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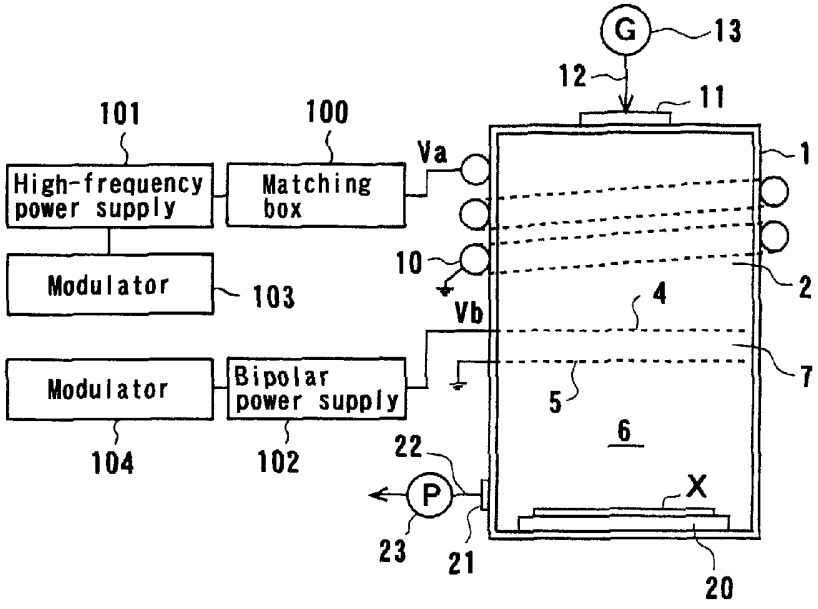
[Continued on next page]

(54) Title: METHOD OF PROCESSING A SURFACE OF A WORKPIECE



(57) Abstract: A plasma generator generates positive ions and negative ions in a plasma. An ion extracting portion (4, 5) selectively extracts the generated positive ions and negative ions from the plasma, and accelerates the extracted ions in a predetermined direction. The positive ions and the negative ions are selectively applied to the workpiece (X). The plasma generator applies a high-frequency voltage to a process gas in a vacuum chamber for generating a plasma which is composed of positive ions and electrons from the process gas, and interrupts the high-frequency voltage for attaching the electrons to the residual process gas to generate negative ions. The application of the high-frequency voltage and the interruption of the high-frequency voltage are alternately repeated.

WO 02/078044 A3

European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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INTERNATIONAL SEARCH REPORT

Inter ıal Application No
PCT/JP 02/02751

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01J37/08 H01J27/02 H01L21/311

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 H01J G21K 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 practical, search terms used)
EPO-Internal, WPI Data, PAJ, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 250 009 A (CUOMO JEROME J ET AL) 10 February 1981 (1981-02-10) abstract; figure 1 column 1, line 53 -column 3, line 44	1,4,8
X	PATENT ABSTRACTS OF JAPAN vol. 014, no. 299 (C-0733), 27 June 1990 (1990-06-27) & JP 02 097664 A (RES DEV CORP OF JAPAN), 10 April 1990 (1990-04-10) abstract; figures	1,4,5,8, 9
X	US 5 827 435 A (SAMUKAWA SEIJI) 27 October 1998 (1998-10-27) abstract	1-4,8
Y	column 4, line 63 -column 8, line 4; figures 3-11	6,7,10, 11,14, 15,18,19

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[X] Further documents are listed in the continuation of box C.

[X] 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)

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"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	Date of mailing of the international search report
18 October 2002	31. 10. 02

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Lang, T

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
Y	PATENT ABSTRACTS OF JAPAN vol. 2000, no. 07, 29 September 2000 (2000-09-29) & JP 2000 100790 A (CANON INC), 7 April 2000 (2000-04-07) abstract & US 6 217 703 A (CANON INC) 17 April 2001 (2001-04-17) column 6, line 50 -column 8, line 34	6,7,10, 11,14, 15,18,19
X	US 5 928 528 A (HAYASHI SHIGENORI ET AL) 27 July 1999 (1999-07-27) abstract column 8, line 59 -column 10, line 2; figures 6-8 column 5, line 32 -column 8, line 75; figures 1-5	1,2,4,6, 8,10
X	KANAKASABAPATHY S K ET AL: "ALTERNATING FLUXES OF POSITIVE AND NEGATIVE IONS FROM AN ION-ION PLASMA" APPLIED PHYSICS LETTERS, AMERICAN INSTITUTE OF PHYSICS. NEW YORK, US, vol. 78, no. 1, 1 January 2001 (2001-01-01), pages 22-24, XP000994391 ISSN: 0003-6951 abstract; figures 1-3 page 22	1,2,4,8
X	EP 0 340 998 A (XEROX CORP) 8 November 1989 (1989-11-08) abstract; figures 1,2 column 4, line 49 -column 5, line 59	1,4,8
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X	US 4 158 589 A (KELLER JOHN H ET AL) 19 June 1979 (1979-06-19) abstract; claims 1,3; figures 1,2	8,9
X	WO 01 06534 A (HATAKEYAMA MASAHIRO ;EBARA CORP (JP); SATAKE TOHRU (JP); WATANABE) 25 January 2001 (2001-01-25) abstract; figures 1,2,8 & EP 1 220 272 A (EBARA CORP (JP)) 3 July 2002 (2002-07-03) paragraphs '0015!-'0022!,'0029!-'0032!	1,3-19

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	WO 97 16946 A (ARAKHNE TECHNOLOGY INC) 9 May 1997 (1997-05-09) page 50, line 6 -page 56, line 27; figures 18A-18C	12,16
X	PATENT ABSTRACTS OF JAPAN vol. 1998, no. 08, 30 June 1998 (1998-06-30) & JP 10 083899 A (EBARA CORP), 31 March 1998 (1998-03-31) abstract; figures 1-3	16,17
X	US 5 818 040 A (KINOSHITA KEIZO ET AL) 6 October 1998 (1998-10-06) abstract; figures 2,4 column 4, line 66 -column 8, line 30	16

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP 02/02751

Box I Observations where certain claims were found unsearchable (Continuation of item 1 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 II Observations where unity of invention is lacking (Continuation of item 2 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, 2, 4-11

A method of processing a surface of a workpiece, comprising generating positive ions and negative ions in a plasma, selectively extracting the generated positive ions and negative ions from said plasma, and accelerating the extracted ions in a predetermined direction; and selectively applying said positive ions and said negative ions, to said workpiece; wherein

- said generating comprises applying a high-frequency voltage to a process gas in a vacuum chamber for generating a plasma which is composed of positive ions and electrons from said process gas; interrupting said high-frequency voltage for attaching said electrons to the residual process gas to generate negative ions; and repeating the application of said high-frequency voltage and the interruption of said high-frequency voltage. (Claim 2)

1.1. Claims: 5,9
Said ions are applied while the workpiece is shielded from a radiation produced by the plasma

1.2. Claims: 6,10
Said ions are applied to a semiconductor device for forming a gate dielectric film thereon

1.3. Claims: 7,11
Said ions are applied to an organic material for etching said material

2. Claim : 3

A method of processing a surface of a workpiece, comprising generating positive ions and negative ions in a plasma, selectively extracting the generated positive ions and negative ions from said plasma, and accelerating the extracted ions in a predetermined direction; and selectively applying said positive ions and said negative ions, to said workpiece; wherein

- said generating comprises generating a plasma composed of positive ions and electrons from a process gas, and attaching said electrons to the residual process gas at a downstream part of a plasma generated space

3. Claims: 12-19

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

A method of processing a surface of a workpiece, comprising generating positive ions and negative ions in a plasma, selectively extracting the generated negative ions, or positive ions and negative ions, from said plasma, and accelerating the extracted ions in a predetermined direction;

- neutralizing the accelerated ions to convert them into neutral particles, and applying said neutral particles to said workpiece.

Please note that all inventions mentioned under item 1, although not necessarily linked by a common inventive concept, could be searched without effort justifying an additional fee.

INTERNATIONAL SEARCH REPORT

Inte nal Application No
PCT/JP 02/02751

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