

(43) International Publication Date
26 September 2013 (26.09.2013)

(51) International Patent Classification:

C23C 18/00 (2006.01) *H01L 21/00* (2006.01)
C09K 13/08 (2006.01) *C23C 14/00* (2006.01)

(21) International Application Number:

PCT/GB2013/050742

(22) International Filing Date:

21 March 2013 (21.03.2013)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

1205178.5 23 March 2012 (23.03.2012) GB

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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, IS, JP, KE, KG, KM, 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, 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, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— of inventorship (Rule 4.17(iv))

Published:

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

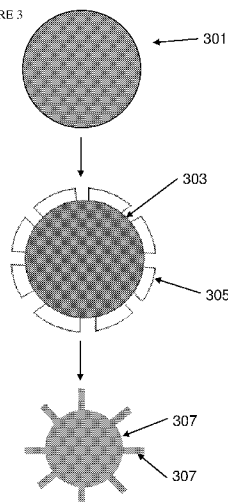
— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

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

3 January 2014

(54) Title: ETCHED SILICON STRUCTURES, METHOD OF FORMING ETCHED SILICON STRUCTURES AND USES THEREOF

FIGURE 3



(57) Abstract: A method of etching silicon of a material comprising silicon, the method comprising the steps of partially covering a silicon surface of the material comprising silicon with an elemental metal and then carrying out a metal-assisted chemical etching of the silicon by exposing the partially covered silicon surface to an etching composition, wherein at least some of the elemental metal for the metal-assisted chemical etching is formed by either: (a) exposing the silicon surface to a composition comprising metal ions, wherein the elemental metal forms by reduction of the metal ions and wherein the composition comprising metal ions is substantially free of HF, or (b) depositing the elemental metal directly onto the silicon surface.

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2013/050742

A. CLASSIFICATION OF SUBJECT MATTER
INV. C23C18/00 C09K13/08 H01L21/00 C23C14/00
ADD.

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)
C23C C09K H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	XUEWEN GENG ET AL: "Metal-Assisted Chemical Etching Using Tollen's Reagent to Deposit Silver Nanoparticle Catalysts for Fabrication of Quasi-ordered Silicon Micro/Nanostructures", JOURNAL OF ELECTRONIC MATERIALS, SPRINGER US, BOSTON, vol. 40, no. 12, 29 September 2011 (2011-09-29), pages 2480-2485, XP019971131, ISSN: 1543-186X, DOI: 10.1007/S11664-011-1771-1 abstract ----- -/-	1-4,6-32



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

12 July 2013

Date of mailing of the international search report

11/11/2013

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB2013/050742

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.: 1, 24-26(all partially)
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:
see FURTHER INFORMATION sheet PCT/ISA/210
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 additional 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 an 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.:
2-4(completely); 1, 6-32(partially)

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.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 2-4(completely); 1, 6-32(partially)

A method of etching silicon comprising the steps of: (i) partially covering a silicon surface with a metal and then (ii) carrying out a metal-assisted chemical etching of the silicon by exposing the partially covered silicon surface to an etching composition. The metal for the metal-assisted chemical etching is formed by exposing the silicon surface to a composition comprising metal ions, wherein the elemental metal forms by reduction of the metal ions and wherein the composition comprising metal ions is substantially free of HF. Etched silicon.

2. claims: 5(completely); 1, 6-23, 25-32(partially)

A method of etching silicon comprising the steps of: (i) partially covering a silicon surface with a metal and then (ii) carrying out a metal-assisted chemical etching of the silicon by exposing the partially covered silicon surface to an etching composition. The metal for the metal-assisted chemical etching is formed by depositing the elemental metal directly onto the silicon surface. Etched silicon.

3. claims: 33, 34

An electrode comprising an active material of etched silicon.

4. claim: 35

A method of forming an electrode, by depositing onto the conductive current collector a slurry comprising etched silicon powder and at least one solvent, and evaporating the at least one solvent.

5. claims: 36, 37

A rechargeable metal ion battery comprising an anode, the anode comprising an electrode capable of inserting and releasing metal ions; a cathode formed from a metal-containing compound capable of releasing and reabsorbing the metal ions; and an electrolyte between the anode and the cathode.

6. claim: 38

A method of etching silicon by (i) electrolessly depositing

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

a first metal onto silicon at a surface of a material comprising silicon, wherein the electrolessly deposited first metal partially covers the silicon surface and wherein the first metal is deposited from a composition comprising ions of the metal, the composition being substantially free of HF, optionally substantially free of fluoride ions; (ii) depositing a second metal over the silicon surface and the electrolessly deposited first metal, wherein a film of the deposited second metal covers substantially all of the surface of the silicon surface; (iii) removing the first metal, and the second metal from regions of the film of the deposited second metal that overlie the first metal to leave the second metal partially covering the surface of the silicon to be etched; and (iv) etching the silicon by exposing the silicon surface to an etching composition.

7. claim: 39

A method of etching silicon of a material comprising silicon, the method comprising the steps of partially covering a silicon surface of the material comprising silicon with an elemental metal and then carrying out a metal-assisted chemical etching of the silicon by exposing the partially covered silicon surface to an etching composition, wherein at least some of the elemental metal for the metal-assisted chemical etching is formed by exposing the silicon surface to a composition comprising metal ions, wherein the elemental metal forms by reduction of the metal ions and wherein the composition comprising metal ions comprises an aldehyde reducing agent and an alkali.

8. claim: 40

A method of etching silicon of a material comprising silicon, the method comprising the steps of partially covering a silicon surface of the material comprising silicon with an elemental metal and then carrying out a metal-assisted chemical etching of the silicon by exposing the partially covered silicon surface to an etching composition, wherein at least some of the elemental metal for the metal-assisted chemical etching is formed by exposing the silicon surface to a composition comprising metal ions, wherein the elemental metal forms by reduction of the metal ions and wherein the composition comprising metal ions comprises a metal citrate, a metal borohydride, a hydrazine or a metal hypophosphite.

9. claims: 41, 42

A method of etching silicon of a material comprising silicon, the method comprising the steps of partially

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

covering a silicon surface of the material comprising silicon with an elemental metal and then carrying out a metal-assisted chemical etching of the silicon by exposing the partially covered silicon surface to an etching composition, wherein at least some of the elemental metal for the metal-assisted chemical etching is formed by exposing the silicon surface to a composition comprising metal ions, wherein the elemental metal forms by reduction of the metal ions and wherein the composition comprising metal ions comprises an alcohol and a metal hydroxide.

10. claims: 43-49

A method of etching silicon of a material comprising silicon, the method comprising the steps of partially covering a silicon surface of the material comprising silicon with elemental metal and then carrying out a metal-assisted chemical etching of the silicon by exposing the partially covered silicon surface to an etching composition, wherein the elemental metal is formed by exposing the silicon surface to a first composition comprising metal ions to form a first portion of the elemental metal on the silicon surface by reduction of the metal ions of the first composition; removing the material from the first composition; and exposing the silicon surface to a second composition comprising metal ions to form a second portion of the elemental metal on the silicon surface by reduction of the metal ions of the second composition, wherein the second composition is different from the first composition.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.2

Claims Nos.: 1, 24-26(all partially)

Independent claim 1. Dependent claim 24. Lack of clarity. Art. 6 PCT.

The expression "substantially free of HF" employed in claim 1 is vague, rendering the type of claim unclear. It also leaves the reader in doubt as to the subject-matter for which protection is sought. As a consequence, claim 1 does not fulfil the requirements of Art. 6 PCT.

In the context of a chemical composition, the term "substantially" renders the concentration unclear. "Substantially free of HF" does not imply that the composition is HF-free and at the same time it implies that the presence of HF should be avoidable. There is no evidence in the description that would clarify the concentration range that would span such expression. Since there is also no generally accepted concentration range for the expression "substantially free of HF", it is necessary to discern whether the expression means that the composition is free of HF or not.

Nowhere in the description support was found for any of these two options, but in comparative example 1a. This example directly compares a method in which step (a) according to claim 1 is carried out in the presence of HF, with example 1, in which step (a) is carried out in the absence of HF. It is understood that comparative example 1a demonstrates that the presence of HF in step (a) is undesirable.

For all the reasons stated above, claim 1 is not in compliance with the provisions of clarity within the meaning of Article 6 PCT. Based on these reasons, the search has been restricted to methods according to claim 1 in which the composition is free of HF.

The same arguments apply mutatis mutandis to the subject-matter of claim 24. Based on these reasons, the search has been restricted to methods according to claim 24 in which the composition is free of fluoride ions.

Dependent claim 25. Lack of clarity. Art. 6 PCT.

Claim 25 depends from claim 1 and implies that the surface is treated with a plurality of compositions comprising metal ions but does not impose any restrictions regarding their chemical nature. As explained above, claim 1 has been interpreted as relating to that step as a HF-free step. This restriction must apply to all compositions employed in step (a).

Therefore, the search has been restricted to methods according to claim 25 in accordance to claim 1, where the compositions are free of HF.

Dependent claim 26. Lack of clarity. Art. 6 PCT.

Claim 26 depends from claim 25 and suggests that HF could optionally be one of the components. However, as explained above, claim 1 has been interpreted as being free of HF. Thus, this facultative feature is considered as contradictory with the subject-matter of claim 1.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Therefore, the search has been restricted to methods according to claim 26 in which the compositions are free of HF.

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guidelines C-IV, 7.2), should the problems which led to the Article 17(2) declaration be overcome.

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2013/050742

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2007 194485 A (UNIV OSAKA; KANSAI TLO KK) 2 August 2007 (2007-08-02) claims 1-4 paragraph [0009] example all -----	1-4,6-32
X	US 2008/090074 A1 (MATSUMURA MICHIO [JP] ET AL) 17 April 2008 (2008-04-17) example 1 -----	1-4,6-32
X,P	EP 2 439 766 A1 (WAKOM SEMICONDUCTOR CORP [TW]) 11 April 2012 (2012-04-11) the whole document -----	1-4,6-32
A	HUANG Z ET AL: "Metal-Assisted Chemical Etching of Silicon: A Review", ADVANCED MATERIALS, WILEY VCH VERLAG, DE, vol. 23, no. 2, 11 January 2011 (2011-01-11), pages 285-308, XP002667196, ISSN: 0935-9648, DOI: 10.1002/ADMA.201001784 [retrieved on 2010-09-21] the whole document -----	1-32

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/GB2013/050742

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JP 2007194485	A	02-08-2007	NONE

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