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(71) Applicant *(for all designated States except US)*: **VARIAN SEMICONDUCTOR EQUIPMENT ASSOCIATES, INC.** [US/US]; 35 Dory Road, Gloucester, MA 01930 (US).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **HATEM, Christopher** [US/US]; 1 Eleventh Street, Salisbury, MA 01952 (US). **RENAU, Anthony** [US/US]; 323 Main Street, West Newbury, MA 01985 (US). **WHITE, James, E.** [US/US]; 3 New Meadow Road, Topsfield, MA 01983 (US).

(74) Agent: **FABER, Scott, R.**; Varian Semiconductor Equipment Associates, Inc., 35 Dory Road, Gloucester, MA 01930-2297 (US).

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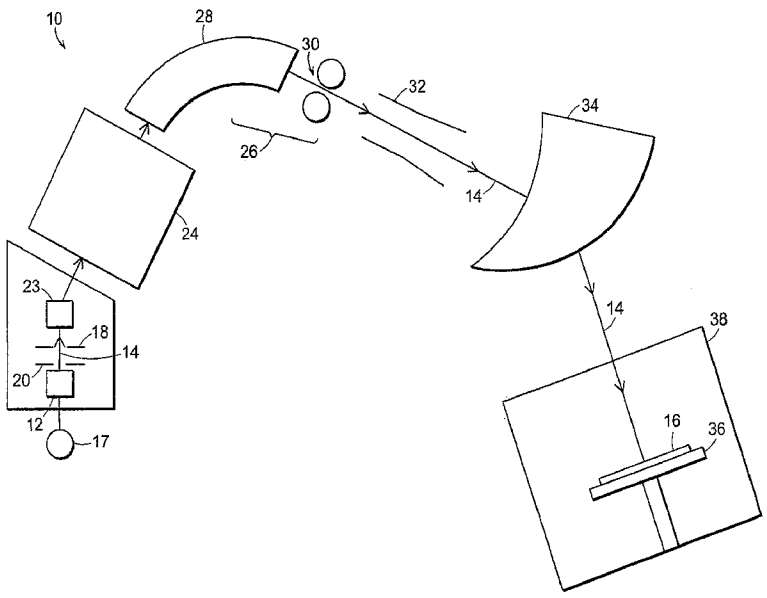
(54) Title: METHODS OF IMPLANTING IONS AND ION SOURCES USED FOR SAME



(57) Abstract: A method of implanting ions comprising generating $C_2B_{10}H_x$ ions from $C_2B_{10}H_{12}$ and implanting the $C_2B_{10}H_x$ ions in a material. In some embodiments, the molecular weight of the $C_2B_{10}H_x$ ions is greater than 100 amu. .In other embodiments, the molecular weight of the $C_2B_{10}H_x$ ions is approximately 132 to 144 amu or approximately 136 to 138 amu. An ion source is also disclosed comprising a chamber housing defining a chamber and a source feed gas supply configured to introduce $C_2B_{10}H_{12}$ into the chamber, wherein the ion source is configured to ionize the source feed gas within the chamber into $C_2B_{10}H_x$ ions.

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METHODS OF IMPLANTING IONS AND ION SOURCES USED FOR SAME

Cross Reference to Related Applications

This application is a continuation-in-part of U.S. Patent Application Ser. No. 11/342,183, titled "Methods of Implanting Ions and Ion Sources Used for the Same" filed January 28, 2006.

Field of Invention

The invention relates generally to ion implantation and, more particularly, to ion sources that use a boron-based source feed gas and methods associated with the same.

Background of Invention

Ion implantation is a conventional technique for introducing dopants into materials such as semiconductor wafers. Dopants may be implanted in a material to form regions of desired conductivity. Such implanted regions can form active regions in resulting devices (e.g., semiconductor devices). Typically, during ion implantation, a source feed gas is ionized in an ion source. The ions are emitted from the source and may be accelerated to a selected energy to form an ion beam. The beam is directed at a surface of the material and the impinging ions penetrate into the bulk of the material and function as dopants that increase the conductivity of the material.

Conventional ion sources may have limitations under certain implantation conditions. For example, conventional ion sources may operate inefficiently at low extraction energies and/or low beam currents which may be used in implantation processes that form implanted regions having ultra-shallow junction depths. As a result, long implant times may be needed to achieve a desired implantation dose and, thus, throughput is adversely affected.

Summary of Invention

Ion implantation methods and ion sources used for the same are provided.

In one aspect, a method of implanting ions is provided. The method comprises generating $C_2B_{10}H_x$ ions from $C_2B_{10}H_{12}$ and implanting the $C_2B_{10}H_x$ ions in a material.

In another aspect, an ion source is provided. The ion source comprises a chamber housing defining a chamber and a source feed gas supply configured to introduce $C_2B_{10}H_{12}$ into the chamber, wherein the ion source is configured to ionize the source feed gas within the chamber into $C_2B_{10}H_x$ ions.

Other aspects, embodiments and features of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings. The accompanying figures are schematic and are not intended to be drawn to scale. In the figures, each identical, or substantially similar component that is illustrated in various figures is represented by a single numeral or notation. For purposes of clarity, not every component is labeled in every figure. Nor is every component of each embodiment of the invention shown where illustration is not necessary to allow those of ordinary skill in the art to understand the invention. All patent applications and patents incorporated herein by reference are incorporated by reference in their entirety. In case of conflict, the present specification, including definitions, will control.

Brief Description of the Drawings

FIG. 1 illustrates an ion implantation system according to an embodiment of the invention.

FIG. 2 illustrates an ion source according to an embodiment in the invention.

FIG. 3 is a plot of optimal mass spectrum for carborane for use in ion implantation.

Detailed Description

Methods of ion implantation and ion sources used for the same are provided. The methods involve generating ions from a source feed gas that comprises multiple elements. For example, the source feed gas may comprise boron and at least two other elements. As described further below, the use of such source feed gases can lead to a number of advantages over certain conventional processes including enabling use of higher implant energies and beam currents when forming implanted regions having ultra-shallow junction depths. Also, in certain embodiments, the composition of the source feed gas may be selected to be thermally stable at relatively high temperatures (e.g., greater than 350 °C)

which allows use of such gases in many conventional ion sources (e.g., indirectly heated cathode, Bernas) which generate such temperatures.

FIG. 1 illustrates an ion implantation system 10 according to an embodiment of the invention. The system includes an ion beam source 12 that generates an ion beam 14 which is transported through the system and impinges upon a wafer 16. The ion beam source includes a source feed gas supply 17. The source feed gas supply may generate the source feed gas from a source feed material, as described further below. Source feed gas from the supply is introduced into the ion beam source and is ionized to generate ionic species. As described further below, the source feed gas may comprise boron and at least two other elements (e.g., $X_aB_bY_c$) according to certain embodiments of the invention. In the illustrative embodiment shown in FIG. 1, an extraction electrode 18 is associated with the ion beam source for extracting the ion beam from the source. A suppression electrode 20 may also be associated with the ion source.

The implantation system further includes a source filter 23 which removes undesired species from the beam. Downstream of the source filter, the system includes an acceleration/deceleration column 24 in which the ions in the beam are accelerated/decelerated to a desired energy, and a mass analyzer 26 which can remove energy and mass contaminants from the ion beam through use of a dipole analyzing magnet 28 and a resolving aperture 30. A scanner 32 may be positioned downstream of the mass analyzer and is designed to scan the ion beam across the wafer. The system includes an angle corrector magnet 34 to deflect ions to produce a scanned beam having parallel ion trajectories.

During implantation, the scanned beam impinges upon the surface of the wafer which is supported on a platen 36 within a process chamber 38. In general, the entire path traversed by the ion beam is under vacuum during implantation. The implantation process is continued until regions having the desired dopant concentration and junction depth are formed with the wafer.

It should be understood that features of the invention may be used in conjunction with any suitable ion implantation system or method. Accordingly, the system illustrated in FIG. 1 may include modifications. In some cases, the system may include additional components than those illustrated. In other cases, systems may not include all of the

illustrated components. Suitable systems include implanters having a ribbon beam architecture, a scanned-beam architecture or a spot beam architecture (e.g., systems in which the ion beam is static and the wafer is scanned across the static beam). For example, suitable implanters have been described in U.S. Patent Nos. 4,922,106, 5,350,926 and 6,313,475.

Though in some embodiments, it may be preferred to use ion sources of the invention in methods that form ultra-shallow junction depths (e.g., less than 25 nanometers), it should be understood that the invention is not limited in this regard. It should also be understood that the systems and methods may be used to implant ions in a variety of materials including, but not limited to, semiconductor materials (e.g., silicon, silicon-on-insulator, silicon germanium, III-V compounds, silicon carbide), as well as other material such as insulators (e.g., silicon dioxide) and polymer materials, amongst others.

As described above, source feed gas supply 17 introduces a source feed gas into the ion beam source. The source feed gas may comprise boron and at least two additional elements (i.e., elements that are different than boron and each other). In general, the additional (i.e., non-boron) elements of the source gas may be any suitable element including carbon, hydrogen, nitrogen, phosphorous, arsenic, antimony, silicon, tin, and germanium, amongst others. In some embodiments, it may be preferred that the source gas comprise boron, hydrogen and carbon. It should be understood that the source gas may also include more than two additional elements.

In general, the source feed gas may have any suitable chemical structure and the invention is not limited in this regard. For example, the source feed gas may be represented by the general formula XBY, wherein B represents boron, and X and Y each represent at least one different element. In some cases, X and/or Y may represent single elements (e.g., X = C, Y = H); and, in other cases, X and/or Y may represent more than one element (e.g., X = NH_4, NH_3, CH_3). Also, it should be understood that the source feed gas XBY may be represented by other equivalent chemical formulas that, for example, may include the same elements in a different order such as BXY (e.g., $B_3N_3H_6$) or XYB. In some embodiments, the source feed gas may be represented by the $X_aB_bY_c$, wherein $a > 0$, $b > 0$ and $c > 0$. It should be understood that in each chemical formula herein, a, b and c are greater than zero.

In some cases, it may be preferred that Y in the above-noted formulas represents at least hydrogen (e.g., the source feed gas comprises $X_aB_bH_c$). It should be understood that, in some embodiments, derivatives of $X_aB_bH_c$ may be used which contain other elements or groups of elements (e.g., CH_3) which replace hydrogen at X and/or B sites. The substituents may be any suitable inorganic or organic species.

In some cases, it may be preferred that X in the above-noted formulas represents at least carbon (e.g., the source feed gas comprises $C_aB_bH_c$). It should be understood that, in some embodiments, derivatives of $C_aB_bH_c$ may be used which contain other elements or groups of elements which replace hydrogen at C and/or B sites). The substituents may be any suitable inorganic or organic species. In some cases, it may be preferred that the source feed gas comprise $C_2B_{10}H_{12}$.

In other embodiments, X in the above-noted formulas may be one or more of N, P, As, Sb, Si, Ge or Sn. For example, the source feed gas may comprise $N_aB_bY_c$ (e.g., $N_aB_{10}H_{12}$ or $B_3N_3H_6$), $N_aB_bH_c$, $P_aB_bH_c$, $As_aB_bH_c$, $Sb_aB_bH_c$, $Si_aB_bH_c$, $Ge_aB_bH_c$ and $Sn_aB_bH_c$. It should be understood that, in some embodiments, other elements or groups of elements may replace hydrogen at the X and/or B sites.

X and Y are typically selected so as not to introduce species that impart overly undesirable properties to the material which, for example, impair device performance. Such species may include sodium, iron and gold, amongst others.

The source feed gas may be ionized to form a variety of different ion species. The ion species may include the same, or similar, boron content as the source feed gas. The ion species may also include the additional elements present in the source feed gas. For example, a source feed gas comprising $X_aB_bY_c$ (e.g., $X_aB_bH_c$) may be ionized to form ion species comprising $X_aB_bY_c^{-1}$ (e.g., $X_aB_bH_c^{-1}$) or $X_aB_bY_c^{+1}$ (e.g., $X_aB_bH_c^{+1}$). When the source feed gas comprises $C_2B_{10}H_{12}$, some ionic species produced include, for example, $(C_2B_{10}H_{12})^+$ or $(C_2B_{10}H_{12})^-$. Some other ionic species of $C_2B_{10}H_{12}$ may include species derived from $C_2B_{10}H_{12}$, such as, for example, $(C_2B_{10}H_5)^+$. It should also be understood that the ion species may include boron and only one of the elements (e.g., Y). In some embodiments, systems of the invention include mechanisms for selecting desired ionic species from those produced for the ion beam and subsequent implantation.

It may be preferred that the source feed gas has a relatively high molecular weight which can lead to formation of ions also having relatively high molecular weight(s). For example, it may be possible to produce ions having the desired molecular weight by appropriately selecting the ionization conditions. The implant depth of an ion depends on the implantation energy and its molecular weight. Increasing the molecular weight of an ion allows use of higher implant energies to achieve the same implant depth. Thus, using source feed gases having a relatively high molecular weight can enable formation of ultra-shallow junction depths (e.g., less than 25 nm) at implant energies sufficiently high to allow operation at desirable efficiency levels. For example, when ionic species comprising $(C_2B_{10}H_{11})^+$ are implanted, a relatively high implant energy (e.g., 14.5 keV) may be used. In this embodiment, the equivalent boron implant energy is about 1 keV (for the case when all of the boron atoms are present as ^{11}B so that $(C_2B_{10}H_{11})^+$ has a weight of 145 amu). In some cases, it is preferred to use equivalent boron implant energies of less than 5 keV; and, in some cases, equivalent boron implant energies of less than 1 keV.

Molecular weight of the source feed gas (and the ionic species which are implanted) is determined by the number and type of atoms in the composition. In some cases, it is preferable for b in the above-noted formulas to be greater than 2; or, more preferably, greater than 8. In some cases, it is preferable for c in the above-noted formulas to be greater than 2; or, more preferably, greater than 8. In some embodiments, it is preferred for the molecular weight of the source feed gas (and the ionic species which are implanted) to be greater than 50 amu; or, in some cases, greater than 100 amu (e.g., about 120 amu).

It should be understood that the above-noted source feed gas compositions may be present in different isomeric forms. That is, the gases may have the same chemical formula, while having a different chemical structure. For example, the source feed gas comprising $C_2B_{10}H_{12}$ may be present as ortho-, meta-, or para-carborane forms. It should also be understood that the source feed gas may be present in different derivative forms.

Also, it should be understood that boron (or any other element) may be present in the source feed gas in any suitable isotope form including the naturally occurring form (e.g., ^{11}B – 80%, ^{10}B – 20%) . For example, boron may be present with an atomic weight of 11 (i.e., ^{11}B) or an atomic weight of 10 (i.e., ^{10}B). In some cases, substantially all of the boron in the

source feed gas may be a single isotope ^{10}B or ^{11}B. The invention is not limited in this regard.

In some cases, the source feed gas has a relatively high decomposition temperature. The decomposition temperature is determined, in part, by the stability of the chemical structure. The composition and structure of the source feed gas may be selected to provide thermal stability at relatively high temperatures (e.g., greater than 350 °C) which allows use of such gases in many conventional ion sources (e.g., indirectly heated cathode, Bernas) which generate such temperatures. For example, the decomposition temperature of the source feed gas may be greater than 350 °C; in some cases, greater than 500 °C; and, in some cases, greater than 750 °C. In particular, source feed gases that comprise boron and at least two additional elements may be suitable for use in conventional ion sources in which relatively high temperature (e.g., greater than 350 °C) are used. However, it should be understood that the decomposition temperature depends on the specific source feed gas used and the invention is not limited in this regard.

In some cases, the source feed gas supply supplied to the ion source is generated directly from a source feed material. In these cases, the source feed gas may be generated in any suitable manner. In some cases, the source feed material may be a solid and, for example, be in a powder form. In other embodiments, the source feed material is a liquid. The source feed gas can be produced via a sublimation and/or evaporation step of a material that comprises boron and at least two additional elements. It should also be understood that the source feed gas may be conventionally available in gaseous form and can be directly supplied to the ion source without the need for the separate generation step. The manner in which the source feed gas is generated and/or supplied depends, in part, on the composition of the source feed gas.

In some embodiments, the source feed material comprises boron and at least two additional elements including any of the compositions noted above. In some of these embodiments, the source feed gas generated from the source feed material also comprises boron and at least two additional elements (e.g., XBY wherein Y is not hydrogen). In embodiments in which the source feed gas includes boron and a single element, the ion species generated may also include boron and only the single element (e.g., Y), where Y is not hydrogen.

In some embodiments, the source feed gas comprising boron and at least two additional elements is a single gaseous compound. That is, the source feed gas is provided as a single gaseous composition . In other embodiments, the source feed gas may be a mixture of more than one type of gas which provides the source feed gas composition of boron and at least two additional elements. The more than one type of gas may be mixed prior to entering the ion source or inside of the ion source chamber.

FIG. 2 illustrates ion beam source 12 according to one embodiment of the invention. Though, it should be understood that the invention is not limited to the type of ion beam source shown in FIG. 2. Other ion beam sources may be suitable as described further below.

In the illustrative embodiment, the source includes a chamber housing 50 which defines a chamber 52 and an extraction aperture 53 through which ions are extracted. A cathode 54 is positioned within the chamber. As shown, a filament 56 is positioned outside the arc chamber in close proximity to the cathode. A filament power supply 62 has output terminals connected to the filament. The filament power supply heats the filament which in turn generates electrons which are emitted from the filament. These electrons are accelerated to the cathode by a bias power supply 60 which has a positive terminal connected to the cathode and a negative terminal connected to the filament. The electrons heat the cathode which results in subsequent emission of electrons by the cathode. Thus, ion beam sources having this general configuration are known as "indirectly heated cathode" (IHC) ion sources. An arc power supply 58 has a positive terminal connected to the chamber housing and a negative terminal connected to the cathode. The power supply accelerates electrons emitted by the cathode into the plasma generated in the chamber. In the illustrative embodiment, a reflector 64 is positioned within the chamber at an end opposite the cathode. The reflector can reflect electrons emitted by the cathode, for example, in a direction towards the plasma within the chamber. In some cases, the reflector may be connected to a voltage supply which provides the reflector with a negative charge; or, the reflector may not be connected to a voltage supply and may be negatively charged by absorption of electrons.

In many embodiments, a source magnet (not shown) produces a magnetic field within the chamber. Typically, the source magnet includes poles at opposite ends of the

chamber. The magnetic field results in increased interaction between the electrons emitted by the cathode and the plasma in the chamber.

Source feed gas from supply 17 is introduced into the chamber. The plasma within the chamber ionizes the source feed gas to form ionic species. A variety of ionic species may be produced which depend upon the composition of the source feed gas, as noted above, and desired ionic species may be selected for the ion beam and subsequent implantation.

It should be understood that other ion source configurations may be used in connection with the methods of the invention. For example, Bernas ion sources may be used. Also, ion sources that generate plasma using microwave or RF energy may be used. As noted above, one advantage of certain embodiments, is the ability to use the source feed gas in ion sources that generate relatively high temperatures (e.g., greater than 350 °C) without the source feed gas decomposing. However, in some embodiments, it may be preferred to use ion sources that operate at relatively low temperatures. For example, "cold wall" ion sources may be used that ionize the source feed gas by using one or more electron beams. Such ion sources have been described in U.S. Patent No. 6,686,595 which is incorporated herein by reference.

It should also be understood that the ion source illustrated in FIG. 2 may include a variety of modifications as known to those of ordinary skill in the art.

FIG. 3 is a plot of optimal mass spectrum for carborane for use in ion implantation. FIG. 3 is normalized and compares beam current to molecular weight of the extracted carborane ions for an optimized carborane source feed gas and a non-optimized carborane source feed gas. The optimal molecular weight of carborane for implant into a wafer is preferably between 132 and 144 amu, and more preferably between 136-138 amu. An optimized carborane source feed gas may not disassociate during the ionization process as much as a non-optimized carborane source feed gas.

As seen in FIG. 3, an optimal carborane source feed gas (illustrated as "Optimal Beam Spectrum"), results in greater beam current than a non-optimized carborane source feed gas (illustrated as "Broken-Up Beam Spectrum"). This non-optimized carborane source feed gas includes at least some break-up during ionization. The optimal carborane source feed gas was found in one experiment to result in as much as twice the measured

beam current compared to the non-optimal carborane source feed gas. Due to break-up during the ionization process, measured beam currents at molecular weights below 132 amu were substantially higher for a non-optimized carborane source feed gas than an optimized carborane source feed gas.

Having thus described several aspects of at least one embodiment of this invention, it is to be appreciated various alterations, modifications, and improvements will readily occur to those skilled in the art. Such alterations, modifications, and improvements are intended to be part of this disclosure, and are intended to be within the spirit and scope of the invention. Accordingly, the foregoing description and drawings are by way of example only.

CLAIMS

What is claimed is:

1. A method of implanting ions comprising:
generating $C_2B_{10}H_x$ ions from $C_2B_{10}H_{12}$; and
implanting the $C_2B_{10}H_x$ ions in a material.

2. The method of claim 1, wherein the $C_2B_{10}H_{12}$ has a decomposition temperature of at least 500 °C.

3. The method of claim 1, wherein the $C_2B_{10}H_{12}$ has a decomposition temperature of at least 750 °C.

4. The method of claim 1, wherein the molecular weight of the $C_2B_{10}H_x$ ions is greater than 100 amu.

5. The method of claim 1, wherein the $C_2B_{10}H_x$ ions have a mass spectrum consisting essentially of a single range of masses between approximately 132 and 144 amu, said mass spectrum being FIG. 3 of the accompanying drawings.

6. The method of claim 1, wherein the molecular weight of the $C_2B_{10}H_x$ ions is approximately 132 to 144 amu.

7. The method of claim 1, wherein the molecular weight of the $C_2B_{10}H_x$ ions is approximately 136 to 138 amu.

8. An ion source comprising:
a chamber housing defining a chamber; and

a source feed gas supply configured to introduce $C_2B_{10}H_{12}$ into the chamber, wherein the ion source is configured to ionize the source feed gas within the chamber into $C_2B_{10}H_x$ ions.

9. The ion source of claim 8, wherein the $C_2B_{10}H_{12}$ has a decomposition temperature of at least 350 °C.

10. The ion source of claim 8, wherein the $C_2B_{10}H_{12}$ has a decomposition temperature of at least 500 °C.

11. The ion source of claim 8, wherein the $C_2B_{10}H_{12}$ has a decomposition temperature of at least 750 °C.

12. The ion source of claim 8, wherein the molecular weight of the $C_2B_{10}H_x$ ions is greater than 100 amu.

13. The ion source of claim 8, wherein the $C_2B_{10}H_x$ ions have a mass spectrum consisting essentially of a single range of masses between approximately 132 and 144 amu, said mass spectrum being FIG. 3 of the accompanying drawings.

14. The ion source of claim 8, wherein the molecular weight of the $C_2B_{10}H_x$ ions is approximately 132 to 144 amu.

15. The ion source of claim 8, wherein the molecular weight of the $C_2B_{10}H_x$ ions is approximately 136 to 138 amu.

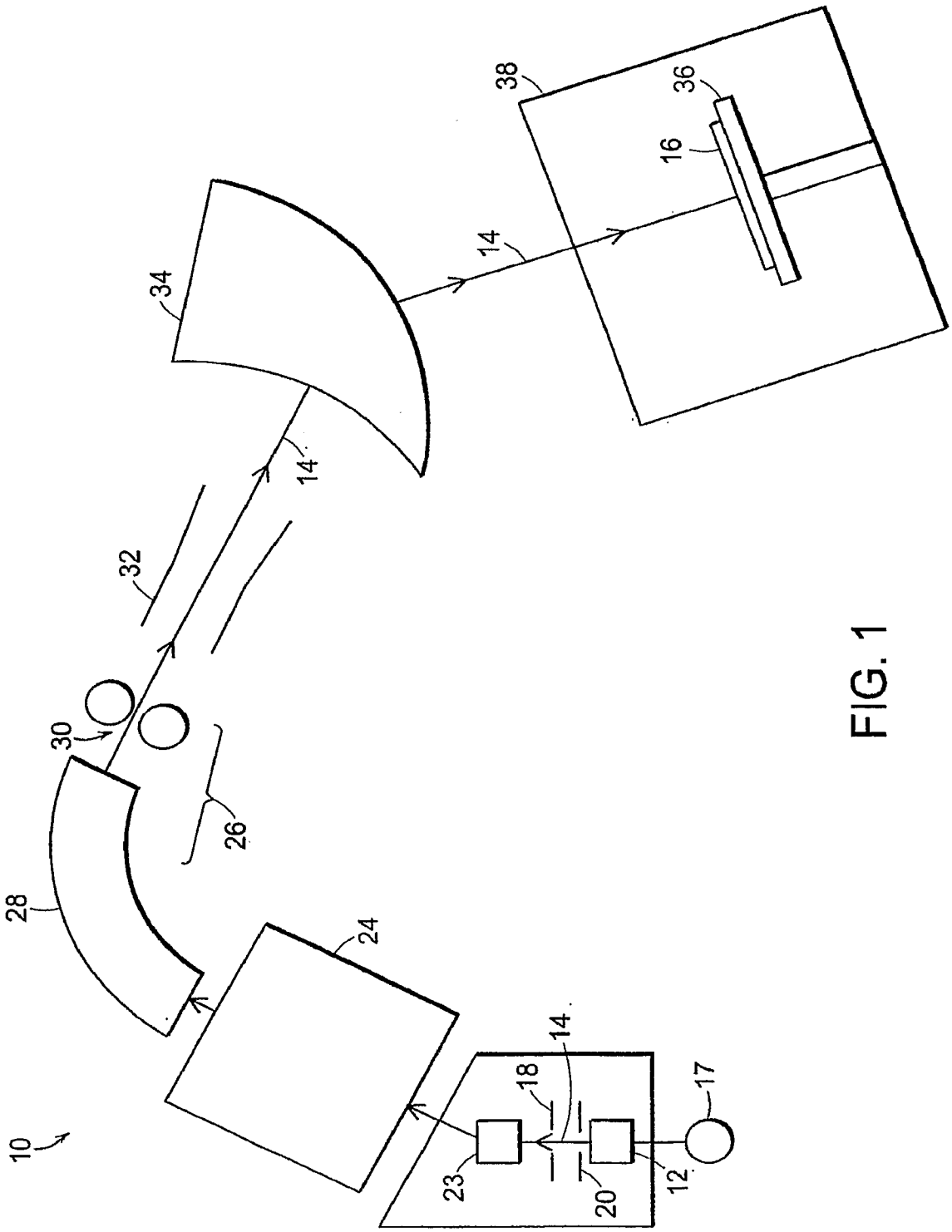

FIG. 1

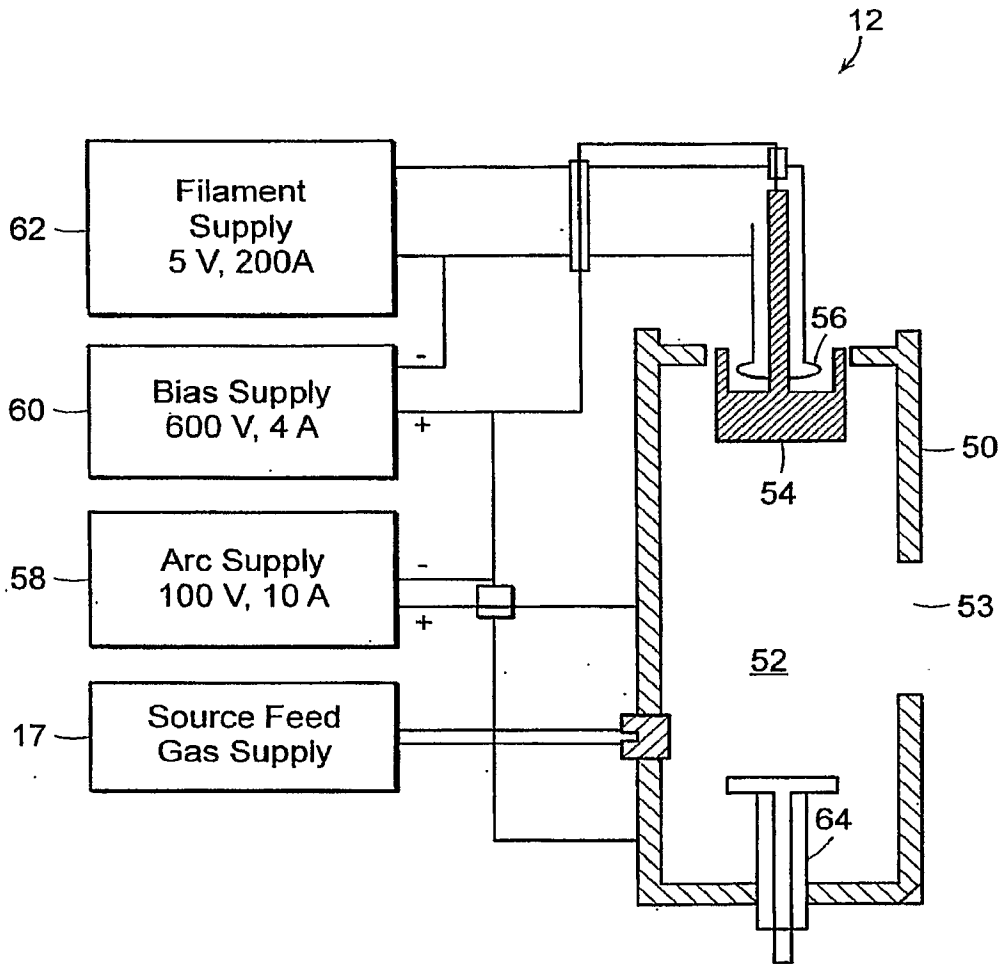
12
Filament Supply 5 V, 200A
62
Bias Supply 600 V, 4 A
60
Arc Supply 100 V, 10 A
58
Source Feed Gas Supply
17
-
+
-
+
56
54
50
53
52
64

FIG. 2

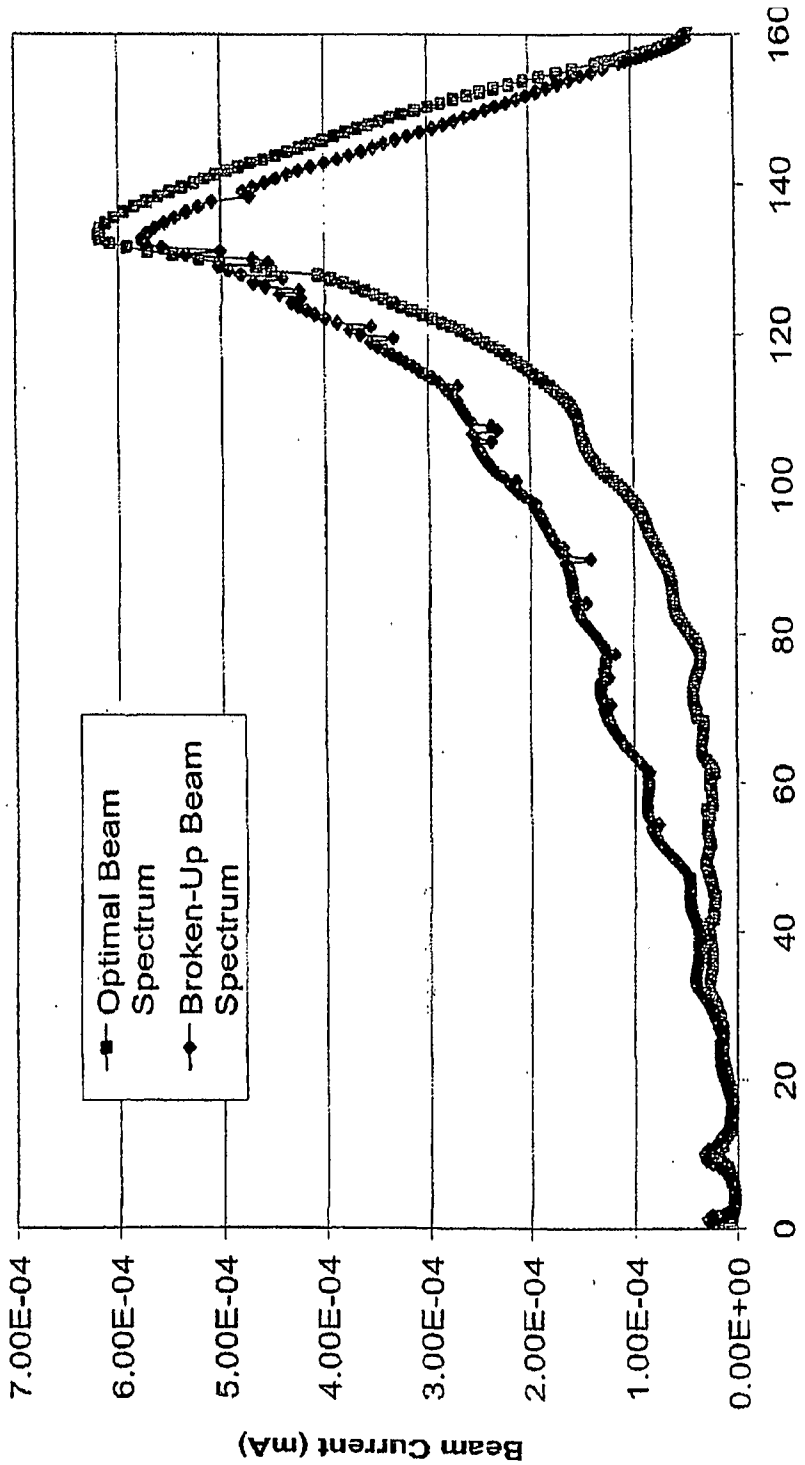
Beam Current (mA)
7.00E-04
6.00E-04
5.00E-04
4.00E-04
3.00E-04
2.00E-04
1.00E-04
0.00E+00
0
20
40
60
80
100
120
140
160
AMU
Optimal Beam Spectrum
Broken-Up Beam Spectrum

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2007/001271

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01L21/265 H01J37/08 H01J37/317 H01J27/02 C23C14/48

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 H01J H01L C03C C04B C30B G02B

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	KOIVISTO H ET AL: "The first results with the new JYFL 14 GHz ECR ion source" NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH, SECTION - B: BEAM INTERACTIONS WITH MATERIALS AND ATOMS, ELSEVIER, AMSTERDAM, NL, vol. 174, no. 3, April 2001 (2001-04), pages 379-384, XP004231421 ISSN: 0168-583X section 3.2.2. Production of 11-B ion beam - p. 383	1-4, 6-12,14, 15
A	US 2005/277246 A1 (KIRKPATRICK ALLEN R [US] ET AL) 15 December 2005 (2005-12-15) paragraphs [0015] - [0020], [0041]	1-4, 6-12,14, 15

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

[X] See patent family annex.

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"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	Date of mailing of the international search report
25 June 2007	05/07/2007

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	Krauss, Jan

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2007/001271

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6 686 595 B2 (HORSKY THOMAS N [US]) 3 February 2004 (2004-02-03) cited in the application column 2, line 63 - column 4, line 10	8-12,14, 15

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2007/001271

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.: 5,13
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:

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

Continuation of Box II.2

Claims Nos.: 5,13

Claims 5 and 13 define a mass spectrum consisting "essentially of a single range of masses between approximately 132 and 144 amu" and further defines the spectrum as "being FIG. 3 of the accompanying drawings". This reference to fig. 3 cannot be seen as "absolutely necessary" in the sense of Rule 6.2a PCT.
In addition, fig. 3 shows two spectra (one thereof with considerable noise), both of which appear to show a distribution of masses between 0 and 160 amu with a maximum at 132 amu. It is therefore further neither clear which of the two spectra is actually addressed, nor which of the apparently contradictory features of a maximum at 132 amu or a range of masses between 132 and 144 amu is actually intended.

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.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2007/001271

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2005277246 A1	15-12-2005	NONE	
US 6686595 B2	03-02-2004	CN 1973346 A	30-05-2007
		US 2004000647 A1	01-01-2004
		US 2004195973 A1	07-10-2004