

[DESCRIPTION]

[Title]

SUBSTRATE PROCESSING APPARATUS, METHOD OF
MANUFACTURING SEMICONDUCTOR DEVICE, AND PROGRAM

5 **[Technical Field]**

[0001]

The present disclosure relates to a substrate processing apparatus, a method of manufacturing a semiconductor device and a program.

[Related Art]

10 [0002]

As a part of manufacturing processes of a semiconductor device, a substrate processing including a step of vaporizing a liquid source containing hydrogen peroxide (H₂O₂) to generate a vaporized gas serving as a process gas and a step of supplying the vaporized gas to a substrate in a process chamber may be performed (refer to, for
15 example, Patent Documents 1 and 2).

[Related Art Document]

[Patent Document]

[0003]

Patent Document 1: International Publication No. WO 2013/077321

20 Patent Document 2: International Publication No. WO 2014/157210

[Disclosure]

[Technical Problem]

[0004]

When a gas containing a compound (such as H₂O₂) of a high reactivity with a
25 metal is used as the process gas and the process gas is exhausted through an exhaust piping made of the metal, the metal may react with the compound to corrode the exhaust piping, or a component of the metal reacted with the compound may adhere to the

substrate in the process chamber to cause metal contamination. On the other hand, an exhaust piping made of a material such as a resin of a low reactivity with the compound may be used. However, it may not be possible to ensure a sufficient pressure resistance or a sufficient gas permeation resistance of the exhaust piping made of the material when increasing a degree of vacuum while the process gas is exhausted through the exhaust piping made of the material (when decreasing an inner pressure of the exhaust piping made of the material).

[0005]

Described herein is a technique capable of exhausting a process gas in a wide pressure range even when a gas containing a compound of a high reactivity with a metal is used as the process gas.

[Technical Solution]

[0006]

According to one aspect of the technique of the present disclosure, there is provided a substrate processing apparatus including: a process chamber in which a substrate is accommodated; a gas supply system configured to supply a process gas containing a compound capable of reacting with a metal into the process chamber; and a gas exhaust system configured to exhaust an inner atmosphere of the process chamber, wherein the gas exhaust system includes: a common exhaust piping in communication with the process chamber; a first exhaust piping made of a resin incapable of reacting with the compound and whose one end is connected to the common exhaust piping via a first valve and the other end is connected to a first exhauster; and a second exhaust piping made of the metal and whose one end is connected to the common exhaust piping via a second valve and the other end is connected to a second exhauster.

[Advantageous Effects]

[0007]

According to some embodiments in the present disclosure, it is possible to

exhaust the process gas in a wide pressure range even when the gas containing the compound of a high reactivity with the metal is used as the process gas.

[Brief Description of Drawings]

[0008]

5 FIG. 1 schematically illustrates a vertical cross-section of a vertical type process furnace of a substrate processing apparatus preferably used in an embodiment described herein.

 FIG. 2 is a block diagram schematically illustrating a configuration of a controller and related components of the substrate processing apparatus preferably used
10 in the embodiment described herein.

 FIG. 3 is a flow chart schematically illustrating an example of a pre-processing step.

 FIG. 4 is a flow chart schematically illustrating an example of a substrate processing performed after the pre-processing step.

15 **[Detailed Description]**

[0009]

<Embodiment of Present Disclosure>

 Hereinafter, an embodiment of the present disclosure will be described with reference to FIGS. 1 through 4.

20 [0010]

(1) Configuration of Substrate Processing Apparatus

 As shown in FIG. 1, a process furnace 202 of a substrate processing apparatus includes a reaction tube 203. For example, the reaction tube 203 is made of a heat resistant material such as quartz (SiO_2), and is configured as a cylinder provided with a
25 gas supply port 203p at an upper end thereof and a furnace opening (also referred to as an “opening”) at a lower end thereof. A process

is adjusted by the APC valve 244b to, for example, the atmospheric pressure so that the inner pressure of the process chamber 201 is returned to the atmospheric pressure and a heat capacity in the process chamber 201 is increased. As a result, it is possible to uniformly heat the wafer 200 and the components in the process chamber 201, and to
5 remove substances (for example, particles, the impurities and the outgas that cannot be removed by the vacuum exhaust) from the process chamber 201. After a predetermined time has elapsed, the inner temperature of the process chamber 201 is lowered to a predetermined unloadable temperature at which the wafer 200 can be unloaded.

[0065]

10 <Substrate Unloading Step S90>

The seal cap 219 is lowered by the boat elevator 115 and the lower end of the reaction tube 203 is opened. Then, the boat 217 accommodating a plurality of processed wafers including the wafer 200 is unloaded out of the reaction tube 203 through the lower end opening of the reaction tube 203. After the boat 217 is unloaded out of the
15 reaction tube 203, the plurality of the processed wafers including the wafer 200 are transferred (discharged) out of the boat 217.

[0066]

According to the present embodiment, it is possible to accurately perform the pressure control from the vicinity of the atmospheric pressure to the vacuum range by
20 configuring the exhaust system of the process chamber 201 as two system lines, that is, the vacuum exhaust system and the slight decompression exhaust system. In addition, since the pressure control can be performed accurately, it is possible to reduce a possibility that the condensation may occur in the components such as the process chamber 201. Since foreign matters or the metal contamination is prevented from
25 occurring on the wafer, it is possible to increase the semiconductor yield.

[0067]

<Other Embodiments of Present Disclosure>

While the embodiment of the technique described above is described by way of an example in which the vaporized gas of the hydrogen peroxide solution is used as the process gas containing the compound of the high reactivity with the metal, the technique is not limited thereto. For example, a process gas containing a compound (other than
5 H₂O₂) of a high reactivity with the metal may be used.

[0068]

While the embodiment of the technique described above is described by way of an example in which the vaporized gas is generated outside the process chamber 201, the technique is not limited thereto. For example, the vaporized gas may be generated
10 inside the process chamber 201. For example, the vaporized gas may be generated by supplying the liquid source to the top plate 217a heated by a heater such as a lamp heater to vaporize the liquid source.

[0069]

While the embodiment of the technique described above is described by way of an example in which the substrate with the polysilazane film formed thereon is
15 processed, the technique is not limited thereto. For example, even when a non-prebaked silicon-containing film formed by a flowable CVD method is processed, it is possible to obtain the same effects according to the embodiment described above.

[0070]

20 The above-described embodiments may be appropriately combined. The processing sequences and the processing conditions of the combinations may be substantially the same as those of the above-described embodiments.

[Description of Reference Numerals]

[0071]

- 25 200: wafer (substrate)
 201: process chamber
 244a, 244b: APC valve

[CLAIMS]

[Claim 1]

- A substrate processing apparatus comprising:
- 5 a process chamber in which a substrate is accommodated;
- a gas supply system configured to supply a process gas containing a compound capable of reacting with a metal into the process chamber; and
- a gas exhaust system configured to exhaust an inner atmosphere of the process chamber,
- 10 wherein the gas exhaust system comprises:
- a common exhaust piping in communication with the process chamber;
- a first exhaust piping made of a resin incapable of reacting with the compound and whose one end is connected to the common exhaust piping via a first valve and the other end is connected to a first exhauster; and
- 15 a second exhaust piping made of the metal and whose one end is connected to the common exhaust piping via a second valve and the other end is connected to a second exhauster.

[Claim 2]

- 20 The substrate processing apparatus of claim 1, wherein the common exhaust piping comprises a metal piping whose inner surface is surface-treated so as not to react with the compound.

[Claim 3]

- 25 The substrate processing apparatus of one of claims 1 and 2, wherein the first exhauster is configured to exhaust an inside of the first exhaust piping to a predetermined first pressure range, and the second exhauster is configured to exhaust an

inside of the second exhaust piping to a predetermined second pressure range lower than the first pressure range.

[Claim 4]

5 The substrate processing apparatus of any one of claims 1 through 3, wherein the first exhauster is made of a resin incapable of reacting with the compound.

[Claim 5]

 The substrate processing apparatus of any one of claims 1 through 4, further
10 comprising:

 a first pressure sensor configured to measure an inner pressure of the common exhaust piping within a first pressure range;

 a second pressure sensor configured to measure the inner pressure of the common exhaust piping within the first pressure range and a second pressure range
15 lower than the first pressure range;

 a first pressure adjusting valve provided on the first exhaust piping more upstream of the first exhauster and whose opening degree is controlled based on a pressure measured by the first pressure sensor; and

 a second pressure adjusting valve provided on the second exhaust piping more
20 upstream of the second exhauster and whose opening degree is controlled based on a pressure measured by the second pressure sensor.

[Claim 6]

 The substrate processing apparatus of claim 5, wherein a pressure range
25 measured by the first pressure sensor is narrower than a pressure range measured by the second pressure sensor.

[Claim 7]

The substrate processing apparatus of claim 6, wherein the first pressure sensor is configured to measure the pressure ranging from 600 Torr to an atmospheric pressure at most, the second pressure sensor is configured to measure the pressure ranging from
5 0 Torr to a pressure less than the atmospheric pressure at most.

[Claim 8]

The substrate processing apparatus of any one of claims 1 through 4, further comprising:

10 a second pressure adjusting valve provided on the second exhaust piping more upstream of the second exhauster,

and a portion of the second exhaust piping between the second pressure adjusting valve and the second exhauster is configured as a metal piping.

15 [Claim 9]

The substrate processing apparatus of claim 8, wherein a portion of the second exhaust piping between the second valve and the second pressure adjusting valve is configured as a metal piping whose inner surface is surface-treated so as not to react with the compound.

20

[Claim 10]

The substrate processing apparatus of any one of claims 5 through 7, further comprising:

a controller configured to control the gas supply system, the first valve and the
25 second valve to perform:

(a) supplying the process gas into the process chamber by controlling the gas supply system while exhausting the inner atmosphere of the process chamber by the

first exhauster with the first valve open and the second valve closed; and

(b) exhausting the inner atmosphere of the process chamber by the second exhauster with the first valve closed and the second valve open.

5 [Claim 11]

The substrate processing apparatus of claim 10, wherein the controller is further configured to control the first pressure adjusting valve such that the pressure measured by the first pressure sensor reaches a predetermined first process pressure in (a), and to control the second pressure adjusting valve such that the pressure measured by the
10 second pressure sensor reaches a predetermined second process pressure lower than the first process pressure in (b).

[Claim 12]

The substrate processing apparatus of claim 11, wherein the first process
15 pressure is a predetermined pressure ranging from 600 Torr to an atmospheric pressure at most.

[Claim 13]

The substrate processing apparatus of any one of claims 1 through 12, wherein
20 the process gas comprises a gas containing hydrogen peroxide as the compound.

[Claim 14]

A method of manufacturing a semiconductor device comprising:

- (a) placing a substrate in a process chamber;
- 25 (b) supplying a process gas containing a compound capable of reacting with a metal into the process chamber and exhausting an inner atmosphere of the process chamber by a common exhaust piping in communication with the process chamber, a

first exhaust piping made of a resin incapable of reacting with the compound and whose one end is connected to the common exhaust piping via a first valve and a first exhauster connected to the first exhaust piping; and

(c) exhausting the inner atmosphere of the process chamber by the common exhaust piping, a second exhaust piping made of the metal and whose one end is connected to the common exhaust piping via a second valve and a second exhauster connected to the second exhaust piping.

[Claim 15]

10 A program that causes, by a computer, a substrate processing apparatus to perform:

(a) placing a substrate in a process chamber;

(b) supplying a process gas containing a compound capable of reacting with a metal into the process chamber and exhausting an inner atmosphere of the process chamber by a common exhaust piping in communication with the process chamber, a first exhaust piping made of a resin incapable of reacting with the compound and whose one end is connected to the common exhaust piping via a first valve and a first exhauster connected to the first exhaust piping; and

(c) exhausting the inner atmosphere of the process chamber by the common exhaust piping, a second exhaust piping made of the metal and whose one end is connected to the common exhaust piping via a second valve and a second exhauster connected to the second exhaust piping.