

CLAIMS:

1. A composite showerhead electrode assembly for generating plasma in a plasma processing apparatus, comprising:

a backing plate comprising top and bottom surfaces with first gas passages extending therebetween, the bottom surface having bridged and unbridged regions, the first gas passages having outlets in unbridged regions to supply a process gas to an interior of the plasma processing apparatus;

an electrode plate having a top surface, a plasma exposed bottom surface, and second gas passages extending therebetween and in fluid communication with the first gas passages, wherein the second gas passages have inlets in unbridged regions of the top surface of the electrode plate;

an interface gel disposed between facing surfaces at each of the bridged regions which establishes thermal contact between the electrode plate and the backing plate without bonding the electrode plate to the backing plate and the interface gel remains as a gel and maintains the thermal contact during movement in a lateral direction of the electrode plate relative to the backing plate during temperature cycling due to mismatch of coefficients of thermal expansion in the electrode plate and the backing plate;

wherein the electrode plate is joined to the backing plate to allow the movement.

2. The composite showerhead electrode assembly of claim 1, wherein the interface gel is electrically conductive.

3. The composite showerhead electrode assembly of claim 1, wherein the electrode plate is joined to the backing plate by a clamping member engaging an outer edge of the electrode plate and resiliently pressing the electrode against the backing plate, wherein a thermally and electrically conductive gasket is interposed between the clamping member and the backing plate.

4. The composite showerhead electrode assembly of claim 1, wherein the electrode plate is joined to the backing plate by an elastomeric adhesive bond.

5. The composite showerhead electrode assembly of claim 1, wherein the backing plate comprises an inner backing plate and an outer backing ring, the outer backing ring surrounding the inner backing plate, wherein the first gas passages are in the inner backing plate and optionally in the outer backing ring, the electrode plate comprises an inner showerhead electrode joined to the inner backing plate and an outer ring electrode joined to the outer backing ring, wherein the second gas passages are in the inner showerhead electrode and optionally in the outer ring electrode.

6. The composite showerhead electrode assembly of claim 5, wherein (a) the surfaces of the inner backing plate and showerhead electrode facing one another are parallel to each other and/or (b) the electrode plate is of single crystal silicon, polycrystalline silicon, graphite or silicon carbide; and the backing plate is of aluminum, graphite, or silicon carbide.

7. The composite showerhead electrode assembly of claim 1, further comprising at least one thermally and electrically conductive gasket disposed between the electrode plate and backing plate surfaces in at least one bridged region.

8. The composite showerhead electrode assembly of claim 7, wherein the interface gel comprises first and second continuous or segmented rings between facing surfaces at two inner bridged regions and the at least one thermally and electrically conductive gasket comprises first and second continuous or segmented rings between the facing surfaces at two outer bridged regions.

9. The composite showerhead electrode assembly of claim 7, wherein the thermally and electrically conductive gasket comprises two or more laminated layers having different physical properties.

10. The composite showerhead electrode assembly of claim 7, wherein at least one portion of the interface gel and gasket has a thermal conductivity between the electrode plate and backing plate surfaces of 0.5 W/mK to 1 W/mK, 1 W/mK to 5 W/mK and/or over 5 W/mK.

11. The composite showerhead electrode assembly of claim 1, wherein the interface gel comprises a silicone based composite, a low molecular weight siloxane and a uniform distribution of thermally conductive filler, or a combination thereof.
12. The composite showerhead electrode assembly of claim 11, wherein the thermally conductive filler is one of boron nitride (BN), aluminum oxide (Al_2O_3), silicon, silicon carbide, and a combination thereof.
13. The composite showerhead electrode assembly of claim 1, wherein a gap distance between the bridged regions of facing surfaces of the backing plate and electrode plate varies by less than $\pm 25 \mu\text{m}$ (0.001 in).
14. The composite showerhead electrode assembly of claim 1, wherein
 - (a) the interface gel is a sheet material;
 - (b) the bridged regions comprise: 1 to 3 continuous or segmented annular zones, 3 to 6 continuous or segmented annular zones, 6 to 8 continuous or segmented annular zones, or 8 to 12 continuous or segmented annular zones; and/or
 - (c) the bridged regions comprise: 1-5%, 5-10%, 10-15%, 15-20%, 20-30%, 30-40%, 40-50%, 50-60%, 60-70%, 70-80%, 80-90%, or 90-95% of the surface area of the facing surfaces of the electrode plate and the backing plate.
15. The electrode plate of claim 1, wherein the first gas passages and the second gas passages are arranged in circumferential rows, and the interface gel is disposed between one or more of the circumferential rows of gas passages.
16. The electrode plate of claim 1, wherein the interface gel is a semi-crosslinked silicone which fills irregularities in the top surface without bonding to the top surface.

WHAT IS CLAIMED IS:

1. A composite showerhead electrode assembly for generating plasma in a plasma processing apparatus, comprising:

5 a backing plate comprising top and bottom surfaces with first gas passages therebetween, the bottom surface having bridged and unbridged regions, the first gas passages having outlets in unbridged regions to supply a process gas to an interior of the plasma processing apparatus;

10 an electrode plate having a top surface, a plasma exposed bottom surface, and second gas passages extending therebetween and in fluid communication with the first gas passages, wherein the second gas passages have inlets in unbridged regions of the top surface of the electrode plate; and

15 an interface gel disposed between facing surfaces at each of the bridged regions which establishes thermal contact between the electrode plate and the backing plate and maintains the thermal contact during movement in a lateral direction of the electrode plate relative to the backing plate during temperature cycling due to mismatch of coefficients of thermal expansion in the electrode plate and the backing plate;

20 wherein the electrode plate is joined to the backing plate to allow the movement.

2. The composite showerhead electrode assembly of Claim 1, wherein the interface gel is electrically conductive.

25 3. The composite showerhead electrode assembly of Claim 1, wherein the electrode plate is joined to the backing plate by a clamping member engaging an outer edge of the electrode plate and resiliently pressing the electrode against the backing plate, wherein a thermally and electrically conductive gasket is interposed between the clamping member and the backing plate.

30 4. The composite showerhead electrode assembly of Claim 1, wherein the electrode plate is joined to the backing plate by an elastomeric adhesive bond.

5. The composite showerhead electrode assembly of Claim 1, wherein the backing plate comprises an inner backing plate and an outer backing ring, the outer backing ring surrounding the inner backing plate, wherein the first gas passages are in the inner backing plate and optionally in the outer backing ring,

5 the electrode plate comprises an inner showerhead electrode joined to the inner backing plate and an outer ring electrode joined to the outer backing ring, wherein the second gas passages are in the inner showerhead electrode and optionally in the outer ring electrode.

10 6. The composite showerhead electrode assembly of Claim 5, wherein (a) the surfaces of the inner backing plate and showerhead electrode facing one another are parallel to each other and/or (b) the electrode plate is of single crystal silicon, polycrystalline silicon, graphite or silicon carbide; and the backing plate is of aluminum, graphite, or silicon carbide.

15 7. The composite showerhead electrode assembly of Claim 1, further comprising at least one thermally and electrically conductive gasket disposed between the electrode plate and backing plate surfaces in at least one bridged region.

20 8. The composite showerhead electrode assembly of Claim 7, wherein the interface gel comprises first and second continuous or segmented rings between facing surfaces at two inner bridged regions and the at least one thermally and electrically conductive gasket comprises first and second continuous or segmented rings between the facing surfaces at two outer bridged regions.

25 9. The composite showerhead electrode assembly of Claim 7, wherein the thermally and electrically conductive gasket comprises two or more laminated layers having different physical properties.

30 10. The composite showerhead electrode assembly of Claim 7, wherein at least one portion of the interface gel and gasket has a thermal conductivity

between the electrode plate and backing plate surfaces of 0.5 W/mK to 1 W/mK, 1 W/mK to 5 W/mK and/or over 5 W/mK.

11. The composite showerhead electrode assembly of Claim 1, wherein
5 the interface gel comprises a silicone based composite, a low molecular weight siloxane and a uniform distribution of thermally conductive filler, or a combination thereof.

12. The composite showerhead electrode assembly of Claim 11, wherein
10 the thermally conductive filler is one of boron nitride (BN), aluminum oxide (Al_2O_3), silicon, silicon carbide, and a combination thereof.

13. The composite showerhead electrode assembly of Claim 1, wherein a
15 gap distance between the bridged regions of facing surfaces of the backing plate and electrode plate varies by less than $\pm 25 \mu\text{m}$ (0.001 in).

14. The composite showerhead electrode assembly of Claim 1, wherein
(a) the interface gel is a sheet material;
(a) the bridged regions comprise: 1 to 3 continuous or segmented annular
20 zones, 3 to 6 continuous or segmented annular zones, 6 to 8 continuous or segmented annular zones, or 8 to 12 continuous or segmented annular zones; and/or
(b) the bridged regions comprise: 1-5%, 5-10%, 10-15%, 15-20%, 20-30%, 30-40%, 40-50%, 50-60%, 60-70%, 70-80%, 80-90%, or 90-95% of the surface area of the facing surfaces of the electrode plate and the backing plate.

15. A method of joining components for a composite showerhead
electrode assembly for a plasma processing apparatus, comprising:
applying an interface gel to a top surface of an electrode plate in a
predetermined pattern within bridging regions, the electrode plate having a plasma
30 exposed bottom surface and a plurality of gas passages extending between the top surface and the bottom surface and having inlets in unbridged regions;

aligning a bottom surface of a backing plate with the top surface of the electrode plate, the backing plate having a top surface and a plurality of gas passages extending between the top surface and the bottom surface having outlets in unbridged regions;

5 attaching the top surface of the electrode plate to the bottom surface of the backing plate with a clamp or adhesive bond, wherein the interface gel is spread laterally into bridging regions between the top surface of the electrode plate and the bottom surface of the backing plate and the gas passages of the backing plate are in fluid communication with the gas passages of the electrode plate.

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16. The method of joining components for a composite showerhead electrode assembly of Claim 15, wherein attaching the top surface of the electrode plate to the bottom surface of the backing plate further comprises:

15 clamping the outer edge of the electrode plate and resiliently pressing the electrode plate against the backing plate using screws and/or a clamp ring having a thermally and electrically conductive gasket between the clamp ring and the backing plate and a dielectric ring between the clamp ring and the electrode; and/or adhesively bonding the electrode plate to the backing plate by an elastomeric adhesive bond.

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17. The method of joining components for a composite showerhead electrode assembly of Claim 15, wherein applying the interface gel to the top surface of the electrode plate comprises applying the interface gel in a plurality of continuous or segmented rings.

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18. The method of joining components for a composite showerhead electrode assembly of Claim 15, wherein applying the interface gel to the top surface of the electrode plate comprises:

30 rotating the electrode plate about its center point and depositing annular or semi-annular zones of the interface gel with a dispenser by contacting outlets of the dispenser with the rotating electrode plate at multiple radial positions relative to the center point.

19. The method of joining components for a composite showerhead electrode assembly of Claim 15, further comprising pressing the backing plate to the electrode plate with the interface gel therebetween in an alignment fixture.

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20. The method of joining components for a composite showerhead electrode assembly of Claim 15, wherein

(a) the attaching further comprises seating the interface gel in the bridging regions by pressing the top surface of the electrode plate and the bottom surface of the backing plate together under compression, under a static weight or optionally by atmospheric pressure within a vacuum bag;

(b) the electrode plate is of silicon, graphite, or silicon carbide; and the backing plate is of aluminum, graphite, or silicon carbide;

(c) applying the interface gel to the top surface of the electrode plate comprises using a transfer sheet;

(d) applying the bottom surface of the backing plate to the interface gel comprises removing a transfer sheet from the interface gel before applying the bottom surface of the backing plate; and/or

(e) the electrode plate comprises an inner showerhead electrode and an outer ring electrode and the backing plate comprises a circular inner backing plate and an outer backing ring and the interface gel is disposed in bridging regions between the inner showerhead electrode and the inner backing plate and/or the outer ring electrode and the outer backing ring.

21. The method of joining components for a composite showerhead electrode assembly of Claim 15, further comprising applying a thermally and electrically conductive gasket between the top surface of the electrode plate and the bottom surface of the backing plate in at least one bridging region.

22. The method of joining components for a composite showerhead electrode assembly of Claim 15, wherein aligning the bottom surface of the backing plate with the top surface of the electrode plate further comprises using an alignment

pin, alignment hole, alignment marking, optical sensor or a combination thereof, wherein the backing plate and/or electrode plate comprise the alignment pin, alignment hole and/or alignment marking.

5 23. A method of processing a semiconductor substrate in a plasma processing apparatus, the method comprising:
 placing a substrate on a substrate support in a reaction chamber of a plasma processing apparatus;
 introducing a process gas into the reaction chamber with the composite
10 showerhead electrode assembly of Claim 1;
 generating a plasma from the process gas in the reaction chamber between the composite showerhead electrode assembly and the substrate;
 processing the substrate with the plasma.

15 24. The method of Claim 23, wherein the processing comprises plasma etching the substrate.

 25. An electrode plate for generating plasma in a plasma processing apparatus, the electrode plate comprising:
20 a top surface to be assembled to a backing plate bottom surface, a plasma exposed bottom surface, and gas passages extending therebetween; and
 an interface gel disposed on the top surface in a predetermined pattern within bridging regions, the gas passages having inlets in unbridged regions.

25 26. The electrode plate of Claim 24, further comprising a transfer sheet covering the interface gel; and/or a thermally and electrically conductive gasket disposed on the top surface of the electrode plate in at least one bridging region.