sensor 272, the matching mechanism 274 and the high frequency power supply 273 through the signal line E; and adjusting flow rates of various gases by the MFCs 252a, 252b and 252c and opening/closing the valves 253a, 253b, 253c and 243a through the signal line F. In addition, the CPU 221a is configured to acquire a temperature value measured by the thermocouple 275 through the signal line C and to acquire a temperature value measured by the thermocouple mechanism 280 through the signal line G in order to perform the contents of the read process recipe.

[0045]

The controller 221 may be embodied by installing the above-described program stored in an external memory device 263 into a computer. For example, the external memory device 263 may include a magnetic tape, a magnetic disk such as a hard disk drive (HDD), an optical disk such as a CD, a magneto-optical disk such as MO, a semiconductor memory such as a USB memory. The memory device 221c or the external memory device 263 may be embodied by a non-transitory computer readable recording medium. Hereafter, the memory device 221c and the external memory device 263 may be collectively referred to as a "recording medium". In the present specification, the term "recording medium" may indicate only the memory device 221c, may indicate only the external memory device 263, and may indicate both of the memory device 221c and the external memory device 263. Instead of the external memory device 263, a communication means such as the Internet and a dedicated line may be used for providing the program to the computer.

[0046]

(2) Substrate Processing

As shown in FIG. 5, the substrate processing according to the first embodiment is mainly constituted by: a pre-processing step (also referred to as a "plasma preheating step") S400 of generating the plasma discharge in the plasma generation space 201a so as to perform a heating process of heating the process chamber 201 (particularly, the upper vessel 210); and a main processing step (also referred to as a "product substrate processing step") S500 in which a product

one of the most preferable to perform the heating process using the plasma discharge as means of heating the process vessel 203 itself according to the apparatus configuration of the present embodiment.

[0069]

Hereinafter, each of the steps constituting the pre-processing step S400 will be described with reference to FIG. 7. In addition, the pre-processing step S400 may be performed in a state where the wafer 200 serving as a dummy substrate is placed on the susceptor 217. However, the present embodiment will be described by way of an example in which the dummy substrate is not used.

[0070]

<Vacuum Exhaust Step S410>

First, the vacuum pump 246 vacuum-exhausts the inner atmosphere of the process chamber 201 such that the inner pressure of the process chamber 201 is at a predetermined pressure. The vacuum pump 246 continuously vacuum-exhausts the inner atmosphere of the process chamber 201 until at least an exhaust and pressure adjusting step S440 described later is completed. The heater 217b is controlled to heat the susceptor 217 continuously from the heater temperature elevating step S100.

[0071]

<Discharge Gas Supply Step S420>

Next, a mixed gas of the O_2 gas and the H_2 gas serving as a discharge gas (also referred to as a “first process gas”) is supplied into the process chamber 201 in the same manner as the reactive gas (the second process gas) in the main processing step S500. The conditions such as specific gas supply procedures, the flow rates of the gases supplied into the process chamber 201 and the inner pressure of the process chamber 201 are the same as those in the main processing step S500.

[0072]

For the purpose of promoting the plasma discharge in a plasma discharge step S430 described later, other gas such as argon (Ar) gas may be supplied with the discharge gas, or at least one among the O_2 gas and the H_2 gas may not be supplied. In addition, conditions such as the flow rates of the gases supplied into the process chamber 201 and the inner pressure of the process chamber 201 may be set differently. However, it is one of the most preferable to use the same discharge gas as the reactive gas of the main processing step S500 since it brings the environment in the process chamber 201 closer to a stable state of the main processing step S500 in addition to heating the upper vessel 210.

[0073]

<Plasma Discharge Step S430>

Next, the high frequency power from the high frequency power supply 273 is applied to the resonance coil 212. The magnitude of the high frequency power supplied to the resonance coil 212 is the same as that of the high frequency power in the main processing step S500. However, the magnitude of the high frequency power may be greater than that of the high frequency power in the main processing step S500 in order to promote the plasma discharge, and may vary within a range from 100 W to 5,000 W in accordance with other processing conditions.

[0074]

As a result, the plasma discharge is generated intensively in the plasma generation space 201a, particularly at the height of the upper end, the middle point and lower end of the resonance coil 212. The generated plasma discharge heats the upper vessel 210 from the inside of the upper vessel

[CLAIMS]

[Claim 1]

A substrate processing apparatus comprising:

a process vessel constituting at least a part of a process chamber where a substrate is processed;

a plasma generator comprising a coil provided to be wound around an outer periphery of the process vessel and a high frequency power supply configured to supply high frequency power to the coil;

a substrate support provided in the process chamber and below a lower end of the coil;

a heater provided in the substrate support;

a temperature sensor configured to measure a temperature of a portion of the process vessel located above an upper end of the coil;

a gas supply system configured to supply a first process gas and a second process gas into the process vessel; and

a controller configured to control the gas supply system and the plasma generator to perform: a process (a) of supplying the first process gas into the process vessel; a process (b) of generating a plasma of the first process gas supplied into the process vessel by supplying the high frequency power to the coil until a temperature measured by the temperature sensor is equal to or higher than a first temperature; a process (c) of placing the substrate on the substrate support after the process (b); a process (d) of supplying the second process gas into the process vessel; and a process (e) of generating a plasma of the second process gas supplied into the process vessel by

supplying the high frequency power to the coil and processing the substrate placed on the substrate support by the plasma of the second process gas,

wherein the controller is further configured to obtain a temperature measured by the temperature sensor after the process (c) through the process (e) are repeatedly performed a predetermined number of times, and store the obtained temperature in a memory device as the first temperature.

[Claim 2]

The substrate processing apparatus of claim 1, wherein the controller is configured to control the plasma generator to, in the process (b), intermittently start and stop supplying the high frequency power to the coil once or repeatedly a plurality of times until the temperature measured by the temperature sensor is equal to or higher than the first temperature.

[Claim 3]

The substrate processing apparatus of claim 1, wherein the controller is configured to control the heater so as to heat the substrate support in all of the process (a) through the process (e).

[Claim 4]

The substrate processing apparatus of claim 1, further comprising: a second temperature sensor configured to measure a temperature of at least one among the heater and the substrate support, and

the controller is configured to control the heater such that a temperature measured by the second temperature sensor is equal to or higher than a second temperature in the process (a) through the process (e).

[Claim 5]

The substrate processing apparatus of claim 4, wherein the controller is configured to perform: a process (f) of elevating the temperature of at least one among the heater and the substrate support by the heater such that the temperature measured by the second temperature sensor is equal to or higher than the second temperature before the process (a).

[Claim 6]

The substrate processing apparatus of claim 1, wherein the temperature sensor is provided so as to measure the temperature of the process vessel at a predetermined height of 15 mm or more and 30 mm or less from the upper end of the coil.

[Claim 7]

The substrate processing apparatus of claim 1, wherein the high frequency power supply is configured to supply the coil with the high frequency power whose wavelength is an integral multiple of an electrical length of an inductive coupling structure comprising the coil.

[Claim 8]

The substrate processing apparatus of claim 1, wherein the controller is configured to control the high frequency power supply to supply the coil with the high frequency power whose frequency range is a resonance frequency of an inductive coupling structure comprising the coil.

[Claim 9]

The substrate processing apparatus of claim 1, wherein the controller is configured to control the high frequency power supply such that a ring-shaped plasma is generated at a height of the upper end of the coil in the process (b).

[Claim 10]

The substrate processing apparatus of claim 1, wherein the process vessel comprises a dome-shaped or a cylinder-shaped vessel made of quartz.

[Claim 11]

The substrate processing apparatus of claim 1, wherein the temperature sensor is provided to measure a temperature of an outer peripheral surface of the process vessel.

[Claim 12]

The substrate processing apparatus of claim 11, wherein the temperature sensor comprises: a thermocouple; and a pressing mechanism configured to press a temperature detection point of the thermocouple against the outer peripheral surface of the process vessel.

[Claim 13]

The substrate processing apparatus of claim 12, wherein a front end portion of the thermocouple is constituted by a plate-shaped component with a surface facing the outer peripheral surface of the process vessel.

[Claim 14]

The substrate processing apparatus of claim 1, wherein the first process gas is same as the second process gas.

[Claim 15]

A method of manufacturing a semiconductor device comprising:

(a) providing a substrate processing apparatus comprising:

a process vessel constituting at least a part of a process chamber where a substrate is processed;

a plasma generator comprising a coil provided to be wound around an outer periphery of the process vessel and a high frequency power supply configured to supply high frequency power to the coil;

a substrate support provided in the process chamber and below a lower end of the coil;

a heater provided in the substrate support;

a temperature sensor configured to measure a temperature of a portion of the process vessel located above an upper end of the coil; and

a gas supply system configured to supply a first process gas and a second process gas into the process vessel;

(b) supplying the first process gas into the process vessel by the gas supply system;

(c) generating a plasma of the first process gas supplied into the process vessel by supplying the high frequency power to the coil until a temperature measured by the temperature sensor is equal to or higher than a first temperature;

(d) placing the substrate on the substrate support after the process (c);

(e) supplying the second process gas into the process vessel;

(f) generating a plasma of the second process gas supplied into the process vessel by supplying the high frequency power to the coil and processing the substrate placed on the substrate support by the plasma of the second process gas; and

(g) obtaining the temperature measured by the temperature sensor after the process (d) through the process (f) are repeatedly performed a predetermined number of times, and storing the obtained temperature in a memory device as the first temperature.

[Claim 16]

A program related to a substrate processing apparatus comprising: a process vessel constituting at least a part of a process chamber where a substrate is processed; a plasma generator comprising a coil provided to be wound around an outer periphery of the process vessel and a high frequency power supply configured to supply high frequency power to the coil; a substrate support provided in the process chamber and below a lower end of the coil; a heater provided in the substrate support; a temperature sensor configured to measure a temperature of a portion of the process vessel located

above an upper end of the coil; and a gas supply system configured to supply a first process gas and a second process gas into the process vessel, wherein the program causes, by a computer, the substrate processing apparatus to perform:

(a) supplying the first process gas into the process vessel;

(b) generating a plasma of the first process gas supplied into the process vessel by supplying the high frequency power to the coil until a temperature measured by the temperature sensor is equal to or higher than a first temperature;

(c) placing the substrate on the substrate support after the process (b);

(d) supplying the second process gas into the process vessel;

(e) generating a plasma of the second process gas supplied into the process vessel by supplying the high frequency power to the coil and processing the substrate placed on the substrate support by the plasma of the second process gas; and

(f) obtaining the temperature measured by the temperature sensor after the process (c) through the process (e) are repeatedly performed a predetermined number of times, and storing the obtained temperature in a memory device as the first temperature.