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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: CONTROLLED NANOTUBE FABRICATION AND USES

(57) Abstract: A method and apparatus are provided for the formation of nanotubes and nanotube related structures. Nanotubes, such as carbon nanotubes, can be prepared to exhibit various physical, chemical and electrical properties.



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INTERNATIONAL SEARCH REPORT

International Application No

PCT/US2004/025878

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C01B31/02 C30B25/04 C01B21/064 C01G39/06 C01G41/00
C01G15/00

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 7 C01B C30B C01G

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 practical, search terms used)

EP0-Internal, WPI Data, PAJ, INSPEC, COMPENDEX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	YA PRINZ V ET AL: "A new technique for fabricating three-dimensional micro- and nanostructures of various shapes" NANOTECHNOLOGY IOP PUBLISHING UK, vol. 12, no. 4, 2001, pages 399-402, XP002308494 ISSN: 0957-4484 the whole document	1-26, 32-37,44
X	SCHMIDT O G ET AL: "THIN SOLID FILMS ROLL UP INTO NANOTUBES" NATURE, MACMILLAN JOURNALS LTD. LONDON, GB, vol. 410, no. 168, 8 March 2001 (2001-03-08), page 168, XP001148344 ISSN: 0028-0836 the whole document	1,32-36
A	----- -/--	2-31,37

☒ Further documents are listed in the continuation of box C.☐ Patent family members are listed in 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 document 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.

"Z" document member of the same patent family

Date of the actual completion of the international search

3 December 2004

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INTERNATIONAL SEARCH REPORT

International Application No

PCT/US2004/025878

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GOLOD S V ET AL: "FABRICATION OF CONDUCTING GESI/SI MICRO- AND NANOTUBES AND HELICAL MICROCOILS" SEMICONDUCTOR SCIENCE AND TECHNOLOGY, INSTITUTE OF PHYSICS. LONDON, GB, vol. 16, no. 3, March 2001 (2001-03), pages 181-185, XP001030220 ISSN: 0268-1242 the whole document	1,31-37
X	----- YAO B D ET AL: "Formation mechanism of TiO2 nanotubes" APPLIED PHYSICS LETTERS, AMERICAN INSTITUTE OF PHYSICS. NEW YORK, US, vol. 82, no. 2, 13 January 2003 (2003-01-13), pages 281-283, XP012034089 ISSN: 0003-6951	1,32-35
A	the whole document	2-31,36,37
X	----- PRINZ A V ET AL: "Semiconductor micro- and nanoneedles for microinjections and ink-jet printing" MICROELECTRONIC ENGINEERING, ELSEVIER PUBLISHERS BV., AMSTERDAM, NL, vol. 67-68, June 2003 (2003-06), pages 782-788, XP004428950 ISSN: 0167-9317 the whole document	1,31-37
X	----- IIJIMA S: "Growth of carbon nanotubes" MATERIALS SCIENCE & ENGINEERING B (SOLID-STATE MATERIALS FOR ADVANCED TECHNOLOGY) SWITZERLAND, vol. B19, no. 1-2, 1993, pages 172-180, XP002308495 ISSN: 0921-5107 "Bill-like capping" figures 6,11	27-31
X,P	----- PRINZ V Y: "A new concept in fabricating building blocks for nanoelectronic and nanomechanic devices" MICROELECTRONIC ENGINEERING, ELSEVIER PUBLISHERS BV., AMSTERDAM, NL, vol. 69, no. 2-4, September 2003 (2003-09), pages 466-475, XP004456697 ISSN: 0167-9317 the whole document	1-26,32-37,44
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INTERNATIONAL SEARCH REPORT

International Application No

PCT/US2004/025878

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	POKROPIVNY A V ET AL: "Dislocation mechanism of nanotube formation" TECHNICAL PHYSICS LETTERS RUSSIA, June 2003 (2003-06), pages 494-495, XP002308493 ISSN: 1063-7850 the whole document -----	1-37

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2004/025878

Box 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.: **1-37 (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 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 fee, this Authority did not invite payment of any additional fee.

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.:
1-37, 44

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ 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: 1-37,44

A method for producing nanotubes comprising forming two molecular structure and joining them. A nanotube comprising two cylindrical portions and a circuit comprising a pattern of nanotubes comprising two portions exhibiting different longitudinal orientation and conductance.

2. claims: 38-43

A method comprising imprinting a crystal lattice onto a substrate, epitaxially forming a molecular layer on the pattern and removing the molecular layer from the pattern.

3. claims: 45-50

A method of making a circuit comprising forming a pattern on a substrate, producing a crystalline molecular layer on it and forming a circuit from the molecular layer.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.2

Claims Nos.: 1-37 (partially)

In view of the wording of the claims presently on file, which render it difficult, if not impossible, to determine the matter for which protection is sought, the present application fails to comply with the clarity requirements of Article 6 PCT (see also Rule 6.1(a) PCT) to such an extent that a complete meaningful search is impossible. An inadequate disclosure is exhibited by all independent method claims 1, 2, 16, 32 and 36. Furthermore, the presence of so many independent claims in the same category gives rise also to a lack of conciseness. Consequently, the search has been carried out for those parts of the application which do appear to be clear, namely to a method for making a nanotube comprising depositing two molecular layers on a substrate and by annealing them (page 5, lines 24-30 and page 11, lines 18-26). The starting molecular layers can optionally be branched and bring to branched nanotubes.

The product disclosed in claim 27 was interpreted as a nanotube exhibiting a junction between two cylindrical portions with different molecular structure and electrical characteristics.

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 Guideline C-VI, 8.5), should the problems which led to the Article 17(2) declaration be overcome.