

mechanism described in Patent Document 1 is configured to adjust an area ratio between a cathode and an anode facing the chamber, that is, an A/C ratio.

[0004] Patent Document 1: Japanese Patent Laid-open Publication No. 2011-228694

SUMMARY

[0005] As one kind of the plasma processing apparatus, there is used a plasma processing apparatus configured to supply a radio frequency power for bias (“radio frequency bias power”) to the lower electrode. The radio frequency bias power is supplied to the lower electrode to increase an etching rate of the substrate by increasing the energy of the ions irradiated to the substrate. In this plasma processing apparatus, if the potential of the plasma is increased, the potential difference between the plasma and the chamber main body is increased, and the energy of the ions irradiated to the inner wall of the chamber main body is also increased. In this regard, it is required to suppress a decrease of the etching rate of the substrate and reduce the energy of the ions irradiated to the inner wall of the chamber main body.

[0005a] According to a first aspect of the present invention, there is provided a plasma etching method performed in a plasma processing apparatus,

wherein the plasma processing apparatus comprises:

a chamber main body in which a chamber is provided;

a stage, including a lower electrode, provided within the chamber main body and configured to support a substrate placed thereon;

a radio frequency power supply configured to supply a radio frequency power for exciting a gas supplied into the chamber; and

one or more DC power supplies configured to generate a negative DC voltage to be applied to the lower electrode,

wherein the plasma etching method comprises:

supplying the radio frequency power from the radio frequency power supply to generate plasma of the gas supplied into the chamber; and

applying the negative DC voltage to the lower electrode from the one or more DC power supplies to attract ions in the plasma onto the substrate, and

wherein, in the applying of the negative DC voltage, the negative DC voltage is applied to the lower electrode periodically, and a duty ratio is set to be equal to or less than 40%, wherein the duty ratio is a percentage occupied within a single cycle by a period during which the negative DC voltage is applied to the lower electrode.

[0005b] According to a second aspect of the present invention, there is provided a plasma processing method performed in a plasma processing apparatus,

wherein the plasma processing apparatus comprises:

a chamber main body in which a chamber is provided;

a stage, including a lower electrode, provided within the chamber main body and configured to support a substrate placed thereon;

a radio frequency power supply configured to supply a radio frequency power for exciting a gas supplied into the chamber; and

one or more DC power supplies configured to generate a negative DC voltage to be applied to the lower electrode,

wherein the plasma processing method comprises:

2b

supplying the radio frequency power from the radio frequency power supply to generate plasma of the gas supplied into the chamber; and

applying the negative DC voltage to the lower electrode from the one or more DC power supplies to attract ions in the plasma onto the substrate,

wherein, in the applying of the negative DC voltage, the negative DC voltage is applied to the lower electrode periodically, and a duty ratio is set to be equal to or less than 40%, wherein the duty ratio is a percentage occupied within a single cycle by a period during which the negative DC voltage is applied to the lower electrode, and

wherein the supplying of the radio frequency power is stopped in the period during which the negative DC voltage is applied, and the radio frequency power is supplied in a period during which the applying of the negative DC voltage is stopped.

[0005c] According to a third aspect of the present invention, there is provided a plasma etching apparatus, comprising:

a chamber main body in which a chamber is provided;

a stage, including a lower electrode, provided within the chamber main body and configured to support a substrate placed thereon;

a radio frequency power supply configured to supply a radio frequency power for exciting a gas supplied into the chamber;

one or more DC power supplies configured to generate a negative DC voltage to be applied to the lower electrode;

a switching unit configured to allow the application of the negative DC voltage to the lower electrode to be stopped; and

a controller configured to control the switching unit,

wherein the controller controls the switching unit such that the negative DC voltage from the one or more DC power supplies is applied to the lower electrode periodically to attract ions in plasma of a gas generated within the chamber onto the substrate and a plasma etching process is performed on the substrate, and such that a duty ratio is set to be equal to or less than 40%, wherein the duty ratio is a percentage occupied within a single cycle by a period during which the negative DC voltage is applied to the lower electrode.

[0006] In one exemplary embodiment, there is provided a plasma etching method performed in a plasma processing apparatus. The plasma processing apparatus includes a chamber main body, a stage, a radio frequency power supply and one or more DC power supplies. An internal space of the chamber main body is configured as a chamber. The stage is provided within the chamber main body. The stage includes a lower electrode. The stage is configured to support a substrate placed thereon. The radio frequency power supply is configured to supply a radio frequency power for exciting a gas supplied into the chamber. The one or more DC power supplies are configured to generate a negative DC voltage to be applied to the lower electrode. The plasma processing method includes (i) supplying the radio frequency power from the radio

WE CLAIM

1. A plasma etching method performed in a plasma processing apparatus,
wherein the plasma processing apparatus comprises:
a chamber main body in which a chamber is provided;
a stage, including a lower electrode, provided within the chamber main body and configured to support a substrate placed thereon;
a radio frequency power supply configured to supply a radio frequency power for exciting a gas supplied into the chamber; and
one or more DC power supplies configured to generate a negative DC voltage to be applied to the lower electrode,
wherein the plasma etching method comprises:
supplying the radio frequency power from the radio frequency power supply to generate plasma of the gas supplied into the chamber; and
applying the negative DC voltage to the lower electrode from the one or more DC power supplies to attract ions in the plasma onto the substrate, and
wherein, in the applying of the negative DC voltage, the negative DC voltage is applied to the lower electrode periodically, and a duty ratio is set to be equal to or less than 40%, wherein the duty ratio is a percentage occupied within a single cycle by a period during which the negative DC voltage is applied to the lower electrode.
2. The plasma etching method of Claim 1,
wherein the duty ratio is set to be equal to or less than 35%.

3. The plasma etching method of Claim 1 or 2,
wherein the plasma processing apparatus comprises multiple DC power supplies, and
the negative DC voltage applied to the lower electrode within each cycle is generated by
negative DC voltages outputted from the multiple DC power supplies in sequence.

4. The plasma etching method of any one of Claims 1 to 3,
wherein the radio frequency power is supplied in the period during which the negative
DC voltage is applied, and the supplying of the radio frequency power is stopped in a period
during which the applying of the negative DC voltage is stopped.

5. A plasma processing method performed in a plasma processing apparatus,
wherein the plasma processing apparatus comprises:
a chamber main body in which a chamber is provided;
a stage, including a lower electrode, provided within the chamber main body and
configured to support a substrate placed thereon;
a radio frequency power supply configured to supply a radio frequency power for exciting
a gas supplied into the chamber; and
one or more DC power supplies configured to generate a negative DC voltage to be
applied to the lower electrode,
wherein the plasma processing method comprises:
supplying the radio frequency power from the radio frequency power supply to generate
plasma of the gas supplied into the chamber; and

applying the negative DC voltage to the lower electrode from the one or more DC power supplies to attract ions in the plasma onto the substrate,

wherein, in the applying of the negative DC voltage, the negative DC voltage is applied to the lower electrode periodically, and a duty ratio is set to be equal to or less than 40%, wherein the duty ratio is a percentage occupied within a single cycle by a period during which the negative DC voltage is applied to the lower electrode, and

wherein the supplying of the radio frequency power is stopped in the period during which the negative DC voltage is applied, and the radio frequency power is supplied in a period during which the applying of the negative DC voltage is stopped.

6. A plasma etching apparatus, comprising:

a chamber main body in which a chamber is provided;

a stage, including a lower electrode, provided within the chamber main body and configured to support a substrate placed thereon;

a radio frequency power supply configured to supply a radio frequency power for exciting a gas supplied into the chamber;

one or more DC power supplies configured to generate a negative DC voltage to be applied to the lower electrode;

a switching unit configured to allow the application of the negative DC voltage to the lower electrode to be stopped; and

a controller configured to control the switching unit,

wherein the controller controls the switching unit such that the negative DC voltage from the one or more DC power supplies is applied to the lower electrode periodically to attract ions in

plasma of a gas generated within the chamber onto the substrate and a plasma etching process is performed on the substrate, and such that a duty ratio is set to be equal to or less than 40%, wherein the duty ratio is a percentage occupied within a single cycle by a period during which the negative DC voltage is applied to the lower electrode.

7. The plasma etching apparatus of Claim 6,

wherein the controller controls the switching unit such that the duty ratio is set to be equal to or less than 35%.

8. The plasma etching apparatus of Claim 6 or 7, further comprising:

multiple DC power supplies, and

wherein the controller controls the switching unit such that the negative DC voltage applied to the lower electrode within each of the cycles is generated by the negative DC voltages outputted from the multiple DC power supplies in sequence.

9. The plasma etching apparatus of any one of Claims 6 to 8,

wherein the controller controls the radio frequency power supply such that the radio frequency power is supplied in the period during which the negative DC voltage is applied, and the supply of the radio frequency power is stopped in a period during which the application of the negative DC voltage is stopped.

10. The plasma etching apparatus of any one of Claims 6 to 8,

wherein the controller controls the radio frequency power supply such that the supply of the radio frequency power is stopped in the period during which the negative DC voltage is applied, and the radio frequency power is supplied in a period during which the application of the negative DC voltage is stopped.

11. The plasma etching method of Claim 1, further comprising:

cleaning an inner wall of the chamber by setting the duty ratio to be larger than 40%.

12. The plasma etching apparatus of Claim 6,

wherein the controller is further configured to clean an inner wall of the chamber by setting the duty ratio to be larger than 40%.

13. The plasma etching apparatus of Claim 6,

wherein the plasma etching apparatus is a capacitively coupled plasma processing apparatus.

14. The plasma etching apparatus of Claim 6,

wherein the plasma etching apparatus is an inductively coupled plasma processing apparatus.