

[0019] In the drawings, reference numbers may be reused to identify similar and/or identical elements.

DETAILED DESCRIPTION

[0020] A processing chamber of a substrate processing system may include a plasma confinement shroud or ring (referred to hereinafter as a confinement ring). The confinement ring may be arranged to confine plasma and other reactants within a desired region in the processing chamber. For example, the confinement ring may be positioned to surround a substrate support and an upper electrode to confine the plasma within a volume above a substrate and below the upper electrode.

[0021] In some examples, the confinement ring comprises a semiconductor material such as silicon, silicon carbide (SiC), etc. The confinement ring, which is grounded, is constructed to have a predetermined conductance to maintain consistent processing performance parameters. However, due to erosion of surfaces of the semiconductor material caused by exposure to plasma and other process materials, the conductance of the confinement ring (and, therefore, the conductance of the processing chamber) changes over time and may cause process drift. Accordingly, the confinement ring may require periodic replacement.

[0022] Systems and methods according to the principles of the present disclosure increase a lifetime of the confinement ring. For example, the confinement ring may implement one or more modifications configured to maintain the predetermined conductance of the confinement ring and reduce process variation as described below in more detail.

[0023] Referring now to FIG. 1, an example substrate processing system 100 is shown. For example only, the substrate processing system 100 may be used for performing etching using RF plasma and/or other suitable substrate processing. The substrate processing system 100 includes a processing chamber 102 that encloses other components of the substrate processing system 100 and contains the RF plasma. The substrate processing chamber 102 includes an upper electrode 104 and a substrate support 106, such as an electrostatic chuck (ESC). During operation, a substrate 108 is arranged on the substrate support 106. While a specific substrate processing system 100 and chamber 102 are shown as an example, the principles of the present disclosure may be applied to other types of substrate processing systems

plasma within a plasma region 182. In some examples, the confinement ring 180 comprises a semiconductor material, such as silicon, silicon carbide (SiC), etc. The confinement ring 180 may include one or more slots 184 arranged to allow gases to flow out of the plasma region 182 to be vented from the plasma chamber ~~106~~ via the valve 150 and the pump 152. In other words, the slots provide fluid communication between the plasma region 182 within the confinement ring 180 and an environment external to the confinement ring 180. The confinement ring 180 according to the principles of the present disclosure is configured to maintain a predetermined conductance as described below in more detail.

[0032] Referring now to FIGS. 2A and 2B, an example confinement ring 200 is shown in more detail. The confinement ring 200 is shown in cross section in FIG. 2A. The confinement ring 200 includes an annular lower wall 204, outer wall 208, and upper wall 212. FIG. 2B shows a top-down view of an upper surface 216 of the lower wall 204.

[0033] The confinement ring 200 includes a plurality of slots 220 for allowing gases to be vented out of a plasma region 224 within the confinement ring 200. Dimensions of the slots (e.g., quantity, overall area, etc.) determine the conductance of the confinement ring 200 (and, therefore, of the conductance within the processing chamber). Over time, exposure to plasma causes the slots 220 to erode and widen, which changes the conductance within the processing chamber. For example only, inner portions of the slots 220 (i.e., portions of the slots 220 nearer to an inner diameter of the confinement ring 200) may erode at a greater rate than outer portions of the slots 220 (i.e., portions of the slots ~~200~~220 nearer to an outer diameter of the confinement ring 200). Erosion of the slots 220 leads to eventual replacement of the confinement ring 200.

[0034] Referring now to FIGS. 3A, 3B, 3C, 3D, and 3E, an example confinement ring 300 according to the principles of the present disclosure is shown. The confinement ring 300 is shown in cross section in FIG. 3A. The confinement ring 300 includes an annular lower wall 304, outer wall 308, and upper wall 312. FIG. 3B shows a top-down view of a portion of an upper surface 316 of the lower wall 304. The lower wall 304 includes a plurality of slots 320.

[0035] The confinement ring 300 further includes a lower ring 324. The lower ring 324 includes a plurality of slots 328. The lower ring 324 is arranged within a recess 332 in a bottom surface of the lower wall 304. For example, the lower ring 324 is arranged

within the recess 332 such that the slots 328 in the lower ring 324 are aligned (e.g., axially) with the slots 320 in the lower wall 304. For example only, the lower ring 324 is bolted to the lower wall 304 to retain the lower ring 324 within the recess 332 (e.g., through bolt holes 334). A thickness of the lower ring 324 may be 5-50% of an overall thickness of the lower wall 304.

[0036] The lower ring 324 comprises and/or is coated with a material that has a greater resistance to erosion (e.g., a greater resistance to plasma etching) than a material of the confinement ring 300. In one example, the lower ring 324 comprises anodized aluminum. In another example, the lower ring 324 comprises yttrium oxide (Y_2O_3). In another example, the lower ring 324 comprises silicon with a CVD diamond coating. The slots 328 of the lower ring 324 have a greater resistance to erosion (and, therefore, widening caused by erosion) than the slots 320 of the lower wall 304. As the slots 320 widen due to erosion, the width of the slots 328 is maintained, which in turn maintains the conductance of the confinement ring 300. Accordingly, a lifetime of the confinement ring 300 is increased significantly (e.g., by four times or more relative to a lifetime of a confinement ring without the lower wall 324304).

[0037] As shown in FIG. 3C, the lower ring 324 is comprised of separate sections 336 (e.g., four 90° sections). In other examples, the lower ring 324 may include fewer or more of the sections 336, or may be a single piece. In some examples, gaps between the sections 336 may be aligned with one of the slots 340 as shown in FIG. 3D. In other examples, the gaps between the sections 336 may be located between adjacent ones of the slots 340 such that a uniform spacing between the slots 340 is maintained.

[0038] Another example lower ring 400 is shown in FIG. 4A. In this example, the lower ring 400 may be comprised of the same material as the confinement ring 300, may be a different material (e.g., anodized aluminum, Y_2O_3 , etc.), and/or may include a coating (e.g., CVD diamond coating), and is also rotatable within the recess 332. For example, the lower ring 400 may be initially installed within the recess 332 such that slots 404 are aligned with the slots 320 of the lower wall 304. As the slots 320 erode over time, the lower ring 400 may be rotated to change an overall a size of an opening corresponding to the slots 320 and the slots 404. As shown in FIG. 4B, the slot 320 has widened due to erosion. Accordingly, the lower ring 400 may be rotated such that the slot 404 is not aligned with (i.e., axially aligned or centered) with the slot 320, reducing a size of an opening 408 formed through the slot 320 and the slot 404.

CLAIMS

~~What is claimed is:~~

1. A confinement ring for a substrate processing system, the confinement ring comprising:
 - 5 a lower wall, an outer wall, and an upper wall defining a plasma region within the confinement ring;
a first plurality of slots formed within the lower wall, wherein the first plurality of slots provides fluid communication between the plasma region within the confinement ring and an environment external to the confinement ring;
 - 10 a recess defined in a lower surface of the lower wall; and
a lower ring arranged within the recess of the lower surface, wherein the lower ring includes a second plurality of slots that provides fluid communication between the plasma region within the confinement ring and ~~an~~the environment external to the confinement ring via the first plurality of slots.
- 15 2. The confinement ring of claim 1, wherein the lower wall comprises a first material and the lower ring comprises a second material different from the first material.
3. The confinement ring of claim 2, wherein the second material has a greater resistance to plasma etching than the first material.
4. The confinement ring of claim 2, wherein the first material includes silicon and
20 the second material includes anodized aluminum.
5. The confinement ring of claim 2, wherein the first material includes silicon and the second material includes yttrium oxide (Y_2O_3).
6. The confinement ring of claim 2, wherein the second material includes a diamond coating.
- 25 7. The confinement ring of claim 6, wherein the diamond coating is deposited onto the lower ring using chemical vapor deposition.

8. The confinement ring of claim 1, wherein a thickness of the lower ring is between 10% and 50% of a thickness of the lower wall.

9. The confinement ring of claim 1, wherein the lower ring comprises a plurality of sections.

5 10. The confinement ring of claim 9, wherein a gap between the sections is axially aligned with one of the second plurality of slots.

11. The confinement ring of claim 9, wherein a gap between the sections is located between adjacent ones of the second plurality of slots.

10 12. The confinement ring of claim 1, wherein spacing between adjacent ones of the second plurality of slots around the lower ring is uniform.

13. The confinement ring of claim 1, wherein the lower ring is configured to rotate within the recess.

15 14. The confinement ring of claim 11, wherein the lower ring is configured to be (i) arranged in a first position within the recess such that each of the second plurality of slots is axially aligned with a respective one of the first plurality of slots and (ii) rotated to a second position within the recess such that each of the second plurality of slots is not axially aligned with the respective one of the first plurality of slots.

15. A method for adjusting a conductance of a confinement ring for a substrate processing system, the method comprising:

20 providing a lower ring within a recess defined in a lower surface of a lower wall of the confinement ring, wherein the confinement ring includes a first plurality of slots and the lower ring includes a second plurality of slots, and wherein the lower ring is in a first radial position relative to the confinement ring;

25 adjusting the lower ring from the first radial position to a second radial position relative to the confinement ring to adjust the conductance of the confinement ring.

16. The method of claim 15, wherein in the first radial position, individual ones of the second plurality of slots are axially aligned with individual ones of the first plurality of slots.

5 17. The method of claim 16, wherein in the second radial position, the individual ones of the second plurality of slots are not axially aligned with the individual ones of the first plurality of slots.

18. The method of claim 15, wherein the lower ring is adjusted from the first radial position to the second radial position subsequent to a predetermined amount of plasma processing being performed within the substrate processing system.

10 19. The method of claim 18, wherein the predetermined amount of plasma processing includes at least one of a predetermined number of etching cycles and a predetermined period of etching.