

electrode, the stop of the application of the DC voltage to the lower electrode, the application of the negative DC voltage to the lower electrode, and the stop of the application of the DC voltage to the lower electrode are repeated.

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SUMMARY

[0006] In plasma etching, it is required to reduce the positive charge quantity of the substrate and improve the etching rate.

[0007] ~~An exemplary embodiment of the present disclosure provides a plasma processing apparatus. The plasma processing apparatus includes a chamber, a substrate support, a radio-frequency power supply, and a power supply unit. The substrate support includes a lower electrode and is provided in the chamber. The radio-frequency power supply is configured to supply a radio-frequency power to generate plasma from a gas in the chamber. The power supply unit is configured to generate a positive DC voltage and a negative DC voltage. The power supply unit is electrically connected to the lower electrode. The power supply unit stops an application of a DC voltage to the lower electrode in a first time period during which plasma is being generated from an etching gas in the chamber. The power supply unit applies a first DC voltage to the lower electrode in a second time period during which the plasma is being generated from the etching gas in the chamber after the first time period. The first DC voltage is a positive DC voltage. The power supply unit applies a second DC voltage to the lower electrode in a third time period during which the plasma is being generated from the etching gas in the chamber after the second time period, in order to etch the substrate placed on the substrate support. The second DC voltage is a negative DC voltage. The DC voltage output by the power supply unit is continuously switched from the first DC voltage in the second time period to the second DC voltage in the third time period.~~

According to a first aspect, there is provided a plasma processing apparatus including: a chamber; a substrate support including an electrode and provided in the chamber; a radio-frequency power supply configured to supply a radio-frequency power, in order to generate plasma from a gas in the chamber; and a power supply configured to generate a positive DC voltage and a negative DC voltage, and electrically connected to the electrode, wherein the power supply is configured to: stop an application of a DC voltage to the electrode in a first time period during which plasma is being generated from an etching gas in the chamber; apply a first DC voltage which is a positive DC voltage to the electrode in a second time period during which the plasma is being generated from the etching gas in the chamber after the first time period; and apply a second DC voltage which is a negative DC voltage to the electrode in a third time period during which the plasma is being generated from the etching gas in the chamber after the second time period, in order to etch the substrate placed on the substrate support, and the DC voltage output by the power supply is continuously switched from the first DC voltage in the second time period to the second DC voltage in the third time period.

[0007a] According to a second aspect, there is provided a plasma processing method performed by a plasma processing apparatus, the plasma processing apparatus including: a chamber; a substrate support that includes an electrode and is provided in the chamber; a radio-frequency power supply configured to supply a radio-frequency power to generate plasma from a gas in the chamber; and a power supply configured to generate a positive DC voltage and a negative DC voltage, and electrically connected to the electrode, the plasma processing method including: stopping an application of a DC voltage from the power supply to the electrode in a first time period during which plasma is being generated from an etching gas in the chamber; applying a first DC voltage which is a positive DC voltage from the power supply to the electrode in a second time period during which the plasma is being generated from the etching gas in the chamber after the first time period; and applying a second DC voltage which is a negative DC voltage from the power supply to the electrode in a third time period during which the plasma is being generated from the etching gas in the chamber after the second time period to etch the substrate placed on the substrate support, wherein the DC voltage output by the power supply is continuously switched from the first DC voltage in the second time period to the second DC voltage in the third time period.

[0008] According to an exemplary embodiment, it is possible to reduce the positive charge quantity of the substrate and improve the etching rate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 is a view schematically illustrating a plasma processing apparatus according to an exemplary embodiment.

FIG. 2 is a flowchart illustrating a plasma processing method according to an exemplary embodiment.

FIG. 3 is a timing chart of an example of an output voltage of a power supply unit in the plasma processing method illustrated in FIG. 2.

DETAILED DESCRIPTION

[0010] Various exemplary embodiments will be described hereinafter.

[0011] An exemplary embodiment provides a plasma processing apparatus. The plasma processing apparatus includes a chamber, a substrate support, a radio-frequency power supply, and a power supply unit. The substrate support includes a lower electrode and is provided in the chamber. The radio-frequency power supply is configured to supply a radio-frequency power to generate plasma from a gas in the chamber. The power supply unit is configured to generate a positive DC voltage and a negative DC voltage. The power supply unit is electrically connected to the lower electrode. The power supply unit stops the application of a DC voltage to the lower electrode in a first time period during which plasma is being generated from an etching gas in the chamber. The power supply unit applies a first DC voltage to the lower

WHAT IS CLAIMED IS:

1. A plasma processing apparatus comprising:
 - a chamber;
 - a substrate support including a ~~lower~~an electrode and provided in the chamber;
 - a radio-frequency power supply configured to supply a radio-frequency power, in order to generate plasma from a gas in the chamber; and
 - a power supply configured to generate a positive DC voltage and a negative DC voltage, and electrically connected to the ~~lower~~ electrode, wherein the power supply is configured to:
 - stop an application of a DC voltage to the ~~lower~~ electrode in a first time period during which plasma is being generated from an etching gas in the chamber;
 - apply a first DC voltage which is a positive DC voltage to the ~~lower~~ electrode in a second time period during which the plasma is being generated from the etching gas in the chamber after the first time period; and
 - apply a second DC voltage which is a negative DC voltage to the ~~lower~~ electrode in a third time period during which the plasma is being generated from the etching gas in the chamber after the second time period, in order to etch the substrate placed on the substrate support, and
 - the DC voltage output by the power supply is continuously switched from the first DC voltage in the second time period to the second DC voltage in the third time period.
2. The plasma processing apparatus according to claim 1, wherein an absolute

value of the first DC voltage is smaller than an absolute value of the second DC voltage.

3. The plasma processing apparatus according to claim 1 or 2, wherein a time length of the third time period is equal to or shorter than a sum of a time length of the first time period and a time length of the second time period.

4. The plasma processing apparatus according to claim 3, wherein the time length of the third time period is 10 μ sec or shorter.

5. The plasma processing apparatus according to claim 3 or 4, wherein the time length of the second time period is equal to or shorter than the time length of the first time period.

6. The plasma processing apparatus according to any one of claims 1 to 5, wherein the power supply repeats the stop of the application of the DC voltage to the ~~lower~~ electrode in the first time period, the application of the first DC voltage to the ~~lower~~ electrode in the second time period, and the application of the second DC voltage to the ~~lower~~-electrode in the third time period.

7. The plasma processing apparatus according to any one of claims 1 to 6, wherein the power supply is further configured to:

apply a third DC voltage which is a negative DC voltage to the ~~lower~~-electrode in a fourth time period during which plasma is being generated from a cleaning gas in the chamber; further stop the application of the DC voltage to the ~~lower~~-electrode in a fifth time period during which the plasma is being generated from the cleaning gas in

the chamber after the fourth time period; and

apply a fourth DC voltage which is a positive DC voltage to the ~~lower~~ electrode in a sixth time period during which the plasma is being generated from the cleaning gas in the chamber after the fifth time period, and

a time length of the fourth time period is longer than a sum of a time length of the fifth time period and a time length of the sixth time period.

8. The plasma processing apparatus according to claim 7, wherein the time length of the fourth time period is longer than the time length of the third time period.

9. The plasma processing apparatus according to claim 7 or 8, wherein the power supply repeats the application of the third DC voltage to the ~~lower~~ electrode in the fourth time period, the stop of the application of the DC voltage to the ~~lower~~ electrode in the fifth time period, and the application of the fourth DC voltage to the ~~lower~~ electrode in the sixth time period.

10. A plasma processing method performed by a plasma processing apparatus, the plasma processing apparatus including:

a chamber;

a substrate support that includes a ~~lower~~an electrode and is provided in the chamber;

a radio-frequency power supply configured to supply a radio-frequency power to generate plasma from a gas in the chamber; and

a power supply configured to generate a positive DC voltage and a negative DC voltage, and electrically connected to the ~~lower~~ electrode,

the plasma processing method comprising:

stopping an application of a DC voltage from the power supply to the ~~lower~~ electrode in a first time period during which plasma is being generated from an etching gas in the chamber;

applying a first DC voltage which is a positive DC voltage from the power supply to the ~~lower~~ electrode in a second time period during which the plasma is being generated from the etching gas in the chamber after the first time period; and

applying a second DC voltage which is a negative DC voltage from the power supply to the ~~lower~~ electrode in a third time period during which the plasma is being generated from the etching gas in the chamber after the second time period to etch the substrate placed on the substrate support,

wherein the DC voltage output by the power supply is continuously switched from the first DC voltage in the second time period to the second DC voltage in the third time period.

11. The plasma processing method according to claim 10, wherein an absolute value of the first DC voltage is smaller than an absolute value of the second DC voltage.

12. The plasma processing method according to claim 10 or 11, wherein a time length of the third time period is equal to or shorter than a sum of a time length of the first time period and a time length of the second time period.

13. The plasma processing method according to claim 12, wherein the time length of the third time period is 10 μ sec or shorter.

14. The plasma processing method according to claim 12 or 13, wherein the time length of the second time period is equal to or shorter than the time length of the first time period.

15. The plasma processing method according to any one of claims 10 to 14, wherein the stopping, the applying the first DC voltage, and the applying the second DC voltage are repeated.

16. The plasma processing method according to any one of claims 10 to 15, further comprising:

applying a third DC voltage which is a negative DC voltage from the power supply to the ~~lower~~-electrode in a fourth time period during which plasma is being generated from a cleaning gas in the chamber;

further stopping the application of the DC voltage from the power supply to the ~~lower~~-electrode in a fifth time period during which the plasma is being generated from the cleaning gas in the chamber after the fourth time period; and

applying a fourth DC voltage which is a positive DC voltage from the power supply to the ~~lower~~-electrode in a sixth time period during which the plasma is being generated from the cleaning gas in the chamber after the fifth time period,

wherein a time length of the fourth time period is longer than a sum of a time length of the fifth time period and a time length of the sixth time period.

17. The plasma processing method according to claim 16, wherein the time length of the fourth time period is longer than the time length of the third time period.

18. The plasma processing method according to claim 16 or 17, wherein the applying the third DC voltage, the further stopping, and the applying the fourth DC voltage are repeated.