

CLAIMS

What is claimed is:

1. A showerhead for processing a substrate in a processing chamber, the showerhead comprising:
 - 5 a first component including a disc-shaped portion and a cylindrical portion extending perpendicularly from the disc-shaped portion, the disc-shaped portion having a greater diameter than an outer diameter of the cylindrical portion, the cylindrical portion having an inner diameter greater than a diameter of the substrate, the disc-shaped portion including first and second sets of holes having first and second
10 diameters, respectively, and the first and second sets of holes extending from a center of the disc-shaped portion to the inner diameter of the cylindrical portion;
a second component being disc-shaped, including first through holes aligned with the first set of holes in the first component, having a top surface, side surfaces, and a bottom surface attached to the disc-shaped portion of the first component on a side
15 opposite to the cylindrical portion and defining a plenum that is in fluid communication with the second set of holes in the first component and that is separate from the first set of holes in the first component, the top surface including a pair of arc-shaped grooves along a periphery and on opposite ends of the top surface and including a plurality of grooves extending between the pair of arc-shaped grooves; and
20 a third component being disc-shaped, including second through holes aligned with the first through holes in the second component and with the first set of holes in the first component, and having a bottom surface attached to the top surface of the second component.
2. The showerhead of claim 1 wherein the first and second sets of holes are
25 arranged in a hexagonal pattern, a triangular pattern, or a combination of a hexagonal pattern and a triangular pattern.
3. The showerhead of claim 2 wherein hexagons in the hexagonal pattern are equilateral hexagons and wherein triangles in the triangular pattern are equilateral triangles.

4. The showerhead of claim 1 wherein:
the first set of holes are arranged in a hexagonal pattern;
the second set of holes are lie on vertices of triangles within hexagons formed by
the first set of holes; and
- 5 one of the first set of holes lies within each of the triangles;
or wherein:
the second set of holes are arranged in a hexagonal pattern;
the first set of holes are lie on vertices of triangles within hexagons formed by the
second set of holes; and
- 10 one of the second set of holes lies within each of the triangles.
5. The showerhead of claim 1 wherein the third component further comprises:
a gas inlet in fluid communication with the plenum;
a fluid inlet in fluid communication with a first one of the pair of arc-shaped
grooves; and
- 15 a fluid outlet in fluid communication with a second one of the pair of arc-shaped
grooves.
6. The showerhead of claim 1 wherein:
the pair of arc-shaped grooves and the plurality of grooves are separate from the
plenum and the first and second sets of holes;
- 20 the pair of arc-shaped grooves surround the first through holes in the second
component; or
the pair of arc-shaped grooves and the plurality of grooves have equal depths.
7. The showerhead of claim 1 wherein the bottom surface of the second
component further comprises a semicircular groove along a periphery of the bottom
surface of the second component and wherein the semicircular groove is in fluid
communication with the plenum and wherein the semicircular groove surrounds the first
through holes in the second component or the semicircular groove surrounds the pair of
arc-shaped grooves.
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8. The showerhead of claim 1 wherein the pair of arc-shaped grooves include a plurality of vertically extending ridges that contact the bottom surface of the third component and wherein a height of the plurality of vertically extending ridges is equal to a depth of the plurality of grooves.
- 5 9. The showerhead of claim 1 wherein:
the plurality of grooves are parallel to each other; or
the plurality of grooves have a zig-zagged shape.
10. The showerhead of claim 1 wherein first ends of the plurality of grooves connect with a first one of the pair of arc-shaped grooves and wherein second ends of the
10 plurality of grooves connect with a second one of the pair of arc-shaped grooves.
11. The showerhead of claim 1 wherein the first through holes in the second component lie between the plurality of grooves.
12. The showerhead of claim 1 wherein:
a ratio of a sum of cross-sectional area of the first set of holes to a cross-
15 sectional area of the cylindrical portion of the first component is between 4.5% and 5.5%;
a ratio of a sum of cross-sectional area of the first set of holes to a cross-sectional area of the cylindrical portion of the first component is between 4% and 6%;
a ratio of a number of the first set of holes to a number of second set of holes is
20 between 1.00 and 1.05; or
a density of the first and second sets of holes is between 4 and 5 holes per square inch.

13. A showerhead for processing a substrate in a processing chamber, the showerhead comprising:

a first component including a disc-shaped portion and a cylindrical portion extending perpendicularly from the disc-shaped portion, the disc-shaped portion having a greater diameter than an outer diameter of the cylindrical portion, the cylindrical portion having an inner diameter greater than a diameter of the substrate, the disc-shaped portion including first and second sets of holes having first and second diameters, respectively, and the first and second sets of holes extending from a center of the disc-shaped portion to the inner diameter of the cylindrical portion;

a second component being disc-shaped, including first through holes aligned with the first set of holes in the first component, having a top surface, side surfaces, and a bottom surface attached to the disc-shaped portion of the first component on a side opposite to the cylindrical portion and defining a plenum that is in fluid communication with the second set of holes in the first component and that is separate from the first set of holes in the first component, the top surface including a pair of arc-shaped grooves along a periphery and on opposite ends of the top surface and including a plurality of grooves extending between the pair of arc-shaped grooves; and

a third component being disc-shaped, including second through holes aligned with the first through holes in the second component and with the first set of holes in the first component, and having a bottom surface attached to the top surface of the second component, wherein the third component comprises:

an annular ridge on a top surface of the third component along a periphery of the third component; and

a recess extending from an inner diameter of the annular ridge to a center of the top surface of the third component.

14. The showerhead of claim 13 wherein:

the inner diameter of the annular ridge is greater than or equal to the inner diameter of the cylindrical portion of the first component; or

an outer diameter of the annular ridge is greater than or equal to an outer diameter of the cylindrical portion of the first component.

15. The showerhead of claim 13 wherein:

a width of the annular ridge is greater than or equal to a thickness of the cylindrical portion of the first component; or

the inner diameter of the annular ridge is greater than the diameter of the substrate.

16. The showerhead of claim 13 wherein:

- 5 a diameter of the recess is greater than or equal to the inner diameter of the cylindrical portion of the first component; or
the recess has a greater diameter than the diameter of the substrate.

17. The showerhead of claim 13 wherein:

- the second through holes in the third component lie within the inner diameter of the annular ridge; or
10 the second through holes in the third component lie within the recess.

18. A system comprising:

- a processing chamber;
a showerhead for processing a substrate in the processing chamber arranged at a top end of the processing chamber, the showerhead comprising:
15 a first component including a disc-shaped portion and a cylindrical portion extending perpendicularly from the disc-shaped portion, the disc-shaped portion having a greater diameter than an outer diameter of the cylindrical portion, the cylindrical portion having an inner diameter greater than a diameter of the substrate, the disc-shaped portion including first and second sets of holes having first and second
20 diameters, respectively, and the first and second sets of holes extending from a center of the disc-shaped portion to the inner diameter of the cylindrical portion;
a second component being disc-shaped, including first through holes aligned with the first set of holes in the first component, having a top surface, side surfaces, and a bottom surface attached to the disc-shaped portion of the first component on a side
25 opposite to the cylindrical portion and defining a plenum that is in fluid communication with the second set of holes in the first component and that is separate from the first set of holes in the first component, the top surface including a pair of arc-shaped grooves along a periphery and on opposite ends of the top surface and including a plurality of grooves extending between the pair of arc-shaped grooves; and

a third component being disc-shaped, including second through holes aligned with the first through holes in the second component and with the first set of holes in the first component, and having a bottom surface attached to the top surface of the second component;

5 the system further comprising:

a plasma generator arranged above the third component of the showerhead to supply a plasma to the showerhead;

a pedestal arranged in the processing chamber, wherein the cylindrical portion of the first component of the showerhead surrounds a top portion of the pedestal;

10 a gas delivery system to supply a gas to the plenum; and

a fluid delivery system to supply a fluid to one of the pair of arc-shaped grooves.

19. The system of claim 18 wherein the first set of holes in the showerhead filters ions from the plasma and pass radicals from the plasma through the showerhead into the processing chamber.

15 20. The system of claim 18 wherein:

a film deposited on the substrate has a non-uniformity of 0.0%;

a film deposited on the substrate has a non-uniformity of less than 0.1%; or

a gap between a bottom surface of the disc-shaped portion of the first component of the showerhead and a top surface of the pedestal is between 0.11 in.

20 and 0.2 in.