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(54) **Title:** ELECTROSTATIC CHUCK WITH HALOGEN MODULATED SILICONE DIKE

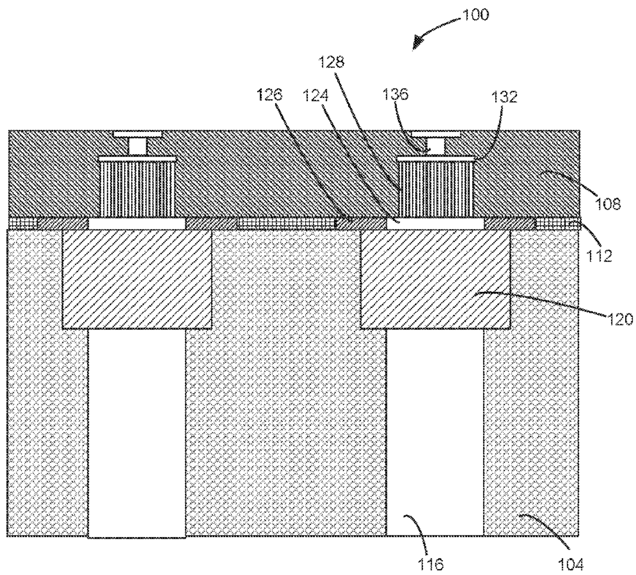

FIG. 1

(57) **Abstract:** An electrostatic chuck for use in a semiconductor processing chamber is provided. A base plate has a plurality of gas passages. A bond layer is on a surface of the base plate. A ceramic plate is on a second side of the bond layer, wherein the bond layer bonds the base plate to the ceramic plate, and wherein the ceramic plate has a plurality of gas outlets. A plurality of gas permeable plugs is in the ceramic plate, wherein each gas permeable plug is placed between a gas outlet of the plurality of gas outlets and a gas passage of the plurality of gas passages. A plurality of dikes comprising halogen modulated silicone is positioned within the bond layer and between the base plate and ceramic plate, wherein each dike of the plurality of dikes has an aperture of a plurality of apertures.

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[Continued on next page]

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ELECTROSTATIC CHUCK WITH HALOGEN MODULATED SILICONE DIKE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of priority of U.S. Application No. 63/433,366, filed December 16, 2022, which is incorporated herein by reference for all purposes.

BACKGROUND

[0002] The background description provided here is for the purpose of generally presenting the context of the disclosure. Information described in this background section, as well as aspects of the description that may not otherwise qualify as prior art at the time of filing, are neither expressly nor impliedly admitted as prior art against the present disclosure.

[0003] In various plasma processing chambers, helium (He) is flowed to a backside of a substrate on an electrostatic chuck (ESC) in order to provide temperature control. The ESC may comprise a baseplate and a ceramic plate with a bond layer between the baseplate and the ceramic plate. He may flow from the baseplate through the bond layer and then through the ceramic plate.

SUMMARY

[0004] To achieve the foregoing and in accordance with the purpose of the present disclosure, an electrostatic chuck for use in a semiconductor processing chamber is provided. A base plate has a plurality of gas passages. A bond layer is on a surface of the base plate, wherein the bond layer has a first side and a second side, wherein the base plate is on the first side of the bond layer. A ceramic plate is on the second side of the bond layer, wherein the bond layer bonds the base plate to the ceramic plate, and wherein the ceramic plate has a plurality of gas outlets. A plurality of gas permeable plugs is in the ceramic plate, wherein each gas permeable plug is placed between a gas outlet of the plurality of gas outlets and a gas passage of the plurality of gas passages. A plurality of dikes, where each dike of the plurality of dikes comprises halogen modulated silicone, is positioned within the bond layer and between the base plate and ceramic plate, wherein each dike of the plurality of dikes has an aperture of a plurality of apertures, wherein each aperture of the plurality of apertures is positioned between a gas permeable plug of the plurality of gas permeable plugs and a gas passage of the plurality of gas passages.

[0005] In another manifestation, a dike for use in a semiconductor processing chamber is provided. A dike body comprises halogen modulated silicone. An aperture is in the dike body.

[0006] In another manifestation, a method for providing a dike for use in a semiconductor processing chamber is provided. A silicone sheet is provided. The silicone sheet is exposed to a

halogen gas, wherein the halogen gas causes halogen modulation of the silicone sheet. A dike is formed from the silicone sheet.

[0007] These and other features of the present disclosure will be described in more detail below in the detailed description and in conjunction with the following figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The present disclosure is illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings and in which like reference numerals refer to similar elements and in which:

[0009] FIG. 1 is a schematic cross-sectional view of part of an electrostatic chuck (ESC) that may be used in an embodiment.

[0010] FIG. 2 is a schematic view of a processing chamber that may be used in an embodiment.

[0011] In the drawings, like reference numerals are sometimes used to designate like structural elements. It should also be appreciated that the depictions in the figures are diagrammatic and not to scale.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0012] The present disclosure will now be described in detail with reference to a few embodiments thereof as illustrated in the accompanying drawings. In the following description, numerous specific details are set forth in order to provide a thorough understanding of the present disclosure. It will be apparent, however, to one skilled in the art, that the present disclosure may be practiced without some or all of these specific details. In other instances, well-known process steps and/or structures have not been described in detail in order to not unnecessarily obscure the present disclosure.

[0013] Newer semiconductor manufacturing processes require very high RF power plasmas. Increasing RF power causes an increase in RF currents and total voltages applied to the Electrostatic Chuck (ESC - wafer susceptor). In some embodiments, 30-40 kilowatts (kW) of RF bias power are provided during processing. The ESC may comprise an electrically conductive baseplate, a ceramic plate, and a bond layer bonding the baseplate to the ceramic plate. The bonding layer may be silicone that is used like glue to bond the ceramic plate to the base plate. Some plasma etch processes require significantly lower RF frequencies (e.g. 2 MHz, 400 kHz, or lower) than previously required. Low RF frequencies cause an additional increase in RF voltage applied across ESC ceramic. High voltage applied across ceramic may cause electrical discharge (arcing) between a wafer and a baseplate or ignition (light-up) of heat transfer gas (e.g. He) in the gas supplying holes. Arcing of the ESC usually causes catastrophic destruction of the part accompanied by wafer destruction, possible damage to other chamber components, and manufacturing process interruption. In the case of the heat transfer gas light-up, ESC destruction could be either catastrophic or could slowly develop affecting multiple wafers with semiconductor device damage, being detected only at much later steps of the manufacturing process. In both cases, ESC failure causes significant loss in wafer production and manufacturer's revenue.

[0014] For low-voltage applications, it is common to use straight holes in a ceramic plate with ceramic sleeves in baseplates opposing holes in the ceramic plate and preventing direct line of sight. For mid-low voltage applications, ceramic sleeves in baseplates are replaced with porous plugs providing a higher withstand voltage than ceramic sleeves. For mid-voltage applications, porous plugs are inserted in the ceramic plate, in addition to the sleeves in the baseplate.

[0015] In order to reduce arcing at high voltage applications, plugs (made of ceramic material, e.g., alumina Al_2O_3 or aluminum nitride AlN), with small lumens (diameter 0.1-100 micrometers) may be placed in a ceramic plate along the flow path of the He. The plugs compartmentalize the gas hole volume into smaller micro-volumes that limit light-up probability by reducing the number of charged particles' collisions and prevent line of sight between a wafer and metal parts of the chuck below the top ceramic plate while ensuring needed He flow through the holes for the wafer backside cooling. Low molecular weight siloxanes may leech out from the silicone into the He flow and may cause plugging of the small lumens. The plugging of the lumens may result in improper and nonuniform cooling, causing nonuniformities in the resulting semiconductor devices.

[0016] To facilitate understanding, FIG. 1 is a schematic cross-sectional view of a spark suppression apparatus in part of an electrostatic chuck (ESC) 100 that may be used in an embodiment. In this embodiment, the ESC 100 comprises a base plate 104 bonded to a ceramic plate 108 by a bond layer 112. In this embodiment, the base plate 104 is a conductive metal base plate, e.g. aluminum. The base plate 104 has a plurality of gas passages 116. At an output end of the gas passages 116 are porous plugs 120. In some embodiments, the porous plugs 120 are porous dielectric ceramic plugs of ceramic alumina or aluminum nitride with a porosity of 30-50%. In some embodiments, the porous plugs 120 extend to the top surface of the base plate 104.

[0017] On second sides of the porous plugs 120 opposite from the first sides of the porous plugs 120 are a plurality of first plenums 124. The first sides of the porous plugs 120 are the base plate sides of the porous plugs 120. The second sides of the porous plugs 120 are ceramic plate sides of the porous plugs 120. The porous plugs 120 are on the first sides or base plate sides of the first plenums 124. The porous plugs 120 and the aperture in the base plate 104 surrounding the porous plug form part of the gas passage 116 in the base plate 104. A plurality of dikes 126 form rings around the first plenums 124 in the bond layer 112, where apertures in the plurality of dikes 126 form the first plenums 124. The surface of the base plate 104 is on the first side or base plate side of the plurality of dikes 126. On the second sides or ceramic plate sides of the first plenums 124, opposite from the first sides, is a dielectric multilumen plug 128 of a plurality of dielectric multilumen plugs, made of alumina or aluminum nitride with a plurality of small through holes and the ceramic plate 108. In some embodiments, the dielectric multilumen plug 128 is bonded to the ceramic plate 108. In some embodiments, the dielectric multilumen plug 128 is a dielectric plug that has 50 to 100,000 lumens, where each lumen has a width of between 1 micron and 200 microns. In some embodiments, the dielectric multilumen plug 128 is a dielectric plug that has 30 to 100,000 lumens. The lumens extend from a first side or base plate side of the dielectric multilumen plug 128, adjacent to the first plenum 124 to a second side or ceramic plate side of the dielectric multilumen plug 128 opposite from the first side. The ceramic plate 108 has a thickness between 0.5 mm and 3 mm. The dielectric multilumen plug 128 has a height of between 0.1 mm and 2.5 mm. In some embodiments, the lumens are straight round tubes forming a honeycomb cross-section. In some embodiments, the lumens may have a hexagonal cross section instead of a round cross section. Since the lumens are straight and extend across the height of the dielectric multilumen plug 128, the lumens have a length of between 0.1 mm and 2.5 mm. In some embodiments, the dielectric multilumen plug 128 has a diameter of 3 to 5 mm. In some embodiments, the dielectric multilumen plug 128 is made of alumina. The ceramic plate 108 is on the second side of the plurality of dikes 126.

[0018] A second plenum 132 of a plurality of second plenums is on the second side of the dielectric multilumen plug 128. At least one gas outlet 136 of a plurality of gas outlets 136 extends from the second plenum 132 to the surface of the ceramic plate 108. In some embodiments, the at least one gas outlet 136 has a diameter of between 0.02 to 0.3 mm. At the top surface of the ceramic plate 108, the at least one gas outlet 136 is shown as being wider, since the wider part may be part of a groove or channel connected between the plurality of gas outlets 136 at the top surface of the ceramic plate 108. The gas passage 116 and the at least one gas outlet 136 form a helium line, wherein the gas passage 116 is a first portion of the gas line and the at least one gas outlet 136 is a second portion of the He line. The gas outlet 136 corresponds to the gas passage 116, when gas flowing through the gas passage 116 is directed to the gas outlet 136. The gas passage 116 flows a temperature control gas, such as helium. In some embodiments, the temperature control gas is a mixture of helium and another gas or the temperature control gas may be other gases.

[0019] Some embodiments have been found to reduce arcing. As a result, damage to the wafers and the semiconductor processing chamber has been reduced. In addition, the utilization time/coefficient has been improved.

[0020] The ring shaped plurality of dikes 126 comprises halogen modulated silicone. In some embodiments, the halogen modulated silicone dike is formed by exposing a silicone body to a halogen gas, wherein the halogen gas causes halogen modulation of the silicone body. In some embodiments, the silicone body is formed from a silicone sheet, where exposure of the silicone sheet to a halogen gas results in a halogen modulated silicone sheet. The ring shaped dikes are then punched from the halogen modulated silicone sheet to form a dike body of halogen modulated silicone. Alternatively, the inner holes of the later dikes are punched out before halogenating the silicone sheet in order to halogenate not only the upper and lower surface of the later dikes but also the inner surface of the later dikes after halogenating the dikes are punched out. In some embodiments, the halogen gas is fluorine (F_2) gas, so that the halogen modulated silicone is fluorine modulated silicone. The halogen modulation, such as fluorine modulation, only converts carbon-hydrogen (C-H) bonds to carbon-fluorine (C-F) bonds, resulting in a polar structure. The hydrogen would be substituted by fluorine through radical substitution. For substituting hydrogen with other halogens (e.g. chlorine), light is applied to start the radical chain reaction. Fluorine would be the most polarizing of the halogens, resulting in the most polar structure. The polar structure reduces the amount of low molecular weight siloxanes in the dike, preventing or reducing the amount of low molecular weight siloxanes that reach the multilumen plug 128. Non-polar materials, such as siloxanes are permeable in other non-polar materials. The more polar a material is, the less permeable the polar material is to non-polar siloxanes. Since fluorine is the most polarizing halogen, the fluorinated surfaces of the dike would be least permeable to low molecular weight siloxanes. As a result, the halogen modulated silicone of the dikes prevents or reduces the plugging of the multilumen plug 128 by low molecular weight siloxanes. In some embodiments, the dike may be first formed from a silicone sheet and then subjected to halogen modulation.

[0021] In some embodiments, the multilumen plug 128 may be replaced by another gas permeable plug, such as a porous plug. In some embodiments, the lumens or pores in the plug have diameters on the order of 1 μm to 30 μm. In some embodiments, the lumens or pores in the plug have diameters on the order of 1 μm to 20 μm. In some embodiments, the lumens or pores in the plug have diameters on the order of 1 μm to 10 μm.

[0022] A fluorine modulated silicone is different from a fluorinated polymer or fluoropolymer. Fluoropolymers are fluorocarbon based polymers with multiple carbon-fluorine bonds. Examples of fluoropolymers are polyvinyl fluoride, polytetrafluoroethylene, and polychlorotrifluoroethylene. Silicone structure is -Si(R2)-O-Si(R2)-, where R2 is an organic group with C-H bonds. For fluorine modulated silicone at least one C-H bond is replaced by a C-F bond. In some embodiments, fluorine modulated silicone molecules may have two fluorine atoms bonded to different carbon atoms by single bonds. In order to manufacture rings of fluoropolymers, more expensive manufacturing processes, such as casting, would be used. In addition, some rings of fluoropolymers would be stiffer than rings of fluorine modulated silicones. Stiffer rings create more stress and increase debonding of the ceramic plate and increase temperature non-uniformities. Therefore, rings of fluorine modulated silicones are less expensive to manufacture and provide softer rings that reduce stress, reduce debonding, and increase temperature uniformity.

[0023] In order to bond the base plate 104 to the ceramic plate 108, silicone to form the bond layer is applied as a liquid. In order to prevent the silicone liquid from filing the first plenums, the dikes 126 are placed on the base plate 104 to provide a barrier to the flow of liquid silicone, so that the dikes 126 act as a seal. Silicone is used to bond the base plate 104 to the ceramic plate 108 when the silicone is cured to form the bond layer 112. In some embodiments, the bond layer 112 is not fluorine modulated silicone, so that the silicone that is not fluorine modulated may provide an improved bond between the base plate 104 and the ceramic plate 108.

[0024] In some embodiments, an outer layer of the dike 126 is fluorine modulated silicone, where the inner parts of the dike 126 are not fluorine modulated. In some embodiments, the outer layer of the dike that is a fluorine modulated silicone has a thickness in the range of 100 μm to 1000 μm. In some embodiments, the fluorine modulated silicone decreases in concentration from the surface of the dike 126 into the dike 126 to forming a decreasing gradient into the dike 126, so that there is a decreasing fluorine concentration or a decreasing halogen concentration from the surface of the dike 126 into the dike 126. The gradient may be according to a diffusion profile from a higher halogen concentration near the surface to a lower halogen concentration away from the surface.

[0025] In some embodiments, a plug is not in the base plate 104. In some embodiments, the silicone may be modulated by exposing a silicone sheet to chlorine (Cl_2) gas. However, a carbon-choride may not be as polarized as a carbon-fluoride bond. As a result, fluorine modulated silicone may provide better protection against plugging than chlorine modulated silicone.

[0026] FIG. 2 is a schematic view of an embodiment of a semiconductor processing chamber 200 that may be used for processing a semiconductor wafer. In one or more embodiments, a semiconductor processing chamber 200 comprises a gas distribution plate 206 providing a gas inlet and an electrostatic chuck (ESC) 100, within an etch chamber 249, enclosed by a chamber wall 252. Within the etch chamber 249, a wafer 203 is positioned over the ESC 100. The ESC 100 is a wafer support. An edge ring 209 surrounds the ESC 100. An ESC source 248 may provide a bias to the ESC 100. A gas source 210 is connected to the etch chamber 249 through the gas distribution plate 206. An ESC temperature control gas source 250 is connected to the ESC 100.

[0027] A radio frequency (RF) source 230 provides RF power to a lower electrode, an upper outer electrode 216, and an upper inner electrode. In this embodiment, the ESC 100 is the lower electrode and the gas distribution plate 206 is the upper inner electrode. In an exemplary embodiment, 400 kilohertz (kHz), 60 megahertz (MHz), 2 MHz, 13.56 MHz, and/or 27 MHz power sources make up the RF source 230 and the ESC source 248. In this embodiment, one generator is provided for each frequency. In other embodiments, the generators may be separate RF sources, or separate RF generators may be connected to different electrodes. Other arrangements of RF sources and electrodes may be used in other embodiments. In other embodiments, an electrode may be an inductive coil.

[0028] A controller 235 is controllably connected to the RF source 230, the ESC source 248, an exhaust pump 220, and the gas source 210. A high flow liner 204 is a liner within the etch chamber 249. The high flow liner 204 in this embodiment is a C-shroud and confines gas from the gas source and has slots 202. The high flow liner 204 allows for a controlled flow of gas to pass from the gas source 210 to the exhaust pump 220.

[0029] During processing, He gas may be provided from the ESC temperature control gas source 250 to the backside of the ESC 100 to provide heat transfer. The RF source 230 provides power to form a plasma. The plasma may cause arcing. The multilumen plug 128 (FIG. 1) reduces arcing and therefore reduces ESC 100 damage. The dikes 126 of a halogen modulated silicone reduce plugging of the multilumen plug 128.

[0030] While this disclosure has been described in terms of several embodiments, there are alterations, modifications, permutations, and various substitute equivalents, that fall within the scope of this disclosure. It should also be noted that there are many alternative ways of implementing the methods and apparatuses of the present disclosure. It is therefore intended that the following appended claims be interpreted as including all such alterations, modifications, permutations, and various substitute equivalents as fall within the true spirit and scope of the present disclosure. As used herein, the phrase "A, B, or C" should be construed to mean a logical ("A OR B OR C"), using a non-exclusive logical "OR," and should not be construed to mean 'only one of A or B or C. Each step within a process may be an optional step and is not required. Different embodiments may have one or more steps removed or may provide steps in a different order. In addition, various embodiments may provide different steps simultaneously instead of sequentially.

CLAIMS

What is claimed is:

1. An electrostatic chuck for use in a semiconductor processing chamber, comprising:

a base plate with a plurality of gas passages in the base plate;

a bond layer on a surface of the base plate, wherein the bond layer has a first side and a second side, wherein the base plate is on the first side of the bond layer;

a ceramic plate on the second side of the bond layer, wherein the bond layer bonds the base plate to the ceramic plate, and wherein the ceramic plate has a plurality of gas outlets;

a plurality of gas permeable plugs in the ceramic plate, wherein each gas permeable plug is placed between a gas outlet of the plurality of gas outlets and a gas passage of the plurality of gas passages; and

a plurality of dikes wherein each dike of the plurality of dikes comprises halogen modulated silicone and is positioned within the bond layer and between the base plate and ceramic plate, wherein each dike of the plurality of dikes has an aperture of a plurality of apertures, wherein each aperture of the plurality of apertures is positioned between a gas permeable plug of the plurality of gas permeable plugs and a gas passage of the plurality of gas passages.

2. The electrostatic chuck, as recited in claim 1, wherein each gas permeable plug of the plurality of gas permeable plugs is a multilumen plug.

3. The electrostatic chuck, as recited in claim 2, wherein each gas permeable plug of the plurality of gas permeable plugs has lumens with a width in a range of 1 micron and 30 microns.

4. The electrostatic chuck, as recited in claim 3, wherein the multilumen plug has 30 to 100,000 lumens.

5. The electrostatic chuck, as recited in claim 1, further comprising a plurality of first plenums, wherein each first plenum of the plurality of first plenums is defined by an aperture of the plurality of apertures.

6. The electrostatic chuck, as recited in claim 1, wherein each dike of the plurality of dikes has a gradient of decreasing halogen concentration from a surface of each dike.

7. The electrostatic chuck, as recited in claim 1, wherein the bond layer comprises silicone.

8. The electrostatic chuck, as recited in claim 1, wherein the halogen modulated silicone is fluorine modulated silicone.

9. A dike for use in a semiconductor processing chamber, comprising:

a dike body comprising halogen modulated silicone; and

an aperture in the dike body.

10. The dike recited in claim 9, wherein the dike body has a gradient of decreasing halogen concentration from a surface of the dike body.

11. The dike, as recited in claim 9, wherein the halogen modulated silicone is fluorine modulated silicone.

12. A method for providing a dike for use in a semiconductor processing chamber, comprising:

providing a silicone sheet;

exposing the silicone sheet to a halogen gas, wherein the halogen gas causes halogen modulation of the silicone sheet; and

forming a dike from the silicone sheet.

13. The method, as recited in claim 12, wherein the forming the dike from the silicone sheet comprises punching the dike out of the silicone sheet.

14. The method, as recited in claim 12, wherein the dike is formed from the silicone sheet after the silicone sheet is exposed to the halogen gas.

15. The method, as recited in claim 12, wherein the dike is formed from the silicone sheet before the silicone sheet is exposed to the halogen gas.

16. The method, as recited in claim 12, wherein the halogen modulation of the silicone sheet forms a gradient of decreasing halogen concentration from a surface of the silicone sheet.

17. The method, as recited in claim 12, wherein the exposing the silicone sheet to a halogen gas, exposes the silicone sheet to fluorine gas.

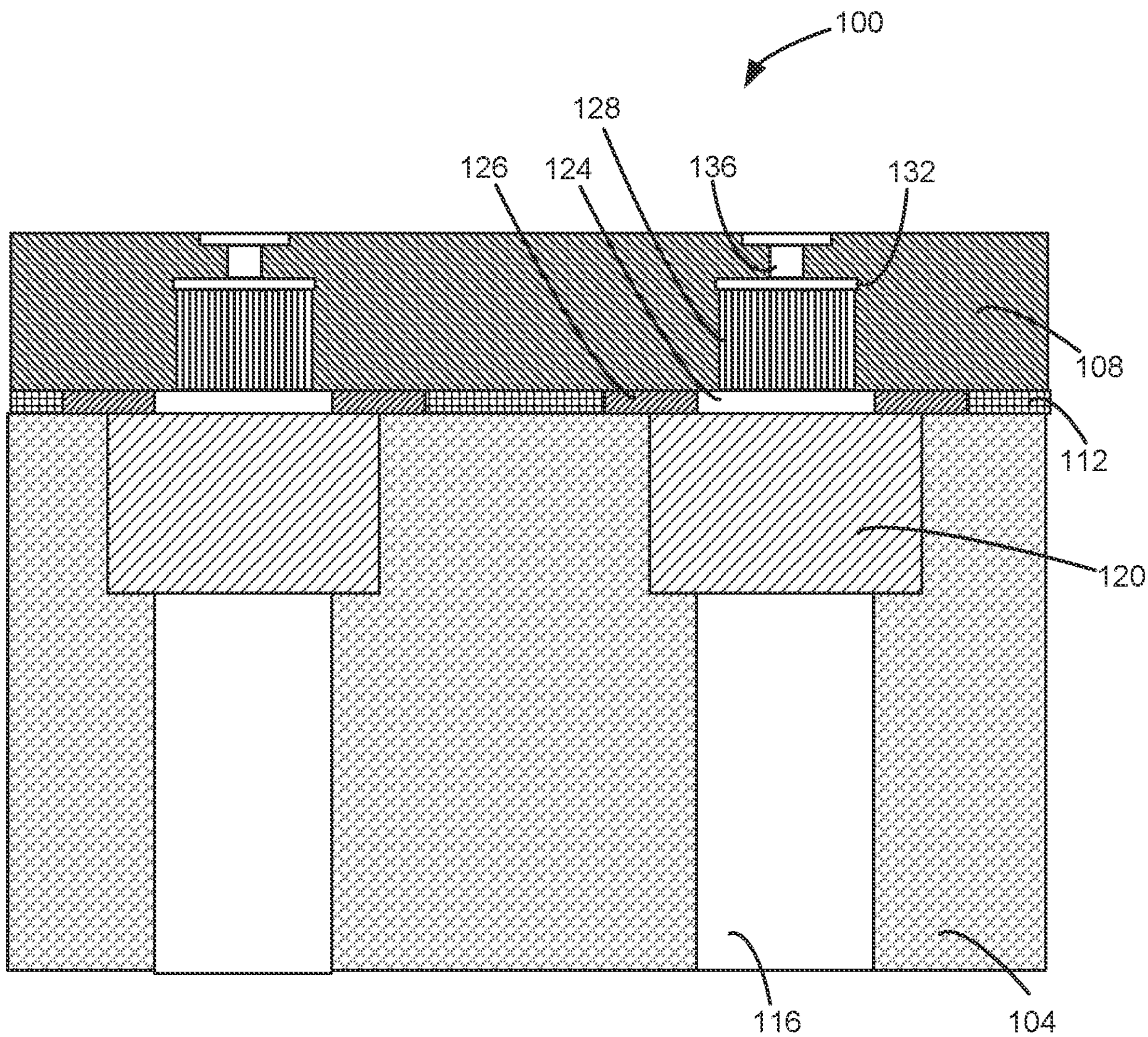

FIG. 1

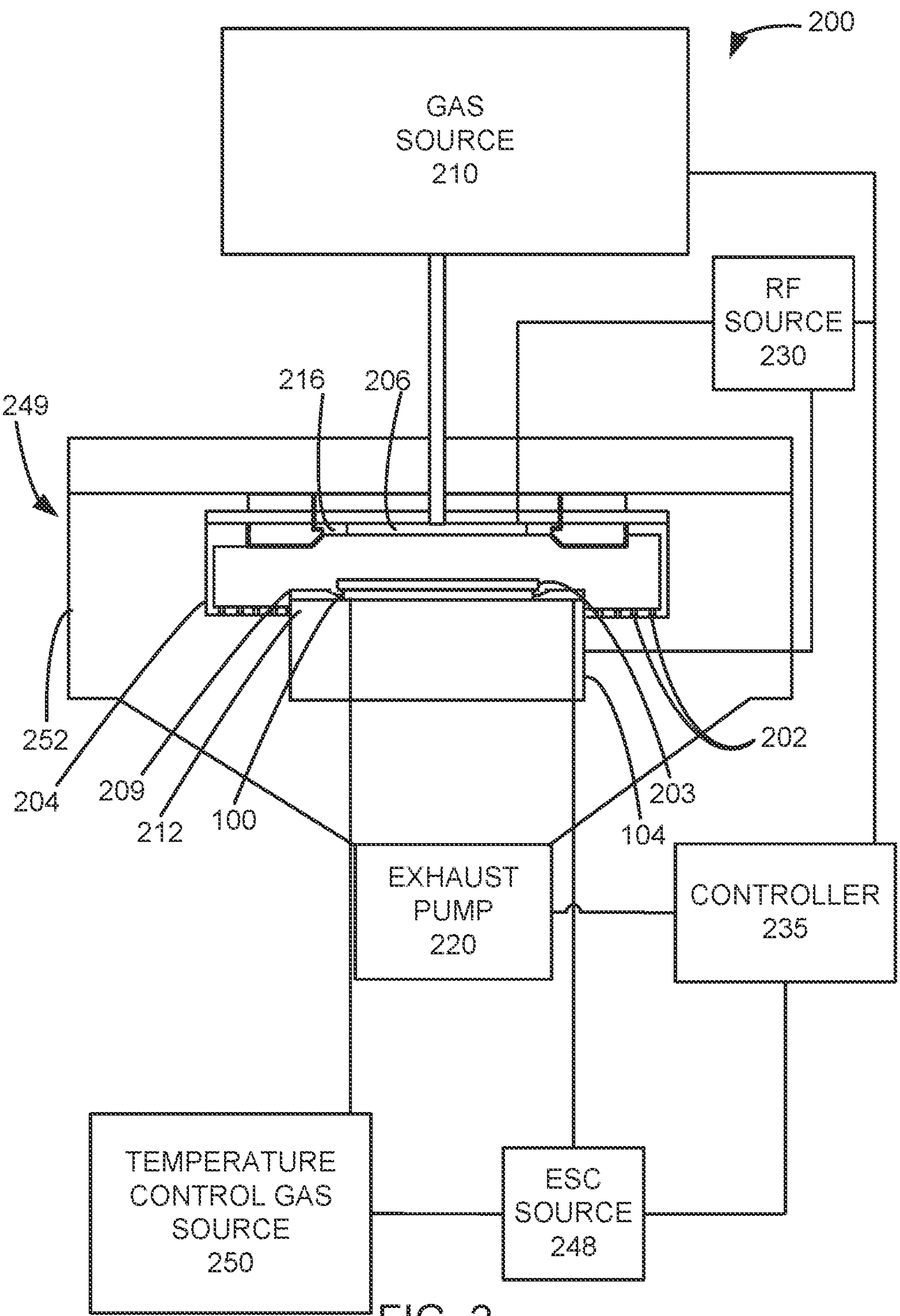
200
GAS SOURCE 210
RF SOURCE 230
216
206
249
252
204
209
212
100
104
203
202
EXHAUST PUMP 220
CONTROLLER 235
TEMPERATURE CONTROL GAS SOURCE 250
ESC SOURCE 248

FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2023/079660

A. CLASSIFICATION OF SUBJECT MATTER

H01L 21/683(2006.01)i; **H01L 21/67**(2006.01)i; **H01L 21/687**(2006.01)i

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)

H01L 21/683(2006.01); B32B 3/26(2006.01); B32B 5/18(2006.01); F16J 15/10(2006.01); H01J 37/32(2006.01); H01L 21/3065(2006.01); H01L 21/67(2006.01); H01L 21/673(2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: dike, halogen, silicone, aperture, bond, electrostatic chuck, fluorine

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2022-0172975 A1 (APPLIED MATERIALS, INC.) 02 June 2022 (2022-06-02) paragraphs [0020]-[0053] and figures 2, 8	1-8
A		9-17
X	CN 217328438 U (YANGTZE MEMORY TECHNOLOGIES CO., LTD.) 30 August 2022 (2022-08-30) paragraphs [0001], [0012]-[0054] and figures 1-3	9-11
Y		1-8,12-17
Y	US 2022-0223387 A1 (LAM RESEARCH CORPORATION) 14 July 2022 (2022-07-14) paragraph [0022] and figure 1	2-4
Y	KR 10-2008-0039110 A (HYNIX SEMICONDUCTOR INC.) 07 May 2008 (2008-05-07) paragraphs [0038]-[0047] and figures 4-6	12-17

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent 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
12 March 2024	**12 March 2024**

Name and mailing address of the ISA/KR	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2023/079660

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2022-0063236 A1 (APPLIED MATERIALS, INC.) 03 March 2022 (2022-03-03) paragraphs [0022], [0023]	1-17

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/US2023/079660

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	2022-0172975	A1	02 June 2022	CN	113853672	A	28 December 2021
				JP	2022-535508	A	09 August 2022
				JP	7387764	B2	28 November 2023
				KR	10-2021-0158874	A	31 December 2021
				TW	202114014	A	01 April 2021
				TW	202318550	A	01 May 2023
				TW	I789585	B	11 January 2023
				US	11380572	B2	05 July 2022
				US	11651987	B2	16 May 2023
				US	2020-0373184	A1	26 November 2020
				WO	2020-242661	A1	03 December 2020
CN	217328438	U	30 August 2022	None			
US	2022-0223387	A1	14 July 2022	CN	112970091	A	15 June 2021
				JP	2022-512852	A	07 February 2022
				KR	10-2021-0072114	A	16 June 2021
				TW	202033060	A	01 September 2020
				WO	2020-092412	A1	07 May 2020
KR	10-2008-0039110	A	07 May 2008	None			
US	2022-0063236	A1	03 March 2022	CN	109599356	A	09 April 2019
				CN	209461436	U	01 October 2019
				CN	211700228	U	16 October 2020
				JP	2019-068044	A	25 April 2019
				JP	2023-171803	A	05 December 2023
				JP	7353024	B2	29 September 2023
				KR	10-2019-0039389	A	11 April 2019
				TW	201916246	A	16 April 2019
				TW	202312345	A	16 March 2023
				TW	I786194	B	11 December 2022
				TW	I806799	B	21 June 2023
				US	10688750	B2	23 June 2020
				US	11192323	B2	07 December 2021
				US	11794441	B2	24 October 2023
				US	2019-0099977	A1	04 April 2019
				US	2020-0276785	A1	03 September 2020