trap mechanism between the reaction chamber and the vacuum pump for collecting the liquid precursor, the by-product, and the like, collection efficiency is decreased. On the contrary, in a case where the exhaust conductance is decreased to increase the collection efficiency, pump exhaust performance is decreased. That is, there is a contradictory relationship. Therefore, there is a problem that sufficient collection efficiency cannot be obtained for the liquid precursor, or exhaust conductance has a small value.

[0006] An object of the present disclosure is to provide a technique for suppressing a decrease in collection efficiency and a decrease in pump exhaust performance.

MEANS TO SOLVE THE PROBLEM

[0007] One aspect of the present disclosure provides a technique including:

a process chamber configured to process a substrate;

a first gas supplier configured to supply a metal-containing gas into the process chamber;

a second gas supplier configured to supply a~~n~~ first oxygen-containing gas into the process chamber; and

an exhauster including a gas exhaust pipe and a trap configured to collect a component of the metal-containing gas contained in an exhaust gas by using plasma, the exhauster being configured to discharge ~~an~~the exhaust gas ~~containing a component of the metal-containing gas~~ from an interior of the process chamber~~,~~

~~wherein the exhauster includes a gas exhaust pipe, a pump configured to exhaust the interior of the process chamber, an auxiliary pump configured to support the pump, and a trap disposed between the pump and the auxiliary pump and configured to collect the component of the metal-containing gas by using plasma~~.

EFFECTS OF THE INVENTION

[0008] The present disclosure can suppress a decrease in collection efficiency and a decrease in pump exhaust performance.

BRIEF DESCRIPTION OF DRAWINGS

[0009] FIG. 1 is a schematic longitudinal cross-sectional view for explaining a substrate processing apparatus suitably used in embodiments of the present disclosure.

FIG. 2 is a vertical cross-sectional view taken along line A-A in FIG. 1.

FIG. 3 is a schematic longitudinal cross-sectional view for explaining a trap suitably used in the embodiments of the present disclosure.

FIG. 4 is a diagram illustrating a configuration of a controller suitably used in the embodiments of the present disclosure.

FIG. 5 is a flowchart for explaining a process of manufacturing a metal oxide film by using a substrate processing apparatus according to preferred embodiments of the present disclosure.

FIG. 6 is a timing chart for explaining a process of manufacturing a metal oxide film by using the substrate processing apparatus according to the preferred embodiments of the present disclosure.

DETAILED DESCRIPTION

(1) Configuration of substrate processing apparatus

[0010] Hereinafter, embodiments will be described with reference to the drawings. However, in the following description, the same components are denoted by the same reference numerals, and repeated description may be omitted. Note that, in order to make description clearer, the drawings may be schematically illustrated in a width, a thickness, a shape, and the like of each component as compared with an actual aspect. However, the illustration is ~~only~~ an example and does not limit interpretation of the present disclosure.

[0011] Hereinafter, a substrate processing apparatus according to preferred embodiments of the present disclosure will be described with reference to the drawings. As an example, the substrate processing apparatus is configured as a semiconductor manufacturing apparatus that performs a film-forming step serving as a substrate processing step in a method of manufacturing

10 into the trap mechanism 10. When the active species activated by the plasma generator 16 is supplied into the trap mechanism 10 via the gas supply pipe 21, the active species reacts with the component of metal-containing gas, and a product adheres to the trap fin 14, whereby the component of metal-containing gas that was not reacted or that contributed to formation of the metal-containing layer is removed from the exhaust gas. The exhaust gas from which the component of metal-containing gas that was not reacted or that contributed to formation of the metal-containing layer was removed is discharged from "Out" of the trap mechanism 10 to the dry pump 11. This makes it possible to prevent deposition of a product in the dry pump 11.

[0039] As a means that generates plasma, any method may be used. For example, inductively coupled plasma (abbreviated as IPC), electron cyclotron resonance plasma (abbreviated as ECR plasma), helicon wave excited plasma (abbreviated as HWP), surface wave plasma (abbreviated as SWP), or the like may be used.

[0040] The first oxygen-containing gas used in the film-forming step and the second oxygen-containing gas used in the trap 100 may be the same gas or different gases. In a case of the same gas, a large amount of O_3 is ~~required~~used in the film-forming step, and it is difficult to ensure the amount used in the trap 100. Therefore, by using O_2 for plasma as a different gas, consumption of O_3 can be reduced. In a case where the amount to be used in the film-forming step and the amount to be used in the trap can be ensured, when O_3 is used as the same gas, an ozonizer can be commonly used, and therefore an apparatus configuration can be simplified.

[0041] The temperature of the exhaust gas ~~is~~may not be particularly ~~required to be~~ controlled, but the exhaust piping may be heated to heat the exhaust gas. By heating the exhaust gas, the organometallic precursor more easily reacts with the oxygen plasma.

[0042] A temperature sensor 263 serving as a temperature detector is disposed in the reaction tube 203, which is configured such that the temperature in the process chamber 201 has a desired temperature distribution by adjusting a degree of energization to the heater 207 based on temperature information detected by the temperature sensor 263. The temperature sensor 263 is formed in an L shape similarly to the nozzles 249a and 249b, and is disposed along an inner wall

[0064] Thereafter, the seal cap 219 is lowered by the boat elevator 115, a lower end of a manifold 209 is opened, and the processed wafers 200 are unloaded from the lower end of the manifold 209 to the outside of the reaction tube 203 in a state of being held by the boat 217 (boat unloading, step S112). Thereafter, the processed wafers 200 are discharged from the boat 217 (wafer discharging, step S112).

[0065] In addition, the present disclosure can also be achieved, for example, by changing a process recipe of an existing substrate processing apparatus. When a process recipe is changed, the process recipe according to the present disclosure can be installed in an existing substrate processing apparatus via a telecommunication line or a recording medium in which the process recipe is recorded, or a process recipe itself of an existing substrate processing apparatus can be changed to the process recipe according to the present disclosure by operating an input/output device of the existing substrate processing apparatus.

[0066] For example, in the above-described embodiments, as the metal-containing gas, for example, a $Zr(O\text{-}tBu)_4$ gas, a tetrakis(dimethylamino)zirconium ($Zr(NMe_2)_4$), (abbreviated as TDMAZ) gas, a tetrakis(ethylmethylamino)zirconium ($Zr[N(CH_3)C_2H_5]_4$), (abbreviated as TEMAZ) gas, a tetrakis(diethylamino)zirconium ($Zr(NETt_2)_4$), (abbreviated as TDEAZ) gas, or a $Zr(MMP)_4$ gas can be used. As the precursor gas, for example, an organometallic precursor gas containing a metal element and carbon, such as a trimethylaluminum ($Al(CH_3)_3$, abbreviated as TMA) gas can also be used. As a reactant gas, a gas similar to that used in the above-described embodiments can be used. As the oxygen-containing gas (first oxygen-containing gas) used in the film-forming step, an O_2 gas, a H_2O gas, an O_3 gas, or the like can be used. As the oxygen-containing gas (second oxygen-containing gas) used in the trap 100, an O_2 gas, a H_2O gas, an O_3 gas, or the like can be used. As the inert gas, a rare gas such as a N_2 gas, an Ar gas, a He gas, a Ne gas, or a Xe gas can be used.

[0067] In addition, in the above-described embodiments, an example in which a film is deposited on the wafer 200 is described. However, the present disclosure is not limited to such embodiments. For example, the present disclosure is also suitably applicable to a case where

WHAT IS CLAIMED IS:

1. A substrate processing apparatus comprising:

a process chamber configured to process a substrate;

a first gas supplier configured to supply a metal-containing gas into the process chamber;

a second gas supplier configured to supply a first oxygen-containing gas into the process chamber; and

an exhauster including a gas exhaust pipe and a trap configured to collect a component of the metal-containing gas contained in an exhaust gas by using plasma, the exhauster being configured to discharge ~~an~~the exhaust gas ~~containing a component of the metal-containing gas~~ from an interior of the process chamber~~,~~

~~wherein the exhauster includes a gas exhaust pipe, a pump configured to exhaust the interior of the process chamber, an auxiliary pump configured to support the pump, and a trap disposed between the pump and the auxiliary pump and configured to collect the component of the metal-containing gas contained in the exhaust gas by using plasma~~.

2. The substrate processing apparatus according to claim 1, wherein the trap is disposed between a pump configured to exhaust the interior of the process chamber and an auxiliary pump configured to support the pump.

~~2~~3. The substrate processing apparatus according to claim 1, wherein the trap includes a trap mechanism configured to collect the component of the metal-containing gas contained in the exhaust gas, a plasma generator configured to generate the plasma, a ~~second~~third gas supplier configured to supply a second oxygen-containing gas to the plasma generator, a high-frequency power supply configured to supply high-frequency power to the plasma generator, and a ~~third~~fourth gas supplier configured to supply a gas from the plasma generator to the trap

mechanism.

~~3~~4. The substrate processing apparatus according to claim ~~2~~3, wherein the plasma generator activates the second oxygen-containing gas by forming plasma from the second oxygen-containing gas and supplies the activated second oxygen-containing gas to the trap mechanism via the ~~third~~fourth gas supplier.

~~4~~5. The substrate processing apparatus according to claim ~~2 or~~ 3, wherein the plasma generator includes an electrode connected to the high-frequency power supply and an electrode connected to a ground that is a reference potential.

~~5~~6. The substrate processing apparatus according to claim ~~3 or~~ 4, wherein the component of the metal-containing gas is caused to react with the second oxygen-containing gas activated by the plasma generator in the trap mechanism.

~~6~~7. The substrate processing apparatus according to claim ~~5~~3, wherein the trap mechanism includes a trap fin to which the component of the metal-containing gas adheres.

~~7~~8. The substrate processing apparatus according to claim ~~6~~7, wherein a product generated by a reaction between the component of the metal-containing gas and the second oxygen-containing gas activated by the plasma generator is caused to adhere to the trap fin.

~~8~~9. The substrate processing apparatus according to claim ~~6 or~~ 7, wherein the trap fin is made of stainless steel.

~~9~~10. The substrate processing apparatus according to claim ~~1~~2, wherein the pump is a dry pump, and the auxiliary pump is a mechanical booster pump.

~~10~~11. The substrate processing apparatus according to claim ~~2~~3, wherein the first oxygen-containing gas and the second oxygen-containing gas are the same gas.

~~11~~12. The substrate processing apparatus according to claim ~~10~~11, wherein the first oxygen-containing gas and the second oxygen-containing gas are ozone.

~~12~~13. The substrate processing apparatus according to claim ~~2~~3, wherein the first oxygen-containing gas and the second oxygen-containing gas are different gases.

~~13~~14. The substrate processing apparatus according to claim ~~12~~13, wherein the first oxygen-containing gas is oxygen, and the second oxygen-containing gas is ozone.

~~14~~15. The substrate processing apparatus according to claim 11 ~~or 13~~, comprising an ozonizer configured to generate ~~the~~ ozone.

~~15~~16. The substrate processing apparatus according to claim ~~2~~1, ~~the apparatus being~~further comprising a controller configured to be capable of controlling the first gas supplier, the second gas supplier, and the exhauster to alternately perform (a) supplying the metal-containing gas from the first gas supplier into the process chamber and (b) supplying the first oxygen-containing gas from the second gas supplier into the process chamber, and perform (c) discharging the exhaust gas containing the component of the metal-containing gas after (a) and (d) collecting the component of the metal-containing gas contained in the exhaust gas.

~~16~~17. An exhauster comprising:

a gas exhaust pipe; and

~~a pump configured to exhaust an interior of a process chamber;~~

~~an auxiliary pump configured to support the pump; and~~

a trap ~~disposed between the pump and the auxiliary pump and~~ configured to collect a component of a metal-containing gas contained in an exhaust gas by using an oxygen-containing gas activated with plasma,

wherein the exhauster is configured to discharge the exhaust gas from an interior of a process chamber.

~~17~~18. A method of manufacturing a semiconductor device, the method comprising:

accommodating a substrate in a process chamber of a substrate processing apparatus including: the process chamber configured to process the substrate; a first gas supplier configured to supply a metal-containing gas into the process chamber; a second gas supplier configured to supply a first oxygen-containing gas into the process chamber; and an exhauster ~~configured to discharge an exhaust gas containing a component of the metal-containing gas from an interior of the process chamber, the exhauster~~ including a gas exhaust pipe, ~~a pump configured to exhaust the interior of the process chamber, an auxiliary pump configured to support the pump,~~ and a trap ~~disposed between the pump and the auxiliary pump and~~ configured to collect ~~the~~a component of the metal-containing gas contained in an exhaust gas by using plasma, the exhauster being configured to discharge the exhaust gas from the process chamber;

supplying the metal-containing gas into the process chamber;

discharging the component of the metal-containing gas from the process chamber; and

collecting the component of the metal-containing gas by the trap.

~~18~~19. A program that causes, by a computer, a substrate processing apparatus including: a process chamber configured to process a substrate; a first gas supplier configured to supply a

metal-containing gas into the process chamber; a second gas supplier configured to supply a first oxygen-containing gas into the process chamber; and an exhauster including a gas exhaust pipe and ~~configured to discharge an exhaust gas containing a component of the metal-containing gas from an interior of the process chamber, the exhauster including a gas exhaust pipe, a pump configured to exhaust the interior of the process chamber, an auxiliary pump configured to support the pump, and~~ a trap ~~disposed between the pump and the auxiliary pump and~~ configured to collect ~~the~~a component of the metal-containing gas contained in an exhaust gas by using plasma, the exhauster being configured to discharge the exhaust gas from the process chamber, to perform a process comprising;

accommodating the substrate in the process chamber;

supplying the metal-containing gas into the process chamber;

discharging the component of the metal-containing gas from the process chamber; and

collecting the component of the metal-containing gas by the trap.