

MEANS FOR SOLVING THE PROBLEMS

[0009] In an exemplary embodiment, a plasma processing apparatus includes a processing vessel having a processing space formed therein; a mounting table provided within the processing space, and configured to mount a processing target object thereon; a dielectric member, disposed at the processing vessel to close the processing space, having an internal space and communication holes through which the internal space is allowed to communicate with the processing space; a first electrode and a second electrode provided within the dielectric member and arranged to face each other with the internal space therebetween; a first gas supply device configured to supply a first processing gas for a plasma process into the internal space; a first high frequency power supply configured to supply a first high frequency power to at least one of the first electrode and the second electrode to generate a first plasma of the first processing gas supplied into the internal space; a depressurizing device configured to depressurize the processing space to introduce the first processing gas and radicals in the first plasma into the processing space from the internal space through the communication holes; a second high frequency power supply configured to supply a second high frequency power to the mounting table to generate a second plasma of the first processing gas introduced into the processing space and to attract ions in the second plasma into the processing target object; and a control unit configured to adjust, by controlling a total amount of the first high frequency power supplied to the first electrode and the first high frequency power supplied to the second electrode, an amount of the radicals in the first plasma introduced into the processing space from the internal space through the communication holes and adjust, by the radicals, an amount of radicals in the second plasma, and configured to adjust, by controlling a ratio between the first high frequency power supplied to the first electrode and the first high frequency power supplied to the second electrode, an amount of electrons in the first plasma introduced into the processing space from the internal space through the communication holes and adjust, by the electrons, an amount of the ions in the second plasma.

wherein the internal space of the dielectric member is divided into a plurality of concentric sub-spaces along a radial direction of the processing target object, each of the sub-spaces communicates with the processing space through the communication holes,

the first electrode and the second electrode are provided at each of the sub-spaces, and arranged to face each other with a corresponding one of the sub-spaces therebetween,

by controlling the total amount of the first high frequency power supplied to the first electrode and the first high frequency power supplied to the second electrode, the control unit adjusts the amount of the radicals in the first plasma introduced into the processing space from each of the sub-spaces through the communication holes and adjusts a distribution of the amount of the radicals in the second plasma along the radial direction of the processing target object by the radicals, and

by controlling the ratio between the first high frequency power supplied to the first electrode and the first high frequency power supplied to the second electrode, the control unit adjusts the amount of the electrons in the first plasma introduced into the processing space from each of the sub-spaces through the communication holes and adjusts a distribution of the amount of the ions in the second plasma along the radial direction of the processing target object by the electrons.

[0009a] In another exemplary embodiment, a plasma processing method performed in a plasma processing apparatus including a processing vessel having a processing space formed therein; a mounting table provided within the processing space, and configured to mount a processing target object thereon; a dielectric member, disposed at the processing vessel to close the processing space, having an internal space and communication holes through which the internal space is allowed to communicate with the processing space; a first electrode and a second electrode provided within the dielectric member and arranged to face each other with the internal space therebetween; a first gas supply device configured to supply a first processing gas for a plasma process into the internal space; a first high frequency power supply configured to supply a first high frequency power to at least one of the first electrode and the second electrode to generate a first plasma of the first processing gas supplied into the internal space; a depressurizing device configured to depressurize the processing space and, thus, introduce the first processing gas and radicals in the first plasma into the processing space from the internal space through the communication holes; a second high frequency power supply configured to supply a second high frequency power to the mounting table to generate a second plasma of the first processing gas introduced into the processing space and to attract ions in the second plasma into the processing target object, the plasma processing method comprising: adjusting an amount of the radicals in the first plasma introduced into the processing space from the internal space through the communication holes and adjusting, by these radicals, an amount of radicals in the second plasma by controlling a total amount of the first high frequency power supplied to the first electrode and the first high frequency power supplied to the second electrode; and adjusting an amount of electrons in the first plasma introduced into the processing space from the internal space through the communication holes and adjusting, by these electrons, an amount of ions in the second plasma by controlling a ratio between the first high frequency power supplied to the first electrode and the first high frequency power supplied to the second electrode.

wherein the internal space of the dielectric member is divided into a plurality of concentric sub-spaces along a radial direction of the processing target object, each of the sub-spaces communicates with the processing space through the communication holes,

the first electrode and the second electrode are provided at each of the sub-spaces, and arranged to face each other with a corresponding one of the sub-spaces therebetween,

the adjusting an amount of the radicals includes by controlling the total amount of the first high frequency power supplied to the first electrode and the first high frequency power supplied to the second electrode, adjusting the amount of the radicals in the first plasma introduced into the processing space from each of the sub-spaces through the communication holes and adjusting a distribution of the amount of the radicals in the second plasma along the radial direction of the processing target object by the radicals, and

the adjusting an amount of electrons includes by controlling the ratio between the first high frequency power supplied to the first electrode and the first high frequency power supplied to the second electrode, adjusting the amount of the electrons in the first plasma introduced into the processing space from each of the sub-spaces through the communication holes and adjusting a distribution of the amount of the ions in the second plasma along the radial direction of the processing target object by the electrons.

WE CLAIM

1. A plasma processing apparatus, comprising:
 - a processing vessel having a processing space formed therein;
 - a mounting table provided within the processing space, and configured to mount a processing target object thereon;
 - a dielectric member, disposed at the processing vessel to close the processing space, having an internal space and communication holes through which the internal space is allowed to communicate with the processing space;
 - a first electrode and a second electrode provided within the dielectric member and arranged to face each other with the internal space therebetween;
 - a first gas supply device configured to supply a first processing gas for a plasma process into the internal space;
 - a first high frequency power supply configured to supply a first high frequency power to at least one of the first electrode and the second electrode to generate a first plasma of the first processing gas supplied into the internal space;
 - a depressurizing device configured to depressurize the processing space to introduce the first processing gas and radicals in the first plasma into the processing space from the internal space through the communication holes;
 - a second high frequency power supply configured to supply a second high frequency power to the mounting table to generate a second plasma of the first processing gas introduced into the processing space and to attract ions in the second plasma into the processing target object; and
 - a control unit configured to adjust, by controlling a total amount of the first high frequency power supplied to the first electrode and the first high frequency power supplied to the second electrode, an amount of the radicals in the first plasma introduced into the processing space from the internal space through the communication holes and adjust, by the radicals, an amount of

radicals in the second plasma; and configured to adjust, by controlling a ratio between the first high frequency power supplied to the first electrode and the first high frequency power supplied to the second electrode, an amount of electrons in the first plasma introduced into the processing space from the internal space through the communication holes and adjust, by the electrons, an amount of the ions in the second plasma,

wherein the internal space of the dielectric member is divided into a plurality of concentric sub-spaces along a radial direction of the processing target object, each of the sub-spaces communicates with the processing space through the communication holes,

the first electrode and the second electrode are provided at each of the sub-spaces, and arranged to face each other with a corresponding one of the sub-spaces therebetween,

by controlling the total amount of the first high frequency power supplied to the first electrode and the first high frequency power supplied to the second electrode, the control unit adjusts the amount of the radicals in the first plasma introduced into the processing space from each of the sub-spaces through the communication holes and adjusts a distribution of the amount of the radicals in the second plasma along the radial direction of the processing target object by the radicals, and

by controlling the ratio between the first high frequency power supplied to the first electrode and the first high frequency power supplied to the second electrode, the control unit adjusts the amount of the electrons in the first plasma introduced into the processing space from each of the sub-spaces through the communication holes and adjusts a distribution of the amount of the ions in the second plasma along the radial direction of the processing target object by the electrons.

2. ~~The plasma processing apparatus of Claim 1,~~

~~wherein the internal space of the dielectric member is divided into a plurality of concentric sub-spaces along a radial direction of the processing target object,~~

~~each of the sub-spaces communicates with the processing space through the communication holes,~~

~~the first electrode and the second electrode are provided at each of the sub-spaces, and arranged to face each other with a corresponding one of the sub-spaces therebetween,~~

~~by controlling the total amount of the first high frequency power supplied to the first electrode and the first high frequency power supplied to the second electrode, the control unit adjusts the amount of the radicals in the first plasma introduced into the processing space from each of the sub-spaces through the communication holes and adjusts a distribution of the amount of the radicals in the second plasma along the radial direction of the processing target object by the radicals, and~~

~~by controlling the ratio between the first high frequency power supplied to the first electrode and the first high frequency power supplied to the second electrode, the control unit adjusts the amount of the electrons in the first plasma introduced into the processing space from each of the sub-spaces through the communication holes and adjusts a distribution of the amount of the ions in the second plasma along the radial direction of the processing target object by the electrons.~~

32. The plasma processing apparatus of Claim 1 ~~or 2~~,

wherein the control unit adjusts a phase difference between the first high frequency power supplied to the first electrode and the first high frequency power supplied to the second electrode.

43. The plasma processing apparatus of Claim 32,

wherein the control unit adjusts the phase difference between the first high frequency power supplied to the first electrode and the first high frequency power supplied to the second electrode to be 180°.

54. The plasma processing apparatus of Claim 1, further comprising:

a second gas supply device configured to supply a second processing gas into the processing space,

wherein the second high frequency power supply supplies the second high frequency power to the mounting table to generate a third plasma of the first processing gas and the second processing gas supplied into the processing space and to attract ions in the third plasma into the processing target object,

the control unit controls ON/OFF of the second high frequency power supply, intermittently, during a period while the second high frequency power supply is controlled to be turned OFF, by controlling the ratio between the first high frequency power supplied to the first electrode and the first high frequency power supplied to the second electrode, the control unit adjusts the amount of the electrons in the first plasma introduced into the processing space from the internal space through the communication holes; activates a surface of the processing target object by the electrons; and generates a reaction product by reacting the activated surface of the processing target object with the radicals in the first plasma introduced into the processing space, and

during a period while the second high frequency power supply is controlled to be turned ON, by controlling the ratio between the first high frequency power supplied to the first electrode and the first high frequency power supplied to the second electrode, the control unit adjusts the amount of the electrons in the first plasma introduced into the processing space from the internal space through the communication holes; adjusts an amount of the ions in the third plasma by the electrons; and etches the reaction product with the third plasma in which the amount of the ions is controlled.

65. A plasma processing method performed in a plasma processing apparatus including a processing vessel having a processing space formed therein; a mounting table provided within the processing space, and configured to mount a processing target object thereon; a dielectric member, disposed at the processing vessel to close the processing space, having an internal space and communication holes through which the internal space is allowed to communicate with the processing space; a first electrode and a second electrode provided within the dielectric member and arranged to face each other with the internal space therebetween; a first gas supply device configured to supply a first processing gas for a plasma process into the internal space; a first high frequency power supply configured to supply a first high frequency power to at least one of the first electrode and the second electrode to generate a first plasma of the first processing gas supplied into the internal space; a depressurizing device configured to depressurize the processing space and, thus, introduce the first processing gas and radicals in the first plasma into the processing space from the internal space through the communication holes; a second high frequency power supply configured to supply a second high frequency power to the mounting table to generate a second plasma of the first processing gas introduced into the processing space and to attract ions in the second plasma into the processing target object, the plasma processing method comprising:

adjusting an amount of the radicals in the first plasma introduced into the processing space from the internal space through the communication holes and adjusting, by these radicals, an amount of radicals in the second plasma by controlling a total amount of the first high frequency power supplied to the first electrode and the first high frequency power supplied to the second electrode; and

adjusting an amount of electrons in the first plasma introduced into the processing space from the internal space through the communication holes and adjusting, by these electrons, an amount of ions in the second plasma by controlling a ratio between the first high frequency power supplied to the first electrode and the first high frequency power supplied to the second electrode,

wherein the internal space of the dielectric member is divided into a plurality of concentric sub-spaces along a radial direction of the processing target object, each of the sub-spaces communicates with the processing space through the communication holes,

the first electrode and the second electrode are provided at each of the sub-spaces, and arranged to face each other with a corresponding one of the sub-spaces therebetween,

the adjusting an amount of the radicals includes by controlling the total amount of the first high frequency power supplied to the first electrode and the first high frequency power supplied to the second electrode, adjusting the amount of the radicals in the first plasma introduced into the processing space from each of the sub-spaces through the communication holes and adjusting a distribution of the amount of the radicals in the second plasma along the radial direction of the processing target object by the radicals, and

the adjusting an amount of electrons includes by controlling the ratio between the first high frequency power supplied to the first electrode and the first high frequency power supplied to the second electrode, adjusting the amount of the electrons in the first plasma introduced into the processing space from each of the sub-spaces through the communication holes and adjusting a distribution of the amount of the ions in the second plasma along the radial direction of the processing target object by the electrons.