

CLAIMS:

1. A semiconductor substrate processing apparatus comprising:
 - a vacuum chamber including a processing zone in which a semiconductor substrate may be processed;
 - a process gas source coupled to and in fluid communication with the vacuum chamber to supply a process gas into the vacuum chamber;
 - a showerhead through which process gas from the process gas source is to be supplied to the processing zone of the vacuum chamber; and
 - a substrate pedestal including an electrostatic chuck comprising a platen formed from a first ceramic material and having an upper surface configured to support the semiconductor substrate thereon during processing and a stem formed from a second ceramic material having an upper stem flange that supports the platen, the platen including a plurality of coplanar electrodes embedded in the platen, the plurality of electrodes including an outer radio-frequency (RF) electrode located near an outer periphery of the platen and at least two inner electrostatic clamping electrodes located within and electrically isolated from each other and the outer RF electrode, the outer RF electrode comprising a ring-shaped electrode and having at least one radially extending feed strip extending from the ring-shaped electrode to a central portion of the platen, the ceramic materials of the platen and the plurality of electrodes comprise a unitary body formed in a single sintering operation.
2. The semiconductor substrate processing apparatus of Claim 1, wherein the platen includes first and second D-shaped electrostatic clamping electrodes inward of the ring-shaped electrode, the radially extending feed strip extending diagonally across the platen and connected to the ring-shaped electrode at two locations 180° apart with the first and second D-shaped electrodes on opposite sides of the radially extending feed strip.
3. The semiconductor substrate processing apparatus of Claim 2, wherein the platen includes a first terminal at a center of the platen, a second terminal radially offset from the first terminal, and a third terminal radially offset from the first terminal, the first terminal electrically connected to the radially extending feed strip

of the ring-shaped electrode, the second terminal electrically connected to the first D-shaped electrode and the third terminal electrically connected to the other D-shaped electrode.

4. The semiconductor substrate processing apparatus of Claim 3, wherein the first, second and third terminals extend axially through openings in the platen and the second and third terminals are aligned along a diagonal line passing through the location of the first terminal.

5. The semiconductor substrate processing apparatus of Claim 1, wherein: (a) the platen is made of aluminum nitride and the electrodes are made of tungsten, (b) the platen includes three through holes configured to receive lift pins, and/or (c) the platen has a diameter of at least 300 mm.

6. The semiconductor substrate processing apparatus of Claim 1, further comprising coplanar resistance heaters embedded in the platen at a location beneath the plurality of coplanar electrodes, each of the coplanar resistance heaters connected to terminals extending from an underside of the platen and the plurality of coplanar electrodes connected to terminals extending from the underside of the platen, the terminals of the coplanar resistance heaters and the terminals of the plurality of coplanar electrodes connected to axially extending feed rods located inside the hollow ceramic stem, the feed rods extending beyond a lower end of the hollow ceramic stem.

7. The semiconductor substrate processing apparatus of Claim 1, wherein the platen includes first, second, third and fourth electrostatic clamping electrodes inward of the ring-shaped electrode, the at least one radially extending feed strip comprising two feed strips extending diagonally across the platen, each of the feed strips connected to the ring-shaped electrode at two locations 180° apart, the feed strips intersecting at the center of the platen with the first, second, third and fourth electrostatic clamping electrodes located between the diagonally extending feed strips.

8. The semiconductor substrate processing apparatus of Claim 2, wherein the ring-shaped electrode is separated from the D-shaped electrodes by a first continuous wall of ceramic material extending around the first D-shaped electrode and a second continuous wall of ceramic material extending around the second D-shaped electrode, the first and second walls having the same width, and the width of the first and second walls of ceramic material is less than a width of the radially extending feed strip.

9. The semiconductor substrate processing apparatus of Claim 1, further comprising coplanar resistance heaters embedded in the platen at a location beneath the plurality of coplanar electrodes, each of the resistance heaters connected to a pair of terminals extending axially through openings in the platen.

10. An electrostatic chuck comprising:

a platen of ceramic material having an upper surface configured to support a semiconductor substrate thereon during processing; and

a plurality of coplanar electrodes embedded in the platen, the plurality of coplanar electrodes including an outer radio-frequency (RF) electrode located near an outer periphery of the platen and at least two inner electrostatic clamping electrodes located within and electrically isolated from one other and the outer RF electrode, the outer RF electrode including a ring-shaped electrode and having at least one radially extending feed strip extending from the ring-shaped electrode, between the at least two inner electrostatic clamping electrodes, to a central portion of the platen, the ceramic material of the platen and the plurality of coplanar electrodes comprise a unitary body formed in a single sintering operation.

11. The electrostatic chuck of Claim 10, wherein the platen includes first and second D-shaped electrostatic clamping electrodes inward of the ring-shaped electrode, the at least one radially extending feed strip comprising a single feed strip extending diagonally across the platen and connected to the ring-shaped electrode at two locations 180° apart with the first and second D-shaped electrodes on opposite sides of the single feed strip.

12. The electrostatic chuck of Claim 10, wherein the platen includes first, second, third and fourth electrostatic clamping electrodes inward of the ring-shaped electrode, the at least one radially extending feed strip comprising two feed strips extending diagonally across the platen, each of the feed strips connected to the ring-shaped electrode at two locations 180° apart, the feed strips intersecting at the center of the platen with the first, second, third and fourth electrostatic clamping electrodes located between the diagonally extending feed strips.

13. The electrostatic chuck of Claim 11, wherein the platen includes a first terminal at a center of the platen, a second terminal radially offset from the first terminal, and a third terminal radially offset from the first terminal, the first terminal electrically connected to the radially extending feed strip of the ring-shaped electrode, the second terminal electrically connected to the first D-shaped electrode and the third terminal electrically connected to the other D-shaped electrode.

14. The electrostatic chuck of Claim 10, further comprising coplanar resistance heaters embedded in the platen at a location beneath the plurality of coplanar electrodes, each of the coplanar resistance heaters connected to terminals extending axially through openings in the platen.

15. The electrostatic chuck of Claim 10, wherein: (a) the platen is made of aluminum nitride and the electrodes are made of tungsten, (b) the platen includes through holes configured to receive lift pins, and/or (c) the platen has a diameter of at least 300 mm.

16. The electrostatic chuck of Claim 11, wherein the ring-shaped electrode is separated from the first and second D-shaped electrodes by a first continuous wall of ceramic material extending around the first D-shaped electrode and a second continuous wall of ceramic material extending around the second D-shaped electrode, the first and second walls having the same width.

17. The electrostatic chuck of Claim 16, wherein the width of the first and second walls of ceramic material is less than a width of the radially extending feed strip.

18. A substrate pedestal module comprising the platen of Claim 10 and a hollow ceramic stem having an upper end diffusion bonded to an underside of the platen.

19. The substrate pedestal module of Claim 18, further comprising coplanar resistance heaters embedded in the platen at a location beneath the plurality of coplanar electrodes, each of the coplanar resistance heaters connected to terminals extending from an underside of the platen and the plurality of coplanar electrodes connected to terminals extending from the underside of the platen, the terminals of the coplanar resistance heaters and the terminals of the plurality of coplanar electrodes connected to axially extending feed rods located inside the hollow ceramic stem, the feed rods extending beyond a lower end of the hollow ceramic stem.

20. The substrate pedestal module of claim 18, wherein the platen includes first and second D-shaped electrostatic clamping electrodes inward of the ring-shaped electrode, the at least one radially extending feed strip comprising a single feed strip extending diagonally across the platen and connected to the ring-shaped electrode at two locations 180° apart with the first and second D-shaped electrodes on opposite sides of the single feed strip.