

outer heating element 206. In one embodiment, distance D1 can range from about 2 mm and about 10 mm, or be any distance that is required for cooling the edges of the wafer 104. In some embodiments, the annular heater setback region 203 is disposed over a portion of the bond layer 108 and at least over part of the plurality of cooling channels 112 disposed along an outer diameter of the base plate 110. The thickness of the ceramic plate 106 is defined by D5. Thickness D5 extends from the bottom surface of ceramic plate 106 to the raised top surface 216 of the ceramic plate 106. In one embodiment, the thickness D5 of the ceramic plate 106 can be about 4.5 mm.

[0060] As further shown in Figure 3A, during processing, the wafer 104 is supported by the raised top surface 216 of the ceramic plate 106. In some embodiments, when a wafer 104 is placed on the top surface of the ceramic plate, a wafer overhang portion 312 of the wafer 104 extends outward over the outer diameter of the raised top surface 216 by a distance D4.

Distance D4 extends from the outer diameter of the raised top surface 216 to the wafer edge 304. In one embodiment, distance D4 can be about 2 mm.

[0061] In some embodiments, a temperature transition zone 310 exists at the boundary interface of the cold edge temperature region 308 and an annular area temperature zone 316 of the ceramic plate 106, e.g., the boundary interface between the outer diameter of the outer heating element and the annular heater setback region. As illustrated in Figure 3A, when the chiller 302 is activated, a cooling fluid flows through the cooling channels 112 which cools the ceramic plate and the annular heater setback region 203 to a temperature value projected based on the chiller set point temperature. The thermal conductive cooling of the annular heater setback region 203 caused by the activation of the chiller 302 results in the cold edge temperature region 308 which in turn keeps a portion of the wafer 104 along its edges at a lower temperature relative to the rest of the wafer. As noted above, the outer heating element 206 is arranged in the annular area of the ESC 102.

[0062] When the outer heating element 206 produces heat, the outer heating element 206 heats the annular area of the ESC 102 which in turn results in the annular area temperature zone 316. As a result, a temperature transition zone 310 exists at the boundary of the cold edge temperature region 308 and the annular area temperature zone 316 of the ceramic plate 106. In some embodiments, the temperature gradient from the cold edge temperature region 308 to the annular area temperature zone 316 is uniform and gradually changes from one zone to another.

[0063] Figure 3A-1 illustrates a temperature plot of the temperature regions of the ceramic plate 106 (e.g., cold edge temperature region 308, annular area temperature zone 316, central

[0075] Figure 6 shows an example schematic of the control system 122 of Figure 1A, in accordance with some embodiments. Although not shown, a similar control system 122 is used in the TCP system of Figure 1B. In some embodiments, the control system 122 is configured as a process controller for controlling the semiconductor fabrication process performed in a plasma processing system. In various embodiments, the control system 122 includes a processor 601, a storage hardware unit (HU) 603 (e.g., memory), an input HU 605, an output HU 607, an input/output (I/O) interface 609, an I/O interface 611, a network interface controller (NIC) 613, and a data communication bus 615. The processor 601, the storage HU 603, the input HU 605, the output HU 607, the I/O interface 609, the I/O interface 611, and the NIC 613 are in data communication with each other by way of the data communication bus 615. The input HU 605 is configured to receive data communication from a number of external devices. Examples of the input HU 605 include a data acquisition system, a data acquisition card, etc. The output HU 607 is configured to transmit data to a number of external devices.

[0076] An example of the output HU 607 is a device controller. Examples of the NIC 613 include a network interface card, a network adapter, etc. Each of the I/O interfaces 609 and 611 is defined to provide compatibility between different hardware units coupled to the I/O interface. For example, the I/O interface 609 can be defined to convert a signal received from the input HU 605 into a form, amplitude, and/or speed compatible with the data communication bus 615. Also, the I/O interface ~~607~~611 can be defined to convert a signal received from the data communication bus 615 into a form, amplitude, and/or speed compatible with the output HU 607. Although various operations are described herein as being performed by the processor 601 of the control system 122, it should be understood that in some embodiments various operations can be performed by multiple processors of the control system 122 and/or by multiple processors of multiple computing systems in data communication with the control system 122.

[0077] In some embodiments, the control system 122 is employed to control devices in various wafer fabrication systems based in-part on sensed values. For example, the control system 122 may control one or more of valves 617, filter heaters 619, wafer support structure heaters 621, pumps 623, and other devices 625 based on the sensed values and other control parameters. The valves 617 can include valves associated with control of a backside gas supply system, a process gas supply system, and a temperature control fluid circulation system. The control system 122 receives the sensed values from, for example, pressure manometers 627, flow meters 629, temperature sensors 631, and/or other sensors 633, e.g.,

CLAIMS

1. An electrostatic chuck, comprising:

5 a base plate;

a bond layer disposed over the base plate;

a ceramic plate having a bottom surface disposed over the bond layer, the ceramic plate having a raised top surface for supporting a substrate, the raised top surface having an outer diameter; and

10 a heater disposed between the bottom surface of the ceramic plate and the bond layer, the heater includes an inner heating element and an outer heating element, said inner heating element is arranged in a central circular area adjacent to the bottom surface of the ceramic plate and said outer heating element is arranged in an annular area that surrounds the central circular area and is adjacent to the bottom surface of the ceramic plate, wherein an outer
15 diameter of the outer heating element is inset from an annular heater setback region of the ceramic plate, the annular heater setback region is between the outer diameter of the raised top surface and the outer diameter of the outer heating element;

wherein the base plate includes a plurality of cooling channels, said plurality of cooling channels are disposed below the inner heating element, below the outer heating
20 element, and below the annular heater setback region, and each of said plurality of cooling channels is configured to flow a cooling fluid to cause thermally conductive cooling in the annular heater setback region of the ceramic plate.

2. The electrostatic chuck of claim 1, wherein the plurality of cooling channels are
25 arranged to circulate said cooling fluid in said base plate, wherein an outer diameter cooling channel of the plurality of cooling channels is disposed below said annular heater setback region

3. The electrostatic chuck of claim 2, wherein said outer diameter cooling channel has a
30 rectangular shape formed within the base plate, a top portion of the rectangular shape is aligned horizontally below said annular heater setback region.

4. The electrostatic chuck of claim 2, wherein said outer diameter cooling channel forms
an interface wall adjacent to said bond layer and below said annular heater setback region.

5. The electrostatic chuck of claim 4, wherein said interface wall has a dimension of not less than about 1 mm and not greater than about 6 mm.
6. The electrostatic chuck of claim 1, wherein said heater is bonded to said bottom surface of the ceramic plate.
7. The electrostatic chuck of claim 1, wherein said bond layer has a thickness of between about 0.1 mm and less than about 2 mm.
8. The electrostatic chuck of claim 7, wherein said bond layer has a thickness of about 0.75 mm.
9. The electrostatic chuck of claim 1, wherein said annular heater setback region is between about 2 mm and about 10 mm.
10. The electrostatic chuck of claim 2, wherein said outer diameter cooling channel of the plurality of cooling channels being disposed below said annular heater setback region places at least part of said outer diameter cooling channel in a region of the base plate that is opposite the annular heater setback region of the ceramic plate.
11. The electrostatic chuck of claim 1, wherein said bond layer is disposed between the base plate and the annular heater setback region of the ceramic plate to provide said thermally conductive cooling of the annular heater setback region of the ceramic plate using said cooling fluid.
12. The electrostatic chuck of claim 1, said thermally conductive cooling of the annular heater setback region of the ceramic plate provides for a cold edge region for the substrate, when the substrate is disposed over the raised top surface.
13. The electrostatic chuck of claim 1, wherein a temperature transition zone is provided in the ceramic plate at an interface between the outer diameter of the outer heating element and the annular heater setback region, wherein the annular heater setback region is setback away from the outer diameter of the outer heating element.

14. The electrostatic chuck of claim 1, wherein the outer heating element does not extend under said annular heater setback region of the ceramic plate, and said annular heater setback region of the ceramic plate is disposed over a portion of the bond layer, and at least over part of one of the plurality of cooling channels disposed along an outer diameter of the base plate.

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15. A method for thermally cooling a region of an electrostatic chuck, the electrostatic chuck including a ceramic plate and a base plate, comprising

providing an inner heating element and an outer heating element between the base plate and the ceramic plate, wherein the outer heating element is positioned away from an annular heater setback region of the ceramic plate;

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flowing a cooling fluid along a plurality of cooling channels disposed in the base plate, wherein at least one of the plurality of cooling channels is disposed under the annular heater setback region, the cooling fluid is configured to cause thermal cooling in the annular heater setback region of the ceramic plate to provide for a cold edge region for a substrate when disposed over the electrostatic chuck;

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activating alternating current (AC) heaters that are connected to the outer heating element and the inner heating element; and

activating a chiller to operate at a set point temperature, said activating the chiller is configured to control flow of the cooling fluid to thermally cool the ceramic plate and the annular heater setback region.

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16. The method as recited in claim 15, further comprising,

operating a controller to manage control of the chiller to operate at said set point temperature.

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17. The method as recited in claim 15, further comprising,

arranging the plurality of cooling channels in said base plate to circulate said cooling fluid, wherein ~~one or more of~~ an outer diameter cooling channel of the plurality of cooling channels is disposed below said annular heater setback region.

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18. The method as recited in claim 15, further comprising,

providing a bond layer over the base plate, said bond layer has a thickness of between about 0.1 mm and less than about 2 mm.

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19. The method of claim 15, further comprising:

measuring temperature data related to the annular heater setback region of the ceramic plate, and

determining if the temperature data is within a temperature value projected based on the set point temperature.