



(51) International Patent Classification:
H01M 2/00 (2006.01)

(21) International Application Number:
PCT/US2014/041051

(22) International Filing Date:
5 June 2014 (05.06.2014)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/831,437 5 June 2013 (05.06.2013) US

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))

[Continued on next page]

(54) Title: MITIGATING THERMAL RUNAWAY IN LITHIUM ION BATTERIES USING DAMAGE-INITIATING MATERIALS OR DEVICES

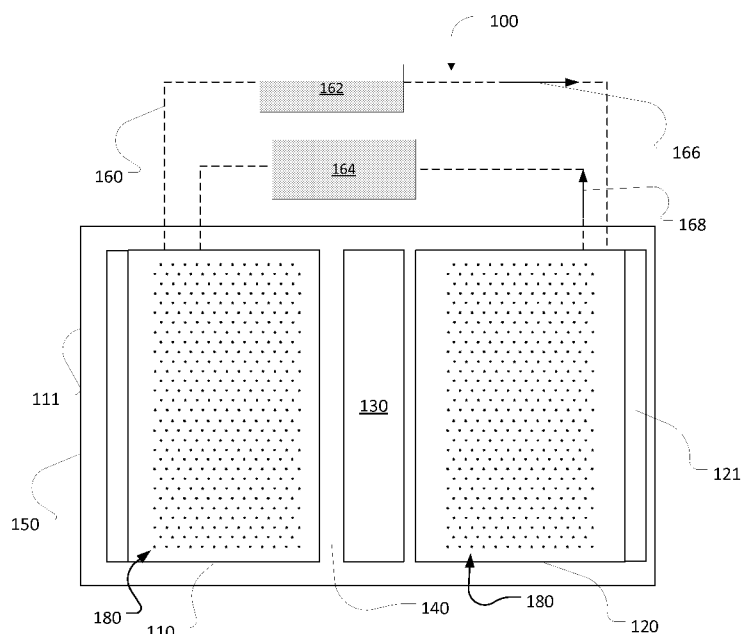


FIG. 1

(57) Abstract: A method of manufacturing a battery includes introducing a first material to the battery, providing an anode, a cathode and a separator of the battery; and assembling the anode, the separator and the cathode. The first material is configured and arranged to increase the internal impedance of the battery upon mechanical or thermal loading.

**Published:****(88) Date of publication of the international search report:**

12 February 2015

- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 14/41051

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - H01M 2/00 (2014.01)

CPC - H01M 2/0257; H01M 2/105; H01M 6/52; H01M 10/5004

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) - H01M 2/00 (2014.01)

CPC - H01M 2/0257; H01M 2/105; H01M 6/52; H01M 10/5004

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
 IPC(8) - H01M 2/00; H01M 10/50 (2014.01) CPC - H01M 2/0257; H01M 2/105; H01M 2/00; H01M 6/52; H01M 10/5004; H01M 10/5079; Y02T 10/7011 USPC-29/623.1, 623.2, 623.3, 623.4, 623.5; 429/50; 429/120

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
 PatBase, Proquest Dialog, Google Patents Search terms used: thermal runaway, battery, reduce, lower, diminish, strength, damage, break, material, expandable graphite, intumescent, self-destruct, crash, impact, collision, crush, penetration, tension, compression, torsion, bending, indentation, impedance, resistance, disposal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2010/0075213 A1 (Mehta et al.) 25 March 2010 (25.03.2010), Fig 3; para [0025], [0033], [0046]	1-16, 25/(4)
A	US 2011/0064997 A1 (Peskar et al.) 17 March 2011 (17.03.2011), abstract; para [0010]-[0019]	1-16, 25/(4)
A	US 2011/0070501 A1 (Chang et al.) 24 March 2011 (24.03.2011), abstract; para [0016]-[0021]	1-16, 25/(4)
A	US 2011/0311882 A1 (Kim et al.) 22 December 2011 (22.12.2011), entire document especially, para [0008], [0014], [0018], [0041]	1-16, 25/(4)
A	US 2010/0028758 A1 (Eaves et al.) 04 February 2010 (04.02.2010), entire document, especially para [0020]	1-16, 25/(4)



Further documents are listed in the continuation of Box C.



* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

17 November 2014 (17.11.2014)

Date of mailing of the international search report

03 DEC 2014

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
P.O. Box 1450, Alexandria, Virginia 22313-1450

Facsimile No. 571-273-3201

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PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 14/41051

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
see extra sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-16 and 25/4

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 14/41051

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: Claims 1-16 and 25/(4), drawn to a method of manufacturing a battery, the method comprising: introducing a first material to the battery; providing an anode, a cathode, charge collectors, and a separator of the battery; and assembling the anode, the separator and the cathode, wherein the first material is configured and arranged to reduce a mechanical strength of the battery upon mechanical loading.

Group II: Claims 17-22, drawn to a method of manufacturing a battery, the method comprising: introducing a first device to the battery; providing an anode, a cathode, a separator and an electrolyte of the battery; assembling the anode, the separator and the cathode, wherein the first device is configured and arranged to promote damages in electrodes or to change configurations of the electrolyte upon mechanical or thermal loading.

Group III: Claims 23, 24, 25/(23,24),26-42, drawn to a battery and method comprising: electrodes; a membrane; an electrolyte; charge collectors; and a first material configured and arranged to increase an internal impedance of the battery upon mechanical or thermal loading to reduce or eliminate thermal runaway.

The inventions listed as Groups I through III do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Special Technical Features

Group I includes the special technical feature of a first material is configured and arranged to reduce a mechanical strength of the battery upon mechanical loading, not included in the other groups.

Group II includes the special technical feature of a device configured and arranged to promote damages in electrodes or to change configurations of the electrolyte upon mechanical or thermal loading, not included in the other groups.

Group III includes the special technical feature of a first material configured and arranged to increase an internal impedance of the battery upon mechanical or thermal loading, not included in the other groups.

Common Technical Features:

The only technical features shared by Groups I-III that would otherwise unify the groups, are a battery comprising an anode, a cathode, charge collectors, membrane, electrolyte and a first material responsive to mechanical or thermal loading. However, these shared technical features do not represent a contribution over prior art, because the shared technical features are disclosed by US 2011/0311882 A1 to Kim et al. (hereinafter Kim) and US 2010/0028758 A1 to Eaves et al. (hereinafter Eaves).

Kim discloses a battery comprising an anode, a cathode, charge collectors, separator, electrolyte (para [0008], [0014], [0018], such features are typical features of batteries) and a means responsive to mechanical or thermal loading (para [0041]). Further, Eaves discloses a material responsive to mechanical or thermal loading (para [0020]).

As the technical feature was known in the art at the time of the invention, this cannot be considered a special technical feature that would otherwise unify the groups.

Therefore, Groups I-III lack unity under PCT Rule 13.