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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: PHYSICAL VAPOR DEPOSITION OF TITANIUM-BASED FILMS

(57) Abstract: High density oxide films are deposited by a pulsed-DC, biased reactive sputtering process from a titanium containing target to form high quality titanium containing oxide films. A method of forming a titanium based layer or film according to the present invention includes depositing a layer of titanium containing oxide by pulsed-DC, biased reactive sputtering process on a substrate. In some embodiments, the layer is TiO₂. In some embodiments, the layer is a sub-oxide of Titanium. In some embodiments, the layer is Ti_xO_y, wherein x is between about 1 and about 4 and y is between about 1 and about 7. In some embodiments, the layer can be doped with one or more rare-earth ions. Such layers are useful in energy and charge storage, and energy conversion technologies.



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INTERNATIONAL SEARCH REPORT

International Application No
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A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C23C14/14 C23C14/08 C23C14/34 H01L21/316

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 C23C

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)

EPO-Internal, PAJ, INSPEC, CHEM ABS Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2003/077914 A1 (LE HIEN-MINH HUU ET AL) 24 April 2003 (2003-04-24) paragraphs '0064!, '0071!, '0072!, '0074!; claim 1 -----	1-3,11, 12,23, 32,38, 42-44, 52,64, 65,79,80
X	EP 1 068 899 A (NIPPON SHEET GLASS CO., LTD) 17 January 2001 (2001-01-17)	42,43, 61,62, 64,79, 80,82
Y	claim 6; example 1 ----- -/--	83-87

☒ 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.

* & * document member of the same patent family

Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US2004/014524

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 5 942 089 A (SPROUL ET AL) 24 August 1999 (1999-08-24) claims 1,5,6; table	1-3,23, 24,38, 39, 42-44, 64,65,79
X	KIM J-Y ET AL: "Frequency-dependent pulsed direct current magnetron sputtering of titanium oxide films" JOURNAL OF VACUUM SCIENCE AND TECHNOLOGY A. VACUUM, SURFACES AND FILMS, AMERICAN INSTITUTE OF PHYSICS, NEW YORK, NY, US, vol. 19, no. 2, March 2001 (2001-03), pages 429-434, XP012005484 ISSN: 0734-2101 cited in the application sections II, III.A; Table I	1-4,23, 38,39, 42-45, 64,65, 67,79,82
X	PATENT ABSTRACTS OF JAPAN vol. 1996, no. 01, 31 January 1996 (1996-01-31) & JP 07 233469 A (ASAHI GLASS CO LTD), 5 September 1995 (1995-09-05)	42,43, 46,64,68
A	abstract	83-87
X	US 2001/041460 A1 (WIGGINS CLAIRE LOUISE) 15 November 2001 (2001-11-15) paragraph '0007!; claims 1,3,4,6	1,2,4
Y	US 3 309 302 A (HEIL OSKAR) 14 March 1967 (1967-03-14) column 2, lines 38-41	83-87

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2004/014524

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.:
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 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.:

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: 1-82

Methods of deposition and resulting layers all involving the feature of pulsed DC, biased reactive sputtering of titanium containing oxides.

2. claims: 83-87

Targets characterised by a particular composition, i.e. TiO, and by the manufacturing method involving hot isostatic pressing.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US2004/014524

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
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