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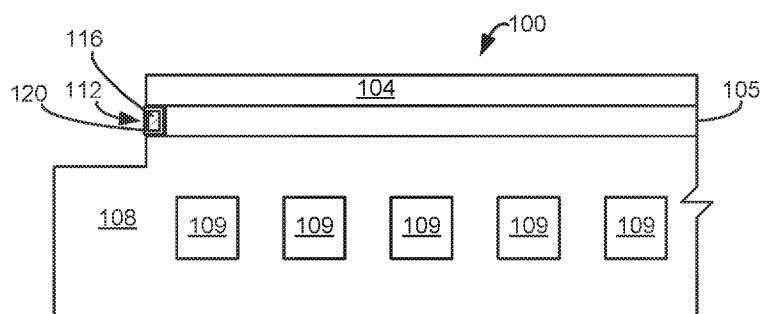


FIG. 1

(57) Abstract: A coated O-ring for use in a plasma processing chamber is provided. The O-ring has a ring-shaped elastomeric body. A coating, comprising a fluoropolymer, covers the ring-shaped elastomeric body, wherein the coating has a higher concentration of fluoropolymer than the ring-shaped elastomeric body or the ring-shaped elastomeric body is fluoropolymer free.



COATED O-RING FOR PROTECTING AN ELECTROSTATIC CHUCK IN A PLASMA PROCESSING CHAMBER

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of priority of U.S. Application No.
5 62/860,666, filed June 12, 2019, which is incorporated herein by reference for all
purposes.

BACKGROUND

[0002] This disclosure relates to components in plasma processing chambers used
in semiconductor processing. More specifically, the disclosure relates to electrostatic
10 chucks used in plasma processing chambers.

[0003] In plasma processing chambers, electrostatic chucks are used to support
substrates being processed. The electrostatic chucks may be subjected to different
temperatures and various plasma processes. Some electrostatic chucks provide a
ceramic plate bonded to a metal base plate. A bonding material bonds the ceramic
15 plate to the metal base plate and is sufficiently flexible to accommodate different
coefficients of thermal expansion for the ceramic plate and metal base plate. The
bonding material also may provide electrical and thermal conductivity between the
ceramic plate and the metal base plate. Some of the bonding material may be exposed
to radicals during plasma processing. The radicals may degrade and/or erode the
20 bonding material.

SUMMARY

[0004] To protect the bonding material in electrostatic chucks and in accordance
with the purpose of the present disclosure, a coated O-ring for use to protect a
bonding material in an electrostatic chuck in a plasma processing chamber is
25 provided. The O-ring has a ring-shaped elastomeric body. A coating, comprising a
fluoropolymer, covers the ring-shaped elastomeric body, wherein the coating has a
higher concentration of fluoropolymer than the ring-shaped elastomeric body or the
ring-shaped elastomeric body is fluoropolymer free.

[0005] In another manifestation, an electrostatic chuck system for a plasma
30 processing chamber is provided. A base plate is provided. A ceramic plate is disposed
over the base plate. A bonding layer bonds the ceramic plate to the base plate. A
coated O-ring surrounds the bonding layer between the ceramic plate and base plate,

where the coated O-ring comprises a ring-shaped elastomeric body and a coating, comprising a fluoropolymer, covering the ring-shaped elastomeric body, wherein the coating has a higher concentration of fluoropolymer than the ring-shaped elastomeric body or the ring-shaped elastomeric body is fluoropolymer free.

- 5 **[0006]** The foregoing summary is illustrative only and is not intended to be limiting. These and other features of the present disclosure will be described in more detail below in the detailed description of the disclosure and in conjunction with the following figures.

BRIEF DESCRIPTION OF THE DRAWINGS

- 10 **[0007]** The disclosed embodiments are 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:
- [0008]** FIG. 1 illustrates a partial cross-sectional view of an electrostatic chuck according to certain embodiments.
- 15 **[0009]** FIG. 2 illustrates a cross-sectional view of an O-ring used in the electrostatic chuck shown in FIG. 1, removed from the electrostatic chuck.
- [0010]** FIG. 3 illustrates a schematic layout of an etch reactor that may be used with an O-ring according to certain embodiments.

DETAILED DESCRIPTION

- 20 **[0011]** Embodiments will now be described in detail with reference to a few of the embodiments thereof as illustrated in the accompanying drawings. In the following description, specific details are set forth in order to provide a thorough understanding of the present disclosure. However, the present disclosure may be practiced without some or all of these specific details, and the disclosure encompasses
- 25 modifications which may be made in accordance with the knowledge generally available within this field of technology. Well-known process steps and/or structures have not been described in detail in order to not unnecessarily obscure the present disclosure.
- [0012]** Certain electrostatic chuck (ESC) systems may require bonding a ceramic
- 30 material to a heat sinking (cooling) base plate made from metal. In an embodiment of an electrostatic chuck, a ceramic plate is bonded to a metal base plate by a bonding material. The bonding material is sufficiently flexible to accommodate different

coefficients of thermal expansion for the ceramic plate and metal base plate.

According to some embodiments, the bonding material may also provide electrical and thermal conductivity between the ceramic plate and the metal base plate. In some embodiments, an O-ring is provided to protect the bonding material. In these
5 embodiments, the O-ring would prevent the bonding material from being exposed to radicals during plasma processing and thus prevent the radicals from degrading and/or eroding the bonding material.

[0013] FIG. 1 illustrates a partial cross-sectional view of an electrostatic chuck (ESC) 100 forming part of an electrostatic chuck system according to certain
10 embodiments. In FIG. 1, a ceramic plate 104 is bonded by a bonding layer 105 to a base plate 108. In some embodiments, the base plate 108 is made of metal. The bonding layer 105, according to some embodiments, may be a polymer adhesive, such as silicone with filler particles to increase the thermal conductivity of the polymer adhesive. In some embodiments, the base plate 108 may contain channels 109 for gas
15 or liquid flow. These channels may, for example, be formed in complex distribution channels in order to cool or heat the electrostatic chuck 100. In some embodiments, the ceramic plate 104 comprises aluminum oxide or aluminum nitride. In FIG. 1, an O-ring 112 is placed around the ESC 100 surrounding the bonding layer 105. According to certain embodiments, the O-ring 112 has a ring-shaped elastomeric body
20 116 and a coating 120 covering the ring-shaped elastomeric body 116. According to some embodiments, the ring-shaped elastomeric body 116 does not contain a fluoropolymer and therefore is fluoropolymer free, but the coating 120 contains a fluoropolymer. In some other embodiments, both the ring-shaped elastomeric body 116 and the coating 120 contain fluoropolymers, but the coating 120 has a higher
25 concentration of fluoropolymer than the ring-shaped elastomeric body 116 or the ring-shaped elastomeric body 116 is fluoropolymer free.

[0014] In an embodiment, the base plate 108 is formed from at least one of aluminum (Al) or aluminum – silicon carbide (Al-SiC). The ceramic plate 104 contains aluminum oxide or aluminum nitride. And, the bonding layer 105 contains
30 silicone.

[0015] FIG. 2 is an enlarged schematic cross-sectional view of the O-ring 112 shown in FIG. 1, removed from the ESC 100 (shown in FIG. 1). The O-ring 112

comprises the ring-shaped elastomeric body 116 and the coating 120. The ring-shaped elastomeric body 116 may contain silicone rubber. In some embodiments, the ring-shaped elastomeric body 116 further comprises conductive filler 124. The conductive filler 124 may be electrically conductive or thermally conductive or both. In some
5 embodiments, the bonding layer 105 (shown in FIG.1) may also contain conductive filler. If the O-ring 112 and bonding layer 105 are equally thermally conductive and electrically conductive, heat and electrical fields may pass uniformly through both the O-ring 112 and bonding layer 105, so that heat and/or electrical charge may be uniform across a substrate. As a result, the substrate may be more uniformly
10 processed.

[0016] In an embodiment, the thickness of the coating 120 is 0.006 ± 0.0004 inches (0.15 ± 0.01 mm). In some embodiments, the thickness of the coating 120 is between 0.05 mm and 1.5 mm. In some embodiments, the thickness (T) of the ring-shaped elastomeric body 116 is about 0.030 inches (0.76 mm) and the thickness (t) of
15 the coating 120 is about 0.010 inches (0.25 mm). In certain embodiments, the thickness (T) of the ring-shaped elastomeric body 116 is at least two times the thickness (t) of the coating 120. In other embodiments, the thickness (T) of the ring-shaped elastomeric body 116 is at least three times the thickness (t) of the coating 120.

20 **[0017]** In various embodiments, the ring-shaped elastomeric body 116 may contain at least one of silicone rubber, fluoroelastomers (FKM), perfluoroelastomers (FFKM), fluorosilicone (FVMQ, FMQ, FPM, FSI). In some embodiments, the ring-shaped elastomeric body 116 is able to stretch to at least two times the original length. Therefore, the ring-shaped elastomeric body 116 is able to have an elongation at break
25 of at least 100%. In other embodiments, the ring-shaped elastomeric body 116 is able to stretch to at least three times the original length, so that the ring-shaped elastomeric body 116 is able to have an elongation at break of at least 200%. Elongation at break is a term of art defined as a ratio between increased length at the time of breakage divided by initial length and is expressed as a percentage.

30 **[0018]** According to certain embodiments, an O-ring 112 of the present disclosure contains a fluoropolymer. Fluoropolymers may be at least one of perfluoroalkoxy alkane (PFA) or fluorinated ethylene propylene (FEP) or modified

polytetrafluoroethylene (modified PTFE). In some embodiments, a fluoropolymer coating contains carbon atoms, wherein each carbon atom of the fluoropolymer is bonded to at least two fluorine atoms. In these embodiments, the coating 120 is at least 90% fluoropolymers by weight. Fluoropolymers are generally more etch
5 resistant than other elastomers. However, fluoropolymers are not as elastic as other elastomers. The fluoropolymer is able to stretch to be no more than two times the original length so that the coating has an elongation at break of no more than 100%. If the ring-shaped elastomeric body 116 were made of fluoropolymers then the ring-shaped elastomeric body 116 would not be sufficiently elastic. The coating 120
10 comprising a fluoropolymer and the ring-shaped elastomeric body 116 not having a fluoropolymer provides an O-ring 112 that is able to stretch to be at least two times the original length and will be etch resistant.

[0019] In an embodiment, a silicone rubber ring may first form the ring-shaped elastomeric body 116. The coating 120 may then be applied around the ring-shaped
15 elastomeric body 116. In another embodiment, the coating 120 may be formed as a hollow tube. Silicone rubber gel or curable fluoroelastomer or perfluoroelastomer may be injected into the coating 120 so that the silicone rubber gel or curable fluoroelastomer or perfluoroelastomer forms the ring-shaped elastomeric body 116. In some embodiments, conductive filler 124 may be mixed with the silicone rubber gel.
20 In some embodiments, the conductive filler 124 may be one or more of metal particles, such as copper, aluminum, or silver, and carbon structures, such as graphene, nanoparticles and nanotubes and semiconductor materials, such as silicon or doped silicon. In addition, in various embodiments, O-rings 112 of the present disclosure may be used at a wide temperature range from temperatures from below -
25 60° C to temperatures above 300° C without losing its sealing effect. If the sealing effect is diminished, the bonding layer 105 and other components of the ESC 100 (shown in FIG. 1) are more easily eroded.

[0020] FIG. 3 is a schematic view of an etch reactor with the ESC 100 in FIG. 1 embedded within. According to some embodiments, the etch reactor includes a
30 plasma processing chamber system 300 comprising a gas distribution plate 306 providing a gas inlet and the ESC 100, within a processing chamber 308, enclosed by a chamber wall 310. Within the processing chamber 308, a substrate 314 is positioned

over the ESC 100. The ESC 100 comprises the ceramic plate 104 bonded to the base plate 108 by the bonding layer 105. The bonding layer 105 is surrounded by the O-ring 112. An edge ring 311 surrounds the ESC 100. An ESC temperature controller 350 is connected to a chiller 318. In some embodiments, the chiller 318 provides a coolant to channels 109 in the base plate 108 of the ESC 100. Various embodiments may be used in plasma processing chamber systems 300 that may operate at a temperature range where the ESC 100 is cooled to temperatures of less than -40° C and heated to temperatures above 200° C.

[0021] In an embodiment, a radio frequency (RF) source 330 provides RF power to a lower electrode. In this embodiment, the lower electrode is a facility plate 320 below the base plate 108 and separated from the base plate 108 by a mount O-ring 324. In an exemplary embodiment, 400 kHz and 60 MHz power sources make up the RF source 330. In this embodiment, an upper electrode, the gas distribution plate 306, is grounded. In this embodiment, one generator is provided for each frequency. Other arrangements of RF sources and electrodes may be used in other embodiments. Referring back to FIG. 3, in some embodiments, a controller 335 is controllably connected to the RF source 330, an exhaust pump 328, and a gas source 332. An example of such plasma processing chamber system 300 is the Flex® etch system manufactured by Lam Research Corporation of Fremont, CA. The processing chamber 308 can be a CCP (capacitively coupled plasma) reactor or an ICP (inductively coupled plasma) reactor. The processing chamber 308 may be a dielectric etch chamber or conductive etch chamber. In other embodiments, the plasma processing chamber system 300 may be used for other plasma processes besides etching.

[0022] According to some embodiments, the O-ring 112 is elastic and can be easily removed and replaced. For example, the O-ring 112 may be stretched and then placed around the bonding layer 105. In another example, a device may be used to press the O-ring 112 between the ceramic plate 104 and the base plate 108. For removal, the O-ring 112 may be stretched or cut for removal. In some embodiments, the O-ring 112 has sufficient etch resistance such that the O-ring 112 may be able to last for more than three months between replacements. In other embodiments, the O-ring 112 may last for more than a year between replacements. Since the O-ring 112

has such a long lifetime between replacements, downtime is reduced. In addition, the O-ring 112 allows for minimal additional servicing of the ESC 100. In addition, the O-ring 112 reduces erosion of the ESC 100, preventing or reducing the need to repair or replace the ESC 100. As a result, downtime, replacement costs, and service costs are further reduced. In the past, ESC 100 failure has been a major concern. ESC 100 failure had been one of the top ten parts to fail in certain processing chambers 308. It is believed that the O-ring 112 will reduce ESC 100 failure by five to ten times.

[0023] While the disclosure has been described in terms of several preferred embodiments, there are alterations, permutations, and various substitute equivalents, which fall within the scope of this disclosure. There are many alternative ways of implementing the methods and apparatuses disclosed herein. It is therefore intended that the following appended claims be interpreted as including all such alterations, permutations, and various substitute equivalents as fall within the true spirit and scope of the present disclosure.

15

CLAIMS

What is claimed is:

1. A coated O-ring for use in a plasma processing chamber, comprising:
a ring-shaped elastomeric body; and
5 a coating, comprising a fluoropolymer, covering the ring-shaped elastomeric body, wherein the coating has a higher concentration of fluoropolymer than the ring-shaped elastomeric body or the ring-shaped elastomeric body is fluoropolymer free.
2. The coated O-ring, as recited in claim 1, wherein the fluoropolymer of the coating comprises carbon atoms, wherein each carbon atom of the fluoropolymer is
10 bonded to at least two fluorine atoms.
3. The coated O-ring, as recited in claim 1, wherein the coating has a thickness of between about 0.05 mm and 1.5 mm.
4. The coated O-ring, as recited in claim 1, wherein the ring-shaped elastomeric body comprises at least one of silicone rubber, fluoroelastomers (FKM),
15 perfluoroelastomers (FFKM), or fluorosilicone (FVMQ, FMQ, FPM, FSI).
5. The coated O-ring, as recited in claim 1, wherein the fluoropolymer is at least one of a perfluoroalkoxy alkane or a fluorinated ethylene propylene or modified polytetrafluoroethylene.
6. The coated O-ring, as recited in claim 1, wherein the ring-shaped elastomeric
20 body has an elongation at break of at least 100%.
7. The coated O-ring, as recited in claim 6, wherein the coating has an elongation at break of no more than 100%.
8. The coated O-ring, as recited in claim 1, wherein the ring-shaped elastomeric body further comprises a filler, wherein the filler is at least one of a thermally
25 conductive or an electrically conductive.
9. The coated O-ring, as recited in claim 8, wherein the filler is both thermally conductive and electrically conductive.
10. An electrostatic chuck system for a plasma processing chamber, comprising:
a base plate;
30 a ceramic plate disposed over the base plate;
a bonding layer bonding the ceramic plate to the base plate; and
a coated O-ring surrounding the bonding layer between the ceramic plate and

base plate, wherein the coated O-ring comprises:

a ring-shaped elastomeric body; and

a coating, comprising a fluoropolymer, covering the ring-shaped elastomeric body, wherein the coating has a higher concentration of fluoropolymer than the ring-shaped elastomeric body or the ring-shaped elastomeric body is fluoropolymer free.

11. The electrostatic chuck system, as recited in claim 10, wherein the fluoropolymer of the coating comprises carbon atoms, wherein each carbon atom of the fluoropolymer is bonded to at least two fluorine atoms.

12. The electrostatic chuck system, as recited in claim 10, wherein the coating has a thickness of between about 0.05 mm and 1.5 mm.

13. The electrostatic chuck system, as recited in claim 10, wherein the ring-shaped elastomeric body comprises at least one of silicone rubber, fluoroelastomers (FKM), perfluoroelastomers (FFKM), or fluorosilicone (FVMQ, FMQ, FPM, FSI).

14. The electrostatic chuck system, as recited in claim 10, wherein the fluoropolymer is at least one of a perfluoroalkoxy alkane or a fluorinated ethylene propylene or modified polytetrafluoroethylene.

15. The electrostatic chuck system, as recited in claim 10, wherein the ring-shaped elastomeric body has an elongation at break of at least 100%.

16. The electrostatic chuck system, as recited in claim 15, wherein the coating has an elongation at break of no more than 100%.

17. The electrostatic chuck system, as recited in claim 10, wherein the ring-shaped elastomeric body further comprises a filler, wherein the filler is at least one of a thermally conductive or an electrically conductive.

18. The electrostatic chuck system, as recited in claim 17, wherein the filler is both thermally conductive and electrically conductive.

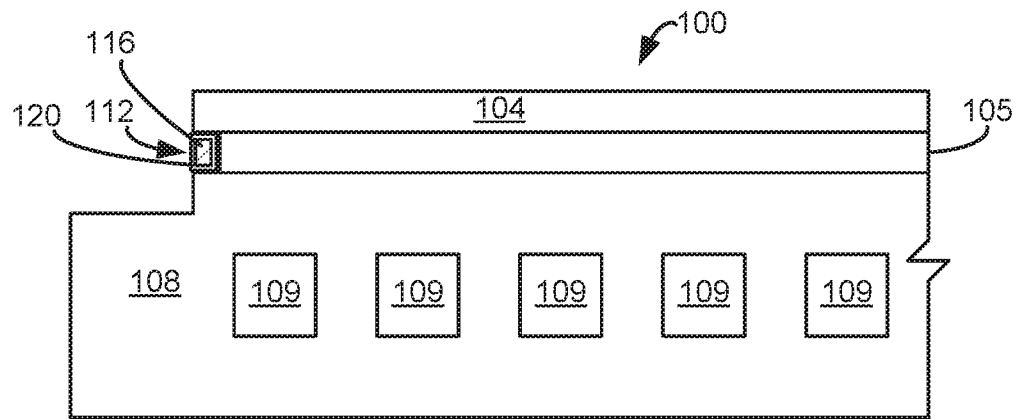


FIG. 1

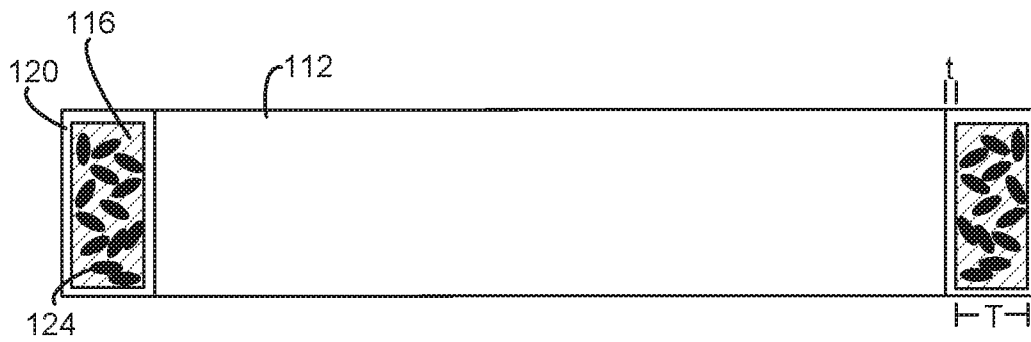


FIG. 2

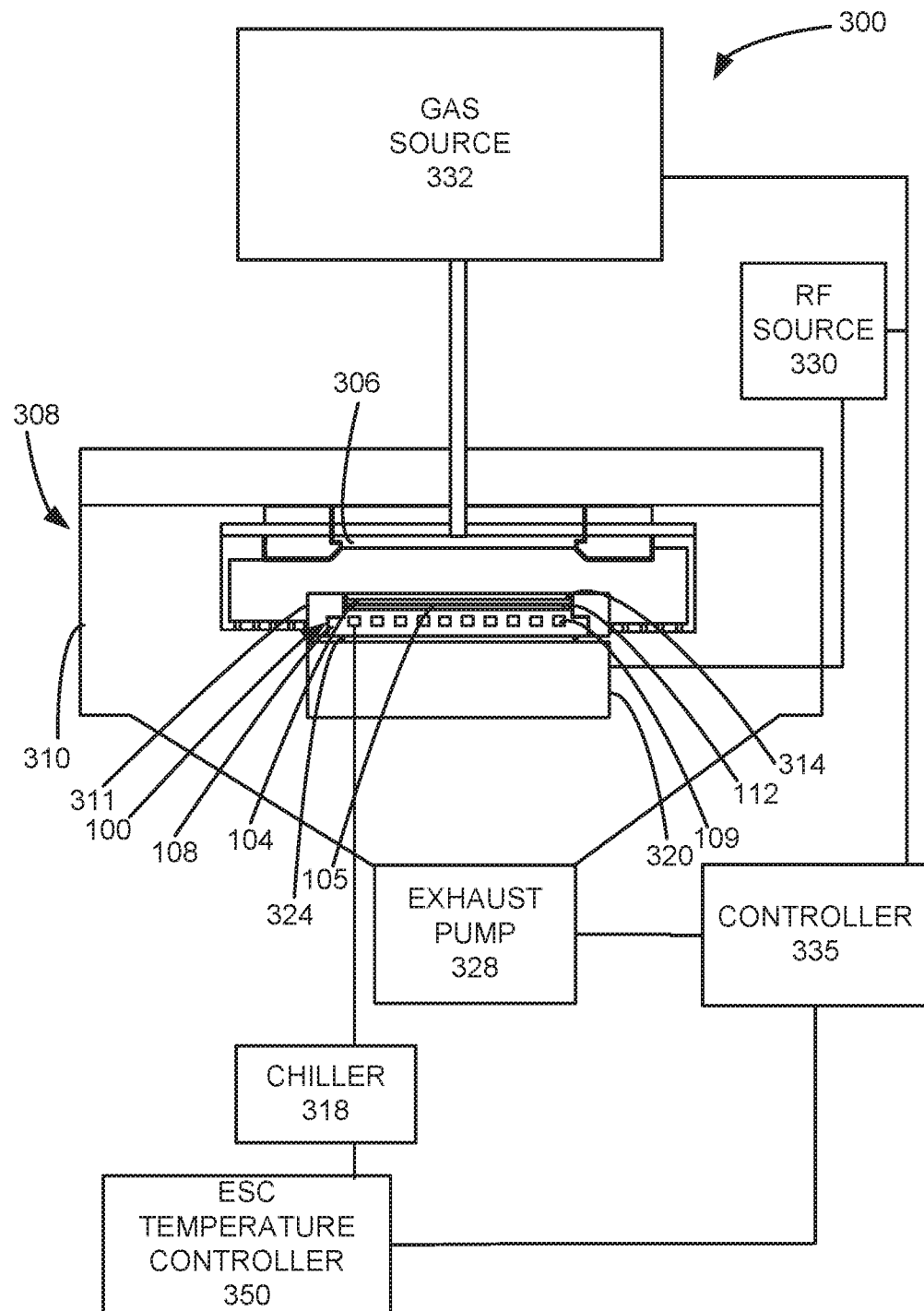


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2020/035765**A. CLASSIFICATION OF SUBJECT MATTER****H01J 37/32(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)

H01J 37/32; C23C 16/00; C23F 1/08; F16J 15/06; F16J 15/10; H01L 21/66; H01L 21/67; H01L 21/683

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: plasma, chamber, electrostatic chuck, coating, O-ring, elastomeric, fluoropolymer

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2011-0083806 A1 (TSUYOSHI NOGUCHI et al.) 14 April 2011 See paragraphs 23-151, claims 1-10 and figures 1-3.	1-18
Y	US 2015-0187614 A1 (LAM RESEARCH CORPORATION) 02 July 2015 See paragraphs 16-34, claims 1-18 and figures 1-7.	1-18
A	JP 2008-164079 A (NICHIAS CORP.) 17 July 2008 See the entire document.	1-18
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A	US 2010-0142114 A1 (ASHWIN M. PUROHIT et al.) 10 June 2010 See the entire document.	1-18



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

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

16 September 2020 (16.09.2020)

Date of mailing of the international search report

16 September 2020 (16.09.2020)

Name and mailing address of the ISA/KR

International Application Division

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2020/035765

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