

CLAIMS

What is claimed is:

1. A semiconductor processing apparatus comprising:

a showerhead, the showerhead including:

5 a body;

a first plenum inlet;

a second plenum inlet;

a plurality of first gas distribution holes; and

a plurality of second gas distribution holes, wherein:

10 the body includes a plurality of layers, the plurality of layers including a proper subset of two or more fractal layers, each fractal layer including a set of first radially symmetric gas distribution features and a set of second radially symmetric gas distribution features,

15 each first radially symmetric gas distribution feature includes a first hub plenum, a plurality of first spoke passages that are fluidically connected to the first hub plenum and that radiate outward from the first hub plenum, and a plurality of first riser ports, each first riser port located at a distal end of one of the first spoke passages,

20 each second radially symmetric gas distribution feature includes a second hub plenum, a plurality of second spoke passages that are fluidically connected to the second hub plenum and that radiate outward from the second hub plenum, and a plurality of second riser ports, each second riser port located at a distal end of one of the second spoke passages, and

25 for each fractal layer of the fractal layers:

each first radially symmetric gas distribution feature of that fractal layer is positioned such that the corresponding first hub plenum is positioned beneath a first riser port of the immediately upstream layer, and

30 each second radially symmetric gas distribution feature of that fractal layer is positioned such that the corresponding second hub plenum is positioned beneath a second riser port of the immediately upstream layer.

2. The semiconductor processing apparatus of claim 1, wherein:

one of the fractal layers also includes a set of first partial radially symmetric gas distribution features, each first partial radially symmetric gas distribution feature having a first hub plenum with a lesser number of first spoke passages fluidically connected therewith compared with any of the first radially symmetric gas distribution features of that fractal layer.

3. The semiconductor processing apparatus of claim 2, wherein the body further includes a feed layer immediately upstream of the fractal layer with the set of first partial radially symmetric gas distribution features, wherein:

the feed layer includes a plurality of first feed plenums, each first feed plenum having a one or more of first feed spoke passages fluidically connected therewith, each first feed spoke passage having a first feed riser port at a distal end thereof, each first feed riser port positioned above, and fluidically connected with, a corresponding one of the first hub plenums in the fractal layer immediately downstream from the feed layer,

the first feed spoke passages that have first feed riser ports that are fluidically connected with first hub plenums of the first radially symmetric gas distribution features in the fractal layer immediately downstream of the feed layer each have a first length, and

the first feed spoke passages that have first feed riser ports that are fluidically connected with first hub plenums of the first partial radially symmetric gas distribution features in the fractal layer immediately downstream of the feed layer each have lengths longer than the first length.

4. The semiconductor processing apparatus of claim 2, wherein:

the fractal layer with the set of first partial radially symmetric gas distribution features also includes a set of second partial radially symmetric gas distribution features, each second partial radially symmetric gas distribution feature having a second hub plenum with a lesser number of second spoke passages compared with any of the second radially symmetric gas distribution features of that fractal layer.

5. The semiconductor processing apparatus of claim 4, wherein the body further includes a feed layer immediately upstream of the fractal layer with the set of first partial radially symmetric gas distribution features and the set of second partial radially symmetric gas distribution features, wherein:

the feed layer includes a plurality of first feed plenums and a plurality of second feed plenums, each first feed plenum having one or more first feed spoke passages fluidically connected therewith and each second feed plenum having one or more second feed spoke passages fluidically connected therewith, each first feed spoke passage having a first feed riser port at a distal end thereof and each second feed spoke passage having a second feed riser port at a distal end thereof, each first feed riser port positioned above, and fluidically connected with, a corresponding one of the first hub plenums in the fractal layer immediately downstream from the feed layer, each second feed riser port positioned above, and fluidically connected with, a corresponding one of the second hub plenums in the fractal layer immediately downstream from the feed layer,

the first feed spoke passages that have first feed riser ports that are fluidically connected with first hub plenums of the first radially symmetric gas distribution features in the fractal layer immediately downstream of the feed layer each have a first length,

the first feed spoke passages that have first feed riser ports that are fluidically connected with first hub plenums of the first partial radially symmetric gas distribution features in the fractal layer immediately downstream of the feed layer each have lengths longer than the first length,

the second feed spoke passages that have second feed riser ports that are fluidically connected with second hub plenums of the second radially symmetric gas distribution features in the fractal layer immediately downstream of the feed layer each have a second length, and

the second feed spoke passages that have second feed riser ports that are fluidically connected with second hub plenums of the second partial radially symmetric gas distribution features in the fractal layer immediately downstream of the feed layer each have lengths longer than the second length.

6. The semiconductor processing apparatus of claim 1, wherein the first radially symmetric gas distribution features of the fractal layers each include four first spoke passages and the second radially symmetric gas distribution features of the fractal layers each include four second spoke passages.

7. The semiconductor processing apparatus of claim 6, wherein the first spoke passages and the second spoke passages for the first radially symmetric gas distribution features and the second radially symmetric gas distribution features, respectively, of at least one fractal layer of the fractal layers are at the same elevation.

8. The semiconductor processing apparatus of claim 6, wherein, for each fractal layer of the fractal layers:

the first spoke passages are each aligned with one of two orthogonal first passage axes,

5 the second spoke passages are each aligned with one of two orthogonal second passage axes, and

the first passage axes are 45° out-of-phase with the second passage axes.

9. The semiconductor processing apparatus of claim 6, wherein, for each of the
10 fractal layers with an immediately upstream fractal layer, the first radially symmetric gas distribution features of that fractal layer each have center-to-center spacings between the corresponding first riser ports thereof that are approximately 50% of the corresponding center-to-center spacings between first riser ports in the first radially symmetric gas distribution features of the immediately upstream fractal layer.

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10. The semiconductor processing apparatus of claim 6, wherein, for each of the fractal layers with an immediately upstream fractal layer, the second radially symmetric gas distribution features of that fractal layer each have center-to-center spacings between the corresponding second riser ports thereof that are approximately 50% of
20 the corresponding center-to-center spacings between second riser ports in the second radially symmetric gas distribution features of the immediately upstream fractal layer.

11. The semiconductor processing apparatus of claim 1, wherein there are at least three fractal layers.

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12. The semiconductor processing apparatus of claim 1, wherein the body is made from a ceramic material.

13. The semiconductor processing apparatus of claim 12, wherein the body is made
30 from multiple discrete layers of ceramic material that are fused together.

14. The semiconductor processing apparatus of claim 12, wherein the body is a 3D-printed structure.

15. The semiconductor processing apparatus of any one of claims 1 through 14,,
5 further comprising:

a processing chamber; and

a pedestal, wherein:

the pedestal is positioned within the processing chamber, and

10 the showerhead is positioned within the processing chamber above the pedestal.