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Electrostatic chuck

Abstract

An electrostatic chuck includes a ceramic dielectric substrate, a base plate, a heater part, and a bypass part. The ceramic dielectric substrate includes a substrate upper surface and a substrate lower surface. The heater part is disposed between the substrate upper surface and the substrate lower surface. The heater part includes at least one heater layer. The heater part includes a heater upper surface and a heater lower surface. The bypass part includes a first bypass portion disposed lower than the substrate lower surface. The first bypass portion including a first bypass upper surface and a first bypass lower surface. A second distance between the heater lower surface and the first bypass upper surface is greater than a first distance between the heater upper surface and the substrate upper surface.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS

(1) This application is based upon and claims the benefit of priority from Japanese Patent Application No. 2022-154770, filed on Sep. 28, 2022, and No. 2023-129267, filed on Aug. 8, 2023; the entire contents of which are incorporated herein by reference.

FIELD

(2) Embodiments described herein relate generally to an electrostatic chuck.

BACKGROUND

(3) A known electrostatic chuck is configured to have a process object such as a semiconductor wafer, a glass substrate, or the like placed thereon. For example, the electrostatic chuck is used to clamp and hold the process object in a plasma processing chamber of a semiconductor manufacturing apparatus that performs etching, CVD (Chemical Vapor Deposition), sputtering, ion implantation, ashing, etc. For example, the electrostatic chuck applies power for electrostatic clamping to an embedded electrode and clamps a substrate such as a silicon wafer or the like by an electrostatic force.

(4) It is desirable for the electrostatic chuck to control the in-plane temperature distribution of the process object such as the wafer, etc. Therefore, for example, the inclusion of a heater that is subdivided into multiple zones is being investigated. The in-plane temperature distribution of the process object can be controlled by independently adjusting the output of each zone. For example, finer control of the in-plane temperature distribution can be performed by increasing the number of zones. The number of such zones has been increasing in recent years and may be, for example, greater than 100 in some cases.

(5) For example, heat-generating resistors that correspond to the zones are provided, and a conduction part is connected to the heat-generating resistors as a path allowing the flow of current from a power supply to the heat-generating resistors. However, there has been a risk that heat generation by the conduction part may degrade the thermal uniformity of the sample holding surface (JP 2020-004820 A).

(6) However, while fine temperature control may be performed by providing multiple zones in the heater, subdividing the bypass part used as the power supply paths to the zones is likely to reduce the cross-sectional area of the bypass part. When the cross-sectional area of the bypass part is small, the bypass part easily generates heat, and the temperature of the placement surface on which the wafer is placed undesirably deviates from the design value due to the heat from the bypass part.

SUMMARY

(7) According to the embodiment, an electrostatic chuck includes a ceramic dielectric substrate, a base plate, a heater part, and a bypass part. The ceramic dielectric substrate includes a substrate upper surface and a substrate lower surface. A process object is placed on the substrate upper surface. The substrate lower surface is at a side opposite to the substrate upper surface. The base plate is configured to support the ceramic dielectric substrate. The base plate includes a base plate upper surface and a base plate lower surface. The base plate upper surface is at the ceramic dielectric substrate side. The base plate lower surface is at a side opposite to the base plate upper surface. The heater part is disposed between the substrate upper surface and the substrate lower surface. The heater part includes at least one heater layer. The heater part heats the ceramic dielectric substrate. The bypass part is a power supply path to the heater part. The heater part includes a heater upper surface and a heater lower surface. The heater upper surface is an upper surface of a heater layer among the at least one heater layer most proximate to the substrate upper surface. The heater lower surface is a lower surface of a heater layer among the at least one heater layer most proximate to the substrate lower surface. The bypass part includes a first bypass portion. The first bypass portion is disposed lower than the substrate lower surface. The first bypass portion including a first bypass upper surface and a first bypass lower surface. The first bypass upper surface is at the substrate lower surface side. The first bypass lower surface is at a side opposite to

the first bypass upper surface. A second distance between the heater lower surface and the first bypass upper surface is greater than a first distance between the heater upper surface and the substrate upper surface.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. **1** is a perspective view schematically illustrating an electrostatic chuck according to an embodiment;

(2) FIG. **2** is a cross-sectional view schematically illustrating the electrostatic chuck according to the embodiment;

(3) FIG. **3** is a cross-sectional view schematically illustrating an electrostatic chuck according to a first modification of the embodiment;

(4) FIG. **4** is a cross-sectional view schematically illustrating an electrostatic chuck according to a second modification of the embodiment; and

(5) FIG. **5** is a cross-sectional view schematically illustrating an electrostatic chuck according to a third modification of the embodiment.

DETAILED DESCRIPTION

(6) A first invention is an electrostatic chuck including: a ceramic dielectric substrate that includes a substrate upper surface on which a process object is placed, and a substrate lower surface at a side opposite to the substrate upper surface; a base plate that supports the ceramic dielectric substrate and includes a base plate upper surface at the ceramic dielectric substrate side, and a base plate lower surface at a side opposite to the base plate upper surface; a heater part that is disposed between the substrate upper surface and the substrate lower surface, includes at least one heater layer, and heats the ceramic dielectric substrate; and a bypass part that is a power supply path to the heater part, wherein the heater part includes a heater upper surface that is an upper surface of a heater layer among the at least one heater layer most proximate to the substrate upper surface, and a heater lower surface that is a lower surface of a heater layer among the at least one heater layer most proximate to the substrate lower surface; the bypass part includes a first bypass portion disposed lower than the substrate lower surface; the first bypass portion includes a first bypass upper surface at the substrate lower surface side, and a first bypass lower surface at a side opposite to the first bypass upper surface; and a second distance between the heater lower surface and the first bypass upper surface is greater than a first distance between the heater upper surface and the substrate upper surface.

(7) According to the electrostatic chuck, the first bypass portion of the bypass part is disposed lower than the substrate lower surface; and the second distance between the heater lower surface and the first bypass upper surface is set to be greater than the first distance between the heater upper surface and the substrate upper surface so that the heater part can be disposed relatively proximate to the placement surface, and the bypass part can be sufficiently distant to the placement surface and the heater part. The effects of the heat from the bypass part on the temperature of the placement surface can be reduced thereby.

(8) A second invention is the electrostatic chuck of the first invention, wherein when viewed along a Z-direction perpendicular to the substrate upper surface, the ceramic dielectric substrate includes a central region positioned at a center of the ceramic dielectric substrate, and an outer circumference region positioned outward of the central region; and the first bypass portion is disposed at a position at which the first bypass portion overlaps the outer circumference region in the Z-direction.

(9) In the electrostatic chuck, the temperature distribution fluctuation in the outer circumference region tends to be greater than the temperature distribution fluctuation in the central region in some

cases. According to the electrostatic chuck, the first bypass portion is disposed at a position at which the first bypass portion overlaps the outer circumference region in the Z-direction so that the bypass part can be sufficiently distant to the placement surface and the heater part in the outer circumference region. Large temperature fluctuation of the placement surface in the outer circumference region can be suppressed thereby.

(10) A third invention is the electrostatic chuck of the first or second invention, wherein the bypass part further includes a second bypass portion disposed between the substrate upper surface and the substrate lower surface; the second bypass portion includes a second bypass upper surface at the substrate upper surface side; the second bypass portion includes a second bypass lower surface at a side opposite to the second bypass upper surface; and a third distance between the heater lower surface and the second bypass upper surface is greater than a fourth distance between the second bypass lower surface and the first bypass upper surface.

(11) According to the electrostatic chuck, the design freedom of the bypass part can be increased by providing the second bypass portion between the substrate upper surface and the substrate lower surface. The second bypass portion can be sufficiently distant to the heater part by setting the third distance between the heater lower surface and the second bypass upper surface to be greater than the fourth distance between the second bypass lower surface and the first bypass upper surface. Even when the bypass part includes the second bypass portion, the effects of the heat from the bypass part on the temperature of the placement surface can be reduced thereby.

(12) A fourth invention is the electrostatic chuck of the third invention, wherein when viewed along a Z-direction perpendicular to the substrate upper surface, the ceramic dielectric substrate includes a central region positioned at a center of the ceramic dielectric substrate, and an outer circumference region positioned outward of the central region; and the second bypass portion is disposed in the central region.

(13) In the electrostatic chuck, the temperature distribution fluctuation in the central region tends to be less than the temperature distribution fluctuation in the outer circumference region in some cases. According to the electrostatic chuck, the temperature fluctuation of the placement surface due to the second bypass portion can be suppressed by providing the second bypass portion in the central region. Even when the bypass part includes the second bypass portion, the temperature fluctuation of the placement surface can be suppressed thereby.

(14) A fifth invention is the electrostatic chuck of the third invention, further including a clamping electrode disposed between the substrate upper surface and the heater upper surface, wherein the clamping electrode includes an electrode upper surface at the substrate upper surface side, and an electrode lower surface at a side opposite to the electrode upper surface; and a fifth distance between the electrode lower surface and the heater upper surface is less than the fourth distance.

(15) According to the electrostatic chuck, by setting the fifth distance between the electrode lower surface and the heater upper surface to be less than the fourth distance between the second bypass lower surface and the first bypass upper surface, the heater part can be more proximate to the placement surface; and the bypass part can be more distant to the placement surface. The effects of the heat from the bypass part on the temperature of the placement surface can be reduced thereby.

(16) Embodiments of the invention will now be described with reference to the drawings. Similar components in the drawings are marked with the same reference numerals; and a detailed description is omitted as appropriate.

(17) FIG. **1** is a perspective view schematically illustrating an electrostatic chuck according to an embodiment.

(18) FIG. **2** is a cross-sectional view schematically illustrating the electrostatic chuck according to the embodiment.

(19) FIG. **1** is a cross-sectional view of a portion of the electrostatic chuck for convenience of description.

(20) FIG. **2** is a cross-sectional view along line A**1**-A**2** shown in FIG. **1**. A process object W is not

illustrated in FIG. **2**.
(21) As illustrated in FIGS. **1** and **2**, the electrostatic chuck **100** according to the embodiment includes a ceramic dielectric substrate **10**, a base plate **20**, a heater part **30**, a bypass part **40**, a bonding part **50**, and a clamping electrode **60**.
(22) The ceramic dielectric substrate **10** is, for example, a flat-plate base material made of a polycrystalline ceramic sintered body. The ceramic dielectric substrate **10** includes a substrate upper surface **10***a* on which the process object W such as a semiconductor wafer or the like is placed, and a substrate lower surface **10***b* at the side opposite to the substrate upper surface **10***a*. The substrate upper surface **10***a* corresponds to the placement surface.
(23) In this specification, the direction perpendicular to the substrate upper surface **10***a* is taken as a Z-direction. In other words, the Z-direction is the direction connecting the substrate upper surface **10***a* and the substrate lower surface **10***b*. In other words, the Z-direction is the direction from the base plate **20** toward the ceramic dielectric substrate **10**. One direction orthogonal to the Z-direction is taken as an X-direction; and a direction orthogonal to the Z-direction and the X-direction is taken as a Y-direction. In this specification, "in the plane" is, for example, in the X-Y plane. In this specification, "when viewed in plan" indicates a state viewed along the Z-direction.
(24) Examples of the material of the crystal included in the ceramic dielectric substrate **10** include, for example, Al.sub.2O.sub.3, AlN, SiC, Y.sub.2O.sub.3, YAG, etc. By using such a material, the infrared transmissivity, thermal conductivity, insulation resistance, and plasma resistance of the ceramic dielectric substrate **10** can be increased.
(25) The clamping electrode **60** is disposed inside the ceramic dielectric substrate **10**. The clamping electrode **60** is interposed between the substrate upper surface **10***a* and the substrate lower surface **10***b*. In other words, the clamping electrode **60** is disposed inside the ceramic dielectric substrate **10**. The clamping electrode **60** is sintered to have a continuous body with the ceramic dielectric substrate **10**. The clamping electrode **60** includes an electrode upper surface **60***a* at the substrate upper surface **10***a* side, and an electrode lower surface **60***b* at the side opposite to the electrode upper surface **60***a*.
(26) The electrostatic chuck **100** clamps and holds the process object W by an electrostatic force by applying a clamping voltage to the clamping electrode **60** to generate a charge at the substrate upper surface **10***a* side of the clamping electrode **60**.
(27) The clamping electrode **60** extends along the substrate upper surface **10***a* and the substrate lower surface **10***b*. The clamping electrode **60** may be monopolar or bipolar. The clamping electrode **60** may be tripolar or another multi-pole type. The number of the clamping electrodes **60** and the arrangement of the clamping electrodes **60** are appropriately selected. The clamping electrode **60** is disposed between the substrate upper surface **10***a* and the heater part **30** described below. The necessary clamping force can be realized thereby.
(28) The base plate **20** is disposed at the substrate lower surface **10***b* side of the ceramic dielectric substrate **10** and supports the ceramic dielectric substrate **10**. The base plate **20** includes a base plate upper surface **20***a* at the ceramic dielectric substrate **10** side, and a base plate lower surface **20***b* at the side opposite to the base plate upper surface **20***a*. A coolant flow path **21** that allows a cooling medium to flow is provided in the base plate **20**. That is, the coolant flow path **21** is provided inside the base plate **20**. Examples of the material of the base plate **20** include, for example, aluminum, aluminum alloys, titanium, and titanium alloys.
(29) The base plate **20** performs the role of temperature adjustment of the ceramic dielectric substrate **10**. For example, when cooling the ceramic dielectric substrate **10**, the cooling medium is caused to flow into the coolant flow path **21**, pass through the coolant flow path **21**, and flow out from the coolant flow path **21**. As a result, the heat of the base plate **20** can be absorbed by the cooling medium; and the ceramic dielectric substrate **10** that is mounted on the base plate **20** can be cooled.
(30) The heater part **30** heats the ceramic dielectric substrate **10**. By heating the ceramic dielectric

substrate **10**, the heater part **30** heats the process object W via the ceramic dielectric substrate **10**. The heater part **30** is disposed between the substrate upper surface **10***a* and the substrate lower surface **10***b*. In other words, the heater part **30** is disposed inside the ceramic dielectric substrate **10**. In other words, the heater part **30** is embedded in the ceramic dielectric substrate **10**. By providing the heater part **30** proximate to the placement surface, the temperature controllability of the placement surface can be increased.

(31) The heater part **30** includes at least one heater layer. In the example, the heater part **30** includes a first heater layer **31** and a second heater layer **32**. One of the first heater layer **31** or the second heater layer **32** may be omitted. The heater part **30** may further include another heater layer in addition to the first heater layer **31** and the second heater layer **32**.

(32) For example, the second heater layer **32** generates a lower heat amount than the first heater layer **31**. In other words, the first heater layer **31** is a high-output main heater; and the second heater layer **32** is a low-output sub-heater.

(33) Thus, because the second heater layer **32** generates a lower heat amount than the first heater layer **31**, the in-plane temperature unevenness of the process object W caused by the pattern of the first heater layer **31** can be finely adjusted by the second heater layer **32**. Accordingly, the in-plane temperature distribution uniformity of the process object W can be increased.

(34) Examples of the materials of the first heater layer **31** and the second heater layer **32** include, for example, metals including at least one of titanium, chrome, nickel, copper, aluminum, molybdenum, tungsten, palladium, platinum, silver, tantalum, molybdenum carbide, or tungsten carbide. It is favorable for the materials of the first heater layer **31** and the second heater layer **32** to include a ceramic material and such metals. Examples of the ceramic material include aluminum oxide (Al.sub.2O.sub.3), yttrium oxide (Y.sub.2O.sub.3), yttrium aluminum garnet (YAG (Y.sub.3Al.sub.5O.sub.12)), aluminum nitride (AlN), silicon carbide (SiC), etc. It is favorable for the ceramic material included in the first heater layer **31** and the second heater layer **32** to be the same as the component of the ceramic dielectric substrate **10**.

(35) The first heater layer **31** and the second heater layer **32** each generate heat when a current flows. The first heater layer **31** and the second heater layer **32** heat the ceramic dielectric substrate **10** by emitting heat. For example, the first heater layer **31** and the second heater layer **32** make the in-plane temperature distribution of the process object W uniform by heating the process object W via the ceramic dielectric substrate **10**. Or, for example, the first heater layer **31** and the second heater layer **32** may intentionally cause a difference in the in-plane temperature of the process object W by heating the process object W via the ceramic dielectric substrate **10**.

(36) The first heater layer **31** includes a first heater upper surface **31***a* at the substrate upper surface **10***a* side, and a first heater lower surface **31***b* at the side opposite to the first heater upper surface **31***a*. The second heater layer **32** includes a second heater upper surface **32***a* at the substrate upper surface **10***a* side, and a second heater lower surface **32***b* at the side opposite to the second heater upper surface **32***a*.

(37) In the example, the first heater layer **31** is disposed on the second heater layer **32** inside the ceramic dielectric substrate **10**. That is, in the example, the first heater upper surface **31***a* and the first heater lower surface **31***b* are positioned between the substrate upper surface **10***a* and the second heater upper surface **32***a*. The second heater upper surface **32***a* and the second heater lower surface **32***b* are positioned between the first heater lower surface **31***b* and the substrate lower surface **10***b*. The first heater layer **31** may be disposed below the second heater layer **32**.

(38) The heater part **30** includes a heater upper surface **30***a* and a heater lower surface **30***b*. The heater upper surface **30***a* is the upper surface of the heater layer most proximate to the substrate upper surface **10***a*. The heater lower surface **30***b* is the lower surface of the heater layer most proximate to the substrate lower surface **10***b*. In the example, the heater layer most proximate to the substrate upper surface **10***a* is the first heater layer **31**. Therefore, in the example, the heater upper surface **30***a* is the first heater upper surface **31***a*. In the example, the heater layer most proximate to

the substrate lower surface **10***b* is the second heater layer **32**. Therefore, in the example, the heater lower surface **30***b* is the second heater lower surface **32***b*.
(39) For example, when the second heater layer **32** is not provided, the heater layer most proximate to the substrate upper surface **10***a* and the heater layer most proximate to the substrate lower surface **10***b* both are the first heater layer **31**. Therefore, in such a case, the heater upper surface **30***a* is the first heater upper surface **31***a*; and the heater lower surface **30***b* is the first heater lower surface **31***b*. Similarly, for example, when the first heater layer **31** is not disposed, the heater layer most proximate to the substrate upper surface **10***a* and the heater layer most proximate to the substrate lower surface **10***b* both are the second heater layer **32**. Therefore, in such a case, the heater upper surface **30***a* is the second heater upper surface **32***a*; and the heater lower surface **30***b* is the second heater lower surface **32***b*.
(40) In the example, the clamping electrode **60** is disposed above the heater part **30** inside the ceramic dielectric substrate **10**. That is, in the example, the clamping electrode **60** is disposed between the substrate upper surface **10***a* and the heater upper surface **30***a*.
(41) The bypass part **40** is a power supply path to the heater part **30**. The bypass part **40** is electrically connected with the heater part **30**, specifically the first heater layer **31** and the second heater layer **32**, via a connection part **45**.
(42) The bypass part **40** is electrically-conductive. When the bypass part **40** is provided inside the ceramic dielectric substrate **10**, the material of the portion of the bypass part **40** disposed inside the ceramic dielectric substrate **10** (i.e., a second bypass portion **42** described below) is, for example, the same as the material of the first heater layer **31** and the second heater layer **32**. When the bypass part **40** is disposed outside the ceramic dielectric substrate **10**, the material of the portion of the bypass part **40** disposed outside the ceramic dielectric substrate **10** (i.e., a first bypass portion **41** described below) is, for example, different from the material of the first heater layer **31** and the second heater layer **32**. In such a case, examples of the material of the bypass part **40** include, for example, metals including at least one of stainless steel, titanium, chrome, nickel, copper, aluminum, Inconel (registered trademark), molybdenum, tungsten, palladium, platinum, silver, tantalum, molybdenum carbide, or tungsten carbide.
(43) For example, the bypass part **40** is covered with an insulating layer **70**. The insulating layer **70** includes, for example, a first insulating part **71** positioned at the placement surface side of the bypass part **40**, and a second insulating part **72** positioned at the side opposite to the bypass part **40**.
(44) Power from the outside is supplied to the bypass part **40** via a power supply terminal (not illustrated). The power that is supplied from the outside is supplied to the heater part **30** (the first heater layer **31** and the second heater layer **32**) via the bypass part **40** and the connection part **45**.
(45) The bypass part **40** includes multiple regions. The bypass part **40** includes, for example, a region connected with the first heater layer **31**, and a region connected with the second heater layer **32**. The region connected with the first heater layer **31** and the region connected with the second heater layer **32** may be arranged in the same plane or may be disposed in different planes.
(46) For example, the voltage and current provided to the region connected with the first heater layer **31** are different from the voltage and current provided to the region connected with the second heater layer **32**. As a result, the output of the first heater layer **31** can be different from the output of the second heater layer **32**. For example, the first heater layer **31** and the second heater layer **32** are separately controlled thereby.
(47) The first heater layer **31** includes, for example, multiple first zones arranged in the same plane. The bypass part **40** includes, for example, a region of the bypass part **40** connected with one zone among the multiple first zones of the first heater layer **31**, and a region of the bypass part **40** connected with one other zone among the multiple first zones. The region connected with the one zone among the multiple first zones of the first heater layer **31** and the region connected with the one other zone among the multiple first zones may be arranged in the same plane or may be disposed in different planes.

(48) The voltage and current provided to the region connected with the one zone among the multiple first zones are, for example, different from the voltage and current provided to the region connected with the one other zone among the multiple first zones. As a result, the output of the one zone among the multiple first zones can be different from the output of the one other zone among the multiple first zones. For example, the multiple first zones included in the first heater layer **31** are separately controlled thereby.
(49) Similarly, the second heater layer **32** includes, for example, multiple second zones arranged in the same plane. The bypass part **40** includes, for example, a region of the bypass part **40** connected with one zone among the multiple second zones of the second heater layer **32**, and a region of the bypass part **40** connected with one other zone among the multiple second zones.
(50) The region of the bypass part **40** connected with the one zone among the multiple second zones of the second heater layer **32** and the region of the bypass part **40** connected with the one other zone among the multiple second zones may be arranged in the same plane or may be disposed in different planes.
(51) The voltage and current provided to the region connected with the one zone among the multiple second zones are, for example, different from the voltage and current provided to the region connected with the one other zone among the multiple second zones. As a result, the output of the one zone among the multiple second zones can be different from the output of the one other zone among the multiple second zones. For example, the multiple second zones included in the second heater layer **32** are separately controlled thereby.
(52) The bypass part **40** may be disposed between the heater part **30** and the base plate upper surface **20***a*. The bypass part **40** may be disposed below the base plate lower surface **20***b*. The bypass part **40** includes the first bypass portion **41**. The first bypass portion **41** is disposed lower than the substrate lower surface **10***b*. That is, the first bypass portion **41** is disposed outside the ceramic dielectric substrate **10**. In the example, the first bypass portion **41** is disposed between the substrate lower surface **10***b* and the base plate upper surface **20***a*. The first bypass portion **41** is disposed between the ceramic dielectric substrate **10** and the base plate **20**. The first bypass portion **41** includes a first bypass upper surface **41***a* at the substrate lower surface **10***b* side, and a first bypass lower surface **41***b* at the side opposite to the first bypass upper surface **41***a*.
(53) In the example, a portion of the first bypass portion **41** is connected with the first heater layer **31** via the connection part **45**. In the example, another portion of the first bypass portion **41** is connected with the second heater layer **32** via the connection part **45**.
(54) When the first bypass portion **41** is disposed between the ceramic dielectric substrate **10** and the base plate **20**, the bonding part **50** is disposed between the ceramic dielectric substrate **10** and the base plate **20** and bonds the ceramic dielectric substrate **10** and the base plate **20**. In the example shown in FIG. **2**, the bonding part **50** includes a first bonding portion **51** and a second bonding portion **52**. For example, the first bonding portion **51** contacts the substrate lower surface **10***b* and the first insulating part **71**. The second bonding portion **52** contacts the base plate upper surface **20***a* and the second insulating part **72**. When the first bypass part **41** is disposed below the base plate **20** (not illustrated), the bonding part **50** includes the first bonding portion **51**; and the first bonding portion **51** contacts the base plate lower surface **20***b* and the first insulating part **71**. One of the first bonding portion **51** or the second bonding portion **52** may be omitted.
(55) For example, an insulating material such as a resin, etc., can be used as the materials of the first and second bonding portions **51** and **52**. Examples of the materials of the first and second bonding portions **51** and **52** include, for example, a silicone resin, etc.
(56) For example, an insulating material such as a resin, a ceramic, etc., can be used as the material of the insulating layer **70**. Polyimide, polyamideimide, etc., are examples when the insulating layer **70** is a resin.
(57) According to the embodiment, a second distance D2 between the heater lower surface **30***b* and the first bypass upper surface **41***a* is greater than a first distance D1 between the heater upper

surface **30***a* and the substrate upper surface **10***a*. The first distance D1 is, for example, not less than 0.4 mm and not more than 1.5 mm, and favorably not less than 0.5 mm and not more than 1.0 mm. When the first bypass portion **41** is disposed between the ceramic dielectric substrate **10** and the base plate **20** as shown in FIGS. **2** and **3**, the second distance D2 is, for example, not less than 0.25 mm and not more than 4.1 mm. When the first bypass portion **41** is disposed below the base plate **20**, the second distance D2 is substantially the thickness of the base plate **20** added to the numerical ranges described above (the details are described below). In such an embodiment, the first bypass portion **41** can be sufficiently separated from the heater part **30**.
(58) A fifth distance D5 between the electrode lower surface **60***b* and the heater upper surface **30***a* is, for example, not less than 0.3 mm and not more than 1.0 mm. If the fifth distance D5 is not less than 0.3 mm, short-circuits between the clamping electrode **60** and the heater part **30** can be suppressed. If the fifth distance D5 is not more than 1.0 mm, the process object W can be rapidly heated, and the surface temperature controllability can be improved. Also, the heat necessary for heating can be reduced.
(59) A sixth distance D6 between the substrate upper surface **10***a* and the electrode upper surface **60***a* is, for example, not less than 0.1 mm and not more than 0.5 mm. If the sixth distance D6 is not less than 0.1 mm, dielectric breakdown of the portion of the ceramic dielectric substrate **10** between the substrate upper surface **10***a* and the electrode upper surface **60***a* can be suppressed. If the sixth distance D6 is not more than 0.5 mm, a reduction of the clamping force can be suppressed.
(60) A seventh distance D7 between the first heater lower surface **31***b* and the second heater upper surface **32***a* is, for example, not less than 0.3 mm and not more than 1.0 mm. If the seventh distance D7 is not less than 0.3 mm, short-circuits between the first heater layer **31** and the second heater layer **32** can be suppressed. If the seventh distance D7 is not more than 1.0 mm, the second heater layer **32** can be sufficiently proximate to the process object W; and the surface temperature controllability can be improved.
(61) An eighth distance D8 between the second heater lower surface **32***b* and the substrate lower surface **10***b*, while arbitrary, may be not less than 0.1 mm and not more than 3 mm as an example.
(62) A ninth thickness T9 (the Z-direction length) of the first insulating part **71** is, for example, not less than 0.025 mm and not more than 0.1 mm. If the ninth thickness T9 is not less than 0.025 mm, the effects of the heat generation from the first bypass portion **41** can be more effectively suppressed, and short-circuit of the first bypass portion **41** can be suppressed.
(63) A first thickness T1 (the Z-direction length) of the first heater layer **31** is, for example, not less than 0.01 mm and not more than 0.20 mm. A second thickness T2 (the Z-direction length) of the second heater layer **32** is, for example, not less than 0.01 mm and not more than 0.20 mm. A third thickness T3 (the Z-direction length) of the first bypass portion **41** is, for example, not less than 0.03 mm and not more than 0.30 mm. A fourth thickness T4 (the Z-direction length) of the clamping electrode **60** is, for example, not less than 0.001 mm and not more than 0.1 mm. A fifth thickness T5 (the Z-direction length) of the ceramic dielectric substrate **10** is, for example, not less than 2.0 mm and not more than 5.0 mm, and favorably not less than 2.5 mm and not more than 4.0 mm. A sixth thickness T6 (the Z-direction length) of the first bonding portion **51** is, for example, not less than 0.1 mm and not more than 1 mm. A seventh thickness T7 (the Z-direction length) of the second bonding portion **52** is, for example, not less than 0.1 mm and not more than 1 mm. An eighth thickness T8 (the Z-direction length) of the insulating layer **70** is, for example, not less than 0.08 mm and not more than 0.5 mm.
(64) The first distance D1 is the sum of the sixth distance D6, the fifth distance D5, and the fourth thickness T4 (D1=D6+D5+T4). The first distance D1 can be adjusted by adjusting one of the sixth distance D6, the fifth distance D5, or the fourth thickness T4.
(65) As an example when the first bypass portion **41** is disposed between the ceramic dielectric substrate **10** and the base plate **20**, the second distance D2 is the sum of the eighth distance D8, the

ninth thickness T9, and the sixth thickness T6 (D2=D8+T9+T6). The second distance D2 can be adjusted by adjusting one of the eighth distance D8, the ninth thickness T9, or the sixth thickness T6. When the first bypass portion **41** is disposed below the base plate **20**, the second distance D2 is the sum of the eighth distance D8, the ninth thickness T9, the sixth thickness T6, the seventh thickness T7, and the thickness of the base plate.
(66) Thus, by positioning the first bypass portion **41** of the bypass part **40** lower than the substrate lower surface **10***b* and by setting the second distance D2 between the heater lower surface **30***b* and the first bypass upper surface **41***a* to be greater than the first distance D1 between the heater upper surface **30***a* and the substrate upper surface **10***a*, the heater part **30** can be disposed relatively proximate to the placement surface; and the bypass part **40** can be sufficiently distant to the placement surface and the heater part **30**. The effects of the heat from the bypass part **40** on the temperature of the placement surface can be reduced thereby.
(67) Although not illustrated in FIGS. **2** and **3**, there are cases where multiple dots on which the process object W is placed and a sealing ring disposed at the outer circumference edge of the ceramic dielectric substrate **10** are provided in the substrate upper surface **10***a* of the ceramic dielectric substrate **10**. Also, there are cases where an inner seal that subdivides the placement surface into multiple zones is provided at the inner side of the sealing ring. There are cases where grooves are provided in the substrate upper surface **10***a* to supply a cooling gas for cooling the back side of the process object W in the state in which the process object W is placed on the dots, the sealing ring, and the inner seal.
(68) In the specification, the “substrate upper surface **10***a*” that is used as the distance calculation starting point of the first distance D1 (“between the heater upper surface **30***a* and the substrate upper surface **10***a*”) and the sixth distance D6 (“between the substrate upper surface **10***a* and the electrode upper surface **60***a*”) refers to the portion on which the process object W is placed. Specifically, when dots and/or seals (the sealing ring and the inner seal) are provided, the “substrate upper surface **10***a*” is the top surface of the dots and/or seals. When the heights of the multiple dots and/or seals change in the placement surface, the “substrate upper surface **10***a*” is taken to be the highest portion.
(69) The ceramic dielectric substrate **10** includes a central region **11** and an outer circumference region **12**. When viewed along the Z-direction, the central region **11** is positioned at the center of the ceramic dielectric substrate **10**. When viewed along the Z-direction, the outer circumference region **12** is positioned outward of the central region **11** and includes the outer circumference edge of the ceramic dielectric substrate **10**. In the electrostatic chuck, the fluctuation of the temperature distribution of the outer circumference region **12** tends to be greater than the fluctuation of the temperature distribution of the central region **11** in some cases.
(70) The central region **11** includes, for example, a center **15** of the ceramic dielectric substrate **10**. The central region **11** is the region inward of a center line CL between the center **15** and an outer circumference edge **10***e* of the ceramic dielectric substrate **10**. That is, the central region **11** is surrounded with the center line CL. The outer circumference region **12** is the region further outward of the center line CL. That is, the outer circumference region **12** is between the center line CL and the outer circumference edge **10***e*.
(71) For example, the first bypass portion **41** is disposed at a position at which the first bypass portion **41** overlaps the outer circumference region **12** in the Z-direction. By providing the first bypass portion **41** at a position at which the first bypass portion **41** overlaps the outer circumference region **12** in the Z-direction, the bypass part **40** in the outer circumference region **12** can be sufficiently distant to the placement surface and the heater part **30**. Large temperature fluctuation of the placement surface in the outer circumference region **12** can be suppressed thereby.
(72) When a step is provided in the outer circumference portion of the ceramic dielectric substrate **10**, “the outer circumference edge of the ceramic substrate” in the specification refers to the

vicinity of the portion at which the clamping electrode **60** is disposed (the outer circumference edge of the upper level).
(73) FIG. **3** is a cross-sectional view schematically illustrating an electrostatic chuck according to a first modification of the embodiment.
(74) FIG. **3** is a cross-sectional view along line A**1**-A**2** shown in FIG. **1**. The process object W is not illustrated in FIG. **3**.
(75) As illustrated in FIG. **3**, other than the second bypass portion **42** being included, the electrostatic chuck **100**A according to the first modification of the embodiment is substantially the same as the electrostatic chuck **100** described above.
(76) In the example, the bypass part **40** further includes the second bypass portion **42** in addition to the first bypass portion **41**. The second bypass portion **42** is disposed between the substrate upper surface **10***a* and the substrate lower surface **10***b*. That is, the second bypass portion **42** is disposed inside the ceramic dielectric substrate **10**. More specifically, the second bypass portion **42** is disposed between the heater lower surface **30***b* and the substrate lower surface **10***b*. The second bypass portion **42** includes a second bypass upper surface **42***a* at the substrate upper surface **10***a* (heater lower surface **30***b*) side, and a second bypass lower surface **42***b* at the side opposite to the second bypass upper surface **42***a*.
(77) In the example, the first bypass portion **41** is connected with the first heater layer **31** via the connection part **45**. That is, the first bypass portion **41** corresponds to the region of the bypass part **40** connected with the first heater layer **31**. In the example, the second bypass portion **42** is connected with the second heater layer **32** via the connection part **45**. That is, the second bypass portion **42** corresponds to the region of the bypass part **40** connected with the second heater layer **32**.
(78) In the example, the second bypass portion **42** overlaps the first bypass portion **41** in the Z-direction. The second bypass portion **42** may overlap the first bypass portion **41** or may not overlap the first bypass portion **41** in the Z-direction.
(79) In the example as well, the second distance D2 between the heater lower surface **30***b* and the first bypass upper surface **41***a* is greater than the first distance D1 between the heater upper surface **30***a* and the substrate upper surface **10***a*. As a result, the heater part **30** can be disposed relatively proximate to the placement surface; the bypass part **40** can be sufficiently distant to the placement surface and the heater part **30**; and the effects of the heat from the bypass part **40** on the temperature of the placement surface can be reduced.
(80) In the example, a third distance D3 between the heater lower surface **30***b* and the second bypass upper surface **42***a* is greater than a fourth distance D4 between the second bypass lower surface **42***b* and the first bypass upper surface **41***a*.
(81) Thus, the design freedom of the bypass part **40** can be increased by providing the second bypass portion **42** between the substrate upper surface **10***a* and the substrate lower surface **10***b*. Also, the second bypass portion **42** can be sufficiently distant to the heater part **30** by setting the third distance D3 between the heater lower surface **30***b* and the second bypass upper surface **42***a* to be greater than the fourth distance D4 between the second bypass lower surface **42***b* and the first bypass upper surface **41***a*. As a result, the effects of the heat from the bypass part **40** on the temperature of the placement surface can be reduced even when the bypass part **40** includes the second bypass portion **42**.
(82) In the example, the clamping electrode **60** is disposed between the substrate upper surface **10***a* and the heater upper surface **30***a*. The fifth distance D5 between the electrode lower surface **60***b* and the heater upper surface **30***a* is less than the fourth distance D4 between the second bypass lower surface **42***b* and the first bypass upper surface **41***a*.
(83) Thus, by setting the fifth distance D5 between the electrode lower surface **60***b* and the heater upper surface **30***a* to be less than the fourth distance D4 between the second bypass lower surface **42***b* and the first bypass upper surface **41***a*, the heater part **30** can be more proximate to the

placement surface; and the bypass part **40** can be more distant to the placement surface. The effects of the heat from the bypass part **40** on the temperature of the placement surface can be reduced thereby.
(84) The ceramic dielectric substrate **10** includes the central region **11** and the outer circumference region **12**. The central region **11** and the outer circumference region **12** are the same as the central region **11** and the outer circumference region **12** of FIGS. **1** and **2** above. In the electrostatic chuck, the fluctuation of the temperature distribution of the central region **11** tends to be less than the fluctuation of the temperature distribution of the outer circumference region **12** in some cases.
(85) For example, the second bypass portion **42** is disposed in the central region **11**. By providing the second bypass portion **42** in the central region **11**, the temperature fluctuation of the placement surface due to the second bypass portion **42** being included can be suppressed. As a result, the temperature fluctuation of the placement surface can be suppressed even when the bypass part **40** includes the second bypass portion **42**.
(86) FIG. **4** is a cross-sectional view schematically illustrating an electrostatic chuck according to a second modification of the embodiment.
(87) FIG. **4** is a cross-sectional view along line A**1**-A**2** shown in FIG. **1**. The process object W is not illustrated in FIG. **4**.
(88) As illustrated in FIG. **4**, other than the bypass part **40** (the first bypass portion **41**) being disposed under the base plate **20**, and other than the insulating layer **70** and the second bonding portion **52** being omitted, the electrostatic chuck **100**B according to the second modification of the embodiment is substantially the same as the electrostatic chuck **100** described above.
(89) In the example, a recess **25** that is recessed upward is provided in the lower portion of the base plate **20**. The bypass part **40** (the first bypass portion **41**) is disposed inside the recess **25**. More specifically, the bypass part **40** (the first bypass portion **41**) is disposed at the lower surface of an insulating substrate **80**. The insulating substrate **80** is fixed to a bottom surface **25***a* of the recess **25** by a fastening member **82**. The insulating substrate **80** includes, for example, an insulating material such as a resin, etc. The fastening member **82** is, for example, a bolt, etc.
(90) By providing the bypass part **40** (the first bypass portion **41**) under the base plate **20**, the bypass part **40** can be sufficiently distant to the placement surface; and the effects of the heat from the bypass part **40** on the temperature of the placement surface can be reduced. Accordingly, the effects of the heat from the bypass part **40** on the thermal uniformity of the placement surface can be reduced.
(91) In the example as well, the second distance D2 between the heater lower surface **30***b* and the first bypass upper surface **41***a* is greater than the first distance D1 between the heater upper surface **30***a* and the substrate upper surface **10***a*. As a result, the heater part **30** can be disposed relatively proximate to the placement surface; the bypass part **40** can be sufficiently distant to the placement surface and the heater part **30**; and the effects of the heat from the bypass part **40** on the temperature of the placement surface can be reduced.
(92) When the second bypass portion **42** also is included, the second bypass portion **42** is disposed inside the ceramic dielectric substrate **10**; and the first bypass portion **41** is disposed under the base plate **20**.
(93) FIG. **5** is a cross-sectional view schematically illustrating an electrostatic chuck according to a third modification of the embodiment.
(94) FIG. **5** is a cross-sectional view along line A**1**-A**2** shown in FIG. **1**. The process object W is not illustrated in FIG. **5**.
(95) As illustrated in FIG. **5**, other than the bypass part **40** (the first bypass portion **41**) being disposed inside the recess **25** of the base plate **20** with a bonding part **55** interposed, and other than the bypass part **40** (the first bypass portion **41**) being sandwiched between a first metal plate **84** and a second metal plate **86**, the electrostatic chuck **100**C according to the third modification of the embodiment is substantially the same as the electrostatic chuck **100**B described above.

(96) In the example, the bypass part **40** (the first bypass portion **41**) is disposed between the first metal plate **84** and the second metal plate **86**. The bypass part **40** (the first bypass portion **41**) is surrounded with the insulating layer **70**. The first metal plate **84** is fixed to the bottom surface **25***a* of the recess **25** via the bonding part **55** inside the recess **25**. The bonding part **55** is disposed between the first metal plate **84** and the base plate **20** and bonds the first metal plate **84** and the base plate **20**. The first metal plate **84** and the second metal plate **86** include, for example, a metal such as aluminum, etc. For example, the examples of the materials of the first and second bonding portions **51** and **52** can be used as the material of the bonding part **55**.
(97) In the example as well, by providing the bypass part **40** (the first bypass portion **41**) under the base plate **20**, the bypass part **40** can be sufficiently distant to the placement surface; and the effects of the heat from the bypass part **40** on the temperature of the placement surface can be reduced. Accordingly, the effects of the heat from the bypass part **40** on the thermal uniformity of the placement surface can be reduced.
(98) In the example as well, the second distance D2 between the heater lower surface **30***b* and the first bypass upper surface **41***a* is greater than the first distance D1 between the heater upper surface **30***a* and the substrate upper surface **10***a*. As a result, the heater part **30** can be disposed relatively proximate to the placement surface; the bypass part **40** can be sufficiently distant to the placement surface and the heater part **30**; and the effects of the heat from the bypass part **40** on the temperature of the placement surface can be reduced.
(99) Embodiments may include the following configurations.
(100) Configuration 1
(101) An electrostatic chuck, comprising: a ceramic dielectric substrate including a substrate upper surface on which a process object is placed, and a substrate lower surface at a side opposite to the substrate upper surface; a base plate configured to support the ceramic dielectric substrate, the base plate including a base plate upper surface at the ceramic dielectric substrate side, and a base plate lower surface at a side opposite to the base plate upper surface; a heater part disposed between the substrate upper surface and the substrate lower surface, the heater part including at least one heater layer, the heater part heating the ceramic dielectric substrate; and a bypass part that is a power supply path to the heater part, the heater part including a heater upper surface that is an upper surface of a heater layer among the at least one heater layer most proximate to the substrate upper surface, and a heater lower surface that is a lower surface of a heater layer among the at least one heater layer most proximate to the substrate lower surface, the bypass part including a first bypass portion disposed lower than the substrate lower surface, the first bypass portion including a first bypass upper surface at the substrate lower surface side, and a first bypass lower surface at a side opposite to the first bypass upper surface, a second distance between the heater lower surface and the first bypass upper surface being greater than a first distance between the heater upper surface and the substrate upper surface.
Configuration 2
(102) The chuck according to configuration 1, wherein when viewed along a Z-direction perpendicular to the substrate upper surface, the ceramic dielectric substrate includes: a central region positioned at a center of the ceramic dielectric substrate; and an outer circumference region positioned outward of the central region, and the first bypass portion is disposed at a position at which the first bypass portion overlaps the outer circumference region in the Z-direction.
Configuration 3
(103) The chuck according to configuration 1 or 2, wherein the bypass part further includes a second bypass portion disposed between the substrate upper surface and the substrate lower surface, the second bypass portion includes: a second bypass upper surface at the substrate upper surface side; and a second bypass lower surface at a side opposite to the second bypass upper surface, and a third distance between the heater lower surface and the second bypass upper surface is greater than a fourth distance between the second bypass lower surface and the first bypass upper

surface.
Configuration 4
(104) The chuck according to configuration 3, wherein when viewed along a Z-direction perpendicular to the substrate upper surface, the ceramic dielectric substrate includes: a central region positioned at a center of the ceramic dielectric substrate; and an outer circumference region positioned outward of the central region, and the second bypass portion is disposed in the central region.
Configuration 5
(105) The chuck according to configuration 3 or 4, further comprising: a clamping electrode disposed between the substrate upper surface and the heater upper surface, the clamping electrode including an electrode upper surface at the substrate upper surface side, and an electrode lower surface at a side opposite to the electrode upper surface, a fifth distance between the electrode lower surface and the heater upper surface being less than the fourth distance.
(106) Thus, according to embodiments, an electrostatic chuck is provided in which the effects of the heat from the bypass part on the temperature of the placement surface can be reduced.
(107) The invention has been described with reference to the embodiments. However, the invention is not limited to these embodiments. Any design changes in the above embodiments suitably made by those skilled in the art are also encompassed within the scope of the invention as long as they fall within the spirit of the invention. For example, the shape, the size the material, the disposition and the arrangement or the like of the components included in the electrostatic chuck are not limited to illustrations and can be changed appropriately.
(108) The components included in the embodiments described above can be combined to the extent possible, and these combinations are also encompassed within the scope of the invention as long as they include the features of the invention.

Claims

1. An electrostatic chuck, comprising: a ceramic dielectric substrate including a substrate upper surface on which a process object is placed, and a substrate lower surface at a side opposite to the substrate upper surface; a base plate configured to support the ceramic dielectric substrate, the base plate including a base plate upper surface at the ceramic dielectric substrate side, and a base plate lower surface at a side opposite to the base plate upper surface; a heater part disposed between the substrate upper surface and the substrate lower surface, the heater part including at least one heater layer, the heater part heating the ceramic dielectric substrate; and a bypass part that is a power supply path to the heater part, the heater part including a heater upper surface that is an upper surface of a heater layer among the at least one heater layer most proximate to the substrate upper surface, and a heater lower surface that is a lower surface of a heater layer among the at least one heater layer most proximate to the substrate lower surface, the bypass part including a first bypass portion disposed lower than the substrate lower surface, the first bypass portion including a first bypass upper surface at the substrate lower surface side, and a first bypass lower surface at a side opposite to the first bypass upper surface, a second distance between the heater lower surface and the first bypass upper surface being greater than a first distance between the heater upper surface and the substrate upper surface.
2. The chuck according to claim 1, wherein when viewed along a Z-direction perpendicular to the substrate upper surface, the ceramic dielectric substrate includes: a central region positioned at a center of the ceramic dielectric substrate; and an outer circumference region positioned outward of the central region, and the first bypass portion is disposed at a position at which the first bypass portion overlaps the outer circumference region in the Z-direction.
3. The chuck according to claim 1, wherein the bypass part further includes a second bypass portion disposed between the substrate upper surface and the substrate lower surface, the second

bypass portion includes: a second bypass upper surface at the substrate upper surface side; and a second bypass lower surface at a side opposite to the second bypass upper surface, and a third distance between the heater lower surface and the second bypass upper surface is greater than a fourth distance between the second bypass lower surface and the first bypass upper surface.

4. The chuck according to claim 3, wherein when viewed along a Z-direction perpendicular to the substrate upper surface, the ceramic dielectric substrate includes: a central region positioned at a center of the ceramic dielectric substrate; and an outer circumference region positioned outward of the central region, and the second bypass portion is disposed in the central region.

5. The chuck according to claim 3, further comprising: a clamping electrode disposed between the substrate upper surface and the heater upper surface, the clamping electrode including an electrode upper surface at the substrate upper surface side, and an electrode lower surface at a side opposite to the electrode upper surface, a fifth distance between the electrode lower surface and the heater upper surface being less than the fourth distance.