[0025] In some implementations, wherein pedestal body may be made of a single piece of metal.

[0026] In some implementations, the first temperature control element may have a coolant passage configured to flow a coolant therein, and the coolant may be clear dry air.

[0027] In some implementations, the coolant may be flowed through the coolant passage at a flow rate of about 50 slm to about 150 slm.

[0028] In some implementations, the apparatus further has a controller having one or more processors and one or more memories that store instructions that are configured to cause the one or more processors to cause material to be deposited on a wafer on the pedestal body, coolant to flow through the coolant passage at a first flow rate for a first time period during material deposition on the wafer, and coolant to flow through the coolant passage at a second flow rate for a second time period during material deposition on the wafer.

[0029] In some implementations, the first flow rate may be different than the second flow rate.

[0030] In some implementations, the first time period may be the same as the second time period.

[0031] In some implementations, the first time period may be different than the second time period.

[0032] In some implementations, the apparatus may further include a showerhead for distributing gases over a surface of a wafer and a processing chamber. The pedestal body may be positioned within the processing chamber and beneath the showerhead.

[0033] In some implementations, a multi-station semiconductor processing system may be provided. The system may have a processing chamber, a plurality of processing stations in the processing chamber, each processing station has a pedestal configured to support a wafer, each pedestal has a pedestal body having a first side and a second side facing in an opposite direction from the first side, a plurality of vacuum clamping channels located on the first side, the vacuum clamping channels fluidically connected with a vacuum passage extending through the pedestal body, the plurality of vacuum clamping channels is configured for vacuum clamping a wafer to the first side of the pedestal body, and a first channel positioned on the second side of the pedestal body, the first channel is configured to receive a first temperature control element having a coolant passage and that is configured to control a temperature of the pedestal body by actively cooling the pedestal body, a showerhead positioned above a respective pedestal, and a controller having one or more processors and one or more memories

(not shown) that may be placed on the pedestal as well and in a location centered on the wafer 230. It is noted that the plurality of flexure springs 290 may be optional and can be omitted in some implementations.

[0084] FIG. 4 depicts an exploded view of the example pedestal of FIGS. 2 and 3 (e.g., the pedestal 220), according to some implementations. As discussed above, to have active control of the pedestal temperature during PECVD processes, the pedestal 220 may include a first temperature control element that is configured to control a temperature of the pedestal 220 by actively cooling the pedestal 220 and a second temperature control element that is configured to control a temperature of the pedestal 220 by actively heating the pedestal 220. Specifically, as can be seen in FIG. 4, the pedestal 220 in this example includes a resistive heater element 271 configured to control a temperature of the pedestal 220 by heating the pedestal 220. The resistive heater element 271 may feature multiple, nested C-shaped segments (e.g., C-shaped segments 271-1) that are joined at their ends by smaller connecting segments such that the C-shaped segments are electrically connected together in series. Also, the pedestal 220 in this example includes a coolant passage loop 280 configured to control a temperature of the pedestal 220 by actively cooling the pedestal 220 (e.g., by circulating a coolant such as clean dry air (CDA) in the coolant passage). In this example, the coolant passage loop 280 features multiple, nested C-shaped segments (e.g., C-shaped segments 280-4 and 280-3) that are joined at their ends by smaller connecting segments such that the C-shaped segments encircles at least 60% of a center region of the pedestal 220. It is understood that the arrangement of C-shaped segments may be feature any suitable symmetrical or non-symmetrical paths.

[0085] The pedestal 220 may, it will be understood, include first and second channels (e.g., discussed in detail below) that are milled into the side of the pedestal (e.g., a second side 220-2) opposite the side thereof that faces the wafer 230 (e.g., the first side 220-1). The first and second channels may each be sized to snugly receive the first or second temperature control element they are receiving, e.g., the resistive heater element 271 or the coolant passage loop 280. The first and second channels may, for example, have bottoms (the surfaces closest to the vacuum clamping region 221) that are semicircular in cross-sectional profile, thereby allowing a circular cross-section resistive heater element 271 or coolant passage loop 280 to be placed into such corresponding channels such that at least 30%, e.g., approximately 50% in some implementations of the exterior of the corresponding temperature control element (e.g., resistive heater element 271 or the coolant passage loop 280) is in close physical conduct with

processing chamber 1215. Further, wafer 1207 may be heated in inbound load lock 1203 to, for example, remove moisture and/or adsorbed gases. Next, chamber transport port 1217 to processing chamber 1215 is opened, and another robot 1219 places wafer 1207 into the reactor on a pedestal of a first station shown in the reactor for processing. While the implementation depicted in FIG. 12 includes load locks, it will be appreciated that, in some implementations, direct entry of wafer 1207 into a processing station may be provided.

[0113] As seen in FIG. 12, processing chamber 1215 includes four process stations, numbered 1 to 4. Each process station may be considered a process module provided above. Each station has a temperature-controlled pedestal (such as temperature-controlled pedestal 1221 of station 1), and gas line inlets, one or more of which may include a corresponding flow adjuster configured to match (or substantially match) flow conditions (e.g., flow conductance, flow velocity, etc.) to the gas line inlets. The pedestal 1221 may be the pedestal provided above and illustrated in Figures 1–9. It will be appreciated that, in some cases, each process station may have different or multiple purposes. For example, in some embodiments, a process station may be switchable between a chemical vapor deposition (CVD) and PECVD process mode. In another example, deposition operations, e.g., PECVD operations, may be performed in one station, while exposure to UV radiation for UV curing may be performed in another station. In some cases, deposition and UV curing may be performed in the same station. Further, although processing chamber 1215 shown as including four stations, embodiments are not limited thereto. For example, processing chamber 1215 may have any suitable number of stations, such as five or more stations, or three or less stations.

[0114] As previously mentioned, multi-station processing tool 1200 may include a wafer handling system (e.g., robot 1219 including spider forks 1201) for transferring and/or positioning wafers within processing chamber 1215. In some embodiments, the wafer handling system may transfer wafers between various process stations and/or between a process station and a load lock. It is contemplated, however, that any suitable wafer handling system may be employed, such as, for example, wafer carousels, other wafer handling robots, etc. Further, multi-station processing tool 1200 may include (or otherwise be coupled to) a system controller 1223 employed to control process conditions and hardware states of multi-station processing tool 1200. System controller 1223 may include one or more memory devices 1225, one or more mass storage devices 1227, and one or more processors 1229. Each processor 1229 may include a central processing unit (CPU) or computer, analog, and/or digital input/output

CLAIMS

1. An apparatus comprising:

a pedestal body having a first side and a second side facing in an opposite direction from the first side;

a plurality of vacuum clamping channels located on the first side, the vacuum clamping channels fluidically connected with a vacuum passage extending through the pedestal body, wherein the plurality of vacuum clamping channels is configured for vacuum clamping a wafer to the first side of the pedestal body; and

a first channel positioned on the second side of the pedestal body, wherein the first channel is configured to receive a first temperature control element that is configured to control a temperature of the pedestal body by actively cooling the pedestal body.

2. The apparatus of claim 1, further comprising:

the first temperature control element, wherein the first channel has a cross-sectional profile that includes a semicircular segment that contacts at least 50% of an exterior of the first temperature control element; and

a second channel positioned on the second side of the pedestal body, wherein the second channel is configured to receive a second temperature control element that is configured to control a temperature of the pedestal body by heating the pedestal body.

3. The apparatus of claim 2, further comprising:

a first insert corresponding to the first channel and configured to compress the first temperature control element into the first channel; and

a second insert corresponding to the second channel and configured to compress the second temperature control element into the second channel.

4. The apparatus of claim 3, wherein the first insert includes a concave surface that faces towards a bottom of the first channel, and wherein the second insert includes a concave surface that faces towards a bottom of the second channel.

5. The apparatus of claim 3, wherein

the first channel follows a first path,

the first insert follows the first path for at least 90% of a length of the first path, and

the first insert is friction stir-welded along the first path to opposing edges of the first channel.

6. The apparatus of claim 3, wherein

the second channel follows a second path,

the second insert follows the second path for at least 90% of a length of the second path, and

the second insert is friction stir-welded along the second path to opposing edges of the second channel.

7. The apparatus of claim 2, wherein the pedestal body is connected with a support column that houses:

a vacuum port fluidically connected with the plurality of vacuum clamping channels;

a coolant passage inlet and a coolant passage outlet that are both fluidically connected with the first temperature control element such that a coolant passage of the first temperature control element is fluidically interposed between the coolant passage inlet and the coolant passage outlet; and

resistive heater cables electrically connected with the second temperature control element.

8. The apparatus of claim 1, wherein:

the plurality of vacuum clamping channels comprises concentric vacuum channels, radial vacuum channels, parallel vacuum channels, or any combination thereof,

when viewing along a direction perpendicular to the first side of the pedestal body, the vacuum clamping channels are positioned entirely within a circular region encircled by an annular seal region, wherein the circular region is smaller than 300mm in diameter, and

the pedestal body is made of a metal or a metal alloy.

9. The apparatus of claim 1, wherein:

the first temperature control element comprises a coolant passage configured to flow a coolant therein, and

the coolant is clear dry air.

10. The apparatus of claim 9, further comprising a controller having one or more processors and one or more memories that store instructions that are configured to cause the one or more processors to cause:

material to be deposited on a wafer on the pedestal body,

coolant to flow through the coolant passage at a first flow rate for a first time period during material deposition on the wafer, and

coolant to flow through the coolant passage at a second flow rate for a second time period during material deposition on the wafer.

11. The apparatus of claim 10, wherein:

the first flow rate is different than the second flow rate,

the first time period is the same as the second time period, or

the first time period is different than the second time period.

12. A multi-station semiconductor processing system, comprising:

a processing chamber;

a plurality of processing stations in the processing chamber, wherein each processing station has:

a pedestal configured to support a wafer, wherein each pedestal has:

a pedestal body having a first side and a second side facing in an opposite direction from the first side,

a plurality of vacuum clamping channels located on the first side, the vacuum clamping channels fluidically connected with a vacuum passage extending through the pedestal body, wherein the plurality of vacuum clamping channels is configured for vacuum clamping a wafer to the first side of the pedestal body, and

a first channel positioned on the second side of the pedestal body, wherein the first channel is configured to receive a first temperature control element having a coolant passage and that is configured to control a temperature of the pedestal body by actively cooling the pedestal body;

a showerhead positioned above a respective pedestal; and

a controller having one or more processors and one or more memories that store instructions for controlling the system, the instructions are configured to cause the one or more processors to cause:

material to be deposited at the same time on a first wafer positioned on a first pedestal in a first processing station and a second wafer positioned on a second pedestal in a second station,

each pedestal to vacuum clamp the respective wafer positioned thereon,

coolant to flow in the coolant passage of the first pedestal at a first flow rate during material deposition on the first wafer, and

coolant to flow through the coolant passage of the second pedestal at a second flow rate during material deposition on the second wafer.

13. A method of semiconductor processing, the method comprising:

providing a first wafer to a first pedestal in a first processing station in a processing chamber;

heating the first wafer to a first temperature with a second temperature control element in the first pedestal;

actively cooling the first pedestal during the heating by flowing a coolant through a coolant passage of the first pedestal;

vacuum clamping the first wafer to the first pedestal during the heating and the active cooling; and

depositing a material on the first wafer while, at the same time, heating the first wafer to the first temperature, actively cooling the first pedestal, and vacuum clamping the first wafer.

14. The method of claim 13, wherein the actively cooling comprises:

flowing the coolant through the coolant passage at a first flow rate, and

flowing the coolant through the coolant passage at a second flow rate different than the first flow rate.

15. The method of claim 13, further comprising:

providing a second wafer to a second pedestal in a second processing station in the processing chamber;

heating the second wafer to the first temperature with a third temperature control element in the second pedestal;

actively cooling the second pedestal during the heating by flowing a coolant through a coolant passage of the second pedestal;

vacuum clamping the second wafer to the second pedestal during the heating and the active cooling; and

depositing, while depositing the material on the first wafer, a material on the second wafer while, at the same time, heating the second wafer to the first temperature, actively cooling the second pedestal, and vacuum clamping the second wafer.