US 20150377732A1

(19) United States
(12) Patent Application Publication
MINAMI
(10) Pub. No.: US 2015/0377732 A1
(43) Pub. Date: Dec. 31, 2015

(54) **PRESSURE MEASURING DEVICE AND PRESSURE MEASURING METHOD**

(71) Applicant: **TOKYO ELECTRON LIMITED**, Tokyo (JP)

(72) Inventor: **Tomohide MINAMI**, Miyagi (JP)

(73) Assignee: **TOKYO ELECTRON LIMITED**, Tokyo (JP)

(21) Appl. No.: **14/733,327**

(22) Filed: **Jun. 8, 2015**

(30) **Foreign Application Priority Data**

Jun. 27, 2014 (JP) 2014-133268

Publication Classification

(51) **Int. Cl.**
G01L 9/02 (2006.01)

(52) **U.S. Cl.**
CPC *G01L 9/025* (2013.01)

(57) **ABSTRACT**

Provided is a pressure measuring device including a first electric resistor that is exposed to gas; a second electric resistor that is exposed to gas and has the same structure as that of the first electric resistor; a first measuring unit that measures a first voltage drop generated across the first electric resistor; a second measuring unit that measures a second voltage drop generated across the second electric resistor; a third measuring unit that measures a third voltage drop generated across the first electric resistor; a calculating unit that calculates a correction value that corrects the third voltage drop, based on a difference between the first voltage drop and the second voltage drop; and an output unit that corrects the third voltage drop using the calculated correction value and outputs a pressure value according to the third voltage value after the correction.

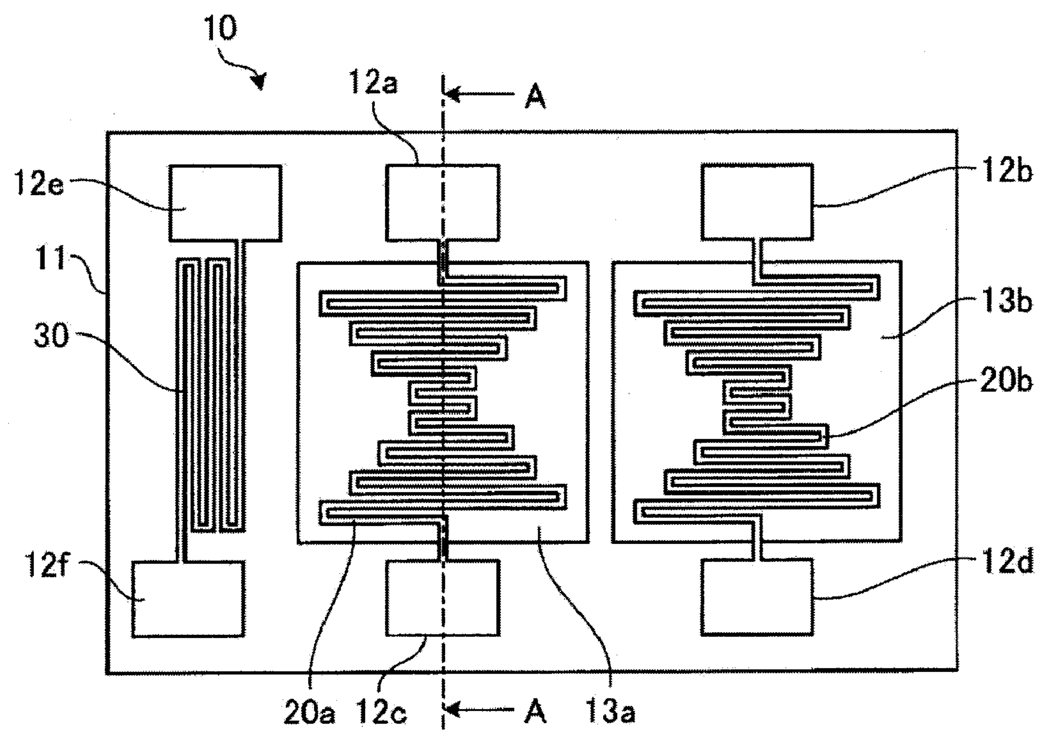


FIG.1

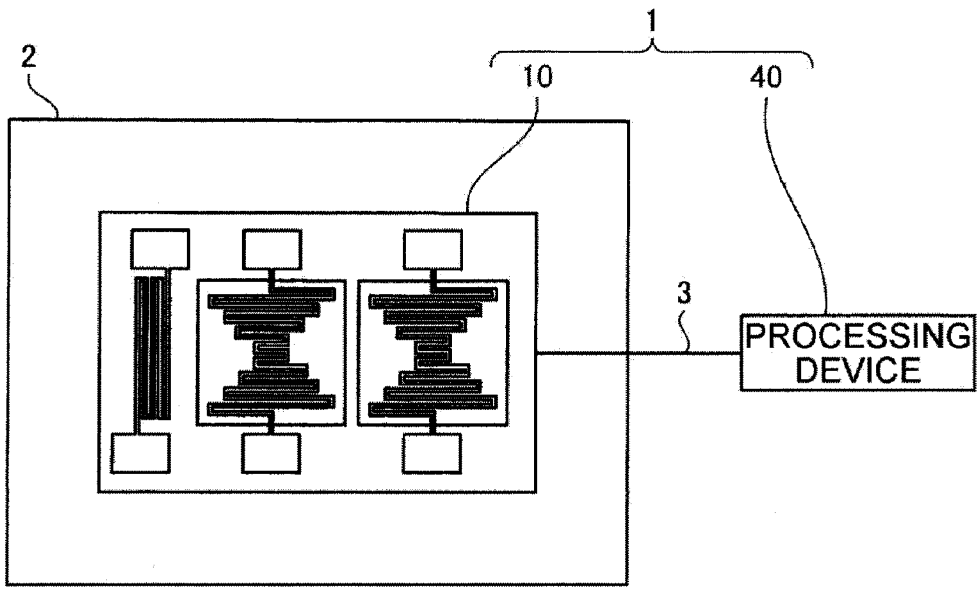

1
2
10
40
3
PROCESSING DEVICE

FIG.2

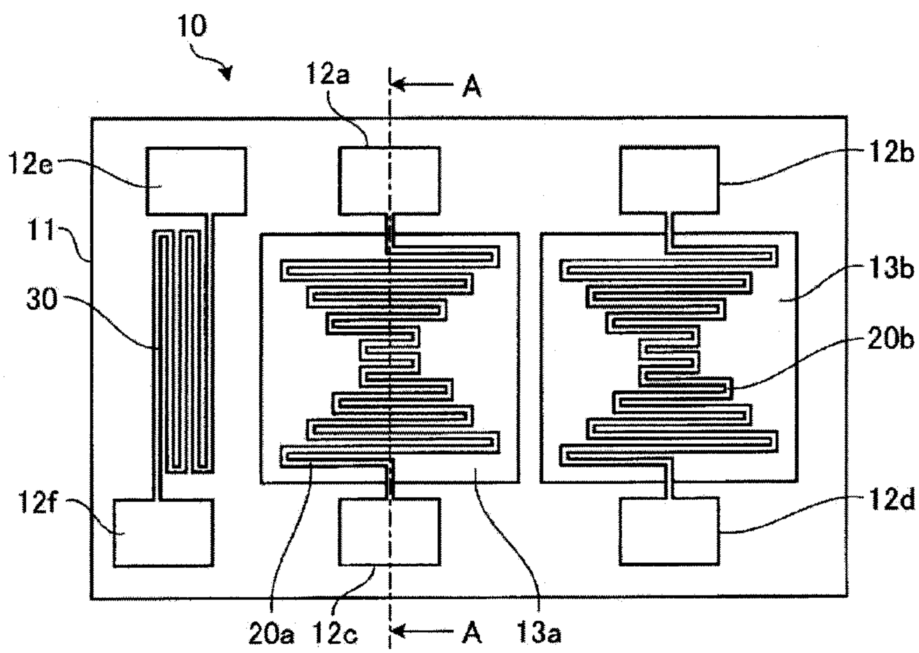

10
12a
A
12e
12b
11
13b
30
20b
12f
12d
20a
12c
A
13a

FIG.3

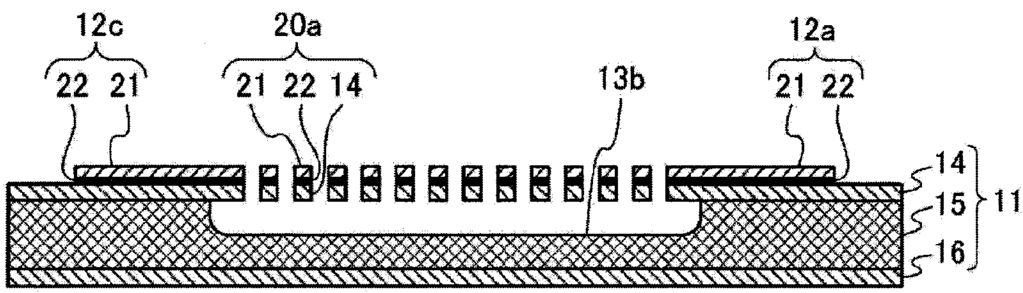


FIG.4

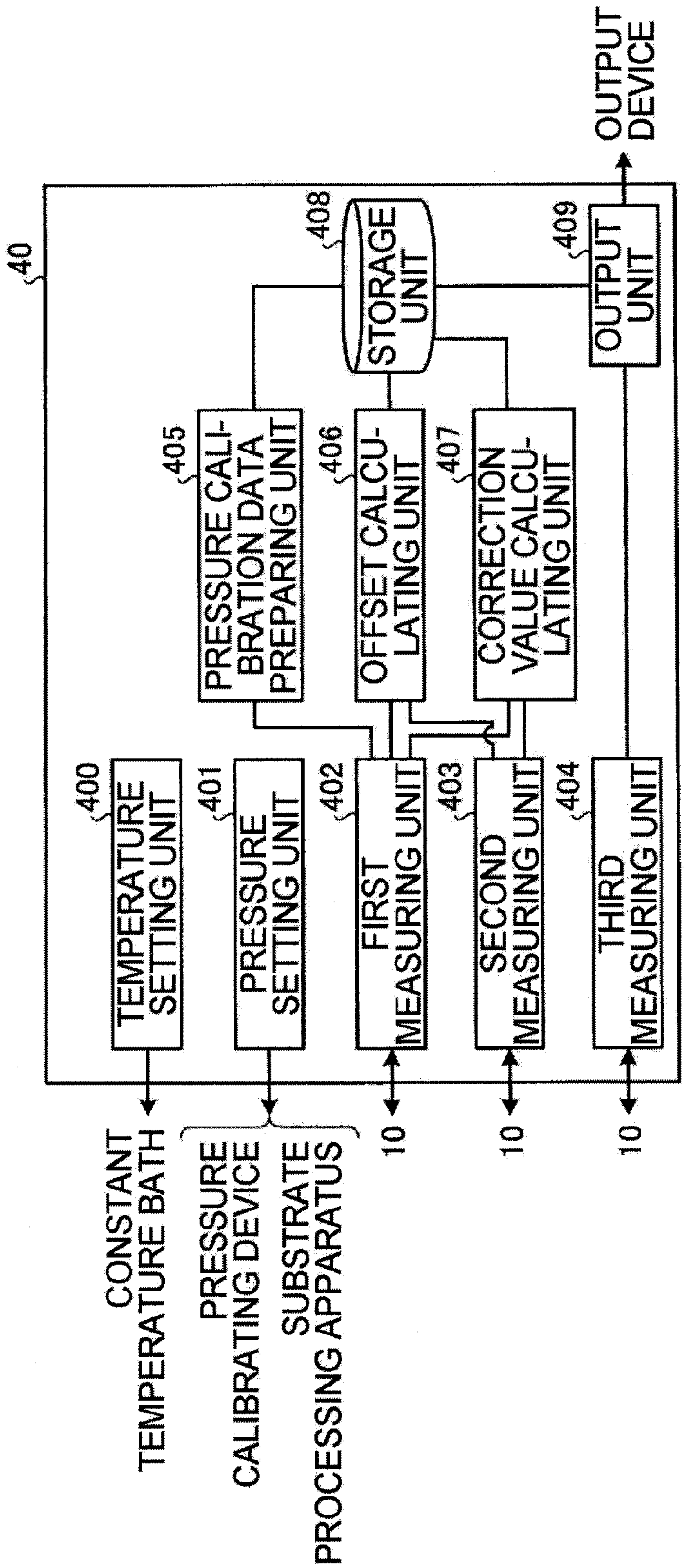

40
TEMPERATURE SETTING UNIT
400
PRESSURE SETTING UNIT
401
FIRST MEASURING UNIT
402
SECOND MEASURING UNIT
403
THIRD MEASURING UNIT
404
PRESSURE CALI-BRATION DATA PREPARING UNIT
405
OFFSET CALCU-LATING UNIT
406
CORRECTION VALUE CALCU-LATING UNIT
407
STORAGE UNIT
408
OUTPUT UNIT
409
OUTPUT DEVICE
CONSTANT TEMPERATURE BATH
PRESSURE CALIBRATING DEVICE
SUBSTRATE PROCESSING APPARATUS
10
10
10

FIG.5

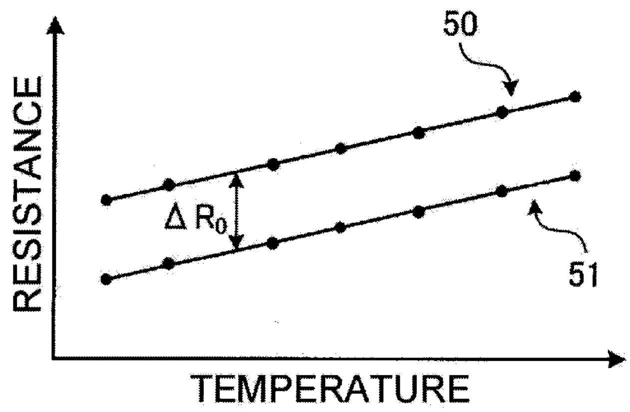

50
51
RESISTANCE
TEMPERATURE
ΔR_0

FIG.6

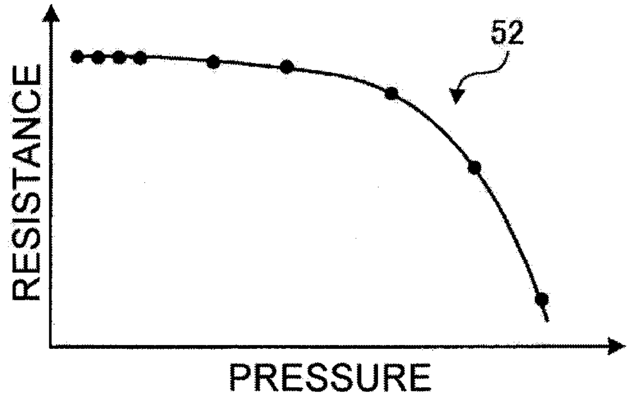

52
RESISTANCE
PRESSURE

FIG.7

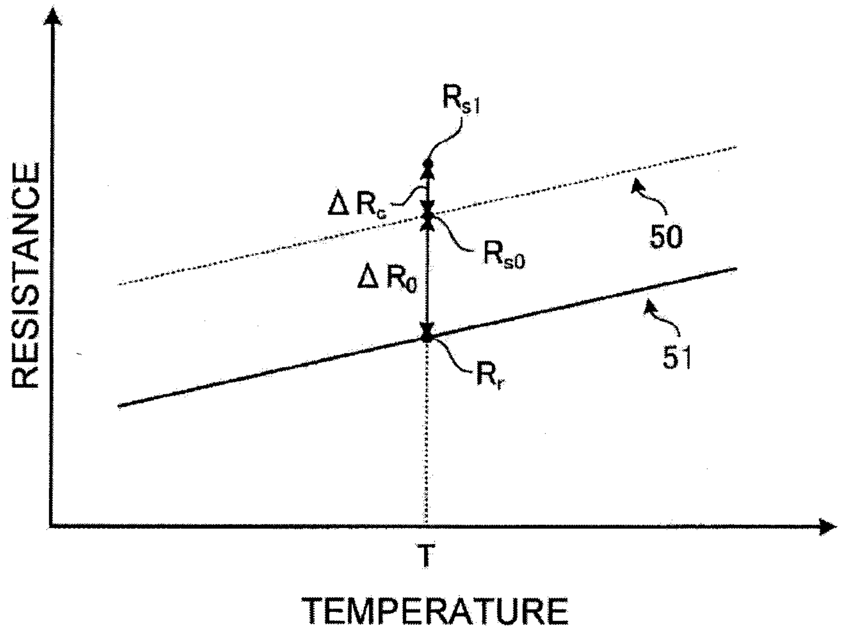

R_s1
ΔR_c
R_s0
ΔR_0
R_r
50
51
RESISTANCE
T
TEMPERATURE

FIG.8

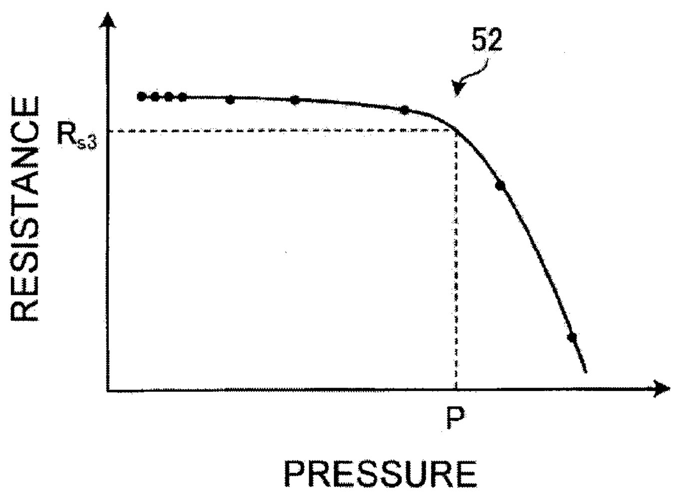

52
R_s3
RESISTANCE
P
PRESSURE

FIG.9

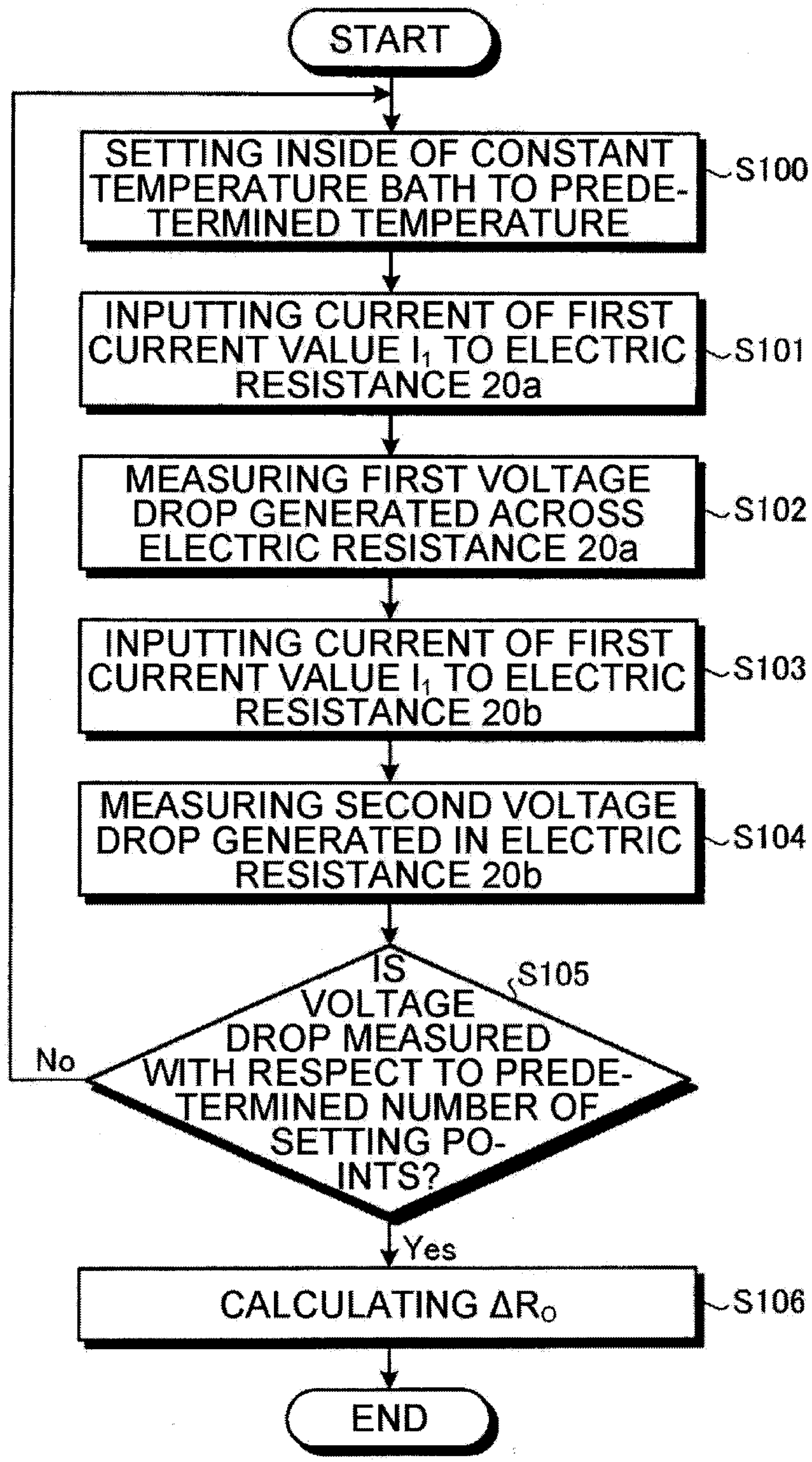

START
SETTING INSIDE OF CONSTANT TEMPERATURE BATH TO PREDETERMINED TEMPERATURE
S100
INPUTTING CURRENT OF FIRST CURRENT VALUE I1 TO ELECTRIC RESISTANCE 20a
S101
MEASURING FIRST VOLTAGE DROP GENERATED ACROSS ELECTRIC RESISTANCE 20a
S102
INPUTTING CURRENT OF FIRST CURRENT VALUE I1 TO ELECTRIC RESISTANCE 20b
S103
MEASURING SECOND VOLTAGE DROP GENERATED IN ELECTRIC RESISTANCE 20b
S104
IS VOLTAGE DROP MEASURED WITH RESPECT TO PREDETERMINED NUMBER OF SETTING POINTS?
S105
No
Yes
CALCULATING ΔRO
S106
END

FIG.10

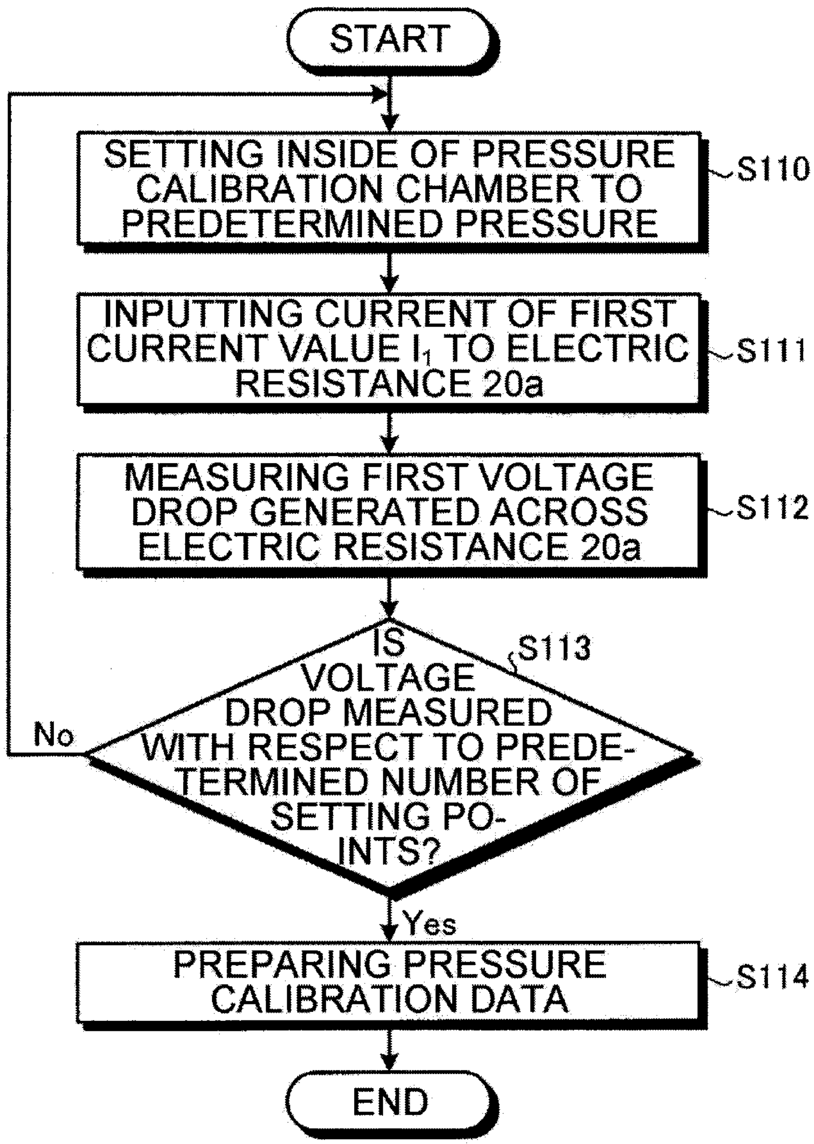

START
SETTING INSIDE OF PRESSURE CALIBRATION CHAMBER TO PREDETERMINED PRESSURE
S110
INPUTTING CURRENT OF FIRST CURRENT VALUE I_1 TO ELECTRIC RESISTANCE 20a
S111
MEASURING FIRST VOLTAGE DROP GENERATED ACROSS ELECTRIC RESISTANCE 20a
S112
IS VOLTAGE DROP MEASURED WITH RESPECT TO PREDETERMINED NUMBER OF SETTING POINTS?
S113
No
Yes
PREPARING PRESSURE CALIBRATION DATA
S114
END

FIG.11

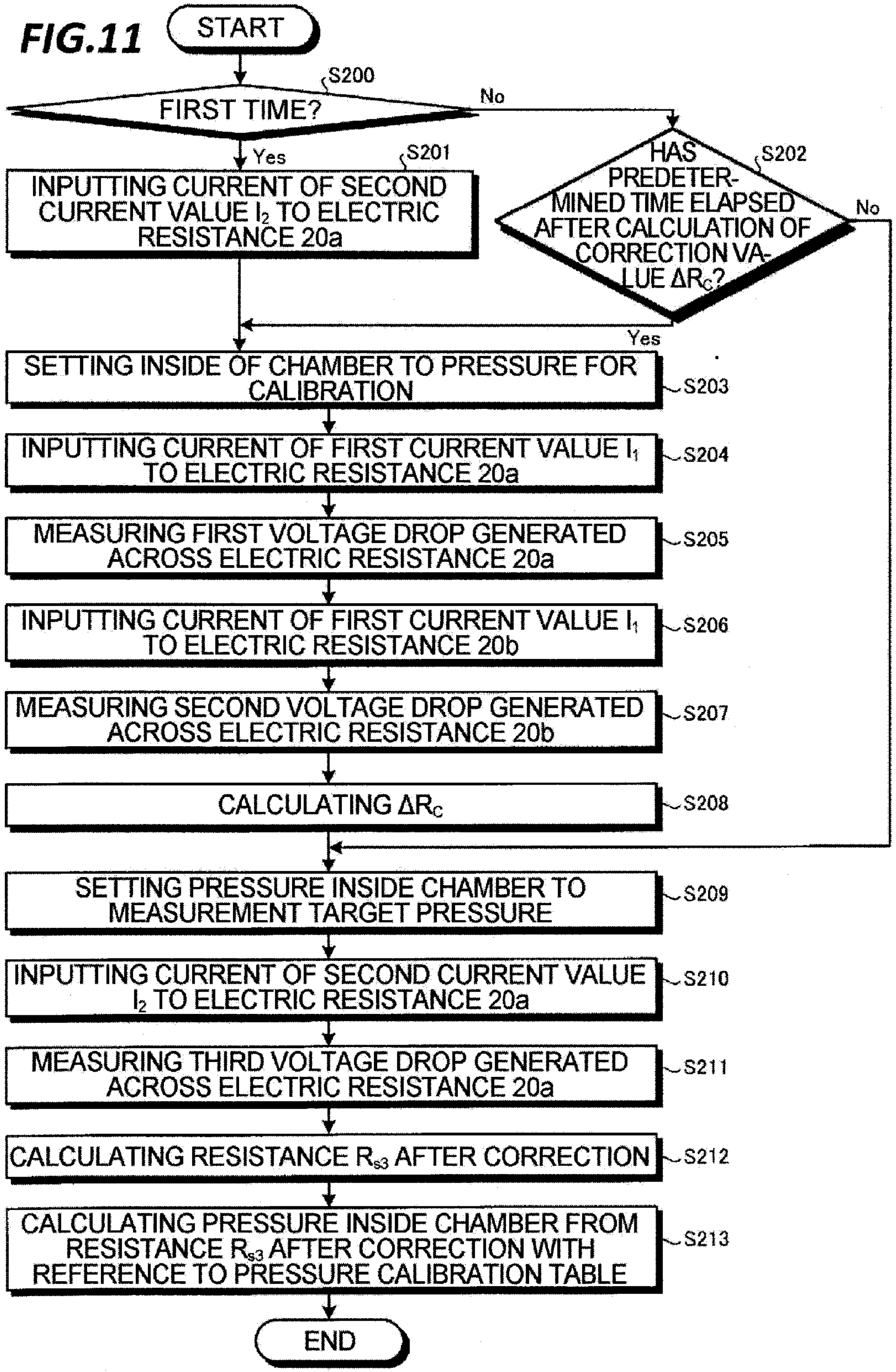

START
FIRST TIME?
S200
No
Yes
S201
INPUTTING CURRENT OF SECOND CURRENT VALUE I2 TO ELECTRIC RESISTANCE 20a
HAS PREDETERMINED TIME ELAPSED AFTER CALCULATION OF CORRECTION VALUE ΔRC?
S202
No
Yes
SETTING INSIDE OF CHAMBER TO PRESSURE FOR CALIBRATION
S203
INPUTTING CURRENT OF FIRST CURRENT VALUE I1 TO ELECTRIC RESISTANCE 20a
S204
MEASURING FIRST VOLTAGE DROP GENERATED ACROSS ELECTRIC RESISTANCE 20a
S205
INPUTTING CURRENT OF FIRST CURRENT VALUE I1 TO ELECTRIC RESISTANCE 20b
S206
MEASURING SECOND VOLTAGE DROP GENERATED ACROSS ELECTRIC RESISTANCE 20b
S207
CALCULATING ΔRC
S208
SETTING PRESSURE INSIDE CHAMBER TO MEASUREMENT TARGET PRESSURE
S209
INPUTTING CURRENT OF SECOND CURRENT VALUE I2 TO ELECTRIC RESISTANCE 20a
S210
MEASURING THIRD VOLTAGE DROP GENERATED ACROSS ELECTRIC RESISTANCE 20a
S211
CALCULATING RESISTANCE Rs3 AFTER CORRECTION
S212
CALCULATING PRESSURE INSIDE CHAMBER FROM RESISTANCE Rs3 AFTER CORRECTION WITH REFERENCE TO PRESSURE CALIBRATION TABLE
S213
END

FIG.12

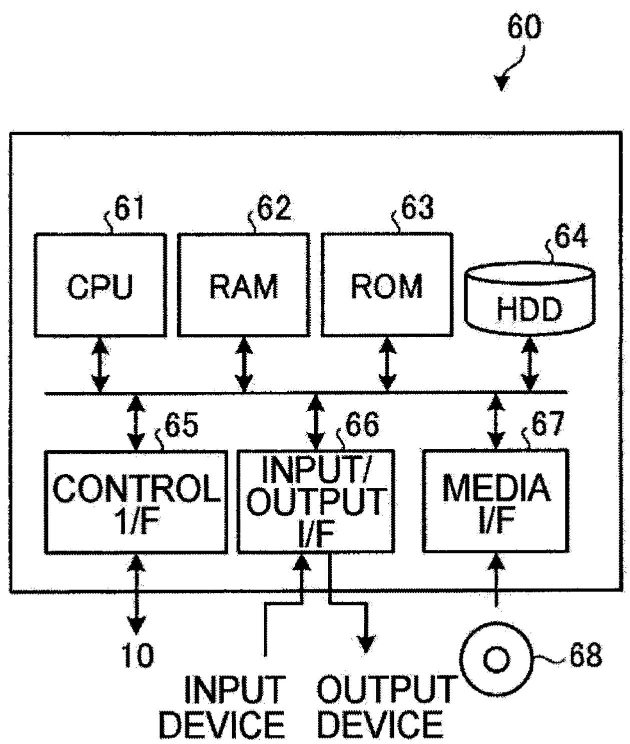
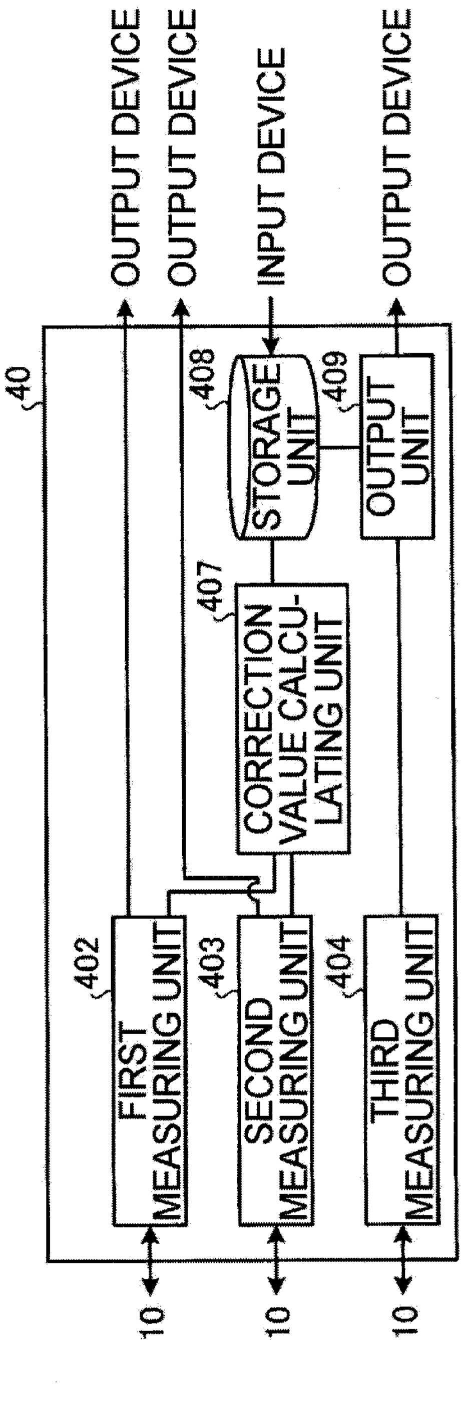

60
61
CPU
62
RAM
63
ROM
64
HDD
65
CONTROL
1/F
66
INPUT/
OUTPUT
I/F
67
MEDIA
I/F
10
INPUT
DEVICE
OUTPUT
DEVICE
68

FIG.13


40
OUTPUT DEVICE
OUTPUT DEVICE
INPUT DEVICE
OUTPUT DEVICE
408
STORAGE UNIT
409
OUTPUT UNIT
407
CORRECTION VALUE CALCU-LATING UNIT
402
FIRST MEASURING UNIT
403
SECOND MEASURING UNIT
404
THIRD MEASURING UNIT
10
10
10

PRESSURE MEASURING DEVICE AND PRESSURE MEASURING METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is based on and claims priority from Japanese Patent Application No. 2014-133268 filed on Jun. 27, 2014 with the Japan Patent Office, the disclosure of which is incorporated herein in its entirety by reference.

TECHNICAL FIELD

[0002] Various aspects and embodiments of the present disclosure are related to a pressure measuring device and a pressure measuring method.

BACKGROUND

[0003] A Pirani vacuum gauge is known as a device for measuring a pressure of a gas. The Pirani vacuum gauge is provided with, for example, a filament (electric resistor) made of a fine metal wire and configured to measure a pressure of a gas based on a quantity of heat loss which is caused by heat exchange between the filament and the gas. Further, with the recent advancement in a micro-electro mechanical system (MEMS) technology, miniaturization of a pressure sensor using the principle of the Pirani vacuum gauge has progressed.

SUMMARY

[0004] According to an aspect, the present disclosure provides a pressure measuring device including: a first electric resistor adapted to be exposed to a gas; a second electric resistor adapted to be exposed to the gas and having the same structure as that of the first electric resistor; a first measuring unit configured to input a current of a first current value to the first electric resistor and measure a first voltage drop generated across the first electric resistor according to the current of the first current value; a second measuring unit configured to input the current of the first current value to the second electric resistor and measure a second voltage drop generated across the second electric resistor according to the current of the first current value; a third measuring unit configured to input a current of a second current value greater than the first current value to the first electric resistor to generate heat from the first electric resistor and measure a third voltage drop generated across the first electric resistor according to the current of the second current value; a calculating unit configured to calculate a correction value that corrects the third voltage drop, based on a difference between the first voltage drop and the second voltage drop; and an output unit configured to correct the third voltage drop using the calculated correction value and output a pressure value according to the third voltage value after the correction.

[0005] The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, and features will become apparent by reference to the drawings and the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. **1** is a view illustrating an exemplary pressure measuring device in an exemplary embodiment.

[0007] FIG. **2** is a plan view illustrating an exemplary sensor module.

[0008] FIG. **3** is a cross-sectional view of the sensor module taken along line A-A in FIG. **2**.

[0009] FIG. **4** is a block diagram illustrating an exemplary functional configuration of a processing device.

[0010] FIG. **5** is an explanatory view illustrating an exemplary offset value.

[0011] FIG. **6** is an explanatory view illustrating exemplary pressure calibration data.

[0012] FIG. **7** is an explanatory view illustrating a relationship between an offset value and a correction value.

[0013] FIG. **8** is an explanatory view illustrating a procedure of determining a pressure from the pressure calibration data.

[0014] FIG. **9** is a flowchart illustrating an exemplary offset value calculating processing.

[0015] FIG. **10** is a flowchart illustrating an exemplary pressure calibration data preparing processing.

[0016] FIG. **11** is a flowchart illustrating an exemplary pressure measuring processing.

[0017] FIG. **12** is a view illustrating an exemplary computer that realizes functions of the processing device.

[0018] FIG. **13** is a block diagram illustrating another functional configuration of the processing device.

DETAILED DESCRIPTION

[0019] In the following detailed description, reference is made to the accompanying drawing, which form a part hereof. The illustrative embodiments described in the detailed description, drawing, and claims are not meant to be limiting. Other embodiments may be utilized, and other changes may be made, without departing from the spirit or scope of the subject matter presented here.

[0020] When a pressure sensor using the principle of the Pirani vacuum gauge is manufactured by the MEMS technology, a metal film is formed on a substrate and the metal film is etched into a predetermined pattern, so that a fine metal wire is formed, which becomes an electric resistor for heat exchange with a gas. The metal film is generally formed through a normal-temperature sputtering.

[0021] Since the metal film formed through the normal-temperature sputtering has a low deposition temperature, a metal atom which has reached the substrate hardly grows into a crystal nucleus. Thus, the metal film formed through the normal-temperature sputtering becomes a film that has small crystals and a lot of voids. In addition, when a current is input to a fine metal wire formed by etching the metal film formed through the normal-temperature sputtering, the voids in the fine metal wire grow, and thus, the resistance thereof is also changed.

[0022] In the Pirani vacuum gauge, a temperature change generated in an electric resistor as a heat quantity is taken out by gas is detected as a resistance change in the electric resistor, and a pressure of the gas is determined based on the resistance change in the electric resistor. However, in a case where the fine metal wire formed by the metal film formed through the normal-temperature sputtering, the resistance of the think metal wire is changed by the current flowing in the metal wiring. Therefore, the resistance of the electric resistor is also changed by a factor other than the heat quantity taken out by the gas, and thus, the precision of measuring the pressure of a gas is degraded.

[0023] In an exemplary embodiment, a pressure measuring device includes a first electric resistor adapted to be exposed to a gas; a second electric resistor adapted to be exposed to the gas and having the same structure as that of the first electric resistor; a first measuring unit configured to input a current of a first current value to the first electric resistor and measure a first voltage drop generated across the first electric resistor according to the current of the first current value; a second measuring unit configured to input the current of the first current value to the second electric resistor and measure a second voltage drop generated across the second electric resistor according to the current of the first current value; a third measuring unit configured to input a current of a second current value greater than the first current value to the first electric resistor to generate heat from the first electric resistor and measure a third voltage drop generated across the first electric resistor according to the current of the second current value; a calculating unit configured to calculate a correction value that corrects the third voltage drop, based on a difference between the first voltage drop and the second voltage drop; and an output unit configured to correct the third voltage drop using the calculated correction value and output a pressure value according to the third voltage value after the correction.

[0024] In an exemplary embodiment, the above-mentioned pressure measuring device may further include a base substrate provided with a temperature sensor. The first electric resistor and the second electric resistor may be disposed on the base substrate.

[0025] In an exemplary embodiment of the above-mentioned pressure measuring device, the second current value may be a current value in a range of 20 times to 40 times the first current value.

[0026] In an exemplary embodiment of the pressure measuring device, the calculating unit may calculate a new correction value when a predetermined time has elapsed after the last calculation of the correction value or when the third voltage drop is measured a predetermined number of times by the third measuring unit.

[0027] In an exemplary embodiment, a pressure measuring method includes inputting a current of a first current value to a first electric resistor that is exposed to a gas; measuring a first voltage drop generated across the first electric resistor according to the current of the first current value; inputting the current of the first current value to a second electric resistor that has the same structure as that of the first electric resistor and is exposed to the gas; measuring a second voltage drop generated across the second electric resistor according to the current of the first current value; inputting a current of a second current value greater than the first current value to the first electric resistor; measuring a third voltage drop generated across the first electric resistor according to the current of the second current value; calculating a correction value that corrects the third voltage drop, based on a difference between the first voltage drop and the second voltage drop; and correcting the third voltage drop using the calculated correction value and outputting a pressure value according to the third voltage value after the correction.

[0028] In an exemplary embodiment of the pressure measuring method, the first electric resistor and the second electric resistor may be configured as a sensor module that is disposed on a base substrate provided with a temperature sensor. The above-mentioned pressure measuring method further includes disposing the sensor module in at least one of a portion in the vicinity of an exhaust port in a substrate processing apparatus that processes a target substrate by plasma of a processing gas, a portion in the vicinity of an ejection port of the processing gas, and a portion inside a pipe that distributes a gas for temperature adjustment, which is formed inside a placing table on which the target substrate is placed.

[0029] According to various aspects and embodiments of the present disclosure, a pressure measuring device and a pressure measuring method, which may measure pressure of gas highly precisely, are realized.

[0030] Hereinafter, exemplary embodiments of a pressure measuring device and a pressure measuring method of the present disclosure will be described in detail with reference to the accompanying drawings. Meanwhile, the present disclosure is not limited to exemplary embodiments described herein. Further, each exemplary embodiment may be combined appropriately within a range that does not contradict the processing contents.

[0031] [Configuration of Pressure Measuring Device **1**]

[0032] FIG. **1** is a view illustrating an exemplary pressure measuring device **1** in an exemplary embodiment. The pressure measuring device **1** includes a sensor module **10** and a processing device **40**. The sensor module **10** and the processing device **40** are connected with each other via a cable **3**. The sensor module **10** is disposed in a sealed space **2** such as, for example, a chamber of a plasma processing apparatus. The processing device **40** measures a state of the sensor module **10** via the cable **3** and outputs a value indicating the pressure of a gas in the sealed space **2** from the state of the sensor module **10**.

[0033] [Configuration of Sensor Module **10**]

[0034] FIG. **2** is a plan view illustrating an exemplary sensor module **10**. FIG. **3** is a cross-sectional view of the sensor module **10** taken along line A-A in FIG. **2**. The sensor module **10** includes a base substrate **11** formed with a recess **13*a*** and a recess **13*b***. On the base substrate **11**, a plurality of electrode pads **12*a*** to **12*f***, an electric resistor **20*a***, an electric resistor **20*b***, and a temperature sensor **30** are formed. The electric resistor **20*a*** has the same structure as that of the electric resistor **20*b*** in the shape and material. The electric resistor **20*a*** is an example of the first electric resistor and the electric resistor **20*b*** is an example of the second electric resistor.

[0035] For example, as illustrated in FIG. **3**, the base substrate **11** includes an insulation layer **14**, an intermediate layer **15**, and an insulation layer **16**. The intermediate layer **15** is formed of, for example, silicon in a thickness of, for example, about 300 μm. Each of the insulation layer **14** and the insulation layer **16** is made of, for example, silicon nitride in a thickness of, for example, about 200 nm. Meanwhile, the insulation layer **14** and the insulation layer **16** may be formed of, for example, silicon oxide.

[0036] For example, as illustrated in FIG. **2**, the temperature sensor **30** is provided between the electrode pad **12*e*** and the electrode pad **12*f***. The temperature sensor **30** is used, for example, for checking the temperature of the base substrate **11**. The temperature sensor **30** is formed linearly on the surface of the base substrate **11** in the vicinity of the electric resistor **20*a***. The temperature sensor **30** is formed in, for example, a meander form with the same material as those of the electric resistor **20*a*** and the electric resistor **20*b***. The temperature sensor **30** is covered with a passivation layer such that the surface is not exposed to the gas.

[0037] The recess **13***a* and the recess **13***b* are formed at a side of the surface of the base substrate **11** on which the insulation layer **14** is provided, for example, in a depth of about 100 μm, respectively. Each of the recess **13***a* and the recess **13***b* has an opening formed, for example, in a rectangular form, of which one side is about 250 μm.

[0038] The electric resistor **20***a* is provided between the electrode pad **12***a* and the electrode pad **12***c*. One end of the electric resistor **20***a* is connected to the electrode pad **12***a* and the other end is connected to the electrode pad **12***c*. Further, the electric resistor **20***b* is provided between the electrode pad **12***b* and the electrode pad **12***d*. One end of the electric resistor **20***b* is connected to the electrode pad **12***b* and the other end is connected to the electrode pad **12***d*. The electrode pads **12***a* to **12***d* are connected to the cable **3**.

[0039] For example, as illustrated in FIG. **3**, the electric resistor **20***a* is supported by the electrode pad **12***a* and the electrode pad **12***c*, and spaced apart from the surface of the recess **13***a*. Similarly to the electric resistor **20***a* illustrated in FIG. **3**, the electric resistor **20***b* is supported by the electrode pad **12***b* and the electrode pad **12***d*, and spaced apart from the surface of the recess **13***b*.

[0040] Here, the electric resistor **20***a* functions as a filament in the Pirani vacuum gauge and generates heat according to a current input from the electrode pad **12***c* via the cable **3**. Since the electric resistor **20***a* is spaced apart from the surface of the recess **13***a*, it is possible to lower the heat quantity transferred from the base substrate **11** to the electrode resistor **20***a*. Accordingly, the temperature change of the electric resistor **20***a* due to the heat exchange with the gas may be detected highly precisely.

[0041] For example, as illustrated in FIG. **3**, the electrode pad **12***a* and the electrode pad **12***c* include a conductor layer **21** and an adhesive layer **22**. Similarly to the electrode pad **12***a* and the electrode pad **12***c* illustrated in FIG. **3**, the electrode pad **12***b* and the electrode pad **12***d* include the conductor layer **21** and the adhesive layer **22**. Further, for example, as illustrated in FIG. **3**, the electric resistor **20***a* includes the conductor layer **21**, the adhesive layer **22**, and the insulation layer **14**. Similarly to the electric resistor **20***a* illustrated in FIG. **3**, the electric resistor **20***b* includes the conductor layer **21**, the adhesive layer **22**, and the insulation layer **14**. In the present exemplary embodiment, the adhesive layer **22** in the electric resistor **20***a* and the electric resistor **20***b* has a function to bond the conductor layer **21** to the insulation layer **14**.

[0042] The conductor layer **21** is formed of a material having a high temperature coefficient of resistance (TCR), which is an amount of change in electric resistance per unit temperature change, such as, for example, platinum or nickel. In addition, the conductor layer **21** may be formed of chromium, silicon, molybdenum, nickel, titanium, tantalum, tungsten, or a quantum well material such as, for example, a conductive alloy, a mixed semiconductor material, or a silicon-germanium (SiGe) single crystal. In the present exemplary embodiment, the film thickness of the conductor layer **21** is, for example, about 50 nm.

[0043] The adhesive layer **22** is formed of, for example, chromium or titanium. In the present exemplary embodiment, the film thickness of the adhesive layer **22** is, for example, about 5 nm. In the present exemplary embodiment, the conductor layer **21** and the adhesive layer **22** are formed through a normal-temperature sputtering under a temperature condition of, for example, 50° C. or less.

[0044] As illustrated in FIG. **2**, the electric resistor **20***a* is formed linearly and extends from the electrode pad **12***a* to the electrode pad **12***c*, for example, in a meander form. Accordingly, the surface area of the electric resistor **20***a*, which is exposed to gas, may be increased. Hence, the temperature change of the electric resistor **20***a* due to the heat exchange with the gas may be detected highly precisely. Meanwhile, similarly to the electric resistor **20***a*, the electric resistor **20***b* is formed linearly and extends from the electrode pad **12***b* to the electrode pad **12***d*, for example, in a meander form.

[0045] When a gas comes into contact with the electric resistor **20***a*, heat exchange is performed between the electric resistor **20***a* and the gas, and thus, the temperature of the electric resistor **20***a* decreases. Since the resistance of the electric resistor **20***a* is temperature-dependent, the temperature of the electric resistor **20***a* may be measured as the resistance of the electric resistor **20***a*. And, when a current is input to the electric resistor **20***a*, the resistance of the electric resistor **20***a* may be measured as a voltage drop across the electric resistor **20***a*.

[0046] When the pressure of the gas is low, the heat quantity taken away by the gas from the electric resistor **20***a* decreases, so that the decrement in the temperature of the electric resistor **20***a* becomes smaller. Meanwhile, when the pressure of the gas is high, the heat quantity taken away by the gas from the electric resistor **20***a* increases, so that the decrement in temperature of the electric resistor **20***a* becomes lager. The pressure of the gas may be measured by measuring the resistance according to the temperature of the electric resistor **20***a*.

[0047] Meanwhile, in the pressure measurement using the principle of the Pirani vacuum gauge, the pressure of the gas is determined based on the temperature change of the electric resistor **20***a* generated according to the heat quantity taken away by the gas. Therefore, as the temperature change of the electric resistor **20***a* increases, the precision of measuring the pressure of the gas is enhanced. Accordingly, in the present exemplary embodiment, the temperature change of the electric resistor **20***a* according to the pressure of the gas is increased by inputting a relatively large current of, for example, several mA (e.g., 2.4 mA in the present exemplary embodiment) to the electric resistor **20***a* to generate heat such that the temperature of the electric resistor **20***a* reaches, for example, about 200° C.

[0048] However, because of the low film formation temperature, the metal film formed through a normal-temperature sputtering has small crystals and a lot of voids. Therefore, when a current flows through the electric resistor **20***a* formed by the conductor layer **21** which is a metal film formed through the normal-temperature sputtering, the voids in the conductor layer **21** grow, and thus, the resistance is changed. By inputting a large current to the electric resistor **20***a* to generate heat therefrom, the growth of the voids in the conductor layer **21** increases, and thus, the change in resistance also increases.

[0049] Accordingly, when the pressure of the gas is measured solely by the electric resistor **20***a* having the conductor layer **21** formed through the normal-temperature sputtering, the resistance of the conductor layer **21** is changed by a factor other than the pressure of the gas. Therefore, the pressure of the gas may not be determined highly precisely.

[0050] Accordingly, in the present exemplary embodiment, the electric resistor **20***b* having the same structure as that of the electric resistor **20***a* is provided in the sensor module **10**. Therefore, deviation of the resistance of the electric resistor

20*a* caused by a large current flowing therethrough may be corrected based on the resistance of the electric resistor **20***b*, so that the precision of measuring the pressure is enhanced.

[0051] As illustrated in the plan view of FIG. **2**, the sensor module in the present exemplary embodiment has a structure in which the electric resistor **20***a* and the electric resistor **20***b* are formed on a rectangular base substrate **11** whose vertical and horizontal sides are, for example, 3.6 mm. Since the sensor module **10** in the present exemplary embodiment is small, the sensor module **10** may be installed in various places to measure the pressure therein. The sensor module **10** in the present exemplary embodiment may be disposed in a portion in the vicinity of an exhaust port that exhaust a processing gas or in the vicinity of an ejection port that supply the processing gas in a substrate processing apparatus that processes a target substrate by plasma of the processing gas, and measure the pressure of the gas in the vicinity of the exhaust port or the ejection port.

[0052] Further, since the sensor module **10** in the present exemplary embodiment is small, the sensor module **10** may be disposed in a pipe that distributes a gas for adjusting the temperature of the target substrate, which is formed inside a placing table on which the target substrate is placed, to thereby measure the pressure inside the pipe. In addition, since the sensor module **10** in the present exemplary embodiment is small, the sensor module **10** may be disposed at a plurality of different positions on a substrate having the same shape as that of the target substrate to thereby measure the pressure distribution of the gas on the substrate.

[0053] [Configuration of Processing Device **40**]

[0054] FIG. **4** is a block diagram illustrating an exemplary functional configuration of the processing device **40**. For example, as illustrated in FIG. **4**, the processing device **40** includes a temperature setting unit **400**, a pressure setting unit **401**, a first measuring unit **402**, a second measuring unit **403**, a third measuring unit **404**, a pressure calibration data preparing unit **405**, an offset calculating unit **406**, a correction value calculating unit **407**, a storage unit **408**, and an output unit **409**.

[0055] In an offset value calculating processing to be descried later, the temperature setting unit **400** transmits a control signal to a control unit of a constant temperature bath to control the temperature in the constant temperature bath. In a pressure calibration data preparing processing to be described later, the pressure setting unit **401** transmits a control signal to a control unit of a pressure calibrating device to control the pressure in a pressure calibration chamber. Here, the pressure calibrating device refers to a device including, for example, the pressure calibration chamber configured to set the internal pressure, and the control unit configured to control the pressure in the pressure calibration chamber.

[0056] In the offset value calculating processing to be described later, the first measuring unit **402** inputs a current of a first current value I_1 to the electric resistor **20***a* via the cable **3** and measures a first voltage drop generated across the electric resistor **20***a*. Then, the information of the measured first voltage drop is sent to the offset calculating unit **406**. The first current value I_1 is a very small current that does not cause a resistance change in the electric resistance **20***a* and the electric resistance **20***b* while flowing in the electric resistance **20***a* and the electric resistance **20***b*. In the present exemplary embodiment, the first current value I_1 is, for example, 0.1 mA.

[0057] Further, in the pressure calibration data preparing processing to be described later, the first measuring unit **402** inputs the current of the first current value I_1 to the electric resistor **20***a* via the cable **3** and measures the first voltage drop generated across the electric resistor **20***a*. Then, the information of the measured first voltage drop is sent to the pressure calibration data preparing unit **405**.

[0058] In the offset value calculating processing to be described later, the second measuring unit **403** inputs the current of the first current value I_1 to the electric resistor **20***b* via the cable **3** and measures a second voltage drop generated across the electric resistor **20***b*. Then, the information of the measured second voltage drop is sent to the offset calculating unit **406**.

[0059] In a pressure measuring processing to be described later, the third measuring unit **404** inputs a current of a second current value I_2 greater than the first current value I_1 to the electric resistor **20***a* via the cable **3** and measures a third voltage drop generated across the electric resistor **20***a*. Then, the information of the measured third voltage drop is sent to the output unit **409**. In the present exemplary embodiment, the second current value I_2 is a current value having a magnitude that causes the electric resistor **20***a* to generate heat at a predetermined temperature (e.g., 200° C.). The second current value I_2 is a current value in a range of, for example, 20 times to 40 times the first current value I_1. In the present exemplary embodiment, the second current value I_2 is, for example, 2.4 mA.

[0060] In the offset value calculating processing to be described later, the offset calculating unit **406** receives the information of the first voltage drop from the first measuring unit **402** and receives the information of the second voltage drop form the second measuring unit **403** at every different temperature. Then, the offset calculating unit **406** determines a resistance of the electric resistor **20***a* at each temperature by dividing the first voltage drop at each temperature by the first current value I_1. The offset calculating unit **406** determines a resistance of the electric resistor **20***b* at each temperature by dividing the second voltage drop at each temperature by the first current value I_1.

[0061] In the present exemplary embodiment, the temperature characteristic of the resistance of the electric resistor **20***a* and the temperature characteristic of the resistance of the electric resistor **20***b* are, for example, as illustrated in FIG. **5**. In the example of FIG. **5**, the temperature change tendency of the resistance of the electric resistor **20***a* is approximated, for example, by a straight line **50** and the temperature change tendency of the resistance of the electric resistor **20***b* is approximated, for example, by a straight line **51**.

[0062] Subsequently, the offset calculating unit **406** determines a difference AR between the resistance of the electric resistor **20***a* and the resistance of the electric resistor **20***b* at each temperature. For example, the offset calculating unit **406** determines, as ΔR, a difference determined by subtracting the resistance of the electric resistor **20***b* from the resistance of the electric resistor **20***a*. Then, the offset calculating unit **406** averages the determined AR and calculates an offset value ΔR_O. Then, the offset calculating unit **406** stores the calculated offset value ΔR_O in the storage unit **408**. In the present exemplary embodiment, since the electric resistor **20***a* and the electric resistor **20***b* have the same structure, the offset value ΔR_O becomes a smaller value.

[0063] In the pressure calibration data preparing processing to be described later, the pressure calibration data preparing unit **405** receives the information of the first voltage drop from the first measuring unit **402** at every different pressure.

Then, the pressure calibration data preparing unit **405** determines a resistance of the electric resistor **20***a* at each pressure by dividing the first voltage drop at each pressure by the first current value I_1. Then, for example, as illustrated in FIG. **6**, a curve **52** that approximates the tendency of the resistance of the electric resistor **20***a* determined at every pressure, is calculated. Then, the pressure calibration data preparing unit **405** stores the information of the calculated curve **52** as a pressure calibration data in the storage unit **408**.

[0064] In the pressure measuring processing to be described later, the correction value calculating unit **407** receives the information of the first voltage drop from the first measuring unit **402** and receives the information of the second voltage drop form the second measuring unit **403**. Then, the correction value calculating unit **407** determines the resistance R_{s1} of the electric resistor **20***a* by dividing the first voltage drop by the first current value I_1. The correction value calculating unit **407** determines a resistance R_r of the electric resistor **20***b* by dividing the second voltage drop by the first current value I_1.

[0065] Here, when the current of the second current value I_2 flows through the electric resistor **20***a* to generate heat from the electric resistor **20***a*, the resistance of the electric resistor **20***a* is changed. Accordingly, after the current of the second current value I_2 is input to the electric resistor **20***a*, the resistance of the electric resistor **20***a* is changed from R_{s0} to R_{s1}, for example, as illustrated in FIG. **7**, even in a case where the current of the first current value I_1 flows in the electric resistor **20***a*. Meanwhile, in the offset value calculating processing, the resistance R_{s0} is a value on the straight line **50** that approximates the temperature characteristic tendency of the resistance measured with respect to the current of the first current value I_1.

[0066] The correction value calculating unit **407** acquires the offset value ΔR_O from the storage unit **408** and calculates the correction value ΔR_C using the offset value ΔR_O, the resistance R_{s1}, and the resistance R_r, for example, by the following equation (1). Then, the correction value calculating unit **407** stores the calculated correction value ΔR_C in the storage unit **408**.

$$\Delta R_C = R_{s1} - R_r - \Delta R_O \quad (1)$$

[0067] In the pressure measuring processing to be described later, the output unit **409** receives the information of the third voltage drop from the third measuring unit **404** and calculates a resistance R_{s2} of the electric resistor **20***a* by dividing the received third voltage drop by the second current value I_2. Then, the output unit **409** acquires the correction value ΔR_C from the storage unit **408** and calculates a resistance R_{s3} of the electric resistor **20***a* by subtracting the acquired correction value ΔR_C from the calculated resistance R_{s2} to correct the resistance R_{s2} of the electric resistor **20***a*.

[0068] As apparent from FIG. **7**, the correction value ΔR_C indicates a change amount of the resistance of the electric resistor **20***a* due to the flow of the current of the second current value I_2 through the electric resistor **20***a*. Further, since the resistance R_{s3} after the correction is a value determined by subtracting the correction value ΔR_C from the resistance R_{s1} of the electric resistor **20***a* which has been changed due to the flow of the current of the second current value I_2, the calculation of the resistance R_{s3} has the same meaning as the calculation of the resistance R_{s0} illustrated in FIG. **7**.

[0069] Subsequently, the output unit **409** acquires the pressure calibration data from the storage unit **408**. Then, for example, as illustrated in FIG. **8**, the output unit **409** calculates a pressure P corresponding to the resistance R_{s3} after the correction by using the curve **52** indicated by the acquired pressure calibration data. Then, the output unit **409** outputs the information of the calculated pressure P to an output device such as, for example, a display.

[0070] The storage unit **408** stores the pressure calibration data prepared by the pressure calibration data preparing unit **405**, the offset value ΔR_O calculated by the offset calculating unit **406**, and the correction value ΔR_C calculated by the correction calculating unit **407**.

[0071] [Offset Value Calculating Processing]

[0072] FIG. **9** is a flowchart illustrating an exemplary offset value calculating processing. After the sensor module **10** is carried into the constant temperature bath, the processing device **40** starts the offset value calculating processing, for example, as illustrated in FIG. **9**.

[0073] First, the temperature setting unit **400** transmits a control signal to a control unit of the constant temperature bath to set the inside of the constant temperature bath to a predetermined temperature (S**100**). Subsequently, the first measuring unit **402** inputs the current of the first current value I_1 to the electric resistor **20***a* via the cable **3** (S**101**). Then, the first measuring unit **402** measures the first voltage drop generated across the electric resistor **20***a* (S**102**). Then, the first measuring unit **402** sends the information of the measured first voltage drop to the offset calculating unit **406**.

[0074] Subsequently, the second measuring unit **403** inputs the current of the first current value I_1 to the electric resistor **20***b* via the cable **3** (S**103**). Then, the second measuring unit **403** measures the second voltage generated across the electric resistor **20***b* (S**104**). Then, the first measuring unit **402** sends the information of the measured second voltage drop to the offset calculating unit **406**.

[0075] Subsequently, the temperature setting unit **400** determines whether any voltage drop is measured with respect to a predetermined number of different temperature setting points (S**105**). When no voltage drop is measured with respect to a predetermined number of temperature setting points (S**105**: No), the temperature setting unit **400** performs the processing described in step S**100** again. In the present exemplary embodiment, the processing device **40** measures the first voltage drop and the second voltage drop, respectively, with respect to, for example, about ten different temperature setting points within a range of, for example, 100° C. to 300° C.

[0076] When a voltage drop is measured with respect to a predetermined number of temperature setting points (S**105**: Yes), the offset calculating unit **406** determines a resistance of the electric resistor **20***a* at each temperature setting point by dividing the first voltage drop at each temperature setting point by the first current value I_1. Further, the offset calculating unit **406** determines a resistance of the electric resistor **20***b* at each temperature setting point by dividing the second voltage drop at each temperature setting point by the first current value I_1.

[0077] Then, the offset calculating unit **406** determines a difference ΔR between the resistance of the electric resistor **20***a* and the resistance of the electric resistor **20***b* at each temperature setting point. Then, the offset calculating unit **406** averages the determined differences ΔR and calculates an offset value ΔR_O. Then, the offset calculating unit **406** stores the calculated offset value ΔR_O in the storage unit **408**, and the processing device **40** terminates the offset value calculating processing illustrated in the flowchart.

[0078] [Pressure Calibration Data Preparing Processing]

[0079] FIG. **10** is a flowchart illustrating an exemplary pressure calibration data preparing processing. After the sensor module **10** is carried into the pressure calibration chamber, the processing device **40** starts the pressure calibration data preparing processing, for example, illustrated in FIG. **10**.

[0080] First, the pressure setting unit **401** transmits a control signal to the control unit of the pressure calibrating device to set the inside of the pressure chamber to a predetermined pressure (S**110**). Subsequently, the first measuring unit **402** inputs the current of the first current value I_1 to the electric resistor **20***a* via the cable **3** (S**111**). Then, the first measuring unit **402** measures the first voltage drop generated across the electric resistor **20***a* (S**112**). Then, the first measuring unit **402** sends the information of the measured first voltage drop to the pressure calibration data preparing unit **405**.

[0081] Subsequently, the first measuring unit **402** determines whether the first voltage drop is measured with respect to a predetermined number of different pressure setting points (S**113**). When the first voltage drop is not measured with respect to a predetermined number of pressure setting points (S**113**: No), the first measuring unit **402** performs the processing described in step S**110** again. In the present exemplary embodiment, the processing device **40** measures the first voltage drop with respect to, for example, about several tens of different pressure setting points within a range of, for example, 0.5 mTorr to 300 mTorr.

[0082] When the first voltage drop is measured with respect to a predetermined number of pressure setting points (S**113**: Yes), the pressure calibration data preparing unit **405** determines a resistance of the electric resistor **20***a* at each pressure setting point by dividing the first voltage drop at each pressure setting point by the first current value I_1.

[0083] Then, the pressure calibration data preparing unit **405** calculates the curve **52** (see FIG. **6**) that approximates the tendency of the resistance of the electric resistor **20***a* with respect to the pressure, by using the resistance of the electric resistor **20***a* calculated at every pressure. Then, the pressure calibration data preparing unit **405** prepares the information of the calculated curve **52** as a pressure calibration data (S**114**). Then, the pressure calibration data preparing unit **405** stores the prepared pressure calibration data in the storage unit **408**, and the processing device **40** terminates the pressure calibration data preparing processing illustrated in the flowchart.

[0084] [Pressure Measuring Processing]

[0085] FIG. **11** is a flowchart illustrating an exemplary pressure measuring processing. After the sensor module **10** is carried into a chamber of a substrate processing apparatus which is a pressure measuring target, the processing device **40** starts the processing measuring processing, for example, illustrated in FIG. **11**.

[0086] First, the correction calculating unit **407** determines whether the sensor module **10** is used for the pressure measuring processing for the first time, that is, whether it is the first time (S**200**). Meanwhile, the case where the sensor module **10** is used for the pressure measuring processing for the first time means that the second current value I_2 never flows in the electric resistor **20***a*. Therefore, deviation of the resistance due to the flow of the second current value I_2 is not generated in the electric resistor **20***a*.

[0087] When the sensor module **10** is used for the pressure measuring processing for the first time (S**200**: Yes), the first measuring unit **402** inputs the current of the second current value I_2 to the electric resistor **20***a* for a predetermined time (e.g., several tens of minutes) (S**201**). Then, the pressure setting unit **401** transmits a control signal to a control unit of the substrate processing apparatus to set the inside of the chamber of the substrate processing apparatus to a pressure for calibration (S**203**). The pressure for calibration may be, for example, 3 Torr to 5 Torr. In the present exemplary embodiment, the pressure for calibration is, for example, 3 Torr.

[0088] Subsequently, the first measuring unit **402** inputs the current of the first current value I_1 to the electric resistor **20***a* (S**204**). Then, the first measuring unit **402** measures the first voltage drop generated across the electric resistor **20***a* (S**205**). Then, the first measuring unit **402** sends the information of the measured first voltage drop to the correction value calculating unit **407**.

[0089] Subsequently, the second measuring unit **403** inputs the current of the first current value I_1 to the electric resistor **20***b* (S**205**). Then, the second measuring unit **403** measures the second voltage drop generated across the electric resistor **20***b* (S**207**). Then, the second measuring unit **403** sends the information of the measured second voltage drop to the correction value calculating unit **407**.

[0090] Subsequently, the correction value calculating unit **407** determines the resistance R_{s1} of the electric resistor **20***a* by dividing the first voltage drop received from the first measuring unit **402** by the first current value I_1. Further, the correction value calculating unit **407** determines the resistance R_r of the electric resistor **20***b* by dividing the second voltage drop received from the second measuring unit **403** by the first current value I_1.

[0091] Subsequently, the correction value calculating unit **407** acquires the offset value ΔR_O from the storage unit **408** and calculates the correction value ΔR_C, for example, by the aforementioned equation (1) using the offset value ΔR_O, the resistance R_{s1}, and the resistance R_r. Then, the correction value calculating unit **407** stores the calculated correction value ΔR_C in the storage unit **408**.

[0092] Subsequently, the pressure setting unit **401** transmits a control signal to a control unit of the substrate processing apparatus to set the inside of the chamber of the substrate processing apparatus to a measurement target pressure (S**209**). Then, the third measuring unit **404** inputs the current of the second current value I_2 to the electric resistor **20***a* (S**210**). Then, the third measuring unit **404** measures the third voltage drop generated across the electric resistor **20***a* (S**211**). Then, the third measuring unit **404** sends the information of the measured third voltage drop to the output unit **409**.

[0093] Subsequently, the output unit **409** calculates the resistance R_{s2} of the electric resistor **20***a* by dividing the third voltage drop received from the third measuring unit **404** by the second current value I_2. Then, the output unit **409** acquires the correction value ΔR_C from the storage unit **408** and calculates the resistance R_{s3} of the electric resistor **20***a* by subtracting the acquired correction value ΔR_C from the calculated resistance R_{s2} to correct the resistance R_{s2} of the electric resistor **20***a*.

[0094] Subsequently, the output unit **409** acquires the pressure calibration data from the storage unit **408**. Then, for example, as illustrated in FIG. **8**, the output unit **409** calculates a pressure P corresponding to the resistance R_{s3} after the correction by using the curve **52** indicated by the acquired pressure calibration data. Then, the output unit **409** outputs the information of the calculated pressure P to an output device such as, for example, a display, and the processing device **40** terminates the pressure measuring processing illustrated in the flowchart.

[0095] In step S**200**, when the sensor module **10** has been used for the pressure measuring processing (S**200**: No), the correction value calculating unit **407** determines whether a predetermined time has elapsed after the last calculation of the correction value ΔR_C (S**202**). The predetermined time may be considered as, for example, several hours or several days. When the predetermined time has elapsed after the last calculation of the correction value ΔR_C (S**202**: Yes), the pressure setting unit **401** performs the processing described in step S**203**. Accordingly, a new correction value ΔR_C is calculated in step S**208**.

[0096] Meanwhile, When the predetermined time has not elapsed after the last calculation of the correction value ΔR_C (S**202**: No), the pressure setting unit **401** performs the processing described in step S**209**. In this case, a new correction value ΔR_C is not calculated, but the output unit **409** acquires the last calculated correction value ΔR_C from the storage unit **408** and calculates the pressure.

[0097] FIG. **12** is a view illustrating an exemplary computer that realizes functions of the processing device **40**. The computer **60** includes a central processing unit (CPU) **61**, a random access memory (RAM) **62**, a read only memory (ROM) **63**, a hard disk drive (HDD) **64**, a control interface (I/F) **65**, an input/output interface (I/F) **66**, and a media interface (I/F) **67**.

[0098] The CPU **61** operates on the basis of a program stored in the ROM **63** or HDD **64** to control each part. The ROM **63** is a booting program executed by the CPU **61** at the time of the start of the computer **60** and stores a program that depends on hardware of the computer **60**.

[0099] The HDD **64** stores a program executed by the CPU **61** and data used by the program. The control interface **65** receives a signal from the sensor module **10** and sends the signal to the CPU **61** via the cable **3**, and transmits a signal produced by the CPU **61** to the sensor module **10** via the cable **3**. Further, the control interface **65** transmits the signal produced by the CPU **61** to a control unit of the constant temperature bath, a control unit of the pressure calibrating device, and a control unit of the substrate processing apparatus.

[0100] The CPU **61** controls an output device such as, for example, a display or a printer, and an input device such as, for example, a keyboard or a mouse, through the input/output interface **66**. The CPU **61** acquires data from the input device through the input/output interface **66**. Further, the CPU **61** outputs the produced data to the output device through the input/output interface **66**.

[0101] The media interface **67** reads the program or data stored in a recording medium **68** and provides the program and the data to the CPU **61** through the RAM **62**. The CPU **61** loads the program from the recording medium **68** onto the RAM **62** through the media interface **67**, and executes the loaded program. The recording medium **68** is, for example, an optical recording medium such as, for example, a digital versatile disc (DVD) or a phase change rewritable disk (PD), a magneto-optical recording medium such as, for example, a magneto-optical disk (MO), a tape medium, a magnetic recording medium, or a semiconductor memory.

[0102] The CPU **61** of the computer **60** realizes the respective functions of the temperature setting unit **400**, the pressure setting unit **401**, the first measuring unit **402**, the second measuring unit **403**, the third measuring unit **404**, the pressure calibration data preparing unit **405**, the offset calculating unit **406**, the correction value calculating unit **407**, the storage unit **408**, and the output unit **409** by executing the program loaded on the RAM **62**. Further, the data in the storage unit **408** is stored in the ROM **63** or the HDD **64**.

[0103] The CPU **61** of the computer **60** reads the program from the recording medium **68** and executes the program. However, in another example, the program may be acquired from other apparatuses via a wired or wireless communication line.

[0104] As such, exemplary embodiments have been described. According to the pressure measuring device **1** of the present exemplary embodiment, the pressure of a gas may be measured highly precisely. Further, according to the pressure measuring device **1** of the present exemplary embodiment, the pressure of a gas may be measured highly precisely even in a case where the sensor module **10** manufactured by normal-temperature sputtering is used. Therefore, the manufacturing cost of the sensor module **10** may be reduced.

[0105] Meanwhile, the present disclosure is not limited to the aforementioned exemplary embodiments, but various modifications may be made within the scope of the present disclosure.

[0106] For example, in the aforementioned exemplary embodiment, when a predetermined time has not elapsed after the last calculation of the correction value ΔR_C, calculation of a new correction value ΔR_C is not performed, but the pressure calculation is performed using the last calculated correction value ΔR_C is performed. However, in another exemplary embodiment, the calculation of the correction value ΔR_C may be performed whenever the pressure calculation is performed. Specifically, in step S**200** of FIG. **11**, when the pressure measuring processing is previously performed (S**200**: No), the pressure setting unit **401** may perform the processing described in step S**203**.

[0107] Further, in the aforementioned exemplary embodiment, it is determined whether a correction value ΔR_C is newly calculated depending on whether a predetermined time has elapsed after the last calculation of the correction value ΔR_C. However, the present disclosure is not limited thereto. For example, the output unit **409** may accumulate the number of times that the pressure measurement is performed, and the correction value calculating unit **407** may newly calculate a correction value ΔR_C whenever the pressure measurement is performed a predetermined number of times.

[0108] Further, in the aforementioned exemplary embodiment, the processing device **40** has functions of the temperature setting unit **400**, the pressure setting unit **401**, the pressure calibration data preparing unit **405**, and the offset calculating unit **406**. However, in another exemplary embodiment, an operator may execute the functions realized by the temperature setting unit **400**, the pressure setting unit **401**, the pressure calibration data preparing unit **405**, and the offset calculating unit **406**. In this case, the processing device **40** has a configuration, for example, as illustrated in FIG. **13**. FIG. **13** is a block diagram illustrating another functional configuration of the processing device **40**.

[0109] According to the processing device **40** illustrated in FIG. **13**, in the offset value calculating processing, after an operator manipulates the constant temperature bath to control the temperature in the constant temperature bath, the first measuring unit **402** inputs the current of the first current value

I_1 to the electric resistor **20***a*, measures the first voltage drop, and outputs the information of the measured first voltage drop to the output device such as, for example, a display. In addition, the second measuring unit **403** inputs the current of the first current value I_1 to the electric resistor **20***b*, measures the second voltage drop, and outputs the information of the measured second voltage drop to the output device such as, for example, a display. Then, the operator calculates the offset value ΔR_O and stores the calculated offset value ΔR_O in the storage unit **408** through the input device such as, for example, a keyboard or a mouse.

[0110] Further, according to the processing device **40** illustrated in FIG. **13**, in the pressure calibration data preparing processing, after the operator manipulates the pressure calibrating device to set the pressure in the pressure calibration chamber, the first measuring unit **402** inputs the current of the first current value I_1 to the electric resistor **20***a*, measures the first voltage drop, and outputs the information of the measured first voltage drop to the output device such as, for example, a display. Then, the operator prepares the curve **52** that approximates the tendency of the change in resistance of the electric resistor **20***a* with respect to pressure and stores the information of the prepared curve **52** as a pressure calibration data in the storage unit **408** through the input device such as, for example, a keyboard or a mouse.

[0111] Further, according to the processing device **40** illustrated in FIG. **13**, in the pressure measuring processing, after the operator manipulates the substrate processing apparatus to set the pressure in the chamber to a pressure for calibration, the first measuring unit **402** inputs the current of the first current value I_1 to the electric resistor **20***a*, measures the first voltage drop, and outputs the information of the measured first voltage drop to the output device such as, for example, a display. In addition, the second measuring unit **403** inputs the current of the first current value I_1 to the electric resistor **20***b*, measures the second voltage drop, and outputs the information of the measured second voltage drop to the output device such as, for example, a display. Then, the operator calculates the correction value ΔR_C and stores the calculated correction value ΔR_C in the storage unit **408** through the input device such as, for example, a keyboard or a mouse.

[0112] Meanwhile, in a case where the pressure measuring processing is performed for the first time, after the operator manipulates the substrate processing apparatus to set the pressure in the chamber to a pressure for calibration, the first measuring unit **402** inputs the current of the second current value I_2 to the electric resistor **20***a* for a predetermined time and then inputs the current of the first current value I_1 to the electric resistor **20***a* to measure the first voltage drop.

[0113] From the foregoing, it will be appreciated that various embodiments of the present disclosure have been described herein for purposes of illustration, and that various modifications may be made without departing from the scope and spirit of the present disclosure. Accordingly, the various embodiments disclosed herein are not intended to be limiting, with the true scope and spirit being indicated by the following claims.

What is claimed is:

1. A pressure measuring device comprising:

a first electric resistor adapted to be exposed to a gas;

a second electric resistor adapted to be exposed to the gas and having the same structure as that of the first electric resistor;

a first measuring unit configured to input a current of a first current value to the first electric resistor and measure a first voltage drop generated across the first electric resistor according to the current of the first current value;

a second measuring unit configured to input the current of the first current value to the second electric resistor and measure a second voltage drop generated across the second electric resistor according to the current of the first current value;

a third measuring unit configured to input a current of a second current value greater than the first current value to the first electric resistor to generate heat from the first electric resistor and measure a third voltage drop generated across the first electric resistor according to the current of the second current value;

a calculating unit configured to calculate a correction value that corrects the third voltage drop, based on a difference between the first voltage drop and the second voltage drop; and

an output unit configured to correct the third voltage drop using the calculated correction value and output a pressure value according to the third voltage value after the correction.

2. The pressure measuring device of claim **1**, further comprising:

a base substrate provided with a temperature sensor,

wherein the first electric resistor and the second electric resistor are disposed on the base substrate.

3. The pressure measuring device of claim **1**, wherein the second current value is a current value in a range of 20 times to 40 times the first current value.

4. The pressure measuring device of claim **1**, wherein the calculating unit calculates a new correction value when a predetermined time has elapsed after the last calculation of the correction value or when the third voltage drop is measured a predetermined number of times by the third measuring unit.

5. A pressure measuring method comprising:

inputting a current of a first current value to a first electric resistor that is exposed to a gas;

measuring a first voltage drop generated across the first electric resistor according to the current of the first current value;

inputting the current of the first current value to a second electric resistor that has the same structure as that of the first electric resistor and is exposed to the gas;

measuring a second voltage drop generated across the second electric resistor according to the current of the first current value;

inputting a current of a second current value greater than the first current value to the first electric resistor;

measuring a third voltage drop generated across the first electric resistor according to the current of the second current value;

calculating a correction value that corrects the third voltage drop, based on a difference between the first voltage drop and the second voltage drop; and

correcting the third voltage drop using the calculated correction value and outputting a pressure value according to the third voltage value after the correction.

6. The pressure measuring method of claim **5**, wherein the first electric resistor and the second electric resistor are configured as a sensor module that is disposed on a base substrate provided with a temperature sensor, and the method further comprises:

disposing the sensor module in at least one of a portion in the vicinity of an exhaust port in a substrate processing apparatus that processes a target substrate by plasma of a processing gas, a portion in the vicinity of an ejection port of the processing gas, and a portion inside a pipe that distributes a gas for temperature adjustment, which is formed inside a placing table on which the target substrate is placed.

* * * * *