

## CLAIMS

1. An electrode assembly comprising a thermal control plate, a silicon-based showerhead electrode, and securing hardware, wherein:

the thermal control plate comprises a backside, a frontside, and one or more process gas passages configured to direct process gas to the frontside of the thermal control plate;

the silicon-based showerhead electrode comprises a backside, a frontside, and a plurality of showerhead passages extending from the backside of the silicon-based showerhead electrode to the frontside of the silicon-based showerhead electrode;

the silicon-based showerhead electrode further comprises a plurality of partial recesses formed in the backside of the silicon-based showerhead electrode, the partial recesses leaving a thickness of silicon-based electrode material between the recess and the frontside of the silicon-based showerhead electrode;

the silicon-based showerhead electrode further comprises backside inserts positioned in the partial recesses along the backside of the silicon-based showerhead electrode;

the thermal control plate further comprises securing hardware passages configured to permit securing hardware to access the backside inserts positioned in the partial recesses along the backside of the silicon-based showerhead electrode;

the thermal control plate and the silicon-based showerhead electrode are engaged such that the frontside of the thermal control plate faces the backside of the silicon-based showerhead electrode, the showerhead passages in the silicon-based showerhead electrode are aligned with the process gas passages in the thermal control plate, and the securing hardware passages are aligned with the backside inserts positioned in the partial recesses along the backside of the silicon-based showerhead electrode;

the securing hardware extends at least partially through the securing hardware passages in the thermal control plate into engagement with the backside inserts positioned in the partial recesses along the backside of the silicon-based showerhead electrode;-and

the securing hardware and the backside inserts are configured to maintain engagement of the thermal control plate and the silicon-based showerhead electrode and to permit disengagement of the thermal control plate and the silicon-based showerhead electrode while isolating the silicon-based electrode material of the silicon-based showerhead electrode from frictional contact with the securing hardware during disengagement; and

the silicon-based electrode material comprises single crystal silicon, wherein the partial recesses are formed within the single crystal silicon.

2. An electrode assembly as claimed in claim 1 wherein the securing hardware and the backside inserts are configured to permit repeated engagement and disengagement of the thermal control plate and the silicon-based showerhead electrode, nondestructive disengagement of the thermal control plate and the silicon-based showerhead electrode, or both.

3. An electrode assembly as claimed in claim 1 wherein the securing hardware, the backside inserts, and the partial recess are configured such that, with the securing hardware and backside inserts in an engaged state, the backside insert is able to move with the securing hardware within the partial recess, without becoming dislodged from the recess.

4. An electrode assembly as claimed in claim 1 wherein the hardness of the backside inserts does not exceed the hardness of the silicon-based electrode material.

5. An electrode assembly as claimed in claim 1 wherein the backside inserts comprise polyetheretherketone (PEEK) formulated and manufactured such that the hardness of the backside inserts does not exceed the hardness of the silicon-based electrode material.

26. An electrode assembly as claimed in claim 1 wherein the thickness of silicon-based electrode material between the recess and the frontside of the silicon-based showerhead electrode is at least approximately 0.25 cm.

37. An electrode assembly as claimed in claim 1 wherein the thickness of silicon-based electrode material between the recess and the frontside of the silicon-based showerhead electrode is at least approximately 25% of the total thickness of the silicon-based showerhead electrode.

8. An electrode assembly as claimed in claim 1 wherein the backside inserts are positioned in the partial recesses such that they are inset relative to the backside of the silicon-based showerhead electrode.

49. An electrode assembly as claimed in claim 1 wherein the backside insert comprises a tool engaging portion and one or more lateral shielding portions configured to permit a tool to engage the backside insert without extending beyond the periphery of the insert.

510. An electrode assembly as claimed in claim 1 wherein: at least one of the backside inserts is configured as an anchor in one of the partial recesses formed in the backside of the silicon-based showerhead electrode; and  
~~the backside insert comprises tabs that are configured to complement undercut portions formed in the electrode material of the showerhead electrode in an insert and rotate manner.~~

11. An electrode assembly as claimed in claim 10 wherein the backside insert comprises tabs that are configured to complement undercut portions formed in the electrode material of the showerhead electrode in an insert and rotate manner.

12. An electrode assembly as claimed in claim 11 wherein the backside insert is secured in the recess in a spring-loaded state.

13. An electrode assembly as claimed in claim 12 wherein the outside diametrical dimensions of the backside insert and the size and shape of the tabs are chosen to allow for movement of the insert in the partial recess in the spring-loaded state.

14. An electrode assembly as claimed in claim 10 wherein the backside insert is anchored in the partial recess by a threaded portion formed in the silicon-based electrode material.

615. An electrode assembly as claimed in claim 10 wherein the partial recess comprises an undercut portion and the backside insert is anchored in the partial recess by positioning it to at least partially extend into the undercut portion of the partial recess.

716. An electrode assembly as claimed in claim 10 wherein the backside insert is configured as a stud comprising a backside extension configured to extend into one of the securing hardware passages in the thermal control plate and the securing hardware

is configured to access the backside extension of the backside insert in the securing hardware passage.

~~817.~~ An electrode assembly as claimed in claim 1 wherein: the securing hardware and the backside inserts are configured to provide spring-loaded engagement of the thermal control plate and the silicon-based showerhead electrode; and at least one of the backside inserts is configured as an anchor in one of the partial recesses formed in the backside of the silicon-based showerhead electrode and the securing hardware comprises a spring element configured to oppose a force of engagement provided when the securing hardware accesses the backside insert.

18. An electrode assembly as claimed in claim 17 wherein at least one of the backside inserts is configured as an anchor in one of the partial recesses formed in the backside of the silicon-based showerhead electrode and the securing hardware comprises a spring element configured to oppose a force of engagement provided when the securing hardware accesses the backside insert.

919. An electrode assembly as claimed in claim 1 wherein the silicon-based showerhead electrode comprises a single-piece, circular showerhead construction or a multi-component, circular showerhead construction comprising a circular central electrode and one or more peripheral electrodes arranged about the circumference of the central electrode.

20. An electrode assembly as claimed in claim 1 wherein the electrode assembly further comprises a thermally conductive gasket positioned between the frontside of the thermal control plate and the backside of the silicon-based showerhead electrode.

~~1021.~~ A plasma processing chamber comprising a vacuum source, a process gas supply, a plasma power supply, a substrate support, and an upper electrode assembly as claimed in claim 1 wherein:

the vacuum source is configured to at least partially evacuate the plasma processing chamber;

the substrate support is positioned in an evacuated portion of the plasma processing chamber and comprises a substrate electrode spaced from the upper electrode assembly;

the substrate electrode and the upper electrode assembly are operatively coupled to the plasma power supply;

the upper electrode assembly comprises a thermal control plate, a silicon-based showerhead electrode, and securing hardware;

the thermal control plate comprises a backside, a frontside, and one or more process gas passages configured to direct process gas from the process gas supply to the frontside of the thermal control plate;

the silicon-based showerhead electrode comprises a backside, a frontside, and a plurality of showerhead passages extending from the backside of the silicon-based showerhead electrode to the frontside of the silicon-based showerhead electrode;

the silicon-based showerhead electrode further comprises a plurality of partial recesses formed in the backside of the silicon-based showerhead electrode, the partial recesses leaving a thickness of silicon-based electrode material between the recess and the frontside of the silicon-based showerhead electrode;

the silicon-based showerhead electrode further comprises inserts positioned in the partial recesses along the backside of the silicon-based showerhead electrode;

the thermal control plate further comprises securing hardware passages configured to permit securing hardware to access the backside inserts positioned in the partial recesses along the backside of the silicon-based showerhead electrode;

the thermal control plate and the silicon-based showerhead electrode are engaged such that the frontside of the thermal control plate faces the backside of the silicon-based showerhead electrode, the showerhead passages in the silicon-based showerhead electrode are aligned with the process gas passages in the thermal control plate, and the securing hardware passages are aligned with the backside inserts positioned in the partial recesses along the backside of the silicon-based showerhead electrode;

the securing hardware extends at least partially through the securing hardware passages in the thermal control plate into engagement with the backside inserts positioned in the partial recesses along the backside of the silicon-based showerhead electrode;

the securing hardware and the backside inserts are configured to maintain engagement of the thermal control plate and the silicon-based showerhead electrode and to permit disengagement of the thermal control plate and the silicon-based showerhead electrode while isolating the silicon-based electrode material of the silicon-based showerhead electrode from frictional contact with the securing hardware during disengagement; and

the silicon-based electrode material comprises single crystal silicon, wherein the partial recesses are formed within the single crystal silicon.

~~11. — A silicon-based showerhead electrode comprising a backside, a frontside, a plurality of showerhead passages, a plurality of backside recesses, and a plurality of backside inserts, wherein:~~

~~the plurality of showerhead passages extend from the backside of the silicon-based showerhead electrode to the frontside of the silicon-based showerhead electrode;~~  
~~the plurality of backside recesses are formed in the backside of the silicon-based showerhead electrode, the backside recesses leaving a thickness of silicon-based electrode material between the recess and the frontside of the silicon-based showerhead electrode;~~

~~the backside inserts are positioned in the backside recesses along the backside of the silicon-based showerhead electrode;~~

~~the backside inserts comprise a threaded outside diameter, a threaded inside diameter, and a tool engaging portion formed in the threaded inside diameter;~~

~~the tool engaging portion is formed such that the backside insert further comprises one or more lateral shielding portions between the tool engaging portion and the threaded outside diameter to prevent a tool engaged with the tool engaging portion of the backside insert from extending beyond the threaded outside diameter of the insert.~~

~~12. — A silicon-based showerhead electrode as claimed in claim 1 wherein the torque receiving slots define a progressively non-constrictive cross sectional profile along a direction parallel to the axis of rotation of the backside insert.~~

22. An electrode assembly comprising a thermal control plate, a silicon-based showerhead electrode, securing hardware, and a thermally conductive gasket, wherein:

the thermal control plate comprises a backside, a frontside, and one or more process gas passages configured to direct process gas to the frontside of the thermal control plate;

the silicon-based showerhead electrode comprises a backside, a frontside, and a plurality of showerhead passages extending from the backside of the silicon-based showerhead electrode to the frontside of the silicon-based showerhead electrode;

the silicon-based showerhead electrode further comprises a plurality of partial recesses formed in the backside of the silicon-based showerhead electrode, the partial recesses leaving a thickness of silicon-based electrode material between the recess and the frontside of the silicon-based showerhead electrode;

the silicon-based showerhead electrode further comprises backside inserts positioned in the partial recesses along the backside of the silicon-based showerhead electrode;

the thermal control plate further comprises securing hardware passages configured to permit securing hardware to access the backside inserts positioned in the partial recesses along the backside of the silicon-based showerhead electrode;

the thermal control plate and the silicon-based showerhead electrode are engaged such that the frontside of the thermal control plate faces the backside of the silicon-based showerhead electrode, the showerhead passages in the silicon-based showerhead electrode are aligned with the process gas passages in the thermal control plate, and the securing hardware passages are aligned with the backside inserts positioned in the partial recesses along the backside of the silicon-based showerhead electrode;

the securing hardware extends at least partially through the securing hardware passages in the thermal control plate into engagement with the backside inserts positioned in the partial recesses along the backside of the silicon-based showerhead electrode;

the securing hardware and the backside inserts are configured to maintain engagement of the thermal control plate and the silicon-based showerhead electrode and to permit disengagement of the thermal control plate and the silicon-based showerhead electrode while isolating the silicon-based electrode material of the silicon-based

showerhead electrode from frictional contact with the securing hardware during disengagement;

the thermally conductive gasket is positioned between the frontside of the thermal control plate and the backside of the silicon-based showerhead electrode;

the silicon-based electrode material comprises single crystal silicon; and

the backside inserts are anchored in the partial recesses via a bonding agent.