

DESCRIPTION

TITLE OF THE INVENTION:

PLASMA PROCESSING APPARATUS AND ADSORPTION CONTROL METHOD

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Field

[0001] The present disclosure relates to a plasma processing apparatus and an adsorption control method.

Background

10 [0002] The following Patent Literature 1 discloses "a placing pedestal including: a first placement table on which a substrate is placed; and a second placement table configured to place thereon a ring-shaped edge ring arranged around the substrate, in which the second

15 placement table includes: an adsorption electrode configured to adsorb the edge ring by being applied with a voltage; and a temperature adjusting mechanism provided on at least one of an inner peripheral side and an outer peripheral side of the edge ring with respect to the

20 adsorption electrode".

Citation List

Patent Literature

[0003] Patent Literature 1: JP 2022-42379 A

Summary

25 Technical Problem

[0004] The present disclosure provides a technique for suppressing generation of particles.

Solution to Problem

[0005]

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Advantageous Effects of Invention

[0006] According to the present disclosure, generation of particles can be suppressed.

Brief Description of Drawings

[0007] FIG. 1 is a diagram illustrating a configuration example of a capacitively coupled plasma processing apparatus.

5 FIG. 2 is a graph illustrating an experimental result.

FIG. 3 is a cross-sectional view illustrating an example of a configuration of an electrostatic chuck according to an embodiment.

FIG. 4 is a plan view illustrating the example of the configuration of the electrostatic chuck according to the embodiment.

FIG. 5 is a diagram illustrating an example of specific disposition conditions of an electrostatic electrode and a control electrode according to the embodiment.

FIG. 6 is a flowchart illustrating an example of a flow of plasma processing according to the embodiment.

FIG. 7 is a diagram schematically illustrating another example of a configuration of the electrostatic chuck according to the embodiment.

FIG. 8 is a diagram schematically illustrating another example of a configuration of the electrostatic chuck according to the embodiment.

FIG. 9 is a diagram schematically illustrating another example of a configuration of the electrostatic chuck according to the embodiment.

FIG. 10 is a diagram schematically illustrating another example of the configuration of the electrostatic chuck according to the embodiment.

FIG. 11 is a diagram schematically illustrating another example of a configuration of the electrostatic chuck according to the embodiment.

FIG. 12 is a diagram schematically illustrating

another example of the configuration of the electrostatic chuck according to the embodiment.

Description of Embodiments

[0008] Hereinafter, an embodiment of a plasma processing apparatus and an adsorption control method will be described in detail based on the drawings. The plasma processing apparatus and the adsorption control method that are disclosed are not limited to the following embodiment.

[0009] In the related art, a plasma processing apparatus that executes plasma processing on a substrate such as a semiconductor wafer (hereinafter, also referred to as "wafer") using a plasma is known. This plasma processing apparatus may have a configuration where an electrostatic chuck is provided in a placing pedestal on which a substrate is placed. The electrostatic chuck electrostatically adsorbs the substrate by applying a voltage to an electrode built therein. However, in the plasma processing apparatus, when a voltage is applied to the electrode of the electrostatic chuck, particles may be generated. Accordingly, a technique for suppressing the generation of particles is expected.

[0010] (Embodiment)

[Apparatus Configuration]

An example of a plasma processing apparatus according to the present disclosure will be described. In the embodiment described below, a case of a plasma processing system including the plasma processing apparatus according to the present disclosure as a system configuration will be described as an example.

[0011] Hereinafter, a configuration example of the plasma processing system will be described. FIG. 1 is a diagram illustrating a configuration example of a capacitively coupled plasma processing apparatus.

[0012] The plasma processing system includes a capacitively coupled plasma processing apparatus 1 and a controller 2. The capacitively coupled plasma processing apparatus 1 includes a plasma processing chamber 10, a gas supply unit 20, a power source 30, and an exhaust system 40. In addition, the plasma processing apparatus 1 includes a substrate support unit 11 and a gas introduction unit. The gas introduction unit is configured to introduce at least one processing gas into the plasma processing chamber 10. The gas introduction unit includes a shower head 13. The substrate support unit 11 is disposed in the plasma processing chamber 10. The shower head 13 is disposed over the substrate support unit 11. In one embodiment, the shower head 13 configures at least a part of a ceiling of the plasma processing chamber 10. The plasma processing chamber 10 includes a plasma processing space 10s defined by the shower head 13, a side wall 10a of the plasma processing chamber 10, and the substrate support unit 11. The plasma processing chamber 10 includes at least one gas supply port for supplying at least one processing gas to the plasma processing space 10s and at least one gas discharge port for discharging gas from the plasma processing space. The plasma processing chamber 10 is grounded. The shower head 13 and the substrate support unit 11 are electrically insulated from a case of the plasma processing chamber 10.

[0013] The substrate support unit 11 includes a main part 111 and a ring assembly 112. The main part 111 includes a central region 111a for supporting a substrate W and a ring-shaped region 111b for supporting the ring assembly 112. The wafer is an example of the substrate W. The ring-shaped region 111b of the main part 111 surrounds the central region 111a of the main part 111 in a plan

view. The substrate W is disposed on the central region 111a of the main part 111, and the ring assembly 112 is disposed on the ring-shaped region 111b of the main part 111 to surround the substrate W on the central region 111a of the main part 111. Accordingly, the central region 111a will also be referred to as the substrate support surface for supporting the substrate W, and the ring-shaped region 111b will also be referred to as the ring support surface for supporting the ring assembly 112.

10 [0014] In one embodiment, the main part 111 includes a base 1110 and an electrostatic chuck 1111. The base 1110 includes a conductive member. The conductive member of the base 1110 may function as a lower electrode. The electrostatic chuck 1111 is disposed over the base 1110.

15 The electrostatic chuck 1111 includes a ceramic member 1111a and an electrostatic electrode 1111b disposed in the ceramic member 1111a. The ceramic member 1111a includes the central region 111a. In one embodiment, the ceramic member 1111a includes the ring-shaped region 111b. The

20 electrostatic chuck 1111 is formed such that the ring-shaped region 111b is lower than the central region 111a. Another member such as a ring-shaped electrostatic chuck or a ring-shaped insulating member that surrounds the electrostatic chuck 1111 may include the ring-shaped region

25 111b. In this case, the ring assembly 112 may be disposed on the ring-shaped electrostatic chuck or the ring-shaped insulating member, or may be disposed on both of the electrostatic chuck 1111 and the ring-shaped insulating member. In addition, at least one RF/DC electrode coupled

30 with an RF (Radio Frequency) power source 31 and/or a DC (Direct Current) power source 32 may be disposed in the ceramic member 1111a. In this case, at least one RF/DC electrode functions as a lower electrode. When a bias RF

signal and/or a DC signal described below is supplied to at least one RF/DC electrode, the RF/DC electrode will also be referred to as a bias electrode. The conductive member of the base 1110 and at least one RF/DC electrode may function
5 as a plurality of lower electrodes. In addition, the electrostatic electrode 1111b may function as a lower electrode. Accordingly, the substrate support unit 11 includes at least one lower electrode. The electrostatic electrode 1111b is connected to a power source 34 through a
10 wire 33. The power source 34 applies a predetermined DC voltage or AC voltage to the electrostatic electrode 1111b through the wire 33 according to a control of the controller 2.

[0015] The ring assembly 112 includes one or a plurality
15 of ring-shaped members. In one embodiment, one or a plurality of ring-shaped members include one or a plurality of edge rings and at least one cover ring. The edge ring is formed of a conductive material or an insulating material, and the cover ring is formed of an insulating
20 material.

[0016] In addition, the substrate support unit 11 may include a temperature adjusting module configured to adjust at least one of the electrostatic chuck 1111, the ring assembly 112, and the substrate to a target temperature.
25 The temperature adjusting module may include a heater, a heat transfer medium, a flow channel 1110a, or a combination thereof. A heat transfer fluid such as brine or gas flows through the flow channel 1110a. In one embodiment, the flow channel 1110a is formed in the base
30 1110, and one or a plurality of heaters are disposed in the ceramic member 1111a of the electrostatic chuck 1111. In addition, the substrate support unit 11 may include a heat transfer gas supply unit configured to supply heat transfer

gas to a gap between a reverse surface of the substrate W and the central region 111a.

[0017] The shower head 13 is configured to introduce at least one processing gas from the gas supply unit 20 into the plasma processing space 10s. The shower head 13 includes at least one gas supply port 13a, at least one gas diffusion chamber 13b, and a plurality of gas introduction ports 13c. The processing gas supplied to the gas supply port 13a passes through the gas diffusion chamber 13b and is introduced from the plurality of gas introduction ports 13c into the plasma processing space 10s. In addition, the shower head 13 includes at least one upper electrode. In addition to the shower head 13, the gas introduction unit may include one or a plurality of side gas injectors (SGI) attached to one or a plurality of openings formed on the side wall 10a.

[0018] The gas supply unit 20 may include at least one gas source 21 and at least one flow controller 22. In one embodiment, the gas supply unit 20 is configured to supply at least one processing gas to the shower head 13 from the gas source 21 corresponding thereto through the flow controller 22 corresponding thereto. Each of the flow controllers 22 may include, for example, a mass flow controller or a pressure-control type flow controller. Further, the gas supply unit 20 may include one or more flow modulation devices that modulates or pulses a flow volume of at least one processing gas.

[0019] The power source 30 includes an RF power source 31 that is coupled with the plasma processing chamber 10 through at least one impedance matching circuit. The RF power source 31 is configured to supply at least one RF signal (RF power) to at least one lower electrode and/or at least one upper electrode. As a result, a plasma is formed

from at least one processing gas supplied to the plasma processing space 10s. Accordingly, the RF power source 31 may function as at least a part of a plasma generating unit configured to generate a plasma from one or more processing gases in the plasma processing chamber 10. In addition, by supplying the bias RF signal to at least one lower electrode, a bias potential can be generated on the substrate W to draw an ionic component in the formed plasma to the substrate W.

10 [0020] In one embodiment, the RF power source 31 includes a first RF generating unit 31a and a second RF generating unit 31b. The first RF generating unit 31a is coupled with at least one lower electrode and/or at least one upper electrode through at least one impedance matching circuit and is configured to generate a source RF signal (source RF power) for generating a plasma. In one embodiment, the source RF signal has a frequency in a range of 10 MHz to 150 MHz. In one embodiment, the first RF generating unit 31a may be configured to generate a plurality of source RF signals having different frequencies. The generated one or more source RF signals are supplied to at least one lower electrode and/or at least one upper electrode.

[0021] The second RF generating unit 31b is coupled with at least one lower electrode through at least one impedance matching circuit, and is configured to generate a bias RF signal (bias RF power). A frequency of the bias RF signal may be the same as or different from a frequency of the source RF signal. In one embodiment, the bias RF signal has a lower frequency than the frequency of the source RF signal. In one embodiment, the bias RF signal has a frequency in a range of 100 kHz to 60 MHz. In one embodiment, the second RF generating unit 31b may be

configured to generate a plurality of bias RF signals having different frequencies. The generated one or more bias RF signals are supplied to at least one lower electrode. In addition, in various embodiments, at least one of the source RF signal and the bias RF signal may be pulsed.

[0022] In addition, the power source 30 may include a DC power source 32 that is coupled with the plasma processing chamber 10. The DC power source 32 includes a first DC generating unit 32a and a second DC generating unit 32b. In one embodiment, the first DC generating unit 32a is connected to at least one lower electrode and is configured to generate a first DC signal. The generated first bias DC signal is applied to at least one lower electrode. In one embodiment, the second DC generating unit 32b is connected to at least one upper electrode and is configured to generate a second DC signal. The generated second DC signal is applied to at least one upper electrode.

[0023] In addition, in various embodiments, at least one of the first and second DC signals may be pulsed. In this case, a sequence of voltage pulses is applied to at least one lower electrode and/or at least one upper electrode. The voltage pulse may have a pulse waveform of a rectangular shape, a trapezoidal shape, a triangular shape, or a combination thereof. In one embodiment, a waveform generating unit for generating a sequence of voltage pulses from the DC signal is connected between the first DC generating unit 32a and at least one lower electrode. Accordingly, the first DC generating unit 32a and the waveform generating unit configure a voltage pulse generating unit. When the second DC generating unit 32b and the waveform generating unit configure the voltage pulse generating unit, the voltage pulse generating unit is

connected to at least one upper electrode. The voltage pulse may have positive polarity or negative polarity. In addition, the sequence of voltage pulses may include one or a plurality of positive voltage pulses and one or a plurality of negative voltage pulses in one period. The first and second DC generating units 32a and 32b may be provided in addition to the RF power source 31, and the first DC generating unit 32a may be provided instead of the second RF generating unit 31b.

10 [0024] The exhaust system 40 may be connected to, for example, a gas discharge port 10e provided in a bottom portion of the plasma processing chamber 10. The exhaust system 40 may include a pressure regulating valve and a vacuum pump. A pressure in the plasma processing space 10s is adjusted by the pressure regulating valve. The vacuum pump may include a turbomolecular pump, a dry pump, or a combination thereof.

15 [0025] The controller 2 executes a computer-executable command that causes the plasma processing apparatus 1 to execute various steps described in the present disclosure. The controller 2 may be configured to control each element of the plasma processing apparatus 1 such that various steps described herein are executed. In one embodiment, a part or all of the controller 2 may be included in the plasma processing apparatus 1. The controller 2 may include a processing unit 2a1, a storage unit 2a2, and a communication interface 2a3. The controller 2 is implemented by, for example, a computer 2a. The processing unit 2a1 may be configured to execute various control operations by reading a program from the storage unit 2a2 and executing the read program. This program may be stored in the storage unit 2a2 in advance or may be acquired through a medium as necessary. The acquired program is

stored in the storage unit 2a2, and is read from the storage unit 2a2 and executed by the processing unit 2a1. The medium may be various storage media that are readable by the computer 2a, or may be a communication circuit
5 connected to the communication interface 2a3. The processing unit 2a1 may be a CPU (Central Processing Unit). The storage unit 2a2 may include a RAM (Random Access Memory), a ROM (Read Only Memory), a HDD (Hard Disk Drive), a SSD (Solid State Drive), or a combination thereof. The
10 communication interface 2a3 may communicate with the plasma processing apparatus 1 through a communication circuit such as a LAN (Local Area Network).

[0026] The overall operation of the plasma processing apparatus 1 configured as described above is controlled by
15 the above-described controller 2. The controller 2 controls plasma processing such as plasma etching. For example, the controller 2 controls the exhaust system 40 such that air inside the plasma processing chamber 10 is exhausted to a predetermined degree of vacuum. The
20 controller 2 controls the power source 34 such that a predetermined DC voltage or AC voltage is applied to the electrostatic electrode 1111b from the power source 34 through the wire 33 to cause the electrostatic chuck 1111 to electrostatically adsorb the substrate W. For example,
25 when the substrate W is electrostatically adsorbed, the power source 34 applies a DC voltage of several kV to the electrostatic electrode 1111b. The controller 2 controls the gas supply unit 20 such that processing gas for plasma processing is introduced from the gas supply unit 20 into
30 the plasma processing space 10s. The controller 2 controls the power source 30 such that, together with the introduction from the processing gas, power is supplied from the power source 30 to generate a plasma in the plasma

processing chamber 10 and plasma processing is executed on the substrate W.

[0027] Incidentally, in the plasma processing apparatus 1, when a voltage is applied to the electrostatic electrode 1111b of the electrostatic chuck 1111 to electrostatically adsorb the substrate W, particles may be generated.

[0028] When a plasma is generated in the plasma processing chamber 10, the ring assembly 112 is charged with the plasma. As a result, a self-bias voltage is generated in the ring assembly 112. A leakage electric field is generated in the periphery of the electrostatic chuck 1111 depending on the voltage applied to the electrostatic electrode 1111b, the self-bias voltage generated in the ring assembly 112, and the potential difference. Particles may be generated depending on the size of the leakage electric field.

[0029] FIG. 2 is a graph illustrating an example of an experimental result for checking a relationship between the voltage applied to the ring assembly 112 and the electrostatic electrode 1111b and the number of particles generated. The experiment is executed with a configuration where the voltage of the ring assembly 112 is changeable. In the experiment, in the plasma processing apparatus 1, the configuration where the voltage of the ring assembly 112 is changeable is implemented by connecting the power source to the ring assembly 112 through the wire and applying a DC voltage from the power source to the ring assembly 112. In the experiment, while changing a potential difference between the DC voltage applied to the ring assembly 112 and the DC voltage applied to the electrostatic electrode 1111b, plasma processing is executed on the substrate W for each potential difference to count the number of particles attached to the substrate

W.

[0030] The horizontal axis of FIG. 2 represents the potential difference Δ (V) of the DC voltage (ESDC) applied to the electrostatic electrode 111b from the DC voltage (FRDC) applied to the ring assembly 112. The minus side of the horizontal axis represents a state where ESDC is lower than FRDC. The plus side of the horizontal axis represents a state where ESDC is higher than FRDC. " V_1 " to " V_4 " shown as scales of the horizontal axis satisfy $|V_1| < |V_2| < |V_3| < |V_4|$. The vertical axis represents the number of particles attached to the substrate W, in which the number of particles increases toward the upper side. In FIG. 2, the number of particles for each potential difference Δ is plotted. In addition, in FIG. 2, a regression line is illustrated by a dotted line on the plus side and the minus side of the potential difference Δ . As illustrated in FIG. 2, as the potential difference Δ decreases, the number of particles tends to decrease, and as the potential difference Δ increases, the number of particles tends to increase. In FIG. 2, an increase rate of the number of particles on the plus side of the potential difference Δ is higher than that on the minus side of the potential difference Δ . However, the increase rate of the number of particles on the plus side is not necessarily higher than that on the minus side. The increase rate of the number of particles changes depending on which one of the plus side and the minus side the number of particles charged is more.

[0031] Based on the result, it is presumed that, as the potential difference between the voltage of the ring assembly 112 and the voltage applied to the electrostatic electrode 111b decreases, the size of the leakage electric

field generated in the periphery of the electrostatic chuck 1111 is weakened, and the number of particles decreases. However, when the voltage applied to the electrostatic electrode 1111b is low, the electrostatic chuck 1111 cannot sufficiently adsorb the substrate W.

[0032] Accordingly, in the embodiment, the electrostatic chuck 1111 is configured as follows. FIG. 3 is a cross-sectional view illustrating an example of a configuration of the electrostatic chuck 1111 according to the embodiment. FIG. 4 is a plan view illustrating the example of the configuration of the electrostatic chuck 1111 according to the embodiment. In FIG. 3, a partial cross-section of the peripheral portion of the substrate support unit 11 is schematically illustrated. The electrostatic chuck 1111 includes the ceramic member 1111a, the electrostatic electrode 1111b, and a control electrode 1112. In the embodiment, the electrostatic electrode 1111b corresponds to the first electrode according to the present disclosure, and the control electrode 1112 corresponds to the second electrode according to the present disclosure.

[0033] The electrostatic electrode 1111b and the control electrode 1112 are provided in the ceramic member 1111a. The electrostatic electrode 1111b and the control electrode 1112 are disposed to follow the central region 111a. The electrostatic chuck 1111 is formed such that the ring-shaped region 111b is lower than the central region 111a. In the central region 111a of the electrostatic chuck 1111, a side surface 111c is formed on the ring-shaped region 111b side.

[0034] In FIG. 4, the central region 111a portion of the electrostatic chuck 1111 is illustrated. The electrostatic electrode 1111b is disposed from a central portion of the central region 111a to the vicinity of the periphery. The

control electrode 1112 is disposed in the peripheral portion of the central region 111a. The control electrode 1112 is formed in a ring shape to surround the periphery of the electrostatic electrode 1111b.

5 [0035] The control electrode 1112 is connected to a power source 36 through a wire 35a. The power source 36 is connected to GND through a wire 35b. The power source 36 is configured as a variable power source where the DC voltage applied to the control electrode 1112 is
10 changeable. The power source 36 applies a DC voltage to the control electrode 1112 through the wire 35a according to a control of the controller 2. A variable resistor 37 is provided in the wire 35a. The variable resistor 37 functions as an adjustment knob for adjusting a response
15 speed of the voltage of the control electrode 1112 with respect to the DC voltage applied from the power source 36. In the variable resistor 37, a resistance value is adjusted such that a rapid voltage change does not occur in the control electrode 1112. On the wire 35a, the variable
20 resistor 37 may be disposed in the electrostatic chuck 1111 or in the base 1110.

[0036] The storage unit 2a2 stores data of the self-bias voltage generated in the ring assembly 112 during plasma processing. For example, the self-bias voltage can be
25 specified in advance by measuring the voltage of the ring assembly 112 when plasma processing is executed in the plasma processing apparatus 1. The storage unit 2a2 stores the data of the self-bias voltage specified in advance.

[0037] When plasma processing is executed, the
30 controller 2 acquires the voltage of the ring assembly 112. For example, the processing unit 2a1 reads the data of the self-bias voltage from the storage unit 2a2, and acquires the self-bias voltage as the voltage of the ring assembly

112. The controller 2 may measure and acquire the actual voltage of the ring assembly 112. In this case, for example, the plasma processing apparatus 1 is configured by connecting a voltmeter to the ring assembly 112 through a wire such that the voltage of the ring assembly 112 is measurable. The processing unit 2a1 acquires the voltage of the ring assembly 112 measured by the voltmeter.

[0038] The controller 2 controls an output voltage of the power source 36 according to the acquired value of the voltage of the ring assembly 112. For example, the controller 2 controls the output voltage of the power source 36 to be within a predetermined potential difference from the value of the voltage of the ring assembly 112. For example, the processing unit 2a1 controls the power source 36 such that a voltage within a predetermined potential difference on the plus or minus side from the acquired self-bias voltage is applied from the power source 36 to the control electrode 1112 through the wire 35a. For example, the processing unit 2a1 controls the power source 36, and, from the power source 36, applies to the control electrode 1112 a voltage within a potential difference of 1000 V, using the self-bias voltage as a reference.

[0039] This way, during plasma processing, the plasma processing apparatus 1 applies a voltage of several kV to the electrostatic electrode 1111b of the electrostatic chuck 1111 to electrostatically adsorb the substrate W. As a result, the plasma processing apparatus 1 can electrostatically adsorb the substrate W using the electrostatic chuck 1111. In addition, the plasma processing apparatus 1 applies a voltage within a potential difference of 1000 V from the self-bias voltage to the control electrode 1112 provided in the periphery of the electrostatic electrode 1111b. As a result, as compared to

the potential difference between the electrostatic electrode 1111b and the ring assembly 112, the plasma processing apparatus 1 can reduce the potential difference between the control electrode 1112 and the ring assembly 112. In addition, the control electrode 1112 functions as a shield for the electrostatic electrode 1111b, and shields a leakage electric field leaking from the electrostatic electrode 1111b to the periphery of the electrostatic chuck 1111. As a result, the plasma processing apparatus 1 can reduce the leakage electric field generated in the periphery of the electrostatic chuck 1111, and can suppress the generation of particles.

[0040] Next, an example of specific disposition conditions of the electrostatic electrode 1111b and the control electrode 1112 will be described. FIG. 5 is a diagram illustrating an example of specific disposition conditions of the electrostatic electrode 1111b and the control electrode 1112 according to the embodiment. In FIG. 5, the electrostatic electrode 1111b of the electrostatic chuck 1111 and the control electrode 1112 are schematically illustrated.

[0041] The ceramic member 1111a of the electrostatic chuck 1111 is configured such that a dielectric voltage is, for example, 13 kV/mm or more. For example, the ceramic member 1111a is made from an alumina sintered body.

[0042] It is preferable that a gap L1 between the electrostatic electrode 1111b and the control electrode 1112 is configured to be 0.5 mm to 1 mm. In addition, it is preferable that a gap L2 between the control electrode 1112 and the side surface 111c of the central region 111a of the electrostatic chuck 1111 is configured to be 0.5 μm or more. For example, it is assumed that, when the substrate W is electrostatically adsorbed, the voltage

applied to the electrostatic electrode 1111b is 6 kV, and the self-bias voltage generated in the control electrode 1112 is 1 kV. In this case, the gap L1 is configured to be 0.8 mm to 1 mm. The gap L2 is configured to be 0.2 mm or more.

[0043] By configuring the electrostatic electrode 1111b and the control electrode 1112 under the above-described disposition conditions, the electrostatic chuck 1111 can maintain the insulation between the electrostatic electrode 1111b and the control electrode 1112.

[0044] [Flow of Plasma Processing]

Next, a flow of plasma processing including an adsorption control method according to the present disclosure will be described. FIG. 6 is a flowchart illustrating an example of the flow of the plasma processing according to the embodiment.

[0045] Through a transfer mechanism such as a transfer arm, the substrate W is carried into the plasma processing chamber 10 through a carry-in port (not illustrated), and is placed on the central region 111a of the substrate support unit 11 (Step S10).

[0046] The controller 2 acquires the voltage of the ring assembly 112 (Step S11). For example, the processing unit 2a1 reads the data of the self-bias voltage from the storage unit 2a2, and acquires the self-bias voltage as the voltage of the ring assembly 112.

[0047] The controller 2 controls an output voltage of the power source 36 according to the acquired value of the voltage of the ring assembly 112 (Step S12). For example, the controller 2 controls the output voltage of the power source 36 to be within a predetermined potential difference from the value of the voltage of the ring assembly 112. For example, the processing unit 2a1 controls the power

source 36, and, from the power source 36, applies to the control electrode 1112 a voltage within a potential difference of 1000 V, using the self-bias voltage as a reference.

5 [0048] The controller 2 controls the power source 34 such that a DC voltage of several kV is applied to the electrostatic electrode 1111b from the power source 34 through the wire 33 to cause the electrostatic chuck 1111 to electrostatically adsorb the substrate W (Step S13).

10 [0049] The controller 2 controls the plasma processing apparatus 1 such that the plasma processing is executed (Step S14). For example, the controller 2 controls the gas supply unit 20 such that processing gas for plasma processing is introduced from the gas supply unit 20 into
15 the plasma processing space 10s. The controller 2 controls the power source 30 such that, together with the introduction from the processing gas, power is supplied from the power source 30 to generate a plasma in the plasma processing chamber 10 and plasma processing is executed on
20 the substrate W.

[0050] When the plasma processing on the substrate W ends, the controller 2 stops the application of the voltage from the power source 34 and the power source 36 to release the electrostatic adsorption of the substrate W (Step S15).

25 [0051] Through a transfer mechanism such as a transfer arm, the substrate W placed on the central region 111a is carried out to the outside of the plasma processing chamber 10 through a carry-out port (not illustrated) (Step S16).

[0052] In the above-described embodiment, the case where
30 one control electrode 1112 is provided is described as the example. However, the disclosed technique is not limited to this example. For example, a plurality of the control electrodes 1112 may be provided. FIG. 7 is a diagram

schematically illustrating another example of a configuration of the electrostatic chuck 1111 according to the embodiment. In FIG. 7, a schematic cross-section of the electrostatic chuck 1111 is illustrated. In the peripheral portion of the central region 111a of the electrostatic chuck 1111, a plurality of the control electrodes 1112 are provided. The plurality of control electrodes 1112 are provided in the electrostatic chuck 1111, and the control electrodes 1112 are disposed at different positions in a thickness direction of the electrostatic chuck 1111. The control electrodes 1112 may be disposed not only at the same position as that of the electrostatic electrode 1111b but also at a position closer to the central region 111a than the electrostatic electrode 1111b and a position farther from the central region 111a than the electrostatic electrode 1111b in the thickness direction of the electrostatic chuck 1111. The plurality of control electrodes 1112 disposed as described above function as a shield such that a leakage electric field leaking from the electrostatic electrode 1111b to the periphery of the electrostatic chuck 1111 can be shielded in a wider range. Therefore, generation of particles can be suppressed. In the example of FIG. 7, the plurality of control electrodes 1112 are provided at regular intervals in the thickness direction, but may be provided at irregular intervals.

[0053] In addition, in the above-described embodiment, the case where the electrostatic electrode 1111b and the control electrode 1112 are disposed to follow the central region 111a is described as the example. However, the disclosed technique is not limited to this example. The control electrode 1112 may be disposed in a direction intersecting an extending direction of the electrostatic

electrode 1111b. For example, the control electrode 1112 is disposed in the electrostatic chuck 1111 such that the extending direction of the control electrode 1112 in a direction following the cross-section of the electrostatic chuck 1111 intersects a plane including the electrostatic electrode 1111b. FIG. 8 is a diagram schematically illustrating another example of a configuration of the electrostatic chuck 1111 according to the embodiment. In FIG. 8, a schematic cross-section of the electrostatic chuck 1111 is illustrated. The electrostatic electrode 1111b is disposed parallel to the central region 111a from a central portion of the central region 111a to the vicinity of the periphery. The control electrode 1112 is disposed in the peripheral portion of the central region 111a in a direction orthogonal to the central region 111a. The control electrode 1112 disposed in the direction intersecting the extending direction of the electrostatic electrode 1111b functions as a shield such that a leakage electric field leaking from the electrostatic electrode 1111b to the periphery of the electrostatic chuck 1111 can be shielded in a wider range. Therefore, generation of particles can be suppressed.

[0054] In addition, in the above-described embodiment, the case where the control electrode 1112 is formed in a ring shape to surround the periphery of the electrostatic electrode 1111b is described as the example. However, the disclosed technique is not limited to this example. The control electrode 1112 may be divided in a peripheral direction of the electrostatic electrode 1111b. FIGS. 9 and 10 are diagrams schematically illustrating another example of a configuration of the electrostatic chuck 1111 according to the embodiment. In FIGS. 9 and 10, the central region 111a portion of the electrostatic chuck 1111

is illustrated. The control electrode 1112 is divided in the peripheral direction of the electrostatic electrode 1111b. For example, in FIG. 9, the control electrode 1112 is divided into two regions in the peripheral direction of the electrostatic electrode 1111b. In FIG. 10, the control electrode 1112 is divided into four regions in the peripheral direction of the electrostatic electrode 1111b. In this case, the wire 35a and the power source 36 may be provided in each of the regions where the control electrode 1112 is divided. In addition, the wire 35a may be branched and connected in parallel to the respective regions where the control electrode 1112 is divided. In the examples of FIGS. 9 and 10, the control electrode 1112 is divided in the same shape, but may be divided in a different shape.

[0055] In addition, in the above-described embodiment, the configuration where the electrostatic electrode 1111b and the control electrode 1112 are embedded in the ceramic member 1111a of the electrostatic chuck 1111 is described as the example. However, the disclosed technique is not limited to this example. The control electrode 1112 may be disposed in the electrostatic chuck 1111 as a separate part. FIGS. 11 and 12 are diagrams schematically illustrating another example of a configuration of the electrostatic chuck 1111 according to the embodiment. In FIGS. 11 and 12, a schematic cross-section of the electrostatic chuck 1111 is illustrated. FIG. 11 illustrates a case where the electrostatic electrode 1111b and the control electrode 1112 are disposed to follow the central region 111a. In the electrostatic chuck 1111, a flat portion 111d having a low height is formed on the outer peripheral side of the central region 111a. A part 1113 is formed in a flat ring shape with a size corresponding to the flat portion 111d of the electrostatic

chuck 1111. The part 1113 includes a ceramic member 1113a and the control electrode 1112. The control electrode 1112 is embedded in the ceramic member 1113a. By attaching the part 1113 to the flat portion 111d of the electrostatic
5 chuck 1111, the control electrode 1112 is disposed to follow the central region 111a. FIG. 12 illustrates a case where the control electrode 1112 is disposed in the direction intersecting the extending direction of the electrostatic electrode 1111b. A part 1114 is formed in a
10 cylindrical shape where the inner diameter is substantially the same as the outer diameter of the central region 111a of the electrostatic chuck 1111. The part 1114 includes a ceramic member 1114a and the control electrode 1112. The control electrode 1112 is embedded in the ceramic member
15 1114a. By attaching the part 1114 to the side surface 111c of the central region 111a of the electrostatic chuck 1111, the control electrode 1112 is disposed in the direction intersecting the extending direction of the electrostatic electrode 1111b.

20 [0056] Hereinabove, the embodiment has been described. As described above, the plasma processing system according to the embodiment includes the plasma processing chamber 10, the base 1110, the electrostatic chuck 1111, the electrostatic electrode 1111b (first electrode), the
25 control electrode 1112 (second electrode), the power source 36, and the controller 2. The base 1110 is disposed in the plasma processing chamber 10. The electrostatic chuck 1111 is disposed over the base 1110, and includes the central region 111a (substrate support surface) and the ring-shaped
30 region 111b (ring support surface). The electrostatic electrode 1111b is disposed under the central region 111a in the electrostatic chuck 1111, and adsorbs the substrate using an electrostatic force. The control electrode 1112

is disposed in the electrostatic chuck 1111 to surround the periphery of the electrostatic electrode 1111b. The power source 36 is electrically connected to the control electrode 1112. The controller 2 executes a process including a step of acquiring a voltage of a ring assembly disposed on the ring-shaped region 111b and a step of controlling an output voltage of the power source 36 according to a value of the acquired voltage. As a result, the plasma processing system according to the embodiment can suppress the occurrence of particles.

[0057] In addition, in the controlling step, the output voltage of the power source 36 is controlled within a predetermined potential difference from the value of the voltage. In addition, in the controlling step, the output voltage of the power source 36 is controlled within 1000 V from the value of the voltage. As a result, the plasma processing system according to the embodiment can suppress the occurrence of particles.

[0058] In addition, the electrostatic electrode 1111b and the control electrode 1112 are disposed to follow the central region 111a. The control electrode 1112 functions as a shield, and shields a leakage electric field leaking from the electrostatic electrode 1111b to the periphery of the electrostatic chuck 1111. As a result, the plasma processing system according to the embodiment can suppress the occurrence of particles.

[0059] In addition, the plurality of control electrodes 1112 are provided in the electrostatic chuck 1111. The control electrodes 1112 are disposed at different positions in a thickness direction of the electrostatic chuck 1111. In addition, each of the control electrodes 1112 is disposed parallel to the central region 111a. In addition, the control electrodes 1112 are disposed at a position

closer to the central region 111a than the electrostatic electrode 1111b and a position farther from the central region 111a than the electrostatic electrode 1111b in the thickness direction of the electrostatic chuck 1111. The
5 plurality of control electrodes 1112 disposed as described above function as a shield, and shield a leakage electric field in a wide range of the periphery of the electrostatic chuck 1111. As a result, the plasma processing system according to the embodiment can suppress the occurrence of
10 particles.

[0060] In addition, the control electrode 1112 is disposed in the direction intersecting the extending direction of the electrostatic electrode 1111b. The control electrode 1112 disposed as described in the
15 direction intersecting the extending direction of the electrostatic electrode 1111b functions as a shield, and shields a leakage electric field in a wide range of the periphery of the electrostatic chuck 1111. As a result, the plasma processing system according to the embodiment
20 can suppress the occurrence of particles.

[0061] In addition, the control electrode 1112 is formed in a ring shape to surround the periphery of the electrostatic electrode 1111b. The control electrode 1112 functions as a shield, and shields a leakage electric field
25 in the entire periphery of the electrostatic chuck 1111. As a result, the plasma processing system according to the embodiment can suppress the occurrence of particles.

[0062] In addition, the electrostatic chuck 1111 is formed such that the ring-shaped region 111b is lower than
30 the central region 111a. The control electrode 1112 functions as a shield such that a leakage electric field generated on the side surface 111c of the central region 111a can be shielded. Therefore, the generation of

particles from the side surface 111c of the central region 111a can be suppressed.

[0063] In addition, the power source 36 is electrically connected to the control electrode 1112 through the wire 5 35a where the variable resistor 37 is provided. As a result, in the plasma processing system according to the embodiment, by changing a resistance of the variable resistor 37, a response speed of the voltage of the control electrode 1112 with respect to the DC voltage applied from 10 the power source 36 can be adjusted.

[0064] The embodiment disclosed herein is exemplary in every respect and should be considered not to be limited. Actually, the above-described embodiment can be implemented in various forms. In addition, for the above-described 15 embodiment, omissions, replacement, and changes may be made in various forms without departing from the attached claims and the scope thereof.

[0065] In addition, regarding the above-described embodiment, the following supplementary notes are 20 disclosed.

Reference Signs List

[0079] 1 PLASMA PROCESSING APPARATUS
2 CONTROLLER
25 2a COMPUTER
2a1 PROCESSING UNIT
2a2 STORAGE UNIT
2a3 COMMUNICATION INTERFACE
10 10 PLASMA PROCESSING CHAMBER
30 11 SUBSTRATE SUPPORT UNIT
30 POWER SOURCE
31 POWER SOURCE
31a FIRST RF GENERATING UNIT

31b SECOND RF GENERATING UNIT
32 POWER SOURCE
32a FIRST DC GENERATING UNIT
32b SECOND DC GENERATING UNIT
5 33 WIRE
34 POWER SOURCE
35a WIRE
35b WIRE
36 POWER SOURCE
10 37 VARIABLE RESISTOR
40 EXHAUST SYSTEM
111 MAIN PART
111a CENTRAL REGION
111b RING-SHAPED REGION
15 111c SIDE SURFACE
111d FLAT PORTION
112 RING ASSEMBLY
1110 BASE
1110a FLOW CHANNEL
20 1111 ELECTROSTATIC CHUCK
1111a CERAMIC MEMBER
1111b ELECTROSTATIC ELECTRODE
1112 CONTROL ELECTRODE
1113 PART
25 1113a CERAMIC MEMBER
1114 PART
1114a CERAMIC MEMBER
W SUBSTRATE

CLAIMS

Claim 1. A plasma processing apparatus comprising:

a plasma processing chamber;

a base disposed in the plasma processing chamber;

5 an electrostatic chuck disposed over the base and
including a substrate support surface and a ring support
surface;

a first electrode disposed under the substrate support
surface in the electrostatic chuck and configured to adsorb
10 a substrate using an electrostatic force;

a second electrode disposed in the electrostatic chuck
to surround periphery of the first electrode;

a power source electrically connected to the second
electrode; and

15 a controller, wherein

the controller executes a process including

a step of acquiring a voltage of a ring assembly
disposed on the ring support surface and

a step of controlling an output voltage of the power
20 source according to a value of the acquired voltage.

Claim 2. The plasma processing apparatus according to
Claim 1, wherein

in the controlling step, the output voltage of the
25 power source is controlled within a predetermined potential
difference from the value of the voltage.

Claim 3. The plasma processing apparatus according to
Claim 1, wherein

30 in the controlling step, the output voltage of the
power source is controlled within 1000 V from the value of
the voltage.

Claim 4. The plasma processing apparatus according to Claim 1, wherein

the first electrode and the second electrode are disposed to follow the substrate support surface.

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Claim 5. The plasma processing apparatus according to Claim 4, wherein

a plurality of the second electrodes are provided in the electrostatic chuck and each of the second electrodes is disposed at different positions in a thickness direction of the electrostatic chuck.

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Claim 6. The plasma processing apparatus according to Claim 5, wherein

each of the second electrodes is disposed parallel to the substrate support surface.

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Claim 7. The plasma processing apparatus according to Claim 5, wherein

the second electrodes are disposed at a position closer to the substrate support surface than the first electrode and at a position farther from the substrate support surface than the first electrode, respectively, in the thickness direction of the electrostatic chuck.

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Claim 8. The plasma processing apparatus according to Claim 1, wherein

the second electrode is disposed in a direction intersecting an extending direction of the first electrode.

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Claim 9. The plasma processing apparatus according to Claim 1, wherein

the second electrode is formed in a ring shape to

surround the periphery of the first electrode.

Claim 10. The plasma processing apparatus according to Claim 1, wherein

5 the second electrode is divided in a peripheral direction of the first electrode.

Claim 11. The plasma processing apparatus according to Claim 1, wherein

10 the ring support surface is lower than the substrate support surface.

Claim 12. The plasma processing apparatus according to Claim 1, wherein

15 the power source is electrically connected to the second electrode through a wire where a variable resistor is provided.

Claim 13. An adsorption control method for a plasma
20 processing apparatus including

 a plasma processing chamber,
 a base disposed in the plasma processing chamber,
 an electrostatic chuck disposed over the base and
including a substrate support surface and a ring support
25 surface,

 a first electrode disposed under the substrate support surface in the electrostatic chuck,

 a second electrode disposed in the electrostatic chuck to surround periphery of the first electrode, and

30 a power source electrically connected to the second electrode, the adsorption control method comprising:

 a step of acquiring a voltage of a ring assembly disposed on the ring support surface; and

a step of controlling an output voltage of the power source according to a value of the acquired voltage.