PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :		(11) International Publication Number: WO 99/58739
C23C 16/44, 16/02, 14/02, H01J 37/32, H01L 21/00, B08B 7/00	**A1**	(43) International Publication Date: 18 November 1999 (18.11.99)

(21) International Application Number: PCT/US99/10392

(22) International Filing Date: 11 May 1999 (11.05.99)

(30) Priority Data:
09/076,589 12 May 1998 (12.05.98) US

(71) Applicant: APPLIED MATERIALS, INC. [US/US]; 3050 Bowers Avenue, Santa Clara, CA 95054 (US).

(72) Inventors: EGERMEIER, John; 6513 Pajaro Court, San Jose, CA 95120 (US). LEWIS, John; 274 Brooklyn Avenue, San Jose, CA 95128 (US).

(74) Agents: BERNADICOU, Michael, A. et al.; Blakely, Sokoloff, Taylor & Zafman LLP, 7th floor, 12400 Wilshire Boulevard, Los Angeles, CA 90025 (US).

(81) Designated States: CN, JP, KR, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: OXYGEN–ARGON GAS MIXTURE FOR PRECLEANING IN VACUUM PROCESSING SYSTEM

(57) Abstract

A method for cleaning, or pre–cleaning, a process objet, such as a substrate, uses a process gas, such as argon, mixed with a quantity of oxygen. The process gas sputter etches material from the surface of the process object to clean or remove oxides, or other contaminants, therefrom. The oxygen reacts with the etched material to form stoichiometrically balanced compounds that deposit in a smooth film on a process kit. The process kit is periodically removed and replaced after a predetermined number of process objects have been processed, or cleaned.

START 300
CLOSE PRE-CLEAN CHAMBER 302
PURGE PRE-CLEAN CHAMBER 304
COMBINE PROCESS GASES (ARGON / OXYGEN) 306
FLOW PROCESS GAS MIXTURE INTO PRE-CLEAN CHAMBER 308
GENARATE PLASMA IN PRE-CLEAN CHAMBER 310
ETCH SUBSTRATE 312
PURGE CHAMBER 314
OPEN CHAMBER 316
END 318

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

OXYGEN-ARGON GAS MIXTURE FOR PRECLEANING IN VACUUM PROCESSING SYSTEM

BACKGROUND OF THE INVENTION

Field of the Invention

This invention generally relates to processing substrates in a vacuum processing system. Specifically, this invention relates to preparing a substrate for subsequent processing by removing oxides and other materials from a surface of a substrate through sputter cleaning.

Background of the Related Art

As integrated circuit (IC) dimensions become increasingly smaller, the need to prevent contamination by particles of the substrates on which the IC's are constructed becomes increasingly more difficult and, hence, more important, because the smaller circuits can be more easily damaged by smaller particles, and the new processes required to construct the smaller circuits are more susceptible to degradation by the smaller particles. Thus, the need for proper cleaning of the substrates is becoming more important.

In order to fabricate a complete IC, typically several substrate processing systems are used, with each system performing a particular step or series of steps in the overall fabrication process. The substrates are transferred between the systems at ambient conditions. The ambient environment is maintained very clean to prevent contamination of the substrates as they are transferred between systems. The substrates may even be transferred in completely enclosed cassettes in order to further prevent contamination thereof. A problem, however, is that it is not possible to prevent the oxygen in the ambient air from forming oxides on the surfaces of the substrates. Because the oxidation of the materials in an IC can seriously alter the electrical properties of the materials, oxidized surfaces are undesirable, and the surface oxides, primarily silicon dioxide and metal oxides, need to be removed or etched from the surfaces of the substrates, in a pre-processing cleaning step, before the substrates are subjected to the primary process of the system such as physical vapor deposition and chemical vapor deposition. Particularly, substrate surface features, such as trenches, grooves or vias into which metal conductors, such as tungsten, aluminum or copper, are

to be deposited need to be cleaned in order to assure a very low interface resistance between layers of deposition.

A pre-clean chamber, such as the Pre-Clean II Chamber available from Applied Materials, Inc., Santa Clara, California, cleans the substrates by removing the undesired layer of oxides. Typically, about 400Å of oxidized material is removed from the surface of the substrates. An example of a pre-clean chamber is shown in Figures 3a and 3b. Generally, the pre-clean chamber 200 has a substrate support 204 disposed in a chamber body member 202 under a quartz dome 206. The dome 206 is typically a part of a process kit that system operators periodically replace during routine maintenance. It is desirable that a process kit has a long useful lifetime, so that the downtime of the system will be a small percentage of the overall processing time.

The process for cleaning a substrate 212 in the pre-clean chamber 200 involves a sputter-etching process using the substrate 212 as the sputtering target. Generally, a cleaning gas such as argon is flowed through the chamber 200, and a plasma is struck in the space 224 in the chamber with a plasma power. Preferably, an RF power is applied to the chamber to inductively couple a plasma into the chamber, and a DC bias is applied to the substrate support 204 to accelerate the ions toward the substrate 212. The pressure in the pre-clean chamber 200 during sputtering is typically maintained at about 0.4mTorr to about 0.5mTorr. Under these conditions, the pre-clean chamber 200 can typically remove about 150Å to about 450Å of SiO_2 at an etch rate of about 300Å/min to about 600Å/min.

The primary purpose of the etch cleaning is to remove oxides that form on the surface of the substrate typically when the substrate was subjected to ambient air conditions while being transported to the vacuum processing system. For a silicon substrate, most of the oxidized surface material is silicon oxide, but metal deposited on the surface of the substrate will have formed metal oxides on the surface as well.

Generally, the prior art argon cleaning process does not completely remove the oxide layer and merely reduces the thickness of the oxide to between about 12 Å and about 30 Å because the partial pressure produced by etching the field oxide during the etch process is so high that it reoxidizes any exposed unoxidized metal in the via holes at a rate that is comparable to or faster than the rate of etching at that location. This reoxidation problem occurs because of three primary reasons. First, the reaction rate or sticking of the oxidizers within the feature aperture is greater than on the field because

of the bouncing that occurs inside the small feature cavities. Second, the etch rate in the bottom of the feature aperture is much smaller than the etch rate on the field. Third, the sidewalls of the feature aperture generally consist of SiO_2 that serves as a source of material to be redeposited on the bottom of the feature aperture, reducing the effective etch rate while still contaminating the feature aperture. Thus, the pure argon etching/cleaning process does not totally remove the oxides in the feature apertures.

During etching with argon gas, several gas species are created which contribute to the composition of a byproduct film which is deposited on the process kit surfaces including the dome 206. These include Si, SiO, SiO_2, O, O_2, O_3, plus metal and metal oxides from the feature aperture on the substrate. The type of metal atoms depends on the process and typically includes Al from AlSiCu alloy or Ti or TiN exposed in the bottom of the feature apertures, or Si from other parts of the substrate where unoxidized silicon may be exposed at the surface. Additionally, compounds remaining from the etching and stripping processes may be present in some cases, including carbon and nitrogen complexes from residual photoresist and polymers containing carbon and/or fluorine and/or chlorine.

Because gas phase collisions predominate over collisions with the walls of the process kit when the etch/pre-clean process is conducted at high pressures, resulting in redeposition of the etch byproducts onto the surface of the substrate, the etch/pre-clean process is typically conducted at a vacuum flow of about 0.5 mTorr so that the byproduct compounds can be removed from the substrate surface with reduced likelihood that gas phase collisions will bounce the removed byproducts back to the substrate surface. However, the vacuum flow etch process prevents some non-condensable etch byproduct species, such as the oxidizing compounds (O, O_2, SiO and O_3), from depositing on the process kit walls, resulting in sub-stoichiometric (*i.e.*, ratio of Si to O is greater than ½) films formed on the process kit surfaces. Furthermore, free metal atoms are left unoxidized in this film. The combination of these effects results in a film or layers of films having varying stoichiometry and/or composition that is inherently unstable from a mechanical and electrical standpoint due to strength, coefficient of thermal expansion and charge up problems.

The etched material sputters off the substrate surface and forms a film on the process kit, including an interior surface of the quartz dome 206. As the film forms on the process kit surfaces, its density may change, resulting in stress on the film. This

stress, along with differences in the coefficients of expansion of the materials in the film, can result in delamination, or flaking, of the film from the surface of the process kit. Thus, the film typically deposits on the surfaces of the process kit as a granular or flaky layer. Eventually, after several hundred substrates have been cleaned, the film becomes so thick and heavy that some of the film starts to flake off and contaminate the substrate being processed. Because these particles can seriously damage the substrates and/or prevent the proper performance of the primary process of the system, the process kit is typically replaced after a certain number of substrates have been cleaned in the system. The selected number of substrates that can be processed before a process kit replacement generally corresponds to a permissible thickness of the film formed on the surfaces of the process kit before flaking occurs. It is desirable that the process kit has a long useful lifetime, so that the downtime of the system will be a small percentage of the overall processing time.

Typically, the lifetime of a process kit is specified as a particular thickness of total etched material. For example, 120μm of total etched material, corresponding to about 3000 substrates, is a common thickness specified for a process kit, and many users in the industry have come to expect a process kit to have this level of performance.

However, the actual lifetime for a process kit frequently falls short of the desired, or specified, lifetime because material begins to delaminate from the process kit after only 60-90μm of etched material has been etched from substrates. Occasionally, a process kit may last for only 20-30μm of etched material. These short lifetimes cause the system operator to have to service the system more often. Additionally, an unexpectedly short useful lifetime for a process kit may result in flakes of material falling off of the dome of the process kit and onto a substrate, damaging many of the ICs formed on the substrate, while the system operator assumes that the process kit is working properly. Thus, several substrates may pass through the system before the system operator is aware that many of the devices are damaged or contaminated.

Another problem is that the metals that are removed from the substrates and deposited on the process kit may build up a capacitive charge, since isolated spots of the metals may be surrounded by insulating material and free electrons from the plasma

or other source may be attracted to these isolated metal deposits. This capacitive charge can become so high that arcing occurs between the spots or layers, resulting in mechanical breakdown of the byproduct film leading to a catastrophic generation of particles.

Therefore, there exists a need for a method for pre-cleaning substrates that prevents premature flaking of material from the film formed on the surfaces of the process kit and prevents capacitive charge build-up in the film. It would be desirable for the method to perform consistently over the specified lifetime of a process kit.

SUMMARY OF THE INVENTION

The invention generally provides a pre-clean chamber in a substrate processing system to clean a substrate by sputter etching a layer of oxides from the surface of the substrate while flowing an oxygen-argon sputtering gas mixture through the chamber. The oxygen preferably oxidizes the etched material, and the oxidized material deposits in a film on the process kit, including the dome of the chamber. As a result, a thicker, more stable film can be deposited on the process kit before the material begins to flake off.

The oxidation of the etched material, such as silicon and various metals, causes the etched material to be stoichiometrically balanced, thereby rendering the material relatively non-reactive, so that a stable film with minimal flaking may form on the process kit. The stoichiometrically balanced material is stabilized because the stoichiometry of $Si/O_2 = \frac{1}{2}$ is maintained by adjusting the Ar/O_2 ratio of the etching gas mixture so that the amount of oxygen needed to bond with the silicon is optimized. An optimum O_2 content of the etch gas mixture is between about 5% and about 30% by volume. The flow of oxygen in the etching gas mixture can be turned off for a short time prior to the end of the cleaning process to minimize oxide formation on the substrate, *e.g.*, in the apertures patterned on the substrate.

Additionally, the oxygen in the process gas oxidizes any metals sputtered off the substrate that deposit on the process kit, thereby reducing their conductive properties. Thus, capacitive charging of isolated locations of the metals on the surfaces of the process kit does not occur and adds to the stability of the film.

BRIEF DESCRIPTION OF THE DRAWINGS

So that the manner in which the above recited features, advantages and objects of the present invention are attained and can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to the embodiments thereof which are illustrated in the appended drawings.

It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

Figure 1 is a schematic top view of a vacuum processing system.

Figure 2 is a flowchart of a pre-clean procedure.

Figure 3a is a side view of a first configuration of a pre-clean chamber.

Figure 3b is a side view of a second configuration of the pre-clean chamber.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Figure 1 generally shows a schematic top view of an embodiment of a vacuum processing system 100 of the present invention. The system 100 is an example of the Endura™ family of systems from Applied Materials, Inc., Santa Clara, California. Although the present invention is described with reference to this system 100, it is understood that the present invention is not limited to this particular type of system, and other types of processing systems are contemplated by the present invention. The vacuum processing system 100 includes a transfer chamber 102 and a buffer chamber 106 typically mounted on a platform (not shown) and generally forming a system monolith 101. The transfer chamber 102 as shown has four process chambers 104 mounted at facets 105 for performing the primary processes on the substrates. The system monolith 101 has two load lock chambers 116 mounted at facets 117 for transitioning the substrates into the vacuum environment of the system 100. An optional mini-environment 124 is shown attached to the load lock chambers 116 to increase the number of substrates that can be processed continually in one run of the process. The transfer chamber 102, the buffer chamber 106 and the mini-environment 124 each have at least one substrate handler or robot 114, 112, 128, for transferring substrates therethrough. A pre-clean chamber is used to clean the substrates before the process chambers 104 perform the primary process of the system 100 on the substrates.

The pre-clean chamber 108 is disposed between the transfer chamber 102 and the buffer chamber 106. Alternatively, a separate chamber 118 attached to the buffer chamber 106 serves as the pre-clean chamber. In another alternative embodiment, the pre-clean chamber may be attached to the transfer chamber 102 in the position of one of the process chambers 104. The pre-clean chamber 108, 118 cleans the substrates by sputter etching a top layer off of the substrates with an etch gas that includes a percentage of oxygen according to the invention.

The process chambers 104 perform the primary process on the substrates in the vacuum processing system 100. Process chambers 104 may be any type of process chamber, such as a rapid thermal processing chamber for heat treating or curing a substrate, a physical vapor deposition chamber, a chemical vapor deposition chamber or an etch chamber. The process chambers 104 may be supported by the transfer chamber 102 or may be supported on their own platforms depending on the configuration of the individual process chambers 104. Slit valves (not shown) in the facets 105 provide access and isolation between the transfer chamber 102 and the process chambers 104. Correspondingly, the process chambers 104 have openings (not shown) on their surfaces that align with the slit valves.

A pre-clean chamber 108 and a cool-down chamber 110 are disposed between the transfer chamber 102 and the buffer chamber 106. Alternatively, both chambers 108, 110 may be pass-through/cool-down chambers. The pre-clean chamber 108 cleans the substrates before they enter the transfer chamber 102, and the cool-down chamber 110 cools the substrates after they have been processed in the process chambers 104. The pre-clean chamber 108 and the cool-down chamber 110 also provides the transition between the vacuum levels of the transfer chamber 102 and the buffer chamber 106. The buffer chamber 106 has two expansion chambers 118 for performing additional processes on the substrates. Alternatively, one of the chambers 118 is a pre-clean chamber. The buffer chamber 106 further has an additional chamber 120 for additional pre-processing or post-processing of the substrates, such as degassing or cooling, if necessary. Yet another chamber 122, such as a substrate aligner chamber, is typically attached to the buffer chamber 106.

The load lock chambers 116 provide the transition between the ambient environment pressure to the buffer chamber vacuum pressure for the substrate. Openings (not shown) in facets 117 provide access and valves provide isolation

between the load lock chambers 116 and the buffer chamber 106. Correspondingly, the load lock chambers 116 have openings on their surfaces that align with the openings in facets 117. The load lock chambers 116 and the mini-environment 124 have corresponding openings (not shown) providing access therebetween, while doors (not shown) for the openings provide isolation.

The mini-environment 124 has four pod loaders 126 attached on its front side. Openings (not shown) with corresponding doors 125 provide access and isolation between the mini-environment 124 and the pod loaders 126. The pod loaders 126 are mounted on the side of the mini-environment 124 and are essentially shelves for supporting the substrate pods (not shown) used to transport the substrates to and from the vacuum processing system 100.

The substrate handler 114 is disposed within the transfer chamber 102 for transferring a substrate 115 between the pre-clean chamber 108, the cool-down chamber 110 and the process chambers 104. A similar substrate handler 112 is disposed within the buffer chamber 106 for transferring a substrate 113 between the load lock chambers 116, the expansion chambers 118, the cool-down chamber 120, the substrate aligner chamber 122, the pre-clean chamber 108 and the cool-down chamber 110. Likewise, one or more substrate handlers 128 are disposed within the mini-environment 124 for transferring the substrates between the pod loaders 126 and the load lock chambers 116. The substrate handler 128 is typically mounted on a track so the substrate handler 128 can move back and forth in the mini-environment 124.

Figures 3a and 3b show side views of a vacuum pre-clean chamber 200 that may be used as the pre-clean chamber 108 above. One such chamber is the Preclean II chamber available from Applied Materials, Inc., of Santa Clara, California. Generally, the pre-clean chamber 200 includes a body member 202 having a substrate support 204 disposed therein below a dome 206 to hold a substrate for processing, or cleaning. The body member 202 has sidewalls 208 which are preferably made of metallic construction such as stainless steel, aluminum or the like. Additionally, the body member 202 is connected to a high-vacuum pump (not shown), such as a cryopump or turbo pump, which is used to control the gas pressure inside the chamber 200. The dome 206 is typically constructed of quartz and forms the top of the chamber 200. The dome 206 mates with the top circumference of the sidewalls 208 of body member 202. Generally, the dome 206 is part of a replaceable process kit for the chamber.

The substrate 212 is inserted into the chamber 200 from the buffer chamber 106 through slit valve opening 214 by a blade of the robot 112 (Figure 1). After the pre-clean process has been performed, the substrate 212 is moved to the transfer chamber 102 through another slit valve opening (not shown) by a blade of the other robot 114. Alternatively, for a pre-clean chamber that is attached as a side chamber to either the buffer chamber 106 or the transfer chamber 102, the substrate 212 is inserted and removed through the same slit valve opening by the same robot. A set of lift pins 216, forming a three-point support, receives the substrate 212 when it enters the chamber 200 by lifting the substrate 212 off of the substrate blade to a position as shown in Figure 3a. A lift mechanism 218 raises and lowers the lift pins 216 to raise and lower the substrate 212 off of and onto the substrate blade of the robots 112, 114 and the substrate support 204. Another lift mechanism 220 raises the substrate support 204 and the substrate 212 thereon to a processing position as shown in Figure 3b. In the processing position, the substrate support 204 and a cavity shield 222 effectively seal off the lower portion of the body member 202 from the space 224 under the dome 206 wherein the plasma is generated, so that the plasma does not leak into and contaminate the rest of the body member 202 during pre-cleaning. The cavity shield 222 typically is made of aluminum or the like.

A gas distribution system with a gas inlet 210 extending through the lift mechanism 220 and the substrate support 204 delivers the process gas mixture, such as argon and oxygen, under and around the substrate 212 and into the space 224. Although the pre-clean procedure described herein is described with reference to this gas distribution system, it is understood that the invention is not so limited, but contemplates the use of other configurations of gas distribution systems, including, but not limited to, a distribution system that includes a gas inlet disposed through a location in the dome or through the sidewall of the chamber or between the dome and the sidewall. The gas distribution system 210 connects to a gas mixer (not shown) which receives the different gases through gas inlets and combines the gases in the appropriate proportions to form the desired process gas mixture.

A high frequency RF power supply (not shown) is capacitively coupled to the substrate support 204 and supplies a negative bias voltage thereto. This bias voltage is coupled to the substrate via a substrate holder (not shown) such as an electrostatic chuck.

A helical shaped RF induction coil 226 is wound exteriorly to dome 206 and is supported by a cover 228. The coil 226 is formed of hollow copper tubing through which coolant water can be flowed during operation. An alternating axial electromagnetic field is produced in the chamber 200 interiorly to the windings of the coil 226. Generally, an RF frequency of from about 420 kHz to about 435 kHz is employed and an RF power supply of conventional design (not shown) operating at this frequency is coupled to the coil 226 by a matching network (not shown) to generate a plasma in the chamber 200. The RF electromagnetic field generates a glow discharge plasma within the space 224 which has a plasma sheath or dark space separating the plasma from the substrate support 204 and the substrate 212. Ions in the plasma bombard the substrate 212 to etch away a layer of material from the surface of the substrate.

In operation, a buffer chamber robot 112 places a substrate 113, such as a silicon substrate, into the pre-clean chamber 108. The pre-clean chamber 108 cleans the substrate while transitioning from the vacuum level of the buffer chamber 106 to the vacuum level of the transfer chamber 102 according to the procedure outlined in the flowchart shown in Figure 2, described below. After the substrate is clean and the vacuum level of the pre-clean chamber 108 reaches the level in the transfer chamber 102, a valve between these two chambers opens, and a transfer chamber robot 114 removes the substrate from the pre-clean chamber 108 and transfers the substrate to a process chamber 104.

Figure 2 is a flowchart outlining a pre-clean procedure. The cleaning process performed by the pre-clean chamber 108 starts at step 300 after a substrate has been loaded into the pre-clean chamber. The pre-clean chamber is sealed (Step 302) from either the buffer chamber 106 or the transfer chamber 102, depending on the configuration of the system 100. The pre-clean chamber is purged (Step 304) with a purge gas, such as argon, for a few seconds after closing the pre-clean chamber, so any gas that entered the chamber while the substrate was being loaded is purged from the pre-clean chamber. The gases that comprise the cleaning gas mixture, such as argon and oxygen, are combined (Step 306) in the desired proportions, preferably between about 5% to about 30% oxygen by volume, and flowed (Step 308) into the pre-clean chamber. Preferably the cleaning gas mixture is flowed between about 1sccm and about 30sccm. The pressure in the pre-clean chamber 200 during sputter cleaning is

typically maintained between about 0.1mTorr and about 5mTorr. A plasma is generated in the chamber (step 310) with a plasma power in the range of about 1W to about 1000W. Preferably, an RF power is applied to the chamber to inductively couple the plasma into the chamber. A DC bias of about 100V to about 600V, with a bias power of about 1W to about 1000W, is applied to the substrate 212 and accelerates the ions toward the substrate 212. Typically, the pre-clean process removes about 150Å to about 450Å of SiO_2 from the substrate 212 (step 312) at an etch rate of about 300Å/min to about 600Å/min for about 15 seconds to about 90 seconds. In some cases, the oxygen supply to the cleaning gas mixture is turned off for a short time (*i.e.*, a few seconds) prior to the end of the cleaning process to minimize the oxide formation on the substrate, *e.g.*, in the apertures formed on the substrate. After the etching/cleaning process, the chamber is purged of all remaining cleaning gases (step 314), and the chamber is opened (step 316) for transfer of the cleaned substrate to the next processing chamber.

The addition of oxygen to the process allows the etch/byproduct materials to deposit onto the interior surface of the kit in a stoichiometrically balanced manner without degrading the etching/cleaning performance as compared to an etch/clean process using argon as the cleaning gas. Oxygen is included in the gas mixture in an amount sufficient to oxidize the etched material that redeposited on the kit surfaces so that the films formed on the kit surfaces are stoichiometrically balanced. Typical concentrations of oxygen in the gas mixture are between about 5% and about 30% by volume. In some cases, the oxygen supply to the cleaning gas mixture is turned off for a short time prior to the end of the cleaning process to minimize the oxide formation in the feature apertures.

The invention provides a further advantage by preventing capacitive charge build-up in the film formed on the process kit. The oxygen in the process gas oxidizes any metals sputtered off the substrate that deposit on the process kit, thereby reducing their conductive properties. Thus, capacitive charging of isolated locations of the metals on the dome surface does not occur and adds to the stability of the film deposited on the dome surface.

While the foregoing is directed to the preferred embodiment of the present invention, other and further embodiments of the invention may be devised without

departing from the basic scope thereof, and the scope thereof is determined by the claims which follow.

CLAIMS:

1. A method of removing material from a substrate comprising:
placing the substrate into a chamber;
flowing a gas mixture of oxygen and a process gas into the chamber;
striking a plasma in the chamber;
sputter etching material from the surface of the substrate.

2. The method of claim 1 further comprising:
oxidizing the etched material with the oxygen of the gas mixture.

3. The method of claim 2 further comprising:
forming the oxidized etched material into a substantially stoichiometric film on a surface of the chamber.

4. The method of claim 3 wherein the steps are repeated on a plurality of process objects and wherein the film is formed to a thickness of about 120μm on a replaceable process kit.

5. The method of claim 4 comprising:
replacing the process kit.

6. The method of claim 1 wherein the step of flowing a gas mixture of oxygen and a process gas comprises:

i) flowing a gas mixture of oxygen and a process gas for a first duration; and

ii) flowing the process gas for a second duration.

7. A method of processing a substrate comprising:
placing the substrate into a chamber;

flowing a gas mixture of oxygen and a process gas into the chamber;
striking a plasma in the chamber; and
bombarding the substrate with ions formed in the plasma.

8. The method of claim 7 wherein the step of bombarding the substrate removes a layer of material from a surface of the substrate.

9. The method of claim 8 wherein the oxygen in the gas mixture oxidizes the removed material.

10. The method of claim 9 wherein the removed material includes a metal and the oxygen oxidizes the metal to prevent capacitive charging of the metal.

11. The method of claim 7 wherein the removed material is stoichiometrically deposited in a film on a surface in the chamber.

12. The method of claim 11 wherein the surface is a surface of a replaceable process kit for the chamber.

13. The method of claim 7 wherein the gas mixture includes oxygen between about 5% and about 30% by volume.

14. The method of claim 13 wherein the process gas is argon.

15. The method of claim 7 wherein the step of flowing a gas mixture of oxygen and a process gas comprises:

i) flowing a gas mixture of oxygen and a process gas for a first duration; and

ii) flowing the process gas for a second duration.

16. A method of processing a substrate in a processing system comprising:
placing the substrate in a first chamber;
flowing a gas mixture of oxygen and a process gas into the first chamber;
striking a plasma in the first chamber;
bombarding the substrate with ions formed in the plasma;
transferring the substrate to a second chamber; and
performing a subsequent processing step on the substrate in the second chamber.

17. The method of claim 16 wherein the step of bombarding the process object removes a layer of material from the surface of the process object.

18. The method of claim 17 wherein the removed material is stoichiometrically deposited in a film on a surface in the first chamber.

19. The method of claim 17 wherein the removed material is stoichiometrically deposited in a film on a surface of a replaceable process kit.

20. The method of claim 17 wherein the oxygen in the mixture oxidizes the removed material.

21. The method of claim 20 wherein the removed material includes a metal and the oxygen oxidizes the metal to prevent capacitive charging of the metal.

22. The method of claim 16 wherein the gas mixture includes oxygen, from about 5% to about 30%.

23. The method of claim 22 wherein the process gas is argon.

24. The method of claim 16 wherein the step of flowing a gas mixture of oxygen and a process gas comprises:

i) flowing a gas mixture of oxygen and a process gas for a first duration; and

ii) flowing the process gas for a second duration.

25. An apparatus for pre-cleaning a substrate, comprising:

a) an etch chamber;

b) a cleaning gas source supplying a cleaning gas to the etch chamber;

c) an oxygen gas source supplying an oxygen gas to the etch chamber; and

d) a controller regulating the cleaning gas source and the oxygen gas source.

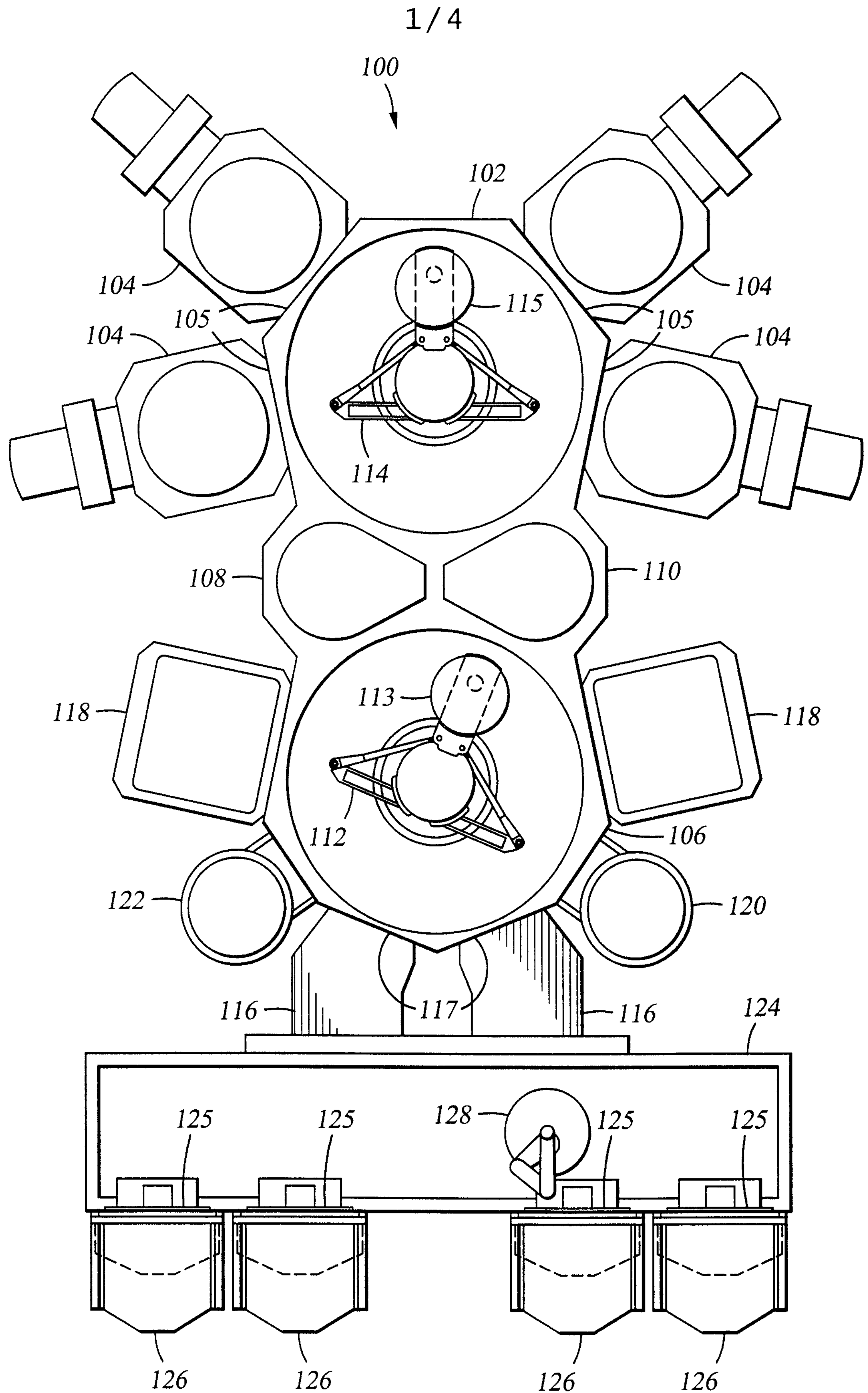

Fig. 1

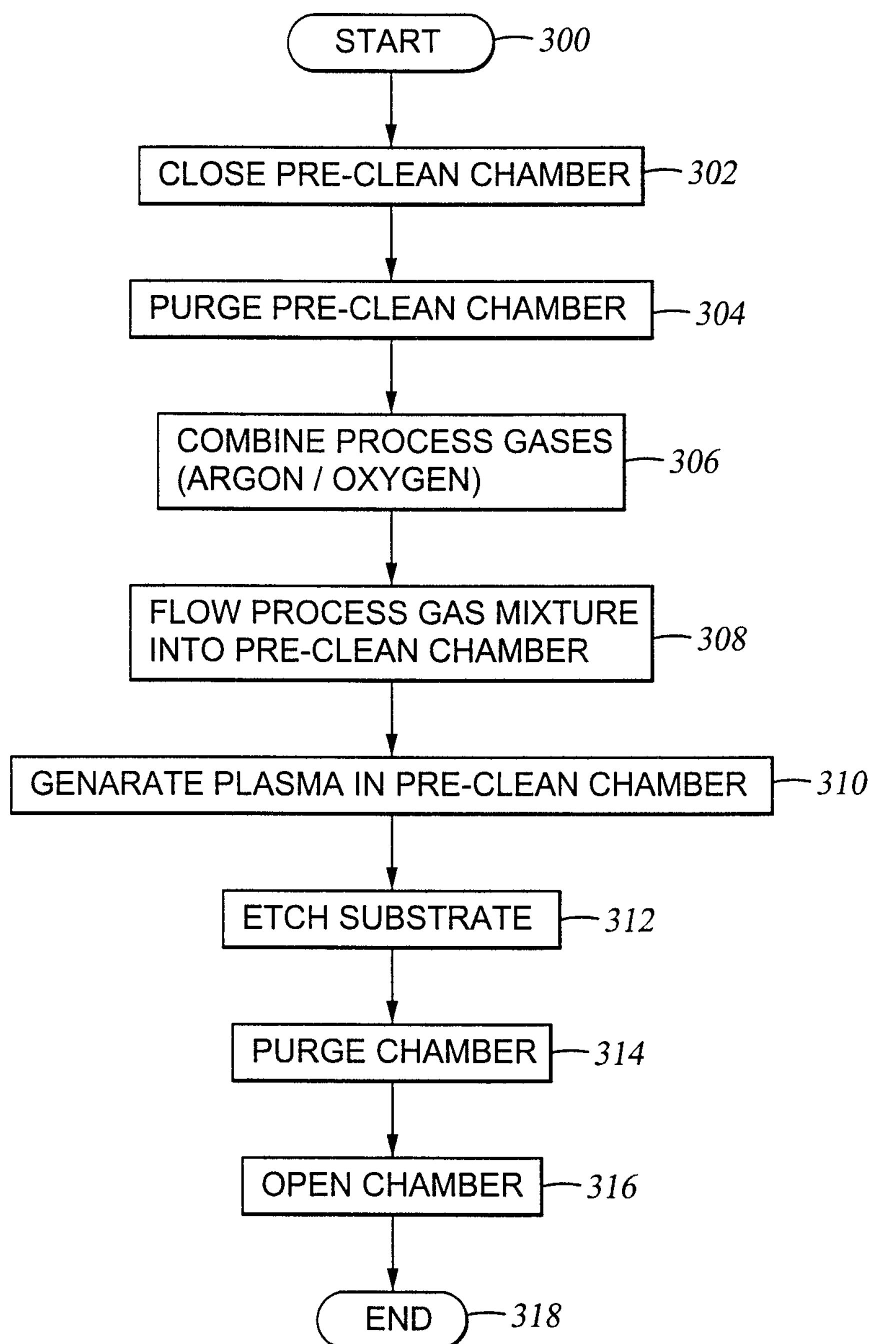

Fig. 2

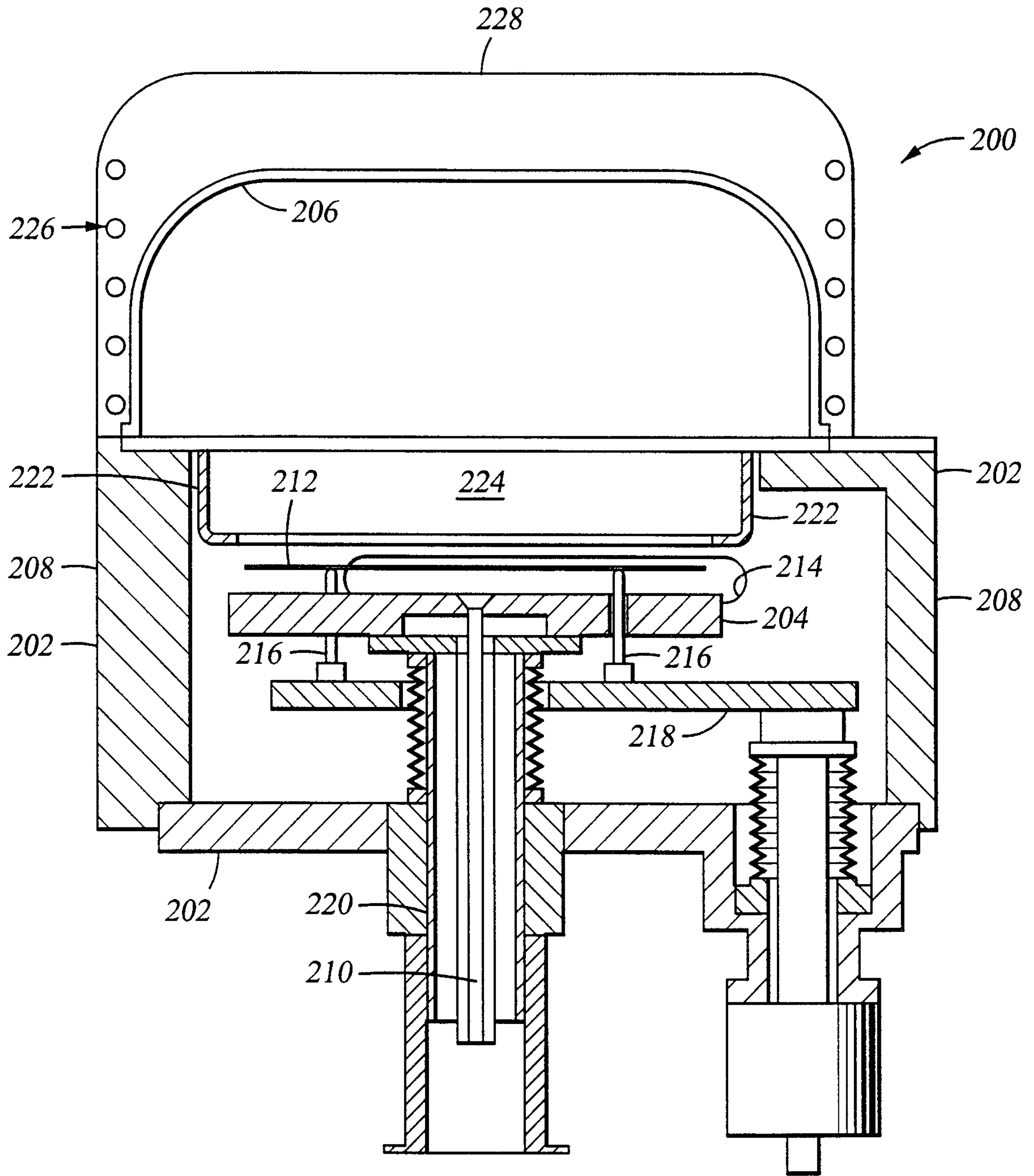

Fig. 3A

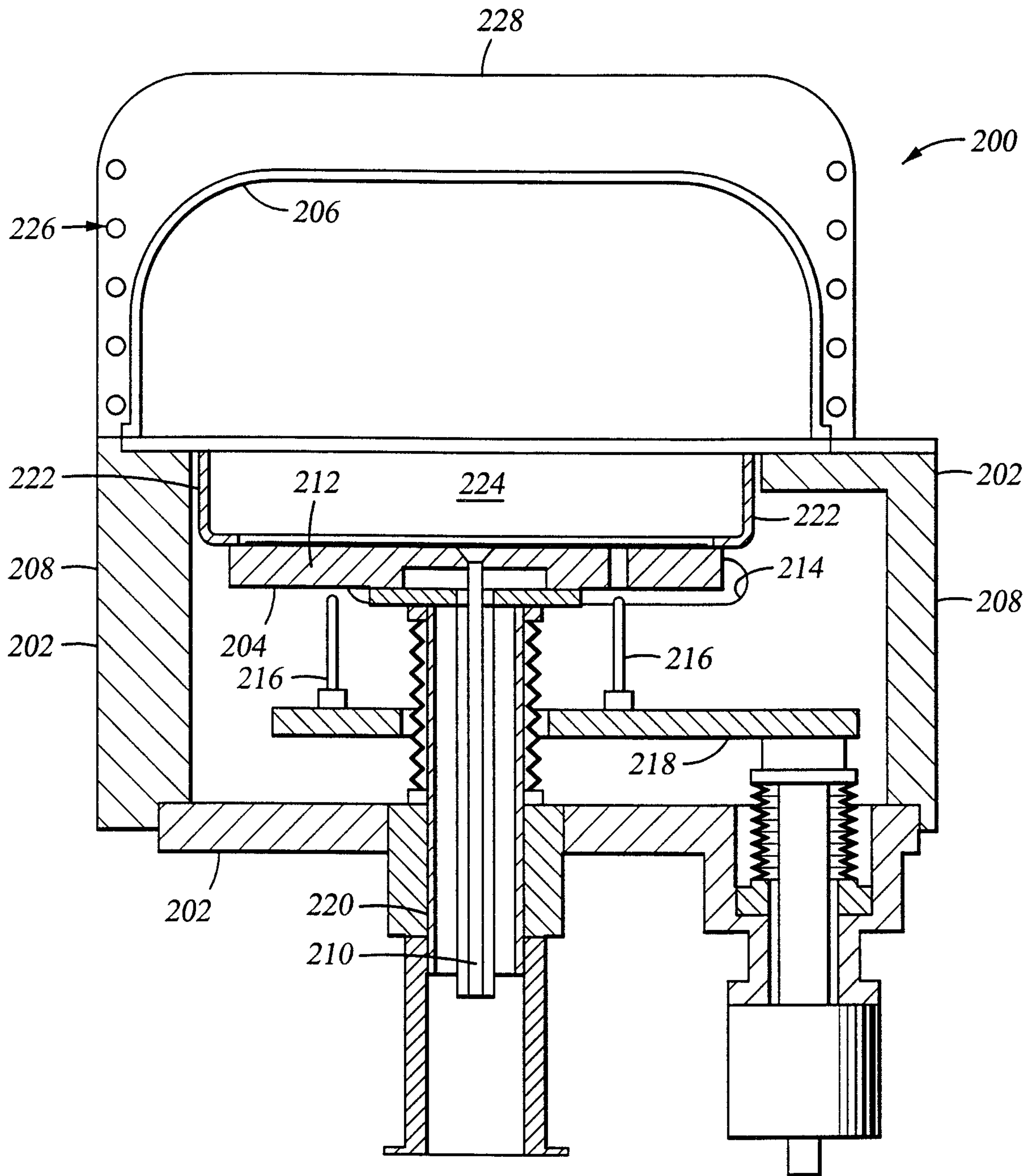

Fig. 3B

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/10392

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 C23C16/44 C23C16/02 C23C14/02 H01J37/32 H01L21/00
B08B7/00

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 6 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)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 732 732 A (APPLIED MATERIALS INC) 18 September 1996 (1996-09-18)	1-3,7-9, 11-14, 16-20, 22,23
Y	the whole document	6,15,24
A		4,5,10, 21,25
Y	PATENT ABSTRACTS OF JAPAN vol. 016, no. 142 (E-1187), 9 April 1992 (1992-04-09) & JP 04 002129 A (FUJITSU LTD), 7 January 1992 (1992-01-07) abstract	6,15,24
X	US 5 494 522 A (TANAKA SUSUMU ET AL) 27 February 1996 (1996-02-27)	25
A	column 9, line 6 - column 10, line 39	1-24

☐ 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	Date of mailing of the international search report
23 August 1999	27/08/1999

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	Ekhult, H

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

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 99/10392

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0732732 A	18-09-1996	US 5759360 A	02-06-1998
		JP 8321491 A	03-12-1996
JP 04002129 A	07-01-1992	NONE	
US 5494522 A	27-02-1996	JP 6267898 A	22-09-1994
		JP 6283474 A	07-10-1994
		JP 6283472 A	07-10-1994
		US 5578129 A	26-11-1996