

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
31 May 2007 (31.05.2007)

PCT

(10) International Publication Number
WO 2007/061945 A3

(51) International Patent Classification:

H01M 4/86 (2006.01) *H01M 4/88* (2006.01)
H01M 4/92 (2006.01) *H01M 8/10* (2006.01)

(21) International Application Number:

PCT/US2006/044883

(22) International Filing Date:

20 November 2006 (20.11.2006)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

60/738,100 21 November 2005 (21.11.2005) US
60/801,377 19 May 2006 (19.05.2006) US

(71) Applicant (*for all designated States except US*):
NANOSYS, INC. [US/US]; 2625 HANOVER STREET,
Palo Alto, CA 94304 (US).

(72) Inventor; and

(75) Inventor/Applicant (*for US only*): NIU, Chunming
[US/US]; 450 LOMA VERDE AVENUE, Palo Alto, CA
94306 (US).

(74) Agents: FEATHERSTONE, DONALD J. et al.;
STERNE, KESSLER, GOLDSTEIN & FOX P.L.L.C.,
1100 NEW YORK AVENUE, N.W., Washington, DC
20005 (US).

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, 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, LV, LY, MA, MD, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, 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, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declaration under Rule 4.17:

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

— *with international search report*

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

30 April 2009

(15) Information about Correction:

Previous Correction:

see Notice of 12 July 2007

(54) Title: NANOWIRE STRUCTURES COMPRISING CARBON

(57) Abstract: The present invention is directed to nanowire structures and interconnected nanowire networks comprising such structures, as well as methods for their production. The nanowire structures comprise a nanowire core, a carbon-based layer, and in additional embodiments, carbon-based structures such as nanographitic plates consisting of graphenes formed on the nanowire cores, interconnecting the nanowire structures in the networks. The networks are porous structures that can be formed into membranes or particles. The nanowire structures and the networks formed using them are useful in catalyst and electrode applications, including fuel cells, as well as field emission devices, support substrates and chromatographic applications.



WO 2007/061945 A3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2006/044883

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. *H01M 4/86* (2006.01) *H01M 4/92* (2006.01) *H01M 4/88* (2006.01) *H01M 8/10* (2006.01)

US Cl. 252/182.1; 429/30

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)

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)

DWPI; USPTO; ESPACE; GOOGLE PATENTS: NANOWIRE, CARBON, CORE, SEMICONDUCTOR, CARBIDE, FUEL CELL, CATALYST FUEL CELL, CATALYST

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y Y	US 2005/0221072 A1 (DUBROW ET AL) 06 October 2005 Paragraphs 0186, 0188, 0008 - 0010, 0215, 0216	1-15, 17-21 23, 99 121-125
X Y	US 2005/0181209 A1 (KARANDIKAR) 18 August 2005 Abstract, paragraphs 20-32, 41, lines 10-16 of paragraph 56, claim 15	1-15, 17-21, 26-31, 33-36 23, 99, 121-125
X Y Y	US 2005/0238810 A1 (SCARINGE ET AL) 27 October 2005 Lines 7-10 of paragraph 1; paragraphs 4, 14, 15, 49, 50 and claims 10-14. Paragraph 64, paragraph 14, lines 16-20 Paragraph 15	1-3, 7-9, 14, 26-29 23, 99 121-125
X	US 2003/0044608 A1 (YOSHIZAWA ET AL) 06 March 2003 Paragraph 25, 26, 35, 38, 113, lines 1-6 of paragraph 114, line 8 of paragraph 145, claim 6	1-4, 7-9, 14, 26-28

☒ Further documents are listed in the continuation of Box C☒ See patent family annex

* Special categories of cited documents:	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	"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
"E" earlier application or patent but published on or after the international filing date	"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
"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)	"&" document member of the same patent family
"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	

Date of the actual completion of the international search
22 August 2007

Date of mailing of the international search report

19 MAR 2008

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:

Blaine R. Copenheaver

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

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2006/044883

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6361861 B2 (GAO ET AL) 26 March 2002 Abstract, column 2, lines 33-35; column 3, line 54- column 4, lines 43; claim 4	1-3, 7-10, 26-28
X	US 5916642 A (CHANG) 29 June 1999 Abstract, column 1, lines 58-64	1-5
Y	US 6504292 B1 (CHOI ET AL) 07 January 2003 Column 6, lines 32 – column 7, line 3	121-125

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2006/044883

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:

Group I: Claims 1-50, 99-100, 115-126, 153-178

Group II: Claims 51-69, 71-73, 76, 82-97, 101-114, 127-152

Group III: Claims 70, 74, 75, 77-81

Group IV: Claim 98

(For details please see supplemental Box I)

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.:
1-50, 99-100, 115-126, 153-178

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.

Supplemental Box I

(To be used when the space in any of Boxes I to VIII is not sufficient)

Continuation of Box No: III (Lack of Unity)

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

In assessing whether there is more than one invention claimed, I have given consideration to those features which can be considered to potentially distinguish the claimed combination of features from the prior art. Where different claims have different distinguishing features they define different inventions.

This International Searching Authority has found that there are different inventions as follows:

- Claims 1-50, 99-100, 115-126, 153-178 are directed to a nanowire comprising a carbon-based layer. It is considered that the "carbon based layer" comprises a first distinguishing feature.
- Claims 51-69, 71-73, 76, 82-97, 101-114, 127-152 are directed to nanowires associated with a metal catalyst. It is considered that the "association of a metal catalyst with the nanowires" comprises a second distinguishing feature.
- Claims 70, 74, 75, 77-81 are directed to a membrane electrode assembly, comprising a proton exchange membrane, an anode electrode, and a cathode electrode, wherein at least one or more of the anode electrodes and cathode electrodes comprise an interconnected network of nanowires. It is considered that "at least one or more of the anode electrodes and cathode electrodes comprise an interconnected network of nanowires" comprises a third distinguishing feature.
- Claim 98 is directed to a bipolar plate for a fuel cell comprising a plurality of inorganic nanowires deposited thereon. It is considered that "a bipolar plate for a fuel cell comprising a plurality of inorganic nanowires deposited thereon" comprises a fourth distinguishing feature.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

Each of the abovementioned groups of claims has a different distinguishing feature and they do not share any feature which could satisfy the requirement for being a special technical feature. Because there is no common special technical feature it follows that there is no technical relationship between the identified inventions. Therefore the claims do not satisfy the requirement of unity of invention *a priori*.

Information on patent family members

PCT/US2006/044883

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. These particulars are merely given for the purpose of information.

Patent Document Cited in Search Report				Patent Family Member			
US	2005/0221072	AU	2004233002	CA	2522678	EP	1617769
		JP	2006526059	WO	2004094303		
US	2005/0181209	WO	2006080936				
US	2005/0238810	US	2006233692				
US	2003/0044608	CN	1406865	JP	2003081621		
US	6361861	AU	78244/00	US	7011771	US	2002004136
		US	2002055010	WO	0076912		
US	5916642	WO	9719208				
US	6504292	EP	1069588	JP	2001096499		