

CLAIMS

1. A substrate processing system for processing a substrate, the substrate processing system comprising:
 - 5 an upper plasma exclusion zone ring arranged above the substrate during plasma treatment of a bevel edge of the substrate;
 - an upper electrode arranged above the substrate during the plasma treatment;
 - a lower plasma exclusion zone ring at least partially arranged underneath the substrate during the plasma treatment; and
 - 10 a lower electrode at least partially arranged underneath the substrate during plasma treatment,wherein the lower plasma exclusion zone ring includes an annular body with:
 - a lower portion at least partially arranged below the substrate; and
 - an upwardly projecting flange extending upwardly from the lower portion of
 - 15 the annular body at a location spaced from a radially outer edge of the substrate, wherein the upwardly projecting flange includes
 - a side surface extending vertically and adjacent the radially outer edge of the substrate to limit an amount of ions impinging upon a lower portion of the radially outer edge of the substrate; and
 - 20 an uppermost surface extending laterally towards a middle portion of the radially outer edge of the substrate.
2. The substrate processing system of claim 1, wherein the lower electrode is located at least partially underneath the lower plasma exclusion zone ring.
- 25 3. The substrate processing system of claim 1, wherein the lower plasma exclusion zone ring includes a plurality of annular steps arranged on a substrate-facing surface thereof.
- 30 4. The substrate processing system of claim 1, wherein the uppermost surface of the upwardly projecting flange is planar.

5. The substrate processing system of claim 4, wherein an arcuate surface extends downwardly from a radially inner edge of the uppermost surface to a location adjacent to an apex of the radially outer edge of the substrate.
- 5 6. The substrate processing system of claim 1, wherein a gap is defined in a horizontal plane between an apex of the radially outer edge of the substrate and the side surface of the upwardly projecting flange, and wherein the gap has a width in a range from 0.1 to 1mm.
- 10 7. The substrate processing system of claim 6, wherein the width is in a range from 0.1 to 0.5mm.
8. The substrate processing system of claim 1, wherein the uppermost surface is located in a plane parallel to a plane including an upper surface of the substrate.
- 15 9. The substrate processing system of claim 1, wherein a thickness of the substrate is in a range from 50 microns to 2 mm.
10. The substrate processing system of claim 1, wherein the lower plasma exclusion zone (PEZ) ring is made of a material selected from a group consisting of alumina and yttria.
- 20 11. The substrate processing system of claim 1, wherein the substrate is attached to a carrier substrate.
- 25 12. A lower plasma exclusion zone ring for a bevel etcher, comprising:
an annular body defining:
a first annular step comprising a first laterally extending upper surface and located underneath and radially inwardly of a radially outer edge of a substrate; and

a second annular step comprising a second laterally extending upper surface and extending upwardly and radially outwardly from the first annular step,

wherein a transition between the first annular step and the second annular step is located radially inwardly of the radially outer edge of the substrate; and

5 an upwardly projecting flange extending upwardly from the second laterally extending upper surface of the second annular step at a location radially outside of the substrate and not underneath the second laterally extending upper surface,

wherein

10 an upward extending surface of the upwardly projecting flange extends upwardly from the second laterally extending upper surface of the second annular step to a location horizontally adjacent to a middle portion of the radially outer edge of the substrate, and

15 the upward extending surface extends from the second laterally extending upper surface to an uppermost surface of the upwardly projecting flange and not underneath the second laterally extending upper surface.

13. The lower plasma exclusion zone ring of claim 12, wherein an uppermost surface of the upwardly projecting flange lies in a plane parallel to a plane including an upper surface of the substrate.

20 14. The lower plasma exclusion zone ring of claim 12, wherein an arcuate surface extends downwardly and inwardly from a radially inner edge of the upwardly projecting flange to a location adjacent to an apex of the radially outer edge of the substrate.

25 15. The lower plasma exclusion zone ring of claim 12, wherein an arcuate surface extends downwardly and inwardly from a radially inner edge of the upwardly projecting flange to the second laterally extending upper surface of the second annular step.

30 16. The lower plasma exclusion zone ring of claim 12, wherein a gap is defined in a horizontal plane between an apex of the radially outer edge of the substrate and a radially inner surface of the upwardly projecting flange, and wherein the gap has a width in a range from 0.1 to 1mm.

17. The lower plasma exclusion zone ring of claim 16, wherein the width is in a range from 0.1 to 0.5mm.

18. The lower plasma exclusion zone ring of claim 12, wherein a thickness of the substrate is in a range from 50 microns to 2 mm.

19. The lower plasma exclusion zone ring of claim 12, wherein the annular body is made of a material selected from a group consisting of alumina and yttria.

20. A lower plasma exclusion zone ring for a bevel etcher, comprising:
an annular body defining:
a first annular step comprising a first laterally extending surface;
a second annular step comprising a second laterally extending surface and extending upwardly and radially outwardly from the first annular step and configured to support a substrate; and
a third annular step comprising a third laterally extending surface and extending upwardly and radially outwardly from the second annular step;
wherein a radially inner surface of the third annular step between the second laterally extending surface and the third laterally extending surface defines:
a first pocket;
a second pocket located radially inwardly from and underneath the first pocket; and
an annular ridge located between the first pocket and the second pocket.

21. The lower plasma exclusion zone ring of claim 20, wherein the second pocket is configured to support the substrate and the annular ridge is located at or above an apex of a radially outer edge of the substrate.

22. The lower plasma exclusion zone ring of claim 20, wherein an uppermost surface of the third annular step lies in a plane parallel to a plane including an upper surface of the substrate.

23. The lower plasma exclusion zone ring of claim 20, wherein a gap is defined in a horizontal plane between an apex of a radially outer edge of the substrate and the annular ridge, and wherein the gap has a width in a range from 0.1 to 1mm.

5 24. The lower plasma exclusion zone ring of claim 23, wherein the width is in a range from 0.1 to 0.5mm.

25. The lower plasma exclusion zone ring of claim 20, wherein a thickness of the substrate is in a range from 50 microns to 2 mm.

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26. The lower plasma exclusion zone ring of claim 20, wherein the annular body is made of a material selected from a group consisting of alumina and yttria.

15 27. The substrate processing system of claim 1, wherein a height of the upwardly projecting flange measured from a laterally extending upper surface of the lower portion to the uppermost surface is less than 2 mm.

28. The substrate processing system of claim 1, wherein a height of the upwardly projecting flange measured from a laterally extending upper surface of the lower portion to the uppermost surface is less than 1 mm.

20 29. The substrate processing system of claim 1, wherein a height of the upwardly projecting flange measured from a laterally extending upper surface of the lower portion to the uppermost surface is 25 microns to 1mm.

30. The substrate processing system of claim 1, wherein the uppermost surface extends laterally towards a portion of the radially outer edge of the substrate between an apex of the radially outer edge and a top surface of the substrate.

31. The substrate processing system of claim 1, wherein the uppermost surface
5 extends laterally towards a portion of the radially outer edge of the substrate between a top surface of the substrate and a point half a distance between a height of the top surface of the substrate and a height of a bottom surface of the substrate.

32. The substrate processing system of claim 1, wherein an upward extending surface of the upwardly projecting flange extends upward to and not past a point half a distance
10 between a height of a top surface of the substrate and a height of a bottom surface of the substrate.

33. The substrate processing system of claim 1, further comprising the substrate.

34. The lower plasma exclusion zone ring of claim 1, wherein the lower portion of the lower plasma exclusion zone ring extends adjacent to the lower electrode, which supports
15 the substrate.

35. The substrate processing system of claim 4, wherein:

an arcuate surface extends downwardly from a radially inner edge of the uppermost surface to the lower portion of the annular body; and

the arcuate surface is a concave surface.

20 36. The substrate processing system of claim 5, wherein the arcuate surface is a concave surface.

37. The lower plasma exclusion zone ring of claim 12, wherein the upward extending surface extends upwardly from the second laterally extending upper surface of the second annular step to a location vertically adjacent to a location above an apex of the radially outer edge of the substrate.

5 38. The lower plasma exclusion zone ring of claim 12, wherein the upward extending surface extends upwardly from the second laterally extending upper surface of the second annular step to a location vertically adjacent to a point half a distance between a height of a top surface of the substrate and a height of a bottom surface of the substrate.

39. The lower plasma exclusion zone ring of claim 12, further comprising a transition
10 surface extending downwardly and radially inwardly from an upwardly extending surface of the upwardly projecting flange to the second laterally extending upper surface of the second annular step.

40. The lower plasma exclusion zone ring of claim 12, wherein a portion of the upward extending surface of the upwardly projecting flange gradually transitions upwardly and
15 outwardly between the second laterally extending upper surface of the second annular step to the uppermost surface of the upwardly projecting flange.

41. The lower plasma exclusion zone ring of claim 12, wherein the upward extending surface of the upwardly projecting flange is arcuate shaped.

42. The lower plasma exclusion zone ring of claim 12, further comprising a transition
20 surface extending downwardly and radially inwardly from the upward extending surface of the upwardly projecting flange towards the middle portion of the radially outer edge of the substrate.

43. The lower plasma exclusion zone ring of claim 12, wherein a height of the upwardly projecting flange measured from the second laterally extending upper surface to the uppermost surface of the upwardly projecting flange is less than 2 mm.
44. The lower plasma exclusion zone ring of claim 12, wherein a height of the
5 upwardly projecting flange measured from the second laterally extending upper surface to the uppermost surface of the upwardly projecting flange is less than 1 mm.
45. The lower plasma exclusion zone ring of claim 12, wherein a height of the upwardly projecting flange measured from the second laterally extending upper surface to the uppermost surface of the upwardly projecting flange is 25 microns to 1mm.
- 10 46. The lower plasma exclusion zone ring of claim 12, wherein:
the first laterally extending upper surface comprises a first radially inner annular ridge;
the second laterally extending upper surface comprises a second radially inner annular ridge; and
15 the uppermost surface of the upwardly projecting flange comprises a third radially inner annular ridge.
47. A substrate processing system comprising:
the lower plasma exclusion zone ring of claim 12; and
the substrate.
- 20 48. The lower plasma exclusion zone ring of claim 12, wherein the lower plasma exclusion zone ring at least one of excludes and controls a plasma profile at the radially outer edge of the substrate.

49. The lower plasma exclusion zone ring of claim 20, wherein the first annular step is configured to support a lower electrode of the bevel etcher.

50. The lower plasma exclusion zone ring of claim 20, wherein the annular ridge extends laterally around the substrate.

5 51. The lower plasma exclusion zone ring of claim 20, wherein the annular ridge extends laterally around the substrate adjacent to an apex of a radially outer edge of the substrate.

52. The lower plasma exclusion zone ring of claim 20, wherein:

the first laterally extending surface comprises a first radially inner annular ridge;

10 the second laterally extending surface comprises a second radially inner annular ridge;

an uppermost surface of the upwardly projecting flange comprises a third radially inner annular ridge; and

15 the first pocket and the second pocket are disposed between the second radially inner annular ridge and the third radially inner annular ridge.

53. A lower plasma exclusion zone ring for a bevel etcher, comprising:

an annular body defining:

a first annular step comprising a first laterally extending surface;

20 a second annular step comprising a second laterally extending surface and extending upwardly and radially outwardly from the first annular step and configured to support a substrate; and

a third annular step comprising a third laterally extending surface and extending upwardly and radially outwardly from the second annular step,

wherein

the third annular step comprises a vertically extending surface and a transition surface,

5 the vertically extending surface extends from the transition surface upward to the third laterally extending surface, and

the transition surface extends outward from the second laterally extending surface to the vertically extending surface.

54. The lower plasma exclusion zone ring of claim 53, wherein the transition surface is tapered upwards.

10 55. The lower plasma exclusion zone ring of claim 53, wherein the transition surface is an arcuate surface.