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- (81) **Designated States** (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
- (84) **Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) **Title:** SUBSTRATE SUPPORT WITH IMPROVED RF RETURN

(57) **Abstract:** Apparatus for processing a substrate are provided herein. In some embodiments, a substrate support includes a body having a support surface; an RF electrode disposed in the body proximate the support surface to receive RF current from an RF source; a shaft to support the body; a conductive element having an interior volume and extending through the shaft, wherein the conductive element is coupled to the RF electrode; and an RF gasket; wherein the conductive element includes features that engage the RF gasket to return the RF current to ground.

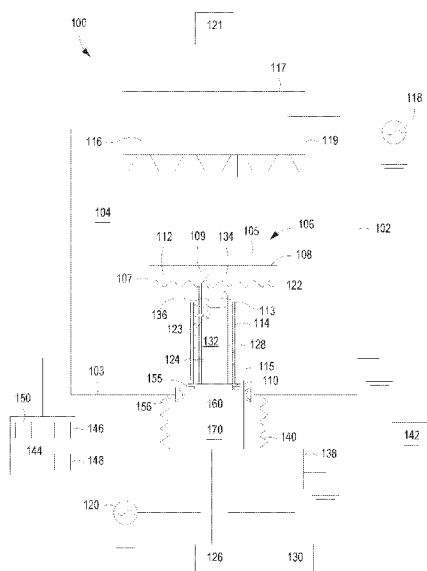


FIG. 1



Published:

— *with international search report (Art. 21(3))*

SUBSTRATE SUPPORT WITH IMPROVED RF RETURN

FIELD

[0001] Embodiments of the present disclosure generally relate to substrate processing systems, and more specifically to substrate supports for use in substrate processing systems.

BACKGROUND

[0002] Substrate processing apparatus typically include a substrate support to support a substrate during processing. The substrate support may include a radio frequency (RF) electrode disposed proximate a substrate processing surface to receive RF current from an RF source. For example, the RF electrode may act as an RF return to ground or have the RF source coupled to the RF electrode. The RF electrode may be coupled to a rod, a wire, or the like to provide RF current to the RF electrode or to return the RF current to ground. The substrate support may further include a heater disposed proximate the substrate processing surface to heat a substrate when disposed on the substrate processing surface. However, the inventors have observed that thermocouples and AC power leads that are in the path of the RF return path are adversely affected by RF noise.

[0003] Thus, the inventors have provided an improved substrate processing apparatus.

SUMMARY

[0004] Apparatus for processing a substrate are provided herein. In some embodiments, a substrate support includes a body having a support surface; an RF electrode disposed in the body proximate the support surface to receive RF current from an RF source; a shaft to support the body; a conductive element having an interior volume and extending through the shaft, wherein the conductive element is coupled to the RF electrode; and an RF gasket; wherein the conductive element includes features that engage the RF gasket to return the RF current to ground.

[0005] In some embodiments, a substrate processing system includes a process chamber enclosing a processing volume; and a substrate support disposed in the processing volume. The substrate support includes a body having a support surface;

an RF electrode disposed in the body proximate the support surface to receive RF current from an RF source; a shaft to support the body; a conductive element having an interior volume and extending through the shaft, wherein the conductive element is coupled to the RF electrode; and an RF gasket, wherein the conductive element includes features that engage the RF gasket to return the RF current to ground.

[0006] In some embodiments, a substrate support includes a body having a support surface; an RF electrode disposed in the body proximate the support surface to receive RF current from an RF source; a shaft to support the body; a conductive element having an interior volume and extending through the shaft, wherein the conductive element is coupled to the RF electrode; and an RF gasket, wherein the conductive element includes features that engage the RF gasket to return the RF current to ground; a heat transfer body to transfer heat to or from the substrate support; an adapter portion coupled between the shaft and the heat transfer body, wherein the RF gasket is disposed between the adapter portion and the heat transfer body; a heater disposed in the substrate support proximate the support surface to provide heat to a substrate when disposed on the support surface, the heater having one or more conductive lines disposed in the interior volume of the conductive element to provide power to the heater; a thermocouple disposed in the interior volume of the conductive element to measure a temperature of a substrate when disposed on the support surface; and an annular biasable element surrounding the adapter portion, wherein the annular biasable element contacts the adapter portion when the substrate support is in a processing position, wherein the annular biasable element is spaced apart from the adapter portion when the substrate support is not in the processing position, and wherein the annular biasable element is coupled to a floor of a process chamber in which the substrate support is disposed.

[0007] Other and further embodiments of the present disclosure are described below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Embodiments of the present disclosure, briefly summarized above and discussed in greater detail below, can be understood by reference to the illustrative

embodiments of the disclosure depicted in the appended drawings. However, the appended drawings illustrate only typical embodiments of the disclosure and are therefore not to be considered limiting of scope, for the disclosure may admit to other equally effective embodiments.

[0009] Figure 1 depicts a schematic view of a substrate processing system in accordance with some embodiments of the present disclosure.

[0010] Figure 2 depicts a partial schematic view of a substrate support in accordance with some embodiments of the present disclosure.

[0011] Figure 3 depicts schematic view of a sheet metal cutout in accordance with some embodiments of the present disclosure.

[0012] To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to the figures. The figures are not drawn to scale and may be simplified for clarity. Elements and features of one embodiment may be beneficially incorporated in other embodiments without further recitation.

DETAILED DESCRIPTION

[0013] Apparatus for processing a substrate is disclosed herein. Embodiments of the inventive apparatus may advantageously shorten the RF current grounding path and prevent the distortion of temperature measurements made by a thermocouple or other temperature monitoring device present in the substrate support.

[0014] The following description will be made with reference to Figures 1 and 2. Figure 1 depicts a schematic view of a substrate processing system in accordance with some embodiments of the present disclosure. Figure 2 depicts a partial schematic view of the substrate processing system of Figure 1. For example, a substrate processing system 100 may include a process chamber 102 having a processing volume 104 and a substrate support 106 disposed in the processing volume 104 for supporting a substrate 105. The process chamber 102 may comprise walls formed of conductive materials, such as aluminum (Al) or the like. In some embodiments, for example, when the process chamber 102 is configured for capacitively or inductively coupled plasma applications, the process chamber may

have a ceiling comprising a dielectric material (not shown). Exemplary process chambers may include any suitable plasma process chamber, such those used for generating one or more of a remote, inductively coupled, or capacitively coupled plasma. Suitable process chambers may include the DPS[®], ENABLER[®], ADVANTEDGE[™], or other process chambers, available from Applied Materials, Inc. of Santa Clara, California. Other suitable process chambers may similarly be used.

[0015] The substrate support 106 may include a body 107 having a support surface 108 and a shaft 110 to support the body 107. Although illustrated in Figure 1 as a pedestal-type design, the substrate support may be any suitable substrate support having a support surface and a member, such as the shaft 110 or any other suitable member for supporting the support surface. In some embodiments, the substrate support 106 may comprise a ceramic material, such as, for example, aluminum oxide (Al₂O₃) or aluminum nitride (AlN). In some embodiments, the substrate support 106 may be coupled to a heat transfer body 170 via an adapter portion 160. The heat transfer body 170 may cool or transfer heat to the substrate support 106 depending on the process being performed. In some embodiments, the heat transfer body 170 includes channels (not shown) through which a coolant is flowed to cool the substrate support 106.

[0016] The substrate support 106 may include an RF electrode 112 (e.g., a first RF electrode) disposed in the substrate support 106 proximate the support surface to receive RF current from an RF source. In some embodiments, the RF electrode 112 may provide an RF return path and may be coupled through a conductive element 114 to ground as illustrated in the primary view in Figure 1. For example, the RF electrode 112 may function as an RF return path, for example, when the process chamber 102 is configured as a capacitively coupled plasma apparatus. In a capacitively coupled plasma apparatus, a second RF electrode 116 may be disposed above the substrate support 106 as illustrated in the primary view in Figure 1. The second RF electrode 116 may be disposed in the processing volume 104 and an RF source 118 may be coupled to the second electrode 116 as illustrated in the primary view in Figure 1. For example, the second RF electrode 116 may be a showerhead (not shown), or part of and/or disposed in a showerhead 119 as

illustrated in Figure 1, or any suitable embodiment of an overhead electrode used in a capacitively coupled plasma apparatus.

[0017] In some embodiments, the process chamber 102 may be configured as an inductively coupled plasma apparatus. In such embodiments, the second RF electrode (*i.e.*, a second RF electrode 117 as illustrated in phantom in Figure 1) may be disposed external to the processing volume 104 of the process chamber 102 and coupled to the RF source 118.

[0018] The showerhead 119 may be coupled to a gas panel 121 as illustrated in Figure 1 to provide one or more process gases to the processing volume 104 to ignite a plasma in the processing volume 104 or the like. The showerhead 119 is merely one exemplary chamber component for delivering one or more process gases to the processing volume 104. Alternatively or in combination, the one or more process gases may be delivered to the processing volume 104 via side injection ports (not shown) disposed about the walls of the process chamber 102, or gas inlets disposed in other regions of the process chamber. Alternatively or in combination, the one or more process gases may be delivered to a remote volume (not shown) where a plasma is formed and then flowed into the processing volume 104.

[0019] In some embodiments, the RF electrode 112 may also be coupled to an output of an RF source (such as the RF source 120 shown in phantom in Figure 1) via a conductive element 114 and having an RF return path via the conductive element 114, which will be described in greater detail with respect to Figures 2 and 3. For example, the RF electrode 112 may be used as an RF bias electrode or the like. The RF electrode 112 may be coupled to the conductive element 114 via, for example, an RF pin 109. However, any conductive fixation element may be used to couple the RF electrode 112 to the conductive element 114.

[0020] Returning to the substrate support 106, in some embodiments, the substrate support 106 may include a heater 122 disposed in the substrate support 106 proximate the support surface 108 to provide heat to the substrate 105 when disposed on the support surface 108. The heater 122 may be any suitable heater used in a substrate support, such as a resistive heater or the like. The heater 122

may include one or more conductive lines 124 that extend from the heater 122 through the shaft 110 to provide power to the heater 122. For example, as illustrated in Figure 1, the one or more conductive lines 124 may couple the heater 122 to a power supply 126 disposed external of the process chamber 102. For example, the one or more conductive lines 124 may include a first line for providing power from the power supply 126 to the heater 122 and a second line for returning power to the power supply 126. The power supply 126 may include an alternating current (AC) power source, a direct current (DC) power source or the like. Alternatively (not shown), the one or more conductive lines 124 may be a single conductive line, which provides power from the power supply 126 to the heater 122. The power may be returned to the power supply 126 or to ground via the conductive element 114. For example, the conductive element 114 may act as an electrical return for both the heater 122 and the RF electrode 112.

[0021] The substrate support 106 may include a thermocouple 128 disposed in the substrate support 106 to measure a desired temperature, such as the temperature of the substrate support 106, the support surface 108, or the temperature of the substrate 105 when disposed on the support surface 108. For example, the thermocouple 128 may be any suitable thermocouple design, such as a thermocouple probe or the like. The thermocouple 128 may be removable. As illustrated in Figure 1, the thermocouple 128 may extend along the shaft 110 of the substrate support 106 to proximate the support surface 108. The thermocouple 128 as illustrated in Figure 1 is merely exemplary, and the tip of the thermocouple may extend to proximate the heater 122 (as illustrated in Figure 1) or to above the heater 122 and proximate the support surface 108 (not shown). The location of the tip of the thermocouple 128 may be adjusted relative to the support surface 108 to provide the most accurate measurement of temperature of the substrate 105 or of some other component such as the support surface 108. The thermocouple 128 may be coupled to a temperature controller 130. For example, the temperature controller 130 may control the power supply 126 based on the temperature measured by the thermocouple 128. Alternatively, the temperature controller 130 may be part of, or coupled to, a system controller, such as the controller 144 that may control the operations of the substrate processing system 100.

[0022] In some embodiments, the conductive element 114 may be disposed along the shaft 110 of the substrate support 106. For example, the conductive element may include an interior volume 132 with the one or more conductive lines 124 and the thermocouple 128 disposed through the interior volume 132 of the conductive element 114. The conductive element 114 may be coupled to the RF electrode 112 as discussed above. For example, the conductive element 114 may have a protrusion 123 at a first end 113 that extends into the interior volume 132. The RF pin 109 may be inserted into or coupled to the protrusion 123 to couple the RF pin 109 and the RF electrode 112 to the conductive element 114. The conductive element 114 may have a second end 115 coupled to ground via an RF gasket 155 disposed on the adapter portion 160, as illustrated in Figures 1 and 2. The RF gasket may comprise copper beryllium or the like. The conductive element 114 includes a plurality of features 202 (also described below with respect to Figure 3) that can be bent into any predetermined position to interface with the RF gasket 155.

[0023] In some embodiments, the conductive element 114 may advantageously provide an electric field of about zero in the interior volume 132 when RF current flows through the conductive element 114. Providing an electric field in the interior volume 132 of about zero advantageously prevents or limits any interference arising from RF current flowing through the conductive element 114 that may affect other electric components disposed in the shaft, such as the thermocouple 128. The inventors have found, for example, that the rod-like conductive element used as an RF return path in conventional substrate supports provide a non-zero electric field in the shaft that interferes with the thermocouple 128 and causes the thermocouple to produce inaccurate temperature measurements. The conductive element 114 may comprise any suitable process compatible conductive materials, such as aluminum (Al), nickel (Ni), tungsten (W), or the like.

[0024] In some embodiments, the conductive element 114 may be disposed in the shaft 110 of the substrate support 106. For example, as illustrated in Figure 1, the conductive element may be cylindrical (as represented by dashed line 136), such as a cylinder or another suitable tubular structure having the interior volume 132 that produces an electric field of about zero in the interior volume when current flows

along the surface of the cylindrical conductive element. The design of the present disclosure advantageously shortens the RF return path.

[0025] In some embodiments, the substrate support 106 may include an annular biasable element 156 that contacts the adapter portion 160 when the substrate support 106 is in a processing position, as shown in Figures 1 and 2. The annular biasable element 156 is coupled to a floor 103 of the process chamber 102. In some embodiments, the annular biasable element 156 comprises copper beryllium, for example, for low temperature applications (e.g., up to 150° C). In some embodiments, the annular biasable element 156 comprises nickel beryllium, for example, for high temperature applications (e.g., up to 300° C). The annular biasable element 156 electrically couples the adapter portion 160 directly to the process chamber 102, thus shortening the RF return path.

[0026] Returning to Figure 1, the substrate 105 may enter the process chamber 102 via an opening (not shown) in a wall of the process chamber 102. The opening may be selectively sealed via a slit valve, or other mechanism for selectively providing access to the interior of the chamber through the opening. The substrate support 106 may be coupled to a lift mechanism 138 that may control the position of the substrate support 106 between a lower position (as shown) suitable for transferring substrates into and out of the chamber via the opening and a selectable upper position suitable for processing. The process position may be selected to maximize process uniformity for a particular process. When in at least one of the elevated processing positions, the substrate support 106 may be disposed above the opening to provide a symmetrical processing region. The lift mechanism 138 may be coupled to the process chamber 102 via a bellows 140 or other flexible vacuum hose to maintain a predetermined pressure or pressure range in the processing volume 104 when the substrate support 106 is moved. The lift mechanism 138 may be grounded as illustrated in Figure 1. For example, the conductive element 114 may be grounded via the lift mechanism 138. Alternatively, the lift mechanism 138 may be ground via the process chamber 102 through the bellows 140.

[0027] The apparatus may include additional components that are common to process chambers, such as an exhaust system 142 for removing excess process gases, processing by-products, or the like, from the processing volume 104 of the process chamber 102. For example, the exhaust system 142 may include a vacuum pump coupled to a pumping plenum via a pumping port for pumping out the exhaust gases from the process chamber 102 (not shown), or any suitable exhaust system. For example, the vacuum pump may be fluidly coupled to an exhaust outlet for routing the exhaust to appropriate exhaust handling equipment. A valve (such as a gate valve, z-motion valve, or the like) may be disposed in the pumping plenum to facilitate control of the flow rate of the exhaust gases in combination with the operation of the vacuum pump.

[0028] To facilitate control of the process chamber 102 as described above, a controller 144 comprises a central processing unit (CPU) 146, a memory 148, and support circuits 150 for the CPU 146 and facilitates control of the components of the process chamber 102. The controller 144 may any form of general-purpose computer processor that can be used in an industrial setting for controlling various chambers and sub-processors. The memory 148, or computer-readable medium, of the CPU 146 may be one or more of readily available memory such as random access memory (RAM), read only memory (ROM), floppy disk, hard disk, or any other form of digital storage, local or remote. The support circuits 150 are coupled to the CPU 146 for supporting the processor in a conventional manner. These circuits include cache, power supplies, clock circuits, input/output circuitry and subsystems, and the like. The methods performed in the process chamber 102, or at least portions thereof, may be stored in the memory 148 as a software routine. The software routine may also be stored and/or executed by a second CPU (not shown) that is remotely located from the hardware being controlled by the CPU 146.

[0029] Figure 3 illustrates a sheet metal cutout 300 in accordance with some embodiments of the present disclosure. The sheet metal cutout 300 is bent into a predetermined shape to form a conductive element (e.g., conductive element 114). The sheet metal cutout 300 may comprise any process compatible conductive materials, such as those discussed above with respect to the conductive element 114. In some embodiments, the sheet metal cutout 300 includes a plurality of

features 302 (e.g., features 202) and one or more protrusions 304 (e.g., 123). The features 302 can be bent into any predetermined position. When the sheet metal cutout 300 is bent into a predetermined shape, the one or more protrusions are aligned and extend into an interior of the final product (i.e., the conductive element). Utilization of sheet metal to form the conductive element advantageously results in increased surface area for the RF return current, thus improving grounding.

[0030] Thus, apparatus for processing a substrate are disclosed herein. Embodiments of the inventive apparatus may advantageously permit RF power to be received by an RF electrode disposed in a substrate support without interfering with other electrical components routed through the substrate support, such as interfering with the accuracy of temperature measurements made by a thermocouple or other temperature monitoring device present in the substrate support.

[0031] While the foregoing is directed to embodiments of the present disclosure, other and further embodiments of the disclosure may be devised without departing from the basic scope thereof.

Claims:

1. A substrate support, comprising:
 - a body having a support surface to support a substrate;
 - an RF electrode disposed in the body proximate the support surface to receive RF current from an RF source;
 - a shaft to support the body;
 - a conductive element having an interior volume and extending through the shaft, wherein the conductive element is coupled to the RF electrode; and
 - an RF gasket, wherein the conductive element includes features that engage the RF gasket to return the RF current to ground.
2. The substrate support of claim 1, further comprising:
 - a heater disposed in the substrate support proximate the support surface to provide heat to a substrate when disposed on the support surface, the heater having one or more conductive lines to provide power to the heater.
3. The substrate support of claim 2, further comprising:
 - a thermocouple disposed in the substrate support to measure a temperature of a substrate when disposed on the support surface.
4. The substrate support of claim 3, wherein one or more conductive lines and the thermocouple are disposed in the interior volume of the conductive element.
5. The substrate support of claim 2, further comprising:
 - a heat transfer body to transfer heat to or from the substrate support coupled to an end of the shaft opposite the body.
6. The substrate support of claim 2, further comprising:
 - an adapter portion coupled between the shaft and the heat transfer body, wherein the RF gasket is disposed between the adapter portion and the heat transfer body.

7. The substrate support of claim 6, further comprising:
an annular biasable element surrounding the adapter portion, wherein the annular biasable element contacts the adapter portion when the substrate support is in a processing position, wherein the annular biasable element is spaced apart from the adapter portion when the substrate support is not in the processing position.
8. The substrate support of claim 7, wherein the annular biasable element comprises copper beryllium or nickel beryllium.
9. The substrate support of any of claims 1 to 8, wherein the conductive element has an electric field of about zero in the interior volume when RF current is flowed through the conductive element.
10. The substrate support of any of claims 1 to 8, wherein the conductive element includes a protrusion extending into the interior volume.
11. The substrate support of claim 10, further comprising:
an RF pin coupled to the RF electrode at a first end and to the protrusion at a second end opposite the first end.
12. The substrate support of any of claims 1 to 8, wherein the conductive element is cylindrical.
13. The substrate support of claim 12, wherein the conductive element is formed from sheet metal.
14. The substrate support of claim 1, further comprising:
a heat transfer body to transfer heat to or from the substrate support;
an adapter portion coupled between the shaft and the heat transfer body, wherein the RF gasket is disposed between the adapter portion and the heat transfer body;

a heater disposed in the substrate support proximate the support surface to provide heat to a substrate when disposed on the support surface, the heater having one or more conductive lines to provide power to the heater; and
a thermocouple disposed in the substrate support to measure a temperature of a substrate when disposed on the support surface.

15. A substrate processing system, comprising:
a process chamber enclosing a processing volume; and
a substrate support as described in any of the preceding claims disposed in the processing volume and electrically coupled to a floor of the process chamber.

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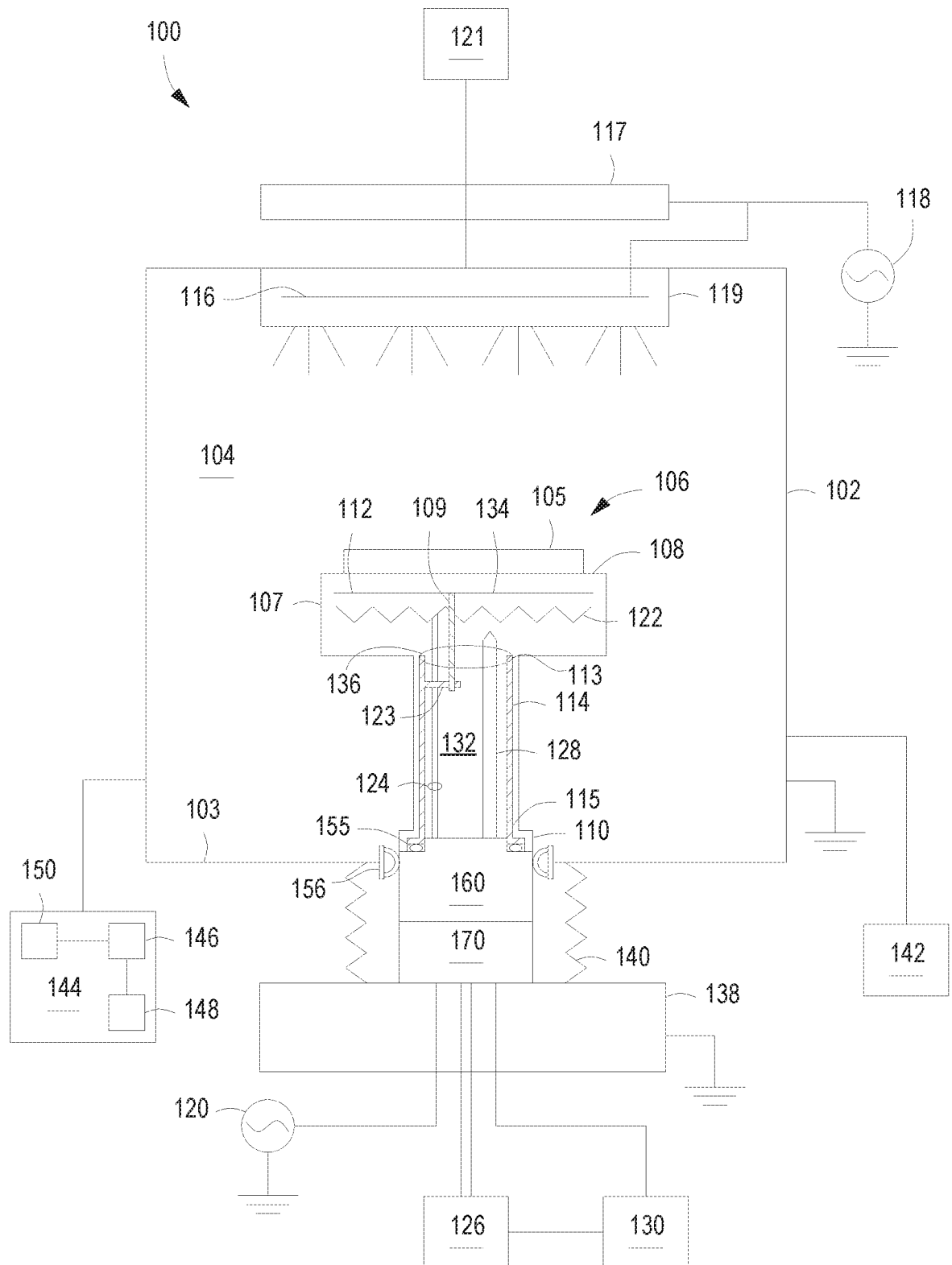


FIG. 1

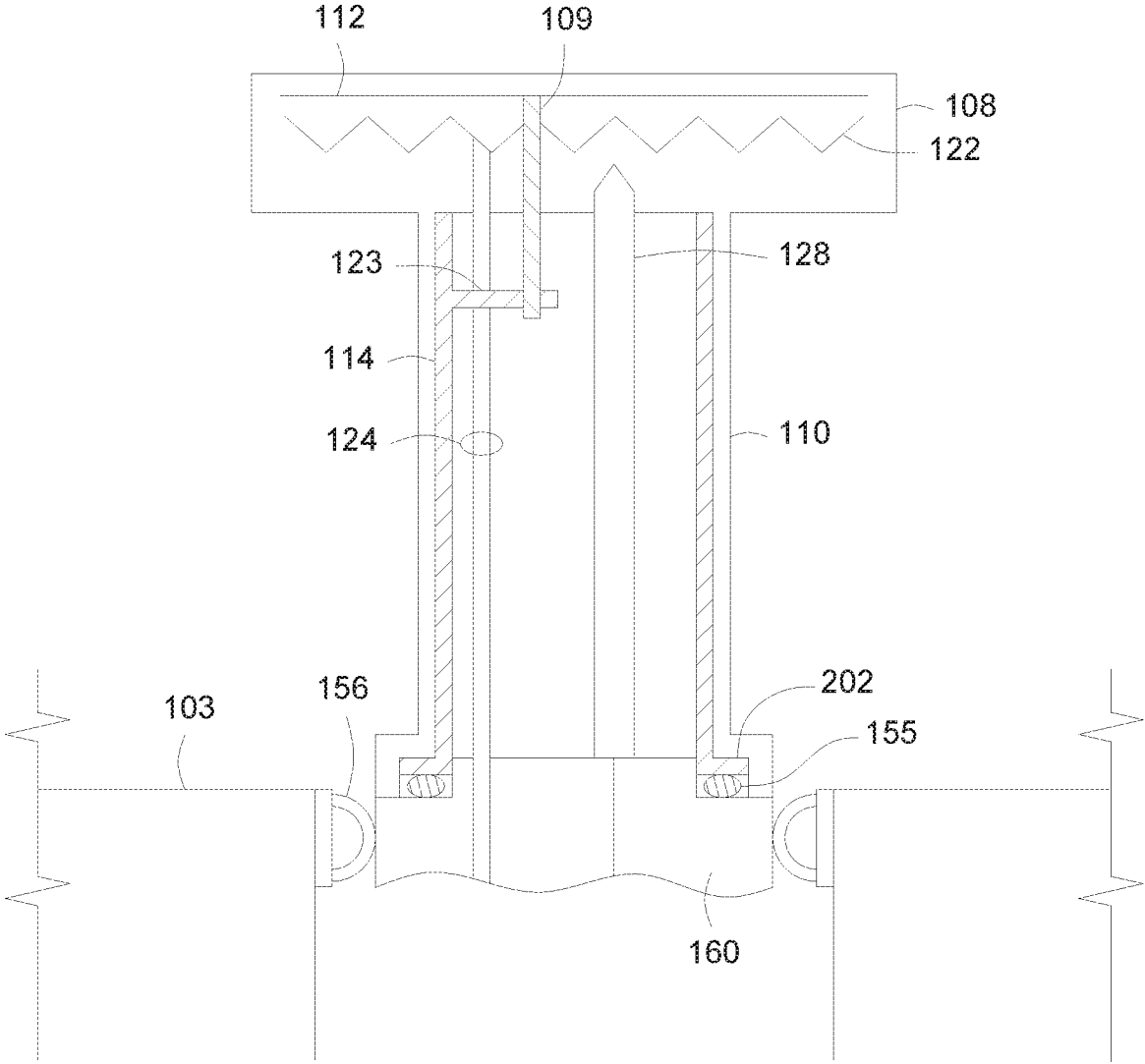


FIG. 2

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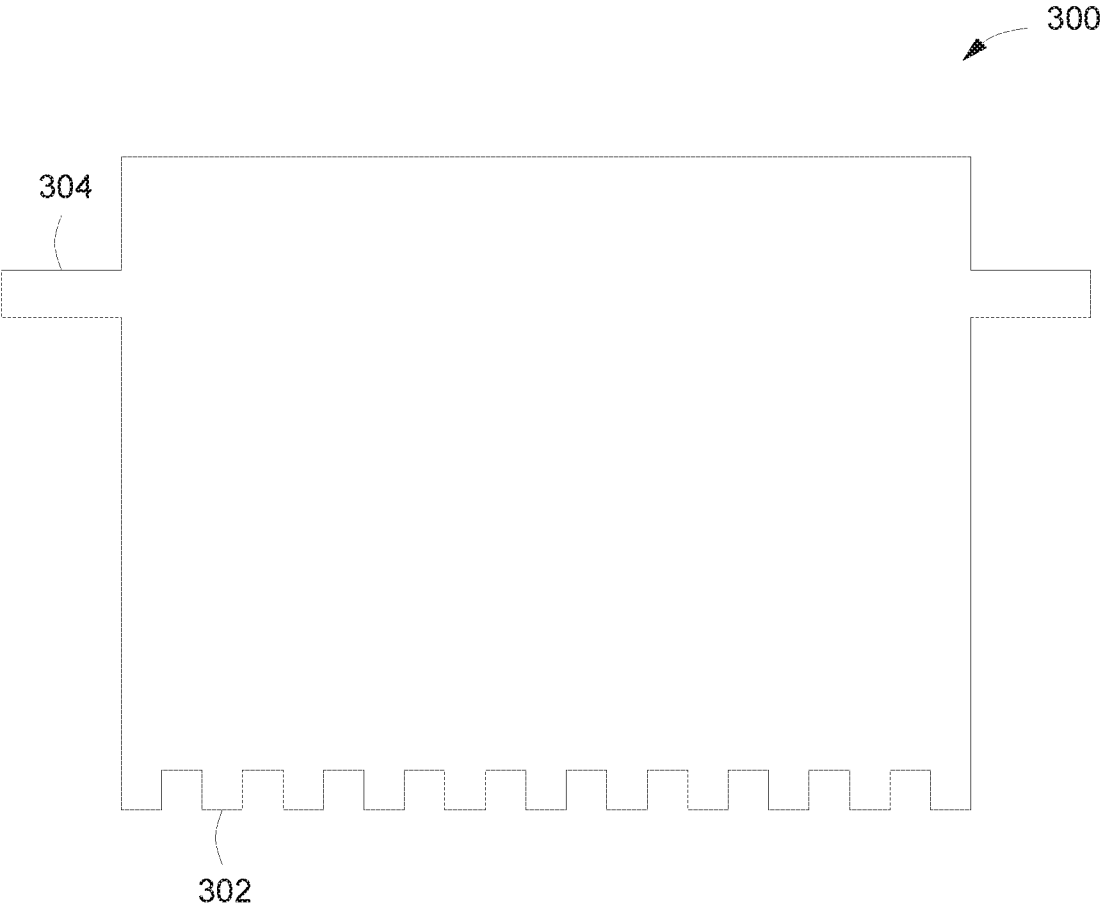


FIG. 3

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/017452**A. CLASSIFICATION OF SUBJECT MATTER****H01L 21/683(2006.01)i, H01L 21/67(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; H01L 21/3065; H01L 21/306; B05B 15/00; F27D 11/02; C23F 1/08; H01L 21/67

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: substrate, support, body, RF electrode, shaft, conductive element, RF gasket, and RF return

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2013-0001215 A1 (CHANG et al.) 03 January 2013 See paragraphs [0015]-[0016], [0020]-[0023], [0026], claims 1, 5, and figures 1-3.	1-14
Y	US 2011-0100552 A1 (DHINDSA et al.) 05 May 2011 See paragraphs [0035], [0043] and figures 3B, 6.	1-14
Y	US 2013-0092086 A1 (KEIL et al.) 18 April 2013 See paragraphs [0030], [0032] and figure 2A.	6-8, 14
A	US 2012-0222815 A1 (SABRI et al.) 06 September 2012 See paragraphs [0114], [0117] and figures 6-7.	1-14
A	KR 10-2010-0004857 A (JUSUNG ENGINEERING CO., LTD.) 13 January 2010 See abstract, paragraph [0052], and figure 1.	1-14



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

"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

19 May 2016 (19.05.2016)

Date of mailing of the international search report

20 May 2016 (20.05.2016)

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea



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INTERNATIONAL SEARCH REPORTInternational application No.
PCT/US2016/017452**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☒ Claims Nos.: 15
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of any additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2016/017452

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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