

fully grown, the electrons emitted from the upper electrode are accelerated toward the processing target object by supplying the negative DC voltage to the upper electrode. Accordingly, the accelerated electrons are bounced off in a direction approaching the upper electrode by the plasma sheath which is being grown in a direction away from the processing target object, *i.e.*, in the direction approaching the upper electrode. As a result, in the prior art, the electric discharge may occur at the upper electrode side due to the bounced electrons.

SUMMARY

[0011] In one exemplary embodiment, a power supply system includes a first high frequency power supply configured to supply a first high frequency power for plasma generation to a lower electrode configured to mount a processing target object thereon; a DC power supply configured to supply a first negative DC voltage or a second negative DC voltage having an absolute value larger than that of the first DC voltage to an upper electrode provided to face the lower electrode; a control unit configured to perform a power supply control process of repeating a supply of the first high frequency power and a stop of the supply of the first high frequency power alternately; stopping a supply of the first DC voltage and a supply of the second DC voltage for a first period, which is a time period from a beginning of the supply of the first high frequency power within a period during which the first high frequency power is being supplied; supplying the first DC voltage for a second period except the first period within the period during which the first high frequency power is being supplied; and supplying the second DC voltage for a period during which the supply of the first high frequency power is stopped; a second high frequency power supply configured to supply a second high frequency power for ion attraction, which is different from the first high frequency power, to the lower electrode; and a

Vpp measuring unit configured to measure a Vpp value which is an amplitude value of a voltage corresponding to the second high frequency power, wherein the control unit is further configured to perform a first calibration process of performing the power supply control process while changing the first period to a plurality of candidate periods as candidates of the first period; calculating a Vpp variation ratio indicating a degree of variation of the Vpp value for each of the candidate periods; selecting, among the candidate periods, a candidate period which allows the Vpp variation ratio to be equal to or less than a preset tolerance value; and correcting the first period to the selected candidate period.

[0011a] In another exemplary embodiment, there is provided a plasma processing apparatus, comprising: a processing vessel; a gas supply unit configured to supply a processing gas into the processing vessel; a lower electrode which is provided within the processing vessel and configured to mount a processing target object thereon; an upper electrode provided within the processing vessel to face the lower electrode; and a power supply system, wherein the power supply system includes: a first high frequency power supply configured to supply a first high frequency power for plasma generation to the lower electrode; a second high frequency power supply configured to supply a second high frequency power for ion attraction, which is different from the first high frequency power, to the lower electrode; a Vpp measuring unit configured to measure a Vpp value which is an amplitude value of a voltage corresponding to the second high frequency power; a DC power supply configured to supply a first negative DC voltage or a second negative DC voltage having an absolute value larger than that of the first DC voltage to the upper electrode; and a control unit configured to perform a power supply control process of repeating a supply of the first high frequency power and a stop of the supply of the first high frequency power alternately; stopping a supply of the first DC voltage and a supply of the second DC voltage

for a first period, which is a time period from a beginning of the supply of the first high frequency power within a period during which the first high frequency power is being supplied;; supplying the first DC voltage for a second period except the first period within the period during which the first high frequency power is being supplied; and supplying the second DC voltage for a period during which the supply of the first high frequency power is stopped, wherein the control unit is further configured to perform a first calibration process of performing the power supply control process while changing the first period to a plurality of candidate periods as candidates of the first period; calculating a Vpp variation ratio indicating a degree of variation of the Vpp value for each of the candidate periods; selecting, among the candidate periods, a candidate period which allows the Vpp variation ratio to be equal to or less than a preset tolerance value; and correcting the first period to the selected candidate period.

[0011b] In another exemplary embodiment, there is provided a power supply control method performed in a power supply system including a first high frequency power supply configured to supply a first high frequency power for plasma generation to a lower electrode configured to mount a processing target object thereon; a second high frequency power supply configured to supply a second high frequency power for ion attraction, which is different from the first high frequency power, to the lower electrode; and a DC power supply configured to supply a first negative DC voltage or a second negative DC voltage having an absolute value larger than that of the first DC voltage to an upper electrode provided to face the lower electrode, the method comprising:

performing a power supply control process of repeating a supply of the first high frequency power and a stop of the supply of the first high frequency power alternately; stopping a supply of the first DC voltage and a supply of the second DC voltage for a first period, which is a time period from a beginning of the supply of the first high frequency power within a period during which the first high frequency power is being supplied; supplying the first DC voltage for a second period except the first period within the period during which the first high frequency power is being supplied; and supplying the second DC voltage for a period during which the supply of the first high frequency power is stopped; measuring a V_{pp} value which is an amplitude value of a voltage corresponding to the second high frequency power for ion attraction; and performing a first calibration process of performing the power supply control process while changing the first period to a plurality of candidate periods as candidates of the first period; calculating a V_{pp} variation ratio indicating a degree of variation of the V_{pp} value for each of the candidate periods; selecting, among the candidate periods, a candidate period which allows the V_{pp} variation ratio to be equal to or less than a preset tolerance value; and correcting the first period to the selected candidate period.

[0012] According to the exemplary embodiments, it is possible to provide a power supply system, a plasma processing apparatus and a power supply control method capable of

WE CLAIM

1. A power supply system, comprising:

a first high frequency power supply configured to supply a first high frequency power for plasma generation to a lower electrode configured to mount a processing target object thereon;

a DC power supply configured to supply a first negative DC voltage or a second negative DC voltage having an absolute value larger than that of the first DC voltage to an upper electrode provided to face the lower electrode;

a control unit configured to perform a power supply control process of repeating a supply of the first high frequency power and a stop of the supply of the first high frequency power alternately; stopping a supply of the first DC voltage and a supply of the second DC voltage for a first period, which is a time period from a beginning of the supply of the first high frequency power within a period during which the first high frequency power is being supplied; supplying the first DC voltage for a second period except the first period within the period during which the first high frequency power is being supplied; and supplying the second DC voltage for a period during which the supply of the first high frequency power is stopped;

a second high frequency power supply configured to supply a second high frequency power for ion attraction, which is different from the first high frequency power, to the lower electrode; and

a Vpp measuring unit configured to measure a Vpp value which is an amplitude value of a voltage corresponding to the second high frequency power,

wherein the control unit is further configured to perform a first calibration process of performing the power supply control process while changing the first period to a plurality of

candidate periods as candidates of the first period; calculating a Vpp variation ratio indicating a degree of variation of the Vpp value for each of the candidate periods; selecting, among the candidate periods, a candidate period which allows the Vpp variation ratio to be equal to or less than a preset tolerance value; and correcting the first period to the selected candidate period.

2. The power supply system of Claim 1, further comprising:

an etching rate acquiring unit configured to acquire an etching rate of the processing target objet,

wherein the control unit is further configured to perform a second calibration process of performing the power supply control process while changing the first period to a plurality of candidate periods as candidates of the first period; calculating an etching rate reduction ratio indicating a degree of reduction of the etching rate for each of the candidate periods; selecting a candidate period which allows the etching rate reduction ratio to be equal to or less than a predetermined tolerance value; and correcting the first period to the selected candidate period.

3. The power supply system of Claim 1 or 2,

wherein a ratio of the first period with respect to the period during which the first high frequency power is being supplied is equal to or less than 40%.

4. The power supply system of any one of Claims 1 to 3,

wherein the first period is equal to or longer than 5 μ sec.

5. The power supply system of any one of Claims 1 to 4,
wherein the DC power supply comprises:
a first DC power supply unit configured to supply the first DC voltage;
a second DC power supply unit configured to supply the second DC voltage;
a selecting circuit configured to selectively connect the first DC power supply unit and the
second DC power supply unit to the upper electrode; and
a discharging circuit connected to a connection point between the selecting circuit and
the upper electrode via a switching circuit,
wherein the control unit is further configured to, when performing the power supply
control process, control the selecting circuit to disconnect the upper electrode from the first and
second DC power supply units and control the switching circuit to connect the discharging circuit
to the connection point for the first period within the period during which the first high frequency
power is being supplied; and control the selecting circuit to connect the first DC power supply
unit to the upper electrode for the second period; and control the selecting circuit to connect the
second DC power supply unit to the upper electrode for the period during which the supply of the
first high frequency power is stopped.

6. A plasma processing apparatus, comprising:
a processing vessel;
a gas supply unit configured to supply a processing gas into the processing vessel;
a lower electrode which is provided within the processing vessel and configured to mount
a processing target object thereon;

an upper electrode provided within the processing vessel to face the lower electrode; and

a power supply system,

wherein the power supply system includes:

a first high frequency power supply configured to supply a first high frequency power for plasma generation to the lower electrode;

a second high frequency power supply configured to supply a second high frequency power for ion attraction, which is different from the first high frequency power, to the lower electrode;

a Vpp measuring unit configured to measure a Vpp value which is an amplitude value of a voltage corresponding to the second high frequency power;

a DC power supply configured to supply a first negative DC voltage or a second negative DC voltage having an absolute value larger than that of the first DC voltage to the upper electrode; and

a control unit configured to perform a power supply control process of repeating a supply of the first high frequency power and a stop of the supply of the first high frequency power alternately; stopping a supply of the first DC voltage and a supply of the second DC voltage for a first period, which is a time period from a beginning of the supply of the first high frequency power within a period during which the first high frequency power is being supplied;; supplying the first DC voltage for a second period except the first period within the period during which the first high frequency power is being supplied; and supplying the second DC voltage for a period during which the supply of the first high frequency power is stopped,

wherein the control unit is further configured to perform a first calibration process of performing the power supply control process while changing the first period to a plurality of candidate periods as candidates of the first period; calculating a Vpp variation ratio indicating a degree of variation of the Vpp value for each of the candidate periods; selecting, among the candidate periods, a candidate period which allows the Vpp variation ratio to be equal to or less than a preset tolerance value; and correcting the first period to the selected candidate period.

7. A power supply control method performed in a power supply system including a first high frequency power supply configured to supply a first high frequency power for plasma generation to a lower electrode configured to mount a processing target object thereon; a second high frequency power supply configured to supply a second high frequency power for ion attraction, which is different from the first high frequency power, to the lower electrode; and a DC power supply configured to supply a first negative DC voltage or a second negative DC voltage having an absolute value larger than that of the first DC voltage to an upper electrode provided to face the lower electrode, the method comprising:

performing a power supply control process of repeating a supply of the first high frequency power and a stop of the supply of the first high frequency power alternately; stopping a supply of the first DC voltage and a supply of the second DC voltage for a first period, which is a time period from a beginning of the supply of the first high frequency power within a period during which the first high frequency power is being supplied; supplying the first DC voltage for a second period except the first period within the period during which the first high frequency power is being supplied; and supplying the second DC voltage for a period during which the supply of the first high frequency power is stopped;

measuring a V_{pp} value which is an amplitude value of a voltage corresponding to the second high frequency power for ion attraction; and

performing a first calibration process of performing the power supply control process while changing the first period to a plurality of candidate periods as candidates of the first period; calculating a V_{pp} variation ratio indicating a degree of variation of the V_{pp} value for each of the candidate periods; selecting, among the candidate periods, a candidate period which allows the V_{pp} variation ratio to be equal to or less than a preset tolerance value; and correcting the first period to the selected candidate period.

8. The power supply control method of Claim 7, further comprising:

acquiring an etching rate of the processing target object; and

performing a second calibration process of performing the power supply control process while changing the first period to a plurality of candidate periods as candidates of the first period; calculating an etching rate reduction ratio indicating a degree of reduction of the etching rate for each of the candidate periods; selecting a candidate period which allows the etching rate reduction ratio to be equal to or less than a tolerance value; and correcting the first period to the selected candidate period.