



- (51) International Patent Classification: **B01J 35/00** (2006.01)
- (21) International Application Number: PCT/US2014/042056
- (22) International Filing Date: 12 June 2014 (12.06.2014)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data: 61/835,380 14 June 2013 (14.06.2013) US
- (71) Applicant: **ARIZONA BOARD OF REGENTS, A BODY CORPORATE OF THE STATE OF ARIZONA, ACTING FOR AND ON BEHALF OF ARIZONA STATE UNIVERSITY** [US/US]; 1475 North Scottsdale Road, Skysong Suite 200, Scottsdale, Arizona 85257 (US).
- (72) Inventors: **TAO, Meng**; 11102 E. Jenan Dr., Scottsdale, Arizona 85259 (US). **HAN, Xiaofei**; 633 W. Southern Ave., Unit 1131, Tempe, Arizona 85282 (US).
- (74) Agent: **RICKS, Ryan**; Snell & Wilmer L.L.P., One Arizona Center, 400 East Van Buren, Phoenix, Arizona 85004-2202 (US).
- (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,

[Continued on next page]

(54) Title: SYSTEM AND METHOD FOR PURIFICATION OF ELECTROLYTIC SALT

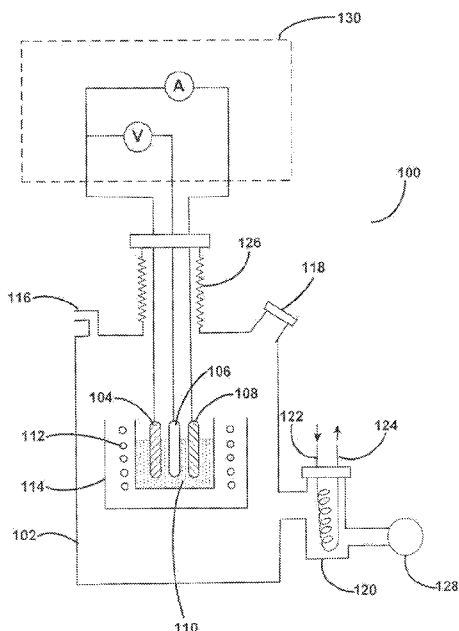


FIG. 1A

(57) Abstract: Methods and systems for removing impurities from an electrolytic salt are disclosed. After removal of impurities from the salt, the salt can be subjected to electrorefining to produce high-purity materials, for example silicon. Impurities are removed from the salt using a system that includes a first working electrode, a counter electrode, and at least one reference electrode. A second working electrode can also be utilized. The salt may be utilized in an electrorefining system, for example a system operated in a single phase or multiple phase operation to produce high-purity materials, such as solar-grade silicon.

WO 2014/201207 A3



TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

— *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))*

Published:

— *with international search report (Art. 21(3))*

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

5 February 2015

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 14/42056

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B01J 35/00 (2014.01)

CPC - B01D 53/007; A62D 3/176; B01D 53/8662

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)-B01J 35/00 (2014.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
CPC-B01D 53/007; A62D 3/176; B01D 53/8662
USPC-204/158.2

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase, Google Patents, Google Scholar (without Patents)

Keywords:purifying silicon working electrode counter electrode reference counter first second electrorefining potential electrolyte

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009/0127125 A1 (Dobberstein) 21 May 2009 (21.05.2009) Abstract, para [0001], para [0009], para [0017], para [0043], para [0056], para [0071], para [0103]	1-6
Y	US 2010/0276297 A1 (Powell et al.) 04 November 2010 (04.11.2010) Abstract	1-6
Y	WO 2013/016215 A2 (Maldonado et al.) 31 January 2013 (31.01.2013) Abstract	1-6
Y	US 4,298,587 A (Kapur) 03 November 1981 (03.11.1981) Abstract	1-6
Y	US 2007/0215483 A1 (Johansen et al.) 20 September 2007 (20.09.2007) Abstract	1-6
A	Sharma et al.; A study on purification of metallurgical grade silicon by molten salt electrorefining; Metall. Trans. B, Vol. 17B, pp 395-397; June 1986 (06.1986); entire document, especially pg 395 col 2 para 2	1-6

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

14 November 2014 (14.11.2014)

Date of mailing of the international search report

10 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

Authorized officer:

Lee W. Young

PCT Helpdesk: 571-272-4300
PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 14/42056

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 supplemental box ...

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.:
1-6

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 14/42056

continued from Box III ...

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 1-6, directed to a system for purifying silicon

Group II: Claims 7-14, directed to a method for purifying a salt having multiple impurities

The inventions listed as Groups I-II 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 requires system for purifying silicon, not required by group II

Group II requires a method for purifying a salt having multiple impurities, not required by group I

Common Technical Features

Groups I-II share the common feature of a first working electrode and second working electrode; a counter electrode; a reference electrode; and a system control to control an electrical potential between at least one of the first working electrode, the second working electrode, and the reference electrode. However, the above shared technical features, do not represent a contribution over prior art, as being anticipated by US 4,859,305 A to Schneider et al. (hereafter 'Schneider'). Schneider teaches a first working electrode and second working electrode; a counter electrode; a reference electrode (abstract; col 2, ln 5-36); and a system control to control an electrical potential between at least one of the first working electrode, the second working electrode, and the reference electrode (col 6, ln 46-55, ..constant current-controlled, second working (scavenger) electrode can be employed resulting in the advantage that the current between the working and reference electrodes may be maintained).

Therefore, Groups I-II lack unity under PCT Rule 13 because they do not share a same or corresponding special technical feature