-solvent (third solvent) in the coagulating solution described below in the preparation process, which is advantageous for the diffusion of the third solvent into the porous film along the surface of the inorganic particles. Thus, large pore structures are formed in the vicinity of the inorganic particles, and the pore structures with large average pore sizes and small average wall thickness between the adjacent pores are easily obtained.

[0023] The particle sizes of the inorganic particles satisfy that the particle size having a volume accumulation of 10% (Dv10) is in a range of 0.015 μm to 3 μm, the particle size having a volume accumulation of 50% (Dv50) is in a range of 0.2 μm to 5 μm, and the particle size having a volume accumulation of 90% (Dv90) is in a range of 1 μm to 10 μm. The particle size (Dv10) having a volume accumulation of 10% refers to particle sizes which reach 10% of the cumulative volume from the side of small particle size in the granularity distribution on a volume basis. The particle size (Dv50) having a volume accumulation of 50% refers to particle sizes which reach 50% of the cumulative volume from the side of small particle size in the granularity distribution on a volume basis. The particle size (Dv90) having a volume accumulation of 90% refers to particle sizes which reach 90% of the cumulative volume from the side of small particle size in the granularity distribution on a volume basis. For example, the inorganic particles having large particle sizes and a narrow peak distribution are used, therefore the exchange speed between the non-solvent (third solvent) in the coagulation solution and the organic solvent (first solvent) in the coating

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solution can be increased during the formation of the porous film, and a porous film structure with a larger average pore size and smaller average wall thickness between the adjacent pores is formed. Within this range, if the particle sizes of the inorganic particles become smaller, the exchange speed between the non-solvent (third solvent) in the coagulation solution and the organic solvent (first solvent) in the coating solution is decreased during the formation of the porous film, the development of the pore structure is slower, the average pore size of the formed pore is decreased, and the average wall thickness between adjacent pores is increased. Conversely, if the particle sizes of the inorganic particles become larger, the exchange speed between the non-solvent (third solvent) in the coagulation solution and the organic solvent (first solvent) in the coating solution is increased, the development of the pore structure is faster, the average pore size of the formed pore is increased, and the average wall thickness between adjacent pores is decreased. However, if the particle sizes of the inorganic particles are too small and are beyond this range, the exchange between the non-solvent (third solvent) in the coagulation solution and the organic solvent (first solvent) in the coating solution will be adversely affected, and it is difficult to form a pore with a large average pore size. If the particle sizes of the inorganic particles are too large and are beyond this range, the surface of the formed porous film is not uniform, the strength of the porous film is decreased, and the adhesion force of the porous film is decreased.

[0024] In some examples, the inorganic particles have particle sizes such that Dv10 is in a range of 1.0 μm to 1.6 μm, Dv50 is in a range of 2.0 μm to 2.6 μm, and Dv90 is in a range of 3.0 μm to 4.0 μm.

[0025] In the above-described porous film, the particle size distribution of the inorganic particles satisfies Dv90/Dv10= 2~100. If Dv90/Dv10 is greater than 100, which will lead to the particle size distribution of the inorganic particles being too wide, the uniformity of the formed pores is poor, and polarization reactions will easily occur in the lithium-ion battery.

[0026] In the above-described porous film, the average wall thickness between adjacent pores is in a range of 20 nm to 500 nm, and the average pore size of the porous film is in a range of 0.3 μm to 20 μm. The average pore size of the porous film according to the present application is larger, so that the porous film has good electrolyte diffusion and absorption capability and high ionic conductivity, and the polarization reaction inside the lithium-ion battery can be reduced, thereby improving the rate performance of the lithium-ion battery. In addition, since the average wall thickness between adjacent pores in the porous film is low, the binder (typically a polymer, for example, polyvinylidene fluoride) can be prevented from swelling in the electrolyte and blocking the pores of the porous film after the porous film is subject to a soaking process in the electrolyte during the preparation of the lithium-ion battery. Therefore, the pore structure in the porous film can be maintained, smoothness of the lithium ion transport channel is ensured and the polarization reaction inside the lithium-ion battery is reduced, the rate performance of the lithium-ion battery can be further improved.

[0027] In the above-described porous film, the pore size distribution coefficient D of the pores in the porous film is in a range of 1 to 5. R10 represents pore sizes which reach 10% of the cumulative pore sizes from the side of small pore size in the pore size distribution curve (the pore sizes of 10% of the pores are less than R10). R90 represents pore sizes which reach 90% of the cumulative pore sizes from the side of small pore size in the pore size distribution curve (the pore sizes of 90% of the pores are less than R90). The pore size distribution coefficient D is equal to

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R90/R10. The closer to 1 the pore size distribution coefficient D is, the more uniform the pore sizes in the porous film will be, and thus the porous film will have better rate performance and cycle performance.

[0028] In the above-mentioned porous film, the porous film has a thickness of 0.2 μm to 10 μm. If the thickness of the porous film is larger, the gas permeability of the porous film becomes deteriorated, and the rate performance of the lithium-ion battery is decreased. If the thickness of the porous film is smaller, the adhesive force of the porous film is reduced, and the porous film tends to fall off due to a poor adhesive force when applied in a lithium-ion battery, resulting in deteriorated safety performance of the lithium-ion battery. In some examples, the porous film has a thickness of 1 μm to 3 μm.

[0029] In the above-described porous film, the porous film has a porosity of 20% to 90%. In some examples, the porous film has a porosity of 40% to 60%.

[0030] In the above-described porous film, the binder is at least one of polyvinylidene fluoride, vinylidene fluoride-hexafluoropropylene copolymer, polyamide, polyacrylonitrile, polyacrylate, polyacrylic acid, polyacrylic acid salt, sodium carboxymethylcellulose, polyvinylpyrrolidone, polyvinyl ether, polymethyl methacrylate, polytetrafluoroethylene and polyhexafluoropropylene.

[0031] In the above-described porous film, the volume ratio of the inorganic particles to the binder in the porous film is in a range of 0.2 to 3.0. If the volume ratio of them is lower than 0.2, the average pore size of the porous film is reduced, the porosity is decreased, and the rate performance of the lithium-ion battery is deteriorated drastically. If the volume ratio of them is greater than 3.0, the adhesive force of the porous film is reduced. When the porous film is applied to a lithium-ion battery, the porous film tends to fall off due to poor adhesion, resulting in deteriorated safety performance of the lithium-ion battery.

[0032] According to a second aspect of the present application, a method for preparing a porous film is provided, which is used for preparing the porous film according to the first aspect of the present application, comprising steps of: (1) mixing inorganic particles with a binder, and then adding a first solvent and uniformly stirring the mixture to obtain a coating solution, wherein the binder is dissolved in the first solvent; (2) uniformly coating the coating solution on at least one surface of a substrate to form a wet film; (3) immersing the substrate with the wet film into a coagulation solution for phase transformation, wherein the coagulation solution comprises a second solvent and a third solvent, and the second solvent and the third solvent are miscible with each other; (4) performing a drying process after the phase transformation is completed, to obtain the substrate whose surface is provided with a porous film, wherein the average wall thickness between adjacent pores in the porous film is in a range of 20 nm to 500 nm, and the average pore size of the porous film is not less than 0.3 μm.

[0033] The above-mentioned substrate may be one of a separator, a positive electrode, and a negative electrode.

[0034] In the above-described method for preparing the porous film, the porous film is prepared using the principle of phase transformation (i.e., non-solvent induced phase separation, NIPS). In the coating solution obtained in the step (1), the first solvent is oily, and the binder (for example, polyvinylidene fluoride) may be dissolved in the first solvent. The third solvent contained in the coagulation solution in step (3) is one or more selected from deionized water, ethanol, propanol, acetone, dimethyl carbonate and diethyl carbonate, and the binder is insoluble in the third solvent (for example, deionized water). Therefore, after the coating solution

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is coated on the substrate and then immersed in the coagulation solution, since the first solvent in the coating solution is extracted into the third solvent (for example, deionized water) in the coagulation solution, the binder in the coating solution is coagulated and separated out, thus forming a porous film.

[0035] In the above-described preparation method for the porous film, in step (1), the first solvent is at least one of N-methylpyrrolidone (NMP), dimethylacetamide (DMAC), dimethylformamide (DMF), triethyl phosphate (TEP), and dimethyl sulfoxide (DMSO). The porous film formed using NMP has the largest average pore size and the highest porosity, the porous film formed using DMF has the smallest average pore size and the lowest porosity, and the porous film formed using DMAC has the average pore size and a porosity between that of the porous films formed using NMP and DMF respectively.

[0036] In the above-described method for preparing the porous film, the solid content of the coating solution in step (1) is in a range of 7% to 25%. Within this range, if the solid content of the coating solution is increased, the viscosity of the coating solution is increased, the exchange speed between the third solvent in the coagulation solution and the first solvent in the coating solution becomes lower, and both the average pore size and porosity of the formed porous film are decreased. Conversely, if the solid content of the coating solution is decreased, both the average pore size and porosity of the porous film are increased. However, if the solid content of the coating solution is too high and is beyond this range, the porous film cannot meet the requirement of gas permeability, and the porous film cannot be used in the lithium-ion battery; if the solid content of the coating solution is too low and is below this range, the strength of the porous film is decreased, and it is difficult to form a film on the surface of the substrate. In some examples, the coating solution has a solid content of 10% to 20%.

[0037] In the above-described method for preparing the porous film, the temperature of the coating solution in step (1) is in a range of 15 degrees Celsius to 30 degrees Celsius. In some examples, the temperature of the coating solution is in a range of 20 degrees Celsius to 25 degrees Celsius.

[0038] In the above-described method for preparing the porous film, the coating of the coating solution in step (2) may be performed using a common coating method, such as roll coating, a gas knife coating, rod coating, scraper coating, gravure coating, screen coating, die coating, micro gravure coating, dip coating or the like. In some examples, the dip coating method is selected as the coating method of the coating solution.

[0039] In the above-described preparation method, the second solvent in step (3) is one or more selected from N-methylpyrrolidone (NMP), dimethylacetamide (DMAC), dimethylformamide (DMF), triethyl phosphate (TEP), and dimethyl sulfoxide (DMSO). The second solvent in step (3) may be the same as the first solvent added in step (1).

[0040] In the above-described preparation method, in step (3), the mass percentage of the second solvent in the coagulation solution is in a range of 20% to 60%. If the content of the second solvent in the coagulation solution is decreased, it is advantageous for the increase of the average pore size and porosity of the porous film. However, if the content of the second solvent is too low, a dense skin may be formed on the surface of the porous film which is away from the substrate, resulting in deteriorated gas permeability of the porous film. If the content of the second solvent is too high, a complete porous structure cannot be formed or the formed porous film has a very low average pore size and a high wall thickness. In some examples, the mass

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percentage of the second solvent in the coagulation solution is in a range of 30% to 40%.

[0041] In the above-described method for preparing the porous film, the temperature of the coagulation solution in step (3) is in a range of 15 degrees Celsius to 30 degrees Celsius. In some examples, the temperature of the coagulation solution is in a range of 20 degrees Celsius to 25 degrees Celsius.

[0042] In the above-described method for preparing the porous film, in step (3), the period for phase transformation is in a range of 10 s to 90 s. In some examples, the period for phase transformation is in a range of 20 s to 60 s.

[0043] In the above-described method for preparing the porous film, in step (4), the drying temperature is in a range of 60 degrees Celsius to 70 degrees Celsius, and the drying period is less than 1 min.

[0044] According to a third aspect of the present application, a separator comprising the porous film according to the first aspect of the present application is provided.

[0045] The separator comprises a porous substrate and a porous film. The porous film is arranged on the surface of the porous substrate. In the above-described separator, there is no particular limitation on the type of the porous substrate, and it may be selected as actually required. Specifically, the porous substrate is at least one of polyethylene film (PE), polypropylene film (PP), polyethylene/polypropylene dual-layer film (PE/PP), polypropylene/polyethylene/polypropylene three-layer film (PP/PE/PP), non-woven fabric, polyimide, polyacrylonitrile porous film (PAN), and glass fiber film.

[0046] A method for preparing the above-described separator is further provided according to the present application, which is used for preparing the separator according to the third aspect of the present application, and which comprise steps of: (1) mixing inorganic particles with a binder, and then adding a first solvent and uniformly stirring the mixture to obtain a coating solution, wherein the binder is dissolved in the first solvent; (2) uniformly coating the coating solution on a surface of the porous substrate (for example, polyethylene) to form a wet film; (3) immersing the porous substrate (for example, polyethylene) with the wet film into a coagulation solution for phase transformation, wherein the coagulation solution comprises a second solvent and a third solvent, and the second solvent and the third solvent are miscible with each other; (4) performing a drying process after the phase transformation is completed to obtain a separator in which a porous film is arranged on the surface of the porous substrate (for example, polyethylene), wherein the average wall thickness between adjacent pores in the porous film is in a range of 20 nm to 500 nm, and the average pore size of the porous film is not less than 0.3 μm.

[0047] In the above-described method for preparing the separator, the parameter setting of the preparation process is consistent with that of the preparation process of the porous film according to the second aspect of the present application, and only the substrate is changed to porous substrate.

[0048] According to a fourth aspect of the present application, an electrode comprising the porous film according to the first aspect of the present application is provided. The electrode comprises a current collector and an active material layer. The active material layer is arranged on the surface of the current collector, and the porous film is arranged on the surface of the active material layer which is away from the current collector.

[0049] In the above-described electrode, the electrode may be either a positive electrode or a negative electrode, depending on the current collector and the active material used. There is no

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particular limitation on the type of the current collector, and it can be selected as actually required. Specifically, the current collector is at least one of aluminum foil, copper foil, nickel foil, titanium foil, silver foil, nickel-copper alloy foil, aluminum-zirconium alloy foil , stainless steel foil and graphene film.

[0050] A method for preparing an electrode is further provided according to the application, which is used for preparing the electrode according to the fourth aspect of the present application, comprising steps of: (1) mixing inorganic particles with a binder, and then adding a first solvent and uniformly stirring the mixture to obtain a coating solution, wherein the binder is dissolved in the first solvent; (2) mixing an active material, a conductive agent and a binder, adding an organic solvent (such as N-methylpyrrolidone) into the mixture, uniformly stirring the mixture under the action of a vacuum stirrer to obtain an electrode slurry, and uniformly coating the electrode slurry on the current collector and then drying to form an active material layer (electrode) on the current collector; (3) uniformly coating the coating solution on the surface of the electrode to form a wet film; (4) immersing the electrode with the wet film into a coagulation solution for phase transformation, wherein the coagulation solution includes a second solvent and a third solvent, and the second solvent and the third solvent are miscible with each other; (5) performing a drying process after the phase transformation to obtain an electrode whose surface is provided with a porous film, wherein the average wall thickness between adjacent pores in the porous film is in a range of 20 nm to 500 nm, and the average pore size of the porous film is not less than 0.3 μm. The electrode may be either a positive electrode or a negative electrode.

[0051] In the method for preparing the electrode described above, the parameter setting of the preparation process is consistent with that of the preparation process of the porous film according to the second aspect of the present application.

[0052] According to a fifth aspect of the present application, a lithium-ion battery is provided. The lithium-ion battery comprises the separator according to the third aspect of the present application, or comprises the electrode according to the fourth aspect of the present application, or comprises both the separator according to the third aspect of the present application and the electrode according to the fourth aspect of the present application. The electrode may be either a positive electrode or a negative electrode.

[0053] In the above-described lithium-ion battery, the positive electrode comprises a positive electrode material capable of intercalation and deintercalation of lithium (Li) (hereinafter sometimes referred to as "positive electrode material capable of intercalation / deintercalation of lithium (Li)"). Examples of the positive electrode material capable of intercalation / deintercalation of lithium (Li) may include one or more of lithium cobaltate, nickel cobalt lithium manganate, nickel cobalt lithium aluminate, lithium manganate, iron manganese lithium phosphate, lithium vanadium phosphate, lithium oxide vanadium phosphate, lithium iron phosphate, lithium titanate, and lithium-rich manganese-based materials.

[0054] In the above-mentioned positive electrode material, the chemical formula of lithium cobaltate may be expressed as $Li_xCo_aM1_bO_{2-c}$, wherein M1 represents at least one selected from the group consisting of nickel (Ni), manganese (Mn), magnesium (Mg), aluminum (Al), boron (B), titanium (Ti), vanadium (V), chromium (Cr), ferrum (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 the values of x, a, b, and c are respectively within the following ranges: $0.8 \leqslant x \leqslant 1.2$, $0.8 \leqslant a \leqslant 1$, $0 \leqslant b \leqslant 0.2$, $-0.1 \leqslant c \leqslant 0.2$.

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[0055] In the above-mentioned positive electrode material, the chemical formula of nickel cobalt lithium manganate or nickel cobalt lithium aluminate may be expressed as $Li_yNi_dM2_eO_{2-f}$, wherein M2 represents at least one selected from the group consisting of cobalt (Co), manganese (Mn), magnesium (Mg), aluminum (Al) , boron (B), titanium (Ti), vanadium (V), chromium (Cr), ferrum (Fe), copper (Cu), zinc (Zn), molybdenum (Mo), tin (Sn), calcium (Ca), yttrium (Sr), tungsten (W), zirconium (Zr), and silicon (Si), and the values of y, d, e, and f are respectively within the following ranges: $0.8 \leqslant y \leqslant 1.2$, $0.3 \leqslant d \leqslant 0.98$, $0.02 \leqslant e \leqslant 0.7$, $-0.1 \leqslant f \leqslant 0.2$.

[0056] In the above-mentioned positive electrode material, the chemical formula of lithium manganate is expressed as $Li_zMn_{2-g}M3_gO_{4-h}$, wherein M3 represents at least one selected from the group consisting of cobalt (Co), nickel (Ni), magnesium (Mg), aluminum (Al), boron (B), titanium (Ti), vanadium (V), chromium (Cr), ferrum (Fe), copper (Cu), zinc (Zn), molybdenum (Mo), tin (Sn), calcium (Ca), strontium (Sr), and tungsten (W), and the values of z, g and h are respectively within the following ranges: $0.8 \leqslant z \leqslant 1.2$, $0 \leqslant g < 1.0$, and $-0.2 \leqslant h \leqslant 0.2$.

[0057] The negative electrode includes a negative electrode material capable of intercalation and deintercalation of lithium (Li) (hereinafter, sometimes referred to as "negative electrode material capable of intercalation/ deintercalation of lithium (Li)"). Examples of the negative electrode material capable of intercalation/deintercalation of lithium (Li) may include a carbon material, a metal compound, an oxide, a sulfide, a nitride of lithium such as LiN_3, lithium metal, a metal which formed an alloy with lithium, and a polymer material. Examples of carbon materials may include low graphitized carbon, easily graphitized carbon, artificial graphite, natural graphite, mesocarbon microbeads, soft carbon, hard carbon, pyrolytic carbon, coke, glassy carbon, organic polymer compound sintered body, carbon fiber and active carbon. Wherein coke may include pitch coke, needle coke, and petroleum coke. The organic polymer compound sintered body refers to materials obtained by calcining a polymer material such as a phenol plastic or a furan resin at a suitable temperature and carbonizing them, and some of these materials are classified into low graphitized carbon or easily graphitized carbon. Examples of polymeric materials may include polyacetylene and polypyrrole.

[0058] Among these negative electrode materials capable of intercalation /deintercalation of lithium (Li), further, materials whose charge and discharge voltages are close to the charge and discharge voltages of lithium metal are selected. This is because that the lower the charge and discharge voltages of the negative electrode material are, the more easily the battery can have a higher energy density. The carbon material can be selected as the negative electrode material, since the crystal structure of the carbon material has only small changes during charging and discharging. Therefore, good cycle characteristics and high charge and discharge capacities can be obtained. In particular, graphite can be selected, since it can provide a high electrochemical equivalent and energy density.

[0059] In addition, the negative electrode material capable of intercalation /deintercalation of lithium (Li) may include elemental lithium metal, metal elements and semi-metal elements capable of forming an alloy together with lithium (Li), alloys and compounds including such elements, etc. In particular, they are used together with the carbon material, since good cycle characteristics and high energy density can be obtained in this case. In addition to alloys comprising two or more metal elements, alloys used herein further include alloys comprising one or more metal elements and one or more semi-metal elements. The alloys may be in the following forms of solid solutions, eutectic crystals (eutectic mixtures), intermetallic compounds,

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and mixtures thereof. Examples of metal elements and semi-metal elements may include tin (Sn), lead (Pb), aluminum (Al), indium (In), silicon (Si), zinc (Zn), antimony (Sb), bismuth (Bi), cadmium (Cd), magnesium (Mg), boron (B), gallium (Ga), germanium (Ge), arsenic (As), silver (Ag), zirconium (Zr), yttrium (Y), and hafnium (Hf). Examples of the above-described alloys and compounds may include a material expressed as a chemical formula: $Ma_sMb_tLi_u$ and a material expressed as a chemical formula: $Ma_pMc_qMd_r$. In these chemical formulas, Ma represents at least one of metal elements and semi-metal elements capable of forming alloys with lithium, Mb represents at least one of these metal elements and semi-metal elements other than lithium and Ma, Mc represents at least one of the non-metal elements, Md represents at least one of these metal elements and semi-metal elements other than Ma, and s, t, u, p, q, and r satisfy $s>0$, $t\geqslant 0$, $u\geqslant 0$, $p>0$, $q>0$, and $r\geqslant 0$, respectively. In addition, an inorganic compound that does not include lithium (Li) may be used in the negative electrode, such as MnO_2, V_2O_5, V_6O_{13}, NiS, and MoS.

[0060] The lithium-ion battery described above further includes an electrolyte, which may be one or more of a gel electrolyte, a solid electrolyte, and an liquid electrolyte. The liquid electrolyte comprises a lithium salt and a non-aqueous solvent.

[0061] The lithium salt is at least one of $LiPF_6$, $LiBF_4$, $LiAsF_6$, $LiClO_4$, $LiB(C_6H_5)_4$, $LiCH_3SO_3$, $LiCF_3SO_3$, $LiN(SO_2CF_3)_2$, $LiC(SO_2CF_3)_3$, $LiSiF_6$, LiBOB, and lithium difluoborate. For example, $LiPF_6$ is used as a lithium salt, since it can provide high ionic conductivity and improve cycle performance.

[0062] The non-aqueous solvent may be a carbonate compound, a carboxylic acid ester compound, an ether compound, other organic solvents or combinations thereof.

[0063] The carbonate compound may be a chain carbonate compound, a cyclic carbonate compound, a fluorinated carbonate compound or combinations thereof.

[0064] Examples of chain carbonate compounds include diethyl carbonate (DEC), dimethyl carbonate (DMC), dipropyl carbonate (DPC), methylpropyl carbonate (MPC), ethyl propyl carbonate (EPC), methyl ethyl carbonate (MEC) and combinations thereof. Examples of the cyclic carbonate compounds include ethylene carbonate (EC), propylene carbonate (PC), butylene carbonate (BC), vinyl ethylene carbonate (VEC), and combinations thereof. Examples of the fluorocarbonate compound include fluoroethylene carbonate (FEC), 1,2-difluoroethylene carbonate, 1,1-difluoroethylene carbonate, 1,1,2-trifluoroethylene carbonate, 1,1,2,2-tetrafluoroethylene carbonate, 1-fluoro-2-methylethyl carbonate, 1-fluoro-1-methyl-ethylene carbonate, 1,2-difluoro-1-methylethylene carbonate, 1,1,2-trifluoro-2-methylethyl carbonate, trifluoromethyl ethylene carbonate, and combinations thereof.

[0065] Examples of carboxylic acid ester compounds include methyl acetate, ethyl acetate, n-propyl acetate, tert-butyl acetate, methyl propionate, ethyl propionate, γ-butyrolactone, decanolactone, valerolactone, mevalonolactone, caprolactone, methyl formate, and combinations thereof.

[0066] Examples of ether compounds include dibutyl ether, tetraethylene glycol dimethyl ether, diethylene glycol dimethyl ether, 1,2-dimethoxyethane, 1,2-diethoxyethane, ethoxy methoxy ethane, 2-methyltetrahydrofuran, tetrahydrofuran, and combinations thereof.

[0067] Examples of other organic solvents include dimethyl sulfoxide, 1,2-dioxolane, sulfolane, methyl sulfolane, 1,3-dimethyl-2-imidazolidinone, N-methyl-2-pyrrolidone, formamide, dimethylformamide, acetonitrile, trimethyl phosphate, triethyl phosphate, trioctyl phosphate, phosphate esters, and combinations thereof.

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[0068] The electrode assembly of the lithium-ion battery to which the porous film of the present application is applied includes not only a wound type electrode assembly, but also a laminated (stacked) type electrode assembly and a folded type electrode assembly.

[0069] The present application is further described in details with examples below. It should be understood that these examples are only for illustrating the application but are not intended to limit the scope of the application. In the examples, only the case where the electrode assembly of the lithium-ion battery is wound type is illustrated, but the application is not limited thereto.

[0070] In the following examples, reagents, materials, and instruments used are commercially available unless otherwise specified.

[0071] Example 1

[0072] (1) Preparation of negative electrode

[0073] The negative electrode active material (artificial graphite), the binder (styrene-butadiene rubber), and the conductive agent (conductive carbon black (Super P)) are mixed uniformly with deionized water at a mass ratio of 92:3:5 to prepare a negative electrode slurry, then the negative electrode slurry is coated uniformly on front and rear surfaces of the negative electrode current collector copper foil, then a negative electrode active material layer is formed by drying the coated negative electrode current collector copper foil at 85 degrees Celsius, followed by cold pressing, slitting and cutting processes and a negative electrode tab is welded so as to obtain a negative electrode.

[0074] (2) Preparation of positive electrode

[0075] The positive electrode active material (lithium cobaltate ($LiCoO_2$)), the binder (polyvinylidene fluoride (PVDF)) and the conductive agent (conductive carbon black (Super P)) are dissolved in the solvent (N-methylpyrrolidone (NMP)) at a mass ratio of 97:1.5:1.5. A positive electrode slurry is prepared by stirring uniformly the mixture, then the positive electrode slurry is coated uniformly on front and rear surfaces of the positive electrode current collector aluminum foil, then a positive electrode active material layer is formed by drying the coated positive electrode current collector aluminum foil at 85 degrees Celsius, followed by cold pressing, slitting and cutting processes and a positive electrode tab is welded so as to obtain a positive electrode.

[0076] (3) Preparation of separator

[0077] Inorganic particles (boehmite) are mixed with the binder (polyvinylidene fluoride) at a volume ratio of 1.2, and then N-methylpyrrolidone (first solvent) is added and uniformly stirred to obtain a coating solution, wherein the coating solution has a solid content of 7%. The coating solution is coated onto a porous substrate (polyethylene) using the dip coating method to form a wet film. The porous substrate (polyethylene) with a wet film is immersed in a coagulation solution containing deionized water (third solvent) and N-methylpyrrolidone (NMP, second solvent) for phase transformation, wherein the mass percentage of N-methylpyrrolidone (second solvent) in the coagulation solution is 40%, and the coating solution and the coagulation solution are at the temperature of 25 degrees Celsius. After being immersed in the coagulation solution for 30 seconds, the porous substrate (polyethylene) with a wet film is dried in an oven at 60 degrees Celsius to obtain a separator with a porous film. The particle size distribution of inorganic particles (boehmite) is such that Dv10 is 0.9 μm, Dv50 is 1.8 μm and Dv90 is 3.0 μm.

[0078] (4) Preparation of electrolyte

[0079] A solution prepared with lithium salt $LiPF_6$ and a non-aqueous organic solvent (ethylene carbonate (EC): diethyl carbonate (DEC): ethyl methyl carbonate (EMC): vinylene carbonate (VC) =

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8:85:5:2, by mass ratio) at a mass ratio of 8:92 is used as the electrolyte.

[0080] (5) Preparation of lithium-ion battery

[0081] An electrode assembly is obtained by winding the positive electrode, the separator and the negative electrode, and followed by packaging, injection of the electrolyte, forming, and suction molding processes are performed to obtain the lithium-ion battery.

[0082] Example 2

[0083] In this example, the preparation methods for the negative electrode, the positive electrode, the electrolyte, and the lithium-ion battery are the same as the corresponding preparation methods described in Example 1. The preparation method of the separator is the same as that described in Example 1, except that the solid content of the coating solution is 10%.

[0084] Example 3

[0085] In this example, the preparation methods for the negative electrode, the positive electrode, the electrolyte, and the lithium-ion battery are the same as the corresponding preparation methods described in Example 1. The preparation method of the separator is the same as that described in Example 1, except that the solid content of the coating solution is 15%.

[0086] Example 4

[0087] In this example, the preparation methods for the negative electrode, the positive electrode, the electrolyte, and the lithium-ion battery are the same as the corresponding preparation methods described in Example 1. The preparation method of the separator is the same as that described in Example 1, except that the solid content of the coating solution is 20%.

[0088] Example 5

[0089] In this example, the preparation methods for the negative electrode, the positive electrode, the electrolyte, and the lithium-ion battery are the same as the corresponding preparation methods described in Example 1. The preparation method of the separator is the same as that described in Example 1, except that the solid content of the coating solution is 25%.

[0090] Example 6

[0091] In this example, the preparation methods for the negative electrode, the positive electrode, the electrolyte, and the lithium-ion battery are the same as the corresponding preparation methods described in Example 1. The preparation method of the separator is the same as that described in Example 1, except that the solid content of the coating solution is 15%, and dimethylacetamide (DMAC) is selected as the second solvent.

[0092] Example 7

[0093] In this example, the preparation methods for the negative electrode, the positive electrode, the electrolyte, and the lithium-ion battery are the same as the corresponding preparation methods described in Example 1. The preparation method of the separator is the same as that described in Example 1, except that the solid content of the coating solution is 15%, and dimethylformamide (DMF) is selected as the second solvent.

[0094] Example 8

[0095] In this example, the preparation methods for the negative electrode, the positive electrode, the electrolyte, and the lithium-ion battery are the same as the corresponding preparation methods described in Example 1. The preparation method of the separator is the same as that described in Example 1, except that the solid content of the coating solution is 15%, and the particle size distribution of inorganic particles (boehmite) is that Dv10 is 0.015 μm, Dv50 is 0.2 μm and Dv90 is 1.5 μm.

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[0096] Example 9

[0097] In this example, the preparation methods for the negative electrode, the positive electrode, the electrolyte, and the lithium-ion battery are the same as the corresponding preparation methods described in Example 1. The preparation method of the separator is the same as that described in Example 1, except that the solid content of the coating solution is 15%, and the particle size distribution of inorganic particles (boehmite) is that Dv10 is 0.2 μm, Dv50 is 1.0 μm and Dv90 is 2.0 μm.

[0098] Example 10

[0099] In this example, the preparation methods for the negative electrode, the positive electrode, the electrolyte, and the lithium-ion battery are the same as the corresponding preparation methods described in Example 1. The preparation method of the separator is the same as that described in Example 1, except that the solid content of the coating solution is 15%, and the particle size distribution of inorganic particles (boehmite) is that Dv10 is 1.6 μm, Dv50 is 2.6 μm and Dv90 is 4.6 μm.

[00100] Example 11

[00101] In this example, the preparation methods for the negative electrode, the positive electrode, the electrolyte, and the lithium-ion battery are the same as the corresponding preparation methods described in Example 1. The preparation method of the separator is the same as that described in Example 1, except that the solid content of the coating solution is 15%, and the particle size distribution of inorganic particles (boehmite) is that Dv10 is 2.2 μm, Dv50 is 3.5 μm and Dv90 is 5.8 μm.

[00102] Example 12

[00103] In this example, the preparation methods for the negative electrode, the positive electrode, the electrolyte, and the lithium-ion battery are the same as the corresponding preparation methods described in Example 1. The preparation method of the separator is the same as that described in Example 1, except that the solid content of the coating solution is 15%, and the particle size distribution of inorganic particles (boehmite) is that Dv10 is 3.0 μm, Dv50 is 5.0 μm and Dv90 is 10.0 μm.

[00104] Example 13

[00105] In this example, the preparation methods for the negative electrode, the positive electrode, the electrolyte, and the lithium-ion battery are the same as the corresponding preparation methods described in Example 1. The preparation method of the separator is the same as that described in Example 1, except that the solid content of the coating solution is 15%, and the mass percentage of N-methylpyrrolidone in the coagulation solution is 20%.

[00106] Example 14

[00107] In this example, the preparation methods for the negative electrode, the positive electrode, the electrolyte, and the lithium-ion battery are the same as the corresponding preparation methods described in Example 1. The preparation method of the separator is the same as that described in Example 1, except that the solid content of the coating solution is 15%, and the mass percentage of N-methylpyrrolidone in the coagulation solution is 60%.

[00108] Example 15

[00109] In this example, the preparation methods for the negative electrode, the positive electrode, the electrolyte, and the lithium-ion battery are the same as the corresponding preparation methods described in Example 1. The preparation method of the separator is the

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same as that described in Example 1, except that the solid content of the coating solution is 15%, alumina is selected as inorganic particles, and the particle size distribution of alumina particles is that Dv10 is 0.9 μm, Dv50 is 1.8 μm and Dv90 is 3.0 μm.

[00110] Example 16

[00111] In this example, the preparation methods for the negative electrode, the positive electrode, the electrolyte, and the lithium-ion battery are the same as the corresponding preparation methods described in Example 1. The preparation method of the separator is the same as that described in Example 1, except that the solid content of the coating solution is 15%, magnesium hydroxide is selected as inorganic particles, and the particle size distribution of magnesium hydroxide particles is that Dv10 is 0.9 μm, Dv50 is 1.8 μm and Dv90 is 3.0 μm.

[00112] Example 17

[00113] (1) Preparation of negative electrode

[00114] The negative electrode active material (artificial graphite), the binder (styrene-butadiene rubber), and the conductive agent (conductive carbon black (Super P)) are mixed uniformly with deionized water at a mass ratio of 92:3:5 to prepare a negative slurry, then the negative slurry is coated uniformly on front and rear surfaces of the negative electrode current collector copper foil, then a negative electrode active material layer is formed by drying the coated negative electrode current collector copper foil at 85 degrees Celsius, followed by cold pressing, slitting and cutting processes and a negative electrode tab is welded to obtain a negative electrode.

[00115] (2) Preparation of positive electrode

[00116] The positive electrode active material (lithium cobaltate ($LiCoO_2$)), the binder (polyvinylidene fluoride (PVDF)), and the conductive agent (conductive carbon black (Super P)) are dissolved in the solvent (N-methylpyrrolidone (NMP)) at a mass ratio of 97:1.5:1.5. A positive slurry is prepared by stirring uniformly the mixture, then the positive slurry is coated uniformly on front and rear surfaces of the positive electrode current collector (aluminum foil), then a positive electrode active material layer is formed by drying the coated positive electrode current collector aluminum foil at 85 degrees Celsius. Inorganic particles (boehmite) are mixed with the binder PVDF at a volume ratio of 1.2, and then N-methylpyrrolidone (first solvent) is added and uniformly stirred to obtain a coating solution, wherein the coating solution has a solid content of 15 %. The coating solution is coated onto the positive electrode current collector on which a positive electrode active material layer is arranged by the dip coating method to form a wet film. The positive electrode current collector with a wet film is then immersed in a coagulation solution containing deionized water (third solvent) and N-methylpyrrolidone (second solvent) for phase transformation, wherein the mass percentage of N-methylpyrrolidone in the coagulation solution is 40%, and the coating solution and the coagulation solution are both at the temperature of 25 degrees Celsius. After being immersed in the coagulation solution for 30 seconds, the positive electrode current collector with a wet film is dried in an oven at 60 degrees Celsius, then cold pressing, slitting and cutting processes are performed and a positive electrode tab is welded to obtain a positive electrode with a porous film. The particle size distribution of inorganic particles (boehmite) is such that Dv10 is 0.9 μm, Dv50 is 1.8 μm and Dv90 is 3.0 μm.

[00117] (3) Preparation of separator

[00118] A polyethylene porous substrate is used as a separator.

[00119] (4) Preparation of electrolyte

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[00120] A solution prepared with lithium salt $LiPF_6$ and a non-aqueous organic solvent (ethylene carbonate (EC): diethyl carbonate (DEC): ethyl methyl carbonate (EMC): vinylene carbonate (VC) = 8:85:5:2, by a mass ratio) at a mass ratio of 8:92 is used as the electrolyte.

[00121] (5) Preparation of lithium-ion battery

[00122] An electrode assembly is obtained by winding the positive electrode, the separator and the negative electrode, and then packaging, injection of the electrolyte, forming, and suction molding processes are performed to obtain the lithium-ion battery.

[00123] Example 18

[00124] (1) Preparation of negative electrode

[00125] The negative electrode active material (artificial graphite), the binder (styrene-butadiene rubber), and the conductive agent (conductive carbon black (Super P)) are mixed uniformly with the solvent (N-methylpyrrolidone (NMP)) at a mass ratio of 92:3:5 to prepare a negative slurry, then the negative slurry is coated uniformly on front and rear surfaces of the negative electrode current collector (copper foil), then a negative electrode active material layer is formed by drying the coated negative electrode current collector copper foil at 85 degrees Celsius. Inorganic particles (boehmite) are mixed with the binder (PVDF) at a volume ratio of 1.2, and then N-methylpyrrolidone (first solvent) is added and uniformly stirred to obtain a coating solution, wherein the coating solution has a solid content of 15 %. The coating solution is coated onto the negative electrode current collector on which the negative electrode active material layer is provided by the dip coating method to form a wet film. The negative electrode current collector with a wet film is then immersed in a coagulation solution containing deionized water (third solvent) and N-methylpyrrolidone (second solvent) for phase transformation, wherein the mass percentage of N-methylpyrrolidone in the coagulation solution is 40%, and the coating solution and the coagulation solution are both at the temperature of 25 degrees Celsius. After being immersed in the coagulation solution for 30 seconds, the negative electrode current collector with a wet film is dried in an oven at 60 degrees Celsius, and then cold pressing, slitting and cutting processes are performed and a negative electrode tab is welded to obtain a negative electrode. The particle size distribution of inorganic particles (boehmite) is such that Dv10 is 0.9 μm, Dv50 is 1.8 μm and Dv90 is 3.0 μm.

[00126] (2) Preparation of positive electrode

[00127] The positive electrode active material (lithium cobaltate ($LiCoO_2$)), the binder (polyvinylidene fluoride (PVDF)), and the conductive agent (conductive carbon black (Super P)) are dissolved in the solvent (N-methylpyrrolidone (NMP)) at a mass ratio of 97:1.5:1.5. A positive slurry is prepared by stirring uniformly the mixture, then the positive slurry is coated uniformly on front and rear surfaces of the positive electrode current collector aluminum foil, then a positive electrode active material layer is formed by drying the coated positive electrode current collector aluminum foil at 85 degrees Celsius, and then cold pressing, slitting and cutting processes are performed and a positive electrode tab is welded to obtain a positive electrode.

[00128] (3) Preparation of separator

[00129] A polyethylene porous substrate is used as a separator.

[00130] (4) Preparation of electrolyte

[00131] A solution prepared with lithium salt $LiPF_6$ and a non-aqueous organic solvent (ethylene carbonate (EC): diethyl carbonate (DEC): ethyl methyl carbonate (EMC): vinylene carbonate (VC) = 8:85:5:2, by a mass ratio) at a mass ratio of 8:92 is used as the electrolyte.

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[00132] (5) Preparation of lithium-ion battery

[00133] An electrode assembly is obtained by winding the positive electrode, the separator and the negative electrode, and packaging, injection of the electrolyte, forming, and suction molding processes are performed to obtain the lithium-ion battery.

[00134] Example 19

[00135] (1) Preparation of negative electrode

[00136] The negative electrode active material (artificial graphite), the binder (styrene-butadiene rubber), and the conductive agent (conductive carbon black (Super P)) are mixed uniformly with the solvent (N-methylpyrrolidone (NMP)) at a mass ratio of 92:3:5 to prepare a negative slurry, then the negative slurry is coated uniformly on front and rear surfaces of the negative electrode current collector (copper foil), then a negative electrode active material layer is formed by drying the coated negative electrode current collector copper foil at 85 degrees Celsius, then cold pressing, slitting and cutting processes are performed and a negative electrode tab is welded to obtain a negative electrode.

[00137] (2) Preparation of positive electrode

[00138] The positive electrode active material (lithium cobaltate ($LiCoO_2$)), the binder (polyvinylidene fluoride (PVDF)) and the conductive agent (conductive carbon black (Super P)) are dissolved in the solvent (N-methylpyrrolidone (NMP)) at a mass ratio of 97:1.5:1.5. A positive slurry is prepared by stirring uniformly the mixture, then the positive slurry is coated uniformly on front and rear surfaces of the positive electrode current collector aluminum foil, then a positive electrode active material layer is formed by drying the coated positive electrode current collector aluminum foil at 85 degrees Celsius. Inorganic particles (boehmite) are mixed with the binder (PVDF) at a volume ratio of 1.2, and then N-methylpyrrolidone (first solvent) is added and uniformly stirred to obtain a coating solution, wherein the coating solution has solid content of 15%. The coating solution is coated onto the positive electrode current collector on which the positive electrode active material layer is provided by the dip coating method to form a wet film. The positive electrode current collector with a wet film is then immersed in a coagulation solution containing deionized water (third solvent) and N-methylpyrrolidone (second solvent) for phase transformation, wherein the mass percentage of N-methylpyrrolidone in the coagulation solution is 40%, and the coating solution and the coagulation solution are both at the temperature of 25 degrees Celsius. After being immersed in the coagulation solution for 30 seconds, the positive electrode current collector with a wet film is dried in an oven at 60 degrees Celsius, and then cold pressing, slitting and cutting processes are performed and a positive electrode tab is welded to obtain a positive electrode with a porous film. The particle size distribution of inorganic particles boehmite is such that Dv10 is 0.9 μm, Dv50 is 1.8 μm and Dv90 is 3.0 μm.

[00139] (3) Preparation of separator

[00140] Inorganic particles (boehmite) are mixed with the binder (PVDF) at a volume ratio of 1.2, and then N-methylpyrrolidone (first solvent) is added and uniformly stirred to obtain a coating solution, wherein the coating solution has a solid content of 15 %. The coating solution is coated onto a porous substrate (polyethylene) by the dip coating method to form a wet film. The porous substrate (polyethylene) with a wet film is immersed in a coagulation solution containing deionized water (third solvent) and N-methylpyrrolidone (second solvent) for phase transformation, wherein the mass percentage of N-methylpyrrolidone in the coagulation solution

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is 40%, and the coating solution and the coagulation solution are both at the temperature of 25 degrees Celsius. After being immersed in the coagulation solution for 30 seconds, the porous substrate (polyethylene) with a wet film is dried in an oven at 60 degrees Celsius to obtain a separator with a porous film. The particle size distribution of inorganic particles (boehmite) is such that Dv10 is 0.9 μm, Dv50 is 1.8 μm and Dv90 is 3.0 μm.

[00141] (4) Preparation of electrolyte

[00142] A solution prepared with lithium salt $LiPF_6$ and a non-aqueous organic solvent (ethylene carbonate (EC): diethyl carbonate (DEC): ethyl methyl carbonate (EMC): vinylene carbonate (VC) = 8:85:5:2, by a mass ratio) at a mass ratio of 8:92 is used as the electrolyte.

[00143] (5) Preparation of lithium-ion battery

[00144] An electrode assembly is obtained by winding the positive electrode, the separator and the negative electrode, and then packaging, injection of the electrolyte, forming, and suction molding processes are performed to obtain the lithium-ion battery.

[00145] Example 20

[00146] (1) Preparation of negative electrode

[00147] The negative electrode active material (artificial graphite), the binder (styrene-butadiene rubber), and the conductive agent (conductive carbon black (Super P)) are mixed uniformly with the solvent (N-methylpyrrolidone (NMP)) at a mass ratio of 92:3:5 to prepare a negative slurry, then the negative slurry is coated uniformly on front and rear surfaces of the negative electrode current collector copper foil, and then a negative electrode active material layer is formed by drying the coated negative electrode current collector copper foil at 85 degrees Celsius. Inorganic particles (boehmite) are mixed with the binder (PVDF) at a volume ratio of 1.2, and then N-methylpyrrolidone (first solvent) is added and uniformly stirred to obtain a coating solution, wherein the coating solution has a solid content of 15 %. The coating solution is coated onto the negative electrode current collector on which the negative electrode active material layer is provided by the dip coating method to form a wet film. The negative electrode current collector with a wet film is immersed in a coagulation solution containing deionized water (third solvent) and N-methylpyrrolidone (second solvent) for phase transformation, wherein the mass percentage of N-methylpyrrolidone in the coagulation solution is 40%, and the coating solution and the coagulation solution are both at the temperature of 25 degrees Celsius. After being immersed in the coagulation solution for 30 seconds, the negative electrode current collector with a wet film is dried in an oven at 60 degrees Celsius, then cold pressing, slitting and cutting processes are performed and a negative electrode tab is welded to obtain a negative electrode with a porous film. The particle size distribution of inorganic particles (boehmite) is such that Dv10 is 0.9 μm, Dv50 is 1.8 μm and Dv90 is 3.0 μm.

[00148] (2) Preparation of positive electrode

[00149] The positive electrode active material (lithium cobaltate ($LiCoO_2$)), the binder (polyvinylidene fluoride (PVDF)), and the conductive agent (conductive carbon black (Super P)) are dissolved in the solvent (N-methylpyrrolidone (NMP)) at a mass ratio of 97:1.5:1.5. A positive slurry is prepared by stirring uniformly the mixture, then the positive slurry is coated uniformly on front and rear surfaces of the positive electrode current collector aluminum foil, then a positive electrode active material layer is formed by drying the coated positive electrode current collector aluminum foil at 85 degrees Celsius, then cold pressing, slitting and cutting processes are performed and a positive electrode tab is welded to obtain a positive electrode.

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[00150] (3) Preparation of separator

[00151] Inorganic particles (boehmite) are mixed with the binder (PVDF) at a volume ratio of 1.2, and then N-methylpyrrolidone (first solvent) is added and uniformly stirred to obtain a coating solution, wherein the coating solution has a solid content of 15%. The coating solution is coated onto a porous substrate (polyethylene) using the dip coating method to form a wet film. The porous substrate (polyethylene) with a wet film is immersed in a coagulation solution containing deionized water (third solvent) and N-methylpyrrolidone (second solvent) for phase transformation, wherein the mass percentage of N-methylpyrrolidone in the coagulation solution is 40%, and the coating solution and the coagulation solution are both at the temperature of 25 degrees Celsius. After being immersed in the coagulation solution for 30 seconds, the porous substrate (polyethylene) with a wet film is dried in an oven at 60 degrees Celsius to obtain a separator with a porous film. The particle size distribution of inorganic particles (boehmite) is such that Dv10 is 0.9 μm, Dv50 is 1.8 μm and Dv90 is 3.0 μm.

[00152] (4) Preparation of electrolyte

[00153] A solution prepared with lithium salt $LiPF_6$ and a non-aqueous organic solvent (ethylene carbonate (EC): diethyl carbonate (DEC): ethyl methyl carbonate (EMC): vinylene carbonate (VC) = 8:85:5:2, by a mass ratio) at a mass ratio of 8:92 is used as the electrolyte.

[00154] (5) Preparation of lithium-ion battery

[00155] An electrode assembly is obtained by winding the positive electrode, the separator and the negative electrode, and then packaging, injection of the electrolyte, forming, and suction molding processes are performed to obtain the lithium-ion battery.

[00156] Comparative example 1

[00157] In this comparative example, the preparation methods for the negative electrode, the positive electrode, the electrolyte, and the lithium-ion battery are the same as the corresponding preparation methods described in Example 1.

[00158] The separator is prepared as follows.

[00159] The boehmite and polyvinylidene fluoride at a volume ratio of 1.2 are added into deionized water and uniformly mixed to prepare a slurry, and the solid content of the slurry is 45%. Then, the slurry is uniformly coated onto front and rear surfaces of the porous substrate (polyethylene) using the micro gravure coating method to form a wet film. After the wet film is dried in an oven, a separator is obtained. The particle size distribution of inorganic particles (boehmite) is that Dv10 is 0.9 μm, Dv50 is 1.8 μm and Dv90 is 3.0 μm.

[00160] Comparative example 2

[00161] In this comparative example, the preparation methods for the negative electrode, the positive electrode, the electrolyte, and the lithium-ion battery are the same as the corresponding preparation methods described in Example 1. The preparation method of the separator is the same as that described in Example 1, except that the solid content of the coating solution is 4%.

[00162] Comparative example 3

[00163] In this example, the preparation methods for the negative electrode, the positive electrode, the electrolyte, and the lithium-ion battery are the same as the corresponding preparation methods described in Example 1. The preparation method of the separator is the same as that described in Example 1, except that the solid content of the coating solution is 30%.

[00164] Parameters of Examples 1-20 and comparative examples 1-3 are shown in Table 1 below.

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Table 1

	Position of porous film	Solid content of the coating solution	Inorganic particle/ μm				Second solvent	Content of second solvent in coagulation solution
			Type	Dv10	Dv50	Dv90		
Example 1	surfaces of separator	7%	boehmite	0.9	1.8	3.0	NMP	40%
Example 2	surfaces of separator	10%	boehmite	0.9	1.8	3.0	NMP	40%
Example 3	surfaces of separator	15%	boehmite	0.9	1.8	3.0	NMP	40%
Example 4	surfaces of separator	20%	boehmite	0.9	1.8	3.0	NMP	40%
Example 5	surfaces of separator	25%	boehmite	0.9	1.8	3.0	NMP	40%
Example 3	surfaces of separator	15%	boehmite	0.9	1.8	3.0	NMP	40%
Example 6	surfaces of separator	15%	boehmite	0.9	1.8	3.0	DMAC	40%
Example 7	surfaces of separator	15%	boehmite	0.9	1.8	3.0	DMF	40%
Example 8	surfaces of separator	15%	boehmite	0.015	0.2	1.5	NMP	40%
Example 9	surfaces of separator	15%	boehmite	0.2	1.0	2.0	NMP	40%
Example 3	surfaces of separator	15%	boehmite	0.9	1.8	3.0	NMP	40%
Example 10	surfaces of separator	15%	boehmite	1.6	2.6	4.6	NMP	40%
Example 11	surfaces of separator	15%	boehmite	2.2	3.5	5.8	NMP	40%
Example 12	surfaces of separator	15%	boehmite	3.0	5.0	10.0	NMP	40%
Example 13	surfaces of separator	15%	boehmite	0.9	1.8	3.0	NMP	20%
Example 3	surfaces of separator	15%	boehmite	0.9	1.8	3.0	NMP	40%

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Example 14	surfaces of separator	15%	boehmite	0.9	1.8	3.0	NMP	60%
Example 15	surfaces of separator	15%	alumina	0.9	1.8	3.0	NMP	40%
Example 16	surfaces of separator	15%	magnesium hydroxide	0.9	1.8	3.0	NMP	40%
Example 3	surfaces of separator	15%	boehmite	0.9	1.8	3.0	NMP	40%
Example 17	surfaces of positive electrode	15%	boehmite	0.9	1.8	3.0	NMP	40%
Example 18	surfaces of negative electrode	15%	boehmite	0.9	1.8	3.0	NMP	40%
Example 19	surfaces of separator and positive electrode	15%	boehmite	0.9	1.8	3.0	NMP	40%
Example 20	surfaces of separator and negative electrode	15%	boehmite	0.9	1.8	3.0	NMP	40%
Comparative Example 1	surfaces of separator	/	boehmite	0.9	1.8	3.0	/	/
Comparative Example 2	surfaces of separator	4%	boehmite	0.9	1.8	3.0	NMP	40%
Comparative Example 3	surfaces of separator	30%	boehmite	0.9	1.8	3.0	NMP	40%

[00165] Performance test

[00166] The performances of the porous film and the lithium-ion battery comprising the porous film prepared in Examples 1-20 and comparative examples 1-3 are tested, and the test method is described as follows.

[00167] (1) Thickness test of porous film

[00168] A separator sample or an electrode sample provided with a porous film is placed on a thickness gauge (Model VL-50 LITEMATIC from Naitutoyo company) using a 5 mm flat bottom probe with a speed of 50 mm/min and a pressure of 0.01 N. Each separator sample or electrode sample provided with the porous film is measured for 60 thickness points, and the average thickness is taken as the measured value. The thickness of the porous film is equal to the thickness of the separator or the electrode coated with the porous film minus the thickness of the separator sample or the electrode sample without the porous film. In a case that there are two porous films, the thickness is divided by 2 to obtain the thickness of each porous layer.

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[00169] (2) Gas permeability test of porous film

[00170] A 100mm x 100mm separator sample provided with a porous film is cut and tested using a US Gurley 4110 N permeability tester with a test gas of 100 cc, and the period that the test gas passes completely through the separator provided with the porous film is recorded as a Gurley value. The Gurley value of the porous film is equal to the Gurley value of the separator provided with the porous film minus the Gurley value of the separator without the porous film (i.e., a pure porous substrate). In a case that the electrode comprises a porous film, since the current collector itself is gas-tight, the gas permeability of the porous film cannot be evaluated according to such a method.

[00171] (3) Porosity test of porous film

[00172] The length, width, and thickness of a separator sample or an electrode sample provided with a porous film are measured, the thickness of the porous film is obtained using the above-described method, and the apparent volume V1 of the porous film is obtained through calculation. The true volume V20 of the separator sample or the electrode sample provided with the porous film is measured using a true density meter (AccuPyc II Model 1340 Gas Pycnometer, Micromeritics Company), and the true volume V0 of the separator sample or the electrode sample without the porous film having the same area is measured. The true volume V2 of the porous film is equal to V20-V0, and the porosity of the porous film is equal to 1-V2/V1.

[00173] (4) Average pore size test of porous film

[00174] The area of the porous film that needs to be measured is observed using the Model Sigma-02-33 Scanning Electron Microscope from Zeiss, and images are saved. The maximum diameter L1 in the transverse direction and the maximum diameter L2 in the longitudinal direction for each pore in the images are measured, and the pore size of the pore is equal to (L1+L2)/2. Pore sizes of 200 adjacent pores are measured and an average value thereof is taken as the average pore size of the porous film.

[00175] (5) Pore size distribution coefficient test of porous film

[00176] The area of the porous film that needs to be measured is observed using the Model Sigma-02-33 Scanning Electron Microscope from Zeiss, and images are saved. Pore sizes of 200 adjacent pores are measured to obtain a pore size distribution curve. R10 represents pore sizes which reach 10% of the cumulative pore sizes from the side of small pore size in the pore size distribution curve (the pore sizes of 10% of the pores are less than R10). R90 represents pore sizes which reach 90% of the cumulative pore sizes from the side of small pore size in the pore size distribution curve (the pore sizes of 90% of the pores are less than R90). The pore size distribution coefficient D is equal to R90/R10. The closer to 1 the pore size distribution coefficient D is, the more uniform the pore sizes will be. The higher the pore size distribution coefficient D is, the poorer the uniformity of the pore sizes will be.

[00177] (6) Average wall thickness test between adjacent pores in the porous film

[00178] The area of the porous film that needs to be measured is observed using the Model Sigma-02-33 Scanning Electron Microscope from Zeiss, and images are saved. The wall thicknesses between each two adjacent pores among 200 adjacent pores are measured and an average value thereof is taken as the average wall thickness between adjacent pores in the porous film.

[00179] (7) Rate performance test of lithium-ion battery

[00180] At 25 degrees Celsius, the lithium-ion battery is discharged to 3.0 V at a constant

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current of 0.2 C, rested for 10 minutes, then charged to 4.4 V at a constant current of 0.7 C, then charged to 0.02 C at a constant voltage of 4.4 V, and rested for 10 min, and is further discharged at a constant current of 0.2 C until the voltage is 3.0 V. The discharge capacity at this point is measured and recorded as Q1. Then, the lithium-ion battery is charged to 4.4 V at a constant current of 0.7C, is then charged to 0.02C at a constant voltage of 4.4 V, rested for 10 minutes, then discharged at a constant current of 2 C until the voltage is 3.0 V. The discharge capacity at this point is measured and recorded as Q2.

[00181] 2 C/0.2 C rate performance (%) of the lithium-ion battery is equal to Q2/Q1 x 100%.

[00182] (8) Cycle performance test of lithium-ion battery

[00183] At 25 degrees Celsius, the lithium-ion battery is charged to 4.4 V at a constant current of 0.7 C, is then charged to 0.02 C at a constant voltage of 4.4 V, rested for 10 minutes, is discharged to 3.0 V at a constant current of 1 C, and rested for 10 minutes. The discharge capacity at this point is measured and recorded as Q3. The above-described procedures are regarded as one cycle of charge and discharge; 200 cycles are performed, and the discharge capacity after the 200 cycles is recorded as Q4.

[00184] The capacity retention rate (%) of the lithium-ion battery after 200 cycles is equal to Q4/Q3 x 100%.

[00185] Test results

[00186] The measured results of Examples 1-20 and comparative examples 1-3 are shown in Table 2 below.

Table 2

	Porous film						Lithium-ion battery	
	Gurley value (s/100cc)	Thickness(μm)	Porosity	Average pore size(μm)	Pore size distribution coefficient D	Average wall thickness (nm)	Rate performance	Cycle performance
Example 1	24	2.4	58%	12	1.5	20	80.50%	86.70%
Example 2	28	2.4	55%	7.8	2.1	90	84.20%	91.10%
Example 3	32	2.4	53%	5	2.5	180	87.30%	95.30%
Example 4	41	2.4	49%	3.6	3.6	320	83.90%	90.70%
Example 5	55	2.4	46%	1.5	4.5	500	79.70%	85.30%
Example 3	32	2.4	53%	5	2.5	180	87.30%	95.30%
Example 6	35	2.4	52%	4.5	3	220	85.10%	92.30%
Example 7	39	2.4	50%	3.7	3.2	300	82.90%	90.00%
Example 8	45	2.4	48%	3.0	3.8	410	84.50%	91.50%
Example 9	40	2.4	50%	4.0	3.4	320	85.40%	92.10%
Example 3	32	2.4	53%	5	2.5	180	87.30%	95.30%

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Example 10	30	3.0	54%	5.5	2.2	160	86.30%	92.40%
Example 11	28	4.0	55%	6.9	2.0	100	82.40%	89.80%
Example 12	26	8.0	57%	8.9	1.8	70	80.20%	86.50%
Example 13	39	2.4	51%	8.1	3.6	50	82.20%	89.30%
Example 3	32	2.4	53%	5	2.5	180	87.30%	95.30%
Example 14	34	2.4	52%	3.5	2.3	300	84.10%	90.20%
Example 15	43	2.4	49%	2.5	3.0	240	80.20%	85.20%
Example 16	38	2.4	51%	3.1	2.9	230	85.20%	89.70%
Example 3	32	2.4	53%	5	2.5	180	87.30%	95.30%
Example 17	/	2.4	53%	4.9	2.6	180	86.90%	94.60%
Example 18	/	2.4	53%	5.1	2.6	180	87.20%	94.90%
Example 19	/	2.4	53%	4.9	2.7	180	85.50%	93.50%
	32	2.4	53%	5	2.5	180		
Example 20	/	2.4	53%	5.1	2.6	180	85.70%	92.90%
	32	2.4	53%	5	2.4	180		
Example 1	36	2.4	46%	/	/	/	68.80%	70.10%
Example 2	20	2.4	61%	18	1.3	12	73.70%	76.30%
Example 3	91	2.4	42%	0.5	5.3	600	72.70%	73.60%

[00187] As can be seen from the relevant data in Table 2 above, the porous film according to the Examples of the present application has a higher porosity, and the lithium-ion battery has better rate performance and cycle performance.

[00188] As can be seen from the analysis of the relevant data of Examples 1-5 and comparative examples 2-3, if the solid content of the coating solution is increased, the viscosity of the coating solution is increased, the exchange speed between the non-solvent (third solvent) in the coagulation solution and the organic solvent (first solvent) in the coating solution becomes lower, the average pore size of the formed porous film is decreased, the average wall thickness between the adjacent pores is increased, the porosity of the porous film is decreased, and the gas permeability of the porous film is deteriorated. However, if the solid content of the coating solution is too low (for example, comparative example 2), it is difficult to form a porous film, and the electrochemical performance of the lithium-ion battery is drastically degraded. The porous film in Example 3 has a larger average pore size, uniform pore size distribution, and a small average wall thickness between adjacent pores. If the solid content of the coating solution is too high (for example, comparative example 3), the porosity of the porous film is too low and the gas permeability of the porous film is very poor. Referring to Figure 3, it can be seen that a small pore size structure tends to be formed in the porous film, and the average wall thickness between the adjacent pores is large, which seriously affects the cycle performance and rate performance of

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the lithium-ion battery.

[00189] As can be seen from the analysis of the relevant data of Example 3 and Examples 15 and 16, the rate performance and cycle performance of the lithium-ion battery is more significantly improved with the inorganic particles containing polar functional groups. This is because the surface of the inorganic particles containing polar functional groups is more easily combined with the non-solvent (third solvent), i.e., deionized water in the coagulating solution, which is advantageous for the diffusion of the deionized water into the porous film along the surface of the inorganic particles, and thus large pore structures are formed in the vicinity of the inorganic particles, and the pore structures with large average pore sizes and a small average wall thickness between the adjacent pores are easily obtained.

[00190] As can be seen from the analysis of the relevant data of Example 3, Example 6 and Example 7, if different organic solvents (second solvent) are selected, the pore structures in the obtained porous films are also different. The porous film formed with NMP has the largest average pore size and the highest porosity, the porous film formed with DMF has the smallest average pore size and the lowest porosity, and the porous film formed with DMAC has the average pore size and a porosity between those of the porous films formed with NMP and DMF respectively.

[00191] As can be seen from the analysis of the relevant data of Example 3 and Examples 8-12, the particle size of the inorganic particles has an effect on the improvement of the rate performance and cycle performance of the lithium-ion battery. If the particle size of the inorganic particles is increased, the exchange speed between the non-solvent (third solvent) in the coagulation solution and the organic solvent (first solvent) in the coating solution is increased, the development of the pore structure is faster, the average pore size of the formed pore is increased, and the average wall thickness between adjacent pores is decreased.

[00192] As can be seen from the analysis of the relevant data of Example 3 and Examples 13-14, the content of the organic solvent (second solvent) in the coagulation solution has a great effect on the rate performance and cycle performance of the lithium-ion battery. If the content of the organic solvent (second solvent) in the coagulation solution is reduced, the average pore size of the pores in the porous film is increased. As can be seen from the analysis of the relevant data of Example 1 and Examples 17-20, the porous film of the application may be formed separately on the separator, the positive electrode, and the negative electrode, or may also be formed on both the separator and the positive electrode or formed on both the separator and the negative electrode. The lithium-ion battery has good rate performance and cycling performance in either case.

[00193] It should be understood by those skilled in the art that the above-described Examples are only illustrative examples. Various changes, substitutions, and alterations could be made to the application without departing from the spirit and scope of the application.

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What is claimed is

1. A porous film, comprising:
a binder; and
inorganic particles;
wherein the porous film comprises pores formed by the binder, the pores at least comprises a part of the inorganic particles, and the average wall thickness between the pores is in a range of 20 nm to 500 nm.

2. The porous film according to claim 1, wherein the porous film has an average pore size of 0.3 μm to 20 μm.

3. The porous film according to claim 1, wherein the inorganic particles have particle sizes that Dv10 is in a range of 0.015 μm to 3 μm, Dv50 is in a range of 0.2 μm to 5 μm, and Dv90 is in a range of 1 μm to 10 μm.

4. The porous film according to claim 3, wherein Dv10 of the inorganic particles is less than Dv50 of the inorganic particles, and Dv50 of the inorganic particles is less than Dv90 of the inorganic particles.

5. The porous film according to claim 1, wherein the inorganic particles have particle sizes that the ratio of Dv90 to Dv10 is in a range of 2 to 100.

6. The porous film according to claim 1, wherein a pore size distribution coefficient of the pores in the porous film is in a range of 1 to 5.

7. The porous film according to claim 1, wherein the inorganic particles are at least one of alumina, silica, magnesia, titanium oxide, hafnium dioxide, tin oxide, cerium dioxide, nickel oxide, zirconia, zinc oxide, calcium oxide, boehmite, aluminum hydroxide, magnesium hydroxide, calcium hydroxide, and barium sulfate.

8. The porous film according to claim 1, wherein the binder is at least one of polyvinylidene fluoride, vinylidene fluoride-hexafluoropropylene copolymer, polyamide, polyacrylonitrile, polyacrylate, polyacrylic acid, polyacrylic acid salt, sodium carboxymethylcellulose, polyvinylpyrrolidone, polyvinyl ether, polymethyl methacrylate, polytetrafluoroethylene and polyhexafluoropropylene.

9. The porous film according to claim 1, wherein the porous film has a porosity of 20% to 90%, and the porous film has a thickness of 0.2 to 10 μm.

10. The porous film according to claim 1, wherein a volume ratio of the inorganic particles to the binder is in a range of 0.2 to 3.0.

11. A lithium-ion battery, comprising:

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a positive electrode;
a negative electrode;
a separator, arranged between the positive electrode and the negative electrode;
non-aqueous electrolyte; and
a porous film, comprising:
a binder; and
inorganic particles;
wherein the porous film comprises pores formed by the binder, the pores at least comprises a part of the inorganic particles, and the average wall thickness between the pores is in a range of 20 nm to 500 nm.

12. The lithium-ion battery according to claim 11, wherein the porous film has an average pore size of 0.3 μm to 20 μm.

13. The lithium-ion battery according to claim 11, wherein the inorganic particles have particle sizes that Dv10 is in a range of 0.015 μm to 3 μm, Dv50 is in a range of 0.2 μm to 5 μm, and Dv90 is in a range of 1 μm to 10 μm.

14. The lithium-ion battery according to claim 13, wherein Dv10 of the inorganic particles is less than Dv50 of the inorganic particles, and Dv50 of the inorganic particles is less than Dv90 of the inorganic particles.

15. The lithium-ion battery according to claim 11, wherein the inorganic particles have particle sizes that the ratio of Dv90 to Dv10 is in a range of 2 to 100.

16. The lithium-ion battery according to claim 11, wherein a pore size distribution coefficient of the pores in the porous film is in a range of 1 to 5.

17. The lithium-ion battery according to claim 11, wherein the inorganic particles are at least one of alumina, silica, magnesia, titanium oxide, hafnium dioxide, tin oxide, cerium dioxide, nickel oxide, zirconia, zinc oxide, calcium oxide, boehmite, aluminum hydroxide, magnesium hydroxide, calcium hydroxide, and barium sulfate.

18. The lithium-ion battery according to claim 11, wherein the binder is at least one of polyvinylidene fluoride, vinylidene fluoride-hexafluoropropylene copolymer, polyamide, polyacrylonitrile, polyacrylate, polyacrylic acid, polyacrylic acid salt, sodium carboxymethylcellulose, polyvinylpyrrolidone, polyvinyl ether, polymethyl methacrylate, polytetrafluoroethylene and polyhexafluoropropylene.

19. The lithium-ion battery according to claim 11, wherein the porous film has a porosity of 20% to 90%, and the porous film has a thickness of 0.2 to 10 μm, and a volume ratio of the inorganic particles to the binder is in a range of 0.2 to 3.0.

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20. The lithium-ion battery according to claim 11, wherein the porous film is arranged on a surface of at least one of the positive electrode, the negative electrode and the separator.

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ABSTRACT

The application provides a porous film and a lithium-ion battery. The porous film according to the present application has excellent adhesion, and the pore structure of the porous film can still be well maintained after being immersed in the electrolyte, thereby reducing the probability of pore blockage of the porous film and allowing the lithium-ion battery to have high ionic conductivity. Therefore, the rate performance of the lithium-ion battery is greatly improved, and the lithium-ion battery provided has excellent rate performance and cycle performance.

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Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	POROUS FILM AND LITHIUM-ION BATTERY
First Named Inventor/Applicant Name:	Jianjian Yi
Filer:	David Michael Dremann/Blake Morgan
Attorney Docket Number:	DHNG001.005AUS

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	300	300
UTILITY SEARCH FEE	1111	1	660	660
UTILITY EXAMINATION FEE	1311	1	760	760
Pages:				
Claims:				
Miscellaneous-Filing:				
LATE FILING FEE FOR OATH OR DECLARATION	1051	1	160	160
Petition:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**1880**

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Warnings:					
Information:					
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2	Drawings-other than black and white line drawings	DHNG001005AUS_Figs.pdf	804973 2a2ad6a2cba504d7b32032cdb5810de23ad63302	no	2
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3		DHNG001005AUS_Spec.pdf	395315 6688590d090cd03f0546c6eec9d065f17d1df792	yes	28

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Claims	25	27
Abstract	28	28

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4	Fee Worksheet (SB06)	fee-info.pdf	36604 815dff0848a8d2f9fea44441837b95b4d10bcddb	no	2
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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.

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