Summary

Problems to Be Resolved by the Invention

[0004]

The technique of the present disclosure reduces gas waste during substrate processing and simplifies a substrate processing apparatus.

Means for Solving the Problems

[0005]

According to an exemplary embodiment, a substrate processing method is provided. The substrate processing method for processing a substrate by supplying a gas from a gas supply part to a substrate processing space in a substrate processing apparatus, wherein the gas supply part includes a plurality of gas sources, a flow path that allows the gas to flow from the plurality of gas sources to the substrate processing space, a valve provided in the flow path to switch between opening and closing the flow of the gas, and a buffer tank provided in the flow path, pulse control is performed to pulse the flow of the gas by alternately repeating the opening and closing of the flow of the gas in the valve, and in the pulse control, a duration of the pulse control and a number of times of opening the flow of the gas during the duration are controlled to control the flow rate of the gas.

Effect of the Invention

[0006]

In accordance with the present disclosure, gas waste during substrate processing can be reduced and the substrate processing apparatus can be simplified.

etching, fluorine in the mixed gas Gα is consumed by the etching, so that the plasma emission amount of fluorine is small. On the other hand, when the etching approaches the end, the fluorine in the mixed gas Gα is no longer consumed by the etching, and the amount of the mixed gas Gα in the substrate processing space 10s increases. Accordingly, the plasma emission of fluorine increases, and the amount detected by the OES increases. In other words, when an increase in the amount of plasma emission of fluorine is detected in the OES, it may be determined that the etching approaches the end (step ST22). In the present embodiment, when the plasma emission amount is less than the threshold, the supply of the mixed gas Gα is continued, and when the plasma emission amount is greater than or equal to the threshold, it is determined that the etching is completed, and the supply of the mixed gas Gα is stopped. Accordingly, the supply of the remaining mixed gas Gα into the substrate processing space 10s can be suppressed. Thereafter, the pulse valve 220a is closed, and the pulse valve 220b is pulse-controlled to execute a next process (step ST24). The process β using the mixed gas Gβ is also monitored in the same manner, and it is determined whether or not the process β is completed (step ST26). When it is determined that the process β is completed, the processing returns to the pulse control of the pulse valve 220a, or the process is completed (step ST28). As the threshold value for the plasma emission amount, the wavelength emission amount that is an indicator of the progress of the process may be predetermined under the process conditions, stored in the storage part, and read out when the process is executed.

[0054]

Although the plasma emission amount of fluorine in the etching gas is detected as the detection target in the above example, the present disclosure is not limited thereto, and the progress of the process may be determined by

CLAIMS

[Claim 1]

A substrate processing method for processing a substrate by supplying a gas from a gas supply part to a substrate processing space in a substrate processing apparatus,

wherein the gas supply part includes a plurality of gas sources, a flow path that allows the gas to flow from the plurality of gas sources to the substrate processing space, a valve provided in the flow path to switch between opening and closing the flow of the gas, and a buffer tank provided in the flow path,

pulse control is performed to pulse the flow of the gas by alternately repeating the opening and closing of the flow of the gas in the valve, and

in the pulse control, a duration of the pulse control and a number of times of opening the flow of the gas during the duration are controlled to control the flow rate of the gas.

[Claim 2]

The substrate processing method of claim 1, wherein the flow path includes a plurality of first flow paths corresponding to the plurality of gas sources, and a second flow path where the plurality of first flow paths join,

the valve is provided in each of the plurality of first flow paths, and

the pulse control is performed on the valve provided in one of the first flow paths to supply the gas to the substrate processing space and close another valve provided in another first flow path.

[Claim 3]

The substrate processing method of claim 2, wherein two or more gas sources among the plurality of gas sources correspond to one of the plurality of first flow paths, and

the gases are supplied from the plurality of gas sources and mixed in the first flow path.

[Claim 4]

The substrate processing method of claim 2 or 3, comprising:

executing the pulse control in one valve;

closing the flow of the gas in the valve; and

executing the pulse control in another valve after a delay time of 10 ms to 1 s has elapsed.

[Claim 5]

The substrate processing method of any one of claims 1 to 3, wherein the substrate processing apparatus includes a detector configured to detect plasma emission in the substrate processing space, and

when the gas supplied to the substrate processing space by the pulse control is an etching gas, during the pulse control, the pulse control is continued if the emission amount of the plasma emission is less than a threshold value, and the pulse control is terminated if the emission amount becomes greater than or equal to the threshold value.

[Claim 6]

The substrate processing method of any one of claims 1 to 3, wherein the substrate processing apparatus includes a detector configured to detect gas components in the substrate processing space, and

during the pulse control, if the existence amount of the gas components supplied to the substrate processing space by the pulse control is greater than or equal to a threshold value, the pulse control is continued, and if the existence amount of the gas components is less than the threshold value, the pulse control is terminated.

[Claim 7]

The substrate processing method of claim 2 or 3, wherein the substrate processing apparatus includes the buffer tank in each of the plurality of first flow paths,

wherein a flow path cross-sectional area of the buffer tank is three times or more a flow path cross-sectional area of the first flow path in which the buffer tank is provided, and

a length of the buffer tank in the flow path direction is greater than or equal to a diameter of the flow path cross-sectional area of the buffer tank.

[Claim 8]

The substrate processing method of claim 7, wherein a volume of the buffer tank is five times or more a target value of the supply amount of the gas in one pulse set.

[Claim 9]

The substrate processing method of claim 8, wherein the volume of the buffer tank is ten times or more the target value of the supply amount of the gas in one pulse set.

[Claim 10]

The substrate processing method of claim 1, wherein the buffer tank is configured such that a volume of the buffer tank is variable, and the volume of the buffer tank is reduced to maintain a constant pressure in the buffer tank during the duration of the pulse control.

[Claim 11]

The substrate processing method of claim 1, wherein the buffer tank is configured such that a gas temperature in the buffer tank is adjustable, and the gas temperature in the buffer tank is increased to maintain a constant pressure in the buffer tank during the duration of the pulse control.

[Claim 12]

The substrate processing method of any one of claims 1 to 3, wherein the substrate processing apparatus includes an upper electrode, and

the gas is supplied from the gas supply part to a vicinity of a center of the upper electrode, diffused in a diffusion space provided in the upper electrode, and introduced into the substrate processing space.

[Claim 13]

A substrate processing apparatus comprising:

a processing chamber where a substrate processing space is formed;

a gas supply part configured to supply a gas to the substrate processing space; and

a controller;

wherein the gas supply part includes a plurality of gas sources, a flow path that allows a gas to flow from the plurality of gas sources to the substrate processing space, a valve provided in the flow path to switch between opening and closing the flow of the gas, and a buffer tank provided in the flow path, and

the controller is configured to execute:

performing pulse control to pulse the flow of the gas by alternately repeating opening and closing of the flow of the gas in the valve when the gas is supplied from the gas supply part to the substrate processing space to process the substrate; and

in the pulse control, controlling the flow rate of the gas by controlling a duration of the pulse control and a number of times of opening the flow of the gas during the duration.

[Claim 14]

The substrate processing apparatus of claim 13, wherein the flow path includes a plurality of first flow paths provided to correspond to the plurality of gas sources and a second flow path where the plurality of first flow paths join,

the valve is provided in each of the plurality of first flow paths, and

the controller is further configured to execute:

performing the pulse control on the valve provided in one of the first flow paths to supply the gas to the substrate processing space and close another valve provided in another first flow path.

[Claim 15]

The substrate processing apparatus of claim 14, wherein two or more gas sources among the plurality of gas sources correspond to one of the plurality of first flow paths, and

the controller is further configured to execute:

supplying the plurality of gases from the plurality of gas sources and mixing the gases in the first flow path.

[Claim 16]

The substrate processing apparatus of claim 13 or 14, wherein the controller is further configured to execute:

executing the pulse control in one valve;

closing the flow of the gas in the valve; and

executing the pulse control in another valve after a delay time of 10 ms to 1 s has elapsed.

[Claim 17]

The substrate processing apparatus of any one of claims 13 to 15, further comprising:

a detector configured to detect plasma emission in the substrate processing space,

wherein the controller is further configured to execute:

when the gas supplied to the substrate processing space by the pulse control is an etching gas, during the pulse control, continuing the pulse control if the emission amount of the plasma emission is less than a threshold value and

terminating the pulse control if the emission amount is greater than or equal to the threshold value.

[Claim 18]

The substrate processing apparatus of any one of claims 13 to 15, further comprising:

a detector configured to detect gas components in the substrate processing space,

wherein the controller is further configured to execute:

during the pulse control, continuing the pulse control when the existence amount of the gas components supplied to the substrate processing space by the pulse control is greater than or equal to a threshold value and terminating the pulse control if the existence amount of the gas components is than the threshold value.

[Claim 19]

The substrate processing apparatus of claim 14 or 15, further comprising:

the buffer tank in each of the first flow paths,

wherein a flow path cross-sectional area of the buffer tank is three times or more a flow path cross-sectional area of the first flow path in which the buffer tank is provided, and

a length of the buffer tank in the flow path direction is greater than or equal to a diameter of the flow path cross-sectional area of the buffer tank.

[Claim 20]

The substrate processing apparatus of claim 19, wherein the buffer tank has a volume that is five times or more a target value of the supply amount of the gas in one pulse set.

[Claim 21]

The substrate processing apparatus of claim 20, wherein the buffer tank has a volume that is ten times or more the target value of the gas supply amount in one pulse set.

[Claim 22]

The substrate processing apparatus of claim 13, wherein the buffer tank is configured such that a volume of the buffer tank is variable, and

the controller is further configured to execute:

reducing the volume of the buffer tank to maintain a constant pressure in the buffer tank during the duration of the pulse control.

[Claim 23]

The substrate processing apparatus of claim 13, wherein the buffer tank is configured such that a gas temperature in the buffer tank is adjustable, and

the controller is further configured to execute:

increasing the gas temperature in the buffer tank to maintain a constant pressure in the buffer tank during the duration of the pulse control.

[Claim 24]

The substrate processing apparatus of any one of claims 13 to 15, further comprising:

an upper electrode,

wherein the controller is further configured to execute:

supplying the gas from the gas supply part to a vicinity of a center of the upper electrode, diffusing in a diffusion space provided in the upper electrode, and introducing the gas into the substrate processing space.