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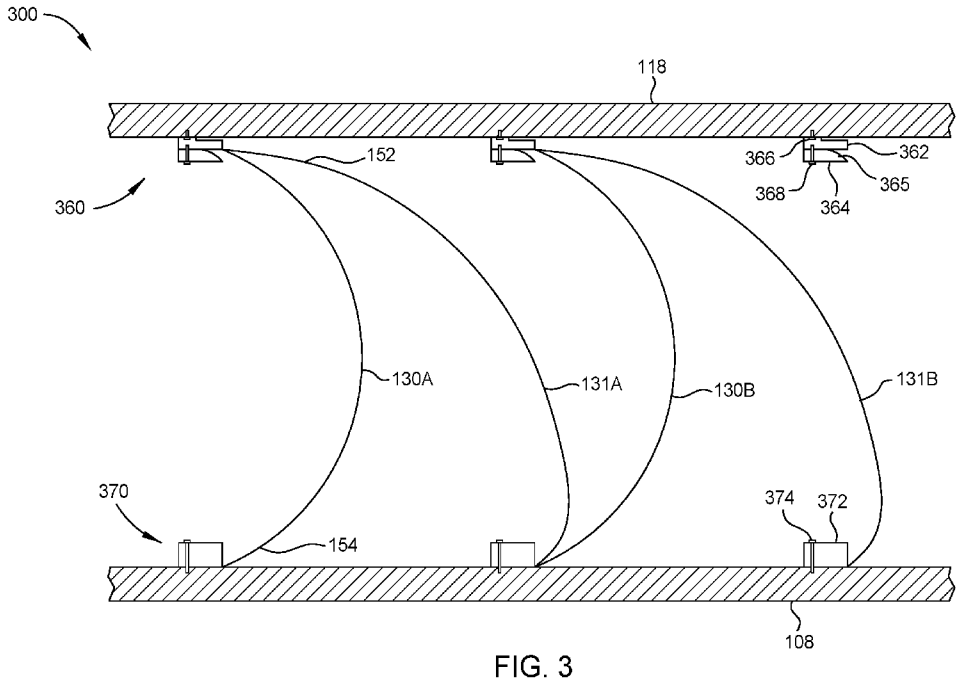


FIG. 3

(57) Abstract: Methods and apparatus for plasma processing a substrate are provided. A substrate processing chamber includes a first ground strap (130A, 130B) and a second ground strap (131A, 131B) coupled to a substrate support (118) and a chamber bottom (108). A top end (152) of the first ground strap (130A, 130B) is coupled to a support connector and is horizontally aligned with a bottom end (154) of the first ground strap (130A, 130B) coupled to a first chamber connector. A top end (152) of the second ground strap (131A, 131B) is coupled to the support connector while a bottom end (154) is coupled to a second chamber connector horizontally offset from the support connector, thus forming a cross double lattice pattern with the first ground strap (130A, 130B).

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GROUNDING STRAP DESIGN

BACKGROUND

Field

[0001] Embodiments of the present disclosure generally relate to methods and apparatus for processing substrates, such as semiconductor substrates, using plasma. More particularly, embodiments of the present disclosure relate to radio frequency (RF) ground straps for a plasma processing chamber.

Description of the Related Art

[0002] Plasma enhanced chemical vapor deposition (PECVD) is used for processing substrates, such as semiconductor substrates, solar panel substrates, and flat panel display substrates. PECVD is generally carried out by introducing one or more precursor gases into a vacuum chamber having a substrate disposed therein on a substrate support. The precursor gases are directed towards a process volume through a gas distribution plate, typically situated near the top of the vacuum chamber. The precursor gases are energized (e.g. excited) into a plasma by radio frequency (RF) power applied to the gas distribution plate by one or more RF power sources. The excited gas then reacts to form a material film layer on a surface of the substrate disposed on the substrate support.

[0003] During processing, the substrate support is RF grounded in order to eliminate any voltage drop across the substrate support, which would affect deposition uniformity of the material film layer across the surface of the substrate. Additionally, if the substrate support is not properly RF grounded, RF arcing between the substrate support and the chamber body may occur due to the high electric potential difference between the substrate support and the chamber body. This results in particle contamination and yield loss, as well as the formation of parasitic plasma.

[0004] The substrate support is typically grounded to the chamber body by thin and flexible ground straps to form an RF current return path. However, conventional ground strap arrangements provide RF return paths with considerable electrical resistance (e.g. impedance). Thus, a significant potential difference between the substrate support and the chamber body still remains, leading to unwanted arcing and parasitic plasma formation at the periphery of the substrate support.

[0005] Accordingly, what is needed in the art are improved substrate processing apparatus having ground strap arrangements with reduced electrical resistance.

SUMMARY

[0006] In one embodiment, a substrate processing chamber includes a chamber body having one or more chamber walls partially defining a process volume. The chamber body also includes chamber bottom having a first chamber connector and a second chamber connector. A substrate support is disposed in the process volume and has a first support connector coupled thereto. The substrate processing chamber further includes a first ground strap and a second ground strap, each having a first end and a second end. The first end of the first ground strap is coupled to the first support connector and the second end is coupled to the first chamber connector. The first end of the second ground strap is coupled to the first support connector and the second end is coupled to a second chamber connector.

[0007] In one embodiment, a substrate processing chamber includes a chamber body having one or more chamber walls and a chamber bottom having a plurality of chamber connectors. The substrate processing chamber further includes a substrate support having a plurality of support connectors coupled thereto that are each horizontally aligned with a corresponding chamber connector. A first plurality of ground straps is coupled to the substrate support and to the chamber bottom by corresponding pairs of support connectors and

chamber connectors. A second plurality of ground straps is coupled to the substrate support and to the chamber bottom by noncorresponding pairs of support connectors and chamber connectors.

[0008] In one embodiment, a substrate processing chamber includes a chamber body having one or more chamber walls partially defining a process volume. The chamber body also includes chamber bottom having a plurality of chamber connectors. Each chamber connector includes a parallel clamp assembly. A substrate support is disposed in the process volume and has plurality of support connectors. Each support connector includes an L-block and clamp assembly and is substantially aligned with a corresponding chamber connector along a horizontal plane. The substrate processing chamber further includes a first plurality of ground straps and a second plurality of ground straps, each ground strap having a first end and a second end. The first ends of the ground straps are coupled to the support connectors and the second ends are coupled to the chamber connectors. The first ends and the second ends of the first plurality of ground straps are substantially aligned along the horizontal plane. The first ends and the second ends of the second plurality of ground straps are offset along the horizontal plane.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] So that the manner in which the above recited features of the present disclosure can be understood in detail, a more particular description of the disclosure, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only exemplary embodiments and are therefore not to be considered limiting of its scope, and may admit to other equally effective embodiments.

[0010] Figure 1 illustrates a cross-sectional view of a substrate processing system having one or more ground straps coupled to a substrate support therein, according to one embodiment of the disclosure.

[0011] Figure 2 illustrates a top view of an exemplary ground strap according to one embodiment of the disclosure.

[0012] Figure 3 illustrates a cross-sectional view of a portion of the substrate processing chamber of Figure 1.

[0013] Figure 4A illustrates a bottom view of the substrate support of Figure 1.

[0014] Figure 4B illustrates a top view of the chamber bottom of Figure 1.

[0015] Figure 4C illustrates another top view of the chamber bottom as depicted in Figure 1.

[0016] To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to the figures. It is contemplated that elements and features of one embodiment may be beneficially incorporated in other embodiments without further recitation.

DETAILED DESCRIPTION

[0017] The present disclosure relates to methods and apparatus for plasma processing a substrate. In one embodiment, a substrate processing chamber includes a first ground strap and a second ground strap coupled to a substrate support and a chamber bottom. A top end of the first ground strap is coupled to a support connector and is horizontally aligned with a bottom end of the first ground strap coupled to a first chamber connector. A top end of the second ground strap is coupled to the support connector while a bottom end is coupled to a second chamber connector horizontally offset from the support connector, thus forming a cross double lattice pattern with the first ground strap.

[0018] Figure 1 is a cross-sectional view of a substrate processing system 100, such as a PECVD apparatus. The substrate processing system 100 is configured to process a large area substrate 114 using plasma during the fabrication of liquid crystal displays (LCD's), flat panel displays, organic light emitting diodes (OLED's) or photovoltaic cells for solar cell arrays. The structures may include p-n junctions to form diodes for photovoltaic cells, metal oxide semiconductor field-effect transistors (MOSFETs), and thin film transistors (TFTs).

[0019] The substrate processing system 100 is configured to deposit a variety of materials on the large area substrate 114, including but not limited to dielectric materials, semiconductive materials, and insulating materials. For example, dielectric and semiconductive materials may include polycrystalline silicon, epitaxial silicon, amorphous silicon, microcrystalline silicon, silicon germanium, silicon dioxide, silicon oxynitride, silicon nitride, and combinations thereof or derivatives thereof. The plasma processing system 100 is further configured to receive gases therein, including but not limited to precursor gases, purge gases, and carrier gases. For example, the plasma processing system may receive gas species such as hydrogen, oxygen, nitrogen, argon, helium, silane, and combinations thereof or derivatives thereof.

[0020] The substrate processing system 100 includes a substrate processing chamber 102 coupled to a gas source 104. The substrate processing chamber 102 comprises chamber walls 106 and a chamber bottom 108 (collectively, a chamber body 101) that partially define a process volume 110. The process volume 110 is generally accessed through a slit valve 112 in the chamber walls 106 that facilitates ingress and egress of the substrate 114 to and from the process volume 110. The chamber walls 106 and chamber bottom 108 are generally fabricated from a unitary block of aluminum, aluminum alloy, or other suitable material for substrate processing. In some embodiments, the chamber walls 106 and chamber bottom 108 are coated with a protective barrier material to reduce effects of corrosion. For example, the chamber walls 106 and chamber

bottom 108 may be coated with a ceramic material, a metal oxide material, or rare earth-containing material.

[0021] The chamber walls 106 support a lid assembly 116. A gas distribution plate 126 is suspended in the substrate processing chamber 102 from a backing plate 128 that is coupled to the lid assembly 116. A gas volume 140 is formed between the gas distribution plate 126 and the backing plate 128. The gas source 104 is connected to the gas volume 140 via a gas supply conduit 142. The gas supply conduit 142, backing plate 128, and gas distribution plate 126 are generally formed from an electrically conductive material and are in electrical communication with one another. In some embodiments, the gas distribution plate 126 and backing plate 128 are manufactured from a unitary block of material. The gas distribution plate 126 is generally perforated such that process gases are uniformly distributed into the substrate processing volume 110.

[0022] A substrate support 118 is disposed within the substrate processing chamber 102 opposing the gas distribution plate 126 in a generally parallel manner. The substrate support 118 supports the substrate 114 during processing. Generally, the substrate support 118 is fabricated from conductive materials, such as aluminum, and encapsulates at least one temperature control device, which controllably heats or cools the substrate support 118 to maintain the substrate 114 at a predetermined temperature during processing.

[0023] The substrate support 118 has a first surface 120 and a second surface 122. The first surface 120 is opposite the second surface 122. A third surface 121, which is perpendicular to the first surface 120 and the second surface 122, couples the first surface 120 and the second surface 122. The first surface 120 supports the substrate 114. The second surface 122 has a stem 124 coupled thereto. The stem 124 couples the substrate support 118 to an actuator (not shown) that moves the substrate support 118 between an elevated processing position (as shown) and a lowered position that facilitates substrate transfer into and out of the substrate processing chamber 102. The stem 124

also provides a conduit for electrical and thermocouple leads between the substrate support 118 and other components of the substrate processing system 100.

[0024] An RF power source 142 is generally used to generate a plasma between the gas distribution plate 126 and the substrate support 118. In some embodiments, the RF power source 142 is coupled to the gas distribution plate 126 via an impedance matching circuit 144 at a first output 146. A second output 148 of the impedance matching circuit 144 is further electrically coupled to the chamber body 101.

[0025] One or more ground straps 130 and one or more ground straps 131 are electrically connected to the substrate support 118 at a top end 152 of each ground strap 130, 131 and to the chamber bottom 108 at a bottom end 154 of each ground strap 130, 131. In some embodiments, the ground straps 130, 131 are electrically connected to the second surface 122 of the substrate support 118 at the top end 152. The substrate processing chamber 102 may include any suitable number of each ground straps 130, 131 for grounding the substrate support 118 to the chamber bottom 108 to form an RF current return path between the substrate support 118 and the chamber bottom 108. For example, one strap, two straps, three straps, four straps, five straps, or more may be used. The ground straps 130, 131 are configured to shorten the path for RF current during processing and minimize arcing near the periphery of the substrate support 118.

[0026] The substrate support 118 includes one or more support connectors 132 coupled thereto. In some embodiments, the one or more support connectors are coupled to the second surface 122 of the substrate support 118. A first, second, third, fourth, and fifth support connector, 132a-132e, respectively, are shown in Figure 1. Other quantities of support connectors, however, are also contemplated. The chamber bottom 108 includes one or more chamber connectors 134. A first, second, third, fourth, fifth, and sixth chamber connector,

134a-134f, respectively, are shown. Other quantities of chamber connectors, however, are also contemplated.

[0027] As illustrated in Figure 1, each support connector 132 is paired with a corresponding chamber connector 134. For example, the first support connector 132a is paired with the first chamber connector 134a, the second support connector 132b is paired with the second chamber connector 134b, and so on. In some embodiments, each support connector 132 is substantially aligned with the corresponding chamber connector 134 along a horizontal plane (x). In another example, the first support connector 132a and the first chamber connector 134a are horizontally offset from each other. The support connectors 132 and the chamber connectors 134 may include any suitable attachment structure, including but not limited to clamps, screws, pins, clasps, toggles, or the like.

[0028] The last chamber connector 134f is disposed at a terminal position of the one or more chamber connectors 134, such as a location adjacent to a point below a corner of the substrate support 118. In some embodiments, the chamber connector 134f does not have a corresponding support connector 132, and thus provides a terminal connection for the ground strap 131e. The chamber connector 134f may be a clamp having a screw disposed through a set hole (not shown) in the chamber bottom 108. Other embodiments, such as a pin, clasp, toggle, or the like, are also contemplated.

[0029] According to one embodiment shown in Figure 1, each of the ground straps 130 (five are shown as 130a-130e) is coupled to the substrate support 118 via a support connector 132 at the top end 152 and to the chamber bottom 108 via a corresponding chamber connector 134 at the bottom end 154. For example, the top end 152a of the first ground strap 130a is coupled to the first support connector 132a and the bottom end 154a of the first ground strap 130a is coupled to the first chamber connector 134a; the top end 152b of the second ground strap 130b is coupled to the second support connector 132b and the

bottom end of 154b of the second ground strap 130b is coupled to the second chamber connector 134b, and so on until reaching the chamber connector 134f. The chamber connector 134f remains uncoupled to any of the ground straps 130. Thus, the top end 152 and the bottom end 154 of each ground strap 130 are substantially horizontally aligned.

[0030] Each of the ground straps 131 (five are shown as 131a-131e) is also coupled to the substrate support 118 via a support connector 132 at the top end 152. However, unlike the ground straps 130, the ground straps 131 do not couple to a chamber connector 134 corresponding to the support connector 132 at which each ground strap 131 is coupled to the substrate support 118. Rather, the ground straps 131 cross over and couple to a noncorresponding and subsequent chamber connector 134, such that the bottom end 154 of each ground strap 131 is horizontally offset or unaligned with the top end 152. This arrangement of the ground straps 131 forms a cross double lattice pattern with the ground straps 130, wherein each of a pair of ground straps 130, 131 coupled to the substrate support 118 at a single support connector 132 are coupled to the chamber bottom 108 at separate chamber connectors 134, and vice versa. For example, the ground strap 131a couples to the support connector 132a at the top end 152a and couples to the chamber connector 134b at the bottom end 154b, the ground strap 132b couples to the support connector 132b at the top end 152b and couples to the chamber connector 134c at the bottom end 154c, and so on. In this configuration, the top end 152 and the bottom end 154 of each ground strap 131 are more horizontally offset along the (x) axis than the top end 152 and the bottom end 154 of each ground strap 130.

[0031] While the examples described above contemplate the first and bottom ends 152, 154 of the ground straps 131 being offset by one chamber connector position, it is also contemplated that the bottom ends 154 of ground straps 131 are horizontally offset by any suitable distance along the (x) axis, for example, by two or more chamber connector positions, or less than one chamber connector position.

[0032] Figure 2 is a top view of an exemplary ground strap 130, 131. The body 232 of ground strap 130, 131 is generally a rectangular piece of thin, flexible aluminum material having a top end 152 and a bottom end 154, with a slit 234 centrally located along the body 232 between the top end 152 and the bottom end 154. In one example, the ground strap 130, 131 is further manufactured with one or more folds (not shown) located between the top end 152 and the bottom end 154. In another example, the one or more folds may form during processing when the substrate support 118 is raised and lowered between a home position and a processing position, thus bending the ground straps 130, 131 and forming the one or more folds. Figure 2 illustrates one example of a ground strap 130, 131 suitable for the processing system described herein. The ground strap 130, 131 is generally any suitable size, shape, and material conducive to substrate processing.

[0033] Figure 3 is a cross-sectional view of a portion 300 of the substrate processing chamber 102 of Figure 1. According to one embodiment shown in Figure 3A, the substrate processing chamber 102 further includes a first clamp assembly 360, which may include an L-block clamp, and a second clamp assembly 370. The first clamp assembly 360 and the second clamp assembly 370 are generally formed of aluminum material. The first clamp assembly 360 and the second clamp assembly 370 are disposed opposite one another in a substantially parallel orientation. The one or more ground straps 130, 131 (two of each are shown) are coupled to the substrate support 118 through the first clamp assembly 360, and are coupled to the chamber bottom 108 through the second clamp assembly 370. In one embodiment, the one or more ground straps 130, 131 are coupled to the chamber bottom 108 through a first clamp assembly 360 disposed on the chamber bottom 108. However, any suitable combination of coupling or clamping mechanisms may be used.

[0034] The first clamp assembly 360 includes an L-block 362 and a clamp 364. In one embodiment, the L-block 362 is coupled to the substrate support 118 via a first coupling mechanism 366. For example, the first coupling mechanism 366 is

a screw or bolt; however, the first coupling mechanism 366 is generally any suitable coupling mechanism. The clamp 364 is coupled to the L-block 362 via a second coupling mechanism 368. For example, the second coupling mechanism 368 is a screw or bolt; however, the second coupling mechanism 368 is generally any suitable coupling mechanism. In one embodiment, the clamp 364 and the L-block 362 are coupled to the substrate support 118 via a single coupling mechanism, for example, a single screw or single bolt. The L-block 362 and the clamp 364 are configured to hold the top ends 152 of the ground straps 130, 131 therebetween. In one example, the top ends 152 of the ground straps 130, 131 are coupled to the L-block and clamp assembly 360 through the second coupling mechanism 368. The clamp 364 further has a curved portion 365 defined by a radial curve to accommodate for folding of the ground straps 130, 131 when the substrate support 118 is raised and lowered between a home position and a processing position.

[0035] The parallel clamp assembly generally includes a planar plate 372 and coupling mechanism 374. The plate 372 may be any suitable shape for coupling the ground straps 130, 131 to the chamber bottom 108, such as rectangular or circular. The plate 372 is coupled to the chamber bottom 108 via the coupling mechanism 374. For example, the coupling mechanism 374 is a screw; however, the coupling mechanism 374 is generally any suitable coupling mechanism.

[0036] Figure 4A is a bottom view of the substrate support 118 having one or more support connectors 132 coupled thereto. According to the embodiment shown in Figure 4A, the substrate support 118 includes five support connectors 132a-132e coupled to the second surface 122 along each edge of the substrate support 118 in a linear fashion. The number of support connectors 132 utilized for processing depends on the number of ground straps 130,131 desired. Each support connector 132 couples a single ground strap 130 and a single ground strap 131 to the substrate support 118 at the top end 152. For example, if three ground straps 131 and three ground straps 132 were utilized along each edge of substrate support 118, then twelve support connectors 132 would be utilized

(three along each edge). Furthermore, support connector 132a would couple to ground straps 130a and 131a, support connector 132b would couple to ground straps 130b and 131b, support connector 132c would couple to ground straps 130c and 131c, and so on.

[0037] Figure 4B is a top view of the chamber bottom 108 in Figure 1. Figure 4B illustrates the position of the substrate support 118 in phantom in relation to the chamber walls 106. As illustrated, the chamber bottom 108 includes five chamber connectors 134a-134e linearly disposed beneath each edge of the substrate support 118, each of the chamber connectors 134 corresponding with a single support connector 132 illustrated in Figure 4A. Additionally, a sixth chamber connector 134e is disposed at a terminal position of each row of chamber connectors 134 when viewing each edge of substrate support 118 in a clockwise direction. Each terminal chamber connector 134e is coupled to the chamber bottom at a location adjacent to a point below a corner of the substrate support 118.

[0038] The number of chamber connectors 134 utilized for processing depends on the number of ground straps 131 desired. Each chamber connector 134 couples a single ground strap 131 to the chamber bottom 108 at the bottom end 154. The ground strap 131 coupled to each chamber connector 134 is also coupled to the preceding support connector 132 at the top end 152, such that the top end and bottom ends 152, 154 of each ground strap 131 are horizontally offset. For example, as illustrated in Figure 1, the chamber connector 134b is coupled to ground strap 131a, the chamber connector 134c is coupled to ground strap 131b, and so on. In addition, each of the chamber connectors 134a-134e is coupled to a single ground strap 130. For example, the chamber connector 134a is coupled to the first ground strap 130a, the chamber connector 134b is coupled to ground strap 130b, the chamber connector 134c is coupled to ground strap 130c, and so on. The terminal chamber connector 134f, however, is not coupled to a ground strap 130.

[0039] Figure 4C is another top view of the chamber bottom 108 in Figure 1 depicting the first surface 120 of the substrate support 118. The substrate support 118 is disposed above the chamber connectors 134a-134e, thus obstructing them from view. However, the terminal chamber connector 134f for each line of chamber connectors 134 is disposed just outside of the perimeter of substrate support 118 and is thus visible. A ground strap 131e is coupled to each terminal chamber connector 134f.

[0040] Although Figures 1, 3, 4A, 4B and 4C illustrate one embodiment having five of each ground strap 130, 131 installed along each side of the substrate support 118, other ground strap quantities, positions, and arrangements are contemplated utilizing the cross double configuration described above. In some embodiments, ground straps 130, 131 may be coupled to one, two, or three sides of the substrate support 118. For example, one or more of each ground strap 130, 131 are installed on one side of the substrate support 118 and the chamber bottom 108, such as a side nearest the chamber wall 106 having the slit valve 112. In another example, one or more of each ground strap 130, 131 are installed on two opposing sides of the substrate support 118 and the chamber bottom 108. In some embodiments, the ground straps 130, 131 are installed at one or more corners of the substrate support 118. For example, one or more of each ground strap 130, 131 are installed at one corner of the substrate support 118.

[0041] In the operation of a conventional plasma processing chamber, the substrate support provides a return path for RF power supplied to the gas distribution plate and the substrate support itself, creating an electrical potential difference between the substrate support and surrounding inner surfaces of the chamber body. This potential difference inadvertently causes electrical arcing between the substrate support and surrounding surfaces, such as the chamber walls. The magnitude of the potential difference, and thus the amount of arcing between the substrate support and chamber walls, is partially dependent on the resistance and size of the substrate support. Arcing is deleterious and results in

particle contamination, film deposition variance, substrate damage, chamber component damage, yield loss, and system downtime.

[0042] The utilization of ground straps coupled to the substrate support and chamber body provides an alternate RF return path for the RF power supplied to either the substrate support or gas distribution plate, thus reducing the probability of electrical arcing between the substrate support and chamber body. However, conventional configurations of ground straps still provide significant electrical resistance and impedance along the alternate RF return path they were meant to create, forming a sufficient electrical potential difference between the substrate support and chamber body to cause arcing therebetween.

[0043] By arranging the ground straps in a cross double configuration as illustrated in Figures 1-4C, impedance of the alternate RF return path provided by the ground straps is significantly reduced, thus increasing the RF grounding efficiency of the ground straps. For example, RF grounding efficiency of the ground straps may be increased by up to or more than 100%. This increased grounding efficiency reduces the electrical potential difference between the substrate support and the chamber body, which in turn eliminates or diminishes arcing therebetween and reduces its deleterious effects.

[0044] As an added benefit of utilizing the cross double configuration of the ground straps, parasitic plasma generation is reduced. During film deposition onto the substrate, the generated plasma generally leaks to other parts of the chamber, becoming parasitic plasma that forms undesired films on various chamber components, such as the chamber walls, the chamber bottom, the substrate support, and the plurality of ground straps. The formation of parasitic plasma typically occurs between the outer edge of the substrate support or gas distribution plate and the surrounding chamber walls, or beneath the substrate support. Parasitic plasma is harmful because such plasma negatively influences the plasma uniformity of thin films deposited on the substrate and may accelerate corrosion of chamber components such as the ground straps themselves.

Reducing or eliminating the formation of parasitic plasma during processing thus extends the lifetime of the ground straps 130 as well as other chamber components.

[0045] Furthermore, the improved RF grounding efficiency of the processing chamber results in increased real load power efficiency. Thus, the amount of power utilized to perform PECVD is reduced while comparable film quality is maintained. For example, overall energy consumption of the processing system may be reduced by up to or more than 25%, such as about 15%, without sacrificing film quality.

[0046] 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, and the scope thereof is determined by the claims that follow.

What is claimed is:

1. A substrate processing chamber, comprising:

a chamber body, comprising:

one or more chamber walls at least partially defining a process volume; and

a chamber bottom coupled to the one or more chamber walls, the chamber bottom having at least a first chamber connector and a second chamber connector coupled thereto;

a substrate support disposed in the process volume, the substrate support having at least a first support connector coupled thereto;

a first ground strap having a first end and a second end, the first end coupled to the substrate support at the first support connector, and the second end coupled to the chamber bottom at the first chamber connector; and

a second ground strap having a first end and a second end, the first end coupled to the substrate support at the first support connector, and the second end coupled to the chamber bottom at the second chamber connector.

2. The chamber of claim 1, wherein the first end of the second ground strap and the second end of the second ground strap are horizontally unaligned.

3. The chamber of claim 1, wherein the first end of the first ground strap and the second end of the first ground strap are horizontally aligned.

4. The chamber of claim 2, wherein the first end of the first ground strap and the second end of the first ground strap are horizontally aligned.

5. The chamber of claim 1, wherein the first ground strap and the second ground strap form a cross double lattice pattern.

6. The chamber of claim 1, wherein the first ground strap and the second ground strap further comprise one or more folds.

7. The chamber of claim 1, wherein the first support connector further comprises an L-block and a clamp.

8. The chamber of claim 7, wherein the clamp further comprises a curved portion defined by a radial curve.

9. A substrate processing chamber, comprising:

a chamber body, comprising:

one or more chamber walls; and

a chamber bottom having a plurality of chamber connectors coupled thereto;

a substrate support, the substrate support having a plurality of support connectors coupled thereto, each of the support connectors substantially horizontally aligned with a corresponding chamber connector;

a first plurality of ground straps, each ground strap having a first end and a second end, the first end coupled to the substrate support by the support connector, and the second end coupled to the chamber bottom by the corresponding chamber connector; and

a second plurality of ground straps, each ground strap having a first end and a second end, the first end coupled to the substrate support by the support connector, and the second end coupled to the chamber bottom by a noncorresponding chamber connector.

10. The chamber of claim 9, wherein the first end and the second end of each of the first plurality of ground straps are substantially aligned along a horizontal plane.

11. The chamber of claim 9, wherein the first end and the second end of each of the second plurality of ground straps are offset along a horizontal plane.

12. The chamber of claim 9, wherein the first plurality of ground straps and the second plurality of ground straps form a cross double lattice pattern.

13. The chamber of claim 9, wherein the first end and the second end of each of the second plurality of ground straps are horizontally offset by at least one chamber connector.

14. The chamber of claim 13, wherein the first end and the second end of each of the second plurality of ground straps are horizontally offset by two or more chamber connectors.

15. A substrate processing chamber, comprising:

a chamber body, comprising:

one or more chamber walls at least partially defining a process volume; and

a chamber bottom coupled to the one or more chamber walls, the chamber bottom having a plurality of chamber connectors coupled thereto, each chamber connector having a parallel clamp assembly;

a substrate support disposed in the process volume, the substrate support having a plurality of support connectors coupled thereto at a bottom surface, each of the support connectors substantially aligned with a corresponding chamber connector along a horizontal plane, and each support connector comprising an L-block and clamp assembly;

a first plurality of ground straps having a first end and a second end, the first ends coupled to the substrate support at the support connectors, and the second ends coupled to the chamber bottom at the corresponding chamber connectors, the first ends substantially aligned with the second ends along the horizontal plane; and

a second plurality of ground straps having a first end and a second end, the first ends coupled to the substrate support at the support connectors, and the second ends coupled to the chamber bottom at the chamber connectors, the first ends substantially offset with the second ends along the horizontal plane.

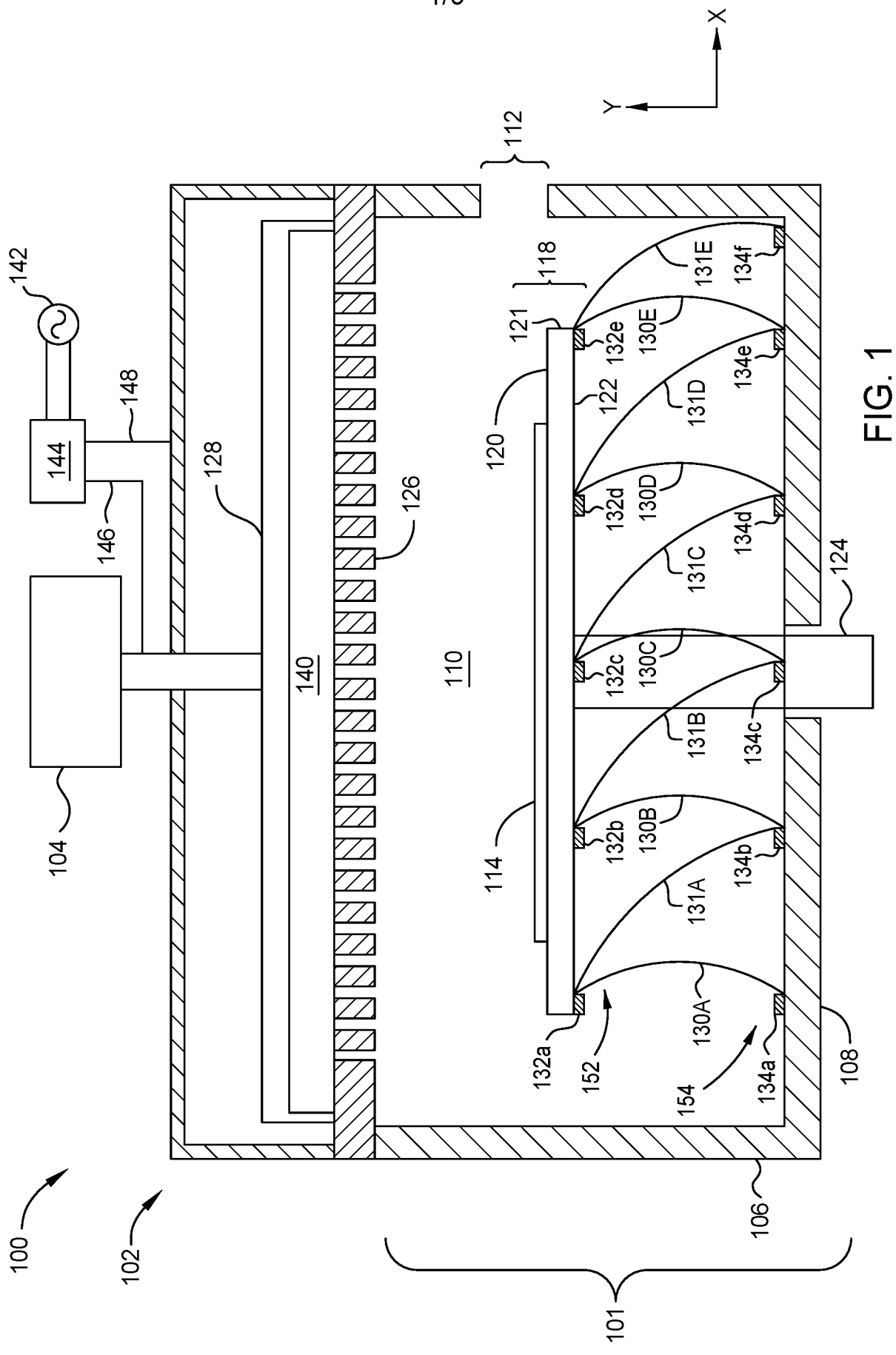

X
Y
112
142
148
144
146
128
126
118
121
120
122
114
124
110
140
104
106
108
101
100
102
131E
134f
132e
130E
131D
134e
132d
130D
131C
134d
132c
130C
131B
134c
132b
130B
131A
134b
132a
130A
134a
152
154

FIG. 1

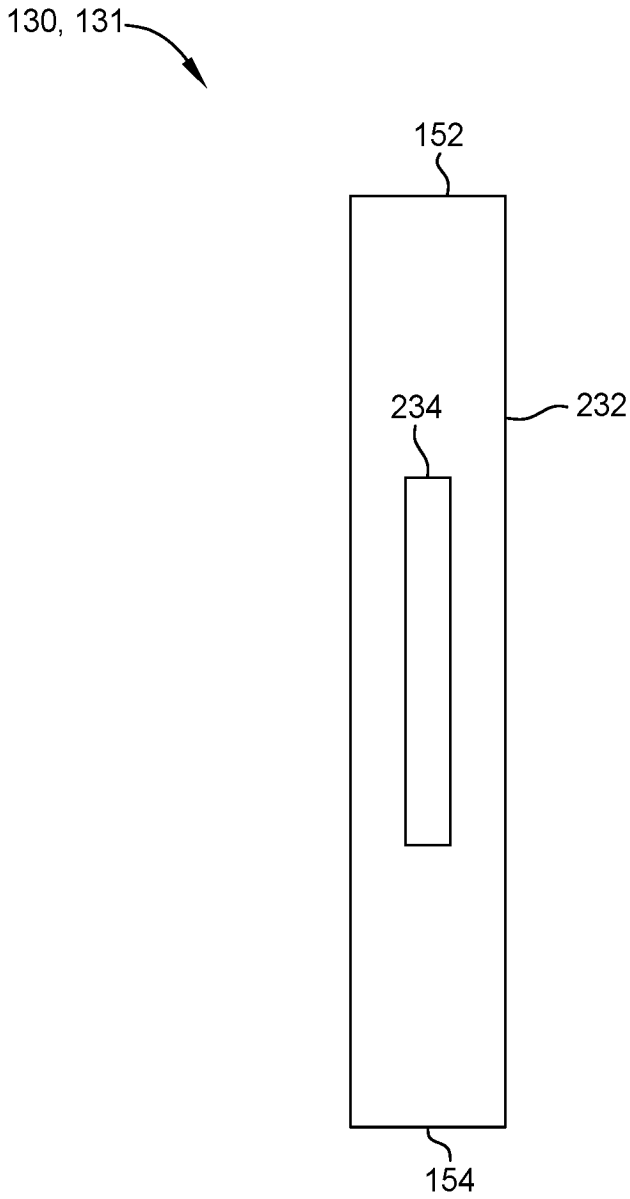


FIG. 2

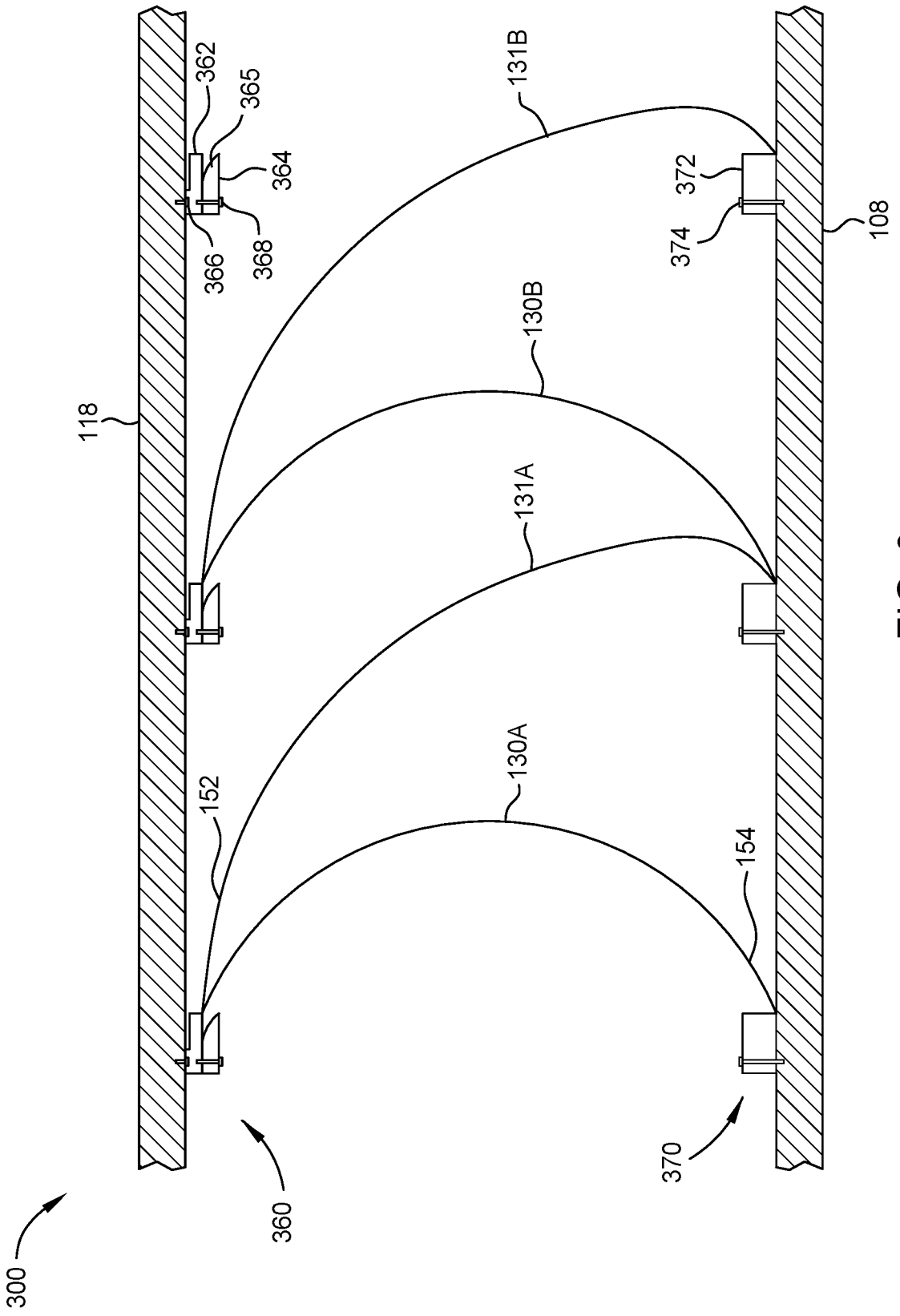

362
365
364
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368
131B
372
374
108
130B
118
131A
130A
152
154
370
360
300

FIG. 3

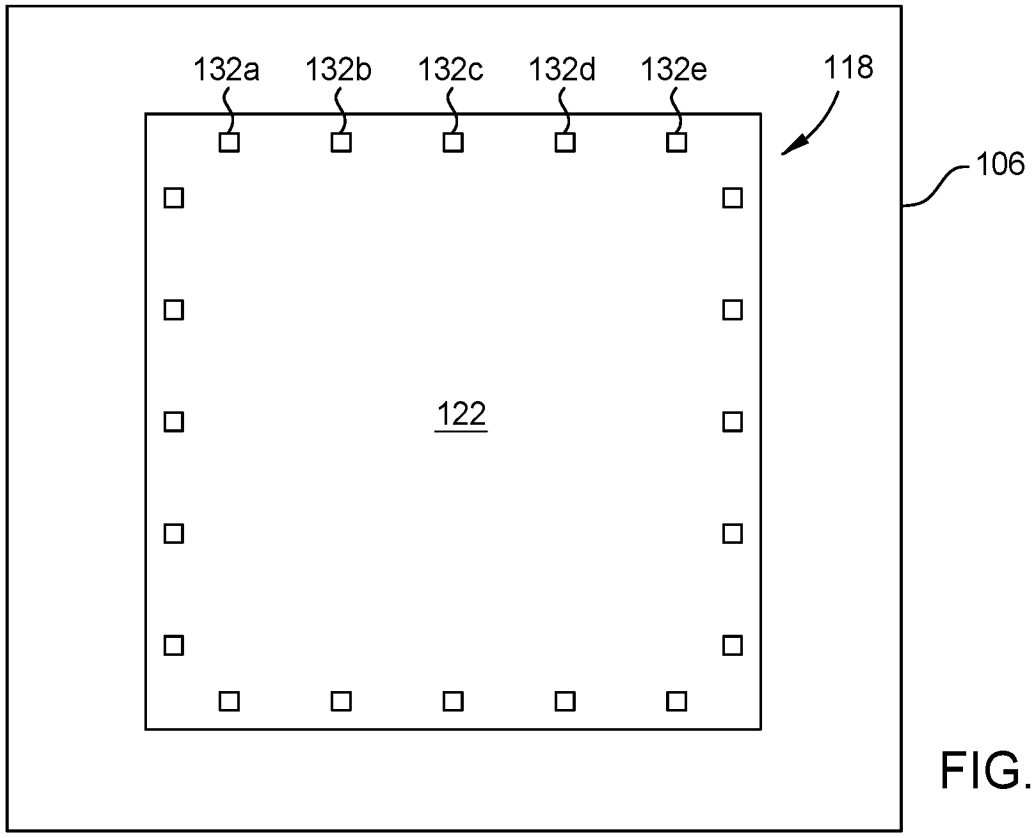

132a
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132c
132d
132e
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106
122

FIG. 4A

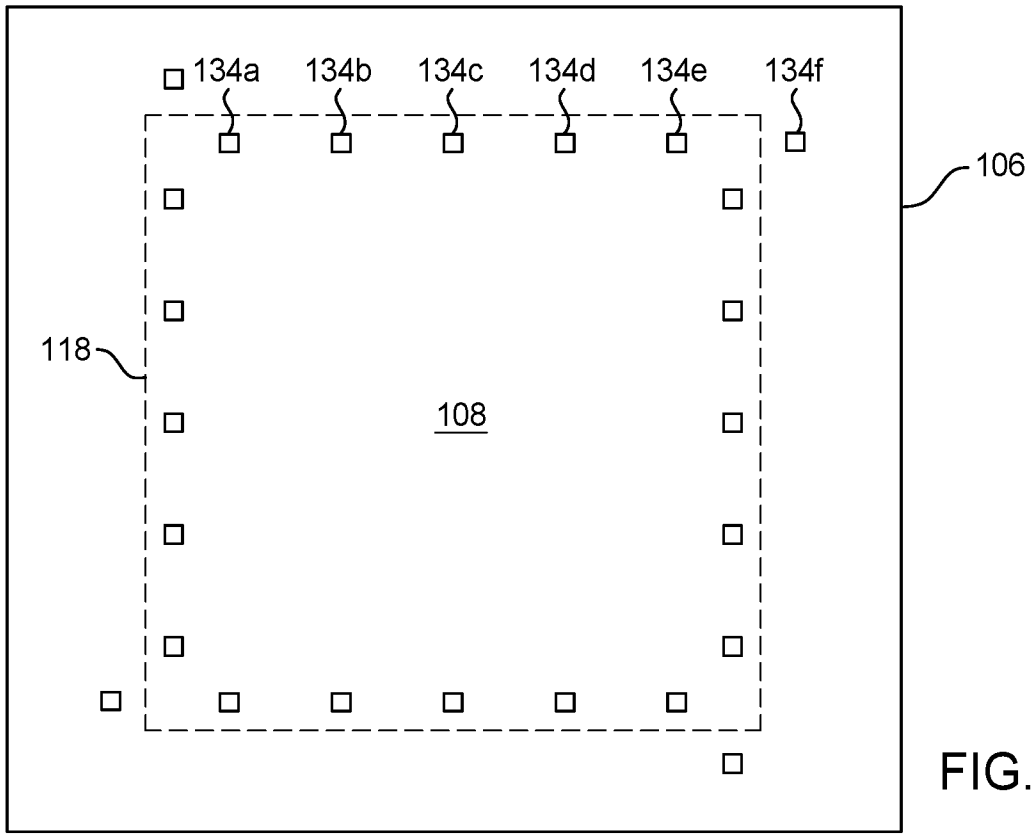

134a
134b
134c
134d
134e
134f
106
118
108

FIG. 4B

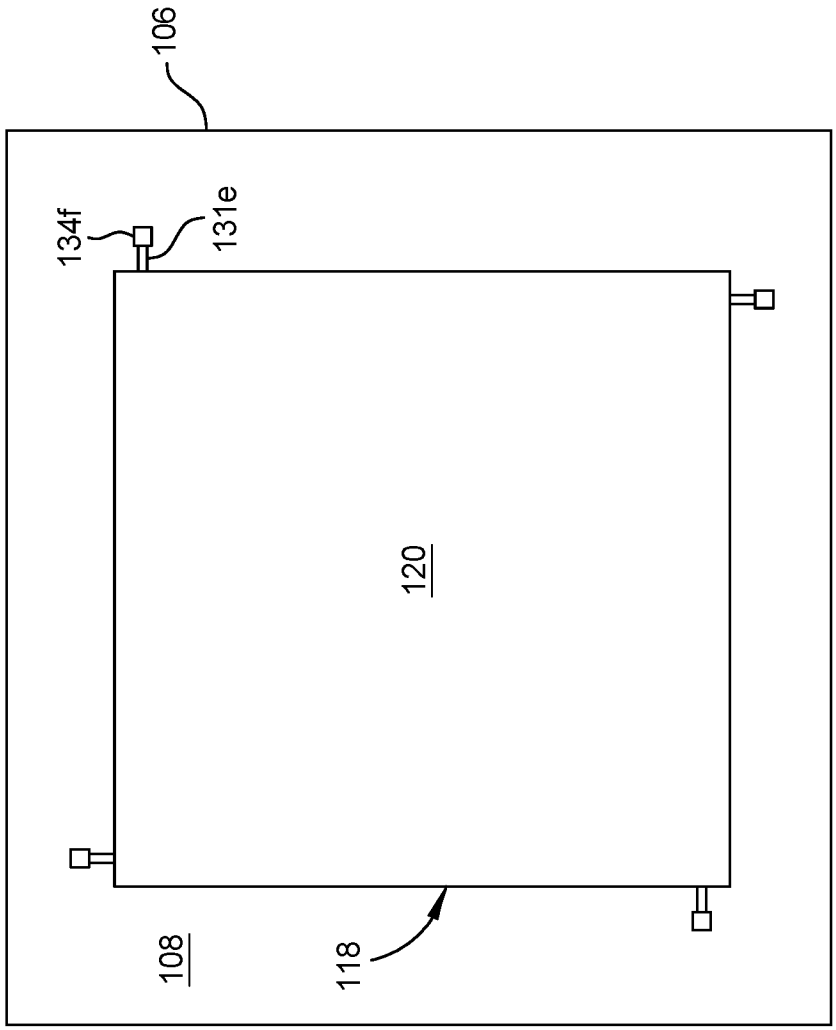


FIG. 4C

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2019/077318

A. CLASSIFICATION OF SUBJECT MATTER

H01J 37/32(2006.01)i; H01L 21/3065(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; H01L

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 practicable, search terms used)

CNPAT,WPI,EPODOC,CNKI,IEEE:CVD,plasma,process+,ground+,strap,support+,chamber

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2018340258 A1 (SAMSUNG DISPLAY CO., LTD.) 29 November 2018 (2018-11-29) description paragraphs [0022]-[0117] and figures 1-9	1-15
A	KR 20070096185 A (JUSUNG ENG.CO., LTD.) 02 October 2007 (2007-10-02) the whole document	1-15
A	WO 2008079742 A2 (APPLIED MATERIALS, INC. ET AL.) 03 July 2008 (2008-07-03) the whole document	1-15
A	CN 102074445 A (JUSUNG ENG.CO., LTD.) 25 May 2011 (2011-05-25) the whole document	1-15
A	CN 103165369 A (BEIJING NORTH MICROELECTRONICS) 19 June 2013 (2013-06-19) the whole document	1-15

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

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"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
10 November 2019	**27 November 2019**

Name and mailing address of the ISA/CN	Authorized officer
National Intellectual Property Administration, PRC **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088** **China**	**ZHENG,Lifen**
Facsimile No. **(86-10)62019451**	Telephone No. **86-(10)-53961483**

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2019/077318

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	2018340258	A1	29 November 2018	KR	20180130642	A	10 December 2018
KR	20070096185	A	02 October 2007		None		
WO	2008079742	A2	03 July 2008	TW	200834688	A	16 August 2008
CN	102074445	A	25 May 2011	TW	201130401	A	01 September 2011
				US	2011120375	A1	26 May 2011
				KR	20110056788	A	31 May 2011
				KR	20110056786	A	31 May 2011
CN	103165369	A	19 June 2013		None		